Comparing Personalization Approaches for Inclusion in Learning Management System

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Master's Thesis Project Description
Master of Science in Media Technology
30 ECTS
Department of Computer Science and Media Technology
Gjøvik University College, 2011

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2011/07/01

Abstract

Personalization is one of the important functions of modern Learning Management Systems. The basic idea of personalization in education is an incorporation of the person's individual characteristics. This thesis is directed to study the main aspects of personalization and how personalization can be applied in LMS, in order to achieve the best results during learning process and make learning more convenient and flexible.

The main objective of our study is to identify the personalization approach or a mix of approaches among Personalized Guidance, Personalized Learning Activities and Personalized Communication that can be more useful for inclusion in the LMS. We have found that a mix of Personalized Learning Activities and Personalized Communication Approaches is most useful for inclusion in the LMS. This mix can contribute to solving some of the problems of students, such as the difficulty of access and retrieval of desired educational materials and a communication problem. We have also examined the basis on which these approaches can provide personalization. Based on our research and analysis, we determined that the Personalized Learning Activities Aproach should include features such as: Study topic and Technical level; Personalized Communication Approach should be based on the Study topic.

Preface

This Master thesis is the final work done at the Master in Media Technology study in the Faculty of Computer Science and Media Technology at Gjøvik University College.

In first order I would like to thank my supervisor Rune Hjelsvold for his excellent supervision, good advices, motivation, control of thesis work and patience. Then I want to say thanks to everyone who participate in my experiments, associate professor Sule Yildirim for assistance with experimental setup. Thanks to my friend Konstantin Nosov for his support and care during this time.

My special gratitude turns to Gjøvik University College and Norwegian government for opportunity to study here.

And last, I want to thank my family for their support.

Vera Nekrasova, 1st July 2011

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1 Introduction

Personalization is one of the important functions of modern Learning Management Systems (LMSs). The basic idea of personalization in education is an incorporation of the person's individual characteristics. As we know all students are different and therefore approaches taken when teaching students and providing information to them must be different. Personalized services are attracting attention as a method of intelligent information service to satisfy informational demands of users in the system [1]. LMSs can be personalized in various degrees. Personalization in the LMSs can be viewed from different angles, such as personalization of the interface, personalization of the information content of courses, personalization of the communications, and personalization of the additional informational materials, etc. At the same time personalization in the LMSs can be based on various features such as educational interests, existing knowledge, knowledge etc.

This thesis is directed to study the main aspects of personalization and how personalization can be applied in LMSs, in order to achieve the best results during learning process and make learning more convenient and flexible. The main purposes of this thesis is to find the important features of personalization, to consider types of personalization that play an important role in providing educational content in the most effective manner for students in LMS. We are going to determine on what personalization should be based on, and the challenges that is related to the interaction with the LMS can be solved by integrating of personalization.

This chapter presents topics that will be covered in this master thesis, a description of the problem area, the justification, the motivation and the benefits. The research questions are also discussed in this part.

1.1 Topic Covered by the Project

LMS is an environment that has the ability to handle and manage the learner process anytime and anywhere [2]. A typical LMS provides course instructors with ability to create and deliver educational materials, to monitor the attendance of students and evaluate those tasks. Students using the LMS can obtain access to educational materials and study courses, solving and download the study exercises. Also it may provide students with the possibility of extended services such as discussion, chat, video conferences, forums, etc. LMSs provide access and management to Learning objects (LO). Concept of LO may include the following: labwares, course works, presentations, on-line courses, assignments, on-line research literature, audio and video lectures etc, that correspond a large amount of information and should be provided efficient for learners. Personalization can serve a way that can contribute to this.

To personalize means to make or change something, so it is suitable for a particular person [3]. [4] define personalization as:

> the ability to provide content and services tailored to individuals based on knowledge about their preferences and behaviour.

An adaptive process for an individual user can take the form of information filtering and/or identification of suitable information based on user interest. Web personalization involves personalization of Web resources - the content, links, web page structure and navigation [5]. Personalization of LMS is an important part [6]. Main objective of personalized learning system is to make the system that considers the queries, requirements and characteristics of each individual user, to help him find desirable information and to improve their web experience. Personalization in education provides searching and filtering of educational material and learning objects that befit the individual user and are appropriate to their preferences and interests. And also it considers in what manner and at what time, information should be provided so that the user could benefit as much as possible from it to spent his time as little as possible [7].

Personalised learning can be built on approaches such as personalized user interface, personalized learning path, personalized learning activities, personalized recommendation of learning materials, personalized communication [8].

1.2 Keywords

Learning management system, personalization, personalization approach, personalized learning styles, personalized guidance, personalized communication.

1.3 Problem Description

Today, learning resources are richer than before, include text, images, video, audio and other formats. An abundance of educational resources can increase the efficiency of learning, because learners can choose easy to understand learning material [9]. However, a large number of educational resources also forces people to spend more time for searching suitable learning materials.

The most part of the LMS is built in a standard way, they are able to manage the learning activities, learning material and communicate with other systems to the Internet through network platforms and programming languages. But the majority of LMS are not able to provide dynamic learning content to learners and change learning activities, they offer only a predefined set of actions to students [10]. They are not able to adapt content to the individual user.

At the same time the most LMSs provide the same content for study to all students or allow students to choose content among a large number of resources without giving any advice or assistance [8]. The LOs are presented uniformly to all learners and are not centered on their background, learning styles and preferences [11]. But all students are different: they perceive information differently and prefer different teaching methods. The learners needs and goals change along with their learning process. Due to the variance of learners' capabilities, intelligent learning systems should be able to provide different course materials and teaching methods [12]. Currently, several personalization approaches are distinguished. Each of these approaches is used for a specific purpose and has their own distinctive features. The question arises – how can we provide a personalization of LMS? What criteria and functionalities are required to produce of personalization in LMS? What kind of students' features should be considered?

1.4 Justification, Motivation and Benefits

Education plays an important part in our lives. More over, our future life depends from it. Therefore, it is important that the learning process should be effective: it must be usable for the learner and conform to his desires and needs. Inclusion of personalization function in the LMS will facilitate student access to resources that will contribute to more comfortable and convenient learning, providing only the desirable information in an understandable and readable form. In addition, recommendation of educational materials in the learner's preferred form and based on learner's background will accelerate the process of learning, because the student will not waste time on searching and filtering necessary materials. Use LMS with function of personalization, students do not adapt to the system but instead the system adapts to the students. With this feature, LMS provides a more flexible approach for studying to learners, makes the process easier and more enjoyable.

Use LMS with function of personalization, teachers can learn more about their students in real time and use this knowledge to improve educational outcomes for each student. For example, if student spends more time for study of a topic than other students do, the teacher can help him to understand the topic. Teachers will be able to understand the desires of each individual student and use it to construct lesson plans. The more teachers know about their students, the more learning process is effective and efficient.

The system, which focuses on the individual users and provides personalization services, improves service quality. Personalization of the LMS is "a seller of the store, which sits in the corner, remembers your previous steps and experiences and based on that helps you to make your next choice". Moreover, limiting navigation options and providing directed links to the desired information, personalization automatically makes the system more navigable, allowing the user to find desired content faster [13].

1.5 Research Questions

The following research questions were identified in this master thesis:

Q.1 — What personalization approach or mix of personalization approaches among personalized guidance, personalized learning activities and personalized communication can be more useful in Learning Management System?

This question compares three personalization approaches of LMS: personalized guidance, personalized learning activities and personalized communication. As result of the question, the most useful approach or approaches mix will be found for inclusion in the LMS.

Q.2 — What features can be as basis for personalization in Learning Management System?

This question is to determine what features can be a basis for personalization in LMS and important points that should be considered when learning resources is personalized.

2 Choice of Methods

The main goals of this master thesis are to identify the most useful personalization approach or mix of approaches among personalized guidance, personalized learning activities and personalized communication in learning management system and identify important points at which personalization can be based. Thereto, we can conduct a survey among students. This may be quantitative (statistical) or qualitative research methods. Quantitative research methods aim to obtain quantitative information about the large number of research objects. The main task of quantitative research is to provide a numerical evaluation of the reaction of respondents to an event. Such studies are used when accurate and statistically reliable numerical data is needed. Qualitative research is focused on obtaining the deep motivation of the user, of detailed information about the subject. Qualitative methods involve gathering information in a free form, they focus not on statistical measurements, and are based on the understanding, explanation and interpretation of empirical data. Qualitative methods are a source of hypothesis formation and productive ideas. Qualitative research methods require a survey in the form of individual interviews with respondents.

In this master thesis we study a inclusion of a new feature in LMS, namely the personalization. Thereto, we will interview with students who use the LMS in their usual learning process. In the interview, we ask questions about the inclusion of personalization in the LMS. Persons are limited in their knowledge and can answer questions only about what they had to experience. They can not imagine what they do not know about such as new technologies, materials, etc. [14]. Therefore, the first step in the study will be to build a prototype that represents the functions which provide personalization in the LMS. The prototype will be based on three personalization approaches of LMS, which are considered in this project: personalized guidance, personalized learning activities and personalized communication. The prototype will provide the basic concepts and objectives of personalization.

Since we use a prototype in our study, that demonstrates the personalization features in the LMS. But we are limited by time of the study. Consequently, we can not show a prototype for a large number of respondents that are required in quantitative research methods. Therefore, a qualitative research method will be the primary. But we can make statistical conclusions about certain issues based on results of the qualitative method.

Respondents will be given an opportunity to explore and interact with the developed prototype. After that individual interviews will be conducted among the participants, in which they will be asked questions relating to the study area. After analysing the responses of participants, we can draw conclusions about our research. We will take into account the views of each individual respondent.

3 Related Work

3.1 Concept of Learning Management System

Modern educational approach is undergoing some changes. A large number of schools and universities use a blended learning approach, which combines the "traditional approach to education, where the transfer of knowledge is achieved mostly by lecturing" [15], and "e-learning approach", that is defined as "the use of new multimedia technologies and the Internet to improve the quality of learning by facilitating access to resources and services as well as remote exchanges and collaboration" [16]. Access to e-learning approach is through an on-line environment using a Learning Management System.

A Learning Management System (LMS) is a standards-based system, and "its goal is to provide standards to describe learning resources, communication protocols between learning resources, systems to manage the overarching delivery and handling of learning resources" [2]. A LMS can be represented as a software application, and web based technology and is used for planning, implementation and management of educational processes by teachers, and provides authentication, registration for courses and access to elements of the courses to students. Through the LMS, a course instructor can create and deliver content, monitor students' participation and assess students' performance [10, 16, 15, 2]. Ryann K. Ellis defines features that are capable of performing full-fledged LMS, as the following [17]:

- centralize and automate administration;
- use self-services and self-guided services;
- assemble and deliver learning content rapidly;
- consolidate training initiatives on a scalable web-based platform;
- support portability and standards;
- personalize content and enable knowledge reuse.

The main objective of LMS is to manage and provide access to Learning Objects (LO). A LO is the main source of information in the LMS. The concept of LO may include various learning methods that involve labware, course work, presentation, on-line course, assignment, on-line research literature, audio and video lecture etc. The Institute of Electrical and Electronics Engineers (IEEE) defines a learning object as "any entity, digital or non-digital, that may be used for learning, education or training" [18]. In this definition, a "non-digital" LO means "people, organizations and events". [19] defines the classification for digital LOs. They point out Integrated, Informational and Practice types of LOs. Under the Integrated type, mini-tutorials, mini case studies, simulations, etc. with supportive information is implied. Informational type includes overviews/summaries; descriptions/definitions; demonstrations/models; worked examples; cases/stories; papers/articles; decision aids. Practice type contains problems/case studies; games/simu-

lations; drill-and-practice exercises; review exercises; tests/assessments.

There are a large number of companies providing LMS, for example such as Fronter [20], Moodle [21], Blackboard [22], CEWebS [23] etc. These LMSs cover a variety of teaching methods and allow us to include a variety of LOs. Most of them correspond to the basic principles defined Ryann K. Ellis.

3.2 Concept of Personalization

Personalization as a phenomenon is probably known since the time of trade relations [24]. In 1870, the first personalized direct marketing letters appeared and were widely used throughout the twentieth century. But in 1970, the cost of postal services rapidly increased, and personalization, as it has been used before, has been given less attention. Anew talking about personalization was in the 1990s due to the expansion of the Internet, the concept of e-commerce emerged and the cost of personalized letter spread was close to zero. Now personalization is widely used in such areas as education, health care, television and etc.

In the literature there are several descriptions of the concept of personalization. Personalization Consortium defines personalization as [25]:

> *Personalization is the use of technology and customer information to tailor electronic commerce interaction between a business and each individual customer. Using information either previously obtained or provided in real-time about customer, the exchange between the parties is altered to fit that customer's stated needs as well as needs perceived by the business based on the available customer information.*

Nowadays marketers and scholars use several different terms when they talk about concept of personalization. The most common ones are mass personalization, customization, profiling, segmentation, filtering, tailoring and etc.

Briefly, the concept of personalization is a process of changing or adding something to an object to make it suitable for the needs of a particular person [26]. The main goal of personalization is to help people find information that interests them, which can significantly improve their web experience. The most difficult aspect of personalization is to understand user preferences and successfully use them [5]. The process of user personalization can be characterized as a process of gathering information about the user during his interaction with the system and use this information to adapt the system in accordance with the requirements and desires of the user. Information collected about the user makes the user profile, which is then used as the basis for the adaptation of the system.

3.2.1 User Profile

User profile, also called the User model, is an abstract representation of the captured information requirements for an individual user. Information to construct an individual user profile can be collected explicitly and implicitly. When the user profile is constructed explicitly, the user data collected by hand through surveys or user feedback [27]. The opposite approach to the extraction of user interests is implicit approach. When the user profile is implicitly built, the user data collected analysis of user behavior and interaction with the system.

Two types of user profiling approaches are distinguished: the static profile and dynamic profile. Static profile is an analysis process of user static and predicted character-

istics. It is stable or changes very slowly during a long period [28]. Usually static profile can be created based on user basic data, that possible includes user's name, sex, age, place of job or studying and etc. The dynamic profile is opposite of static profile and can be built in real time based on user behavior data. It changes, if over time the interest of user changed. The dynamic profile is represented by short term and long-term interests. Short-term interests represent the interests of the current time, and long-term interests represent the interests of the user that does not change over a long period of time [29].

3.2.2 Web Personalization Approaches

There are many different approaches to personalization. Anand and Mobasher [30] classified approaches to web personalization by the usage of user profile data, the way of data processing, the usage of information and the place where the personalization process occurs.

Most systems use classification of personalization approaches as the use of user data. The following techniques are produce: Content-based filtering, Collaborative filtering and Hybride filtering.

Content-based Filtering

Personalization system based on content-based filtering approach unobtrusively monitors user behavior in the system. Personalization is based on finding similarities between the existing information in the system and user behavior in the previous session in the system [31]. In content-based filtering, each user is considered independently. As a result, only the data can be used, which were derived from user behavior in the system [32]. Information is provided to user and it has high similarity to his/her previous interests or user profiles.

[30, 33] notes the benefits of the content - based filtering approach. This approach can be applied on the client side, that ensures privacy of the user. The disadvantage of the approach is that the approach focuses on previous user interests. Also, the problem arises when a new user is coming who does not have or has a little experience with the system, hence the user profile is submitted to bad and personalization is carried out inaccurate.

Collaborative Filtering

This approach, also called social filtering, is an alternative approach to content-based filtering approach. It uses not only a single user profile, as well as other users with similar interests [30]. Users with similar interests is called active user's neighborhood. The collaborative filtering approach is based on the ratings provided by the user who have liked the item before [31]. The system tries to predict the useful items to individual users based on the items that was priced by other users who have similar interests [33].

[30, 33] distinguish the advantages and disadvantages of the collaborative filtering approach. The advantage is that the user gets the recommendation only items with the highest rating. Following disadvantage is when new items added to the system, then the estimates are not available from this items. Consequently, it can not be offered to anyone. Another disadvantage is the same as in content-based filtering approach, user must have a certain number of assessments items, before she/he starts getting successful recommendations.

Hybrid filtering

Hybrid filtering combines the advantages of content-based and collaborative filtering [31]. Usually in this approach, the user profile consists of a topic profile and group profile. A user's group profile reflects what users' interests similar to the user. The topic profile shows the individual user's interests. Different ways to combine collaborative and content-based approaches into a hybrid recommendation system can be classified as follows [33]:

1. Implementing collaborative and content-based methods separately and combining their prediction [34]. In this approach, we make two separate recommendations for collaborative and content-based methods, and at some point, use a recommendation that gives us a better result than the other [35].
2. Incorporating some content-based characteristics into a collaborative approach [9]. In the first stage of this approach, the recommendation is based on collaborative approach. In the second stage content-based approach is applied to the received recommendations, based on topic profile. The result of two stages is presented to the user [35].
3. Incorporating some collaborative characteristics into a content-based approach. This approach is an alternative to the previous approach. At the beginning of the recommendations made by using content-based approach based on the topic profile. And then the collaborative approach is applied to the results obtained on the basis of group profile [33, 35].
4. Constructing a general unifying model that incorporates both content-based and collaborative characteristics. Various methods are used to combine approaches. [36] proposed a tree-way aspect model. Model parameters are learned using expectation maximization (EM) algorithm.

Metadata Based Approach

Hicks and Totcherman view metadata based personalization approach. This approach is based on the concept of metadata as data about data or as a mechanism for describing information resources. Metadata "serves as the mechanism for capturing and maintaining personalizations that are made to information items" [37]. Thus, this approach gets the personalization information locally, when a user interacts with the system, and personalizes the information and items. Metadata contained in a digital catalogue of the system describes information resources. The system allows users to describe their objectives and desired resources. Then, relevant resources are searched in the digital catalogue based on information provided by the user.

The main difference between this approach and previous is to the effect that it does not store user information in the system information repository. But digital catalogue contains information about the stored items, which should be structured and well documented.

The choice of approach depends on the goals to be achieved as a result of personalization. It should also be based on what data about the user can be obtained. Before choosing an approach, we must ask ourselves, for example the following questions: Do we have the opportunity to receive feedback on the user viewed documents? Is there enough information to be obtained through analysis of user behavior?

3.3 Personalization in LMS

Ryann K. Ellis [17] considers personalization as one of the essential and important functions of the LMS. This is based on the fact that there is a lot of LOs and learning resources in the LMS, and every day they become more and more. [9] describes this situation as:

> *Nowadays learning resources become richer than before, including text, image, video, audio and other format. Abundant learning resources can increase the user's study efficiency because they are vivid and easily understandable. However, the rapid growth of learning resources also make people have to pay more time to look for right learning resources suitable for them.*

It shows that LMS should not only provide access, control and share of LOs, this must be done in an efficient and personalized manner.

Personalization is of particular importance in the LMS. Alan Nelson [6] says:

> *To be a success, any programme must get the learner to engage. And we have learnt that the key to this is personalization - making content and learning experience work for and relevant to the individual learner.*

[26, 6] identifies four key factors of an on-line learning personalization:

- Providing flexible learning outcomes. - It means that the study programme should be clear and simple in the structure, be based on prior knowledge of learners and yet allow them to navigate the system themselves.
- Meeting the needs of individual learning styles. - An effective on-line learning program should provide a mix of learning information, LOs and learning activities that learner can choose to go through in their own sequence and at their own pace. Personalization should take into account how the learner perceives the information and manages it.
- Keeping the learner engaged. - In this case, the main point is relevance. It does not matter how good the information is presented, structured and balanced, if they do not contain examples that pointedly fit the student, it will be a significant barrier to achieving educational goals.
- Enabling the learner to use their time well. - It means that the provision of educational content should provide the most flexible form, as it is allowed.

Providing educational information and educational resources in a personalized manner must take into account more keys factors as possible. Main objective of personalized LMS is to make the system that considers the queries, requirements and characteristics of each individual user, to help him find the necessary information and to improve the web experience.

3.3.1 Approaches of Personalization in LMS

As we discussed above, the interactivity and personalization are the most important features of LMS. Personalization is a goal for the development of interactivity. Thus to

achieve a personalized learning through interactivity with the student is a primary goal of personalization strategy in the LMS. Analyzing the learning process, [8] identifies the following personalization approaches, which may be included in the LMS: personalized user interface, personalized learning resource, personalized learning activities, personalized guidance, personalized communication.

Personalized User Interface

The different interfaces are provided to different users. It is a personalization of a work space, students are allowed to customize their own Learning Enviroments. Also, the user can select the device on which system is used (eg PC, laptop, PDA, Cell phone) [12].

[38] distinguish two types of user interface: static, which contains objects with fix position and size, and dynamic, which consist of objects with relation to another object and involves changing in process of training. Basis interface objects can be personalized, which include windows, menus, buttons, sliders, forms etc, their visibility and their enabled/disabled status is based on the user's actions [39]. Here, windows is a visual area that is defined by graphic displays, and can be resized, moved, hidden, restored, and/or closed [38]. The concept of form is used to indicate the shape and structure of pages; content, its substance, meaning ideas, or expressive effects. Also examples of basis interface objects can be images and text [40]. All interface objects can be personalized for the individual user.

[41] distinguishes applications interfaces of LMS in which different user roles have a different access right or authorizations. Different information and access to educational materials available to various users including teachers and students. Figure 1 shows personalized user interface model.

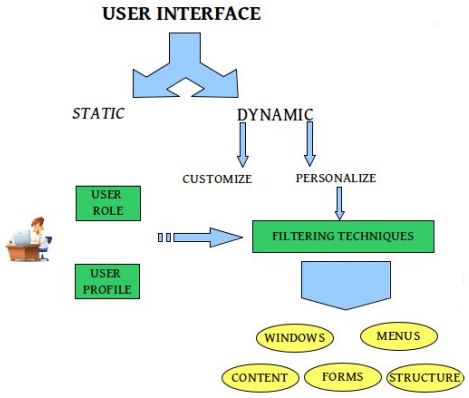


Figure 1: Personalized user interface model

The use of personalization of user interface is a useful tool in facilitating navigation and increased speed of access, but can also affect the reduction of cost and time to find useful information.

Personalized Learning Resource

Educational resources, such as multimedia courseware, practice homework and other, are filtered to the student based on its current characteristics and background knowledge. Individual learning content is available to students and individual learning is constructed based on existing knowledge. Also, students can subscribe to various resources

that they find interesting [8]. Usually as a result of this type of personalization, student has individual learning path. It means the learning content is proposed based on current knowledges and abilities of the student. This approach is successfully applied in distance learning. Approach to personalized learning resources are guided by existing knowledge of the student and the objectives to be achieved as a result of the course. Content of the course is chosen appropriate to individual learner. [42] provides with personalization of learning resource based on the course material difficulty and learner ability, because these variables reflect learner interests and learning results. Before starting the course, usually students are tested, that always to determine their knowledge background [15, 43]. During the course, learner ability is based on user feedback and also through testing. This allows the user to define success in moving to a desired goal and pick up course materials based on the desired complexity depending on learner ability. Course material difficulty reflects the depth of educational material in a particular area.

Another aspect is time suitability that could be considered for personalization of learning resource [44]. In this case, the learning materials are offered depending on how much time the student will spend on the lesson. In this case, the system offers the resources whose learning time estimated by the teacher does not exceed the time that the user would like to spend learning the lesson.

Applying personalized learning resource into LMS, the student receives lessons tailored to each student. Using this technique into LMS can achieve personalized learning and helps learners to study more effectively and efficiently.

Personalized Learning Activities

Learning activities are different and describe how user perceives information and prefers some form of LO (visual, auditory, text, etc.) [45, 46]. The idea of this approach consists in the personalization of learning content based on learning style of the user. [47] describe learning styles as

> *characteristic cognitive, affective, and psychological behaviors that serve as relatively stable indicators of how learners perceive, interact with, and respond to the learning environment.*

There are not two identical students. They have different backgrounds, strengths and weaknesses, interests, ambitions and sense of responsibility, levels of motivation and learning approach [47]. Students have different learning styles, preferentially focusing on different types of information and tending to operate on perceived information in different ways [47, 45]. Application of different learning styles for different students improves learning performance, increases the rate of perception of the educational material, helps students become self-directed [26, 48].

There are a large number of models of determining learning styles. The most widely used model is the Fleming's VARK model [49], which identifies the following four learning styles: Visual learning, Auditory learning, Read/Write learning and Kinesthetic learning. These styles differ in the way of perception. Visual learner prefers to receive information presented in charts, graphs, and other symbolic devices; as if the information is presented in the form of abstracts, and lists; like to watch videos. Auditory learner prefers to learn from spoken lessons and talking, notice sound effects in movies, and likes to take part in group discussions, for better memorization of facts and lines uses association. Read / Write learner prefers to receive educational information in the form

of printed text, and it is peculiar to do a lot of records. Kinesthetic learner tends to learn through direct practice, this may be conducting experiments, solving exercises, etc. Popularity VARK model is its face validity, its simplicity, it's easy of use, and the wealth of learning materials that have been designed to accompany it [49]. [49] also notices that in life clearly defined style of information perception is uncommon, usually students have a mixture learning styles.

Some educational theories consider personalized learning activities as an important factor in the learning process and that their introduction into the learning process leads to the facilitation of the learning process [50]. In addition, the knowledge of their learning style will help students understand why they have difficulty to learn some study point, and achieve success in these weaknesses.

Personalized Guidance

The system analyzes learners data: their interests, desires, and etc., and then give different personalized guidance and recommendations to every learner [8]. Many systems use this type of personalization, such as [34, 9, 27, 51]. The problem of representation personalized content is often described as providing recommends materials to user [52].

This approch of personalization is the recommendation of additional educational materials based on individual learner interests. [9] describes an ideal LMS the following words:

> "*One perfect personalized LMS should recommend right learning resources for right learner at right time and can adapt to users' changed needs.*"

The system should make personalization of learning materials at the student requests based on student interests. [53] define paper recommendation problem as follow:

> "*Given a representation of my interests, find me relevant papers.*"

To design an effective recommendation education system, it is important to understand that the user desires. [52] identifies the following qualities for a good recommendation system:

1. *Provide personalized view* - A good recommender system should be based on the user's interests and their background.
2. *Provide customize search* - To help users find information, search should be based on choice.
3. *Recommend materials at the appropriate time or location* - Recommendation of materials must be based on other documents viewed by the user, time of recommendation, etc.
4. *Support non-disruptive view experience* - That means that the user should be able to choose relevant information among the suggested materials.

The system with includied personalized guidance makes personalized recommendation of study materials. Study materials can be presented by web page, magazine articles, conference papers, workshop papers, technical reports, video demonstration, video lecture etc [51, 52].

Recommendations which are based only on the user's interesting topic, can be insufficient to meet learner desires. [54, 51] consider technical level as important features for recommendation of personalized materials. The technical level of papers is a difficulty

degree of learning object. The technical level is introduced due to the fact that different students have different knowledge background; also students differ in their speed of perception and understanding of the educational materials. A good example of using different levels of technical paper is presented by [51]:

> "*Some instructors will recommend learners to read an interesting magazine paper, such as a related article in Communications of ACM, before a technical paper, because they believe it will help learners understand the technical paper and make them less intimidated*".

[55] determines three difficulty levels of LO:

- Basic level – Information presented is based on fundamental principals or concepts. It is introduction material. It is level for novice learners.
- Intermediate level – Information presented is based on more difficulty concepts and understanding this information require more advanced knowledge and skills in interesting topic. It is level for medium learners.
- Advanced level – Information presented devotes to highly advanced concepts and new techniques of learner interesting topic. This difficulty level of the materials is required a well-rounded knowledge, an ability, and an experience in using of learner interesting topic. It is level for advanced learner.

Including personalized guidance into LMS facilitate the search of relevant learning materials, and make learning more comfortable, giving the user the materials meet his personal needs.

Personalized Communication

The group of collaborative learning is an important form of learning. Communication between team members is important for knowledge sharing. Personalized communication approach offers persons: teachers or other students that have similar interests and are knowledgeable in certain areas [56].

The use of personalized communication into the LMS is based on the fact that communication plays an important role in the learning process [57]. The process of knowing consists of sharing, thinking and learning components. People believe that through a process of communication and sharing knowledge, they quickly reached an understanding of the studied materials [58]. Human communication between students and between student and teacher is an essential element of learning; no matter in what form this is done, written or oral [57]. Internet expands ways to the communication. Using Internet, communication process can be carried out through e-mail, chat rooms, group discussions, conferencing and Internet-based audio / video application [59]. Advantage of the Internet, as a way to communicate, is the fact that we may at any time to ask questions and to get an answer. The positive side of using the Internet is also based on the social aspect: sometimes to ask a question on the Internet is easier than in living. Then there is a problem: "Who can give an answer?" Personalized communication into LMS is focused on the solved of this problem.

The purpose of this approach of personalization is to provide persons for study communication and knowledge sharing to the student and quick to find an consulter in the

interest issue.

3.3.2 Overall Architecture of LMS with Personalization

LMS enables its users a wide range of services. [60] examines in detail the architecture of the LMS. The main feature of the architecture of LMS is that each system component performs its own function. Each component is a separate module in the system architecture. Thus, personalization in the LMS is also represented by separate modules.

In general, the personalization process in the LMS can be formulated as following:

Step 1: Collect student personal information.

Step 2: Identify learner status based on personal information.

Step 3: Select recommended LOs from the repository for individual students based on student interests.

Step 4: Display the recommended LOs to learner.

There are many papers, that consider the architecture of personalization module in LMS [42, 52, 51]. They identify three main components of the module personalization in LMS: Interface; Repository; Recommender. For clarity, the system architecture is based on three components: Interface; Repository; Recommender is shown in Figure 2.

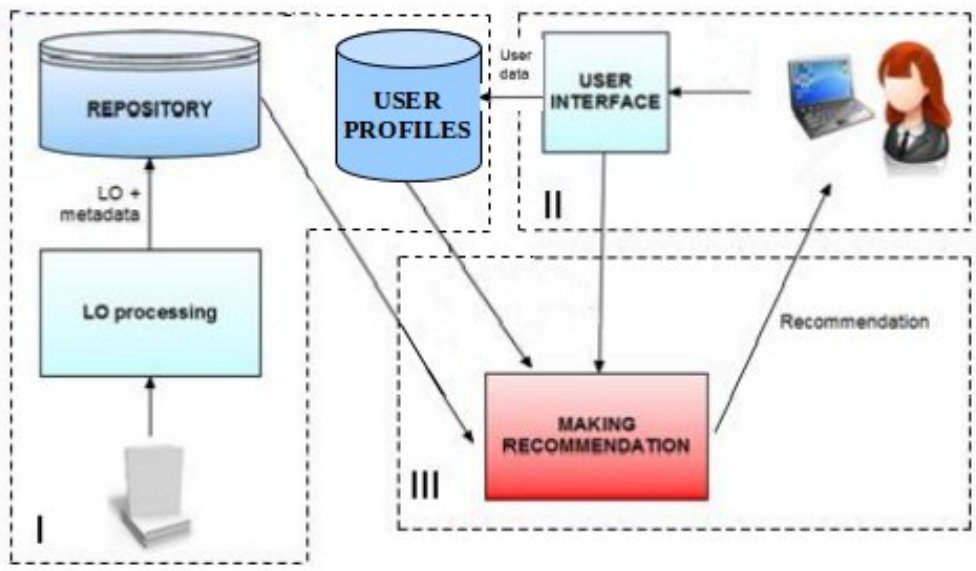


Figure 2: Architecture of personalization module with three components in LMS, where I – Repository; II – Interface; III – Recommender

First, Interface component manages communication with students and creates a user profile. It identifies student status, transfers student queries and returns the recommended LO to students. It can be used as human-machine interactive interface. Interface component provides a friendly interface for interacting with students and also is used as an information provider for Recommender component. The interface component provides the functions of student interests identifier, transfers students information and displaying the recommended LO to students [42].

Second, Repository component is a database that contains LOs, and their corresponding descriptions. LO contained in repository is classified into predefined course units.

Usually course units meet the course topics and are determined by the course instructor manually [51]. Repository is a learning objects storage, which also indexes and structures of these LO. In that way, repositories not only provide efficient search and retrieval, but also increase the reusability of LO and allow to personalize LOs [61]. There are different kinds of repositories [62, 63]. One kind of repository is a representation LOs as a collection of information about it like a library catalog, which can include a description of the LOs. The catalog description is referred to as the "metadata". The metadata is a label, that is marked the every LO [63] and an information that identifies and describes the LOs [64]. The use of the metadata provides search LOs appropriate to specific learning contexts, levels and styles, and also search for non-text LO. All LOs are contained in the learning object repository. Contained learning objects in the repository should be described for a successful search. There are several related works that describe representation of digital LOs in repositories [31, 52, 54, 65, 51, 64]. Based on these articles, the main metadata to describe the LO in the repository were selected as following:

- Title – The name is given to LO. It may be original name under which LO was published.
- Authors – The creator of LO. It may be individual person or group, and also a company or service.
- Link – A Internet address, location of LO on the Internet.
- LO Type – Format of the LO, which describes the nature and characteristics of learning objects.
- Keywords - Category contents in term of keywords.
- Description – It can include article abstract, themes, etc.
- Technical level - Technical level of paper is a difficulty degree of learning object.

Other learning resources, such as information about person, also should be described by metadata in repository. Persons are described by user profile. Details of the person should be described based on the following metadata [42, 65, 66]:

- Name – The name of person, it can include given name and family name.
- Position –It is a kind of occupation (student, teacher).
- Contact information – It is a way of communication (for example e-mail).
- Knowledge about field - This option consists of two components: topic of interests and level of qualification on this topic.

Such an item, as a level of qualification is included in information about persons [65, 66] . This is done to improve the recommendations and outputs. Only a person that does for communication in a certain field, can help. Those persons will be offered to the students who have the same knowledge level or above.

Third, Recommender component aims to analyze student interests, ability and other

student information and select appropriate LOs for students based on considered student interests. Recommender component receives data from the Interface component about the students interests and analyzes them. It compares this information with data stored in the Repository component. Therefore, Recommender component is a mediator between Interface component and Repository component [42].

3.4 Summary

This chapter provides an overview of existing work in the field of personalization in LMS. The items are considered such as: concept of personalization, namely the user profile and web personalization approaches, approaches of personalization in LMS and its implementation and realization. Web personalization approaches were considered, such as content-based filtering, collaborative filtering, hybrid filtering and metadata based. Approaches of personalization in the LMS have been presented and described such as the personalized user interface, personalized learning resource, personalized learning activities, personalized guidance, personalized communication. Therefore, we also consider how different personalization approaches can be applied in the LMS. This chapter also addresses what features are used for recommending personalized learning objects and what technologies are applied for implementation of personalization in LMS.

4 Survey Setup

This master thesis aims to study the including process of personalization in the LMS, namely, what approaches of personalization can be useful for students, what functions should be a basis for implementation personalization and in what cases it may be applicable. To achieve the objectives we should to conduct interviews with students, which will help us answer the questions. But students may not have enough skills about the concept of personalization and its characteristics. For these purposes, the most appropriate solution would be to develop a prototype that shows the use of personalization in LMS. The prototype should demonstrate the basic objectives, opportunities and features of personalization of learning objects. Using the prototype, students can understand the basic principles and characteristics of personalization, and also give their opinion about this and formulate more precisely their desired outcomes.

4.1 Choice of Personalization Approaches in LMS

In section 3.3 of Related work chapter, we consider approaches of personalization that can be included in the LMS: personalized user interface, personalized learning resource, personalized learning activities, personalized guidance, personalized communication. Requirements for their implementation will be reviewed.

Personalized user interface involves setting the workspace for individual students, for example convenient location of windows, color, support of different devices. This type of personalization is well studied and used in varying degrees in almost every LMS.

Personalized learning resource is a change and a construction of learning courses content based on the user's interests and existing knowledge. The result of this approach is a individual learning path for each student. This approach is mainly used in distance learning, where students of the course independent of each other. This kind of personalization requires changes in the educational process.

Personalized learning activities includes recommendations for learner of learning resources in a form that the learner prefers better (for example - audio, video, text). To implement the inclusion of this approach of personalization in the LMS, it is necessary that the study material was presented in various forms, that can be and appropriate for student learning styles.

Personalized guidance includes the recommendation of additional learning resources based on topics of learner interests. This kind of personalization requires a study material with which the student will be able to get the required amount of information.

Personalized communication requires the recommendation of other students and teachers who can help learners with interesting questions. To use this approach of information is necessary to have people with knowledge in required subjects.

While working on a master thesis, there are some limitations such as time, resource, etc. For example, for the implementation of personalized user interface, it is necessary to use several devices; for personalized learning resource a change should be in the educational process. And so realization of comparing all approaches of personalization is not possible. Due to limitations of the master thesis, following types of personalization were

selected for study: personalized learning activities, personalized guidance, personalized communication.

4.2 Data Set

We have identified in Chapter 2 - Choice of Methods that we should to create a prototype. Before to start creating of the prototype, we should to determine on what basis we will design it. In order for students to leave his true feedback, they should have a good understanding of the study area. Therefore, implementation of the prototype will be focused on one particular course and as respondents we will use a group of students that study this course.

We will use the Artificial Intelligence Course [67] to create the prototype. This course is taught at Gjøvik University College [68] (GUC) for the second-year bachelor students. This course is presented on the basis of LMS Fronter. The choice of this course is associated with the following: first, the learning process of the course includes both theoretical studying and application of this theory, and therefore, several types of LOs and teaching methods are used; second, students studying this course, already have experience of working with LMS and can identify the pros and cons of it.

4.3 Persionalization in LMS Fronter

Artificial Intelligence Course, which we consider as a basis for our prototype, is studied in the GUC. GUC uses LMS Fronter to manage learning courses. LMS Fronter provides ample opportunities for the management of educational content, access to study courses, etc.

LMS Fronter provides individual users with opportunity of personalized interface. Upon request, students can set up access to courses, e-mail, calendar, news, etc. in convenient form for them. Examples of individual learning environment in the LMS Fronter is shown in Figure 3.

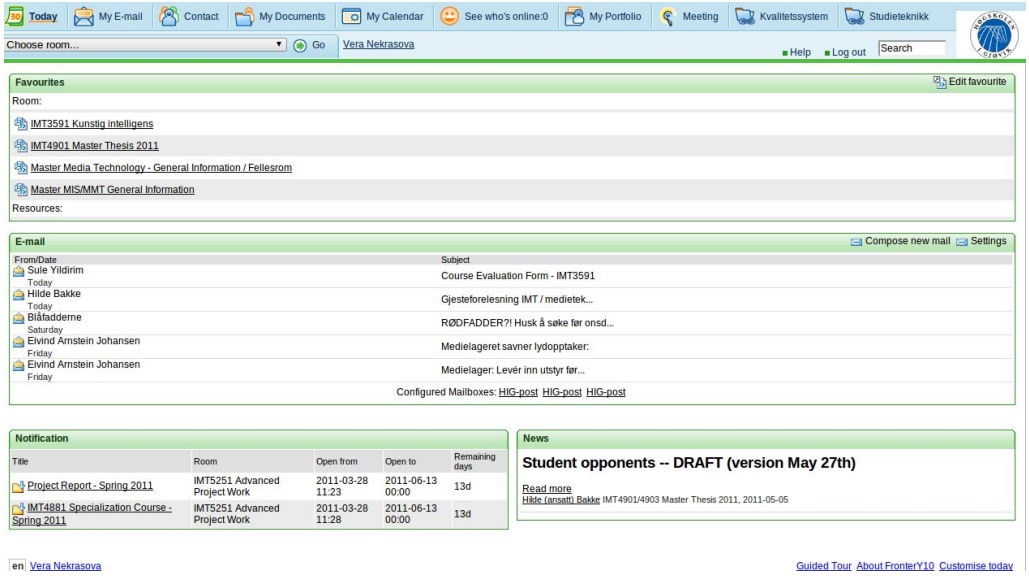


Figure 3: Example of individual learning environment

Also, the language of learning environment can be selected among English and Nor-

wegian on request. Appearance of the learning environment can also be changed by the user. Student can install for themselves the necessary HTML styles, change the background, color, font and size of text.

Each course in the LMS Fronter is presented by the individual area that called “Room”. Students do not have opportunities for personalization inside Rooms. All content of courses is the same for all students.

Thus, LMS Fronter provides students with only the possibility of personalized user interface of the learning environment, namely to set up easy and convenient access to the study courses and tools (e-mail, calendar, news and etc.), and also to change its appearance, but any possibility of educational content personalization is not available.

4.4 Contextual Features

We consider how three approaches of personalization can be included in the LMS like Fronter and on what features it might be based. As already stated above, Artificial Intelligence Course has a room in the LMS Fronter. Screenshot of the Artificial Intelligence Course room is presented in Figure 4. The Room provides a student syllabus course, access to lecture materials and additional resources, course participants, student portfolio - statistics of visiting the rooms and management course materials (read LO, uploaded projects and solved exercises). All information provided on this page is the same for all students, with the expection of student individual statistic information.

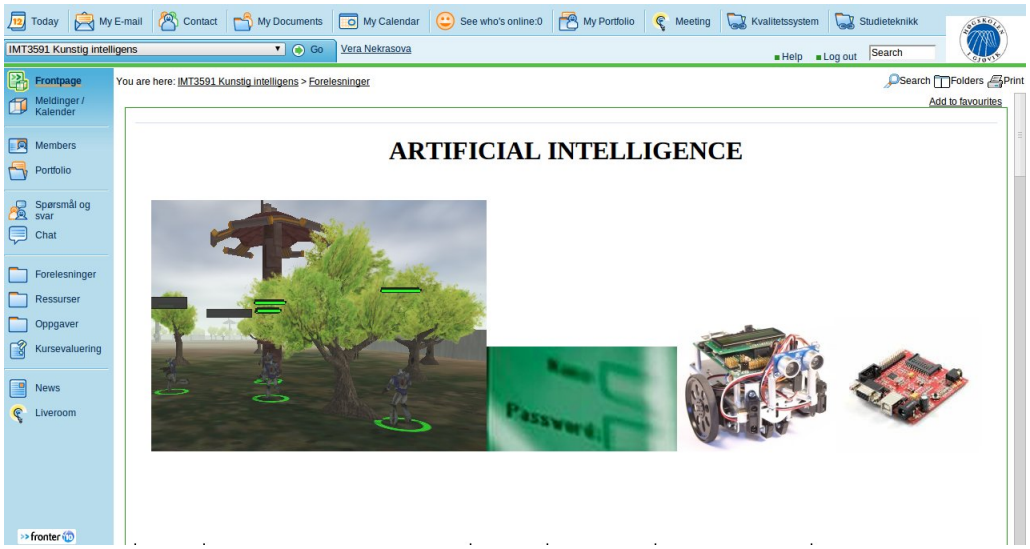


Figure 4: Screenshot of the Artificial Intelligence Course Room

4.4.1 Personalized Guidance Approach

Personalized Guidance Approach denotes a personalized recommendation of additional training materials on the user’s request. Next we will consider as additional educational material are presented in the Artificial Intelligence Course Room. This course is presented by such kinds of teaching materials such as technical reports, textbooks, journal papers, technical articles, tutorials, demonstration video, etc. In Figure 5 of the syllabus of the course is presented. It displays the time and topic lectures, lecture slides, and where we can find more information about the topic. Additional educational materials are pre-

sented in column "Notes" of course syllabus and marked the red line in the Figure 5. Also additional educational materials are presented in the list on the page after the Artificial Intelligence Course Syllabus, as shown in Figure 6, and in the folder Resources, as it is shown in Figure 7. As can be seen from figures 5, 6, 7, that the LO does not contain any description excepting the name, which does not reflect the essence of LO in some cases.

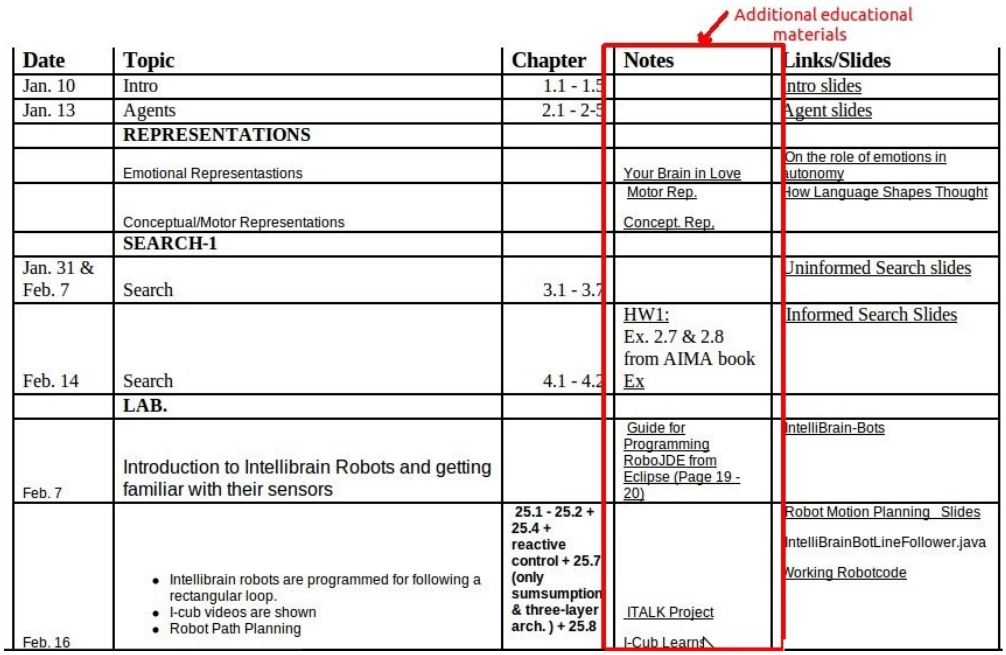


Figure 5: Example of syllabus part of Artificial Intelligence Course

Considering the educational materials provided as part of the course, we noticed that a number of documents was submitted for a basic level knowledge, some of the LOs may require additional skills, and part of the LOs were for optional informational purposes. Level of complexity of information is nowhere represented, and the student can spend more time if, for example, he/she starts to read a complex LO instead simple on the first education step.

Thus, we concluded that the Artificial Intelligence Course is represented by different LOs. These learning objects have different levels of complexity, have different objectives, and provides a in variety of formats. But students may have some difficulties in finding the desired information, and also spend more time for studying. Thus, the introduction of personalization based on the subject topic and the level of complexity of information in this topic may help to facilitate the search of desired information and assist to study.

4.4.2 Personalized Learning Activities Approach

Personalized Learning Ativities Approach denotes a provision of learning materials to students based on the their preferred learning styles, i.e. on the basis of the form in which the student perceive an information better. Different learning styles are considered in the personalization of Learning Activities. We will examine how this type of personalization can be used in the LMS. VARK model presents four learning styles: Visual learning styles, Auditory learning styles, Read / Write learning styles, Kinesthetic learning styles.

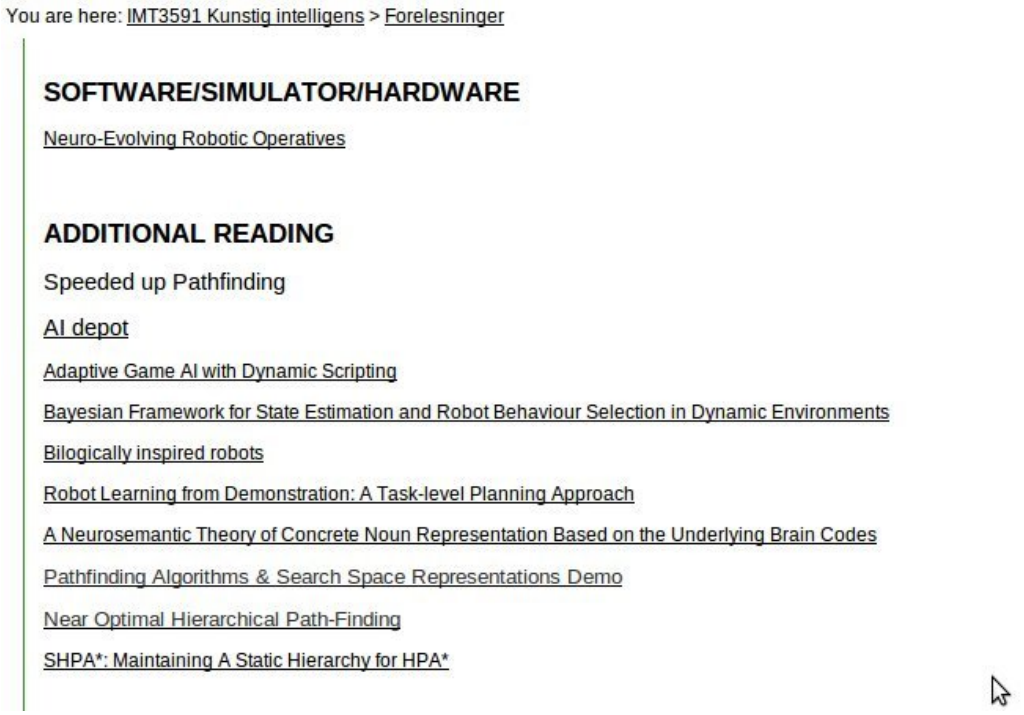


Figure 6: Additional reading of Artificial Intelligence Course

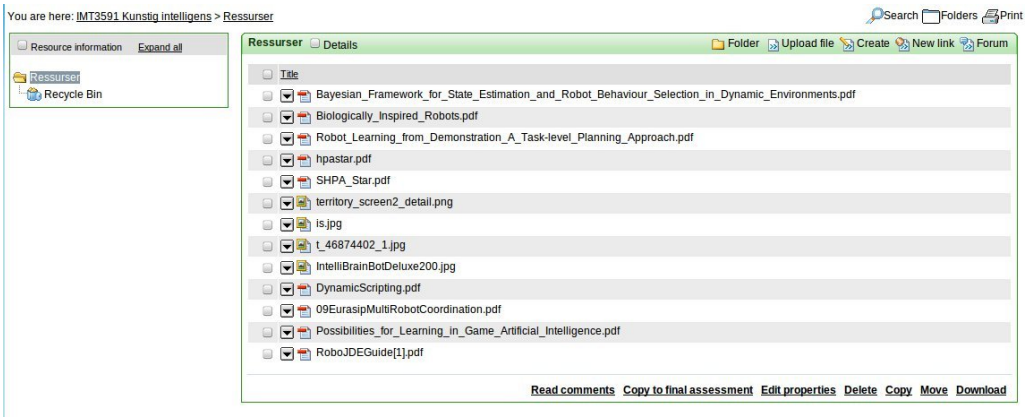


Figure 7: Resources of Artificial Intelligence Course

Learning style	**Visual Learning Style**	**Auditory Learning Style**	**Read/Write Learning Style**	**Kinesthetic Learning Style**
LO types	Video Slides Images	Video Audio	Slides Textbook Article Paper Tutorial	Slides Applet Excercises Examples Program

Table 1: Types of LOs for each learning styles

Based on the distinctive features of each learning style, that was described in Chapter 3.3.1 of Related work, we can conclude what types of learning objects relate to each learning style. Types of LOs for each learning style are presented in table 1. The following LOs correspond to visual learning: video files in form of training videos, where speech is combined with displaying of subject matter; slides contain the key theses of the subject, often supplemented with diagrams, charts, examples; images representing the diagrams and figures,that can help to understand better and remember the studied subject. For Auditory learning, the useful types of LOs are training videos, audio files, in form of audio lessons, and audio books. For Read / Write style, LO types are textual sources of information, such as various kinds of articles, textbooks, tutorials etc. For Kinesthetic learning, the following types of learning objects are useful: slides, that represent a small amount of theory, and supplemented with examples of the use of theoretical knowledge and exercises; exercise, that allows to apply theoretical knowledge, example and packaged applications, that demonstrate the application of the theory.

As we can see from the table 1, for different learning styles some types of learning objects are the same. For example, for visual and kinesthetic learning styles it can be slides, or common type for visual and for auditory learning styles may be video files.

Consider how different learning styles can be applied to Artificial Intelligence Course, based on Fleming's VARK model, which identifies the following four learning styles: Visual learning, Auditory learning, Read / Write learning and Kinesthetic learning. In table 1, we determined what learning styles match what types of LOs. Here we will consider what types of LOs are used in the Artificial Intelligence Course. As already mentioned, this course includes both theory and practical application. Types of LOs of this course are the lecture notes, textbook, tutorials, articles and papers, assignments, different applets and source code examples. Lecture notes are presented in the form of slides and contain the basic theoretical concepts in the form of theses, examples and exercises for the studied materials. Examples of lecture notes of Artificial Intelligence Course are shown in Figure 8. Each lecture refers to a textbook, a syllabus of the course indicates chapters for each lecture. Example of Syllabus Part for Artificial Intelligence Course, where references to chapters of the textbook are marked in red, is shown in Figure 9. In addition, LOs are provided, such as video demos, applets that demonstrate the using of different algorithms, etc., for some of the topics of the Artificial Intelligence Course. Artificial Intelligence Course is not represented by audio records.

Thus, we can summarize that this course is represented by wide range of types of LOs. Links to the used LO are presented in the course syllabus. But to find the desired

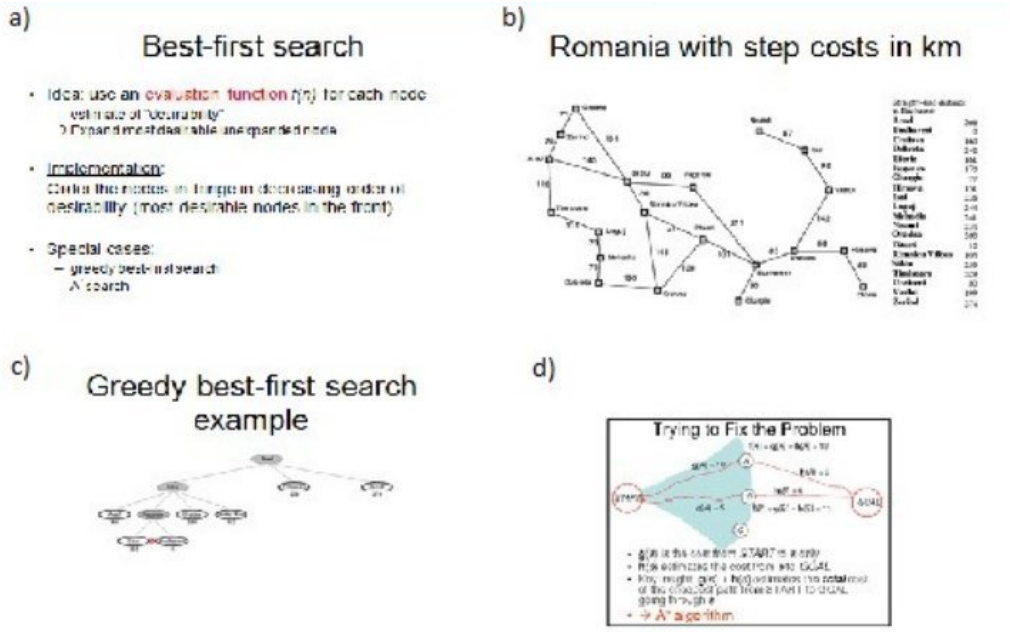


Figure 8: Example of lecture notes of Artificial Intelligence Course, where a) the use of theses; b) application of the theory, c) an example of solving exercises; d) the use of figures

Textbook chapters for each lecture

Date	Topic	Chapter	Notes	Links/Slides
Jan. 10	Intro	1.1 - 1.5		Intro slides
Jan. 13	Agents	2.1 - 2-5		Agent slides
	SEARCH-1			
Jan. 31 & Feb. 7	Search	3.1 - 3.7		Uninformed Search slides
Feb. 14	Search	4.1 - 4.2	HW1: Ex. 2.7 & 2.8 from AIMA book Ex	Informed Search Slides
	LAB.			
Feb. 7	Introduction to Intellibrain Robots and getting familiar with their sensors		Guide for Programming RoboJDE from Eclipse (Page 19 - 20)	IntelliBrain-Bots

Figure 9: Example of syllabus part for Artificial Intelligence Course

LOs, students may have difficulty because LOs are not described. Students are unable to determine what the LO contains without its opening. The name of the LO not always reflects its content accurately. Personalization of LOs on the basis of learning styles will help to facilitate the search of the necessary learning materials, and contribute to faster and more comfortable learning. For Artificial Intelligence Course, the usage of the following three learning styles of VARK model would be the most convenient: Visual learning, Read/Write learning and Kinesthetic learning. This choice is based on the fact that auditory learning styles are not widely represented within the framework of the course.

4.4.3 Personalized Communications Approach

Personalized Communication Approach denotes a recommendation of persons able to assist the learner in his learning tasks. We will consider based on the example of Artificial Intelligence Course, what opportunities for communication the LMS "Fronter" offers. Figure 10 shows an example of room for Artificial Intelligence Course, ways to communicate is marked by red. Fronter offers three ways of communication within the room:

1) Members - This tab displays a list of all course participants and instructors responsible to the course. We can see a list of registered people on the course, know their status (student / teacher / staff). Sample list of course participants is shown in Figure 11. We can also see a personal information about students of the course. An example of personal information about a student is shown in Figure 12. Personal information includes only the student's photo and contact information, and does not contain any information about the interests, preferences, etc.

2) Questions and Answers - This tab provides an opportunity to ask the teacher or for public discussion.

3) Chat - This tab provides opportunities to communicate in real time.

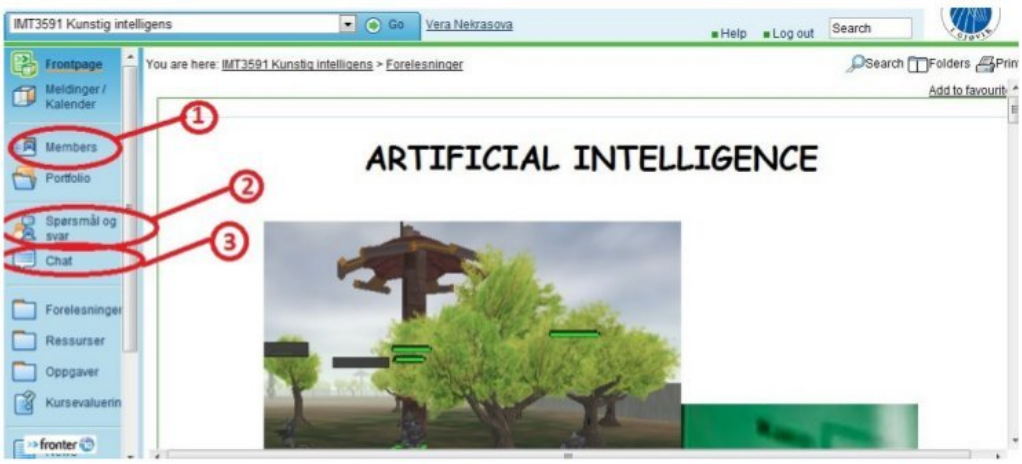
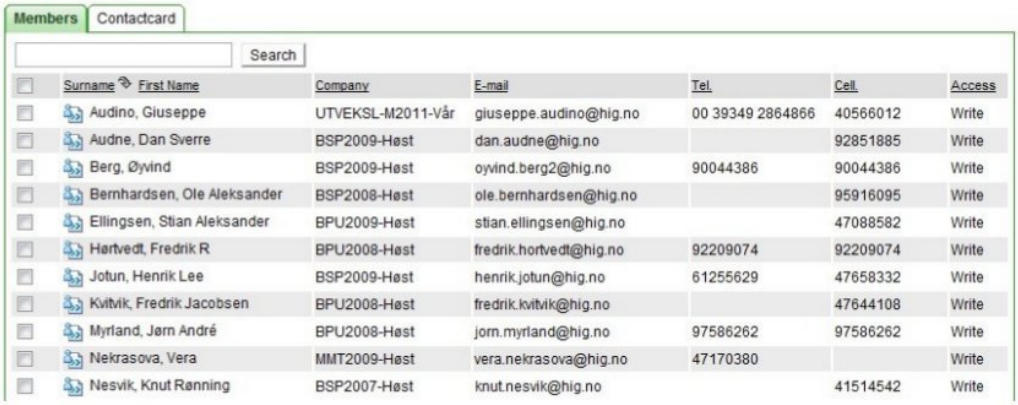


Figure 10: Example of communication tools in Artificial Intelligence Course Room. 1) Members; 2) Questions and Answers; 3) Chat

From the presented above, we can conclude that the "Fronter" system provides wide opportunities for communication and knowledge sharing between students and between teachers and students. But due to lack of information about the interests and preferences of students, we cannot understand who could help us with our problem and whom directly to ask a question. In this problem, a system can help by recommendations to users



Surname First Name	Company	E-mail	Tel.	Cell.	Access
Audino, Giuseppe	UTVEKSL-M2011-Vår	giuseppe.audino@hig.no	00 39349 2864866	40566012	Write
Audne, Dan Sverre	BSP2009-Høst	dan.audne@hig.no		92851885	Write
Berg, Øyvind	BSP2009-Høst	oyvind.berg2@hig.no	90044386	90044386	Write
Bernhardsen, Ole Aleksander	BSP2008-Høst	ole.bernhardsen@hig.no		95916095	Write
Ellingsen, Stian Aleksander	BPU2009-Høst	stian.ellingsen@hig.no		47088582	Write
Hørtvedt, Fredrik R	BPU2008-Høst	fredrik.hortvedt@hig.no	92209074	92209074	Write
Jotun, Henrik Lee	BSP2009-Høst	henrik.jotun@hig.no	61255629	47658332	Write
Kvitvik, Fredrik Jacobsen	BPU2008-Høst	fredrik.kvitvik@hig.no		47644108	Write
Myrland, Jørn André	BPU2008-Høst	jorn.myrland@hig.no	97586262	97586262	Write
Nekrasova, Vera	MMT2009-Høst	vera.nekrasova@hig.no	47170380		Write
Nesvik, Knut Rønning	BSP2007-Høst	knut.nesvik@hig.no		41514542	Write

Figure 11: List of course participants

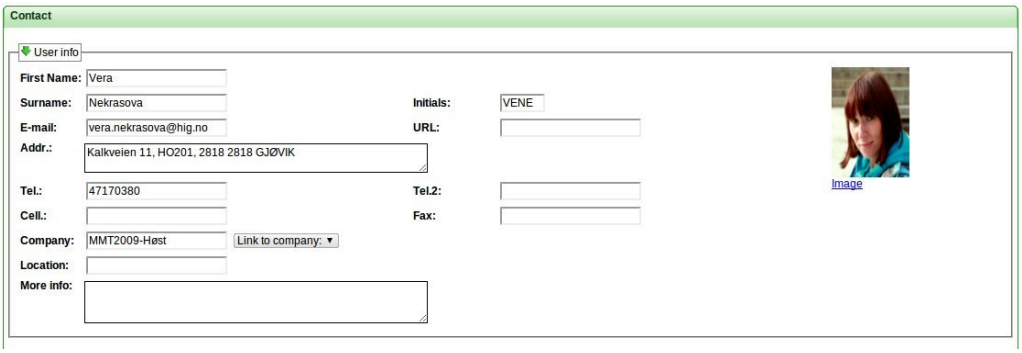


Figure 12: User information

depending on their needs, teachers and students with similar interests.

4.5 Summary

The main purpose of this chapter define the boundaries of the experiment. We have identified personalization approaches on which we base our experiment: personalized learning activities, personalized guidance, personalized communication. Artificial Intelligence Course have been chosen for the experiment, which is taught in a Gjøvik University College. LMS Fronter is used to control LOs and the educational process of the course. We have reviewed the course contents relative to selected approaches of personalization. Personalized Guidance Approach can be applied in this course based on the study topics and different levels of its complexity. Personalized Learning Activities Approach can be established within the Artificial Intelligence Course based on follow learning styles: Visual learning, Read / Write learning and Kinesthetic learning. Application of Personalized Communications Approach in Artificial Intelligence Course may be based on a study topic and the required level of knowledge in the topic.

5 Survey Prototype

5.1 Justification of Prototype Development

During the work on the study the prototype have been developed. There are several reasons for the development of the prototype. First, as we mentioned earlier survey participants may not know much about functionality of new product, but based on the prototype it will be more convenient to leave their feedback. In addition, the prototype allows us to analyze ideas and explore design and different approaches. Thus, prototyping is an important part of the study.

5.2 Planning and Preparations

There are many ways to present prototypes from a paper version to a fully working development. In our case, it is important that participants of survey would be able to interact with the prototype. Key points of the prototype will be functionality and behaviour. We will not focus on the design of a prototype.

The goal of the prototype is to demonstrate a new features in the LMS and understand the reaction of the students to them. Students use the LMS in their usual educational process. Our task is to show what the educational process might be with the introduction of personalization, and find what personalization features in the LMS can be most useful for the student. Thus, our prototype must correspond to the page of the Artificial Intelligence Course in LMS Fronter, with the addition of personalization features. In this project, we consider three approaches of personalization in education that can help us to identify the most important and useful personalization features in the LMS: personalized learning activities, personalized guidance, personalized communication.

Technology was reviewed, which was used to build a prototype. As already mentioned, the main task of the prototype is to provide personalization features, the study of interface and usability is beyond the scope of this master thesis. Therefore, we use the markup language for web pages HTML to implement the user interface. It allows us to create simple user interfaces and does not take much time for its implementation. XML [69] format is used for storing repository of LOs. In this case, the repository is a XML file that follows some standard schema and is associated with related metadata. XML is applied for convenient presentation of LOs descriptions by metadata, that are used for personalization. PHP [70] scripting language is applied to provide personalization features.

As it has already noted that the study of the interface is beyond the scope of the project. But the user design is important when the experiment is conducted. User interface design of the system should be simple as it may be possible, be intuitive and provide additional descriptions of the new study functions. Thus, the user design of the prototype should be minimalist, but at the same time should not be boring.

5.3 Development

We have considered the possible architecture for personalizing module in the LMS in 3.2.2 Chapter of Related work. In this chapter, construction of a single prototype for each approach of personalization (personalized learning activities, personalized guidance, personalized communication) was described based on the previously considered architecture. Let us remember that the personalizing module consists of three main components: Interface, Repository and Recommender.

5.3.1 Repository

Repository is a storage of LOs, that also indexes and structures of these LO. In this project, the repository is a directory of links and descriptions of the LOs. There are separate repositories for different personalization approaches. Differences among repositories is that different Learning Object Metadata are used. Learning Object Metadata is the data model, which is used to describe the LO. Meta-data that is used for personalization process, are interesting topic and technical level for personalized guidance and personalized communication approaches; interesting topic and preferred learning styles for personalized learning activities approach.

As already mentioned, XML format is used for presentation of the repository in a structured form. Structure of the repository is based on the topics and sub-topics that are considered within the Artificial Intelligence Course. Each LO refers to one or more topics, and is described by metadata.

Realistic learning environment was reconstructed for the study. Repositories was created for prototypes, based on information and study materials provided in the Artificial Intelligence Course, and also articles from free encyclopedia Wikipedia [71] and from site *videolectures.net* that distributes videos and lectures. Repository is considered for each type of personalization separately.

Repository for Personalized Guidance Approach

System with personalized guidance provides the recommendation of additional educational materials based on individual learner interests. Characteristics of this approach is to use of the content LOs for the recommendations. Metadata, which are used to describe a LOs for system with personalized guidance, and examples of LO descriptions are presented in table 2. Basically, standard metadata is used that describes in the table 2 and in the Related work Chapter 3.3.2. But for a some metadata is necessary to define an ontology, such as the Technical Level and Type.

In Related work chapter, the concept and importance of Technical Level was described. There are the three difficulty levels of LO: Basic level, Intermediate level and Advanced level. LO Type is used to characterize the LO. In this type of personalization, LOs are recommended from that learner can gain new knowledge and additional information. Therefore, the following types of LO are used: textbook, journal paper, conference paper, workshop paper, tutorial, technical report, research article, wiki.

Distribution of LOs among technical levels was based on the definition of each level. To the basic level, LOs refer that provide information about the basic principles and concepts. For example, it can be such LOs as wiki articles, tutorials or textbooks, that have a basic level of complexity. To the intermediate level, LOs relate that contain information

METADATA NAME	EXPLANATION	EXAMPLE
Title	The name is given to LO. It's may be original name under which LO was published.	Toward User - Centeric Privact - Aware User Profile Ontology for Future Services
Author	The creator of LO. It's may be individual person or group, and also a company or service.	Iqbal, Zahid; Noll, Josef; Alam, Sarfraz; Chowdhury, Mohammad M. R.
Description	Description of LO content	This paper proposes a user-centric personalization approach. The core of this approach is a user-centric user profile where user is in the centre and experience perceived control over his information. We present profile and privacy enhancement mechanism to increase profile applicability and user privacy respectively. The paper also offers a policy based approach to ensure authorized access of user profiles among third parties.
Keywords	Category content in term of keywords	Personalization, Policy, Privacy, Semantic Web, Social Network, User Profile
URL	The URL of LO content	http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=arnumber=5532755
Technical Level	Technical level of paper is a difficulty degree of learning object	Intermediate level
Type	Publication LO type	Conference paper
Date	Date that LO was submitted	13-19 June 2010

Table 2: Learning Object Metadata for personalized guidance approach

about more complex concepts than in basic level and requires knowledge and skills for understanding it. For example, the intermediate level includes such LOs as research articles, conference paper, video lecture and etc. To advanced level, LOs are attributed the level of which is beyond the scope of the course. They are aimed to a deeper acquaintance with the study area. For example, it can be a workshop paper, a conference paper and etc. Separation of learning objects on different technical levels may seem a subjective process. Therefore, separation of learning objects on the different technical levels was coordinated with teacher of Artificial Intelligence Course for eliminations mistakes.

Repository for Personalized Guidance Approach consists of 64 learning objects. XML file of the repository is presented in Part A.1.2 of Appendix. DTD schema of the XML file is decribed its structure and presented in Part A.1.1. 38 LOs are used for the Basic technical level, 17 LOs are for Intermediate technical level and 9 LOs are for Advanced technical level.

Repository for Personalized Learning Activities Approach

System with personalized learning activities provides LOs that correspond to the users' interests and is presented in a users' preferred format of information perception. A main characteristic for this recommendations is to present the LO respectively preferred student's learning styles of information perception. Metadata, which are used to describe a LO for system with personalized learning activities, and examples of LO descriptions are presented in the Table 3. Basically, the standard metadata is used that describes in the table and in the Related work Chapter 3.3.2. But for some metadata, it is necessary to define an ontology, such as Type. Type describes the information that is presented in the LO. The following classification is used to indicate the LO type: Video, Lecture notes, Image, Text, Exercise, Example, Applet; where a Video type is a video lecture, a demonstration video, a study films; Lecture notes - slides of presentation from the lecture, that can include different types of information such as a text, am example of source code, images; Image type includes a graph, a chart, a map, etc.; Text type - resource that consists of words to read: e.g. textbook, articles, papers, tutorials, etc.; Exercise – a task conducive to learning and practical application of theoretical knowledge; Example – an example of source code; Applet - a program or an application demonstrating the practical application of theory in practice. The Table 1 in Chapter 4.4.2 shows what type of LO correspond to the learning styles.

Repository for Personalized Learning Activities Approach consists of 90 learning objects, where 27 Text LOs, 10 Video LOs, 20 Lecture notes, 14 Applets, 13 Examples of Source Code and 6 Assignments are used. XML file of the repository is presented in Part A.2.2 of Appendix. DTD schema of the XML file is decribed its structure and presented in Part A.2.1.

Repository for Personalized Communication Approach

System with personalized communication provides persons with similar interests on-demand. Learning resource is information about persons in such system. The main characteristics for this personalization approach are providing profiles of people who are studying or teaching related areas and have a required level of knowledge in this area. Metadata are used to describe people and presenting the user profile. As in previous cases, each person belongs to one or more category or unit of the course. In each cate-

METADATA NAME	EXPLANATION	EXAMPLE
Title	The name is given to LO. It's may be original name under which LO was published.	Learning from Observation
Author	The creator of LO. It's may be individual person or group, and also a company or service.	Associate Professor Sule Yildirim
Description	Description of LO content	This is lecture notes form Artificial Intelligence Course. Lecture note is about "Learning" topic. It cover the following subtopics: Learning agents; Inductive learning; Decision tree learning.
Keywords	Category content in term of keywords	Learning agents; Inductive learning; Decision tree learning
URL	The URL of LO content	https://fronter.com/hig/links/link.phtml?desc=1iid=759103
Type	Publication of LO type	Lecture note
Date	Date that LO was submitted	Spring semester 2011

Table 3: Learning Object Metadata for personalized learning activities approach

gory, a person can have a certain level of knowledge, which is designated as a Qualification level. Three levels of classification skills is identified: Elementary level, Intermediate level and Advanced level. Metadata, which are used to describe a LO for system with personalized communication, and examples of LO descriptions are presented in Table 4.

METADATA NAME	EXPLANATION	EXAMPLE
Name	The name of person, it can include given name and family name	Vera Nekrasova
Position	Kind of occupation, e.g. student/teacher	Master Student
Contact information	It's ways of communication, e.g. Telephone number, e-mail etc.	vera.nekrasova@gmail.com
Qualification Level	Qualification level on the interesting topic	Intermediate

Table 4: Learning Object Metadata for personalized communication approach

Repository for personalized communication approach is presented in Part A.3.2 of Appendix. DTD schema of the XML file is decribe its structure and presented in Part A.3.1. Information representation about the person in the repository has to be agreed with the person. The privacy of every person must not be infringed . At the same time

collection information from students about their knowledge is not logical and subjective. To avoid these problems, information about teachers and teacher assistants that teach the Artificial Intelligence Course and related areas with it, is used to create the repository for personalized communication approach. Information for describing the people has been agreed with these persons.

Search Index File

LOs are stored in repository. The more LOs are contained in the repository, the more it is useful, but more difficulties exist to navigate and search. Search Index Files are created for more quick and handy LOs search. Search Index Files store indexing information about LOs. It provides a quick search of necessary items in the repository. Search Index File is presented by MySQL [72]. The created repository in XML format is indexed by scripting language PHP. PHP function for creating Search Index File in MySQL from XML file is presented in Part B.1 of Appendix. Indexing process is schematically shown in Figure 13. It is unnecessary to keep all information about LO in MySQL format. It would be redundant and useless. Only the information about the LO is be indexed, that is useful for the search.

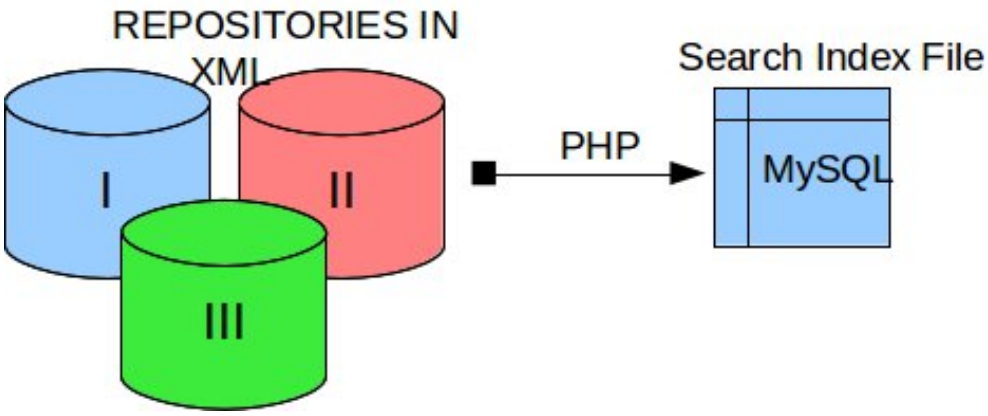


Figure 13: Process of repositories indexing; where I – Repository for Personalized guidance approach, II – Repository for Personalised learning activities approach, III – Repository for Personalized communication approach

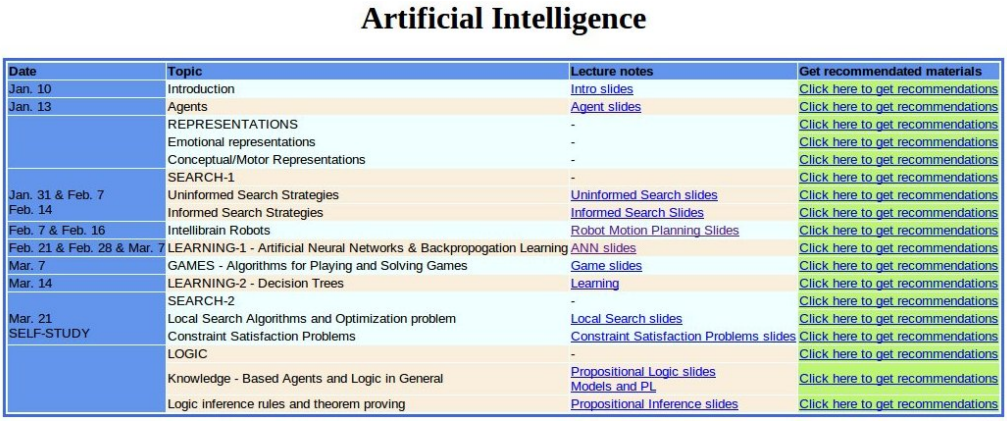
The above-described repository is based on toics and sub-topics of Artificial Intelligence course. The identifiers of the toics or sub-topics that the LOs belong, and identifiers of the LOs are used for indexing. Also, additional information is included that is necessary for personalization. So for personalized guidance and personalized communication approaches this is a technical level or qualification level respectively, and for personalized learning activities approach, this is a publication type of the LOs. There are a search index files for each personalization approach. Search index files will be used for finding the required LO for the recommendations.

5.3.2 Interface

The interface provides a user interaction with the system. The main objective of interface prototype is to provide the new features as simple and understandable as possible to users and that they are able to examine and evaluate innovations. In this case, the prototype interface should be similar to the interface with which users work every day.

As already mentioned that the study of the interface is beyond the scope of this master thesis. But at the same time, the interface is a important part in introducing of new studied functionalities. The standard tools of HTML is used to implement a simple user interface.

An interface of the prototype for Artificial Intelligence Course is based on the syllabus of this course. An example of prototype interface for Artificial Intelligence Course is shown in Figure 14. As we can see the prototype interface is presented in the form of the Artificial Intelligence Course Sullabus. Here the syllabus of the course is presented on the basis of the lecture date and the topics of this lecture. For each topic recommendations can be obtained. Comments are added to the new functions, which give them descriptions, to eliminate the users' misunderstanding during interaction with the system prototype.



Artificial Intelligence

Date	Topic	Lecture notes	Get recommendated materials
Jan. 10	Introduction	Intro slides	Click here to get recommendations
Jan. 13	Agents	Agent slides	Click here to get recommendations
	REPRESENTATIONS	-	Click here to get recommendations
	Emotional representations	-	Click here to get recommendations
	Conceptual/Motor Representations	-	Click here to get recommendations
	SEARCH-1	-	Click here to get recommendations
Jan. 31 & Feb. 7	Uninformed Search Strategies	Uninformed Search slides	Click here to get recommendations
Feb. 14	Informed Search Strategies	Informed Search Slides	Click here to get recommendations
Feb. 7 & Feb. 16	Intellibrain Robots	Robot Motion Planning Slides	Click here to get recommendations
Feb. 21 & Feb. 28 & Mar. 7	LEARNING-1 - Artificial Neural Networks & Backpropogation Learning	ANN slides	Click here to get recommendations
Mar. 7	GAMES - Algorithms for Playing and Solving Games	Game slides	Click here to get recommendations
Mar. 14	LEARNING-2 - Decision Trees	Learning	Click here to get recommendations
	SEARCH-2	-	Click here to get recommendations
Mar. 21	Local Search Algorithms and Optimization problem	Local Search slides	Click here to get recommendations
SELF-STUDY	Constraint Satisfaction Problems	Constraint Satisfaction Problems slides	Click here to get recommendations
	LOGIC	-	Click here to get recommendations
	Knowledge - Based Agents and Logic in General	Propositional Logic slides Models and PL	Click here to get recommendations
	Logic inference rules and theorem proving	Propositional Inference slides	Click here to get recommendations

Figure 14: Interface of prototype

The Interface module creates user profiles of students. User profiles are constructed explicitly. Students manually define their interests, when they need with system recommendations. Besides students interests, supplementary parameters are set for each type of personalization. Interfaces of the prototypes are different for each studied personalization approach. Namely for personalized guidance and personalized communication approach, the supplementary parameter is a technical level or qualification level, respectively; for personalized learning styles approach, it is a preferred learning style. Data received from the user is sent to the Recommender module. And so, the user must click on the link "Click here to get recommendation" on against the desired topic. And depending on the personalization approach, he/she goes to the next window in which additional parameter for personalization is set up. A window to specify additional options for personalized guidance approach is shown in Figure 15. Here user can choose a technical level of the recommended materials for required topic. To eliminate the problems in choosing a required technical level, describing of levels are shown. After selecting the technical level, the user has to click "Get recommendation". A window to specify additional options for personalized learning activities approach is shown in Figure 16. This figure demonstrates a form for selecting of the preferred learning style that the best fits to the student. The student may choose multiple styles, this is due to the fact that one-way style exists rarely in nature, and most often there is mix of styles. The user has to click "Get recommendation" after selecting styles. To eliminate the students' misunderstanding

in the learning styles, definitions are provided to users in the comments. A window to specify additional options for personalized communication approach is shown in Figure 17. Indication of the additional parameters for this personalization approach is very similar to the personalized guidance type. So based on the user interaction with the forms, user profile is created and sent to the Recommender component.

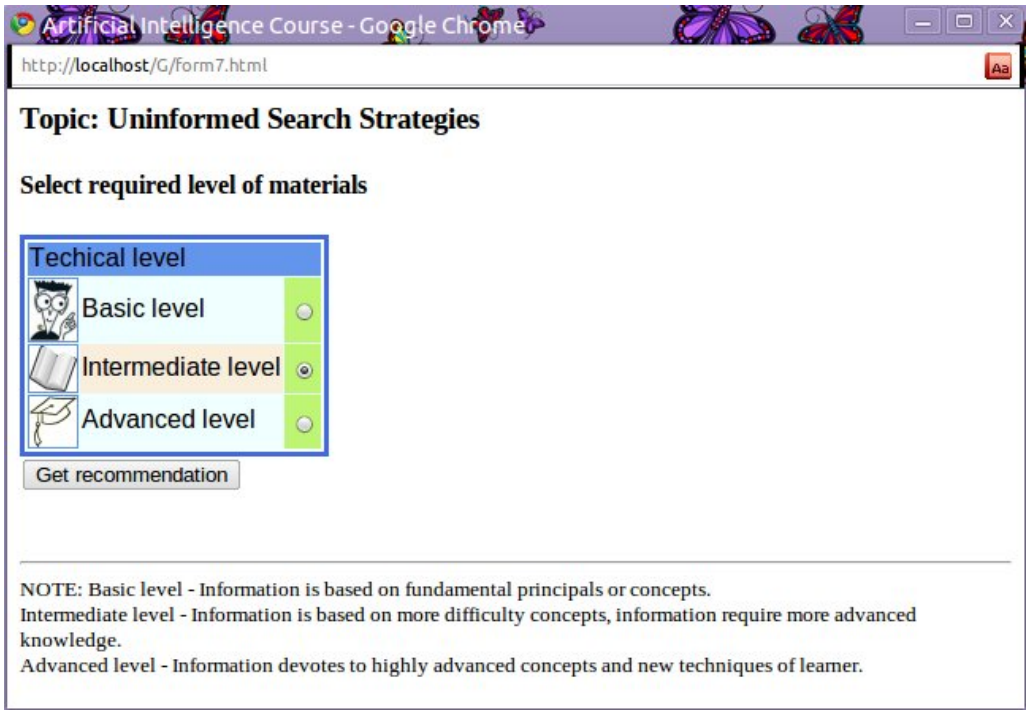


Figure 15: The window to specify additional options for personalized guidance approach

By-turn, Recommender component sends made recommendations to the Interface component. Interface component displays these recommendations to the student. Each received item from Recommender component has a brief description. Figure 18 shows an example of system response for personalized guidance approach. As we see from the figure, the system provides a items list, which corresponds to the student's desires, namely to the selected study topic and technical level. The each item is described by the title, the author, the description and the publication type. A student can go to the contents of the LO by the header of each items. If a recommendations are not satisfy to the students, they can return to the selection of the recommendations parameters. Figure 19 shows the recommendation system for personalized communication type. For user convenience, the system separates the recommended LO on the different learning styles and presents for each selected style an own list of the LOs. As in the previous type of personalization, all submitted items are described and the user can go to the content of the LO by the link. An example of recommendations for personalized communication approach is shown in Figure 20. The system recommends person who satisfy the students requirements. Recommended person is described by the name, the position and the e-mail.

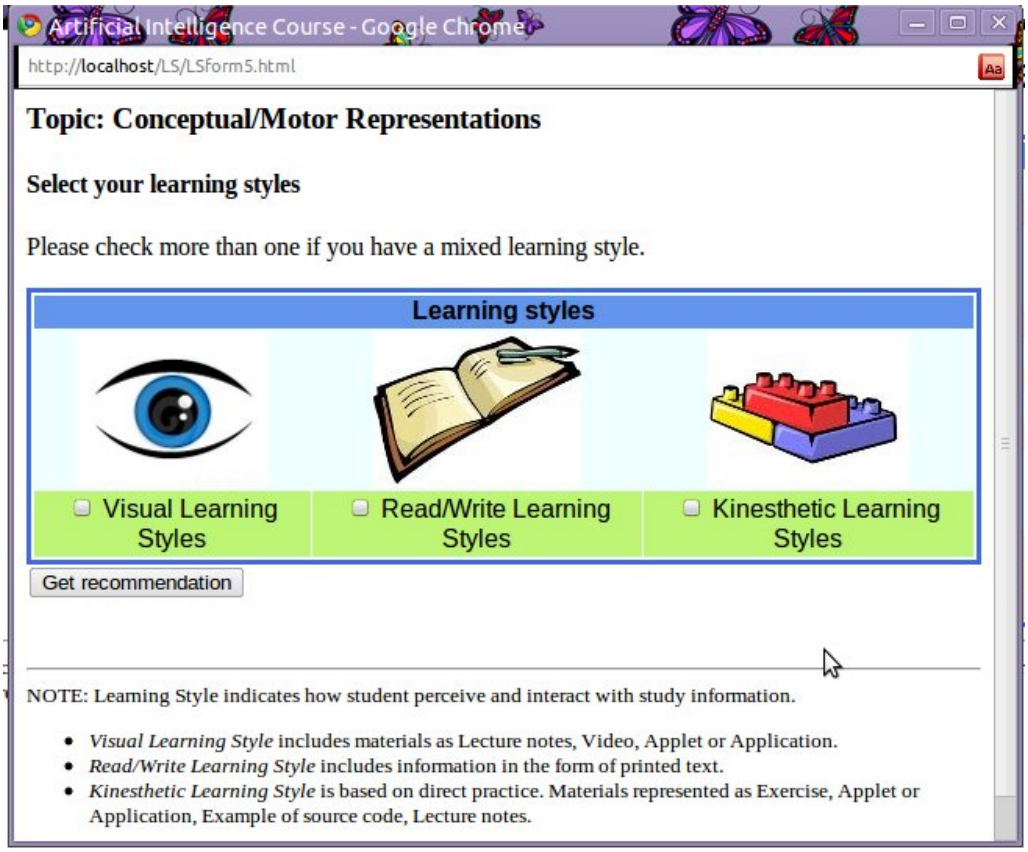


Figure 16: The window to specify additional options for personalized learning activities approach

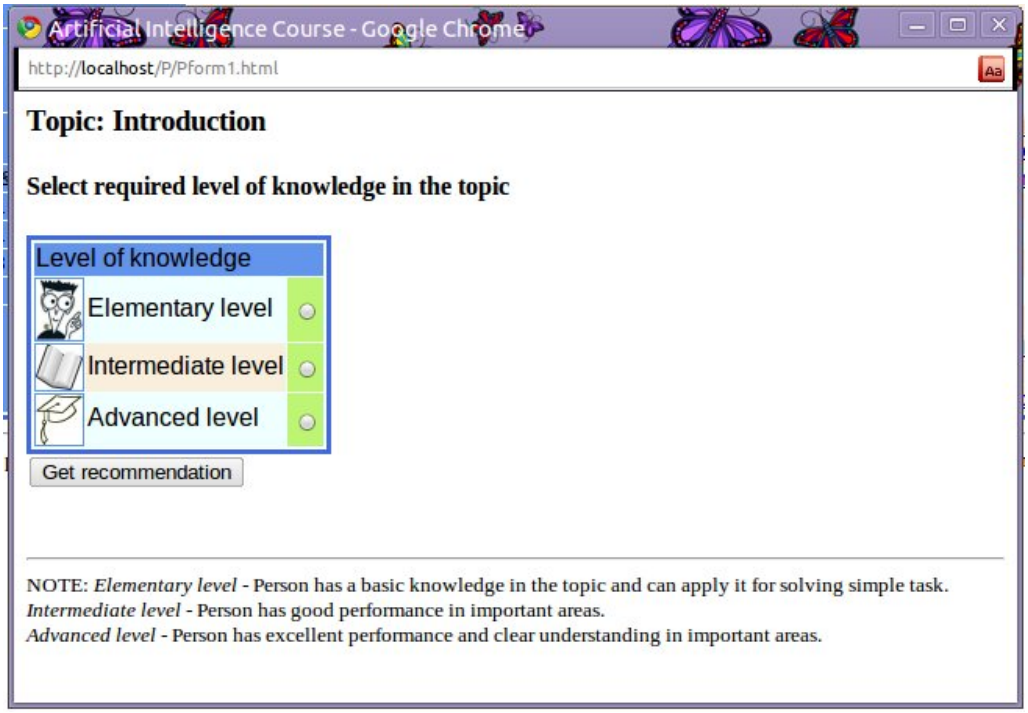


Figure 17: The window to specify additional options for personalized communication approach

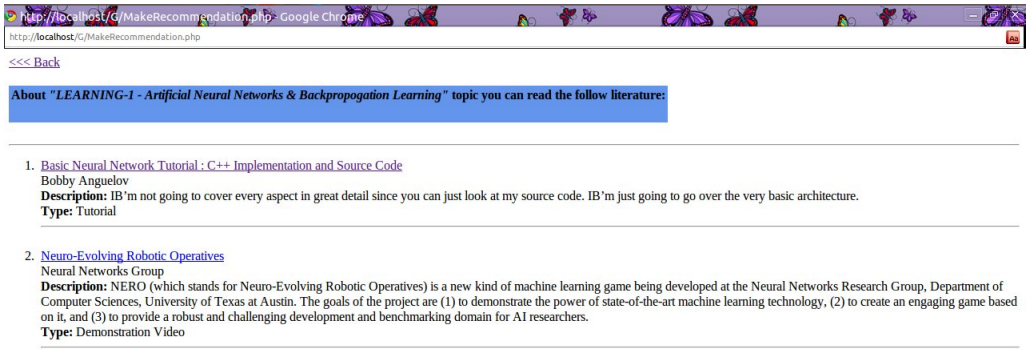


Figure 18: Example of the system response for personalized guidance approach

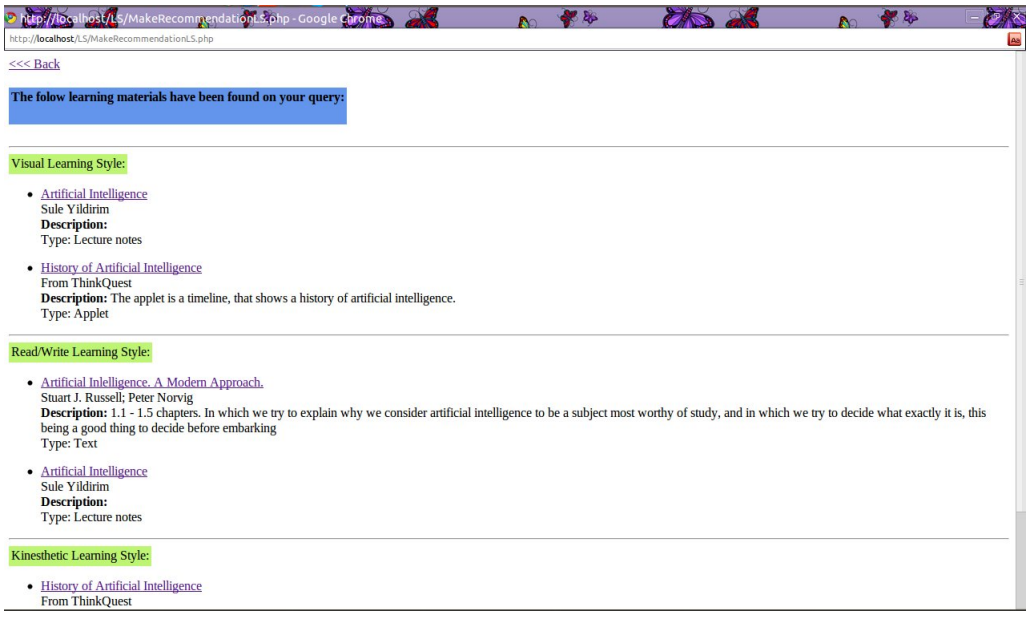


Figure 19: Example of the system response for personalized learning activities approach

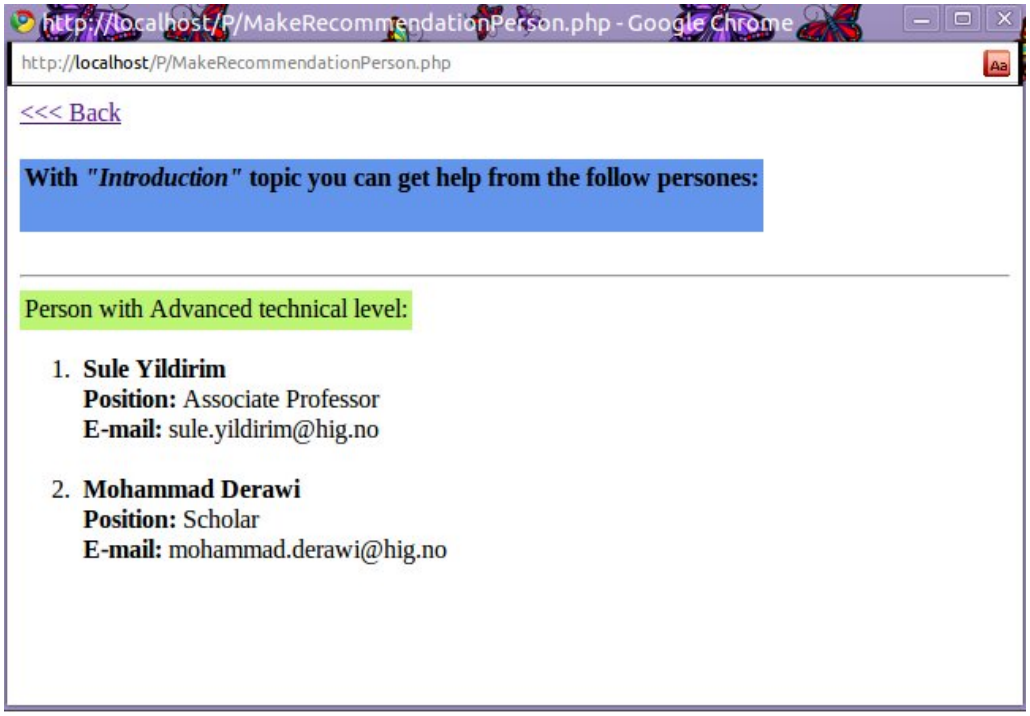


Figure 20: Example of the system response for personalized communication approach

5.3.3 Recommender

Metadata based personalization approach is used in the prototype, which have been described in Chapter 3.2.2 of Realated work. The Recommender component receives data from the Interface component about the students interests and analyses them. It compares this information with data stored in the Repository component and founds the necessary LOs that correspond to the characteristics of users. Therefore, the Recommender component is a mediator between the Interface component and the Repository component.

Student data for personalization are different for each personalization approach. Also, each personalization approach has its own separately-formed repository and search index file. For instance, in personalized guidance or personalized communication approaches, system receives students interests and technical level of those interests or qualification level in the required area from the Interface component. Then indexes LOs are determined based on these data by SQL query. And information about the required file is found in an appropriate repository of the particular personalization approach. The found information about LO is transmitted to the Interface component for output. Figure 21 shows the block diagram for the recommender component of personalized guidance or personalized communication approaches, where the level represents technical or qualification level. PHP code of recommender component for personalized guidance approach is presented in Part B.2.1 of Appendix. PHP code of recommender component for personalized communication approach is presented in Part B.2.3 of Appendix.

In personalized learning activities approach, system receives students interests and preferred learning styles from the Interface component. The system determines the types of publications LO based on the chosen styles of learning. For example, the student has

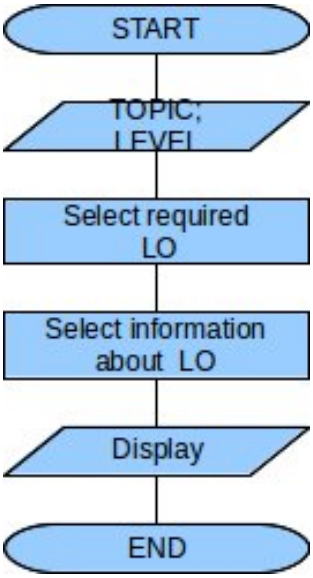


Figure 21: Block diagram for the recommender component of personalized guidance or personalized communication approaches

chosen visual learning style, then the system selects the next LO publication types: a lecture note, a video lecture, etc. Then, a list of LOs indexes is determined on the basis of user interest and required publication types of LOs by MySQL query. Then, the system finds the information in the repository about the selected LOs on the basis of previously defined indexes. Information about the LO is transferred to the Interface component. Figure 22 shows the block diagram for the recommender component of the personalized learning activities approach. PHP code of recommender component for personalized learning activities approach is presented in Part B.2.2 of Appendix.

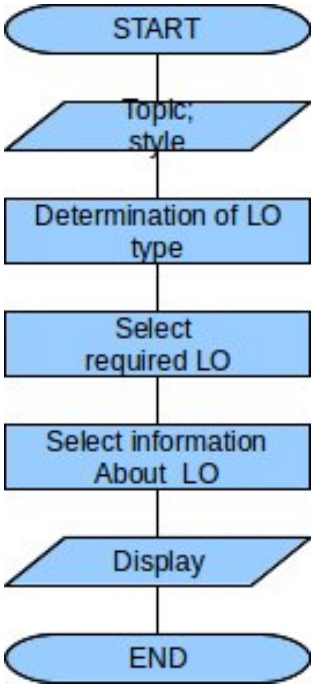


Figure 22: Block diagram for the recommender component of personalized learning activities approach

6 Results

6.1 Survey Preparations

The main part of this master thesis is based on a individual interview with students. It is important to get a clear view of students on the inclusion of personalization in the learning process, to learn what problems they experience in their learning process working with educational materials in the LMS and to determine what should be a basis for personalization in the LMS. For these purposes, a number of interview questions was developed based on which we are able to identify points of interest to us. Questions is directed to the study of how students react to personalization, whether personalization is included in the LMS, and based on what functions and approaches it should be implemented. At the same time, we need to understand what problems students are experiencing during the learning process working with LMS and whether the personalization can solve part of the problem and make the learning process easier and more comfortable. Interview guide, namely asked types of questions, are presented in B Appendix.

As described earlier, a prototype have been developed for the convenience of the study which helps us to demonstrate the basic functions of personalization and helps students understand how it could be used in their educational process. Prototype, its features and development process was described in Chapter 5 - Survey prototype.

6.2 Participants

As is known, the prototype has been developed based on Artificial Intelligence Course of Gjøvik University College. Participants have been interviewed students of this course. A notification about the experiment was done on the Artificial Intelligence Course Lecture for attraction students to participate in an interview. For convenience, we created meeting on the service Doodle [73], where students can register by selecting the slot with a convenient time for them. As well, students of other courses have participated in the interview, which also have been experiencing with the LMS in their learning process. Invite members of other courses is related to the fact that the number of students enrolled in Artificial Intelligence Course is low, and many students have not had free time to take part in the experiment. But attraction of students from other courses is also a positive factor. We do not focus our investigation on only one course, and have the opportunity to evaluate the personalization from the different sides, for different courses and form different points of view. We addressed individually to the students of other courses to involve their in the experiment.

The total number who have participated in the experiment, is 14 students. Individual interviews has been conducted and developed prototype has been demonstrated to each student individually. Among the participants 6 students are from the Artificial Intelligence Course, and also other students are from master and bachelor courses. Figure 23 represents a diagram of the experiment participants. Participants in the experiment are Norwegian students and students from other countries studying at present time in Gjøvik University College, such as Italy, Macedonia, Russia.

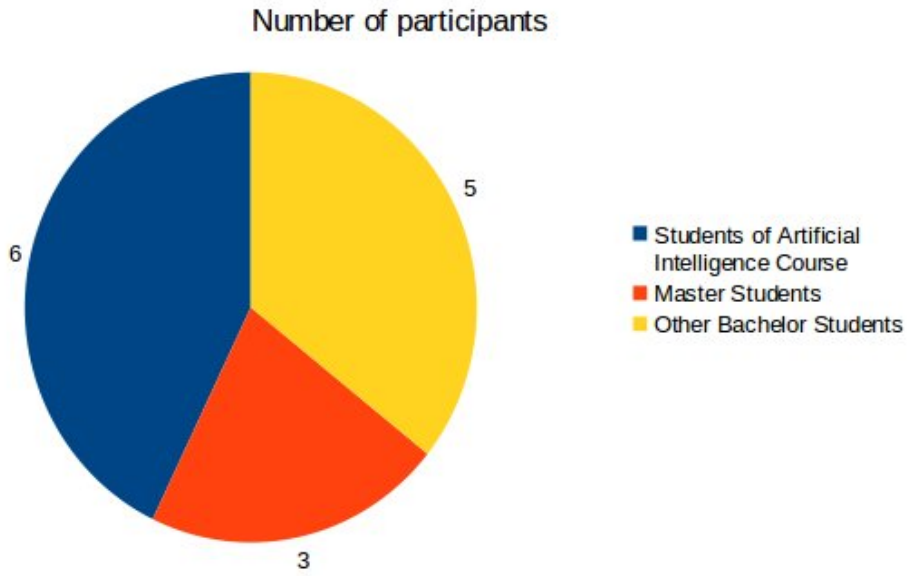


Figure 23: Participants of the experiment

6.3 Survey Results

6.3.1 Conducting Interviews

Interviews have been conducted in three steps. In the first step, we have asked basic questions to participants interview about the familiarity with the concept of personalization and about the possibilities of this in the LMS. If students have not been familiar with concept of personalization, we have told them definition and described the main features and purposes. The students have been given to understand that in our case, we consider the personalization process in terms of adaptation learning.

The second step have consisted of three parts. In this step, we have presented three developed prototypes to user and demonstrated them using of personalization to the learning content. Scenarios have been proposed to students, modelling the learning process and demonstrating how and when the opportunity presented in the prototype can be used. So for the demonstration of Personalized Guidance Approach and Personalized Learning Activities Approach, the process of preparing for the exam have been offered as a scenario. The following situation has been described to participants:

A few days later you have an exam. You have a list of topics which have been studied in class. For each topic, you have Lecture notes in the form of presentation slides. But the slides are of insufficient information and contain only abstracts, to prepare for the exam we need to better understand the problem. You must apply to additional sources.

For Personalized Communication Approach, the process of the projectization was proposed as a scenario. The following situation have been described:

You are working on the project. This process of working begs the some question and you can not find the answer yourself on that. You decide to ask for help to the person who are knowledgeable in your area of interest and may help you find the answer to your question.

After the prototype demonstration, users have been asked several questions regarding the possible application in the educational process presented prototypes, of their advan-

tages and disadvantages.

The third step of the interview is summarized. At this step, the participants can already imagine the possibilities of personalization and its basic features, and also determine for their the most useful factors of personalization. Also in this part of the interview, we have asked questions about what problems users experience in the learning process , and when the inclusion of personalization could help them. Questions about the existing problems have been asked after the interaction with the prototype, because prior to the interaction of users could not think about the existence of any problems.

6.3.2 Interview Results

In this chapter we provide a brief student excerpts and quotations from interviews, review their answers and statistics.

Questions Before Student Interacted with Prototype

The main purpose of the questions of this part is to understand what students know about personalization in general and how it can be used in LMS. Here we clarify how well students are aware of the personalization, how new this feature will be for them and whether they need clarification on this, so that they correctly understand the concept and purpose of our research and prototype.

On the question of whether students are familiar with the concept of personalization, the majority of respondents have answered positively and only two people had not heard before on such a concept. Figure 24 shows the student responses to the question of familiarity with the concept of personalization.

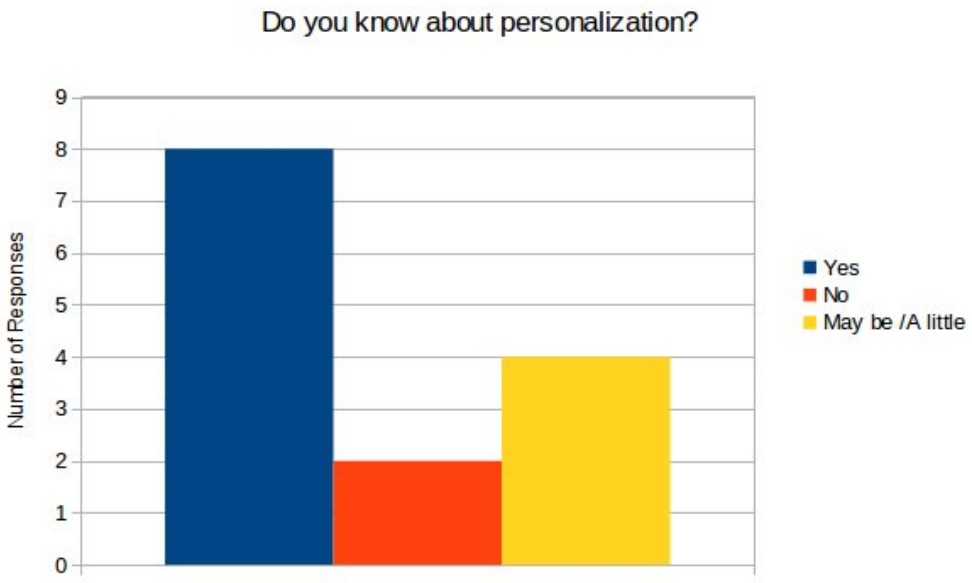


Figure 24: Responses to the question about familiarity with the concept of personalization

Figure 25 shows the student responses to the question of whether they know about the using of personalization in the LMS. Students understand the using of personalization in the LMS, as something to customize for themselves, such as the examples have been cited on the improvement of interface, change the background of the work area.

The main advantage of personalization stands out as to spend less time for searching of relevant information, but nobody thought about how this could be realized in the LMS. Students also had never thought about the existence of adaptive learning and in what cases it might be good for them. All students, who know about the concept of personalization and for what it is applied, suppose the possibility of use this in the LMS.

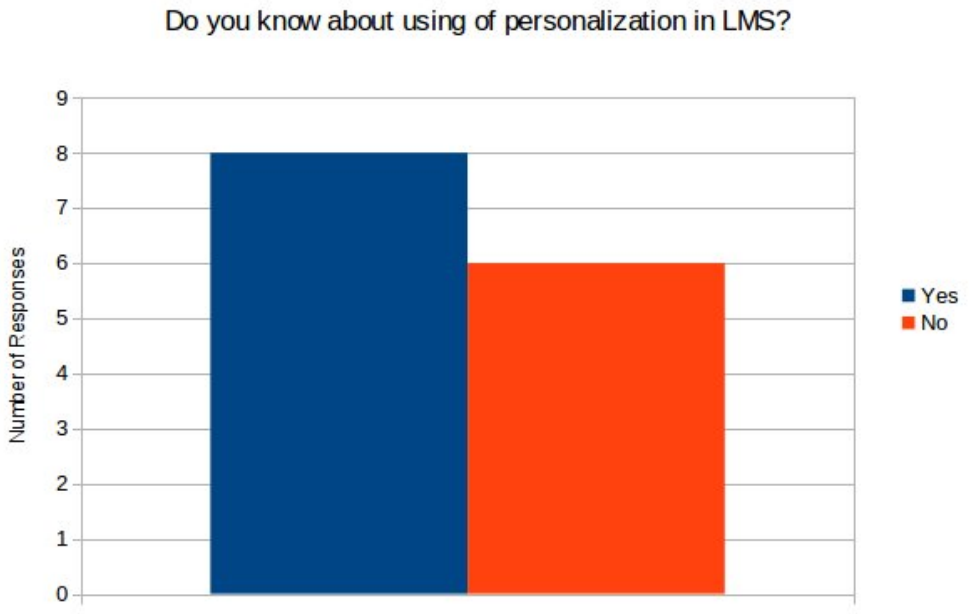


Figure 25: Responses to the question about familiarity with the using of personalization in the LMS

Questions after Student Interacted with Each Type of Personalizationn

As mentioned earlier in this part of the interview, we have shown the experimental prototype to the participants, which demonstrates different approaches to personalization in the LMS. After the interaction with the prototype, the students have answered a few questions.

Personalized Guidance Approach

This approach demonstrates first to students. In the prototype, Personalized Guidance Approach is to provide recommendation of learning objects to users of the LMS, based on the user interests and required difficulty level. Figure 26 shows the student responses to the question about useful to include this personalization approach in the LMS. Overall, it have been described by students on the positive side, and they likes the basic idea, because not all students learn equally. For example, reaction to this approach are the following:

> *Yes, it is a very good idea that helps to characterize themselves. You do not get unwanted information if you do not need it.*

> *I like the idea of this approach. But the division of the technical level can be subjective, I can expect one and get another.*

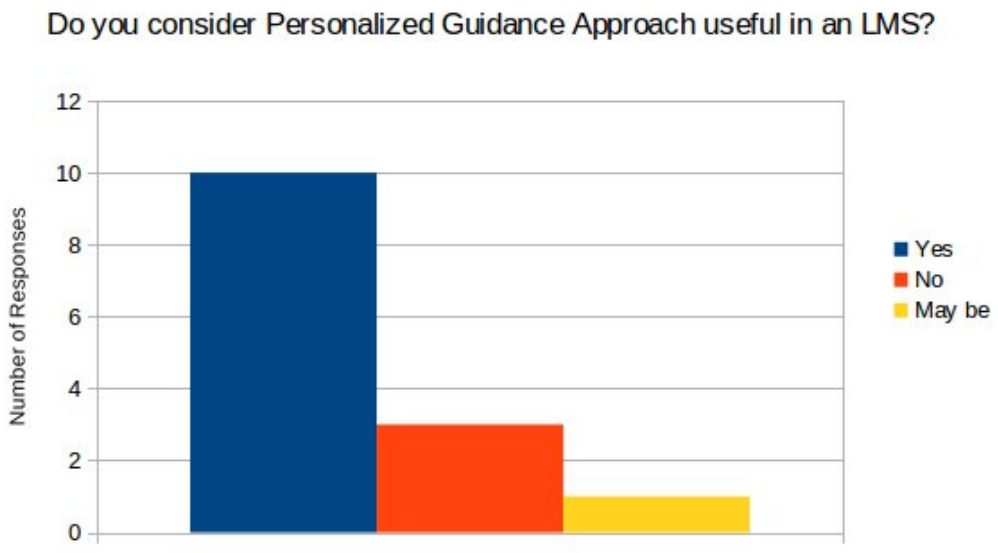


Figure 26: Responses to the question about the usefulness of Personalized Guidance Approach in the LMS

To the advantages of this approach, the students carried then that only the necessary training materials is provided and redundant learning objects is eliminated. Also it was noted that this approach allows us to explore one topic deeply, and another perfunctory, i.e. make it possible to be self-supervisory. Students likes that it is possible to change the level of difficulty, which may depend on their task.

Personalized Learning Activities Approach

This is the second approach which have been shown to students. Personalized Learning Activities Approach is to advise the learning materials for students, depending on the topic of interest and preferred learning style. Students quite positive and friendly think about this personalization approach. Only one student responded negatively to this approach.The student reaction to this approach is:

> *It is a good idea. According to my perception of the real world, I can get useful information for me and do not waste time on something that I do not perceive.*

To the advantages of this approach, the interviewed participants attributes factors such as receiving information in the better perceived format. And as a consequence is that there is no need to waste time on the information in a format that is difficult to understand. Students note that this approach can actually help their save time and facilitate the study process. Students also mention that the most of study courses offer information in a single form for all, and they like the ability to manage their learning process and to choose only what they like. On the positive side, students attribute to the simultaneously choice of several styles of information perception.

The interviewed participants assign to the negative side of this approach the following:

> *I must be sure that choosing one learning style, such as video, I get the same amount of*

information, as if I am reading a book.

Confidence should be that we obtain from given learning objects for a certain learning style the same amount of information as if we had chosen a other learning style. Likewise, in the presented prototype, only three learning style is being considered, namely Visual, Read / Write and Kinesthetic. Participants of the experiment indicate that more options will provide more convenience and benefits.

Personalized Communication Approach

This is the last approach, which have been shown to students. In this prototype Personalized Communication Approach is the recommendation of people who are knowledgeable in specific areas of student interests a certain level of difficulty. Almost all students have responded positively to inclusion of this personalization approach in the LMS and found this idea very useful.

When asked about the usefulness of this approach, students responded as follows:

This idea is very useful if the teacher is very busy, and we can find other people who can be free. This may be not only teachers but also students.

It is a good idea to contact with other people. And exactly, it will be useful, because you can talk with someone about a your problem, and if you do exercise and do not understand something, then you can ask one or more persons.

Students identify this type of personalization as a good opportunity to communicate with others about a particular issue. Experiments participants assign that the teacher of the course is busy very often, but this approach offers ample opportunities for finding an answer to their questions. Also they have determined that it would be good to contact not only with teachers, but also with students from other courses, with students from previous years and finishing studies, as well as with people from a job market. Very often the problem arises during the learning process, and learners do not know with whom to contact. And this approach can be useful, so that allows direct interaction about relevant issues. At the same time, students worry about the issues related to privacy, not all students would like that their individual information can be shared among other students.

Also some students have noted that the talking to strangers can be difficult, because there is a chance that the asked question may seem silly. Also, some students find that only experts can help really.

Conclusive Question

After the presentation of prototypes, we have asked common questions about personalization of students. Now they have been already aware of how personalization can be applied in the educational process and what it can be established, and they can give us their opinion about it.

The reaction of students to inclusion of personalization in LMS is positive. Figure 27 shows the student responses to the question about the usefulness of the inclusion of personalization in the LMS. Interviewed students find personalization as a very useful part of the LMS, which allows to expand the system options. Some students are not happy with the current use of their LMS, they use it only as a tool for checking e-mail and uploading

of educational tasks. But they believe that the additional option of personalization will be motivated to use the LMS to its destination. Personalization helps to make LMS more modern offering accessible methodology to students that can really help make learning more flexible. Also survey respondents have noted that:

> *It is possible at the initial stage, new functions can seem complicated and unnecessary. But it is perhaps when I will accustom to use a such LMS, I can realize that it does not annoy them or even really helps me.*

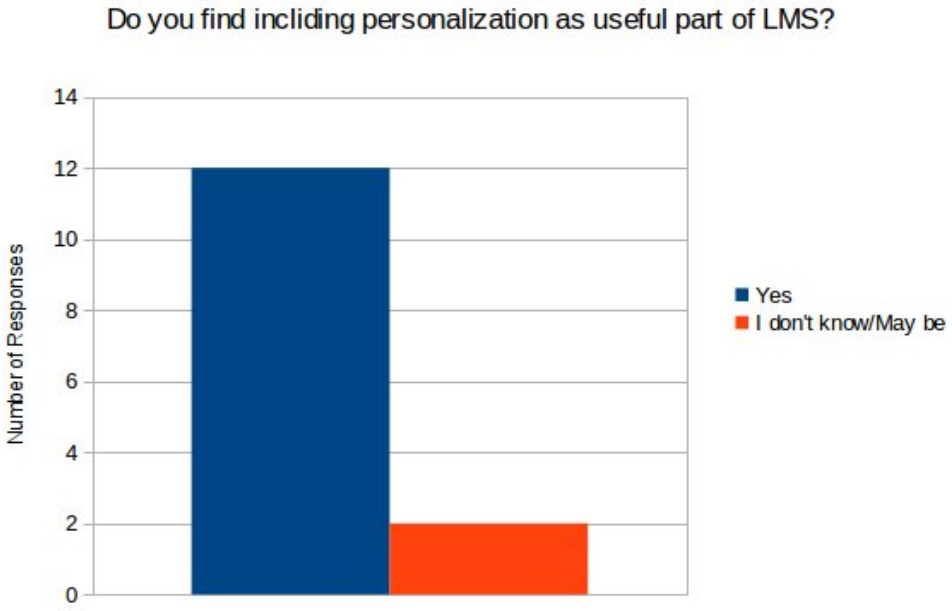


Figure 27: Responses to the question about the usefulness of the inclusion of personalization in the LMS

On the question about what features personalization should be based on, students reacted differently. Figure 28 illustrates students responses about the important of features as the basis for personalization. Of course, they believe, that the primary feature should be studied topic, depending on which and also the desired goals and objectives other features will be. All interviewed students indicated its importance. Personalization on the basis of publication type of LO can be useful in Personalized Guidance Approach in some cases, such as when a large number of recommendations are given, and if only LO is required in a specific format. Students said that the need to identify a specific publication type in a Personalized Learning Activities Approach does not exist.

Ideally, as noted by participants in the experiment, it would be better if it will be a mix of a few features, such as the publication type of LO and their technical level, because:

> *Thus, the recommendations will conform to the most desired results, and I will receive information in the required format and it will be not easier and not more complicated than they need.*

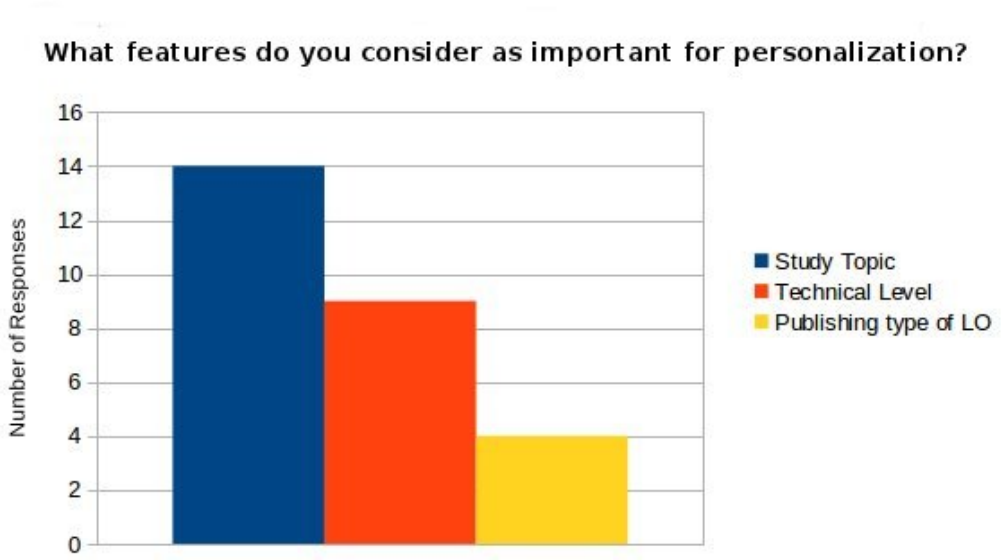


Figure 28: Responses to the question about the key features for personalization

It is hard to choose something specific. All features should be combined. Feature selection depends not only on the preferences of the person, but also on the task. In a one day can be a useful one, but in another day more.

It is convenient to choose the topic first, and then any other options depending on the task.

Figure 29 shows what combinations of features that the students have selected. Figure 30 shows what features and their combinations, different types of students have chosen, namely Master students, students from Artificial Intelligence Course and other Bachelor students.

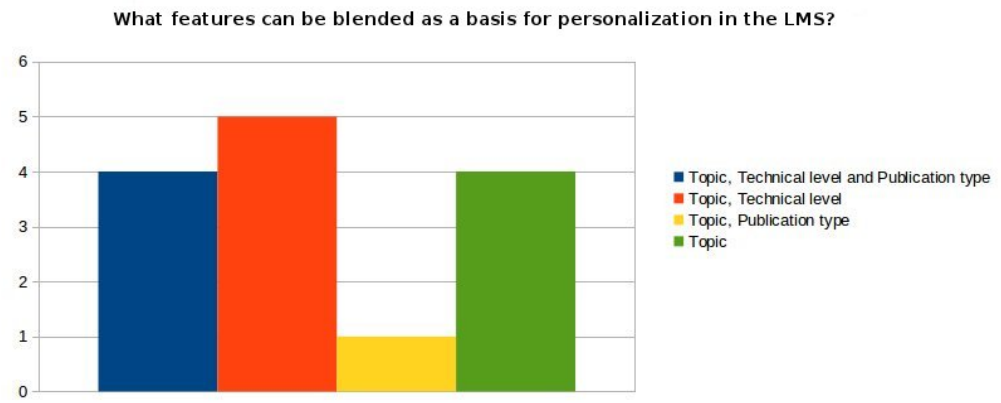


Figure 29: Responses to the question about the most useful combination of features as basis for personalization

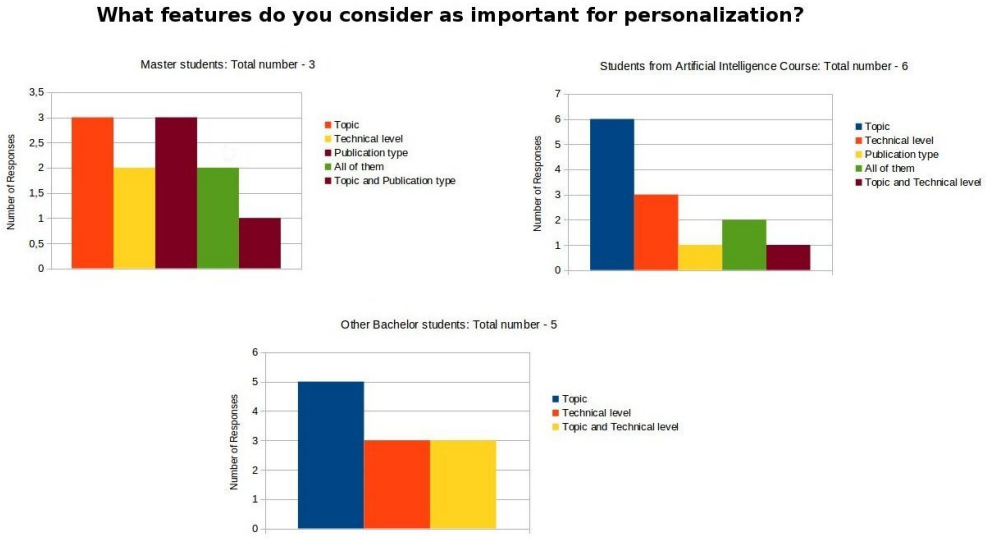


Figure 30: Responses of different types of students to the question about the most useful features as basis for personalization

Figure 31 shows a digram of personalization approaches usefulness. On figure 31, approaches, such as Personalized Learning Activities and Personalized Communication, are the most useful in students' opinions. But the majority of students are choosing the combined personalization approach. Figure 32 demonstrate student responses about the most suitable combination of personalization approaches. Hybrid approach is chosen for reasons that such system meets the needs of many people to provide more options and can be applied to various learning situations.

In those cases, when student have selected Personalized Communication Approach, regardless of whether alone or in combination with other techniques, they indicates that it would be better simply to recommend people, not divide them by different levels of difficulty. Cases of choice of all three approaches have been commented so:

> *So, I will be able to get the necessary educational materials, study them and if I will have any questions, it will be convenient to ask for help to people.*

Among the approaches suggested the most appropriate and useful, students deemed Personalized Learning Activities Approach, whether it is used in combination or separately.

Table 5 show what personalization approaches different types of students have chosen. Personalized Learning Activities Approach is a popular among students of the courses that have many practical tasks. Students also noted that Personalized Guidance Approach can be helpful on the theoretical courses. Participants of the experiment have indicated that Personalized Communication Approach will be useful in practical and theoretical courses.

As is well known, providing of personalization requires user interaction with the sys-

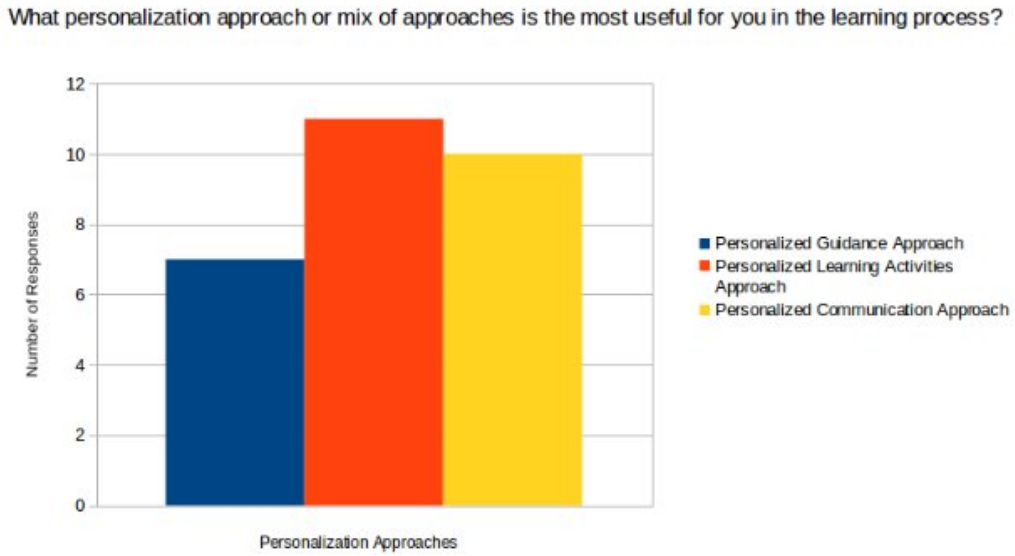


Figure 31: Responses to the question about the most useful approach to personalization in LMS

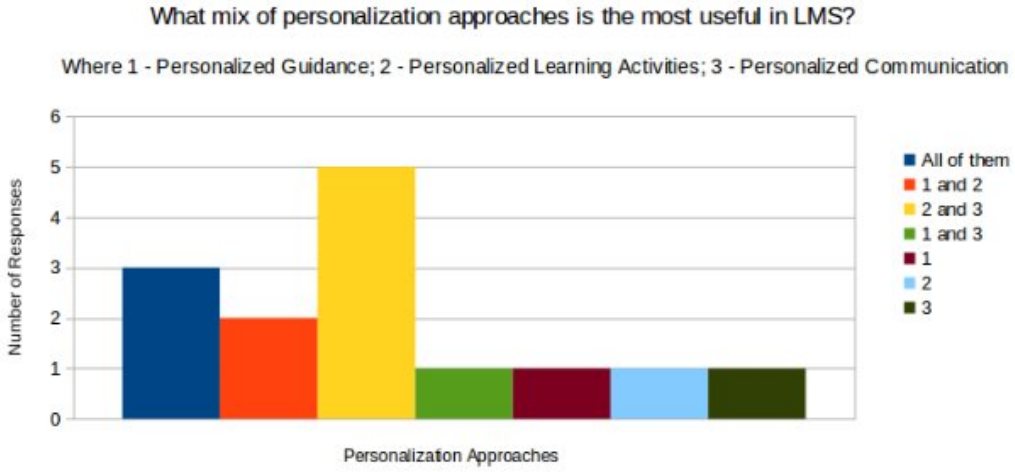


Figure 32: Responses to the question about the most useful combination of personalization approaches

What personalization approach or mix of approaches is the most useful for you in the learning process?	
Approach or Mix of Approaches	Number of Responses
Master Students' Responses	
Personalized Guidance Approach	1
Personalized Learning Activities Approach	3
Personalized Communication Approach	2
Personalized Guidance and Personalized Learning Activities Approaches	1
Personalized Learning Activities and Personalized Communication Approaches	2
Responses of Students from Artificial Intelligence Course	
Personalized Guidance Approach	3
Personalized Learning Activities Approach	6
Personalized Communication Approach	4
Personalized Guidance and Personalized Learning Activities Approaches	2
Personalized Learning Activities and Personalized Communication Approaches	3
All Approaches	1
Other Bachelor students' responses	
Personalized Guidance Approach	3
Personalized Learning Activities Approach	2
Personalized Communication Approach	3
Personalized Guidance and Personalized Communication Approaches	1
All Approaches	1
Only Personalized Guidance Approach	1
Only Personalized Learning Activities Approach	1
Only Personalized Communication Approach	1

Table 5: Responses of different types of students to the question about the most useful approach or mix of approaches to personalization in LMS

tem, such as tuning of the system under him/her, adding personal information, such as the interests, prior knowledge. Figure 33 shows the student responses to the question about the desire to interact with the LMS to provide personalization. Most students respond positively to the interaction with the system:

> *Now the system is not convenient to use (about LMS "Fronter"), and if personalization will make the learning process easier, I will interact with the system.*

The negative reaction was characterized by the fact that at present time the LMS satisfies in all, and the new features and interaction with their may create difficulties. The positive reactions of the interviewed participants also have been commented:

> *I will interact with the system only if this process will be fast and easy. If this process will consist of a large number of steps, then I am not going to work.*

Likewise, students indicate their reluctance to add personal information into the system, such as date of birth and/or interests outside of school, and would not like that provided information about them can be available to any other person. Students also note that a real result should be felt after the interaction with the system and the learning process should be facilitated. Also there are positive factors of interaction with LMS, that it can motivate to education and make learning process more interactive and interesting.

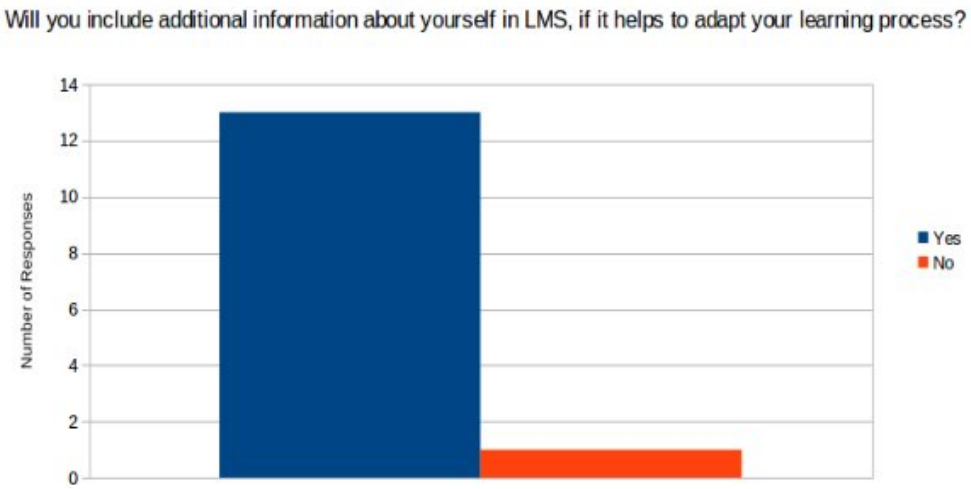


Figure 33: Responses to the question about the desire to add additional information to the system for personalization

The purpose of personalization is to facilitate the learning process. And for this we need to determine what can be facilitated and what challenges is faced by students in their learning process. Figure 34 shows the student responses to the question about the existence of problems in the learning process in during interaction with the LMS. Students who do not have problems, have commented it as the following:

> *I trust the teacher and I think that all materials that he proposes, are useful and there is no need to sort them in any case. And if something is not clear to me, I can use Google.*

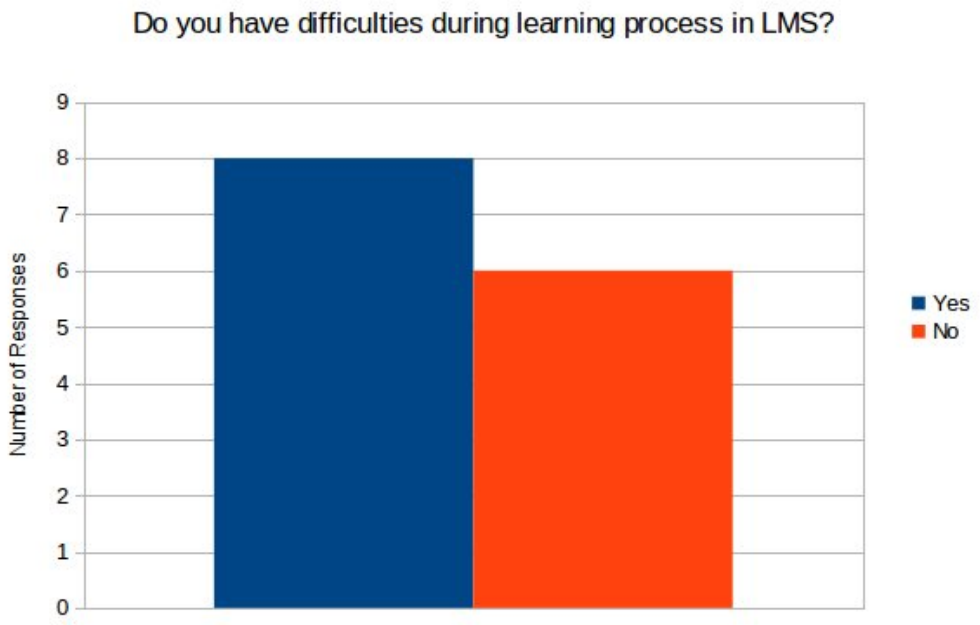


Figure 34: Responses to the question about the existence of difficulties in the learning process

Students who have problems in the educational process, have faced with the follow difficulties:

> *Every course has its own structure. Each teacher adds educational material by different ways. I spend a lot of time on searching of desired information.*

> *Now the system is not convenient to operate, there is no centralization in the publication of materials. Learning content is normal, but presented badly.*

> *Study materials do not have descriptions. I spend a lot of time to open them and review what they contain.*

So firstly, LOs are stored often unsorted, and it complicates search of LOs. At the same time there is not any description of these objects. Therefore, a lot of time is spent on opening LO and defining, whether this information is or is not appropriate. This process takes palace often because information contained in the textbooks is not enough and deeper knowledge is required. Second, there is not a unified structure and centrality for the publication of educational materials. Students note that, it would be easier if they had the opportunity to adjust systems for their. Now they spend much time on search. Another problem that is assigned by students, is lack of teacher time and lack of knowledge about who else can help their with study. But at the same time, almost all students find the usefulness of personalization to a greater or lesser degree, regardless of whether there are or not difficulties.

On the question about in what cases personalization can help, the students have responded the following:

Personalization can be useful when the lecture is cancelled.

It would be useful in solving educational tasks.

It would be helpful during the preparation for the exam.

Thus, students specify the following cases: solution of tasks and exercises, project implementation, preparation for the exam, skipping lectures and cancelled the lecture. Students believe that personalization would be particularly useful for them during the self-training. Students suppose that the search for relevant information can be facilitate by personalization. They also think it can help to self-check and to determine on what stage of the course, they are.

7 Discussion

7.1 Introduction

This project aims to study personalization in learning, what personalization approaches should be useful to students in LMS. Our study builds on previous studies reviewed in the Related work chapter. [38] defines the different approaches of personalization that can be used in the LMS. This article is the basis of this research. [38] singles out five basic approaches: Personalized User Interface, Personalized Learning Resources, Personalized Learning Activities, Personalized Guidance, Personalized Communication. Before the study, we have examined these types of personalization and evaluated how we can apply them in our study under the existing conditions and opportunities. Current study is limited by time and available resources. Therefore, we started our study on three personalization approaches in the LMS: Personalized Learning Activities, Personalized Guidance, Personalized Communication. We consider personalization and approaches which can be used as a way to make learning adaptive, how to adapt the educational content.

One of the main details on which we focus our project is to define the approach of personalization or a mix of approaches that will be most useful in the LMS. Defining a useful approach is based not only on what the student is interested. We must also consider such aspects as, in which cases personalization can be useful in LMS, what challenges are faced by users of the system during their learning process. It is important to gather all information together. To understand what personalization approach/es will be useful in LMS and what they are based on, we should find answers to three questions:

- What reasons can be to use personalization? The answer to this question must consider the existing problems of the students during the learning process in interaction with the LMS and to determine whether personalization is able to solve these problems and contribute to their solution.
- When can we use personalization? The answer to this question is to determine the place and time of personalization in the learning process.
- What can be personalized? The answer to this question is what educational content of the information should be personalized.

Answering the questions, it will be easier to understand what type of personalization can be useful. We will be able to consider each type of personalization based on specific responses.

In addition to identifying approaches for personalization in our study, we are also exploring on which features personalization should be based. Thus, features for personalization have been implemented in the prototype, such as a study topic, a technical levels and publication type of educational resources. These features have been chosen after examination of existing works. The choice of these features was primarily based on the fact that we can implement them in the system to demonstrate their function. We

are also able to determine what features should be considered in the first place and what may be of minor importance.

7.2 Personalization in LMS

Before the representation of our prototype, experiment participants heard about the concept of personalization, but did not perceive it as an adaptation of educational content. Students understood personalization only as a change and configuration of interface for themselves. In addition, they have not thought that their learning could somehow be improved or facilitated. This reaction of students can we explain by the fact that the LMS «Fronter», which is now used in the learning process of interviewed participants, gives the opportunity to customize the user interface. Students of this system can configure convenient access for desired courses to choose styles, but the presentation of educational content in a single course is the same for everyone, we have considered the possibilities of personalization in LMS "Fronter" in chapter 4.3. Such reaction demonstrates the conclusions of the article [14]. The interviewed participants can talk and discuss only about the fact of what they were dealing with. These facts confirm the correctness of the decision on the representation of visual prototypes that demonstrate the basic properties and personalization features, which can be implemented in the LMS.

Using prototype in the study helped to present new opportunities in LMS and encourage students to reflect on their learning process, on the problems that exist, and what can be changed and improved. Students responded positively to personalization. They felt such innovation comfortable and modern. Modern technologies allow much more possibilities for the development of education than LMS, which just stores information about courses and learning objects and provides access to them. And also it might be a good assistant in the the management of learning objects. Judging from the responses of the respondents, we can identify the following advantages of using the personalization in the LMS: providing easier access for interesting and desired resources. As a consequence it is facilitating access to information, making interaction with system more directive, that can motivate learners to use LMS, and gives an opportunity of self-control. The main disadvantages of the personalization is based on process of interaction between LMS and the notion of the personalization purposes. These disadvantages are related to the fact that students are afraid that the interaction with the system can be complicated and they can not understand the purpose of the new features. Sometimes, when getting acquainted with innovations in old system or new system, users initially have a number of inconveniences. But usually these inconveniences leave or become usual with a long and constant use. In any case, we should take into account the desire of experiment participants that interaction with new features in the LMS should be quick, easy, and not contains of a large number of steps.

Providing the personalization may require additional action from the user during interaction, such as an indication of personal interests. Although the students express their consent to the interaction with the system for the personalization, but they indicate that this process should be easy, ie, not have a large number of steps in filling, have a friendly interface, and do not be too intrusive. The result of the interaction should be visible and users should receive a real benefit. But consideration of how to implement the user interface is beyond the scope of this master thesis. Our main aim is to consider the perceptions of students to the possibility of new features. Also, analysing student responses,

we can understand that the information for the personalization should not be distributed to other users of the system. There may be include only information relevant for school and useful for the personalization process and does not contain any personal data, like birthday, gender etc.

We can make the first conclusions based on results that presented in 6.3.2 chapter. First, students believe that changes are needed in current system. Second, students see advantages from the use of personalization. And third, the students have desire to interact with the system. Therefore, we are not looking at a number of deficiencies and observations, we can judge that personalization in LMS can be useful and our further study on identifying the most useful approach/s for personalization and the main features of personalization can make sense.

7.3 Reasons for Using the Personalization in the LMS

As we mentioned in the section 6.3.2 Interview Results, students distinguish a number of problems that they face when interacting with LMS in the learning process. All the problems declared by students relate to difficulty of searching for the desirable educational information. But the personalization, as we consider in the this master thesis is not aimed to facilitate the search process, it is aimed to facilitate the learning process. We are considering personalization of educational materials as a substitute for search process. The problem of search and access is due to absence of single structure of LOs representation, description of LOs, and very often sorting them by study topic. Personalization of learning materials can help to solve some problems, depending on which it is based on. For example, a personalized recommendation of educational materials on a particular subject excludes selection process of a large number of unsorted published course material.

Students also determine the existence of problems in communication. This problem is characterized by factors such as the frequent lack of free time of course teacher, lack of knowledge about people that are able to help, etc. We can judge what students want to interact with other persons, but they often do not know with who to contact on a particular issue. But as we know the exchange of experience and knowledge plays an important role in the learning process, it motivates to obtain new knowledge, and enhances obtained. Personalized recommendations of LMS users based on common interests can contribute in the solving the problem of communication.

Also, study participants noted that the overall learning process can be easier. From this we can see that there are areas for further improvement of LMS. Adaptation of learning based on the personalization of learning materials may be the direction of forward movement. This may allow not only make learning more convenient and comfortable, but also to transfer learning to a new level, making it more interactive and tailored to the individual user.

Participants of the experiment indicated that personalization would be most helpful during self-training, we considered it in 6.3.2 chapter. Any learning process includes such cases. Moreover, individual training is very useful and stimulating for development of qualities such as thinking, logic, ability to control, introspection and self-esteem. Personalization of learning materials facilitates these situations by offering, for example, the desired educational information about a particular topic. Thus, the user of such system will not lose time for search and can spend it more usefully. Cases requiring self-

directed learning may be the following: solving tasks and exercises, project implementation, preparation for the exam, skipped or cancelled lecture. These cases cover the entire educational process, and hence the need for personalization of can occur throughout the learning process.

7.4 Personalization Approaches

7.4.1 Personalized Guidance Approach

The main goal is to recommend useful information for studying on a particular topic. This approach aims to assist in the study of a topic. It should offer learning materials that would be useful in the study, and where student can find the desirable information. But as we know, learning materials can be of varying complexity, some may offer only the basic concepts and definitions and to be an introduction to a topic, while others deeply consider a narrow domain. Therefore, under this approach, we also demonstrate the possibility of personalization on the basis of the required technical level in order to achieve the highest quality recommendations.

We have considered four qualitatives of good recommendation system in chapter 3.3.1 of Related work based on [52] article. The qualitatives are to provide personalized view, to provide personalized search, to recommend materials at the appropriate time or location and support non-disruptive view experience. We will estimate Personalized Guidance Approach by these described qualitatives. This approach provides recommendations based on user interests, thus it facilitates access to learning materials and partially exclude their search. Students can use this approach on demand at any time, if they have access to the LMS. The result of this approach is a list of recommendations that are provided with a description. Students can choose from the list those that most equal to their desires. Therefore, we can conclude that this approach satisfy the qualitatives for good recommendation system.

In general, this approach was found useful to survey participants. Positive aspects of the approach characterized by the fact that information is offered only in the conformity with the desired topic,and excludes redundant information. This approach can solve several problems that exist within the educational process when working with the LMS. It provides convenient access to necessary materials, and take less time for search. This approach can help during any of the previously described cases of necessity for personalization and can greatly facilitate self-directed learning.

7.4.2 Personalized Learning Activities Approach

This approach aims to provide learning materials in accordance with the preferred learning styles of students. This approach allows to individualize the learning process to a large extent, considering not only the educational interests, but also the convenience for students to perceive information. Learning style describes the ability of perception of the information provided in the a specific format. This approach allows to save more learning time and not spend it for searching the desirable learning resources. Educational information is provided in a convenient format. This approach takes into account the fact that all students are different and perceive information for study differently. Personalized Learning Activities Approch satisfy the qualitatives that described in chapter 3.3.1 of Related work, as is Personalized Guidance Approach.

The reaction of experiment participants on this approach was positive. Although users

did not specify the problems associated with the provision of information in different ways, but rather noted that the quality of the educational content of courses is very good and presented in different ways. But it is also noted the inconvenience of access to these materials. This means that to use learning materials of courses, students spend a lot of time to access them.

Personalized Learning Activities Approach can help in solving problems that may exist within the educational process of work in the the academic environment. Thus, it can make acess to educational material more convinient. Moreover adapting educational content, according to a preferred learning style, the learning process is getting easier. Like the previous approach, this approach will be useful in any suspected cases of individual preparation and contribute to its facilitation.

7.4.3 Personalized Communication

This approach enables communication on a specific topic, providing advice of persons with respect on interesting topic. This approach allows personalization of directed contact with a persones, knowing that they are able to help in the issue on a particular topic. We have already noted the importance of communication in the learning process. This approach aims to share knowledge and contribute to it.

Representations of the personalization approach designed to ensure communications was received positively. Students have noted its importance and usefulness. Moreover, they also have determined the problem that this approach could solve. During the self-training, we can often have questions, the answer on which is difficult to find in educational materials. In such cases, the possibility to ask for a competent persons will be very important and may save time of learning process.

Different opinions of the respondents also exist about who can be recommended as helpful people. A number of students notice that the students from other courses and students from past years can be helpers. Perhaps this is due to the fact that it is easier for students to communicate with their equals, to ask for help and not feel confused. But other students point out that only experts should be recommended. Of course, offering people we must be sure that the correct people are recommend that can help and not harm to the students. And addressing to their, students should also feel confident that person, who helps him, is competent in their questions.

7.4.4 Choice of the Useful Approach

Considering each of the proposed approaches separately, we find that they can be helpful in the learning process and are able to facilitate it. To determine the most useful approach, we revert to questions that we identified earlier in this chapter. Namely, what is necessary to personalize, when to personalize, and what should be personalized. Following the problems that occur in the learning process, we can conclude that it is necessary to personalize the educational materials presented in the learning environment and opportunities for communication. As we already explained earlier, the personalization will be especially helpful during self-training. Reasons for personalization have been identified as follow: providing convenient access to the material, not knowing people that can help in certain areas.

We consider the personalization approaches regarding defined indicators. Firstly, we found that there is a need for personalization of learning materials. Personalization of educational materials is provided by two approaches: Personalized Guidance and Per-

sonalized Learning Activities. Both of these approaches can solve the existing problem of how to provide easy access to materials represented as part of the course. Also, these approaches can help with self preparation. But by analyzing the reaction of users, we can determine that the Personalized Learning Activities Approach provides more opportunities, makes the learning process more individualized. Users of LMS is insufficiently to get just a recommendations of learning materials on a particular topic, it also should be taken into account their preferences and capabilities. The more system are capable, the more comfortable learning process can be. Also, if to take a look on statistics presented in the Chapter 6.3.2 in Figure 31, this approach is most useful among the approaches considered by respondents.

Also, as a result of the interview, we determined that there is a need for recommendations for communication. This need can be solved by Personalized Communication Approach. This approach can help to solve the problem that exists among users in the the current educational process. Personalized Communication Approach is aimed to ensuring the communication of people, is able to recommend the right people at the right time. Moreover in the statistical parameters represented in Figure 31 in the Chapter 6.3.2, this approach is on the second leading position.

Thus it appears that a combined approach is the most useful for the inclusion in LMS which includes personalization of learning activities and communication. If we look to statistics presented to Figure 32 in the Chapter 6.3.2, we see that the combination of these two approaches participants of interview also considered the most useful. Thus we can judge that the inclusion of such combination in the LMS is rather than in isolation and can bring real benefits. The inclusion of a combination of approaches to the LMS will give more opportunities to provide a more comfortable learning and allow users greater control over their learning process.

7.5 Features for Personalization

In this master thesis, we have examined three features that can be used as a basis for personalization, namely a study topic, a technical level and a publication type of study materials. In this chapter, we analyse and discuss the students' answers on questions about the applicability of the various features, that presented in chapters 6.3.2.

7.5.1 Study Topic

Study topic is a features that is used to determine the user's interests, for which personalized recommendation can be obtained. In our case, study topic is a basis for all three personalization approaches. We defined the goals and desires of users for the particular course using this feature. We rely on this fact, because defined topic list should be studied within the course and, accordingly based on these topics, students receive assignments and prepare for exams, etc. Also, the teacher of the course provides study materials that are relevant to certain topics. Therefore the use of study topic can help in personalization of educational materials within a course. Moreover, providing information on the basis of the study topic, we are reducing the impact of the problem of ambiguity. Concept can be described using various terms, which may have different depths. Thus one term may indicate a specific area, and the other gives the general knowledge. And using study topic as a features for personalization, we unify concepts within the course.

Analysing students' answers that is presented in the figure 28, we can conclude that

they responded positively on the providing of personalization based on study topic. Moreover, they note the need and convenience of this feature. We can judge that it is convenient for students to define their interests by using the predefined settings, so the need to formulate a search query is eliminated, and therefore additional actions and interactions with the system is excluded and time is saved. Provided recommendations based on particular study topic eliminate ambiguity and misunderstanding, allowing the student to exactly understand in what area he/she is studying.

Analysing the responses of students during the interview, we can conclude that there are cases where a student can not understand in what areas can apply his/her question. To avoid this problem, each topic should have a brief description of what it includes.

7.5.2 Technical Level

Technical level is a feature that allows to determine the level of student knowledge in a particular area. Personalization on the basis of this feature does not give unnecessary information, such as too difficult or too easy. Thus, this feature provides a more personalized recommendations and study materials, and can help to ensure that the recommended materials will be more useful, i.e. they will rather conform to the interests and desires of students. We use the technical level feature in two personalization approaches: Personalized Guidance and Personalized Communication.

The interviewed participants have reacted differently to the possibility of selecting the desired technical level. For example, some students have responded positively to the choice of technical level in Personalized Guidance Approaches, they justify in that the possibility of providing redundant information is avoided. The positive qualities were also attributed that this feature allows to determine the level of student knowledge in a certain area, providing a good opportunity for self-control. But not all participants understood the difference between the various technical levels. Also, some participants of the interview have supposed that if the instructor of the course offers some information, then it should be studied, no matter to what level of difficulty it is. Separation of learning objects on various technical levels may seem rather subjective, each person determines for himself the boundaries between the levels of their own way. One solution to this problem can be to identify the different technical levels for each course topic, i.e. to specify exactly what concept involves every level of a particular topic and how deeply it considers them. Such feature also allows students to determine at what learning stage they are at the current moment.

In Personalized Communication Approach, we have also offered to students to determine their technical level of issue. But this idea has not received approval. This is due to the fact that having a question, we often do not know for what level of complexity to include it. Since we can not find the answer by yourself, then it is complicated. Complexity of the issue is quite subjective indicator. At the same time, we want to get an accurate response from specialist in a particular area. Therefore, the application of the technical levels in the under this approach, we can assume not profitable.

7.5.3 Publication Type of Learning Objects

Publication type of learning objects is a feature that allows us to determine the desired format of learning objects. The use of this feature is based on the fact that all students are different accept information presented in different ways. Some students are more receptive to the information visually, others by hearing. Each way of perception of the

information will correspond to different formats of learning objects. In our case, the personalization of learning materials based on their publication types were implemented implicitly in the Personalized Learning Activities Approach. We offer to choose their preferred learning style and, on the basis of which the system recommends learning materials.

Analysing student responses presented in the chapter 6, we can see that the personalization of learning materials on the basis of learning style meets the needs of users in a convenient representation of the desirable materials. There is not the need to specify an exact format of learning LO. But this need can be useful in some cases in Personalized Guidance Approach for the more accurate the recommendations of additional learning materials. This feature is not widely popular among students.

7.5.4 Choice of Features for Personalization

Considering separately each feature, we can assume that in certain cases they can serve as a basis for personalization features. It should be noted that we can not get good recommendations based on only technical level or publication type of LO. Also recommendations should be based on a specific topic or correspond to a specific area. Analysing respondents' answers, which are described in chapter 6.3.2 and represented in Figure 28, we can also see that the study topic is given special attention and all the students believe that the recommendations should be based on the study topic. Moreover, students say that it is very convenient and useful on the first step to choose a topic of the recommendations, and then other features for personalization.

Using a combination of features allow to make recommendations more appropriate for each individual user, to eliminate unnecessary information. In such proposal we came to analyse student responses, which are presented in Chapter 6.3.2 and in Figure 29. Most students choose a combination of features.

We can assume that personalization can be based on the following combination of features:

- Topic and technical level
- Topic and publication type of LO
- Topic, publication type of LO and technical level

Choice of required features can not only depend on the preferences of users and their interests, it must be based on the user tasks. At the same time, the choice of necessary personalization features, also should be based on what personalization approaches are used in the LMS. So for example if we use the Personalized Guidance Approach, then use a combination of topic and technical level for easy access to educational materials, sorts them and removes excess, in some cases it can be useful to use a combination of all three features. So the recommendation can more accurately reflect the interests and needs of users.

As we have previously determined that the Personalized Learning Activities Approach does not require to specify publication type of LOs, because we already point out the preferred learning style. But in students opinion, adding technical level can be very helpful in this approach. There is an opportunity not only to obtain appropriate study materials

Personalized Guidance Approach	Personalized Learning Activities Approach	Personalized Communication Approach
Topic Technical level Publication type of LO	Topic Technical level	Topic

Table 6: Features for personalization in a variety of approaches

for particular learning style, but also that these materials can match the user's knowledge.

Personalized Communication Approach is based on the recommendations of the people, so we can not apply to it the features of publication type of LOs. Also based on the reaction of students we can judge that the application of technical level is also not very useful in this approach. And it can only complicate the interaction with the system and lead to erroneous recommendations.

Table 6 presents some features that may be a basis for different personalization approaches.

We already have written about what the problems could happen that is associated with understanding technical level and that study topic involves in itself. To avoid these problems, it is necessary that descriptions of study topics and difficulty levels in each topic exist. So for example the description of topics may include any sub-topics and discussed concepts. Descriptions of levels of complexity may contain information on how deeply the concept is considered in the level. This can allow users to better interact with the system, to eliminate the problem of ambiguity and subjectivity of judgements.

7.6 Findings

We found in this study that students are dissatisfied with and experience problems during the interaction with the current LMS. Also, we have identified these problems, such as the difficulty of access to and retrieval of desired learning material; a communication problem. We found that personalization can help solve these problems.

The main objective of our study is to identify the personalization approach or a mix of approaches that can be more useful for inclusion in the LMS. We found that a mix of Personalized Learning Activities and Personalized Communication Approaches is most useful for inclusion in the LMS. This mix can contribute to solving some of the problems of students, such as the difficulty of access and retrieval of desired educational materials and a communication problem. We also examined the basis on which these approaches can provide personalization. Based on our research and analysis, we determined that the Personalized Learning Activities Aproach should include features such as: Study topic and Technical level; Personalized Communication Approach should be based on the Study topic.

We have identified four key factors of on-line learning personalization in Chapter 3.3 based on [26, 6], such as providing flexible outcomes; meeting the needs of individual learning styles; keeping the learner engaged; enabling the learner to use their time well. We will examine how a system with inclusion Personalized Learning Activities and Personalized Communication Approaches corresponds to these factors. We have not con-

sidered in our study changes in the learning process, but only studied the possibility of providing personal recommendations. In our case, Personalized Learning Activities Approach is based on a technical level and study topic, considers the knowledge of users and provides easy navigation to the topics being studied and relevant learning material. Both approaches are able to consider how the user perceives the information. If the learner prefers to communicate, the system can provide him/her with people knowledgeable in the area of interest, at the same time, the system allows the learner to choose desirable ways of information perception of learning material based on learning styles VARK model. System with inclusion personalization based on a mix of approaches, firstly, considers the topic of interested material, thus easy navigation is provided to learning materials. If student have access to the LMS, he/she also receives access to personalization features. Thus, we can enclose that LMS with inclusion of mix of Personalized Learning Activities and Personalized Communication Approaches corresponds to the key factors of on-line learning personalization.

7.7 Criticism of Chosen Methodology

In this chapter, we are reviewing the limitations and issues of the project. The prototype have been developed that demonstrates the basic functions and purposes of personalization in LMS. We have restricted the creation of a simple prototype, that is to provide personalization features based on three approaches: personalized guidance, personalized learning activities and personalized communication. We have not considered such approach, as a personalized user interface because of time constraints. This approach requires a different devices, and also additional time is required for software development.

The prototype provides personalized study materials on demand. The user profile used for personalization is built during the users' interaction with the prototype. The prototype do not store any data about the students in the system. It can not record the last students' interaction in the system and carry out their analysis. All the information required for personalization available explicitly from students. This approach is chosen due to time constraints as well. We had only one meeting with interview participants in which they interacted with the prototype and answered questions of the survey. It would be difficult in a short period of time to conduct a study with obtaining of students' interests implicitly. The prototype should be implemented in the current LMS for student use during the learning process. But implementation was also impossible due to the fact that the LMS Fronter, which is now used in Gjøvik University College, is not an open source system.

Another limitation in the prototype is a user interface. The simple user interface was created in the prototype. And it is based on simplicity and consistency. Its main aim is to show the functionality of the prototype. We did not study its usability. In our experiment, the participants are not asked questions about the prototype interface. Separate research about user interface should be conducted to implement the personalization features in the LMS.

The prototype is based on the study course Artificial Intelligence Course. The main criteria for choosing the course were the following factors: the students of courses must have sufficient experience with LMS; study course should include a practical and theoretical learning material. Another factor in the choice of Artificial Intelligence Course was the fact that it is taught in English. Most courses at Gjøvik University College are taught

in Norwegian. It could cause problems when the repositories of learning resources is created.

In our study, Personalized Learning Activities Approach is based on VARK model. This model involves four learning styles: visual, auditory, read / write and kinesthetic. But only three styles: visual, read / write and kinesthetic are used in the developed prototype used. This is due to the fact that the Artificial Intelligence Course is not sufficiently represented by learning objects for all styles. There are not enough learning objects for auditory learning style. However, this issue did not affect the display of the personalization approach. The main idea of the approaches had been conveyed to participants in the experiment. For other learning styles of VARK model, learning objects are used by which Artificial Intelligence Course is represented. The classification of learning objects on the different learning styles was based on the definition of these styles.

Based on Personalized Guidance Approach, we also demonstrated a personalization feature, such as Technical level, which made it possible to determine the level of desired learning materials or persons' knowledge. In our research, we use the following levels: Basic / Elementary, Intermediate and Advanced. The choice was made based on the fact that this classification is simple to understand and has a clear description in the existing literature. But there are also classifications with more levels. But for their use, more time would require for the classification of learning objects on different levels and concordance with the teacher.

Initially, interview was planned to conduct only among students Artificial Intelligence Course, on which the prototype was based. But limitations was made in the process of study, and the interview was carried out among other students. But all students experienced enough with the LMS, and could evaluate and understand the advantages and disadvantages of the interaction with the learning environments. There was not differences among students of Artificial Intelligence Course and other students during the demonstration of the prototype and the interview. In both cases, the purposes of the prototype and its basic functions were demonstrated. Asked interview questions was about the use of LMS in the whole learning process. This limitations did not affect the results of the study.

8 Conclusion

In this master thesis, we have studied the main aspects of personalization and how personalization can be applied in Learning Management System in order to achieve the best results during learning process and make learning more convenient and flexible. We determined to study research area and related literature that there are problems such as:

- the majority of LMS is not able to provide a dynamic learning content to learners and change learning activities;
- the learners needs and goals change along with their learning process.

One solution of these problems can be personalization of learning content, which considers the interests of each individual student. But the next problem arises - in what manner personalization should be implemented in education. We have considered different personalization approaches, which may be included in the LMS, and chose those that can adapt to the learning process. In this project, we compared three personalization approach: Personalized Guidance, Personalized Learning Activities and Personalized Communication. These approaches were chosen for the following reasons: they allow us to personalize the learning content, they do not require changes in the educational process and they do not require the use of various devices.

A prototype has been developed to conduct research, which demonstrate the basic functions of personalization approaches and show their differences. The prototype helped us to show students the basic idea of personalization and its necessity and usefulness in the learning process. In this study, we have conducted interviews with students. Based on an analysis of student responses, we can answer our research questions.

What personalization approach or mix of personalization approaches among personalized guidance, personalized learning activities and personalized communication can be more useful in Learning Management System?

We can conclude by studying the responses of students that each of the approaches considered by us is able to make an adaptive learning process, but they do it in varying extents. Therefore, in order to determine the most useful approach/es, we have studied what problems students experience in their learning process during the interaction with the LMS, and in what cases personalization may be the most useful, and what can be personalized.

We have determined that the possibility of personalizing the LMS may be most useful in during of self-learning, for example during exam preparation or making of the project, etc. Each of the approaches considered by us is able to help with self-learning. So Personalized Guidance Approach recommends additional learning material that can help students in their learning tasks. Personalized Learning Activities Approach also recommends learning material, but allows students to choose preferred ways of perceiving information. It helps to facilitate and make the educational process more enjoyable

and rewarding. Personalized Communication Approach involves the recommendation of knowledgeable persons in a particular area and can assist the user in their learning questions.

We have identified the problems that exist in the students' interaction with the LMS, such as an inconvenient access to educational materials and a lack of knowledge about persons who can help in the learning problems. Also, we have determined what information should be personalized to the LMS. In the opinion of students, this is a learning material and knowledgeable person in a certain area. Two considered approaches can personalize learning material and facilitate access to them. This is Personalized Guidance Approach and Personalized Learning Activities Approach. In this case, Personalized Learning Activities Approach would be most useful, as we can judge to study the responses and reactions of students. This approach offers more opportunities to adapt study content. It does not only consider the interests of students, but also their abilities and capabilities, and allows you to make the learning process easier for each individual student. Personalized Communication Approach can serve as solving the problem related to lack of knowledge about persons who could help in a particular area.

Thus, the answer this research question is a mix of Personalized Learning Activities and Personalized Communication Approaches.

What features can be as basis for personalization in Learning Management System?

We study in this research question on what features personalization can be based, namely on what the approaches defined in last question should be based. In the prototype, we introduced three personalization features: Study topic, Technical level and Publication type of LO. Feature Study topic was used in all three approaches, Technical level was applied in Personalized Guidance and Personalized Communication Approaches, and Publication type of LO was indirectly used in Personalized Learning Activities Approach. Publication type of LO can not be applied in Personalized Communication Approach.

Personalized Learning Activities Approach may be based on the following features: study topic, technical level and publication type of LO. We have analyzed the responses and reactions of students and can make the following conclusions. First, the primary feature is the study topic. Secondly, the use of technical level in this approach may be very useful and provide more opportunities. Third, the explicit use of Publication type of LO features would be redundant and useless in this approach, because this approach already have personalized the educational material based on the desired learning style.

Personalized Communication Approach may be based on the following features: study topic and technical level. We can conclude the follow based on the students' responses. First, study topic, as is in Personalized Learning Activities Approach, is an important and primary feature. Secondly, the use of technical level in this approach is not useful and can lead to erroneous recommendations.

Thus the answer this research question is Study topic and Technical level features for Personalized Learning Activities Approach and Study topic for Personalized Communication Approach.

9 Further Work

In this master thesis some personalization approaches were proposed to be used in Learning Management System. To further increase the validity and relevance of them, a proposal for future work would be the follow: to apply these approaches in real-life LMS and study their impact on the real learning process and evaluate the usefulness of this inclusion.

Another suggestion for future work is to study existing learning model that can be applied in Personalized Learning Activities Approach and compare applying of these models in LMS.

Another proposal is to study what kind of person may be relevant for Personalized Communication Approaches. Study should be conducted to determine that the recommended persons must be experts in a particular area or they may be students that learn related fields? Also the future study may be about opportunity to consider the communication between different universities and international cooperation.

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A Appendix - XML Files of Repositories

A.1 Repository of Personalized Guidance Approach

A.1.1 DTD Schema of XML File for Personalized Guidance Approach

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<!ELEMENT id (#PCDATA)>
<!ELEMENT name (#PCDATA)>
<!ELEMENT paper (id_p, title, author, description, keywords, url, technicalLevel, type, date)>
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<!ATTLIST paper idp CDATA #REQUIRED>

]>
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A.1.2 XML File for Personalized Guidance Approach

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      <id_p>01</id_p>
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      <author>Stuart J. Russell; Peter Norvig</author>
      <description>1.1 — 1.5 chapters. In which we try to explain why we consider
      artificial intelligence to be a subject most worthy of study, and in which we try to decide what
      exactly it is, this being a good thing to decide before embarking </description>
      <keywords>Artificial Intellegence, introduction, history</keywords>
      <url>http://ask.bibsys.no/ask/action/show?pid=101436254\&amp;kid=biblio </url>
      <technicalLevel>Basic level</technicalLevel>
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      <date>2010</date>
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        ntelligence are traced to philosophy, fiction, and imagination. Early inventions in electronics,
        engineering, and many other disciplines have influenced AI. Some early milestones include work in
      problems solving which included basic work in
      learning, knowledge representation, and inference as well as demonstration programs
      in language understanding, translation, theorem proving, associative memory, and knowledge—based systems.
       The article ends with a brief examination of in?uential organizations and current issues facing the field.</description>
      <keywords>Artificial Intellegence, History</keywords>
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      <title>WHAT IS ARTIFICIAL INTELLIGENCE?</title>
      <author>John McCarthy</author>
      <description>This article for the layman answers basic questions about artificial intelligence.
The opinions expressed here are not all consensus opinion among researchers in AI.</description>
      <keywords>Artificial intelligence, Introduction</keywords>
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65        <title>Artificial Inlelligence. A Modern Approach. </title>
          <author>Stuart J. Russell; Peter Norvig</author>
67        <description>2.1 — 2.5 chapters. In which we discuss the nature of agents, perfect or otherwise,
 the diversity of enviroments, and the resulting menagere of agent types.</description>
69        <keywords>Intelligent Agents, enviroments</keywords>
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71        <technicalLevel>Basic level</technicalLevel>
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73        <date>2010</date>
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75      <paper idp="06">
          <id_p>06</id_p>
77        <title>Intelligent Agents</title>
          <author>John Loyd</author>
79        <description>An agent is an entity that receives percepts from
           the environment in which it is operating and applies actions to the environment in order
81         to achieve its goals. The notion of an agent provides a unifying conceptual framework for
 current research in artificial intelligence.
83         In these three lectures, I will introduce the basic ideas of agents, describe some agent
           architectures, and comment briefly on relevant philosophical and historical issues.</description>
85        <keywords>Intelligent Agents, enviroments</keywords>
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87        <technicalLevel>Basic level</technicalLevel>
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91      <paper idp="07">
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93        <title>Intelligent agent</title>
          <author>From Wikipedia, the free encyclopedia</author>
95        <description>The article presents the basic information about Intelligent Agents. </description>
          <keywords>Intelligent Agents</keywords>
97        <url>http://en.wikipedia.org/wiki/Intelligent_agent</url>
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99        <type>wiki</type>
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101     </paper>
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103       <id_p>08</id_p>
          <title>Is it an Agent, or just a Program?: A Taxonomy for Autonomous Agents</title>
105       <author>Stan Franklin and Art Graesser</author>
          <description>Abstract: The advent of software agents gave rise to much
107 discussion of just what such an agent is, and of how they differ from programs in general.
 Here we propose a formal definition of an autonomous agent which clearly distinguishes a
109 software agent from just any program. We also offer the beginnings of a natural kinds taxonomy
 of autonomous agents, and discuss possibilities for further classification. Finally, we discuss
111 subagents and multiagent systems.</description>
          <keywords>Intelligent Agents, Agent Classifications</keywords>
113       <url>http://www.msci.memphis.edu/~franklin/AgentProg.html</url>
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115       <type>Workshop paper</type>
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127         <title>On the role of emotion in biological and robotic autonomy</title>
            <author>Tom Ziemke</author>
129         <description>This paper reviews some of the differences
 between notions of biological and robotic autonomy, and how these differences
131 have been reflected in discussions of embodiment, grounding and other concepts in
 AI and autonomous robotics. Furthermore, the
133 relations between homeostasis, emotion and embodied cognition are discussed as well
 as recent proposals to model their interplay
135 in robots, which reflects a commitment to a multi—tiered affectively/emotionally
 embodied view of mind that takes organismic
137 embodiment more serious than usually done in biologically inspired robotics.</description>
            <keywords>Autonomy; Autopoiesis; Cognitive robotics; Grounding;
139  Homeostasis; Embodied cognition; Emotion; Organismic embodiment</keywords>
            <url>article/Tom Ziemke — 2008.pdf</url>
141         <technicalLevel>Basic level</technicalLevel>
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143         <date>May 31, 2007</date>
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147         <title>Your Brain in Love</title>
            <author>Scientific American Magazine</author>
149         <description>Cupid's arrows, laced with neurotransmitters, find their marks</description>
            <keywords>Mind, brain</keywords>
151         <url>http://www.scientificamerican.com/article.cfm?id=your—brain—in—love—graphsci\&amp;WT.mc_id=SA_WR_20110217</url>
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161         <id_p>11</id_p>
            <title>How Language Shapes Thought</title>
163         <author>Lera Boroditsky</author>
            <description>The languages we speak affect our perceptions of the world</description>
165         <url>article/Conceptual Representations.pdf</url>
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        <title>Novel Rock Detection Intelligence for Space Exploration
Based on Non–Symbolic Algorithms and Concepts</title>
        <author>Sule Yildirim, Ronald L. Beachell, Henning Veflingstad</author>
        <description>Future space exploration can utilize artificial
intelligence as an integral part of next generation space rover
technology to make the rovers more autonomous in performing mission objectives. The main advantage of the
increased autonomy through a higher degree of intelligence is that it allows for greater utilization of rover resources by
reducing the frequency of time consuming communications between rover and earth. In this paper, we propose a space
exploration application of our research on a non–symbolic algorithm and concepts model. This model is based on one
of the most recent approaches of cognitive science and artificial intelligence research, a parallel distributed processing
approach. We use the Mars rovers, Sprit and Opportunity, as a starting point for proposing what rovers in the future
could do if the presented model of non–symbolic algorithms and concepts is embedded in a future space rover. The
chosen space exploration application for this paper, novel rock detection, is only one of many potential space
exploration applications which can be optimized (through reduction of the frequency of rover–earth communications,
collection and transmission of only data that is distinctive/novel) through the use of artificial intelligence technology
compared to existing approaches. </description>
        <keywords>Space Rover, Novel Rock Detection, Artificial Intelligence, Non–Symbolic Algorithms and Concepts,
Connectionism</keywords>
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        <title>The Mind Agents in Netlogo 3.1</title>
        <author>Sule Yildirim, Gregory L. Dam, James C. Houk</author>
        <description>In [Houk, 2005], the "Agents of the mind" idea
 is proposed as a suitable framework for studying the dynamics and complexities of mind.
"Agents of the mind" is inspired by the society of mind idea of Marvin Minsky [Minsky, 1988]. According to the society of mind,
       the mind is a complex system. The mind agents are elusive to identify.The mind is proposed as a hierarchy of agents.
The higher hierarchy agents compose of lower hierarchy agents. Higher level agents do not
command lower level agents but they basically trigger or invoke lower level agents.
Agents are functional entities and they interact with each other. One important part
of the society of mind idea is that agents at the lowest level are the real workers.
Higher level functionalities emerge as a result of the functioning of the lower level
agents and the interactions between them.
 In agents of the mind project, computational distributed processing modules (DPM) are
posited for corresponding anatomically defined assemblies and they are referred to as
 the agents of the mind. M1 is an anatomical area in the cerebral cortex which produces
 voluntary commands via its loops through basal ganglia and cerebellum. M1–DPM is a
computational distributed processing module which simulates M1 area and its loops for
voluntary commands production. We use Netlogo 3.1 agent–based programming environment
to illuminate the properties of mind. In this work, the attractor network in cerebellar
loop and the effects of Purkinje cell on production of motor commands have been studied.
The results are reported in this paper.</description>
        <keywords>Mind agents, distributed processing modules, computational microscopic module</keywords>
        <url>article/ADS2007_YILDIRIM_DAM_HOUK.pdf</url>
        <technicalLevel>Intermediate Level</technicalLevel>
        <type>Conference paper</type>
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        <title>A Neurosemantic Theory of Concrete Noun Representation Based on the Underlying Brain Codes</title>
        <author></author>
        <description>This article describes the discovery of a set of biologically–driven semantic
        dimensions underlying the neural representation of concrete nouns, and then demonstrates how
        a resulting theory of noun representation can be used to identify simple thoughts through their
        fMRI patterns. We use factor analysis of fMRI brain imaging data to reveal the biological
        representation of individual concrete nouns like apple, in the absence of any pictorial
        stimuli. From this analysis emerge three main semantic factors underpinning the neural
        representation of nouns naming physical objects, which we label manipulation, shelter, and
        eating. Each factor is neurally represented in 3–4 different brain locations that correspond
        to a cortical network that co–activates in non–linguistic tasks, such as tool use pantomime
        for the manipulation factor. Several converging methods, such as the use of behavioral ratings
        of word meaning and text corpus characteristics, provide independent evidence of the centrality
        of these factors to the representations. The factors are then used with machine
        learning classifier techniques to show that the fMRI–measured brain representation of an
        individual concrete noun like apple can be identified with good accuracy from among 60
        candidate words, using only the fMRI activity in the 16 locations associated with these factors.
        To further demonstrate the generativity of the proposed account, a theory–based model
        is developed to predict the brain activation patterns for words to which the algorithm has
        not been previously exposed. The methods, findings, and theory constitute a new approach of
        using brain activity for understanding how object concepts are represented
        in the mind.</description>
        <keywords>Neurosemantic Theory, Noun Representation, Underlying Brain Codes</keywords>
        <url>http://www.plosone.org/article/info%3Adoi%2F10.1371%2Fjournal.pone.0008622</url>
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        <type>Research article</type>
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      <author>Stuart J. Russell; Peter Norvig</author>
      <description>3.1 — 3.7 chapters. In which we see how an agent can
find a sequence of actions that achieves its goals when no single action will do.</description>
      <keywords>Intelligent Agents, Search, Solving problem by searching,
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      <title>A Brief Introduction to Search in AI</title>
      <author>Jordan Thayer, Wheeler Ruml</author>
      <description>In this video we present four fundamental heuristic
search algorithms including uniform cost search, greedy best first search, A*, and weighted A*.
We provide a brief description and pseudo code for each algorithm, after which we visualize its
execution on a two-dimensional path-finding problem.</description>
      <keywords>Intelligent Agents, Search, Solving problem by searching,
Uninformed Search Strategies, Infromed Search Strategies</keywords>
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      <title>Search and Games</title>
      <author>Adi Botea</author>
      <description>Search is a major direction in current AI research and a powerful solving technology in a wide range of real-
            life problems. This course focuses on single-agent search techniques. Pathfinding in games is used as an
            application domain.</description>
      <keywords>Intelligent Agents, Search, Solving problem by searching, Uninformed Search Strategies, Infromed Search
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        <author>David Poole and Alan Mackworth</author>
        <description>This section presents three uninformed search strategies
that do not take into account the location of the goal. Intuitively, these algorithms ignore
where they are going until they find a goal and report success.</description>
        <keywords>Uninformed Search, Depth-First Search, Breadth-First Search,
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        <url>http://www.cs.ubc.ca/~poole/aibook/html/ArtInt_52.html</url>
        <technicalLevel>Basic Level</technicalLevel>
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        <title>ARTIFICIAL INTELLIGENCE FOUNDATIONS OF COMPUTATIONAL AGENTS</title>
        <author>David Poole and Alan Mackworth</author>
        <description>This section presents information about Heuristic Search and informed search strategy. </description>
        <keywords>Heuristic Search, A* Search</keywords>
        <url>http://www.cs.ubc.ca/~poole/aibook/html/ArtInt_56.html</url>
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        <title>SHPA*: Maintaining A Static Hierarchy for HPA*</title>
        <author>Alex Kring</author>
        <description>In 2004, Botea, Muller, and Schaeffer published
the HPA* algorithm
(Hierarchical Path-Finding A*), which is arguably the most popular hierarchical pathfinding
algorithm in the video games industry. One of the most pressing concerns for
HPA* is the complexity involved in modifying the graph hierarchy, which is required for
connecting arbitrary start and goal nodes. Maintaining a dynamic hierarchy slows
performance, and complicates programming and debugging. I will explain the problems
with modifying the graph hierarchy, and then I will explain how the SHPA* algorithm
alleviates these problems by maintaining a static hierarchy. Compared to HPA*, SHPA*
is shown to be up to nine times faster in the best case, and about twice as fast for many
common cases, while finding paths that are within 4% optimality of HPA*.</description>
        <keywords>Hierarchical Path-Finding A*, Graph Hierarchy</keywords>
        <url>article/SHPA_Star.pdf</url>
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        <type>Research paper</type>
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        <title>Near Optimal Hierarchical Path-Finding</title>
        <author>Adi Botea, Martin Muller, Jonathan Schaeffer</author>
        <description>The problem of path-finding in commercial computer
games has to be
solved in real time, often under constraints of limited memory and CPU resources. The computational
effort required to find a path, using a search
algorithm such as A*, increases with size of the search space. Hence, path-finding on large maps can
result in serious performance bottlenecks.
This paper presents HPA* (Hierarchical Path-Finding A*), a hierarchical approach for reducing problem
complexity in path-finding on grid-based
maps. This technique abstracts a map into linked local clusters. At the local level, the optimal
distances for crossing each cluster are pre-computed and
cached. At the global level, clusters are traversed in a single big step. A hierarchy can be
extended to more than two levels. Small clusters are grouped
together to form larger clusters. Computing crossing distances for a large cluster uses distances
computed for the smaller contained clusters.
Our method is automatic and does not depend on a specific topology.
Both random and real-game maps are successfully handled using no domain-
specific knowledge. Our problem decomposition approach works very well
in domains with a dynamically changing environment. The technique also
has the advantage of simplicity and is easy to implement. If desired, more
sophisticated, domain-specific algorithms can be plugged in for increased
performance. The experimental results show a great reduction of the search effort.
Compared to a highly-optimized A*, HPA* is shown to be up to 10 times
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faster, while finding paths that are within 1% of optimal.</description>
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        <author>RidgeSoft</author>
        <description>The IntelliBrain—Bot educational robot
 is designed to bring computer science, robotics and engineering concepts alive for students.</description>
        <keywords>IntelliBrain—Bot, robot</keywords>
        <url>http://www.ridgesoft.com/</url>
        <technicalLevel>Basic level</technicalLevel>
        <type>Tutorial</type>
        <date>2010</date>
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        <title>Guide for Programming RoboJDE</title>
        <author>RidgeSoft, LLC</author>
        <description>By providing a modern, easy to use, software
development environment built for
robotics applications, the RoboJDE Java —enabled robotics software development environment
 opens the door to object oriented software
development for educational and hobby robotics projects.  RoboJDE enables you to quickly
and easily develop software to control your robot.</description>
        <keywords>RoboJDE, Java Programming, Eclipse</keywords>
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        <author>Stuart J. Russell; Peter Norvig</author>
        <description>25 chapter. In which agents are endowed with physical
 affectors with which to do mischief. 25.1 — Introduction; 25.2 — Robot Hardware;
25.4 — Planning to move; 25.6.3 — Reactive control; 25.7.1 — Subsumption architecture;
25.7.2 — Three—layer architecture; 25.8 — Apllication domain</description>
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        <type>Textbook</type>
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        <title>Real—Time Randomized Path Planning for Robot Navigation </title>
        <author>James Bruce, Manuela Veloso</author>
        <description>Mobile robots often find themselves in a situation
 where they must find a trajectory to another position in their environment,
subject to constraints posed by obstacles and the capabilities of the robot
itself. This is the problem of planning a path through a continuous domain,
 for which several approaches
have been developed. Each has some limitations however, including requiring
state discretizations, steep
efficiency vs. accuracy tradeoffs, or the diffculty of adding interleaved execution.
 Rapidly—Exploring
Random Trees (RRTs) are a recently developed representation on which fast continuous
domain path
planners can be based. In this work, we build a path planning system based on RRTs
that interleaves planning and execution, first evaluating it in simulation
and then applying it to physical robots. Our planning algorithm, ERRT (execution extended RRT),
 introduces two novel extensions of previous RRT work,
the waypoint cache and adaptive cost penalty search, which improve replanning efficiency and the quality
of generated paths. ERRT is successfully applied to a real—time multi—robot system.
 Results demonstrate
that ERRT is signifficantly more efficient for replanning than a basic RRT planner,
performing competitively with or better than existing heuristic and reactive real—time
 path planning approaches. ERRT is a
signifficant step forward with the potential for making path planning common on real
 robots, even in challenging continuous, highly dynamic domains.</description>
        <keywords>Path Planning, Robot Motion Planning</keywords>
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        <technicalLevel>Advanced Level</technicalLevel>
        <type>Conference paper</type>
        <date>2002</date>
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        <id_p>26</id_p>
        <title>Robot Learning from Demonstration: A Task—level Planning Approach </title>
        <author>Staffan Ekvall and Danica Kragic</author>
        <description>In this paper, we deal with the problem of
 learning by demonstration, task level learning and planning
for robotic applications that involve object manipulation. Preprogramming robots for
execution of complex domestic
tasks such as setting a dinner table is of little use, since the same order of subtasks
may not be conceivable in the
run time due to the changed state of the world. In our approach, we aim to learn the goal of the task and use a task
planner to reach the goal given different initial states of the world. For some tasks,
there are underlying constraints
that must be fulfille, and knowing just the  final goal is not sufficient. We propose
two techniques for constraint
identification. In the first case, the teacher can directly instruct the system about the underlying constraints. In the
second case, the constraints are identified by the robot itself based on multiple observations. The constraints are
then considered in the planning phase, allowing the task to be executed without violating any of them. We evaluate
our work on a real robot performing pick—and—place tasks. </description>
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483         <keywords>Programming by demosntration, task learning, task planning, object manipulation </keywords>
            <url>http://www.nada.kth.se/~danik/Papers/2007_PLANNING_ek_IAR.pdf</url>
485         <technicalLevel>Advanced level</technicalLevel>
            <type>Research paper</type>
487         <date>2008</date>
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489       <paper idp="27">
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491         <title>Biologically Inspired Robots </title>
            <author>Fred Delcomyn</author>
493         <description>The idea of building machines that emulate features of animals that we see around us has a
    long history. Leonardo da Vinci's drawings of machines that fly like birds are one familiar
495 example. It was not until the middle of the 19th
     century, however, that scientific knowledge
497 had advanced enough for realistic and realizable plans for such machines to be made
    (Raibert, 1986) and truly successful attempts to make walking or crawling robots
499 proliferated only in the last few decades of the 20th
     century (e.g., Raibert, 1990).
501 In the sense that any machine that swims, flies, or walks can be said to be inspired by fish,
    birds, or legged animals, every mobile robot that employs one of these means of locomotion
503 can be said to be biologically inspired. However, the term biologically inspired and the
    current concept of biologically inspired robotics originated in the last few decades of the 20th
505 century. The first use of the phrase in the title of a journal article appears to have been by
    Beer et al. (1997). In this article, Beer and his colleagues make a distinction between merely
507 emulating some general feature of an animal like legs or wings and a more considered
    approach in which specific structural or functional elements of particular animals is
509 emulated in hardware or software.</description>
            <keywords>Bioinspiration, Robotic Performance, Crawling Robots, Walking Robots</keywords>
511         <url>article/Biologically_Inspired_Robots.pdf</url>
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521         <id_p>28</id_p>
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523         <author>Stuart J. Russell; Peter Norvig</author>
            <description>18 chapter. In which we describe agents that can improve their behavior through diligent study of their own
                    experience. 18.7 — Artificial Neural Networks</description>
525         <keywords>Artificial Neural Networks, Learning, Back—Propagation learning</keywords>
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527         <technicalLevel>Basic level</technicalLevel>
            <type>Textbook</type>
529         <date>2010</date>
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531       <paper idp="29">
            <id_p>29</id_p>
533         <title>Basic Neural Network Tutorial — Theory</title>
            <author>Bobby Anguelov</author>
535         <description>Well this tutorial has been a long time coming.
    Neural Networks (NNs) are something that i'm interested in and also a technique that gets mentioned
537 a lot in movies and by pseudo—geeks when referring to AI in general. They are made out to be these really
     intense and complicated systems when in fact
539 they are nothing more than a simple input output machine (well at least for the standard Feed
    Forward Neural Networks (FFNN) ). As with any field the more you delve into it the more technical
541 it gets and NNs are the same, the more research you do into them the more complicated architectures,
    training techniques, activation functions become. For now this is just a simple primer into NNs.</description>
543         <keywords>Neural Network</keywords>
            <url>http://takinginitiative.wordpress.com/2008/04/03/basic—neural—network—tutorial—theory/</url>
545         <technicalLevel>Basic Level</technicalLevel>
            <type>Tutorial</type>
547         <date>April 3, 2008</date>
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549       <paper idp="30">
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551         <title>Backpropagation</title>
            <author>Wikipedia, the free encyclopedia</author>
553         <description>The article presents a basic infromation about Backpropagation Learning.</description>
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555         <url>http://en.wikipedia.org/wiki/Back—propagation</url>
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563         <author>Wikipedia, the free encyclopedia</author>
            <description>The article presents a basic infromation about Feedforward neural network.</description>
565         <keywords>Feedforward neural network, Learning</keywords>
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567         <technicalLevel>Basic level</technicalLevel>
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573         <title>Neural Networks</title>
            <author>Graham Kendall</author>
575         <description>In this section we are going to consider neural networks.
     More correctly, we should call them Artificial Neural Networks (ANN) as we not building neural networks
577  from animal tissue. Rather, we are simulating, on a computer, what we understand about neural networks in
     the brain. But, during this course we will use the term neural network and artificial neural network interchangeably.</
            description>
579         <keywords>Neural Networks</keywords>
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581         <technicalLevel>Basic level</technicalLevel>
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583         <date>September 21, 2001</date>
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587         <title>Basic Neural Network Tutorial : C++ Implementation and Source Code</title>
            <author>Bobby Anguelov</author>
589         <description>I'm not going to cover every aspect in great detail
since you can just look at my source code. I'm just going to go over the very basic architecture.</description>
591         <keywords>C++ Implementation, Neural Network</keywords>
            <url>http://takinginitiative.net/2008/04/23/basic-neural-network-tutorial-c-implementation-and-source-code/</url>
593         <technicalLevel>Intermediate level</technicalLevel>
            <type>Tutorial</type>
595         <date>April 23, 2008</date>
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597       <paper idp="34">
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599         <title>Neuro-Evolving Robotic Operatives</title>
            <author>Neural Networks Group</author>
601         <description>NERO (which stands for Neuro-Evolving Robotic Operatives)
is a new kind of machine learning game being developed at the Neural Networks Research Group,
603 Department of Computer Sciences, University of Texas at Austin. The goals of the project are (1)
to demonstrate the power of state-of-the-art machine learning technology,
605 (2) to create an engaging game based on it, and (3) to provide a robust and challenging development
and benchmarking domain for AI researchers.</description>
607         <keywords> Neuro-Evolving Robotic Operatives,</keywords>
            <url>http://nerogame.org/</url>
609         <technicalLevel>Intermediate level</technicalLevel>
            <type>Demonstration Video</type>
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615         <title>Pattern Classification (2nd Edition) </title>
            <author>Richard O. Duda, Peter E. Hart, David G. Stork</author>
617         <description>The first edition, published in 1973, has become a
classic reference in the field. Now with the second edition, readers will find information on key
619 new topics such as neural networks and statistical pattern recognition, the theory of machine learning,
and the theory of invariances. Also included are worked examples, comparisons between different methods,
621 extensive graphics, expanded exercises and computer project topics.
An Instructor's Manual presenting detailed solutions to all the problems in the book is
623 available from the Wiley editorial department.</description>
            <keywords>Pattern Classification, Pattern Recognition </keywords>
625         <url>http://ask.bibsys.no/ask/action/show?pid=001231219\&amp;kid=biblio </url>
            <technicalLevel>Advanced level</technicalLevel>
627         <type>Textbook</type>
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633     <name>Games — Algorithms for Playing and Solving Games</name>
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635       <id_p>36</id_p>
          <title>Artificial Inlelligence. A Modern Approach.</title>
637       <author>Stuart J. Russell; Peter Norvig</author>
          <description>5 chapter. In which we examine the problems that
639 arise when we try to plan ahead in a world where other agents are planning against us.
5.1 — Games; 5.2 — Optimal Decision in Games; 5.3 — Alpha-beta Pruning;
641 5.4 — Imperfect real-time decision; 5.7 — State-of-the-art Game Programs</description>
          <keywords>Games; Optimal Decision in Games; Alpha-beta Pruning;
643 Imperfect real-time decisions</keywords>
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647       <date>2010</date>
        </paper>
649     <paper idp="37">
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651       <title>Adaptive Game AI with Dynamic Scripting</title>
          <author>Pieter Spronck, Marc Ponsen, Ida Sprinkhuizen-Kuyper, and Eric Postma.</author>
653       <description>Online learning in commercial computer games
allows computer-controlled opponents to adapt to the way the game is being played. As such it provides
655 a mechanism to deal with weaknesses in the game AI, and to respond to changes in
human player tactics. We argue that online learning of game AI should meet four
657 computational and four functional requirements. The computational requirements
are speed, effectiveness, robustness and efficiency. The functional requirements are
659 clarity, variety, consistency and scalability. This paper investigates a novel online
learning technique for game AI called 'dynamic scripting', that uses an adaptive rulebase for
661 the generation of game AI on the fly. The performance of dynamic scripting
is evaluated in experiments in which adaptive agents are pitted against a collective of
663 manually-designed tactics in a simulated computer roleplaying game. Experimental
results indicate that dynamic scripting succeeds in endowing computer-controlled
665 opponents with adaptive performance. To further improve the dynamic-scripting
technique, an enhancement is investigated that allows scaling of the difficulty level
667 of the game AI to the human player's skill level. With the enhancement, dynamic
scripting meets all computational and functional requirements. The applicability
669 of dynamic scripting in state-of-the-art commercial games is demonstrated by implementing the
technique in the game Neverwinter Nights. We conclude that
671 dynamic scripting can be successfully applied to the online adaptation of game AI. </description>
          <keywords>Computer Game, Reinforcement Learning, Dynamic Scripting</keywords>
673       <url>DynamicScripting.pdf</url>
          <technicalLevel>Advanced level</technicalLevel>
675       <type>Research paper</type>
          <date>June 2006</date>
677     </paper>
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        <paper idp="38">
683       <id_p>38</id_p>
          <title>Artificial Inlelligence. A Modern Approach. </title>
685       <author>Stuart J. Russell; Peter Norvig</author>
          <description>18.1 — 18.3. In which we describe agents that
687 can improve their behavior through diligent study of their own experience. </description>
          <keywords>Learning, Decision Trees</keywords>
689       <url>http://ask.bibsys.no/ask/action/show?pid=101436254\&amp;kid=biblio </url>
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691       <type>Textbook</type>
          <date>2010</date>
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693         </paper>
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695           <id_p>39</id_p>
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697           <author>Richard O. Duda, Peter E. Hart, David G. Stork</author>
              <description>Chapter 1.5 — Learning refers to some form of
699 algorithm for reducing the error on a set of training data. Learning comes in several general forms.</description>
              <keywords>Learning, Supervised, Unsupervised, Reinforcement</keywords>
701           <url>http://ask.bibsys.no/ask/action/show?pid=001231219\&amp;kid=biblio </url>
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703           <type>Textbook</type>
              <date>2001</date>
705         </paper>
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707           <id_p>40</id_p>
              <title>Possibilities for Learning in Game Artificial Intelligence </title>
709           <author>Arild Jacobsen1, Sindre Berg Stene, Sule Yildirim1</author>
              <description>In our earlier research, we looked into the need
711 for and use of AI in video games. Our
    survey on the existing literature on game artificial intelligence and our hands–on
713 experience with some of the games which were developed through 1990s up to today have shown that
    the Artificial Intelligence in commercially available video games has made significant
715  progress over the decades, but one area which commercial games have largely ignored is
    the use of learning AI. Meanwhile, game artificial intelligence research continues to
717  look into and create examples of using such artificial intelligence techniques, e.g. reinforcement
    learning, evolutionary algorithms, in academic games. At the moment these techniques are
719  largely employed only by game artificial intelligence research; however, considering that
    game environments in commercial games are becoming more dynamic and unpredictable, one would
721 think that these techniques will be more capable of handling such environments
    and as such would be more widely used by commercial developers. Even so, it is still rare that
723  commercial game developers employ these techniques in their games. In this paper, we
    will investigate the reasons behind that by looking at the possible benefits and problems,
725  as well as the current state of learning in game artificial intelligence.  </description>
              <keywords>Learning, Game, Artificial Intelligence</keywords>
727           <url>article/Possibilities_for_Learning_in_Game_Artificial_Intelligence.pdf</url>
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735           <author>From Wikipedia, the free encyclopedia</author>
              <description>The article presents a basic infromation about Supervised learning.</description>
737           <keywords>Supervised learning</keywords>
              <url>http://en.wikipedia.org/wiki/Supervised_learning</url>
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747           <description>The first edition, published in 1973, has become
    a classic reference in the field. Now with the second edition, readers will find information
749 on key new topics such as neural networks and statistical pattern recognition, the theory of machine
    learning, and the theory of invariances. Also included are worked examples, comparisons between
751 different methods, extensive graphics, expanded exercises and computer project topics.
    An Instructor's Manual presenting detailed solutions to all the problems in the book is available
753 from the Wiley editorial department.</description>
              <keywords>Pattern Classification, Pattern Recognition  </keywords>
755           <url>http://ask.bibsys.no/ask/action/show?pid=001231219\&amp;kid=biblio </url>
              <technicalLevel>Advanced level</technicalLevel>
757           <type>Textbook</type>
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759         </paper>
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761   <category>
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765       <id>14</id>
          <name>Local Search Algorithms and Optimization Problems</name>
767       <paper idp="43">
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769         <title>Artificial Inlelligence. A Modern Approach.</title>
            <author>Stuart J. Russell; Peter Norvig</author>
771         <description>4.1 chapter. In which we describe local search
    algorithms and optimization problems closer to the real world. </description>
773         <keywords>Hill Climbing, Stochastic Search, Simulated Annealing, Local Beam Search, Genetic Algorithms</keywords>
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775         <technicalLevel>Basic level</technicalLevel>
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783       <paper idp="44">
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785         <title>Artificial Inlelligence. A Modern Approach.</title>
            <author>Stuart J. Russell; Peter Norvig</author>
787         <description>6.1 — 6.2 chapter. In which we see how treating
    states as more than just little black boxes leads to the invention of a range of powerful new
789 search methods and a deeeper understanding of problem structure and complexity.</description>
            <keywords>Constraint Satisfaction Problems, Backtracking search for Constraint Satisfaction Problems</keywords>
791         <url>http://ask.bibsys.no/ask/action/show?pid=101436254\&amp;kid=biblio </url>
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that can form representations of a complex world, use a process of inference
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these new representations to deduce what to do.</description>
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          <author>Alwen Tiu</author>
          <description>This video lecture is an introduction to logic.
In the first part it cover propositional logic, equivalence, validity, satisfiability.</description>
          <keywords>Propositional Logic, Equivalence, Validity, Satisfiability</keywords>
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          <author>Stuart J. Russell; Peter Norvig</author>
          <description>7.5 — 7.7 chapter.  In which we design agents
that can form representations of a complex world, use a process of inference
           to derive new representations about the world, and use these
new representations to deduce what to do.</description>
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 In the first part it cover logic inference rules and theorem proving.</description>
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          <author>Stuart J. Russell; Peter Norvig</author>
          <description>8.1 — 8.3, 8.5 chapter. In which we notice
that the world is blessed with many objects, some of which are related to other
           objects, and in which we endeavor to reason about them. </description>
          <keywords>First Order Logic, Wumpus world in FOL, Syntax and semantics of FOL</keywords>
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          <author>Stuart J. Russell; Peter Norvig</author>
          <description> 9 chapter. In which we define effective procedures for answering questions posed in FOL. </description>
          <keywords>First Order Logic, Logic programming</keywords>
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913         <author>Stuart J. Russell; Peter Norvig</author>
            <description> 10 chapter. In which we see how an agent can take advantage of the structure of a prblem to
915          construct complex plans action.</description>
            <keywords>Planning, Forward planning, Heuristics, Partial—Order Planning  </keywords>
917         <url> http://ask.bibsys.no/ask/action/show?pid=101436254\&amp;kid=biblio </url>
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919         <type>Textbook</type>
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923         <id_p>53</id_p>
            <title>Motion planning of multiple agents in virtual environments</title>
925         <author>Yi Li</author>
            <description>Describes and demonstrates in simulation the use of coordination graphs to avoid collisions of multiple
                   agents in tasks requiring motion of multiple agents.</description>
927         <keywords>Motion Planning,Multiple Agents, Virtual Environments</keywords>
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931         <date> July 3, 2007</date>
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933       <paper idp="54">
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935         <title>Artificial Intelligence Planning</title>
            <author>Jussi Rintanen</author>
937         <description>The course presents the most important
      approaches to state space traversal used in planning, including techniques based on
939   propositional satisfiability testing, heuristic state—space search, and logic—based data
      structures like binary decision diagrams. The main applications of these techniques in
941   classical planning and in more complex forms of planning is discussed.</description>
            <keywords>Planning, Propositional Satisfiability Testing, Heuristic State—Space Search </keywords>
943         <url>http://videolectures.net/aaai07_li_mpma/</url>
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953         <id_p>55</id_p>
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955         <author>Stuart J. Russell; Peter Norvig</author>
            <description> 12 chapter. In which we show to use
957   first—order logic to represent the most important
             aspects of the real world, such as action, space,
959   time, thoughts, and shopping.</description>
            <keywords>  Ontological Engineering, Categories, Situation Calculus, Event Calculus, Semantic Networks</keywords>
961         <url>http://ask.bibsys.no/ask/action/show?pid=101436254\&amp;kid=biblio </url>
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963         <type>Textbook</type>
            <date>2010</date>
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967         <id_p>56</id_p>
            <title>Knowledge Representation and Reasoning</title>
969         <author>Maurice Pagnucco</author>
            <description>Research in knowledge representation and
971   reasoning has a long history in artificial intelligence and logic—based approaches
      have played a major part in the fields development. In this course we will survey
973   logic—based in KRR from non—monotonic logics though to description logics and the semantic web.</description>
            <keywords>Knowledge representation, Description logic, Ontology </keywords>
975         <url>http://videolectures.net/ssll09_pagnucco_krr/</url>
            <technicalLevel>Intermediate level</technicalLevel>
977         <type>Video lecture</type>
            <date>April 1, 2009</date>
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981         <id_p>57</id_p>
            <title>Design and Implementation of Semantic Enhance Social—Aware User Profile </title>
983         <author>Z. Iqbal, J. Noll, S. Alam, M. Chowdbury</author>
            <description>This paper proposes a semantic enhance
985   social—aware user profile to address the issues of capturing and modeling user
      information for personalized services and contents. We also identify design requirements
987   for user—centric profile to enhance its applicability in different domains and usage scenarios.
      In addition, the paper also provides the refinement algorithm to confine the user profile to most
989   recurrent preferences. We use a policy base approach to ensure user privacy and authorize sharing of
       profile information with third parties. We formally represent authorization policies by exploiting
991   Semantic Web Rule Language. The paper also provides evaluation of the proposed ontology by comparing
      it with the selected existing user profile ontologies.</description>
993         <keywords>User Profile, Semantic Web, Ontology</keywords>
            <url>http://ieeexplore.ieee.org/xpl/freeabs_all.jsp?arnumber=5610630</url>
995         <technicalLevel>Advanced level</technicalLevel>
            <type>Conference paper</type>
997         <date>2010</date>
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999       <paper idp="58">
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1001        <title>Towards user—centric privacy—aware user profile ontology for future services</title>
            <author>Z. Iqbal, J. Noll, S. Alam, M. Chowdbury</author>
1003        <description>Personalization is one of the key features of the future Internet.
       However, the success of personalized services mostly relies on user profiles. Therefore, a generic, shareable,
1005   and reusable user profile is crucial for service providers for the uptake of personalized services.
       This paper proposes a user—centric personalization approach. The core of this approach
1007  is a user—centric user profile where user is in the center and experience perceived control
      over his information. We use Ontology Web Language (OWL—DL) to formally represent user
1009  relevant information in ontology. We present profile and privacy enhancement mechanism
```

```
 to increase profile applicability and user privacy respectively. The paper also offers
1011 a policy based approach to ensure authorized access of user profiles among third parties.
 Furthermore, we formally represent authorization policies by exploiting Semantic Web Rule
1013 Language (SWRL) and evaluate policies by employing Semantic Query Enhanced Web Rule Language (SQWRL).</description>
        <keywords>User Profile, Semantic Web, Social Network, Personalization, Policy, Privacy</keywords>
1015    <url>http://www.computer.org/portal/web/csdl/doi/10.1109/CTRQ.2010.49</url>
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1017    <type>Conference paper</type>
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1027    <author>Stuart J. Russell; Peter Norvig</author>
        <description> 22 chapter.  In wich we see how to make use
1029 of the copious knowledge that is expressed in natural language.</description>
        <keywords>  Language Models, Information Extraction</keywords>
1031    <url>http://ask.bibsys.no/ask/action/show?pid=101436254\&amp;kid=biblio </url>
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1037    <id_p>60</id_p>
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1039    <author>Stuart J. Russell; Peter Norvig</author>
        <description> 23 chapter.  In which we see how humans
1041 communicate with one another in natural language, and how computar agents might join in the conversation.</description>
        <keywords>Phrase Structure Grammars, Parsing, Augmented Grammars, Machine Translation, Speech Recognition</keywords>
1043    <url>http://ask.bibsys.no/ask/action/show?pid=101436254\&amp;kid=biblio </url>
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1045    <type>Textbook</type>
        <date>2010</date>
1047  </paper>
      <paper idp="61">
1049    <id_p>61</id_p>
        <title>A Neurosemantic Theory of Concrete Noun Representation Based on the Underlying Brain Codes</title>
1051    <author></author>
        <description>This article describes the discovery of a set of biologically—driven semantic
1053    dimensions underlying the neural representation of concrete nouns, and then demonstrates how
        a resulting theory of noun representation can be used to identify simple thoughts through their
1055    fMRI patterns. We use factor analysis of fMRI brain imaging data to reveal the biological
        representation of individual concrete nouns like apple, in the absence of any pictorial
1057    stimuli. From this analysis emerge three main semantic factors underpinning the neural
        representation of nouns naming physical objects, which we label manipulation, shelter, and
1059    eating. Each factor is neurally represented in 3—4 different brain locations that correspond
        to a cortical network that co—activates in non—linguistic tasks, such as tool use pantomime
1061    for the manipulation factor. Several converging methods, such as the use of behavioral ratings
        of word meaning and text corpus characteristics, provide independent evidence of the centrality
1063    of these factors to the representations. The factors are then used with machine
        learning classifier techniques to show that the fMRI—measured brain representation of an
1065    individual concrete noun like apple can be identified with good accuracy from among 60
        candidate words, using only the fMRI activity in the 16 locations associated with these factors.
1067    To further demonstrate the generativity of the proposed account, a theory—based model
        is developed to predict the brain activation patterns for words to which the algorithm has
1069    not been previously exposed. The methods, findings, and theory constitute a new approach of
        using brain activity for understanding how object concepts are represented
1071    in the mind.</description>
        <keywords>Neurosemantic Theory, Noun Representation, Underlying Brain Codes</keywords>
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1085    <author>From Wikipedia, the free encyclopedia</author>
        <description>The article presents the basic information about Multi—agent system.</description>
1087    <keywords>Multi—Agent System, Properties, Applications in the real world</keywords>
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1095    <title>Prioritized Multihypothesis Tracking by a Robot with Limited Sensing</title>
        <author>Paul E. Rybski and Manuela M. Veloso</author>
1097    <description>To act intelligently in dynamic environments, mobile robots must estimate object positions using
              information obtained from a
variety of sources. We formally describe the problem of estimating the state
1099 of objects where a robot can only task its sensors to
view one object at a time. We contribute an object tracking method that generates
1101  and maintains multiple hypotheses consisting of
probabilistic state estimates that are generated by the individual information
1103  sources. These different hypotheses can be generated
by the robot's own prediction model and by communicating robot team members.
1105 The multiple hypotheses are often spatially
disjoint and cannot simultaneously be verified by the robot's limited sensors.
1107 Instead, the robot must decide towards which
hypothesis its sensors should be tasked by evaluating each hypothesis on its
1109 likelihood of containing the object. Our contributed
algorithm prioritizes the different hypotheses, according to rankings set by the
1111  expected uncertainty in the object's motion model,
as well as the uncertainties in the sources of information used to track their
1113 positions. We describe the algorithm in detail and
show extensive empirical results in simulation as well as experiments on actual
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```
 robots that demonstrate the effectiveness of our
approach.</description>
        <keywords>Target detection , Performance evaluation , Simulation , Algorithm , Information source , State estimation ,
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        <title>Motion planning of multiple agents in virtual environments</title>
        <author>Yi Li</author>
        <description>Describes and demonstrates in simulation
 the use of coordination graphs to avoid collisions of multiple agents in tasks requiring motion of multiple agents.</
        description>
        <keywords>Motion Planning,Multiple Agents, Virtual Environments</keywords>
        <url>http://videolectures.net/aaai07_li_mpma/</url>
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A.2 Repository of Personalized Learning Activities Approach

A.2.1 DTD Schema of XML File for Personalized Learning Activities Approach

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A.2.2 XML File for Personalized Learning Activities Approach

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        <author>Stuart J. Russell; Peter Norvig</author>
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              worthy of study, and in which we try to decide what exactly it is, this being a good thing to decide before
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      <author>Stuart J. Russell; Peter Norvig</author>
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            enviroments, and the resulting menagere of agent types.</description>
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      <author>John Lloyd</author>
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            actions to the environment in order to achieve its goals. The notion of an agent provides a unifying conceptual
            framework for current research in artificial intelligence.
In these three lectures, I will introduce the basic ideas of agents, describe some agent architectures, and comment briefly on
       relevant philosophical and historical issues.</description>
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      <author>Sule Yildirim</author>
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Environment types; Agent types</description>
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      <title>Vacuum Demo</title>
      <author>Stuart J. Russell; Peter Norvig</author>
      <description>A simple graphical application for experiments with vacuum cleaner agents. It demonstrates different agents
            described in chapter two of Artificial Intelligence a Modern Approach (AIMA3e). The red — pac man like — character
            represents an agent playing the role of an intelligent vacuum. The squares (A and B) represent the different tiles
            in the Agents environment. A clean tile is colored white while a dirty tile is colored gray. The goal for the Agent
             is to ensure all tiles are clean.</description>
      <keywords>Agent, Animation, Vacuum Cleaner Agent</keywords>
      <url>http://www.ai.sri.com/~oreilly/aima3ejava/aima—gui—VacuumApp.jnlp</url>
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      <author>Stuart J. Russell; Peter Norvig</author>
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        <author>Tom Ziemke</author>
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            these differences
have been reflected in discussions of embodiment, grounding and other concepts in AI and autonomous robotics. Furthermore, the
relations between homeostasis, emotion and embodied cognition are discussed as well as recent proposals to model their interplay
in robots, which reflects a commitment to a multi—tiered affectively/emotionally embodied view of mind that takes organismic
embodiment more serious than usually done in biologically inspired robotics.</description>
        <keywords>Autonomy; Autopoiesis; Cognitive robotics; Grounding; Homeostasis; Embodied cognition; Emotion; Organismic
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        <description>Cupid's arrows, laced with neurotransmitters, find their marks</description>
        <keywords>Mind, brain</keywords>
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        <author>Lera Boroditsky</author>
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Based on Non—Symbolic Algorithms and Concepts</title>
        <author>Sule Yildirim, Ronald L. Beachell, Henning Veflingstad</author>
        <description>Future space exploration can utilize artificial intelligence as an integral part of next generation space
            rover
technology to make the rovers more autonomous in performing mission objectives. The main advantage of the
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increased autonomy through a higher degree of intelligence is that it allows for greater utilization of rover resources by
143 reducing the frequency of time consuming communications between rover and earth. In this paper, we propose a space
exploration application of our research on a non-symbolic algorithm and concepts model. This model is based on one
145 of the most recent approaches of cognitive science and artificial intelligence research, a parallel distributed processing
approach. We use the Mars rovers, Sprit and Opportunity, as a starting point for proposing what rovers in the future
147 could do if the presented model of non-symbolic algorithms and concepts is embedded in a future space rover. The
chosen space exploration application for this paper, novel rock detection, is only one of many potential space
149 exploration applications which can be optimized (through reduction of the frequency of rover-earth communications,
collection and transmission of only data that is distinctive/novel) through the use of artificial intelligence technology
151 compared to existing approaches. </description>
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153 Connectionism</keywords>
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        <date>2007</date>
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        <title>The Mind Agents in Netlogo 3.1</title>
161     <author>Sule Yildirim, Gregory L. Dam, James C. Houk</author>
        <description>In [Houk, 2005], "the Agents of the mind" idea is proposed as a suitable framework for studying the
              dynamics and complexities of mind. "Agents of the mind" is inspired by the society of mind idea of Marvin Minsky
              [Minsky, 1988]. According to the society of mind, the mind is a complex system. The mind agents are elusive to
              identify.The mind is proposed as a hierarchy of agents. The higher hierarchy agents compose of lower hierarchy
              agents. Higher level agents do not command lower level agents but they basically trigger or invoke lower level
              agents. Agents are functional entities and they interact with each other. One important part of the society of
              mind idea is that agents at the lowest level are the real workers. Higher level functionalities emerge as a
              result of the functioning of the lower level agents and the interactions between them.
163  In agents of the mind project, computational distributed processing modules (DPM) are posited for corresponding anatomically
      defined assemblies and they are referred to as the agents of the mind. M1 is an anatomical area in the cerebral cortex
      which produces voluntary commands via its loops through basal ganglia and cerebellum. M1-DPM is a computational
      distributed processing module which simulates M1 area and its loops for voluntary commands production. We use Netlogo
      3.1 agent-based programming environment to illuminate the properties of mind. In this work, the attractor network in
      cerebellar loop and the effects of Purkinje cell on production of motor commands have been studied. The results are
      reported in this paper.</description>
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        <title>Route Finding Agent</title>
177     <author>Stuart J. Russell; Peter Norvig</author>
        <description>An example of a route finding agent application. It provides a demonstration of the different agents/search
              algorithms described in chapters three and four of AIMA3e, for tackling route planning tasks within simplified map
              based environments.</description>
179     <keywords/>
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187     <author>Stuart J. Russell; Peter Norvig</author>
        <description>An example of the 8-puzzle, which consists of a 3x3 board with eight numbered tiles and a blank space. The
              goal is to reach the specified goal state as detailed in Figure 3.4 of AIMA3e (depicted left). Provides a
              demonstration of the different search algorithms described in chapters three and four of AIMA3e. You can choose to
              solve the problem yourself by selecting tiles next to the empty square to which you want to move the empty square.
189     </description>
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191     <url>http://www.ai.sri.com/~oreilly/aima3ejava/aima-gui-RouteFindingAgentApp.jnlp</url>
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        <author>Stuart J. Russell; Peter Norvig</author>
199     <description>The goal of the n-queens problem is to place n queens on a chessboard such that no queen attacks any other (A
              queen attacks any piece in the same row, column or diagonal). Provides a demonstration of the different search
              algorithms described in chapters three and four of AIMA3e. You can choose to solve the problem yourself by
              selecting board positions to where you wish to place Queens.
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201     <keywords/>
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203     <type>Applet</type>
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209     <author>Stuart J. Russell; Peter Norvig</author>
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              Thiord Edition</description>
211     <keywords>Depth First; Breadth First; Depth Limited Search; Iterative Deepening; A*; Hill Climbing; Simulated Annealing</
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        <url>http://code.google.com/p/aima-java/</url>
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219     <author>Jordan Thayer, Wheeler Ruml</author>
        <description>In this video we present four fundamental heuristic search algorithms including uniform cost search, greedy
              best first search, A*, and weighted A*. We provide a brief description and pseudo code for each algorithm, after
              which we visualize its execution on a two-dimensional path-finding problem.</description>
221     <keywords>Intelligent Agents, Search, Solving problem by searching, Uninformed Search Strategies, Infromed Search
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      <author>Adi Botea</author>
      <description>Search is a major direction in current AI research and a powerful solving technology in a wide range of real—
          life problems. This course focuses on single—agent search techniques. Pathfinding in games is used as an
          application domain.</description>
      <keywords>Intelligent Agents, Search, Solving problem by searching, Uninformed Search Strategies, Infromed Search
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      <author>RidgeSoft</author>
      <description>The IntelliBrain—Bot educational robot is designed to bring computer science, robotics and engineering
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      <author>RidgeSoft, LLC</author>
      <description>By providing a modern, easy to use, software development environment built for
robotics applications, the RoboJDE Java —enabled robotics software development environment opens the door to object oriented
      software
development for educational and hobby robotics projects.  RoboJDE enables you to quickly and easily develop software to control
       your robot.</description>
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335         <author>Sule Yildirim</author>
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349         <author>Bobby Anguelov</author>
            <description>In the zip file you'll find the complete visual studio 2k8 project for the following:
351 The neural network class (has CSV logging, and has supports for momentum and batch/stochastic learning);
    The CSV data reader class (loads CSV files, has several data partitioning approaches built in);
353 The test data files for the above problem;
    A test implementation of the above training problem.</description>
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363         <author>Bobby Anguelov</author>
            <description>I'm not going to cover every aspect in great detail since you can just look at my source code. I'm just going
                  to go over the very basic architecture.</description>
365         <keywords>C++ Implementation, Neural Network</keywords>
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371         <id>32</id>
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373         <author>Graham Kendall</author>
            <description>In this section we are going to consider neural networks. More correctly, we should call them Artificial
                  Neural Networks (ANN) as we not building neural networks from animal tissue. Rather, we are simulating, on a
                  computer, what we understand about neural networks in the brain. But, during this course we will use the term
                  neural network and artificial neural network interchangeably.</description>
375         <keywords>Neural Networks</keywords>
            <url>http://www.cs.nott.ac.uk/~gxk/courses/g5aiai/006neuralnetworks/neural—networks.htm</url>
377         <type>Text</type>
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            <title>Object—Oriented Neural Networks in C++</title>
383         <author>Joey Rogers</author>
            <description>This zip—file contains a foundation from which any neural network architecture can beconstructed. The author
                  has employed object—oriented design and object—oriented programming concepts to develop a set of foundation neural
                  network classes, and shows how these classes can be used to implement a variety of neural network architectures
                  with a great deal of ease and flexibility. A wealth of neural network formulas (with standardized notation), object
                  code implementations, and examples are provided to demonstrate the object—oriented approach to neural network
                  architectures and to facilitatethe development of new neural network architectures. </description>
385         <keywords>Neural—Network Base Classes; ADALINE Network; Backpropagation Neural Network; Self—Organizing Neural Network;
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            <title>Neuro—Evolving Robotic Operatives</title>
393         <author>Neural Networks Group</author>
            <description>NERO (which stands for Neuro—Evolving Robotic Operatives) is a new kind of machine learning game being
                  developed at the Neural Networks Research Group, Department of Computer Sciences, University of Texas at Austin.
                  The goals of the project are (1) to demonstrate the power of state—of—the—art machine learning technology, (2) to
                  create an engaging game based on it, and (3) to provide a robust and challenging development and benchmarking
                  domain for AI researchers.</description>
395         <keywords> Neuro—Evolving Robotic Operatives,</keywords>
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403         <author>Sule Yildirim</author>
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405         <keywords> Artificial Neural Networks, Backpropagation Learning; Signal Integration</keywords>
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413       <author>Stuart J. Russell; Peter Norvig</author>
          <description>18 chapter. In which we describe agents that can improve their behavior through diligent study of their own
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415       <keywords>Artificial Neural Networks, Learning, Back—Propagation learning</keywords>
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423       <author>NeuralWare</author>
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425       <keywords> Neural Network Solutions</keywords>
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433       <author>Peltarion Corporation</author>
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443       <author>NeuroDimension, Inc.</author>
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445       <keywords> Neural Network Software</keywords>
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457       <author>Stuart J. Russell; Peter Norvig</author>
          <description>5 chapter. In which we examine the problems that arise when we try to plan ahead in a world where other
                agents are planning against us. 5.1 — Games; 5.2 — Optimal Decision in Games; 5.3 — Alpha—beta Pruning; 5.4 —
                Imperfect real—time decision; 5.7 — State—of—the—art Game Programs</description>
459       <keywords>Games; Optimal Decision in Games; Alpha—beta Pruning; Imperfect real—time decisions</keywords>
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469       <keywords>Alpha—beta pruning</keywords>
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477       <author>Stuart J. Russell; Peter Norvig</author>
          <description>A demonstration of the Minimax and Alpha—Beta adversarial search algorithms as described in chapter 5 of
                AIMA3e, using the tic—tac—toe game as an example. You can choose to play the game yourself by selecting board
                positions or have the Agent propose moves.</description>
479       <keywords>Alpha—beta pruning, Minimax</keywords>
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507       <author>Sule Yildirim</author>
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      <author>Arild Jacobsen1, Sindre Berg Stene, Sule Yildirim1</author>
      <description>In our earlier research, we looked into the need for and use of AI in video games. Our
survey on the existing literature on game artificial intelligence and our hands—on experience with some of the games which were
      developed through 1990s up to today have shown that
the Artificial Intelligence in commercially available video games has made significant progress over the decades, but one area
      which commercial games have largely ignored is
the use of learning AI. Meanwhile, game artificial intelligence research continues to look into and create examples of using
      such artificial intelligence techniques, e.g. reinforcement
learning, evolutionary algorithms, in academic games. At the moment these techniques are largely employed only by game
      artificial intelligence research; however, considering that
game environments in commercial games are becoming more dynamic and unpredictable, one would think that these techniques will be
      more capable of handling such environments
and as such would be more widely used by commercial developers. Even so, it is still rare that commercial game developers employ
      these techniques in their games. In this paper, we
will investigate the reasons behind that by looking at the possible benefits and problems, as well as the current state of
      learning in game artificial intelligence. </description>
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        <title>Route Finding Agent</title>
        <author>Stuart J. Russell; Peter Norvig</author>
        <description>An example of a route finding agent application. It provides a demonstration of the different agents/search
            algorithms described in chapters three and four of AIMA3e, for tackling route planning tasks within simplified
            map based environments.</description>
        <keywords/>
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        <title>8-Puzzle Demo</title>
605     <author>Stuart J. Russell; Peter Norvig</author>
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              goal is to reach the specified goal state as detailed in Figure 3.4 of AIMA3e (depicted left). Provides a
              demonstration of the different search algorithms described in chapters three and four of AIMA3e. You can choose
              to solve the problem yourself by selecting tiles next to the empty square to which you want to move the empty
              square.
607     </description>
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609     <url>http://www.ai.sri.com/~oreilly/aima3ejava/aima-gui-RouteFindingAgentApp.jnlp</url>
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615     <title>N-Queens Problem Demo</title>
        <author>Stuart J. Russell; Peter Norvig</author>
617     <description>The goal of the n-queens problem is to place n queens on a chessboard such that no queen attacks any other
              (A queen attacks any piece in the same row, column or diagonal). Provides a demonstration of the different search
               algorithms described in chapters three and four of AIMA3e. You can choose to solve the problem yourself by
              selecting board positions to where you wish to place Queens.
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627     <author>Stuart J. Russell; Peter Norvig</author>
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629     <keywords>Depth First; Breadth First; Depth Limited Search; Iterative Deepening; A*; Hill Climbing; Simulated Annealing<
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641     <author>Stuart J. Russell; Peter Norvig</author>
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651     <author>Sule Yildirim</author>
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661     <author>Stuart J. Russell; Peter Norvig</author>
        <description>Application which demonstrates basic constraint algorithms based on map coloring problems, as described in
              chapter 6 of AIMA3e. It shows the constraint graph, lets the user select a solution strategy, and allows them to
              follow the progress step by step.</description>
663     <keywords/>
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671     <author>Stuart J. Russell; Peter Norvig</author>
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681     <author>Sule Yildirim</author>
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711         to derive new representations about the world, and use these new representations to deduce what to do.</description>
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839         <author>Stuart J. Russell; Peter Norvig</author>
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                related to other
841         objects, and in which we endeavor to reason about them. </description>
            <keywords>First Order Logic, Wumpus world in FOL, Syntax and semantics of FOL</keywords>
843         <url>http://ask.bibsys.no/ask/action/show?pid=101436254&amp;kid=biblio </url>
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845         <date>2010</date>
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847       <LO id="75">
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849         <title>Introduction to logic</title>
            <author>Alwen Tiu</author>
851         <description>This video lecture is an introduction to logic. In second part it cover first order.</description>
            <keywords>Logic Inference Rules, Theorem Proving</keywords>
853         <url>http://videolectures.net/ssll09_tiu_intlo/</url>
            <type>Video</type>
855         <date>April 1, 2009</date>
          </LO>
857       <LO id="76">
            <id>76</id>
859         <title>First-order logic</title>
            <author>Sule Yildirim</author>
861         <description>Outline: Why FOL? Syntax and semantics of FOL; Fun with sentences; Wumpus world in FOL</description>
            <keywords>First-Order Logic</keywords>
863         <url>https://fronter.com/hig/links/link.phtml?idesc=1&amp;iid=743843 </url>
            <type>Lecture notes</type>
865         <date>2011</date>
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867     </unit>
        <unit>
869       <id>18</id>
          <name> Inference in FOL </name>
871       <LO id="77">
            <id>77</id>
873         <title>Artificial Inlelligence. A Modern Approach. Second Edition.</title>
            <author>Stuart J. Russell; Peter Norvig</author>
875         <description> 9 chapter. In which we define effective procedures for answering questions posed in FOL. </description>
            <keywords>First Order Logic, Logic programming</keywords>
877         <url>http://ask.bibsys.no/ask/action/show?pid=101436254&amp;kid=biblio </url>
            <type>Text</type>
879         <date>2010</date>
          </LO>
881       <LO id="78">
            <id>78</id>
883         <title>Inference in first-order logic</title>
            <author>Sule Yildirim</author>
885         <description>Outline: Reducing first-order inference to propositional inference; Unification; Generalized Modus Ponens;
                Forward and backward chaining; Logic programming; Resolution</description>
            <keywords>Inference rules, First-Order Inference; First-Order Logic</keywords>
887         <url>https://fronter.com/hig/links/link.phtml?idesc=1&amp;iid=743843 </url>
            <type>Lecture notes</type>
889         <date>2011</date>
          </LO>
```

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      <LO id="79">
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        <title>Java implementation of algorithms</title>
        <author>Stuart J. Russell; Peter Norvig</author>
        <description>Implemented Algorithms are described in chapter 9 of Artificial Inlelligence. A Modern Approach. Thiord
            Edition</description>
        <keywords>Subst SubstVisitor; Unify; FOL-FC-Ask; FOL-BC-Ask; CNF; Resolution; Demodulation; Paramodulation; Subsumption<
            /keywords>
        <url>http://code.google.com/p/aima-java/</url>
        <type>Example</type>
        <date>2010</date>
      </LO>
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  <category>
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    <LO id="80">
      <id>80</id>
      <title>Artificial Inlelligence. A Modern Approach. Second Edition.</title>
      <author>Stuart J. Russell; Peter Norvig</author>
      <description> 10 chapter. In which we see how an agent can take advantage of the structure of a prblem to
       construct complex plans action.</description>
      <keywords>Planning, Forward planning, Heuristics, Partial-Order Planning </keywords>
      <url>http://ask.bibsys.no/ask/action/show?pid=101436254&amp;kid=biblio </url>
      <type>Text</type>
      <date>2010</date>
    </LO>
    <LO id="81">
      <id>81</id>
      <title>Motion planning of multiple agents in virtual environments</title>
      <author>Yi Li</author>
      <description>Describes and demonstrates in simulation the use of coordination graphs to avoid collisions of multiple
          agents in tasks requiring motion of multiple agents.</description>
      <keywords>Motion Planning,Multiple Agents, Virtual Environments</keywords>
      <url>http://videolectures.net/aaai07_li_mpma/</url>
      <type>Video</type>
      <date> July 3, 2007</date>
    </LO>
    <LO id="82">
      <id>82</id>
      <title>Artificial Intelligence Planning</title>
      <author>Jussi Rintanen</author>
      <description>The course presents the most important approaches to state space traversal used in planning, including
          techniques based on propositional satisfiability testing, heuristic state-space search, and logic-based data
          structures like binary decision diagrams. The main applications of these techniques in classical planning and in
          more complex forms of planning is discussed.</description>
      <keywords>Planning, Propositional Satisfiability Testing, Heuristic State-Space Search </keywords>
      <url>http://videolectures.net/aaai07_li_mpma/</url>
      <type>Video</type>
      <date> July 3, 2007</date>
    </LO>
    <LO id="83">
      <id>83</id>
      <title>Planning</title>
      <author>Sule Yildirim</author>
      <description>Outline: FOL; Planning Problem as Search; Forward planning; Heuristic; POP Algorithm </description>
      <keywords>Planning, Forward planning, Heuristic, POP Algorithm</keywords>
      <url>https://fronter.com/hig/links/link.phtml?idesc=1&amp;iid=752732 </url>
      <type>Lecrture notes</type>
      <date>2011</date>
    </LO>
  </category>
  <category>
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    <LO id="84">
      <id>84</id>
      <title>Artificial Inlelligence. A Modern Approach. Second Edition.</title>
      <author>Stuart J. Russell; Peter Norvig</author>
      <description> 12 chapter. In which we show to use first-order logic to represent the most important
       aspects of the real world, such as action, space, time, thoughts, and shopping.</description>
      <keywords>  Ontological Engineering, Categories, Situation Calculus, Event Calculus, Semantic Networks</keywords>
      <url>http://ask.bibsys.no/ask/action/show?pid=101436254&amp;kid=biblio </url>
      <type>Text</type>
      <date>2010</date>
    </LO>
    <LO id="85">
      <id>85</id>
      <title>Knowledge Representation and Reasoning</title>
      <author>Maurice Pagnucco</author>
      <description>Research in knowledge representation and reasoning has a long history in artificial intelligence and logic-
          based approaches have played a major part in the fields development. In this course we will survey logic-based in
          KRR from non-monotonic logics though to description logics and the semantic web.</description>
      <keywords>Knowledge representation, Description logic, Ontology </keywords>
      <url>http://videolectures.net/ssll09_pagnucco_krr/</url>
      <type>Video</type>
      <date>April 1, 2009</date>
    </LO>
  </category>
  <category>
    <id>21</id>
    <name>>NLP - Natural Language Processing</name>
    <LO id="86">
      <id>86</id>
      <title>Artificial Inlelligence. A Modern Approach. Second Edition.</title>
      <author>Stuart J. Russell; Peter Norvig</author>
      <description> 22 chapter.  In wich we see how to make use of the copious knowledge that is expressed in natural language.<
          /description>
      <keywords>  Language Models, Information Extraction</keywords>
      <url>http://ask.bibsys.no/ask/action/show?pid=101436254&amp;kid=biblio </url>
      <type>Text</type>
      <date>2010</date>
    </LO>
    <LO id="87">
      <id>87</id>
```

```
      <title>Artificial Inlelligence. A Modern Approach. Second Edition.</title>
      <author>Stuart J. Russell; Peter Norvig</author>
      <description> 23 chapter.  In which we see how humans communicate with one another in natural language, and how computar
          agents might join in the conversation.</description>
      <keywords>Phrase Structure Grammars, Parsing, Augmented Grammars, Machine Translation, Speech Recognition</keywords>
      <url>http://ask.bibsys.no/ask/action/show?pid=101436254&amp;kid=biblio </url>
      <type>Text</type>
      <date>2010</date>
    </LO>
    <LO id="88">
      <id>88</id>
      <title>Communication and Language</title>
      <author>Sule Yildirim</author>
      <description>Outline: Communication; Grammar; Syntactic analysis; Problems</description>
      <keywords>Natural Language Processing, Communication, Grammar</keywords>
      <url>https://fronter.com/hig/links/link.phtml?idesc=1&amp;iid=752732 </url>
      <type>Lecture notes</type>
      <date>2011</date>
    </LO>
  </category>
  <category>
    <id>22</id>
    <name>Multi — Agent Systems</name>
    <LO id="89">
      <id>89</id>
      <title>Prioritized Multihypothesis Tracking by a Robot with Limited Sensing</title>
      <author>Paul E. Rybski and Manuela M. Veloso</author>
      <description>To act intelligently in dynamic environments, mobile robots must estimate object positions using information
          obtained from a
variety of sources. We formally describe the problem of estimating the state of objects where a robot can only task its sensors
        to
view one object at a time. We contribute an object tracking method that generates and maintains multiple hypotheses consisting
        of
probabilistic state estimates that are generated by the individual information sources. These different hypotheses can be
        generated
by the robot's own prediction model and by communicating robot team members. The multiple hypotheses are often spatially
disjoint and cannot simultaneously be verified by the robot's limited sensors. Instead, the robot must decide towards which
hypothesis its sensors should be tasked by evaluating each hypothesis on its likelihood of containing the object. Our
        contributed
algorithm prioritizes the different hypotheses, according to rankings set by the expected uncertainty in the object's motion
        model,
as well as the uncertainties in the sources of information used to track their positions. We describe the algorithm in detail
        and
show extensive empirical results in simulation as well as experiments on actual robots that demonstrate the effectiveness of our
approach.</description>
      <keywords>Target detection , Performance evaluation , Simulation , Algorithm , Information source , State estimation ,
          Probabilistic approach , Object detection , Robotics , Moving robot , Target tracking</keywords>
      <url>http://www.ri.cmu.edu/pub_files/2009/1/09eurasip—signal—proc—prybski.pdf</url>
      <type>Text</type>
      <date>2009</date>
    </LO>
    <LO id="90">
      <id>90</id>
      <title>Motion planning of multiple agents in virtual environments</title>
      <author>Yi Li</author>
      <description>Describes and demonstrates in simulation the use of coordination graphs to avoid collisions of multiple
          agents in tasks requiring motion of multiple agents.</description>
      <keywords>Motion Planning,Multiple Agents, Virtual Environments</keywords>
      <url>http://videolectures.net/aaai07_li_mpma/</url>
      <type>Video</type>
      <date> July 3, 2007</date>
    </LO>
  </category>
</RepositoryForPersonalizedLearningStyles>
```

A.3 Repository of Personalized Communication Approach

A.3.1 DTD Schema of XML File for Personalized Communication Approach

```
<!DOCTYPE RepositoryForPersonalizedPerson [

<!ELEMENT category (id,name,person+)>
<!ELEMENT person (id, name, position, email, level)>
<!ELEMENT id (#PCDATA)>
<!ELEMENT name (#PCDATA)>
<!ELEMENT position (#PCDATA)>
<!ELEMENT email (#PCDATA)>
<!ELEMENT level (#PCDATA)>

<!ATTLIST paper idp CDATA #REQUIRED>

]>
```

A.3.2 XML File for Personalized Communication Approach

```
<RepositoryForPersonalizedPerson>
  <category>
    <id>01</id>
    <name>Introduction</name>
    <person id='01'>
      <id>01</id>
      <name>Sule Yildirim</name>
      <position>Associate Professor</position>
      <email>sule.yildirim@hig.no </email>
      <level>Advanced</level>
    </person>
    <person id='21'>
      <id>21</id>
      <name>Mohammad Derawi</name>
```

```
      <position>Scholar</position>
      <email>mohammad.derawi@hig.no </email>
      <level>Advanced</level>
    </person>
  </category>
  <category>
    <id>02</id>
    <name>Intelligent Agents</name>
    <person id='02'>
      <id>02</id>
      <name>Sule Yildirim</name>
      <position>Associate Professor</position>
      <email>sule.yildirim@hig.no </email>
      <level>Advanced</level>
    </person>
    <person id='22'>
      <id>22</id>
      <name>Mohammad Derawi</name>
      <position>Scholar</position>
      <email>mohammad.derawi@hig.no </email>
      <level>Advanced</level>
    </person>
  </category>
  <category>
    <id>03</id>
    <name>Representations</name>
    <person id='03'>
      <id>03</id>
      <name>Sule Yildirim</name>
      <position>Associate Professor</position>
      <email>sule.yildirim@hig.no </email>
      <level>Advanced</level>
    </person>
    <person id='18'>
      <id>18</id>
      <name>Mohammad Derawi</name>
      <position>Scholar</position>
      <email>mohammad.derawi@hig.no </email>
      <level>Advanced</level>
    </person>
    <unit>
      <id>04</id>
      <name>Emotional Representastions</name>
      <person id='20'>
        <id>20</id>
        <name>Vera Nekrasova</name>
        <position>Student</position>
        <email>vera.nekrasova@hig.no </email>
        <level>Basic</level>
      </person>
    </unit>
    <unit>
      <id>05</id>
      <name>Conceptual/Motor Representations</name>
    </unit>
  </category>
  <category>
    <id>06</id>
    <name>Search I</name>
    <person id='05'>
      <id>05</id>
      <name>Sule Yildirim</name>
      <position>Associate Professor</position>
      <email>sule.yildirim@hig.no </email>
      <level>Advanced</level>
    </person>
    <person id='23'>
      <id>23</id>
      <name>Mohammad Derawi</name>
      <position>Scholar</position>
      <email>mohammad.derawi@hig.no </email>
      <level>Advanced</level>
    </person>
  </category>
  <category>
    <id>07</id>
    <name>Intellibrain Robots</name>
    <person id='06'>
      <id>06</id>
      <name>Sule Yildirim</name>
      <position>Associate Professor</position>
      <email>sule.yildirim@hig.no </email>
      <level>Advanced</level>
    </person>
    <person id='15'>
      <id>15</id>
      <name>Katrin Franke</name>
      <position>Professor</position>
      <email>katrin.franke@hig.no </email>
      <level>Advanced</level>
    </person>
    <person id='18'>
      <id>18</id>
      <name>Mohammad Derawi</name>
      <position>Scholar</position>
      <email>mohammad.derawi@hig.no </email>
      <level>Advanced</level>
    </person>
  </category>
  <category>
    <id>08</id>
    <name>Learning I — Artificial Neural Networks and Backpropogation Learning</name>
    <person id='08'>
      <id>08</id>
      <name>Sule Yildirim</name>
      <position>Associate Professor</position>
```

```
121       <email>sule.yildirim@hig.no </email>
          <level>Advanced</level>
123     </person>
        <person id='16'>
125       <id>16</id>
          <name>Katrin Franke</name>
127       <position>Professor</position>
          <email>katrin.franke@hig.no </email>
129       <level>Advanced</level>
        </person>
131     <person id='14'>
          <id>14</id>
133       <name>Frode Haug</name>
          <position>Lecturer</position>
135       <email>frode.haug@hig.no </email>
          <level>Advanced</level>
137     </person>
        <person id='19'>
139       <id>19</id>
          <name>Mohammad Derawi</name>
141       <position>Scholar</position>
          <email>mohammad.derawi@hig.no </email>
143       <level>Advanced</level>
        </person>
145   </category>
      <category>
147     <id>09</id>
        <name>Games — Algorithms for Playing and Solving Games</name>
149     <person id='09'>
          <id>09</id>
151       <name>Sule Yildirim</name>
          <position>Associate Professor</position>
153       <email>sule.yildirim@hig.no </email>
          <level>Advanced</level>
155     </person>
        <person id='15'>
157       <id>15</id>
          <name>Frode Haug</name>
159       <position>Lecturer</position>
          <email>frode.haug@hig.no </email>
161       <level>Advanced</level>
        </person>
163     <person id='24'>
          <id>24</id>
165       <name>Mohammad Derawi</name>
          <position>Scholar</position>
167       <email>mohammad.derawi@hig.no </email>
          <level>Advanced</level>
169     </person>
      </category>
171   <category>
        <id>10</id>
173     <name>Learning II — Decision Trees</name>
        <person id='10'>
175       <id>10</id>
          <name>Sule Yildirim</name>
177       <position>Associate Professor</position>
          <email>sule.yildirim@hig.no </email>
179       <level>Advanced</level>
        </person>
181     <person id='17'>
          <id>17</id>
183       <name>Katrin Franke</name>
          <position>Professor</position>
185       <email>katrin.franke@hig.no </email>
          <level>Advanced</level>
187     </person>
        <person id='25'>
189       <id>25</id>
          <name>Mohammad Derawi</name>
191       <position>Scholar</position>
          <email>mohammad.derawi@hig.no </email>
193       <level>Advanced</level>
        </person>
195   </category>
      <category>
197     <id>11</id>
        <name>Search II — Local Search Algorithms and Optimization Problems</name>
199     <person id='11'>
          <id>11</id>
201       <name>Sule Yildirim</name>
          <position>Associate Professor</position>
203       <email>sule.yildirim@hig.no </email>
          <level>Advanced</level>
205     </person>
        <person id='26'>
207       <id>26</id>
          <name>Mohammad Derawi</name>
209       <position>Scholar</position>
          <email>mohammad.derawi@hig.no </email>
211       <level>Advanced</level>
        </person>
213   </category>
      <category>
215     <id>12</id>
        <name>Logic</name>
217     <person id='12'>
          <id>12</id>
219       <name>Sule Yildirim</name>
          <position>Associate Professor</position>
221       <email>sule.yildirim@hig.no </email>
          <level>Advanced</level>
223     </person>
        <person id='27'>
225       <id>18</id>
          <name>Mohammad Derawi</name>
```

```
227         <position>Scholar</position>
            <email>mohammad.derawi@hig.no </email>
229         <level>Advanced</level>
          </person>
231       <unit>
            <id>13</id>
233         <name>Knowledge — Based Agents and Logic in General</name>
            <person id='13'>
235           <id>13</id>
              <name>Vera Nekrasova</name>
237           <position>Student</position>
              <email>vera.nekrasova@hig.no </email>
239           <level>Basic</level>
            </person>
241       </unit>
          <unit>
243         <id>14</id>
            <name>Logic Inference Rulesand Theorem Proving</name>
245       </unit>
        </category>
247   </RepositoryForPersonalizedPerson>
```

B Appendix - Source Code Snippets

B.1 PHP Function for Creation of Search Index File

```
<?
function XML2MYSQL($filename)
{
$xml = simplexml_load_file($filename);

echo $xml->getName() . "<br />";

foreach($xml->children() as $category)
{
  echo $category->getName() . "<br />";
  foreach($category->children() as $child)
  {
    if ($child->getName() == 'id')
    {
      //echo  $child->getName().  ":" . $child . "<br />";
      $id_category = $child;
      echo $id_category;
    }
    if ($child->getName() == 'paper')
    {
      foreach($child->children() as $paper)
      {
        if ($paper->getName() == 'id_p')
        {
          //echo  $paper->getName(). ":" . $paper . "<br />";
          $id_paper = $paper;
        }
        if ($paper->getName() == 'technicalLevel')
        {
          //echo  $paper->getName(). ":" . $paper . "<br />";
          $technicalLevel = $paper;
        }
      }
      $sql = "INSERT INTO IndexFile (id_category, id_paper, technicalLevel) VALUES ('".$id_category."', '".$id_paper."', '".
          $technicalLevel."') ";
      $result = mysql_query($sql);
      echo $id_category ." ". $id_paper . " ". $technicalLevel. "</br>";
    }


    if ($child->getName() == 'unit')
    {
      foreach($child->children() as $unit)
      {
        if ($unit->getName() == 'paper')
        {
          foreach($unit->children() as $paper)
          {
            if ($paper->getName() == 'id_p')
            {
              //echo  $paper->getName(). ":" . $paper . "<br />";
              $id_paper = $paper;
            }
            if ($paper->getName() == 'technicalLevel')
            {
              //echo  $paper->getName(). ":" . $paper . "<br />";
              $technicalLevel = $paper;
            }

          }
          $sql = "INSERT INTO IndexFile (id_category, id_paper, technicalLevel) VALUES ('".$id_category."', '".$id_paper."', '".
              $technicalLevel."') ";
          $result = mysql_query($sql);
          echo $id_category ." ". $id_paper . " ". $technicalLevel. "</br>";
        }
      }


    }
    if ($child->getName() == 'unit')
    {
      foreach($child->children() as $unit)
      {
        if ($unit->getName() == 'id')
        {
          //echo  $unit->getName().  ":" . $unit . "<br />";
          $id_unit = $unit;
        }
        if ($unit->getName() == 'paper')
        {
          foreach($unit->children() as $paper)
          {
            if ($paper->getName() == 'id_p')
            {
              //echo  $paper->getName(). ":" . $paper . "<br />";
              $id_paper = $paper;
            }
            if ($paper->getName() == 'technicalLevel')
            {
              //echo  $paper->getName(). ":" . $paper . "<br />";
```

```
89                $technicalLevel = $paper;
                }
91            }
              $sql = "INSERT INTO IndexFile (id_category, id_paper, technicalLevel) VALUES ('".$id_unit."', '".$id_paper."', '".
                    $technicalLevel."') ";
93            $result = mysql_query($sql);
              echo $id_unit ." ". $id_paper . " ". $technicalLevel. "</br>";
95          }
            //echo $id_unit." ".$id_paper." ".$technicalLevel;
97        }

99

      }
101

    }
103
}
105 }
>
```

B.2 PHP Code of Recommender Components

B.2.1 PHP Code of Recommender Component for Personalized Guidance Approach

```
<?php
2   ini_set('display_errors',1);
    error_reporting(E_ALL);
4
      if (isset($_SERVER['HTTP_REFERER']))
6     {
         echo '<a style="margin-right:20px;"
8        href="'.$_SERVER['HTTP_REFERER'].'">
         <<< Back</a> <br/><br/>';
10    }

12  $xml = simplexml_load_file("PersonalizedGuidance.xml");

14

    function db_connect($user='root', $password='nkon86', $db='RepositoryForPersonalizedGuidance'){
16      mysql_connect('localhost', $user, $password)
        or die('I cannot connect to db: ' . mysql_error());
18      mysql_select_db($db);}

20  db_connect();

22

    if (!empty($_POST["TechnicalLevel"]))
24  {
      $id_category = $_POST["category"];
26    $topic = $_POST["topic"];
      $techical_level = $_POST["TechnicalLevel"];
28    echo '<table bgcolor=#6495ed ><tr><td> <h4> About <i>"', $topic, '"</i> topic you can read the follow literature: </h4></td
          ></tr></table> <br/>';
      echo '<hr/>';
30    $sql = "SELECT id_paper FROM IndexFile WHERE id_category = '".$id_category."' && technicalLevel = '".$techical_level."'";
      $result = mysql_query($sql);
32    /*if (mysql_fetch_array($result) == '0')
      {
34      echo 'Results of queries not found';
      }*/
36
      echo '<ol>';
38    $f = 0;
      while($row = mysql_fetch_array($result))
40    {
        $f=$f+1;
42      $id_paper = $row['id_paper'];

44      foreach($xml->children() as $category)
        {
46        foreach ($category->children() as $paper)
          {
48          if ($paper->getName() == 'paper' and $paper->attributes() == $id_paper)
            {
50            foreach ($paper -> children() as $elm )
              {
52              if ($elm->getName() == 'title' )
                {
54                $title = $elm;
                }
56              if ($elm->getName() == 'description' )
                {
58                $description = $elm;
                }
60              if ($elm->getName() == 'author' )
                {
62                $author = $elm;
                }
64              if ($elm->getName() == 'keywords' )
                {
66                $keywords = $elm;
                }
68              if ($elm->getName() == 'url' )
                {
70                $url = $elm;
                }
72              if ($elm->getName() == 'type' )
                {
74                $type = $elm;
                }
```

```
76                if ($elm->getName() == 'date' )
                  {
78                  $date = $elm;
                  }
80              }
                echo '<li> <a href="', $url, '" target="_blank">', $title , '</a> <br/>', $author, '<br/> <b>Description: </b>',
                      $description , '<br/> <b>Type: </b>', $type;
82              echo '<br/> <hr/> <br/>';
              }
84
              if ($paper->getName() == 'unit')
86            {
                foreach ($paper -> children() as $unitpaper)
88              {
                  if ($unitpaper->getName() == 'paper' and $unitpaper->attributes() == $id_paper)
90                {
                    foreach ($unitpaper -> children() as $elm )
92                  {
                      if ($elm->getName() == 'title' )
94                    {
                        $title = $elm;
96                    }
                      if ($elm->getName() == 'description' )
98                    {
                        $description = $elm;
100                   }
                      if ($elm->getName() == 'author' )
102                   {
                        $author = $elm;
104                   }
                      if ($elm->getName() == 'keywords' )
106                   {
                        $keywords = $elm;
108                   }
                      if ($elm->getName() == 'url' )
110                   {
                        $url = $elm;
112                   }
                      if ($elm->getName() == 'type' )
114                   {
                        $type = $elm;
116                   }
                      if ($elm->getName() == 'date' )
118                   {
                        $date = $elm;
120                   }
                    }
122                 echo '<li> <a href="', $url, '" target="_blank" >', $title , '</a> <br/> by ', $author, '<br/> <b>Description: </
                          b>', $description , '<br/> <b>Type: </b>', $type;
                    echo '<br/> <hr/> <br/>';
124               }
                }
126           }
            }
128       }
          }
130

132     echo '</ol>';

134     if ($f ==0)
        {
136       echo 'Results of queries not found';
        }
138
    }
140 else
    {
142   echo "<h3>Please select technical level<h3>";
    }
144
?>
```

B.2.2 PHP Code of Recommender Component for Personalized Learning Activities Approach

```
1  <?php
     ini_set('display_errors',1);
3    error_reporting(E_ALL);

5      if (isset($_SERVER['HTTP_REFERER']))
       {
7        echo '<a style="margin-right:20px;"
         href="'.$_SERVER['HTTP_REFERER'].'">
9        <<< Back</a> <br/><br/>';
       }
11
   $xml = simplexml_load_file("PersonalizedLearningStyles.xml");
13

15 function db_connect($user='root', $password='nkon86', $db='RepositoryForPersonalizedGuidance'){
       mysql_connect('localhost', $user, $password)
17     or die('I cannot connect to db: ' . mysql_error());
       mysql_select_db($db);}
19
   db_connect();
21
   $id_category = $_POST["category"];
23 $var = 0;

25
```

```
27  if (!empty($_POST['Type']))
    {
29    echo "<table bgcolor=#6495ed ><tr><td> <h4>The folow learning materials have been found on your query: </h4></td></tr></
          table> <br/>";
      $type=$_POST['Type'];
31
      foreach ($type as $val)
33    {

35      if ($val=='V')
        {
37        $style= array('Video', 'Lecture notes', 'Applet');
          $learning = 'Visual Learning Style';
39        $f=0;
        }
41      if ($val=='R')
        {
43        $style= array('Text', 'Lecture notes');
          $learning = 'Read/Write Learning Style';
45        $f=0;
        }
47      if ($val=='K')
        {
49        $style= array('Example', 'Assignment', 'Applet', 'Lecture notes');
          $learning = 'Kinesthetic Learning Style';
51        $f=0;
        }
53
        echo "<hr/>";
55      echo "<table bgcolor=#bef574 ><tr><td>$learning: </td></tr></table>";
        foreach ($style as $style_name)
57      {
          $sql = "SELECT id_lo FROM IndexFileLS WHERE id_category = '".$id_category."' && style = '".$style_name."'";
59        $result = mysql_query($sql);


61
          while($row = mysql_fetch_array($result))
63        {
            echo '<ul>';
65          $f=$f+1;
            $id_lo = $row['id_lo'];
67
              foreach($xml->children() as $category)
69            {
                foreach ($category->children() as $lo)
71              {
                  if ($lo->getName() == 'LO' and $lo->attributes() == $id_lo)
73                {
                    foreach ($lo -> children() as $elm )
75                  {
                      if ($elm->getName() == 'title' )
77                    {
                        $title = $elm;
79                    }
                      if ($elm->getName() == 'description' )
81                    {
                        $description = $elm;
83                    }
                      if ($elm->getName() == 'author' )
85                    {
                        $author = $elm;
87                    }
                      if ($elm->getName() == 'keywords' )
89                    {
                        $keywords = $elm;
91                    }
                      if ($elm->getName() == 'url' )
93                    {
                        $url = $elm;
95                    }
                      if ($elm->getName() == 'type' )
97                    {
                        $type = $elm;
99                    }
                      if ($elm->getName() == 'date' )
101                   {
                        $date = $elm;
103                   }
                    }
105                 echo '<li> <a href="', $url, '" target="_blank">', $title , '</a> <br/>', $author, '<br/> <b>Description: </b>'
                        , $description, '<br/> Type: ', $type, '<br/>';

107               }

109               if ($lo->getName() == 'unit')
                  {
111                 foreach ($lo -> children() as $unitlo)
                    {
113                   if ($unitlo->getName() == 'LO' and $unitlo->attributes() == $id_lo)
                      {
115                     foreach ($unitlo -> children() as $elm )
                        {
117                       if ($elm->getName() == 'title' )
                          {
119                         $title = $elm;
                          }
121                       if ($elm->getName() == 'description' )
                          {
123                         $description = $elm;
                          }
125                       if ($elm->getName() == 'author' )
                          {
127                         $author = $elm;
                          }
129                       if ($elm->getName() == 'keywords' )
                          {
```

```
                        $keywords = $elm;
                      }
                      if ($elm->getName() == 'url' )
                      {
                        $url = $elm;
                      }
                      if ($elm->getName() == 'type' )
                      {
                        $type = $elm;
                      }
                      if ($elm->getName() == 'date' )
                      {
                        $date = $elm;
                      }
                    }
                    echo '<li> <a href="', $url, '" target="_blank" >', $title, '</a> <br/>', $author, '<br/> <b>Description:
                          </b>', $description, '<br/> Type: ', $type, '<br/>';
                  }
                }
              }
            }

          }
          echo '</ul>';
        }

        }

      if ($f == 0)
      {
        echo '<h3> Unfortunatly Learning materials  for ', $learning, ' is not found. </h3>';
      }


    }
  }
  else
  {
    echo '<h3>You did not select any learning styles.</h3>';
  }


?>
```

B.2.3 PHP Code of Recommender Component for Personalized Communication Approach

```
<?php
  ini_set('display_errors',1);
  error_reporting(E_ALL);

  if (isset($_SERVER['HTTP_REFERER']))
    {
      echo '<a style="margin-right:20px;"
      href="'.$_SERVER['HTTP_REFERER'].'">
      <<< Back</a> <br/><br/>';
    }

  $xml = simplexml_load_file("PersonalizedPerson.xml");


  function db_connect($user='root', $password='nkon86', $db='RepositoryForPersonalizedGuidance'){
      mysql_connect('localhost', $user, $password)
      or die('I cannot connect to db: ' . mysql_error());
      mysql_select_db($db);}

  db_connect();

  if (!empty($_POST["TechnicalLevel"]))
  {
    $id_category = $_POST["category"];
    $topic = $_POST["topic"];
    $Tlevel = $_POST["TechnicalLevel"];
    if ($Tlevel == 'Basic level')
    {
      $technical_level = array('Basic', 'Intermediate', 'Advanced');

    }
    if ($Tlevel == 'Intermediate level')
    {
      $technical_level = array('Intermediate','Advanced');

    }
    if ($Tlevel == 'Advanced level')
    {
      $technical_level = array('Advanced');

    }


    echo '<table bgcolor=#6495ed ><tr><td> <h4> With <i>"', $topic, '"</i> topic you can get help from the follow persones: </h4
          ></td></tr></table> <br/>';

    foreach ($technical_level as $val)
    {
      $sql = "SELECT id_person FROM IndexFilePerson WHERE id_catalog = '".$id_category."' && level = '".$val."'";
      $result = mysql_query($sql);
      $f = 0;
      echo '<hr/>';
      echo '<table bgcolor=#bef574 ><tr><td> Person with ', $val, ' technical level: </td></tr></table>';

```

```
      echo '<ol>';

      while($row = mysql_fetch_array($result))
      {
        $f=$f+1;
        $id_person = $row['id_person'];

        foreach($xml->children() as $category)
        {
          foreach ($category->children() as $person)
          {
            if ($person->getName() == 'person' and $person->attributes() == $id_person)
            {
              foreach ($person -> children() as $elm )
              {
                if ($elm->getName() == 'name' )
                {
                  $name = $elm;
                }
                if ($elm->getName() == 'position' )
                {
                  $position = $elm;
                }
                if ($elm->getName() == 'email' )
                {
                  $email = $elm;
                }
                if ($elm->getName() == 'level' )
                {
                  $level = $elm;
                }
              }
              echo '<li> <b>', $name, '</b> <br/> <b>Position:</b> ', $position, '<br/> <b>E-mail: </b>', $email, '</li> <br/>'
                  ;

            }

            if ($person->getName() == 'unit')
            {
              foreach ($person -> children() as $unitperson)
              {
                if ($unitperson->getName() == 'person' and $unitperson->attributes() == $id_person)
                {
                  foreach ($unitperson -> children() as $elm )
                  {
                    if ($elm->getName() == 'name' )
                    {
                      $name = $elm;
                    }
                    if ($elm->getName() == 'position' )
                    {
                      $position = $elm;
                    }
                    if ($elm->getName() == 'email' )
                    {
                      $email = $elm;
                    }
                    if ($elm->getName() == 'level' )
                    {
                      $level = $elm;
                    }
                  }
                  echo '<li> <b>', $name, '</b> <br/> <b>Position:</b> ', $position, '<br/> <b>E-mail: </b>', $email, '</li> <
                      br/>';

                }
              }
            }
          }
        }

        }


      echo '</ol>';

      if ($f ==0)
      {
        echo 'Person with ', $val, ' technical level can not be found for the ', $topic, ' topic.';

      }
    }
  }
  else
  {
    echo "<h3>Please select technical level<h3>";
    echo '<hr/>';
  }


?>
```

C Appendix - Interview Questions

Questions before student interacted with prototype

1. Do you know about personalization?
2. Do you know about using of personalization in Learning Management System as Fronter?
3. How do you understand using of personalization in an LMS? (The question about that the students understand that "personalization in an LMS" is the same as "adaptive learning")
4. What does personalization in an LMS mean for you?

Questions after student interacted with each type of personalization

1. Do you consider this type of personalization useful in an LMS?
2. What do you like in that type of personalization? Why?
3. What do you not like in that type of personalization? Why?

Conclusive questions

1. Do you find including of personalization as useful part of an LMS?
2. What features do you consider as important for personalization?
3. Why is/are the feaure(s) important?
4. What type of personalization or mix of personalization types is the most useful for you in the learning process?
5. Why do you think that is useful?
6. Will you include additional information about yourself in an LMS, if it helps to adapt the learning process?
7. Do you have difficulties during interaction with learning objects in the learning enviroment (LMS) when you solve learning tasks?
8. What problems do you face during interaction with learning objects in the learning enviroment (LMS) when you solve learning tasks?
9. What solutions of the problems do you see?
10. Do you know about personalization?