NTNU
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Software engineering of Arduino based art systems

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Problem Description

By OSS (Open Source Software) we mean those computer programs which can be used freely and whose source code is available for modification. Arduino is an instance of technology for creativity.

The ArTe (www.artentnu.com) project has been using Arduino as supporting technology for developing artistic projects, like ArTime.

The goal of this project is to assess the quality of Arduino artifacts produced in the context of ArTe and compare them to other significant ones. Moreover this project will engineer ArTime in order to make it into a stable system that can function in museums and exhibitions. The cooperation with both Liv Arnesen foundation with focus on the Water challenge and Experts in Team 2011 and the established connections to Science Museum in Trondheim and Folkebibliotek are valuable input to this project.

The contributions of this work will be a re-engineered art system based on Arduino and a set of lesson learnt that can be generalized to the design and maintenance of other Arduino based art systems.

Assignment given: 13 January 2011

Supervisor: Maria Letizia Jaccheri

Software engineering of Arduino based art systems

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Abstract

The approaching of user satisfaction in Digital Media is raising new questions and challenges in the interactivity relationship between creator and audience. In this work interactivity is defined as a technology attribute that endows a media environment with the capability of reciprocal communication amidst user and technology through the technology. What are the key focus extents for managing technology based art project? What I propose is a new layer of interaction, in which the user is viewed as part of the interactive installation, being prompted by its pro-active behavior, redefining him as a creative source. In this dimension, in addition to the language of the artist, what changes is also the perspective of use of the Work of Art: The user is now a living part of every creation, contributing to change each time the characteristics. Thanks to technology, it becomes possible to completely revolutionize the way we conceive and design any type of cultural experience and to create spaces for an absolutely innovative use. This thesis will engineer the artistic Arduino based installation ArTime in order to make it into a stable system that can function in museums and exhibitions, experimenting the new layer of interaction with scientific approaches.

Acknowledgements

First of all, I would like to thank Professor Letizia Jaccheri for her supervision during my specialization course and master thesis. I would like to extend my thanks to Jan Olav Owren for his guidelines about the previous version of ArTime, and to all the good friends I have met during these two years. A special thanks goes to my parents, that blindly supported this incredible experience I had at NTNU.

Contents

1 Introduction

The project is a follow up of my autumn project "Collaborative artwork creations using sharing activities and open source software tools" that investigates in the intersection between Art and Technology with enphasis on open source technologies and interactive tools. It is part of the main project "ArTe" in which the global vision of it is researching and disseminating IT issues to Norwegian and International audience with focus on creativity, cooperation, and openness of processes and content.

In project ArTe the term "new media art" is used to describe artworks involving digital images, animations, digital music, computer games, digital poetry and literature, computer based installations, and robots. A main aspect of the ArTe project is the concept of "Openness", in which computers have viewed as machine to create and share culture, as well as calculate.

By OSS (Open Source Software) we mean those computer programs which can be used freely and whose source code is available for modification. Arduino is an instance of technology for creativity. The ArTe project has been using Arduino as supporting technology for developing artistic projects, like ArTime.

The goal of this project is to assess the quality of Arduino artifacts produced in the context of ArTe and compare them to other significant ones. Moreover this project will engineer ArTime in order to make it into a stable system that can function in museums and exhibitions.

The contributions of this work will be a re-engineered art system based on Arduino and a set of lesson learnt that can be generalized to the design and maintenance of other Arduino based art systems.

ArTime, the interactive installation product of the Arte project, focuses on the interaction between old and new technology. It explores the physical vs the digital domain and uses new media in its sonic and visual expression. It is made of recycled materials and uses Arduino to interact with the user and has been submitted to the ArTe-competition at the Norwegian

University of Science and Technology in Trondheim.
The field of natural language processing (NLP), that is an area of very active research, is considered as the core of the system. The application of an NLP system is the creation of a new layer of interaction within the visitor and the interactive installation, pursuing a system that is able to actively and pro-actively interact with the visitor, making him aware of his active role in the act of interacting with the installation. Such a system is a program that tries to simulate a human conversation written and spoken in natural language, and that allows the user to have a deeper and two-way interaction with ArTime.

1.1 Research questions, goals and process

The approaching of user satisfaction in Digital Media is raising new questions and challenges in the interactivity relationship between creator and audience. I assert interactivity as a technology attribute that endows a media environment with the capability of reciprocal communication amidst user and technology through the technology. The Human-computer interaction is strictly connected to the topic of the digital art; it is a discipline whose aim is to give people the power of computers and communication systems using ways and forms that are both accessible than helpful in the creation of an artwork, or for communicational purposes and so on. The increasing number of artistic installations requires a design that is able to take into account the different possible contexts of use, the goals of users and new interaction technologies. The computer thus becomes more and more discipline-oriented.
In this thesis the intersection of art and software interests is going to be analyzed.
This project will go through the following research question:

- What are the key focus extents for managing technology based art project?

The approach to achieve the research goal is a combination of literature study and surveys developed during the demonstration of the interaction installation. First to analyze the world

in which the intersection between art and technology is and later using the surveys information in order to achieve scientific results. Thus, a practical contribute will be given by assessing, re-engineering end enhance the project ArTime analyzing the extents for managing the efforts in handling a technology based art project by engineers and artists. The proposed concept of "pro-active behavior" of the installation will be introduced as the *piece de resistance* to manage a pioneeristic new interaction layer that contributes in the answering of the research question.

The re-engineering of the artistic installation will include all the software engineering steps, focusing on software architecture details.

A meeting with Ivete and Jan Olav (co-authours of ArtTime 2.0) has been done in order to understand which were their requirements compared to the ones of ArTime 3.0, having in mind that requirements in an artistic installation are more exploratives than rationals, difficult to be caught at the beginning[2].

An open source software named Fritzing[1]is used to manage the communication between artists ant technologists for the software architecture part. Fritzing (Figure 1.1.1) is an open-source initiative to support designers, artists, researchers and hobbyists to work creatively with interactive electronics. The software and website are in the spirit of Processing and Arduino, developing a tool that allows users to document their prototypes, share them with others, teach electronics in a classroom, and to create a pcb layout for professional manufacturing.

[1]http://fritzing.org/

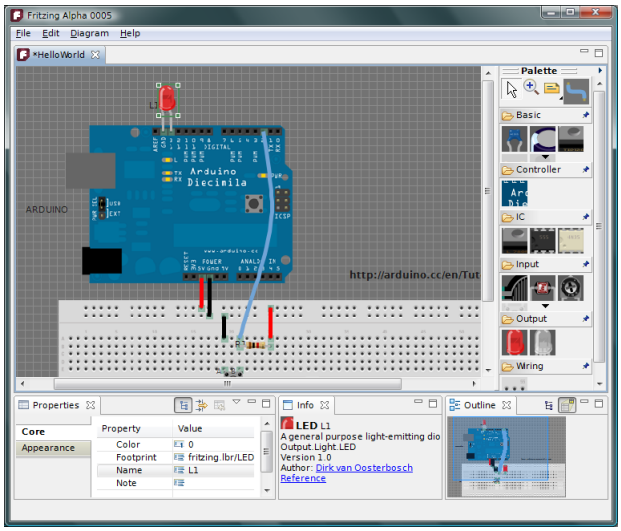

Figure 1.1.1: Hardware Documenting

My goal will be also to add functionalities to the project ArTime giving it a poetical message using technology having as a valuable input the prospects to have the requirement to show it at the Science Museum in Trondheim. The basic idea is to give the interactive installation the ability to interact with the visitor with the above mentioned pro-active behavior.

The results of this project can be analyzed and discussed from the point of view of the project ArTe, in understanding its issues, and giving it scientific replies to its research questions showing the intersection between art and technology.

Figure 1.1.2: This moodboard shows different objects and styles that inspired the process of this project. A moodboard is useful to open the mind and help explaing the way to the chosen process and solution.

1.2 Call for papers

The secondary goal of the work is to write a paper (See Appendix A) to be submitted to ACE2011[2] 8th International Conference on Advances in Computer Entertainment and Technology in Lisbon, Portugal, about the enhaced version of ArTime, showing the artistic installation not only seen as a "waiting for input from the visitor" but giving it the possibility to interact with the visitor in a pro-active way.

[2]ACE2011 http://img.di.fct.unl.pt/ace2011/calls.html

Figure 1.2.1: ACE2011, the conference objective of the paper.

1.3 Motivation

What I felt during the realization of the master project still gave me the motivation to go ahead in the research field in between technology and other areas, especially with art. I still have a strong interest in open source software and in the open source philosophy since I studied in two universities (in Rome at "Tor Vergata" and in Trondheim at NTNU) where the open source philosophy is strongly encouraged and supported, and the ArTe project headed by my supervisor Letizia Jaccheri has been a good point of start for the specialization project, and a excellent support for the realization of the master thesis. Still, by having had, during my accademic path, an exclusive mathematics and informatic background, without using any artistic software and without having faced any artistic challenge or art related project has made grown up the idea of learning and doing research into a new branch of the computer science using this open source philosophy while doing research.

Moreover, the consciousness of the rapid growing of the possibilities of the art to interact with the technology and the modernity of the topic of the research has developed in myself the curiosity of analyzing in a scientific way what I can taste from everyday experience.

The good feedback I had from the recent experience with the autumn project made me understand that my attitude towards the topic has been appreciated, giving to me a natural disposition in the will of achieving an even better research result with the master thesis.

1.4 The intersection of art and technology

The relationship between artists and technology is long-lived and coincides with the first tools used in the second world war. The earliest examples of interaction between art and technology experiments are represented by two mathematicians, Ben Laposky and Manfred Frank[23], who realized in the 1950, a "oscillogram" through a mathematical formula; they got the basis for a specially created graphics and projection distortion. It is from their experiments that we start to talk about digital art and we began to pave the way for wider use of computers to create artworks.

Among these, even the electronic music genre born from the marriage between music and computers to arrange and create sound samples. More or less close kinship with digital art is also known as ASCII art, using the images produced on the basis of ASCII characters, a coding system of 7-bit characters commonly used in computers, often used for the production of films and video.

The awareness of the enormous potential of technological means associated with artistic production was born as early as the sixties in the United States, when we witness the birth of a movement, named after EAT - Experiment in Art and Technology. The movement was born as a result of collaboration between the engineer Rauschenberg and Billy Kluver[24], as expressed in various projects such as the festival "9 Evenings: Theater and ENGINEERING" which was a mix of theater and engineering involving the musicians John Cage and David Tudor, the painter Robert Rauschenberg Whitman and the exhibition "Some More Beginnings" which had a large number of works characterized by the use of innovative techniques and electronic media. The experiment achieved a resounding success and attracted the attention - and funding - of large companies, thus allowing the manufacture of various works and making it possible for each of the two worlds to be aware of the other: in this way the technology and computers are senn as a tool for artistic creation. The first major

example of this union in Europe is represented by Ars Electronica[3](Figure 1.4.1), the first festival dedicated to art and digital media.

Figure 1.4.1: Ars Electronica since 1979 has been researching in the consequences of the Digital Revolution.

Born in 1979 in Linz, Austria, over the years has become a meeting place elected by all the designers, researchers and artists working in the field of digital technologies, and during the festival alternates seminars, exhibitions, theater performances and artistic performances covered by a strong cross-disciplinary approach and issues related to the world of digital art.

[3]Ars Electronica - http://new.aec.at/news/en

2 Theoretical background

2.1 State of Art

This project, as being object of research in the intersection of art and technology, will investigate in the cloverleaf of heterogeneous areas, such as human-computer interaction (HCI), system-usability performing in enertainment technology, natural language processing and the contrast theme between Arts and Humanities and technology.

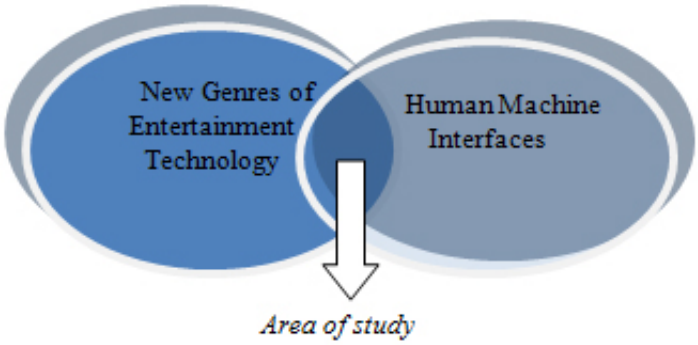

Figure 2.1.1: Area of study

As it is understandable, it is a really challenge to discuss about such huge scientific open-fields, so that an explaination of the status of the art and a bright overview the area of studying necessitates a discussion about what subsets of research areas and topics will be held [25].

In the human-computer interaction I will focus on the interaction with artistic installations in which a good knowledge of the human factors associated to the usability and user-satisfaction is mandatory. I will thereupon talk about interactivity not just as an evolution of technologies and languages but also as the design of the environments through we interact with information and emotions. Beyond the confines of artistic experimentation with new media interactive installations we experiment the conditions of perceptual processes subtly interrelated with cognitive ones. Conditions that stress the value at the lowest possible degree of experiential

knowledge. For centuries we have focused the development of our cognitive processes based on nonlinear dynamics of the writing on screen and then we reached the audiovisual interaction. Yet we know that our sensitivity is more stimulated by random combinations, simultaneous and non-linear. Our consciousness is dynamic and is enriched by experiential values that concerns the processes of perception, possibly associated with motor activity. Inscribed as experience in our minds the information are received with a higher value.

These considerations are, at a functional assessment of the concept of interactivity, expressed by digital systems in relation to the evolution of perceptual and cognitive set. The condition raises the interactive practice of the emancipation from the linear dynamics in order to project a new process of psychological development, which can be called "pro-actively influenced" [27], prepared for a continuum association of ideas. The thought makes the action of the reader-navigator-visitor closer to the artistic installation in which we can select the information.

I am going to question the potential of interactive systems for assessing certain aspects that go far beyond the dimension of interactivity within the screen of a computer to capture the characteristics of what can be called interaction design or the design of the modes of interaction: a physical environment, in a public space [27]. It's a key point of reflection on the digital future to probe the terms of a new human interaction with computer systems [28]. The issue is crucial and cannot be limited only to technological models but influences the psychological and cultural collective imagination.

It is for this reason that I need a poetic experimentation of these modes to test under playful creative conditions our perception and, consequently, my ability to develop direct experience in a process of interaction.

The current research axioms of science and technology is therefore necessary to impact the experience to understand the phenomenology of perception. And that is what is behind this research.

2.1.1 Status of Art of Software engineering in interactive installation

As reported by scientific documents investigating in the intersection of software engineering and art [1][2][25][26], software engineering methodologies are not completely adapted to create new media applications and interactive installations. Important challenges appear when engineers face new media applications with designers and artists.

Software engineers are not accustomed with the ethereal, shapeless, doubtful idea of "user experience". They always have to create systems that deal with real-world goals. Defining the requirements is already a difficult challenge for engineers and concretizing the system characteristics is way more complicated when the usage ambience is not known or not understood, the system assumes then for the scientific engineer an idiosyncratic appearance. User experience of systems is not well defined, well grasped and easy to express with engineering quality attributes like usability, performance, mainteinance and functionality.

According to [1] a metamorphosis of the software engineering methods facing artistic installations (Fig 2.1.2) has to be achieved, *new software engineering methods and processes are required to:*

- *Capture new class of highly intangible and volatile requirements;*
- *Adequately define system specifications;*
- *Successfully embody the expected quality attributes in the emergent system;*
- *Satisfactorily deliver the expected values to stake holders.*

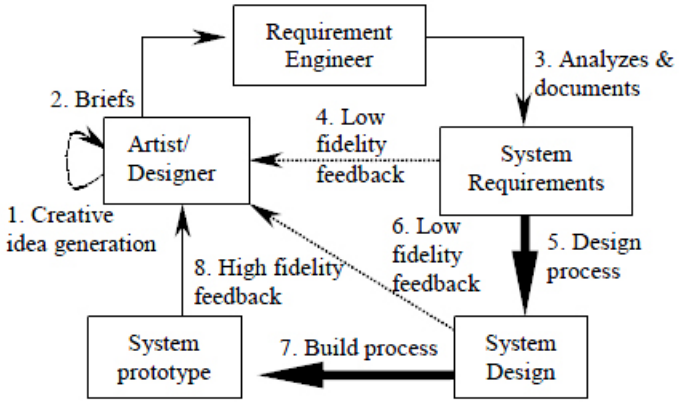

Figure 2.1.2: Software engineering engages Art, the standard approach [1]

Technologists altogether take part in the artistic proceeding, and artists barely are involved in the software or technologic development [2]; artists follow a development process that is completely based on creativity and new on-the-flow ideas , so that it is effortful to establish requisites and to plan the expected output from the beginning. *It is extremely important that both software developers and artists are aware that in interactive installation art requirements are difficult to capture, vague at the beginning and frequently changeable.*

[4] developed a study of IS research in the computer art domain. The first approach is that "computer art might be seen as a kind of information system". A software engineering artifact is viewed as a black box that has an input, eaborates it and the output is showed to the user. Interactive installations can be concoct with this delineation, they indeed receive input that is elaborated and the eventually the output is showed back to the audience.

[5] affirms that that the technology used within the interactive installations is not a far cry from from the technology used on the industrial machines; the difference is grounded in the artist point of view: he needs the technology to be accessible in order to develop the creative part while constructing the artifact.

Albeit artists every so often prefer "access to deeper levels of the computer's programming system" [6] the instruments and CASE that are apposite for software engineers does not fit artists' prerogatives.

[3] and [1] propose a new evolving workflow that aims to approach the effort of the engineerings and artists getting their mouthful closer through a low-fidelity prototyping, automating the well-known part of the application development, facilitating the communication and stimulating the creative design, splitting the development work into two indipendent flows (Figure 2.1.3).

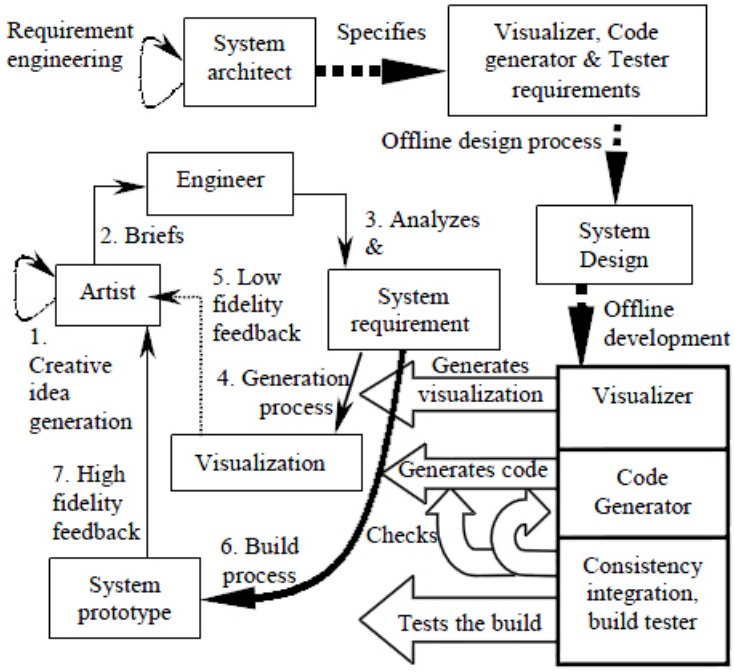

Figure 2.1.3: Software engineering engages Art, the prototype generator approach [3][1]

Using this method engineers can detail artist's requirements while generate code at the same time while the visualizer elaborates low-fidelity concretizations of the design specifications that artists can understand.

2.1.2 The ArTe project

As above mentioned, the project is part of the main project "ArTe" in which the global vision is to disseminate IT issues to Norwegian and International audience with focus on creativity,

cooperation, and openness of processes and content. The aim of the project ArTe is to surge the common knowledge about digital art and to increase the awareness of information technology by using the language of digital art [2]. In the ArTe project the technology is seen as a possibility to introduce more creativity in life, as well as cooperation and openness. It is based on scientific researches documented in papers and books and on spontaneous cooperation between researchers, artists, students, and audience.

A main aspect of the project is the concept of "Openness", in which computers have viewed as machine to create and share culture, as well as calculate. This concept is based on three important openness issues, namely licenses, formats, and tools. Humans continuously need new technologies, and the more technology is created, the more is needed. It is needed to make our job faster, and our concept of working and cooperative working, easier in the practical aspect, thinking for example of the train and the cell phone. And also to make the lives much more enjoyable and lighter, with games, television, I-Pod etc.

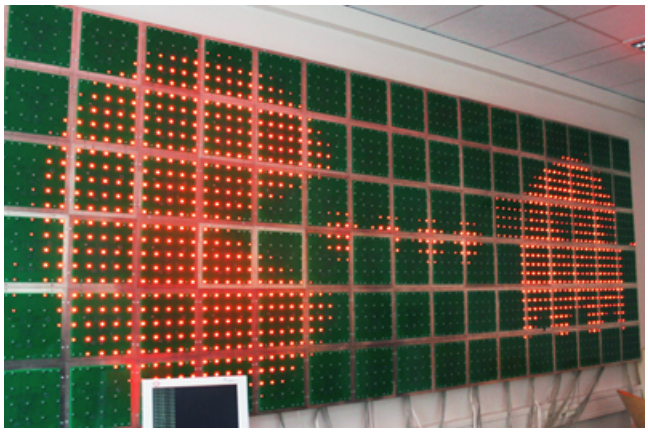

Figure 2.1.4: The open wall project, one of the most appreciated open project of ArTe.

In the ArTe project the technology is seen as a possibility to introduce in the life more creativity, cooperation, and openness[29]. It is based on scientific researches documented in papers and books and on spontaneous cooperation between researchers, artists, students, and

audience. ArTe is open to deal with the concept of unfinished and the conversations about the role of information technology in the society is encouraged. The intersection of art and software interests, includes and attracts people with diverse background to come together and work in common projects. It is based on open source softwares and open source philosophy in which there is a tight connection between the product and the process. Regarding the product:

- The code is open (can be seen and changed)
- There is a well defined license (GNU, BSD, Apache, etc.)

And regarding the process:

- The process is open (mailing lists and public discussions)
- The developer is the user
- The user becomes a developer
- Community/motivation/participation

Open Source software tools are selected with the ArTe goals as reference for Openness: for each tool the degree of openness of its source code and the format of the developed files is analyzed. One of the goals of the ArTe project is to attract students to the IT-field. While evaluating the tools this question was in mind: "does this tool make its users aware of IT issues, such as programming?".

2.2 The role of Human-Computer interaction

The human-computer interaction is a discipline whose aim is to bring the power of computers and communication systems for people using roads and forms that are both accessible than helpful in the work, learning, communication facilities and so on. The increasing use of

computer applications requires a design that is able to take into account the different possible contexts of use, the goals of users and new interaction technologies. The computer thus becomes more and more discipline-oriented and focused on the interaction with the user.
The achievements of this interactive device defy the eye and the ear, creating perceptual events to be considered as the *trompe l'oeil*. In this environment I measure the quality of fundamental research that goes beyond the categories of interpretation of art. It is a matter that is expanding with the new interactive technologies, but by focusing on ArTime, it is very emblematic the trick that shows that displacement between the natural and the artificial. This is based on the interaction between physical action of the viewer and audio-video representation, where, for example, the sensors detect noises or voice, determining the necessary input for the responsiveness of the answer: "sensitive areas" where human sensitivity tailor the system with a creative input that knows how to be masqueraded by the technology camouflage solution. In this interaction lies the key to understanding the central importance of art history that is interwoven with the history of science human evolution as a whole. The perceptions of what is measured, as always, depends on the technological advancement of science and philosophy and that a fortiori aesthetics that determines the extent of our world.

Interaction taxonomy – The user role as an active component The design of the new millennium computer-based installation environment raises new questions and processes of discovering the user interaction type. In order to improve the environment sketch, theories and new empirical studies are to be done about how user-satisfaction and innovation design of interfaces occur[14][15]. Interacting with an artistic installation amends the user experience, as being a passive observer does not achieve the same stimulus from the interaction [4]. Edmonds, Turner & Candy enrooted a taxonomy of art categorization onward a continuum of interactivity [13]: art is classified as static, dynamic-passive or dynamic-interactive, in which

the static artworks are those that do not include any interactive possibility, dynamic-passive react to the physical environment and dynamic-interactive create outputs corresponding to user's input. Our focus is both on technical and cognitive psychology aspects of the interactive artistic installation, then on cultural and aesthetic level of analysis [13]. What we propose is a new layer of interaction, in which the user is viewed as part of the interactive installation, being prompted by its pro-active behavior, redefining the user as a creative source. "Just as telescopes, microscopes, and cameras are powerful devices that enable discoveries and innovations, they are still only tools; the act of creation is carried out by the users" [16].

2.3 Natural Language Processing and Knowledge-Based systems

Computational linguistic is an interdisciplinary field that combines the statistical study of natural languages from the perspective information[30]. This discipline is not limited to any particular field of linguistics. Computational Linguistics in the beginning was a field of study assigned to specialized computer program applications designed to handle natural language, but research has shown that a language is much more complex than previously thought, so now computational personnel and linguists work in groups together. The computational linguists are usually a mixed group of linguists, computer scientists, experts in artificial intelligence, cognitive psychologists and logicians. Computational linguistics is closely related to artificial intelligence: it is usually defined as the ability to make the computer perform certain functions and some reasoning that are altogether typical of the human mind. The correlation between language and intelligence would be most evident in the fact that the Turing test (see chapter 3.2.2) is based largely on the language capacity. The NLP (Natural Language Processing) is therefore a research field which is exactly halfway between the AI and linguistics. It covers the theories and algorithmic solutions to enable a computer to process the spoken and written language. It is defined as an AI-complete problem in the sense that its complete resolution seems to imply the use of a fully functional AI. The NLP

field is segmented into a series of subproblems [31]:

- Segmentation of speech, or understanding of where to begin and end the various parts of the text (words, phrases, ...).
- Segmentation of the text, namely the identification of single words.
- Disambiguation of words, or choosing a particular meaning from those available for the single word.
- Disambiguation of syntax, that is the choice of a particular significance in the case of ambiguous sentences.
- Normalization of the text, or the elimination of errors in grammar and writing.
- Metaphorical meaning, namely the identification of possible meanings meta-language (ie "You know what time is it?" does not require "yes" for an answer, but the time).

In this field there are three stages of elaboration:

- Translation of human language into an intermediate language (input).
- Preparation of the intermediate language.
- Translation from intermediate language to natural language (output).

In the first step you need to understand what the person who interacts with the system is telling. The second point is certainly the most important point, studies on this topic have led to the emergence of tools such as rules engines, Lisp and Prolog, and the first expert systems (Expert Systems) onwards. There have also been evolved in parallel tools as neural networks. There are various types of existing systems today for the elaboration of meaning (30):

- Keywords based

- Rules Based
- Expert Systems
- Neural Networks

Keywords based systems This is the simplest feasible system. It avoids the complex and detailed analysis of the entire sentence in natural language and it is limited to intercept specific keywords or topics (roots) of these. Although this approach is extremely limited, it is rather efficient in case there is a context of very little dialogue.

Rule-based systems The rule-based systems have an additional tool to process incoming messages. They are based on inferences of forward-chaining, or systems of rules that link a set of rules that match and proceed with the backward chaining (backward linkage) based on a list of assumptions, and work the current data by the resulting of the previous computation to see if there are valid results on the basis of assumptions. It starts from an initial state and then activates more rules in sequence, until it reaches a point where it no longer matches the rule, ending the algorythm. The advantage of these systems is that they can perform more complex processing and are able to manipulate the incoming data with data that are already internal tothe system to draw conclusions and consequences basing on them. With such systems it is possible, also, to perform a simple grammatical analysis, as the rule-based systems have similarities with the rules of grammar production. The efficiency of this system is not inherent in the model, but depends on the rules that are loaded. In this way it is possible to delegate to a rules engine all three layers of the NLP:

1. Having a text input, it makes a grammatical and semantic analysis.
2. Basing on the analysis, it develops the output on the basis of responses of the internal state and the discussion history.

3. Found an answer, it generates the text output.

Expert System Expert systems are one of the first results of studies on artificial intelligence. Expert systems are based on a set of rules that analyze the provided information. In particular it focuses on a specific field of problems and are able to perform complex operations of deduction. It is usually used for troubleshooting or for the analysis of complex systems (such as analysis of large amounts of data, etc.). Their roots are still based on the rule-based systems (both forward chaining that backward chaining), but the important value is founded on the basis of knowledge they have internally, or on their internal programming. Indeed all knowledge of an expert system is included in the program, which is limited to draw conclusions based on data in its possession. An expert system consists of two parts:

1. Inference Engine, which is the engine that draws conclusions, independent of the problem to be solved.

2. Rule Base, or all the rules (classes, data, reports) that represent the scope of a specific expert system.

Neural networks An artificial neural network [32] is usually called just "neural network" and is a mathematical model/computer calculation based on biological neural networks. This model consists of a group of information consisting of interconnections of artificial neurons. In most cases, an artificial neural network is an adaptive system that changes its structure based on external or internal information that flows through the network during the learning phase. In practical terms, neural networks are non-linear structure of statistical data organized as modeling tools. They can be used to simulate complex relationships between inputs and outputs that other analytic functions can not represent. An artificial neural network receives external signals on a layer of nodes (processing units) at the entrance, each of which is connected with many internal nodes, organized into several levels. Each node

processes the received signals and transmits the result to subsequent nodes. The creation of the network of nodes and relations is not a party to the proceedings. Neural networks are essentially based on self-learning. There are several algorithms and three possible approaches, each of which is chosen depending on the type of problem to be solved:

1. Supervised Learning: provides value pairs in input and output, and let the network be modified to generate the specific output value presented by the given input value.

2. Unsupervised learning: it is provided with a cost function that must be minimized. In this way the neural network tries to produce results that most minimezes the function-

3. Reinforced Learning: the input is provided as a result of the actions of the neural network environment in which it is inserted, with a cost function that is not explicitly defined. In this way the neural network learns how to interact with the complex dynamics of reference, dynamically and often unknown or too complex.

It is evident that neural networks are very effective, but only for certain categories of problems and is difficult to understand how that could be useful in order to give a pro-active behavior to the artistic installation. For the complex nature associated with the learning phase, a neural network could be used as an element of emotional control, rather than the logic of language. That is why I chosed a keywords-based approach with pattern matching and string recognition to develop the project.

2.4 Arduino and the open source design

Open source is not just about software but also hardware. The arduino open-hardware platform is the demonstration.

What does open source hardware mean?

It means that the electrical schematics and other information to reconstruct the details are available to the public. Arduino (Fig. 2.4.1) is a cheap and suitable microcontroller for rapid

prototyping and consists of an electronic card as big as a credit card. Arduino interacts with the environment in which it is receiving information from a variety of sensors, and controlling lights, motors and other actuators. In fact, the card is equipped with a set of input and output connectors, has a power outlet to connect the device to the main power supply and a USB port for the connection to the PC. It can be connected LEDs, motion sensors and temperature devices, wifi, serial, Ethernet, webcam, servo motors etc..

It can be used for a diverse number of products that range in many areas: creating musical instruments, MP3 players, laboratory instruments for countries in economic development.

The project started at Ivrea in Italy, in 2005, with the aim to make available to students a device for the to enhance of interaction design projects that was cheaper than other prototyping systems available at that time.

Arduino has open source software programming, easy to use for beginners implemented using C + + libraries.

The Arduino controller is pre-programmed with a bootloader that makes it easy to load programs into flash memory on the chip, compared to other devices that require, usually, an external programmer.

All the Arduino new versions and other related products are built on the improvements of previous versions. The continuous production with the board members led to a degree of stability, strength and design that meet the interests of hobbyists and professionals.

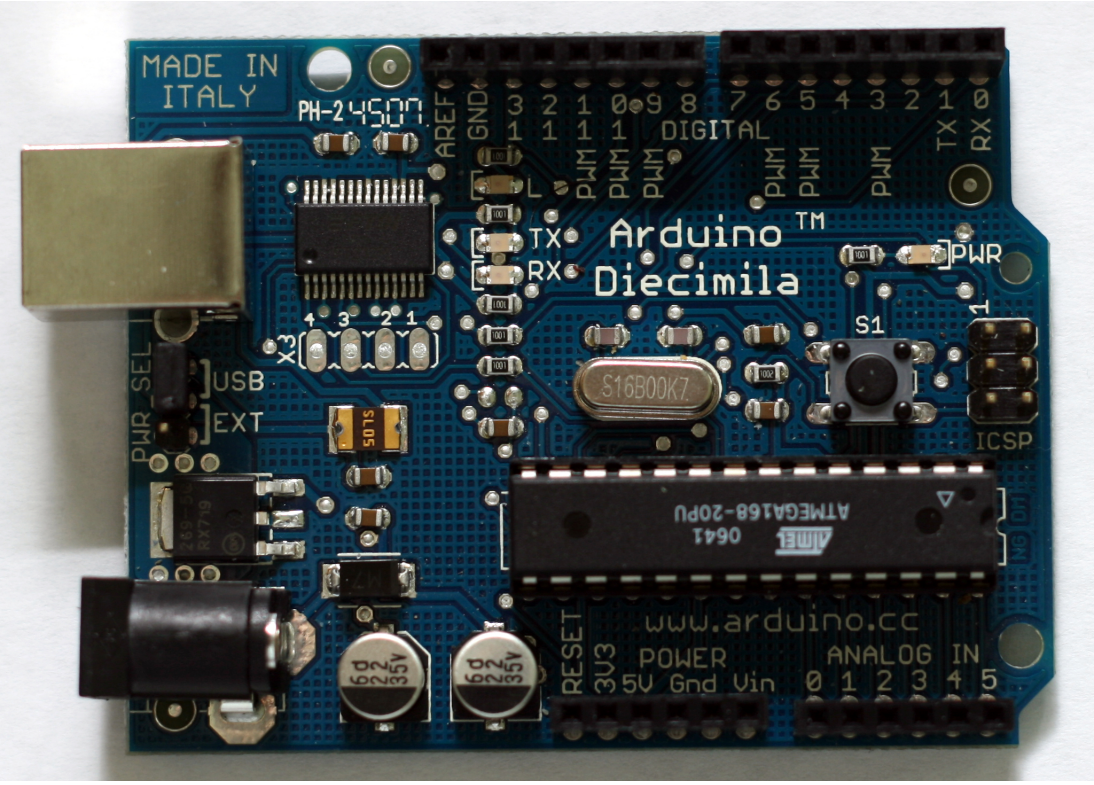

Figure 2.4.1: The Arduino microcontroller

3 The ArTime project 3.0 engineered

3.1 The ArTime project

The passing of time is usually perceived as a negative attribute of technology, conveying a message of obsolescence.

ArTime challenges the concept of time, both in technology and art, by focusing on reuse.

ArTime is based on the relationship between novelty and familiarity.

The old is remodeled so that it can contain the new and the new is represented as traditional.

Its software is based on the open source software .

Processing and audiovisual content can be brought to the work in dialogue with societal inputs.

(ArTime 2.0 poetical message)

ArTime focuses on the interaction between old and new technology. It explores the physical vs the digital domain and uses new media in its sonic and visual expression. It is made of recycled materials and uses Arduino to interact with the user and has been submitted to the ArTe-competition at the Norwegian University of Science and Technology in Trondheim.

ArTime has one pair of headphones connected to it for playback of its sonic expression and it uses integrated speakers to play sounds that the observing audience trigger my interaction. The ideal presentation place is a gallery, not too close to other sound installations so that the sound from the speakers could disturb other sonic work and vice versa. A volume control is accessible if it should be necessary to adjust the volume.

A gallery is preferred over a public space because of practical reasons but also for research reasons: ArTime is a part of the project «ArTe» that hosts research and dissemination activities at the intersection of Art and Technology. ArTime version 2.0 was presented for NTNU's anniversary in September. Here, a logging function was included to observe how the audience interacted with the clock. We wish to explore differences in the interaction patterns between different presentation places.

The first version of ArTime was created as a project accomplished by students in the course «Experts in Teamwork» at the Norwegian University of Science and Technology (NTNU) in January 2010. The group's theme was «Art and IT». The current version, v2.0, pursued the central aspect that the artwork should be further developed, manipulated and created new versions of for new events.

ArTime invites the audience to reflect about how important the type and novelty of technology in a cooperation project between artists and technologists is with the digital tools integrated into the mechanical, the "retrolutionary" aspect of re-using and manipulation of an old object, the interaction, the open source technology and the process towards the final result. A pendulum clock works as a framework for all the versions. Hence, the concept of time will always be a central part of the expression. From the first group's report:

The concept was talked over and we understood that there were different views and thoughts about time within the group; based on cultural backgrounds, and also on the different fields of study. Some members understood time as a universal structure and some understood it as a manmade system to divide natural cycles into years, months, weeks etc. Time has been important for the history of the humanity. Everything that exists and have existed and will exist, relates to it. Time embraces several phenomenon, natural ones such as the moon phases, the motion of the sun across the sky and the seasons; the scientific ones such as the swing of a pendulum and the definition of a second; the social importance, economic value ("time is money") as well as personal value, due to the awareness of the limited time in each day and in human life spans. Because time has so many different approaches, it being the fundamental of important subjects in science as well as in philosophy, it was a very good concept for the artwork.

ArTime was made in January 2010 and they did not see any limitation on its evolution. Version 2.0 (Fig 3.1.1) was presented in a two-day event in September. During this time, the exhibition room was visited by a large audience. The first day, employees from NTNU

was invited to come and observe and interact with the artwork. The second day, the visiting crowd consisted of 400 teenagers. The audience was eager to explore how they could influence the sounds by moving their hands in front of a sensor and trigger sounds by pushing buttons. This event became an excellent test to see if the artwork was robust enough to handle a large audience. There will not be any need for connective maintenance during the future period. If anything unforeseen might happen to the artwork, the instruction document will be guiding and Owren will be available for assistance. If a software error should occur, the integrated computer could easily be rebooted. As long as the artwork is approached with normal behavior, nothing hazardous could happen. Exhibition guards should observe that such behavior is obliged so that the artwork does not i.e. fall to the ground or cause other unwanted situations.

Figure 3.1.1: ArTime 2.0

3.2 The new layer of interaction: a pro-active behavior

There are reasons to argue that there are no real interactive systems - with the possible exception of cardiac pacemakers and defibrillators – and that the true interaction implies that the user responds to the system at least with the same frequency with which the system responds to the user, and, even more important, that the initiatives taken by the user alters the system's behavior. One of the metaphors I used to design this ability of the interactive installation is that of a musical instrument, like a flute, which is owned by its user and respond

instantly and consistently with the wishes of its owner. Imagine how absurd it would be a one-second delay between the act of blowing a note and listening to it. What I propose is a new layer of interaction, in which the user is viewed as part of the interactive installation, being prompted by its pro-active behavior and redefining the user as a creative source.

On the screen of the interactive installation it is showed a visual avatar that converses with the user through a software that uses Natural Language Processing, a microphone that allows the user to communicate to the installation with a speech recognition technology, a semantic knowledge extraction programming code and a speaker with a text-to-speech technology. The goal of an intelligent system capable of analyzing human behavior, should be of being able to process, interpret and respond contextually to questions provided as input from the user, providing a satisfactory response even in the absence of a specific answer within the knowledge.

Being able to make correct inferences is sometimes part of a rational agent, as a way to act rationally and think in logical terms, to conclude that a given action will lead to the fulfillment of its objectives, and then act accordingly.

On the other hand, the correct inference does not represent all the rationality, because in many situations it cannot be shown that there is a particular "right" answer to say, but still something must be said. Human behavior is adapted to a specific environment, and is the product of an complicated evolutionary process largely unknown, which is still far from achieving perfection.

Another important point to bear in mind is the impossibility of achieving perfect rationality, to say the right thing, it is not feasible in the context of complex systems, because the computational requirements are simply too high.

I used the artificial intelligence markup language (AIML) as the knowledge repository, integrating it with an AIML interpreter and knowledge extractor called ProgramD. The voice support is given by a text-to-speech engine prompted by Javascript. When the user talks to

the artistic installation, the words are recognized and put as text from the speech syntethizer.

Figure 3.2.1: Interacting with ArTime

3.2.1 Knowledge extraction

When the interaction installation server is running, the engine of the application loads all the AIML files in a data structure called “Graphmaster" (see Figure 3.2.3).

It works like a dictionary or an encyclopedia: When searching for a word, it does not start to look at the beginning of the dictionary until it find the word but it is looking for the first letter, then the second and so on until the word is found.

In the Graphmaster, the knowledge repository abstraction, keywords “*” and “_” acts as two special letters that come before the “0” and after "Z" respectively, useful to be placed in spots when the speech sysnthetizer is not able to detect a certain word.

The Graphmaster consists of a collection of nodes called "Nodemappers”. These nodes map the branches from each node. The branches are either single words, wildcards such as "*" and "_ ".

The root is a Graphmaster Nodemapper with about 2,000 branches, one for each of the first words of each pattern. The number of leaves in the graph is equal to the number of categories(below explained), and each leaf node contains the tag <template>.

Figure 3.2.2 shows how the engine response to user input. The most important process that occurs in the construction are given below.

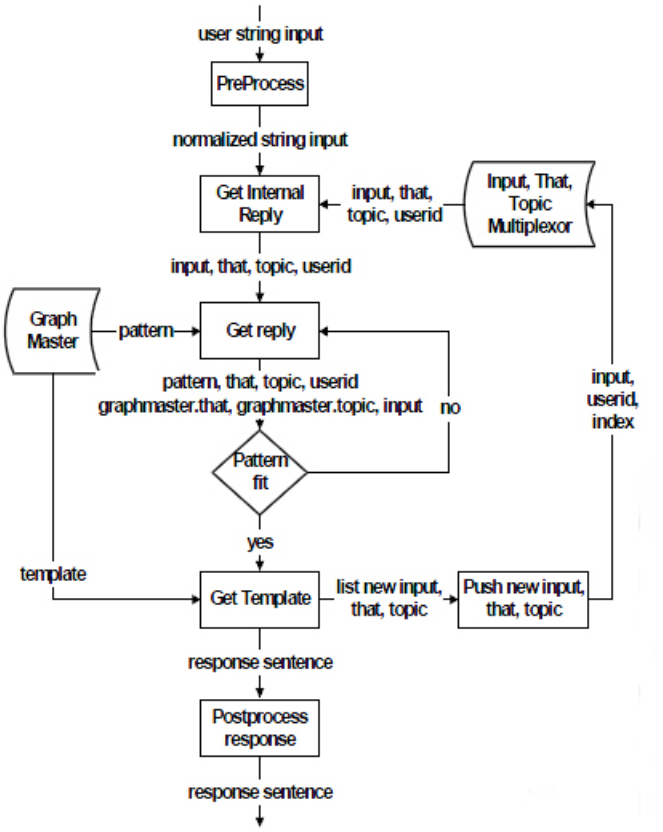

Figure 3.2.2: The path of the construction of the output

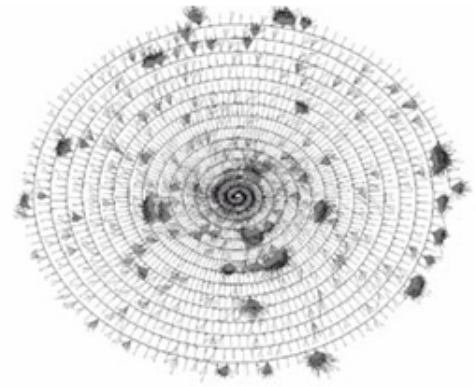

Figure 3.2.3: The graphmaster

Preprocessing of user input string The engine has a class called Substituter who shall perform a number of grammatical and syntactical substitutions on strings as input. A goal

is to remove ambiguous punctuation input to prepare it for the segmentation in individual sentences. Another goal is to expand all the contractions, this process is called normalization. The same class shall also correct any spelling errors.

Internal response - Using the story of the conversation AIML has several tags to access the history of the conversation as:

- <topic> and <get_topic/> - these tags create conversation topic, and also have the ability to move from one topic to another.
- <input> and <input index="n"/> - these tag returns the entire input. The value "n" is a reference to previous responses.
- <that> and <that index="nx", "ny"/> - give these tags provide access to previous responses from the chatbot.
- <set_xxx> and <get_xxx> - <set_xxx> X </ set_xxx> create a predicate for "XXX" and set its value to X.

Pattern-matching operations There are three important steps to run the "matching" of an input to a pattern in the knowledge repository. If the engine has an input that begins with the word "X" and a "Nodemapper" graph, which is a branch containing a word or phrase, the steps of the pattern-matching operations are divided to check if the Nodemapper contains the key "_". In this case, it look for the subgraph rooted in the child node linked by "_". It tries all the remaining suffixes of the input following "X" to see if one matches. If not found, it tries to check whether the Nodemapper contains the key "X". In that case, it looks for the subgraph rooted in the child node linked by "_", using the tail of the input (or input with the suffix "X" removed). If not found, it tries to check whether the Nodemapper contains the key "*". If it contains it, it looks for the subgraph rooted in the child node linked by "*". It tries all remaining suffixes of the input followed by "X" to see if one matches.

If not found, it returns from the node to the parents, and put “X” in the head of the input. For completeness there should also be a terminal case. If the input is zero (no other word) and the Nodemapper <template> holds the key, then a match is found. Then it ends the search and returns the node in question. The root of Nodemapper contains a key “*” that points to a leaf node, then the algorithm guarantees to find a match. At each node, the “_” has the highest priority, followed by a keyword atom, and “*” corresponds to the lowest priority.

The pattern does not need to be sorted alphabetically, only partially ordered so that “_” is the first word.. The “matching” is word by word, not category by category. The algorithm combines the input pattern, the <that>, and <topic> in one way or phrase, such as: “PATTERN THAT” <that> <topic> “TOPIC” and treats the token and <that> <topic> as ordinary words. They can contain multiple wildcards. The basic algorithm is a restricted version of the algorithm to visit in depth. It is possible to simplify the algorithm by removing the wildcard “_”, whereas only the latter two steps and with the simple case of pattern and without <that> <topic>.

Enter new input, That, topic - Saving the conversation The conversation is saved in XML format in <input> piles <that> <topic> piles, so that the program has a ”memory” that can be reused at any time to respond properly to the user on the basis of what has been written. For example, the fragment of conversation below:

```
User: My name is Riccardo.
Application: Riccardo, what do you think about this interactive installation?
User: I think it is really interesting
Application: What car you drive?
User: I drive a fiat.
```

```
Here are the values of the stack of
<input>: <input index="1"/> = drive a fiat.
<input index="2"/> = it is really interesting
<input index="3"/> = My name is Riccardo.
The values of the stack
<that>: <that index="1,1"/> = What car you drive?
<that index="2,1"/> = <set_name> <set_name/>
Riccardo, what do you think about this interactive installation?
The values of the stack
<topic>: <topic index="1"/> = * The <input index="n"/>
returns the entire input.
The tag <that index="nx,ny"/> returns the whole response of the tag
<set_name> and stores the user name.
```

Post-processing of the response The responses are processed in XML format so the client browser is able to show them. The post-processing of the responses combines all the sentences with the appropriate values as variables, hostnam, etc.

3.2.2 The Turing Test

The Turing Test, proposed by Alan Turing in 1950 [7] has been designed to provide a satisfactory operational definition of intelligence. Instead of proposing a long and perhaps controversial list of features required for a computer to be considered intelligent, Turing suggested a test based on the impossibility to distinguish it from entities that are without doubt human beings.

The computer will pass the test if a human examiner, having asked a few questions in a written form, will not be able to tell if the answers come from a real person or not. The

computer then, should possess the following skills:

- Interpretation of natural language to communicate with the examiner as a human language.
- Representation of knowledge to memorize what he knows or hears.
- Automated reasoning for using the stored knowledge to answer questions and draw new conclusions.
- Learning to adapt to new circumstances, detect and extrapolate patterns.

We must give credit to Turing that he had designed a test that remained significant at a distance of sixty years. However, researchers have devoted much effort to attempt to build a system capable of passing the Turing test, considering more important the studying of the principles underlying intelligence.

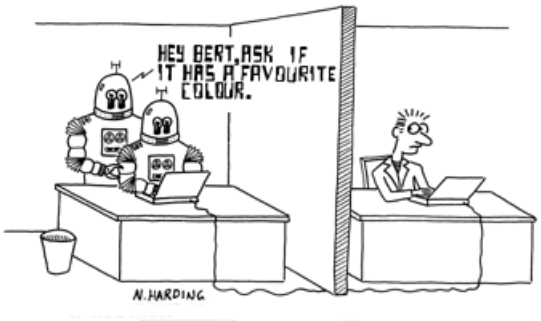

Figure 3.2.4: Turing Test

3.2.3 Interactive systems

The design and development of interactive interfaces is probably the most intense part of labor and difficult process of developing tools for engineers. To get an idea [8] of this, just think that 50% of the code of a modern software is dedicated to the interface and that 75% of revisions of software concern still Interface [9].

The main reason for this is that designing an interface provides a variety of choices and design decisions involving users and the possible tasks that could be carried out through the interface, and most of the consequences of these decisions are unpredictable. It is primarily for this reason that the design of interactive interfaces is an experimental activity in which development methodologies are conceived with evaluation techniques, and new approaches are constantly offered such as contextual design [10].

Design, implementation and evaluation have traditionally been regarded as separate stages of the development processes of human-machine systems. One of the most important contributions in the design of interactive systems has been the introduction of the concept of iterative design, in which the design and evaluation are iterated until reaching a satisfactory result, allowing the artist to give continuous inputs to the engineering activity.

The evaluation phase pervades this entire process: the design is necessary to evaluate the current system, human activity and the context in which it takes place, the design solutions are typically in the form of prototypes.

The principles to be taken to an ergonomic design, user-centered, are varied and have been worded differently, but still the four pioneering principles, formulated by Gould and Lewis [11] are a good reference system to which all formulations following are based:

1. Understanding the user. We must make an explicit representation of both cognitive skills and aptitude that is the nature of the cognitive work that needs to be done.

2. Interactive design. A representative sample of users should be part of the design team throughout the development process.

3. Constant measurement of results. From the first stages of the design potential end-users must be involved in testing the usability of the product, and human-computer system must be tested and evaluated as a whole system.

4. The ITER project. The design must have a cyclical nature: design, test and measure,

redesign, until a human-computer system performance that meets the purpose for which that system was designed is achieved.

Indeed, a design that can take into account the various possible contexts of use, the user goals and the new interaction technologies are required. The model that underlies the vision of interactivity is the conversation between two human counterparts. The image that it evokes is of a conversation, erratic and unpredictable, which continues without stopping - and without a discipline imposed in advance – developing in the same way both of the interlocutors' dialogues. I am trying to reach this feature by implementing a pro-active behavior on the artistic installation, ArTime, seeing how it impacts the user satisfaction and how the interactivity challenges change.

3.3 System architecture

All the architecture, like the computer used on ArTime, is completely hidden to the user, that sees only a headset and a microphone on the ArTime installation.

The main core is not controlled by a single program but a collection of stand-alone client-server communicating via TCP / IP. The client in this case is itself a server, specifically a HTTP server.

Figures 3.3.1 and 3.3.2 show a subsequence of the processes involved in a typical transaction with ArTime through its engine.

It implements AIML, and is responsible for receiving the input string and generate the response by activating and interpreting the pro-active brain. The client (user) uses a browser in a hidden way to connect to the server where there is the application and transmits the query. The response contains HTML and XML markup and the browser interprets it.

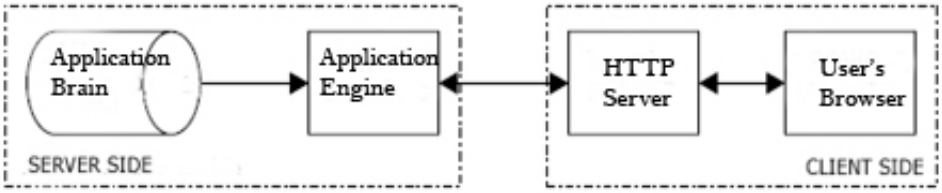

Figure 3.3.1: A typic transaction with ArTime

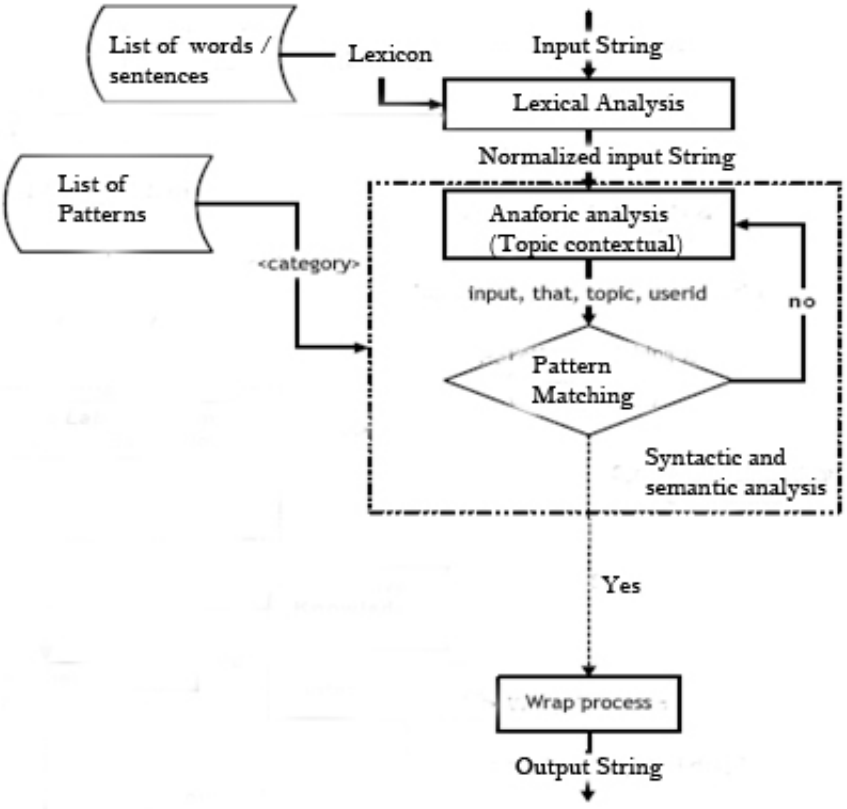

Figure 3.3.2: The process of interacting with ArTime

3.3.1 AIML structure

AIML is an XML language, which implies the observation of certain grammatical meta-rules. The choice of XML syntax enables integration with other tools such as XML editors. Another motivation is the fact that XML is well known, especially to people with HTML experience.

AIML is a list of statements called categories. The most important units of AIML are given by the following tags [19] :

- <aiml>: the tag that opens and closes each AIML document.
- <category>: the tag that marks the single unit of knowledge in a knowledge based system.
- <pattern>: the tag is used to contain a simple string that might coincide with the user typed.
- <topic>: The tag used to define a topic of conversation.
- <that>: the tag that refers to the previous system response.
- <template>: the tag that contains the response to user input, there is much freedom of expression in the construction of the response.

<category> Category </ category> Each category contains an input pattern and a response. The tags are not case-sensitive. Each opening tag has its associated tag-Off value, which of course comes from the XML syntax. The syntax of the tag category is therefore:

```
<category>
<pattern> Input </ pattern>
<template> Response </ template>
</ Category>
or
<category>
<pattern> Input </ pattern>
<that> THAT </ that>
<template> Response </ template>
```

```
</ Category>
```

Pattern <pattern> </ pattern> The tag pattern is the "stimulus" or input tag category. The pattern is an expression in a formal language that consists of:

1. Words in natural language
2. The symbol "*" which consists of a sequence of one or more words.
3. The symbol "_" which is equal to "*" but that comes after "Z" lexicographic order. Note that there is a big difference between the pattern "Hello" and "Hello *". "Hello" she answers only to the sentence of a word "Hello" and "Hello *" meets every sentence of two or more words that begin with "Hello".

<topic> Topic </ topic> Topic allows to respond with answers that are relevant to a certain topic of conversation. This allows to create a conversation topic, but without losing the ability to change the subject. In this way is possible to duplicate patterns within the same database but in different contexts (topic), allowing the application to have different responses compared with the same input depending on the context. The topic tag contains one or more category tags, and each tag within these patterns is associated exclusively with that subject (topic) specific. Here's an example:

```
<topic name="theme">
<category>
<pattern> PATTERN </ pattern>
<that> THAT </ that>
<template> template </ template>
</ Category>
</ Topic>
```

The concept is that the knowledge creator uses the tag "<set_topic>" to set the topic of discussion. Once that it is set, when the client sends an input, for which the application must reply, the topic <category> inserted inside the tag in use is analyzed first, and if there is no response it analyzes the responses outside the topic tags used.
As mentioned previously, so is it possible to create the same category with the same tag in <pattern> different topic, each with a different answer depending on the current topic. Such as:

```
<topic name="books">
<category>
<pattern> you like the lord of the rings? </ Pattern>
<template> Yes, a lot! </ Template>
</ Category>
</ Topic>
<topic name="movies">
<category>
<pattern> you like the lord of the rings? </ Pattern>
<template> No, not at all! </ Template>
</ Category>
</ Topic>
```

In this example you can see that, depending on the topic of conversation, for both books and movies, to the same question "do you like the lord of the rings?" the application responds positively in the first case, negative in the second. Using these techniques is it possible also to provide contextual responses in the absence of a specific response to user input.

That <that> </ that> The tag That includes what has been communicated by the chatbot previous user input. A common example of use of That is:

```
<category>
<pattern>YES </ pattern>
<that> Do you like movies </ that>
<template> What is your favorite movie? </ Template>
</ Category>
```

This category examines the answer "Yes" if the user and the application previously made by the application is "Do you like movies," then answer is "What is your favorite movie?"

A nice example of the tag is given below [20]:

<category>	Client: KNOCK KNOCK.
<pattern>KNOCK KNOCK</pattern>	Robot: Who's there?
<template>Who's there?</template>	Client: BANANA.
</category>	Robot: banana Who?
<category>	Client: KNOCK KNOCK.
<pattern>*</pattern>	Robot: Who's there?
<that>WHO IS THERE</that>	Client: BANANA.
<template><person/> Who?</template>	Robot: banana Who?
</category>	Client: KNOCK KNOCK.
<category>	Robot: Who's there?
<pattern>*</pattern>	Client: ORANGE.
<that>* WHO</that>	Robot: orange Who?
<template>Ha ha very funny, <getname/>.	Client: ORANGE NOT BANANA.
</template> </category>	Robot: Ha ha very funny, Ska.

3.3.2 Context diagram

There are three entities involved in the system as (see figure 3.3.3):

1. The user who sends the input string and receives the response.

2. The categories that contain the list of AIML pattern.

3. A multiplexer that takes care to store the conversations.

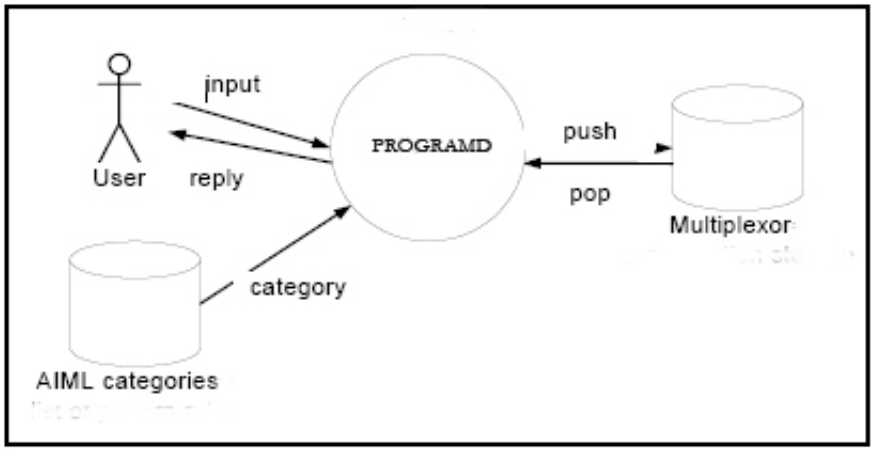

Figure 3.3.3: Context diagram of the system

3.3.3 Use cases

Name	User input
Description	User give the input to the system
Actors	User
Preconditions	-
Exceptions	-
Result	Normalizing input and semantic and syntactic analysis

Name	Input normalization
Description	Recognize and corrects the input
Actors	-
Preconditions	User has submitted the input
Exceptions	-
Result	Input is normalized

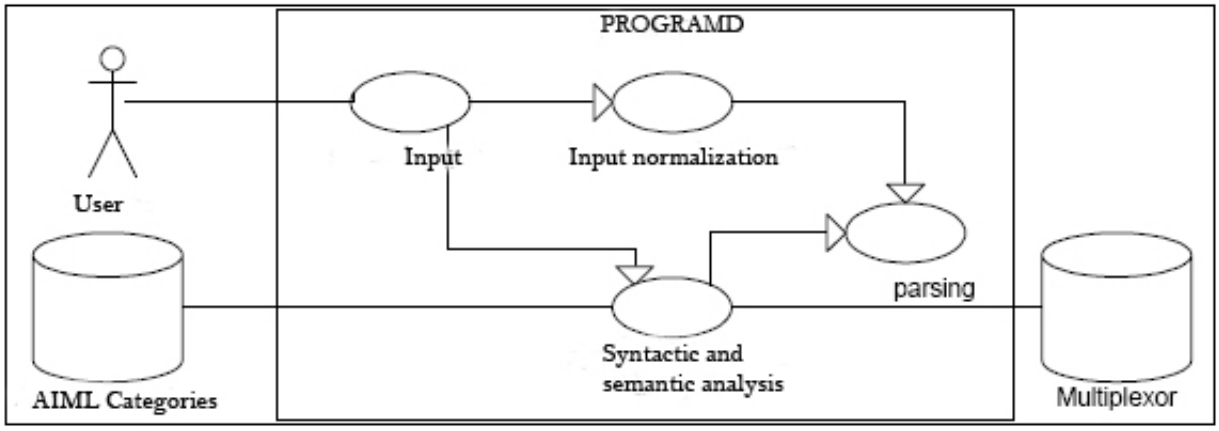

Figure 3.3.4: Use case diagram

Name	Syntactic and semantic analysis
Description	Answer generation
Actors	Pattern list and conversation history
Preconditions	Input is normalized
Exceptions	-
Result	The answer is given to the user

Name	Parsing
Description	Parsing of the strings, word by word
Actors	-
Preconditions	-
Exceptions	-
Result	String is processed

3.3.4 Class diagram

The application consists of 17 packages (Fig. 3.3.5):

1. org.Alicebot.server.core, this package contains 11 classes. The classes are:

(a) Graphmaster that contains a list of patterns.

(b) BotProperty that guides the loading and access to the preferences of the chatbot, who heads the Global access to the server

(c) Multiplexer that drives save information during the conversation, and providing AbstractClassifier the construction of the response.

2. org.Alicebot.server.core.loader, this package contains two classes that guide the loading of the categories in AIML graphmaster and a "watcher" that monitors if there are additional new AIML categories.

3. org.Alicebot.server.core.logging, this package contains four classes that manage the logging of events in the log file.

4. org.Alicebot.server.core.node, this package consists of two classes: Nodemapper and Nodemaster. Both classes map to the branches in the tree Graphmaster.

5. org.Alicebot.server.core.parser, this package contains 12 classes that handle the parsing of both forms of XML and AIML.

6. org.Alicebot.server.core.processor, this package contains 36 classes that are used to recognize the tag in AIML form and are used by the parser package.

7. org.Alicebot.server.core.loadtime, this package contains 18 classes. AIML tags are used to recognize the file to be loaded when the server starts the first time.

8. org.Alicebot.server.core.responder, this package contains 10 classes. They are used to process and store input and output in a given channel (Text, HTML, FLASH and AIM)

9. org.Alicebot.server.core.targeting, this package contains seven classes used by the parser to read or write to a target file.

10. org.Alicebot.server.core.targeting.gui, this pacage contains two classes for the sake of the demo GUI.

11. org.Alicebot.server.core.util, this package contains 13 classes. They are used to perform operations on strings and other uses required by other packages.

12. org.Alicebot.server.net, this package contains three classes that are used to configure the server.

13. org.Alicebot.server.net.listener, this package contains five classes. They are used to interface to a specific channel: AIM, IRC, ICQ and JAB.

14. org.Alicebot.server.net.server, this package only contains a class that is used to manage the Java Servlet.

15. org.Alicebot.server.sql, this package contains 40 classes that are using the shell to access other java classes or database.

16. org.Alicebot.server.sql.pool, this package contains 4 classes that are used to manage a pool of database reference.

17. org.alicebot.server.sql.util, this package contains 10 classes that are used as the use of other classes.

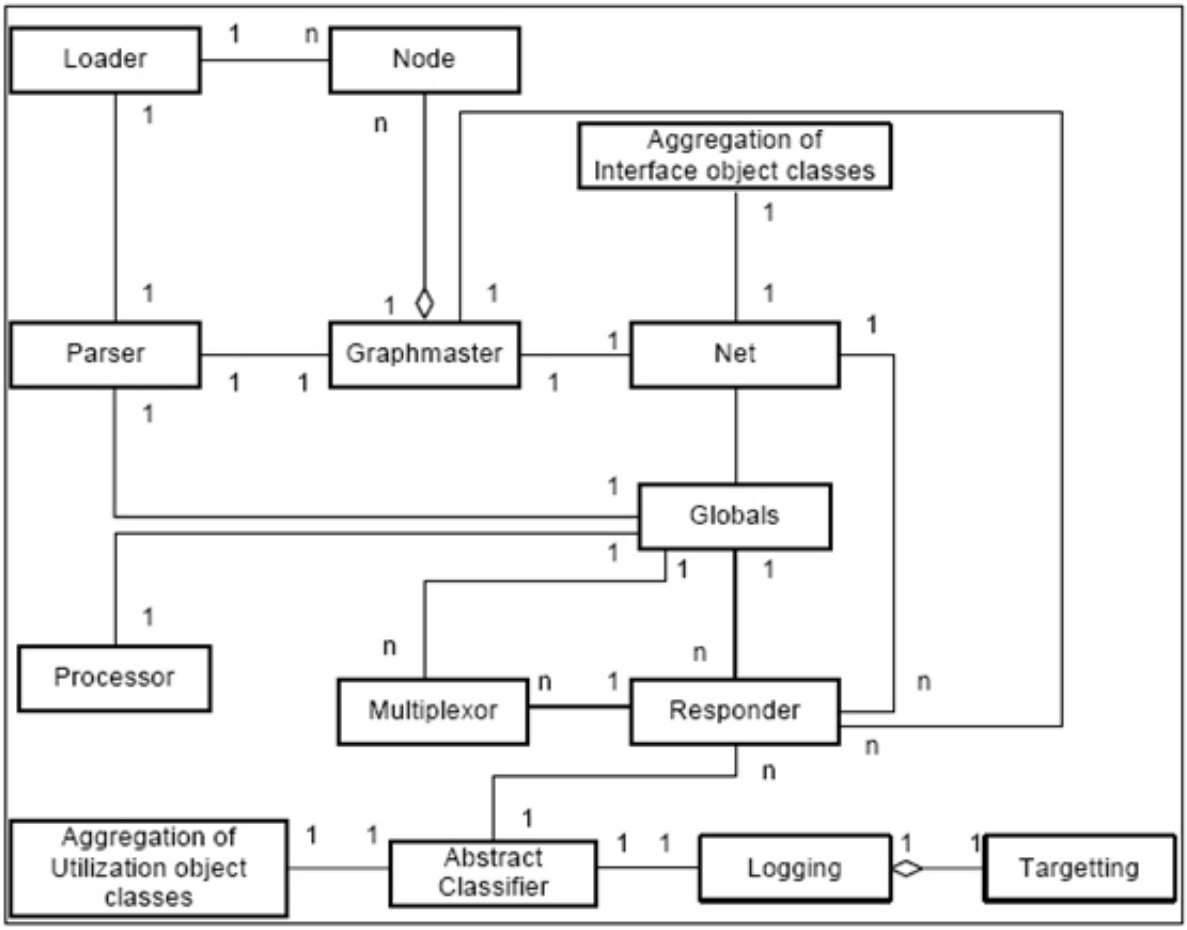

Figure 3.3.5 Class diagram

3.3.5 Sequence diagrams

Application scenario is divided into two parts:

1. Load time: When the system starts, it loads all the patterns in the graphmaster and the list of words / phrases in the multiplexer.

2. Talk Time: When the system receives the user input string and the system constructs a reply using the classes of syntactic and semantic analysis.

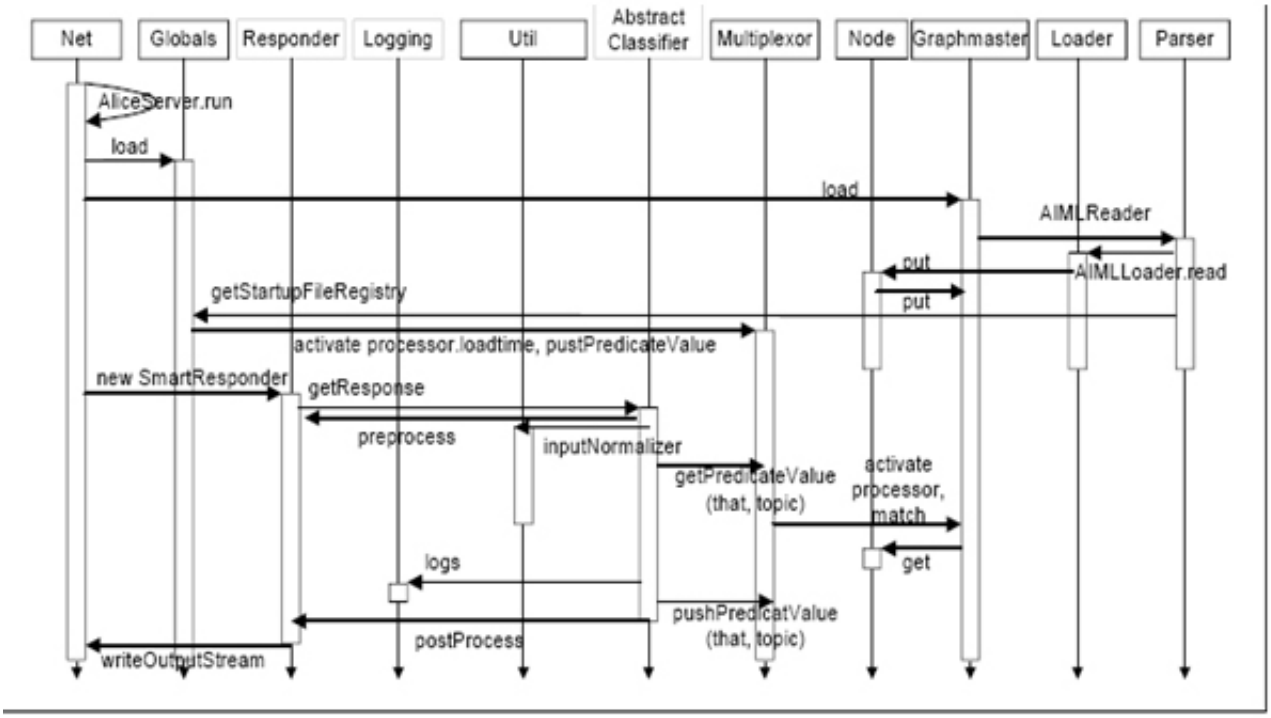

Figure 3.3.6 Sequence diagram

3.3.6 Application Structure

Here is summarized the structure of the application.

1. The bots folder. This folder contains all the AIML files, but also startup.xml where the bot is configured with the root tag called <programd-startup> and contains exactly one child element called <bots>. Inside <bots> there are one or more elements <bot> every <bot> has two important attributes: id and enabled. The first provides an identifier, which must be unique for the bot. It is used internally by the engine. The enabled attribute must have the value “true” or “false”. If the value is set to true, the engine will try to upload the bot when the server is activated. Inside <bot> elements are defined:

(a) Bot properties, the bot predicates are properties that can not be changed while running the bot, but that may be included in AIML pattern. A property common to define the bot is “name”.

(b) Substitutions, the substitutions have different purposes, depending on their type. The substitutions contribute input to the process of normalization of the input itself.

(c) Sentence-splitters, the sentence-splitter, heuristics are applied to an input trying to break the sentence into shorter sentences: <sentence-splitters> <splitter value=”.”/> <splitter value=”!”/> <splitter value=”?”/> <splitter value=”;”/> </ Sentence-splitters> startup.aiml. The bots use this file to load the AIML file. This file contains a category:

```
<aiml>
<category>
<pattern> ROBOT LOAD </ pattern>
<template>
<Learn filename = "/ home / Alicebot / brain / <filename-1>" />
<Learn filename = "/ home / Alicebot / brain / <filename-2>" />
...
<Learn filename = "/ home / Alicebot / brain / <filename-n>" />
</ Template>
</ Category>
</ AIML>
```

<learn> Using the tag, the reader will load all the AIML categories in the Graphmaster.

2. build folder. This folder contains the executable files to compile ProgramD.

3. classes folder. This folder contains classes of ProgramD.

4. conf folder. This folder contains a file: Jetty.xml. This file is the web interface of ProgramD. It is programmed to work as a servlet.

5. database folder. This folder contains files for the database schema.

6. ffm folder. This folder contains the log files of the predicates (INPUT, THAT and TOPIC), which are stored in the conversation by userid.

7. Lib folder. This folder contains all the Java libraries that are needed to compile and run the program

8. logs folder. This folder contains the chat logs, errors, etc. and database notifications. This folder does not exist until the server is started first.

9. Src/org/alicebot/server/. This folder contains the Java source file to ProgramD.

10. template folder. This folder contains two subfolders: flash/ and html/. The folder contains the flash file chat.flash that is used to build the interface of the chatbot using FLASH. The html/ contains chat.html that is used to build the web interface through simple HTML.

11. The file server.property.xml. This file contains all the server configuration including startup.xml. This file is used to load all the files in AIML graphmaster. This file contains:

    (a) The database configuration.

    (b) The configuration of the shell and the console.

    (c) startup configuration file.

    (d) Program to handle the timeout.

(e) User Configuration.

(f) Javascript Configuration.

(g) Other server properties and configurations. Server.properties is documented in the file

11. targets/ folder. Data for the targeting feature, this folder is not active until the server is activated.

3.4 The role of Arduino

The "heart" of ArTime 2.0 is given by the Arduino microcontroller. The chosen microcontroller working on the installation is an Atmel AVR ATmega168.
The platform consists of:

- A card on which there are several key components for programming and useful in times of: the ATmega, a voltage regulator, a USB port, a converter Serial-USB, etc.
- It is designed to make the simplest possible programming work; on the microcontroller there is a preloaded bootloader that allows to write programs directly in memory via USB.
- It is open-hardware and provides all the specifications and schemas. It offers macro and C libraries ready to simplify the hardware management
- It offers an Integrated Development Environment (IDE), open-source, multiplatform and easy to use.
- It is designed and is being pursued by a large international community

The goal of the previous version of ArTime (ArTime 2.0) was to create a enhanced version of the 1.0 one for the NTNU's 100th anniversary, reflecting the chosen topic. The aesthetic

part was fundamental, finding solutions for connecting and hiding cables, the computer while improving the use of open source tools.

They provided also an evaluation mechanism, to log the interaction of the visitor with the installation to study data for later research.

The functions are (Fig 3.4.1):

- *Two separate sound sources: Integrated speakers and headphones.*
- *Play random sounds from speakers when the clock strikes.*
- *Play a continuous changing soundtrack in the headphones.*
- *Trigger random sounds by pushing a button.*
- *Some of the sounds in the headphones should be able to manipulate by interacting with a sensor.*
- *Manipulated images showed in the photo frame.*
- *Logging of movement in front of sensor.*

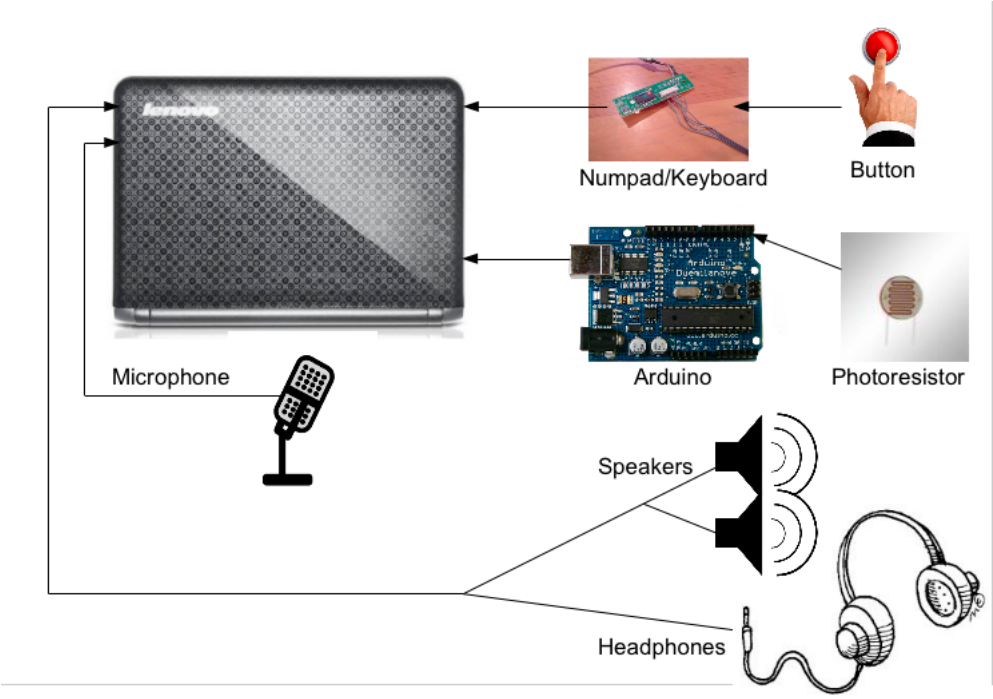

Figure 3.4.1 ArTime 2.0 schema

Following the architecture and the schematic of ArTime 2.0.

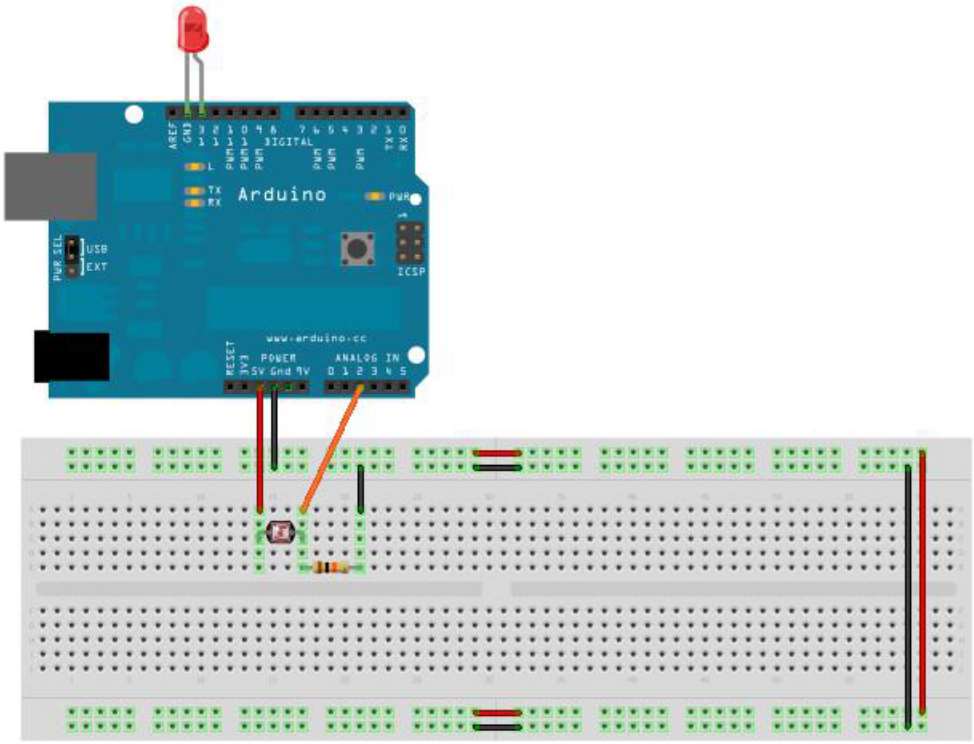

Figure 3.4.2 ArTime 2.0 Arduino system architecture.

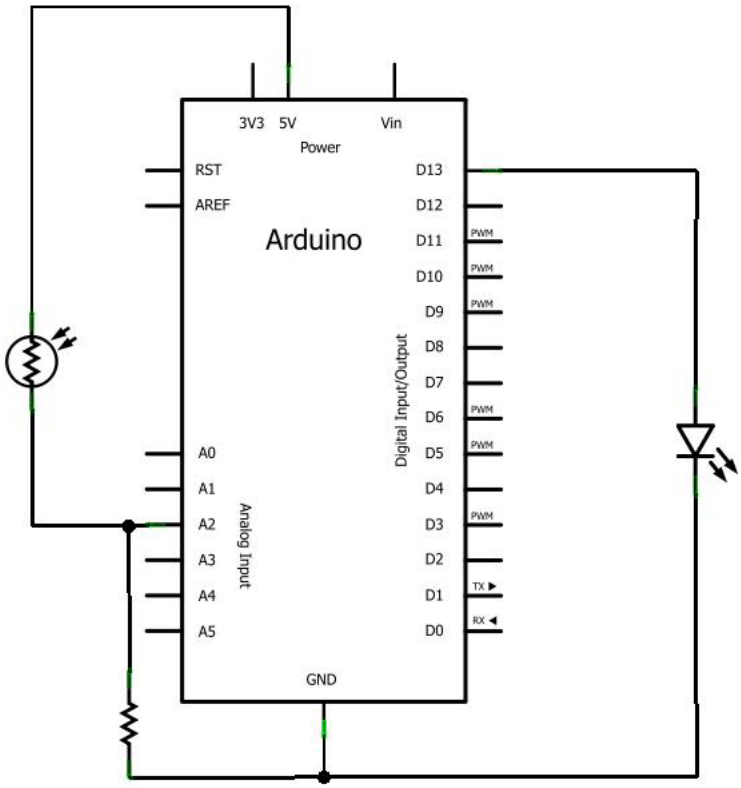

Figure 3.4.2 ArTime 2.0 Arduino schematics

The goal of Arduino on ArTime 3.0 is to display the output text of the application, in addition to the voice output, on the LCD screen (Fig 3.4.2) used during the specialization project. While is it possible to input the installation pro-active behavior only with the voice, is it possible to use both the audio and the visual as outputs, or receiving the installation turnout only in a visual or text form.

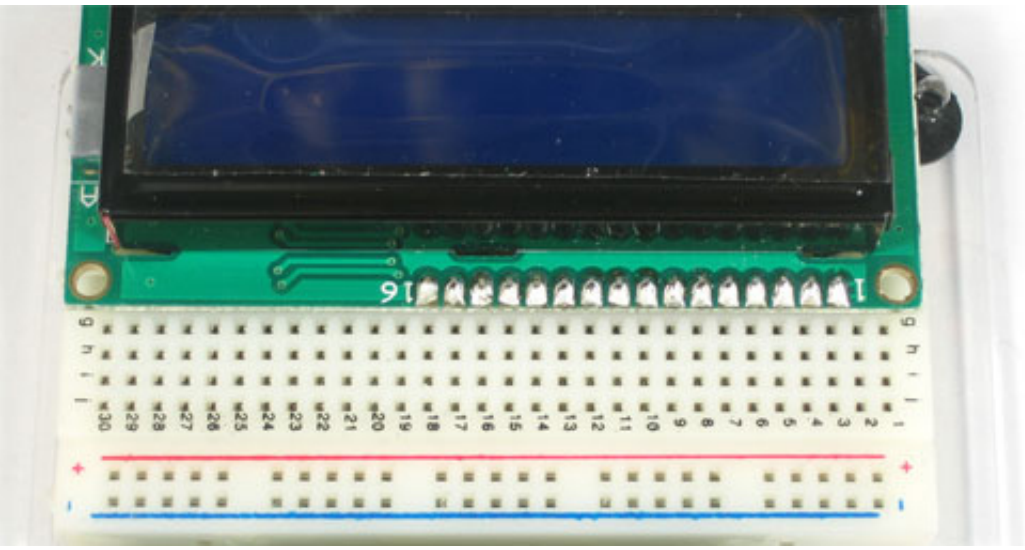

Figure 3.4.3 The LCD screen.

The LCS is a 16x2 (16 characters, 2 rows) lcd screen called HD44780, bought for the specialization project, that I installed on the breadboard. I had to solder the Strip of 0.1" header to the LCD in order to make it work properly.

Since the output signal comes from the application on the computer, I had to transfer the output from the application to a text file, gathering the data from the application output, and giving this data in Input to Arduino.

As I did for the previous project, I used python [22] to manage the output message with the python Serial library to send data to the COM port, then I used the “LiquidCrystal” library to print the characters of the output on the lcd screen from the incoming pacet from python, finally i put Arduino in a “listening” mode:

```
ser = serial.Serial('COM4', 9600, timeout=0)
#Api library Serial to connect to Arduino
text = 'output.txt'


previousDisplay = "";
```

```
while(True):
        #Read from the url address
        display = urllib.urlopen(text).read()
        #If the String is different from the one already said by the
        #Artistic installation I send it to Arduino
        if(blankDisplay != display):
                ser.write(display)
                previousDisplay = message
        #Wait 2 second before checking any input from the visitor
        time.sleep(2)
```

The stun part was that I did not have to change the Arduino LiquidCrystal code used to display the text:

```
#include <LiquidCrystal.h>

LiquidCrystal lcd(7, 8, 9, 10, 11, 12); // Here I define the logic




void setup() // Arduino standard
{
Serial.begin(9600); // Instantiate a serial communication
lcd.begin(2,16);  // Describing the display I have, 16 chars x 2 rows
}
```

```
void loop()
{
if(Serial.available() > 0) // If it is possible to connect
{
lcd.clear(); // Clean the screen
lcd.setCursor(0,0); // Set the cursor to the first position
//Write every character to the progressive LCD position
for(int i = 0; Serial.available() > 0; i++)
{
lcd.print(Serial.read(), BYTE); // print on the LCD
}
}
delay(2000);
}
```

Following the architecture and the schematic of ArTime 3.0.

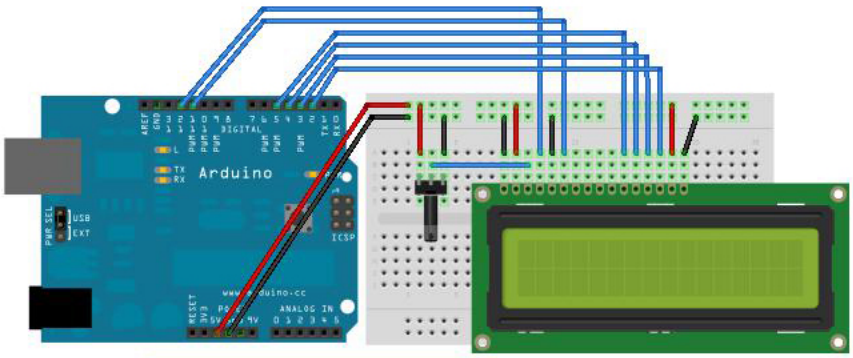

Figure 3.4.4 ArTime 3.0 Architecture

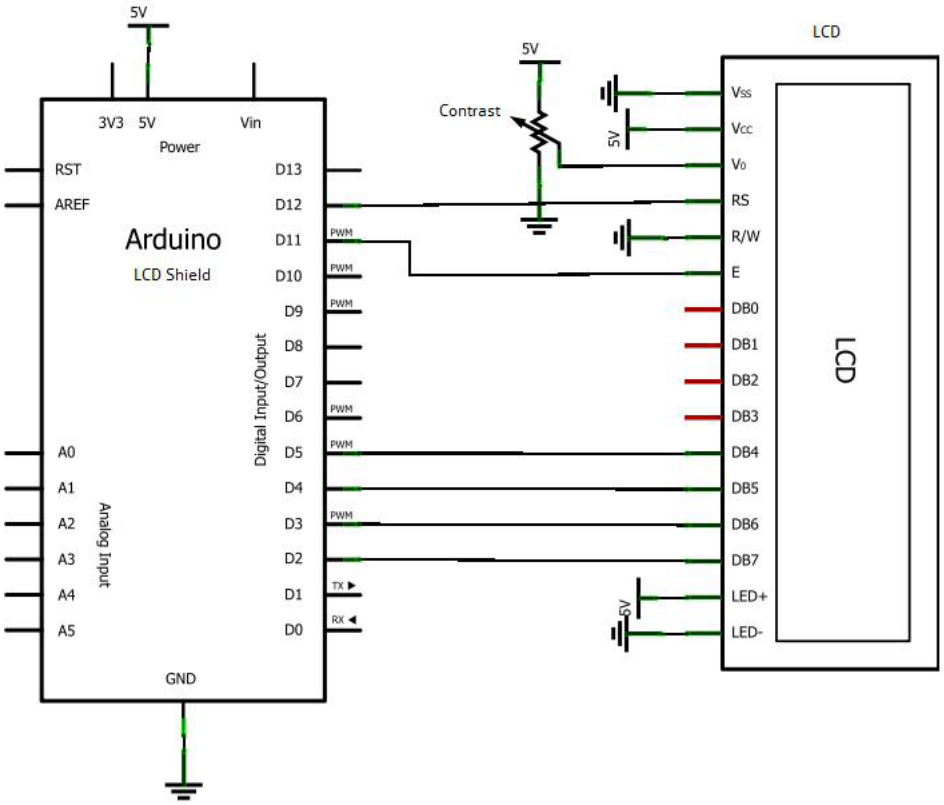

Figure 3.4.5 ArTime 3.0 Schematics

4 Conclusions

4.1 Measures and evaluation of experimental results

Measures are done with two different kinds of users. Those who used the installation without the pro-active behavior tool, interacting with the sounds of the Arduino platform, the integrated microphone and the lights, and those who use the installation provided with the avatar, the language processing and the pro-active behavior, with a total of 30 peopleof different cultural background. A Likert scale is adopted as it is a psychometric scale used in common questionnaires (See appendix B), and is the most used in survey research. For each item of the questionnaire one of the five options is selected by the user:

- Strongly disagree
- Disagree
- Neither agree nor disagree
- Agree
- Strongly agree

Perception of Interactivity To evaluate the degree of interaction of the interactive installation two question has been posed to the users: How much did you feel involved while interacting with the installation? Was this an interaction installation? The participants in the pro-active conditions evaluated this experience as definitely more interactive than the participants in the non-interactive conditions.

User satisfaction The quality of the interaction has been evaluated asking the users their enjoyment during the experience and how much fun did they have [5]. The enjoyment of the users expressed and documented on the questionnaires shows a maximum user-satisfaction

while interacting with the installation within the pro-active behavior, mostly all the participants strongly agreed regarding the satisfaction and participation.

Creative personality This measure affects the new layer of interaction I proposed, assessing the creative personality the users put while interacting with the installation. Two question, "Were you part of the creative process of the interaction?" "Does this piece and pieces like this have a future as industry innovation?" were proposed. How high the pro-active behavior alters their input and participation, and how much they were involved and seen as part and parcel of the installation [6]. All the participants interactive with the installation that used the pro-active behavior answered "Agree" and "Strongly agree" to the question "I affected the behavior of the installation", conscious that what their interaction with it influenced the whole interactive process and the installation itself.

4.2 Conclusions and future work

I wondered about the value of interactivity that is nor automatic neither a click on random buttons and I designed the entire project for a different composition of thought. I focused on interaction between bodies and intelligent spaces, capable of managing informative and interactive systems.

I figured out how effectively the pro-active behavior enhanced the interaction and the user satisfaction with ArTime, and how this new layer of interactivity indubitably exists, and that before it was only hidden by the limitation of the technology adopted. The people involved in the interaction with the artistic installation were visibly astonished about the way they could interact with it, and they revealed it on the Likert questionnaires.

It is a work that has future in interaction design that is needed in museums and science parks, to go beyond the representation of structured information and that try to grasp the essence of a knowledge-based perceptual and emotional impact, immersive and experiential-

based. This experience of research is contextualized within the framework of an evolution of systems of representation, gambled through interactivity. Up to what we call the virtual world against which these experiences of interaction design are propaedeutics.

The next practical improvement that could be done is the introduction of the face-recognition with a webcam on the installation, in order to augment the pro-active attitude of it, by recognising the person that has already come in front of it, greeting properly and remembering the history of their past conversation. It does not create a new layer of interaction, but it fosters the consolidation and evolution of the pro-active attitude experimented.

The e-dimension is producing profound changes: it changes the movement of the optical speed and even more the synaptic function of our brain. It is therefore mandatory to understand the extent to which the psychological dimension takes these changes as a new sensory nature. Any interaction with a particular environment tend to reconfigure the perceptual relationship with the space: it requires a radical revision of the status quo settings but after the first experiences everything is absorbed, exceeds the fracture, displacement, and becomes natural.

It is important to design multimedia environments that are able to stimulate the perceptive dimension through cultural and educational actions that are able to harmonize the cognitive development with the senses.

The conclusions of this work are juxtaposed with a trend that is called edutainment (conjugated with the educational entertainment: the active ingredient of the game and the spectacle): a key to developing new technologies of communication in an evolutionary opportunity, stemming the dangerous drift carried by automatism, and to ensure, through creative design, to compensate the technology with a psychology layer based on the new social and cultural changing in the digital environment.

The digital environment created can thus be contemplated as a new space-time to interact with, creating new forms of relationship that go beyond the ergonomics of the human-computer state towards a degrees of freedom of the body “in action” through the interfaces.

The fact that the graphical interface of an interactive screen can therefore be seen as a threshold for entry into the digital environment, in which the user-satisfaction is a crucial matter, open a rising cultural reflection on the future of the Information Society that has been demonstrated with the settings of the new layer of pro-active interaction discussed in this research.

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Appendix A

Enhancing User Experience in an Artistic Installation with a Pro-Active Behavior

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ABSTRACT
The approaching of user satisfaction in Digital Media is raising new questions and challenges in the interactivity relationship between creator and audience. In this work interactivity is defined as a technology attribute that endows a media environment with the capability of reciprocal communication amidst user and technology through the technology.
The increasing number of artistic installations requires a design that is able to take into account the different possible contexts of use, the goals of users and new interaction technologies.
What are the key focus extents for managing technology based art project?
What I propose is a new layer of interaction, in which the user is viewed as part of the interactive installation, being prompted by its pro-active behavior, redefining the user as a creative source.

Categories and Subject Descriptors
J.5 [**Arts and Humanities**]: Arts, fine and performing.

General Terms
Experimentation, Human Factors.

Keywords
interactive art, user satisfaction, natural language processing, new media technology.

1. INTRODUCTION
The approaching of user satisfaction in Digital Media is raising new questions and challenges in the interactivity relationship between creator and audience. I assert interactivity as a technology attribute that endows a media environment with the capability of reciprocal communication amidst user and technology through the technology. Human-computer interaction is strictly connected to the topic of digital art; it is a discipline whose aim is to give people the power of computers and communication systems using ways and forms that are both accessible than helpful in the creation of an artwork, or for communicational purposes and so on. The increasing number of artistic installations requires a design that is able to take into account the different possible contexts of use, the goals of users and new interaction technologies.
The computer thus becomes more and more discipline-oriented. It is primarily for this reason [1] that the design of interactive interfaces is an experimental activity in which are conceived development methodologies, evaluation techniques, and new approaches such as contextual design are constantly offered.

The principles to be taken to achieve an ergonomic and user-centered design, in which the analysis of the impact of the interactive system on user satisfaction is evaluated, are varied and have been worded differently, but still the first pioneering principle, formulated by Gould and Lewis [2], is a good reference system to which the following formulations is based: Understanding the user. We must make an explicit representation of both cognitive skills and aptitude, and the nature of the cognitive work that needs to be done.

Indeed, a design that can take into account the various possible contexts of use, the user goals and the new interaction technologies are required.
The model that underlies the vision of interactivity is the conversation between two human counterparts. The image that it evokes is of a conversation, erratic and unpredictable, which continues without stopping - and without a discipline imposed in advance – developing in the same way both of the interlocutors' dialogues.

I developed this feature by implementing a pro-active behavior on an artistic installation, called ArTime, seeing how it impacts the user satisfaction and how the interactivity challenges change.

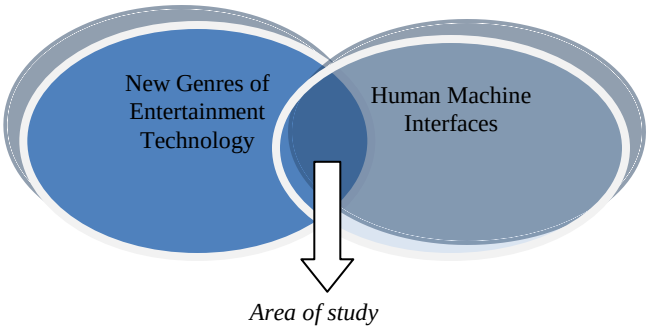
This paper is structured as follow: Section 2 describes the technology and the architecture of the interactive installation; Section 3 presents the research method used to achieve measurements and results. Section 4 concludes the paper.

2. Bulk of the work
ArTime (Figure 1) is made of recycled materials and uses Arduino to interact with the user and has been submitted to the ArTe-competition at the Norwegian University of Science and Technology in Trondheim. It focuses on the interaction between

old and new technology and explores the physical vs the digital domain and uses new media in its sonic and visual expression.

Figure 1. ArTime interactive installation

The project is part of the main project "ArTe" in which the global vision is to disseminate IT issues to Norwegian and International audience with focus on creativity, cooperation, and openness of processes and content. The aim of the project ArTe is to surge the common knowledge about digital art and to increase the awareness of information technology by using the language of digital art [7].
In the ArTe project technology is seen as a possibility to introduce more creativity in life, as well as cooperation and openness[12]. It is based on scientific research documented in papers and books and on spontaneous cooperation between researchers, artists, students, and audience.



Interaction taxonomy – The user role as an active component

Interactivity is not just an evolution of technologies and languages but also the design of the environments through we interact with information and emotions. Beyond the confines of artistic experimentation with new media interactive installations we experiment the conditions of perceptual processes subtly interrelated with cognitive ones. Conditions that stress the value at the lowest possible degree of experiential knowledge.
For centuries humans have focused the development of our cognitive processes based on nonlinear dynamics of the writing on screen and then we reached the audiovisual interaction. Yet we know that our sensitivity is more stimulated by random combinations, simultaneous and non-linear. Our consciousness is dynamic and is enriched by experiential values that concerns the processes of perception, possibly associated with motor activity. Inscribed as experience in our minds the information are received with a higher value.
These considerations are, at a functional assessment of the concept of interactivity, expressed by digital systems in relation to the evolution of perceptual and cognitive set.
The condition raises the interactive practice of the emancipation from the linear dynamics in order to project a new process of psychological development, which can be called "pro-actively influenced", prepared for a continuum association of ideas. The thought makes the action of the reader-navigator-visitor closer to the artistic installation in which we can select the information.
I am going to question the potential of interactive systems for assessing certain aspects that go far beyond the dimension of interactivity within the screen of a computer to capture the characteristics of what can be called interaction design or the design of the modes of interaction: a physical environment, in a public space. It's a key point of reflection on the digital future to probe the terms of a new human interaction with computer systems. The issue is crucial and cannot be limited only to technological models but influences the psychological and cultural collective imagination. It is for this reason that I need a poetic experimentation of these modes to test under playful creative conditions our perception and, consequently, our ability to develop direct experience in a process of interaction.
The design of the new millennium computer-based installation environment raises new questions and processes of discovering the user interaction type. In order to improve the environment sketch, theories and new empirical studies are to be done about how user-satisfaction and innovation design of interfaces occur[9][10].
Interacting with an artistic installation amends the user experience, as being a passive observer does not achieve the same stimulus from the interaction [3].
Edmonds, Turner & Candy enrooted a taxonomy of art categorization onward a continuum of interactivity [4]: art is classified as *static*, *dynamic-passive* or *dynamic-interactive*, in which the static artworks are those that do not include any interactive possibility, dynamic-passive react to the physical environment and dynamic-interactive create outputs corresponding to user's input.
The achievements of this interactive device defy the eye and the ear, creating perceptual events to be considered as the *trompe l'oeil*. In this environment I measure the quality of fundamental research that goes beyond the categories of interpretation of art. It is a matter that is expanding with the new interactive technologies, but by focusing on ArTime, it is exemplary the trick that shows that displacement between the natural and the artificial. This is based on the interaction between physical action of the viewer and audio-video representation, where, for example, the sensors detect noises or voice, determining the necessary input for the responsiveness of the answer: "sensitive areas" where human sensitivity tailor the system with a creative input that knows how to be masqueraded by the technology camouflage

solution.
In this interaction lies the key to understanding the central importance of art history that is interwoven with the history of science human evolution as a whole. The perceptions of what is measured, as always, depends on the technological advancement of science and philosophy and that a fortiori aesthetics that determines the extent of our world.
Our focus is both on technical and cognitive psychology aspects of the interactive artistic installation, then on cultural and aesthetic level of analysis [11].
What I propose is a new layer of interaction, in which the user is viewed as part of the interactive installation, being prompted by its pro-active behavior, redefining the user as a creative source.
"Just as telescopes, microscopes, and cameras are powerful devices that enable discoveries and innovations, they are still only tools; the act of creation is carried out by the users" [8].
The axioms of science and technology is therefore necessary to impact the experience to understand the phenomenology of perception. And that is what is behind this research.

The pro-active behavior

On the screen of the interactive installation it is showed a visual avatar that converses with the user through a software that uses *Natural Language Processing*, a microphone that allows the user to communicate to the installation with a speech recognition technology, a semantic knowledge extraction programming code and a speaker with a text-to-speech technology.
The goal of an intelligent system capable of analyzing human behavior, should be of being able to process, interpret and respond contextually to questions provided as input from the user, providing a satisfactory response even in the absence of a specific answer within the knowledge.
Being able to make correct inferences is sometimes part of a rational agent, as a way to act rationally and think in logical terms, to conclude that a given action will lead to the fulfillment of its objectives, and then act accordingly.

On the other hand, the correct inference does not represent all the rationality, because in many situations it cannot be shown that there is a particular "right" answer to say, but still something must be said.
Human behavior is adapted to a specific environment, and is the product of an complicated evolutionary process largely unknown, which is still far from achieving perfection.

Another important point to bear in mind is the impossibility of achieving perfect rationality, to say the right thing, it is not feasible in the context of complex systems, because the computational requirements are simply too high.
I used the artificial intelligence markup language (AIML) as the knowledge repository, integrating it with an AIML interpreter and knowledge extractor called ProgramD. The voice support is given by a text-to-speech engine prompted by Javascript.


Figure 2. Interacting with ArTime

3. Measures and results

Measures are done with two different kinds of users. Those who used the installation without the pro-active behavior tool, interacting with the sounds of the Arduino platform, the integrated microphone and the lights, and those who used the installation provided with the avatar, the language processing and the pro-active behavior, with a total of 30 people of different cultural background.

A Likert scale is adopted as it is a psychometric scale used in common questionnaires, and is the most used in survey research. For each item of the questionnaire one of the five options is selected by the user::

- Strongly disagree
- Disagree
- Neither agree nor disagree
- Agree
- Strongly agree

Perception of Interactivity

To evaluate the degree of interaction of the interactive installation two question has been posed to the users: How much did you feel involved while interacting with the installation? Was this an interaction installation? Did you enjoy the interaction with the installation?

The participants in the pro-active conditions evaluated this experience as definitely more interactive than the participants in the non-interactive conditions.

User satisfaction

The quality of the interaction has been evaluated asking the users their enjoyment during the experience and how much fun did they have [5].

The enjoyment of the users expressed and documented on the questionnaires shows a maximum user-satisfaction while interacting with the installation within the pro-active behavior,

mostly all the participants strongly agreed regarding the satisfaction and participation.

Creative personality

This measure affects the new layer of interaction I proposed, assessing the creative personality the users put while interacting with the installation. Two question, "Were you part of the creative process of the interaction" "Does this piece and pieces like this have a future as industry innovation?", were proposed. How high the pro-active behavior alters their input and participation, and how much they were involved and seen as part and parcel of the installation [6].
All the participants interactive with the installation that used the pro-active behavior answered "Agree" and "Strongly agree" to the question "I affected the behavior of the installation", conscious that what their interaction with it influenced the whole interactive process and the installation itself.

4. Conclusions

I wondered about the value of interactivity that is nor automatic neither a click on random buttons and I designed the entire project for a different composition of thought. I focused on interaction between bodies and intelligent spaces, capable of managing informative and interactive systems.

I figured out how effectively the pro-active behavior enhanced the interaction and the user satisfaction with ArTime, and how this new layer of interactivity actually exists, and that before it was only hidden by the limitation of the technology adopted within the intersection of art and technology.

It is a work that has future in interaction design that is needed in museums and science parks, to go beyond the representation of structured information and that try to grasp the essence of a knowledge-based perceptual and emotional impact, immersive and experiential-based. This experience of research is contextualized within the framework of an evolution of systems of representation, gambled through interactivity. Up to what I call the virtual world against which these experiences of interaction design are propaedeutics.

The e-dimension is producing profound changes: it changes the movement of the optical speed and even more the synaptic function of our brain. It is therefore mandatory to understand the extent to which the psychological dimension takes these changes as a new sensory nature.
Any interaction with a particular environment tend to reconfigure the perceptual relationship with the space: it requires a radical revision of the status quo settings but after the first experiences everything is absorbed, exceeds the fracture, displacement, and becomes natural. It is important to design multimedia environments that are able to stimulate the perceptive dimension through cultural and educational actions that are able to harmonize the cognitive development with the senses. A trend that is called edutainment (conjugated with the educational entertainment: the active ingredient of the game and the spectacle), is a key to developing new technologies of communication evolutionary opportunity, stemming the dangerous drift carried by automatism, and to ensure, through creative design, to compensate the technology with a psychology layer based on the new social and cultural changing in the digital environment.

The digital environment created can thus be contemplated as a new space-time to interact with, creating new forms of relationship (interaction design) that go beyond the ergonomics of human-computer state towards a degrees of freedom of the body "in action" through the interfaces.

The fact that the graphical interface of an interactive screen can therefore be seen as a threshold for entry into the digital environment, in which the user-satisfaction is a crucial matter, open a rising cultural reflection on the future of the Information Society that has been demonstrated with the settings of the new layer of pro-active interaction discussed in this research.

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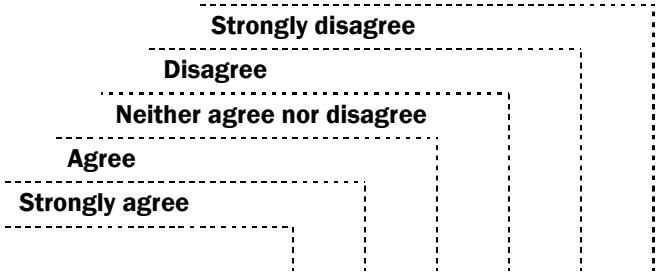
Appendix B

ArTime

Likert Questionnaire

For each item of the questionnaire one of the five options can be selected.



1.	I felt involved while interacting with the installation	1	2	3	4	5
2.	The installation was interactive	1	2	3	4	5
3.	I enjoyed the interaction with the installation	1	2	3	4	5
4.	I would recommend the installation to friends	1	2	3	4	5
5.	I was part of the creative process of the interaction	1	2	3	4	5
6.	I affected the behaviour of the installation	1	2	3	4	5
7.	Does this piece and pieces like this have a future as industry innovation? If agree, in which way?	1	2	3	4	5