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Virtual Trondheim: A Virtual Environment for Tourism and Education

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Master in Information Systems

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Abstract

The purpose of this study is to investigate whether educational activities in tourism can be supported by virtual reality technologies, using virtual world frameworks. Settings of virtual world of SecondLife and a recent Virtual Reality technology known as Oculus Rift were used in the thesis work with the city of Trondheim as the main context.

Theoretical studies on Virtual Reality systems were conducted and data for the research were obtained through empirical studies conducted in Trondheim. Data for this study were collected on the basis of empirical studies on existing prototype which was developed in Fall 2014, with Trondheim tourist office visitors, with tourism professionals such as tourist guide course instructor and students attending guide course. Data obtained were analysed and an improved version of Virtual Trondheim, a touristic educational island, was implemented that include major tourist attractions and some facilities to learn about Trondheim city. After the implementation a further evaluation was done in which respondents filled a form to express their opinions. It was conducted with high school students on Åpendag at NTNU and visitors at tourist office and Vitensenterest. Also interviews were conducted for detailed evaluation with tourist office employees and with students at NTNU(Norges teknisk-naturvitenskapelige universitet).

The results suggests that virtual reality systems have a potential in tourism industry. The Virtual Trondheim in the virtual world of SecondLife have possibilities to use it as an educational tool in tourism industry and also it can be useful for the tourist as an information source. In addition it is possible for the tourism professionals to use the system as educational aid and for the promotion of the place. Yet another possibility is that this can be useful for students to learn about the place in general.

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Chapter 1

Introduction

1.1 Project Significance and Motivation

Virtual Reality and Virtual Worlds are getting popular nowadays and has got many applications in different fields of Science and technology, in gaming and education. We can see that these type of systems can be used in education in order to teach or share knowledge [1]. Virtual reality can be defined as a technology which can create computer generated domain that provide an immersive effect so that people can explore the environment and interact with the contents visualised there [2].

Gigante, Michael A, the author of the book "Virtual reality: definitions, history and applications", had given a definition for virtual reality as: "VR is characterized by, the illusion of participation in a synthetic environment rather than external observation of such an environment. VR relies on three dimensional(3D), stereoscopic, head tracked displays, hand/body tracking and binaural sound. VR is an immersive, multisensory experience"[3]. The article, Learning in Virtual Reality, authored by Bricken, William, explains how virtual reality can be used for education, especially for teaching purposes. Here author describes that through virtual reality it is possible to teach something to the students through virtual experience. VR provides an immediate sensing experience to the user. A student can understand what he heard and visualised without further explanation of the same. Here the teaching is through VR experience [4]. Also the paper "Virtual Reality for Education" by Allison and Hodges, describes how virtual reality systems can be used for education using their Virtual Gorillas Project works and evaluation methods[5].

In the book "Designing Virtual Worlds", Bartle is defining virtual world as "Virtual worlds are places where the imaginary meets real". It is a computer simulated environment that can share and be used by multiple users synchronously [6]. Virtual worlds can provide better understanding and support variety of activities. These help learners to understand or provide more awareness through collaboration and thus can complete the work successfully[7]. Also Whitton is describing in his book about these type of multiuser virtual worlds for learning[8]. The paper by Maria Roussou, "Learning by Doing and Learning Through Play: An Exploration of Interactivity in Virtual Environments for Children", investigates immersive virtual worlds for children, that helps to educate them with interactive learning through play, immersion, story telling and illusion [9].

A special type of virtual reality environment that uses computer generated virtual worlds are 3D Collaborative Virtual Environments (3DCVEs). In the paper "Collaborative Virtual Environments in education", the author specified different applications of virtual reality systems in education. One of the application is "Multi-user, distributed worlds" which helps multiple users to work together from different physical locations. He pointed out that these distributed worlds, otherwise called as collaborative virtual environment, can be used for education [10].

In the paper "Place metaphors in educational CVEs: an extended characterisation" the author is describing CVEs as, "A Collaborative Virtual Environment (CVE) is a computer-based, distributed, virtual space where people can meet and interact with others, with agents or with virtual objects"[11]. Collaborative virtual environments can be used in educational settings and can support learning communities. It helps for information sharing, enhance communication between learners, improve awareness and can provide a virtual space for various activities such as meeting places, exhibition and demonstrations and also can act as a sharable workspace [12]. Also in many occasions collaborative learning is more beneficial than single user learning since it helps understand the context very well by working together. [13, 14]. CVEs allow creating contents in the environment by the users itself and can be shared with other users and used collaboratively for different purposes. Also in the environment users can interact in a way such that they get a feel of sense of presence as that in the real world situations[15].

SecondLife is a type of 3D Collaborative Virtual Environment that recently become popular for educational purposes. In the paper "Virtual research arena: presenting research in 3D virtual environments" the author is describing SecondLife as, "It is the most successful 3DCVEs that helps learning communities to work collaboratively and to explore different possibilities in the field of education and training"[15]. It is argued in the book[16] that SecondLife is a multiuser virtual world that can be used for educational purposes since it can provide a realistic experience with virtual reality techniques and reduce the barrier of physical existence between students and the teacher.

In the book "Learning with digital games: A practical guide to engaging students in higher education" it was explained that "there has been rapidly growing interest among educationalists in recent years regarding the potential for learning three-dimensional immersive virtual worlds such as Second Life. These worlds allow participants to interact with one another in a vast multi-user virtual space, where people create their own representations, or avatars, and can move around, interact with objects and locations, talk to other people and even create their own objects and environments"[8].

From my studies on virtual reality and virtual worlds, it was found that virtual reality can be used for tourism purposes and there are virtual worlds that create educational and touristic destinations. Virtual reality techniques are having so many applications in the tourism industry. Guttentag in his paper "Virtual reality: Applications and implications for tourism " describe briefly the applications of virtual reality techniques in the tourism industry and also about the benefits of using VR in the tourism industry [17]. The paper "Defining the virtual tourist community: Implications for tourism marketing" explains how the travel industry can make use of virtual reality techniques and virtual communities for different purposes [18]. Also the virtual world SecondLife contains virtual environments or otherwise called as islands that are created with touristic and educational preferences [19].

These were the motivations to do this particular thesis about VR and virtual worlds that have quite vast possibilities in the tourism and educational fields.

1.2 Target Audience

This project is principally targeted to the people those who have interest in exploring different places i.e the tourists those who are interested in visiting places and learn from their visits. Another group of target audience were tourist guides who can use the system as an educational tool in their tour guidance course. In addition, another group of audience were the students that are fascinated with virtual reality systems and virtual worlds, that provide an exciting learning experience. In addition, it can also apply for those who are interested to use new technologies such as virtual reality systems for tourism and education. It is possible to access the project online and have an experience with it. The chapters presented here include both technical and nontechnical sections. Even though the system is complex in its implementation chapters, it should not be hard for non technical people to follow it.

1.3 Project Goal

The main goal of this project was to investigate on how virtual reality systems and virtual worlds can support educational activities in tourism. Here there is an analysis on how it influences tourists activities and tourism industry, how it could be used for educational purposes in professional tourism, Will it could be used to educate students and how it can be beneficial to those who are interested to learn through experience and play. Also another major goal was to analyse the effect of these kind of systems for different age groups. The reader can gain knowledge about this new technology of play and learn.

1.4 Report Outline

Chapter 2 explains the research methodology followed for this particular thesis work. Here the entire research process execution is specified. This includes Motivation of the project, Literature Review, Existing system description, Research question and the descriptions, Research Strategy followed and the Final system.

Chapter 3 discusses the literature studies conducted for the project together with the examples of similar projects. This Literature Review and Theoretical considerations chapter includes theoretical studies on Virtual Reality and Virtual worlds that support learning and Tourism and the examples of Virtual cities that supports education and tourism. Major trends in similar virtual cities and the analysis from

Literature review are also explained.

Chapter 4 describes a detailed explanation on general background of the work that includes SecondLife, existing prototype explanations and about the tools used like Blender and Oculus Rift.

Chapter 5 presents the pre study that had done during the initial phase of the project. It includes Interviews with tourist guide instructor, Demonstration of the system to the visitors at tourist office, demonstration of the system to students from tourist guide training program.

Chapter 6 describes about the requirements emerged out during the pre-studies.

Chapter 7 contains a detailed explanation of the implementation of the prototype together with some problems encountered during the implementation.

Chapter 8 presents the evaluation conducted after the implementation and the results obtained.

Chapter 9 gives an overview about the pre studies and post studies, the result analysis and shows how the research objectives has accomplished. Also it presents improvements and suggestions about the system, some findings from the work and the limitations of the system.

Chapter 10 outlines the conclusion and the future works.

Chapter 2

Research Methodology

The research approach for this thesis is presented in this chapter. Here an iterative process of research methodology was followed and this particular work was based on the specialization project "Virtual Trondheim" implemented in Fall 2014[20]. Specifically this is an improvisation of the already developed environment of Virtual Trondheim by the author itself, but having more wider analysis with the virtual world and virtual reality systems in tourism and education fields. One target group was tourist guide-students who were doing the tourist guide course in Trondheim. The goal was to investigate the usage of the system for educational purposes. Another target group was tourists, who were the common people that have an urge to travel and explore different parts of the world.

The work started by doing the literature review and with the studies on existing framework that was completed in Fall 2014. The findings helped to continue with the same systems and to make improvements on the same, so that the research can extend to a wider perspective. The research question was formulated and conducted empirical studies followed by data analysis and requirement acquisition. As per the initial requirements, improvements were made on the prototype and got the final system evaluated to prove the research question. The overall process is shown in 2.1

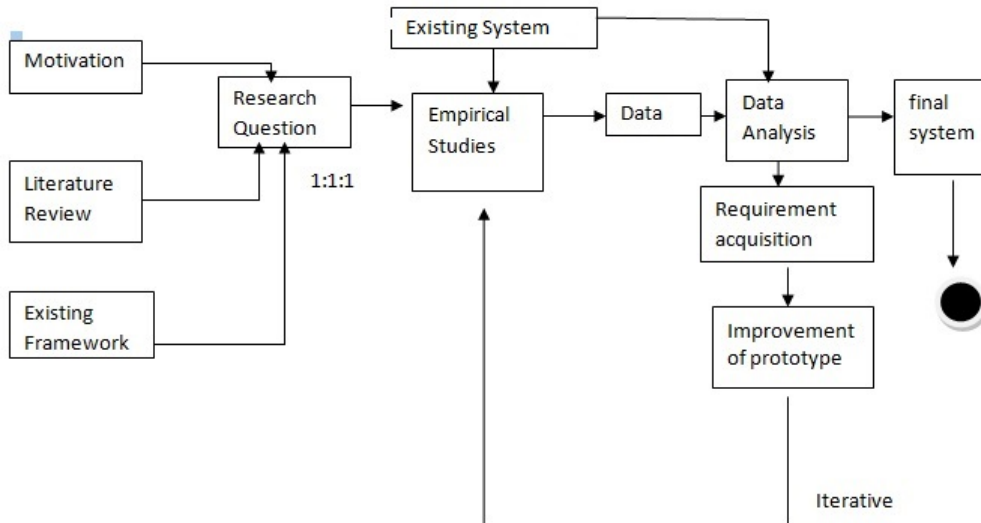


Figure 2.1: Research Process

2.1 Motivation

During my theoretical studies on new trends in computer systems, it was identified that virtual reality systems are expanding nowadays and have potentials in the future. The attractive part of VR system was that we can learn with fun incorporated, by experiencing an illusion of a reality, rather than reading a book[3]. And further search process resulted in study about the projects that started at NTNU such as Travel in Europe[21] and Virtual Campus of NTNU [22]. These projects were mainly concentrated on virtual reality systems and collaborative working environment. Based on these projects, a further study was conducted on possibilities of SecondLife and virtual reality systems. From this, the idea of touristic destination emerged and a prototype of Virtual Trondheim[20] was implemented in Fall 2014. Analysis made on this project helped to broaden the same idea and motivated for further research.

2.2 Literature Review

The work started by studying the literature related with Three Dimensional collaborative virtual environment, the possibilities of SecondLife and virtual reality tools. From my theoretical studies it was found that there are educationalists and researchers working on the same field to investigate the applications of virtual reality techniques in the educational field [23, 24, 25]. Also there are various possibilities

in educational tourism and have different applications of VR in tourism [17]. Many studies were being conducted on VR to use it as a tool for heritage preservation [26, 27], as training tool in both public and private sectors and as an information and educational source [28]. The literature studies mainly contain the theoretical studies about the virtual reality applications in education and tourism fields [17] and possibilities of SecondLife in education [29, 30]. Literature studies were conducted via online and from university library, by reading the articles and papers submitted by the researchers and educationalists in the same field.

2.3 Research Question

The thesis work was mainly concentrated on the development of a 3D Model of The City of Trondheim Norway, with Virtual Reality technologies, that can influence educational tourism and to analyse the influence of such a city for professional tourism and tourists in their touristic activities. Accordingly, the main Research Question was formulated as follows:

RQ: How could the educational activities in tourism can be supported by virtual reality and virtual worlds, in the context of Virtual Trondheim?

This question was chosen since it was identified from the literature review that virtual worlds and virtual reality techniques have great potentials in the field of tourism and education. Also from the studies on the existing system, it was spotted out that virtual environment can enhance the learning possibilities and the public is interested to experiment new VR technologies. It can act as educational resource and people can enjoy learning through virtual reality since this is a kind of game play with users as avatars in a virtual city. In addition I believe that VR Technologies are beneficial for people who prefer to visit cities like Trondheim to know about its culture and tradition and also for the people that is searching for the possibilities of learning accompanied with fun via social networks because of the limitations of time, money and health for a real visit. So I suppose this research study can be beneficial to people who are interested in the fields of both tourism and education.

The main research question can be decomposed into sub questions:

RQ1: What are the requirements of Virtual Trondheim to support educational activities for tourism professionals and the tourist?

From the preliminary studies, we can see that virtual reality techniques have great

potential in the future tourism industry and educational fields. Tourism Professionals are the people who works for tourists who visit particular places of interest. The tourist guides and tourist office employees together form tourism professionals. So the environment should contribute to both tourism professionals and the tourists. Also it should be helpful for educational purposes. Here the virtual reality techniques can be applied to tourism, which helps the visitors to learn from their visit. The requirements should be formulated on the basis of tourist attractions that are valuable within educational field. In the mean time the environment should contain valuable contents that can be beneficial to tourism professionals also.

RQ2: How can we design and implement Virtual Trondheim environment as per the requirements?

In order to satisfy the requirements of both tourism professionals and the tourists, the environment should be designed in such a way that it can be beneficial for both. To implement virtual city of Trondheim for educational purposes with preferred tourist attractions, the real Trondheim city should be considered as the basic scenario and need to acquire knowledge about major tourist attractions, public interests, culture and tradition of the people here. Also we need to consider the attitude of the people towards new technologies, emerging trends, usability and usefulness of the system and should maintain the quality and level of detail of the environment. Also the possibilities and potentials of implementing such a system should be considered seriously. In the same way to use the environment as a tool for the tourism professionals, the major tourism industry needs should be considered which helps professionals to promote their own place to the tourists and also to use the environment for their primary tourist guidance activities.

RQ3: In what ways the Virtual Trondheim environment can support tourism professionals and tourists?

The challenge here was to inquire the influence of Virtual Trondheim on touristic activities and tourism professionals. It is important to find out the usefulness of the particular system in tourists perspective and tourism professionals perspective. Also to find out the educational benefits of the system in much wider perspective that includes general public, students and virtual communities.

2.4 Existing System

Studies were conducted on Virtual Campus of NTNU project [31] in NTNU island that mainly consist of NTNU campus buildings, Forsknings torget and Studentersamfundet during the specialisation project in Fall 2014. From this a new prototype of Virtual Trondheim was implemented in Fall 2014. Again studies were conducted on this implemented prototype of Virtual Trondheim which was a 3D visualisation of Trondheim with famous tourist attractions such as Nidaros Cathedral, Trondheim Royal Palace and Vårfrue Kirke in the same NTNU island. Also theoretical studies were conducted with other virtual cities in SecondLife, that are of touristic importance and can be used as an educational resource. All these prestudies conducted with the existing systems helped to acquire requirements for improvements so that a new improved version of Virtual Trondheim can be constructed with contents that can be valuable for both educational and tourism fields. Also it can be improved so that the scope for using it for educational activities in wider perspective can be fulfilled.

2.5 Research Strategy

Research Strategy used for the thesis was as follows. Initially the prestudies was done on existing system followed by data collection, data analysis, requirement acquisition and improvement of prototype which follows an iterative process, then resulted to a final system after the evaluation to prove the research question. The prime aim was to evaluate the existing system and to analyse it in the perspective of tourists and tourism professionals which includes tourist guides and other employees. Theoretical studies were done on virtual worlds and its educational possibilities, particularly with SecondLife and its possibilities. Also studies were conducted on virtual cities, applications of virtual reality in tourism, virtual reality techniques and tools and the relevance of VR technologies in education through literature review. Furthermore, performed virtual tours through various educational and touristic destinations in SecondLife.

Empirical studies were conducted by arranging interviews and questionnaires with tourism professionals and the tourists at Trondheim tourist office. The members include Tourist office employees, the tourist guidance course instructor, tourist

guides that completed their tour guidance course and the tourists that visits Trondheim tourist office. In this process an explanation was given about virtual reality systems and SecondLife in particular, and about the existing prototype of Virtual Trondheim. Semi-structured interviews were conducted and asked for their opinions to do improvisation which can help to attract more tourist and to use the system for professional touristic activities. These studies helped to evaluate the system and to acquire requirements for Virtual Trondheim.

From the proper evaluation of the opinions and comments, the requirements were formulated. Direct observations of the participants' activities and their comments about the system helped a lot to understand about the interest on the system since attitudes can be easily captured from their behavior to the system during the practical sessions. Data collected from detailed interviews, surveys and demonstrations were analyzed qualitatively and quantitatively. Quantitative data analysis was done by the evaluation of the data obtained through questionnaires with the help of graphs. Qualitative data analysis was done by transcript of interviews, and by understanding and observing the people and their interaction with the technology and tools. From the analyzed data, requirements were formulated and implementation was done. After the implementation of the requirements a further evaluation was done on the basis of that and has concluded about the influence of virtual reality and the virtual Trondheim for educational touristic activities.

2.6 Final System

In accordance with the requirements acquired, implementation was done and the completed work was assessed to ensure that the aim of research proposal is accomplished. The evaluation of data and prototyping was an iterative process, which was followed by concluding the process with analysed data to prove that the research objective has been accomplished.

Chapter 3

Literature Review

The following sections in the chapter explain my theoretical studies during the initial phase of the thesis work. The study was based on objectives of research works which have to be accomplished after the implementation. A detailed study on Virtual Reality techniques that support education and tourism was conducted. In addition, similar works were considered and analysis was done to identify the major trends in this field.

3.1 Virtual Reality and Virtual worlds supporting learning

It is recently common to learn through experience with virtual reality and the design of virtual worlds with educational perspectives are expanding nowadays. In the book "Designing Virtual Worlds" the author Bartle is explaining the difference between virtual reality and virtual worlds as "Virtual reality is primarily concerned with mechanisms by which human interacts with computer simulated environments". For e.g. The computer simulated environments can be experienced by head-mounted devices such as Oculus Rift. Virtual worlds are computer simulated environments where users are considered as its inhabitants [6]. This means virtual reality environments are a type of virtual world by which human uses virtual reality techniques to interact with it.

Virtual Reality environments have possibilities to improve learning experience with its high potential of immersive effect and the possibility to learn through play [8]. The paper "Virtual reality and mixed reality for virtual learning environments"

explores educational uses by illustrating possibilities of virtual learning environments using several examples. One of the example is an immersive training scenario that creates a model of a US soldier who take part in peace-keeping mission in Bosnia [32].

In the paper "Presence: a unique characteristic in educational virtual environments", TA Mikropoulos investigated the effect of presence on learning outcomes in educational virtual environments and he presented a graphical representation for personal presence, social presence and involvement mean values for all cases of his studies on the pupils. And he confirms that "the content of the Virtual Environment together with specific learning tasks is an important factor affecting presence and task performance" [33].

There are possibilities for online learning with virtual reality and collaborative environments. The paper "Virtual reality for collaborative e-learning" explains that with the popularity of Internet as an information source is increasing, many online resources are available for "e-learning" [34]. Also it is illustrated that the collaborative e-learning system has possibilities in the future that allows students to communicate with each other and also with instructors, thus enhancing the communication between them, helps in socialising and also to learn together online. Virtual Reality technologies can make students more aware about the situation by visualising the classroom environments with their classmates available online and to communicate with them without considering the physical locations they are available in the real world[34]. This paper also explains how the virtual environments can support e-learning with their studies on "CLEV-R a Collaborative Learning Environment with Virtual Reality, which is a web-based multi-user 3D environment" [34].

In the paper "Overview of Virtual Reality Technologies", a variety of new virtual reality devices such as Oculus Rift were explained. It describes how it can be applied in educational settings also so that the user can understand the concepts in better way [35]. Education can be supported through learning spaces such as virtual worlds that uses emerging immersive technologies such Oculus Rift [36]. With Virtual Reality devices such as Oculus rift the person feels that he is getting immersed in the world which is a representation of the real world, through the computer interface. There is a feeling of getting immersed into an environment that is created

based on a real life environment with Head Mounted Displays [37]. Also the article "New landscapes and new eyes: The role of virtual world design for supply chain education" explains experiments with two setups, using Second Life and Oculus Rift Head-Mounted Display (HMD) and showed qualitatively how the virtual worlds and virtual reality technologies support learning and how it can facilitate the learner an awareness about the concepts he learns, rather than reading text books [36].

The paper "Immersive training systems: Virtual reality and education and training" explains the VR Techniques, its possibilities and usefulness in the field of education and training. It is explained that VR technology can improve immersion and has the potential of "multi sensory integration" that promotes learning, with real life training example of Training NASA flight controllers [25].

VR is helpful for educating students of different ages in a variety of subjects, including history for e.g. Museums, heritage and other tourist sites, since there is sense of presence with fully immersion mechanisms, that helps to involve and remain engage in their studies and they can learn fast through VR techniques[17]. In the paper "Reviving the past : Cultural Heritage meets Virtual Reality" by Gaitatzez, Christopoulos, Roussou, it is depicted that VR technologies, both hardware and software, can be used efficiently in a number of educational programs. It is possible to reconstruct the historic places and visit those places with VR techniques, can examine archaeological details, culture and traditions which are relevant in the field of Historical science [26]. Also heritage preservation can be done through virtual reality techniques and can be used for educational purposes in order to explore and do the research for the same. Here author is describing this method as 3D Documentation and 3D representation [27].

There are educational possibilities with virtual worlds and collaborative environments. Collaborative virtual environments are a special type of virtual worlds, where the users share knowledge of a particular 3D environment or world, through a computer network [38]. SecondLife is a type of 3D collaborative environments where users can work collaboratively [15] and a "most popular multiuser platform used for education" [29].

The paper "Virtual Worlds and Education" by Peter Twining, illustrates about the educational possibilities of virtual worlds like SecondLife, with users represented

as avatars and interact with each other over the Internet. Also in this paper he argues that "Virtual worlds may provide opportunities to engage learners in activity which is 'more real' than anything they typically experience in their physical world schooling" [39]. The book "Learning and teaching in virtual worlds of SecondLife", the author describes elaborately, about the possibilities of virtual reality techniques and virtual worlds. This book gives a theoretical foundation about SecondLife environment, about its learning and teaching potentials with some examples. There are explanations about educational environments, that help to motivate students and teachers in their educational activities and also about its effects on their performances in various tasks and responsibilities[16].

Whitton describes SecondLife as follows:"Use of multiuser 3D virtual environment such as SecondLife for learning has increased greatly in recent years, since it have the potential to create interactive and exploratory environment. This is a type of serious game and can be used as instructional tool effectively" [8]. Also he is believing that SecondLife can be considered as a game framework for learning because of the immersive nature of the environment and the game-like graphics and interaction it employs. Students can experiment their ability to create contents and they can explore island by navigation, meet and collaborate with each other by joining in communities, in the virtual space provided as educational islands. Here collaborative learning is possible, students can work together to achieve the tasks and can act as educational media. But this can have some disadvantages like lack of privacy, bad reputation because of certain typical behaviour of the environment [8]. Livingstone D arguments in his paper says that there is an increased use of virtual worlds and Second Life in educational field and virtual environment can benefit more in terms of teaching and learning with chat rooms and lecture rooms for live meetings [40].

There are different universities and institutions for learning in SecondLife, with their own virtual islands and resources for tutoring practices and other educational disciplines [41]. The science circle, which is an alliance of scientists and educators who gather in SecondLife on a grid and participates in discussions and presentations. They share knowledge and provide a forum for the exchange of ideas from different disciplines[42]. Also another example is Stanford university, a virtual library in

Second Life that was developed by "Stanford University's Libraries and Academic Information Resources (SULAIR)", where we can see and experience the possibilities of this virtual university [43].

In SecondLife we can find majority of destinations for tourism and education such as virtual cities[41]. In the paper "Virtual research arena: presenting research in 3D virtual environments" author conducted empirical studies to design a virtual city guided by an existing virtual city, The city of Yoshkar Ola (VCYO), which is a city in Russia. "VCYO is a multiuser virtual environment representing the central part of the real city designed same as that in real physical world, with buildings, streets etc" [15]. The paper "Virtual City as a Place for Educational and Social Activities" author conducted a study on virtual cities, how it can facilitate learning and socializing by means of VR techniques provided by the 3D virtual world of SecondLife. In this paper virtual city is defined as "an environment representing a real or fictional city and supporting a range of different activities for the purposes of education, cultural development, entertainment and socializing for local communities and virtual tourists" [44]. Also there is a proposal of initial design of the city of Trondheim in the paper [45] with some major buildings, based on experience from two projects Travel in Europe and Virtual City of Yoshkar-Ola. Another possibility with this type of virtual city is attracting potential tourists and providing information about the city [44].

3.2 Virtual Reality and Virtual worlds in Tourism

Virtual Reality can contribute to tourism in a number of different ways. Guttentag in his paper, "Virtual Reality: Applications and Implication of tourism", depicts applications of virtual reality techniques within tourism sector such as planning and management, education, entertainment and marketing areas since VR techniques are progressing nowadays [17]. In a Teaching and Learning Forum 2014, it is explained that with the introduction of new VR technology device, Oculus Rift, a low cost head mounted display, the feasibility to introduce virtual environments are expanding and "there is a strong potential for applications using the Oculus Rift (or future HMDs of similar quality) in education, training, entertainment, and tourism "[46].

In the book "Information and Communication Technologies in Support of the

Tourism Industry" the author is describing about several virtual reality applications that includes applications in tourism for virtual tours to specific destination, its marketing possibilities and the potentials for heritage protection [47].

Guttentag in his paper "Virtual Reality: Applications and Implication of tourism" explains what is virtual reality in general, analyse primary uses for VR within tourism, the possibility of using VR to have some tourism experiences even if it cannot be a substitute for real tourism. The potential uses of VR in tourism should be exploited since it has opportunities in the future and also suggests numerous ideas for future research related to VR[17].

Many tourists are now using Internet as one of their tool to search for queries in travelling. In the paper "Searching for experiences:The Web-Based Virtual Tour in Tourism Marketing" it is implied that through the virtual tours, the visitors get more travel information about the place and helps both travellers and tourism organizers to communicate well and provide appropriate information [48]. Also the paper "Defining the virtual tourist community: implications for tourism marketing" explains how the virtual communities can pave a way to travel industry that can make use of virtual reality techniques and virtual communities for different purposes that also includes their marketing business since Internet is now dominating the global economy [18].

In the paper "The virtual threat to travel and tourism" author is describing about virtual tourism and explained that it can serve as a powerful tool to enhance tourism such as for the "formulation of tourism policy and tourism marketing" to use it as a marketing tool for the travel agencies. VR have more advantages over traditional brochures in marketing" that helps the tourism sector to encourage people for a real visit [49].

In the paper "Virtual reality and tourism: fact or fantasy?", it is described that tourism industry will use VR techniques or will be challenged by VR in three areas such as for the creation of virtual theme parks for entertainment, use of VR as a sales and promotion tool and for the creation of artificial tourism [50]. In the paper "Sustainable tourist space: From reality to virtual reality?", Jean-Michel Dewailly explains the possibilities of VR in tourism. VR is becoming important in tourism as a tool for tourism promotion and as a tourist destination [51].

The paper "Searching for experiences: The Web-Based Virtual Tour in Tourism Marketing" examines the effects of "Web-based virtual tour on tourism marketing" and explained the properties of virtual tour. The paper discusses on utilizing the web-based virtual tour for marketing the tourist destinations by various tourism organisations [48]. The paper suggests that "virtual tours: (1) Enable tourists to effectively translate experiential attributes into "objective" evaluation criteria; (2) Provide the basis for more efficient information search; (3) Provide more extensive/rich information thereby increasing the quality of the destination image; (4) Increase users confidence of expectation, and (5) Increase visitor satisfaction". Also this helps the tourist to evaluate the destinations and to avoid risks in decision making, and they can find destinations of interest and can memorise in a better way as a story in their mind. This kind of virtual tours are cost effective too [48].

Guttentag also pointed out that the potentials of VR in education are exploiting by different tourist sites. He states that it can educate tourist and can also function as an investigating tool to gain knowledge about the tourist attractive sites by providing examples worth in this area such as exhibitions by Greek Cultural institution, a 'Virtual Reality Gorilla Exhibit' by zoo Atlanta etc. He also provides many examples of VR entertainment applications in Tourism sectors such as Dream world Theme park, Aladdin's Magic carpet studio in Disney Quest, VR theme parks etc. Also there are several examples mentioned in the paper about the Heritage preservation sites with VR techniques [17].

There are existence of virtual communities nowadays since people are using Internet as a primary tool for their commercial online activities and for travel assistance [17]. There are possibilities for virtual tourism to advance over time and can gratify some of the tourists' demands for travel experiences. With VR, poor can also access rich touristic destinations using Internet, even though it does not provide a full sense of presence of the place[51].

In an article of rough guides, Mr. Steve Vickers write about virtual reality applications in different fields. There is description about the potentials of a virtual reality device 'Oculus Rift' with travel, for those who are unable to travel, it can act as a tool to explore the new world. He has shown a video of an old lady who is not able to travel or even walk in the room as she was suffering from Cancer, using

the Oculus Rift and virtual world, exploring the new world and have enjoyment, get a temporary relief [52]. There is also explanation about using virtual reality technologies by pilots, geologists, and architects. "The travel industry is also making use of VR, holiday companies have plan to use this. When compared with staying in one place, because of money troubles, or illness, or fear of flying, or work, or any of the other stuff that life throws at us, travelling virtually still holds a certain appeal" the article says. Also the article describes potentials of VR and some virtual tour applications like Virtual Egypt, Virtual Eiffel Tower and a Virtual Snow in Dubai [52]. VR and Virtual worlds can offer a chance to explore the world for the people with lifelong disabilities and hence there is a need for proper investigation about the usage of VR technique such as SecondLife so that it might be helpful for them to reduce loneliness and enhance communication [53].

In the paper "Immersive Guided Tours for Virtual Tourism through 3D City Models", it is described that VR systems allow users to explore virtual world in an immersive manner. "Through the 3D city representations using HMDs, the tourists can visit places by natural locomotion". In this paper, the author explains the virtual tour possibilities with the use of Oculus Rift for 3D immerse effect and Kinect sensor devices for the virtual movement mechanism, in a 3D virtual environment [54]. "Tourism destinations are hoping, the new technology will act as a lure; by giving a taste of what they have to offer, venues hope to attract new tourists and their money". There will be great value to this technology, when it comes to tourism marketing[55]. Virtual reality headsets like Oculus Rift can help to see the places we want to visit virtually and in immersed mode and "lure us" to visit the particular place in real[56].

3.3 Virtual Cities that supports Education and Tourism

This section describes significant similar projects in the virtual world of SecondLife. Inspiration to add some relevant elements that can support the research objectives were identified from the studies of these similar projects. These projects have different objectives such as for entertainment and fun, for educational aspects and for using it as tourist destinations. Also there are a variety of virtual cities of

touristic importance created in Second Life that are real replicas of famous landmarks and locations.

3.3.1 Roma

Roma is a 3D visualisation of Ancient Rome that helps to carry out more research studies about the historical aspects and the way of life in Ancient Rome. Roma is the representation of Roman empire in SecondLife and has been opened since October 2006. It is functioning with large number of residents, more than thousand active members, as well as twenty associated groups, and so many different attractions which are always open to the visitors. It is not an exact replication of the original Rome. But it is built up based on roman architectural forms and represents roman culture and several archaeological backgrounds. This particular island has the main objective of using it for educational purposes by including several components that are useful to study about ancient roman culture. In the island we can see forms of ancient virtual inhabitants representation carrying some information for the visitors. Also there are some gaming elements by which the visitor can follow so that he can get some historical information about ancient Roman culture. Also there are role playing possibilities for the visitors since this environment can provide immerse effect and the residents feels that they are citizens of ancient Rome. It is also possible to join in different roman communities and participate in various social events[57, 58].



Figure 3.1: Ancient Roman Themed land in SecondLife

3.3.2 The 1920s Berlin Project

In SecondLife, this project is the recreation of the real 1920 Berlin and it shows the marvelous modern houses where modern rich people have a life in the latest fashion with leisure and also shows the messy and polluted, narrow streets with small apartments where the poor people struggle to survive. "Berlin in the 1920s was a very interesting time, politically, culturally and in many other ways"[59]. There are visualisation of old train stations, post offices, orphanages and hospitals. Also we can see old museums, city center and churches in old Berlin. Also many practical information regarding the buildings and also about the virtual tours, were provided using the notecard messages. Also there were representations of humans in the past such as newspaper boy, real estate supporters and several shopkeepers.



Figure 3.2: The 1920s Berlin Project

The 1920s Berlin Project offers the visitors a chance to explore the different places in Berlin and it is possible to join the communities or groups, that helps visitors to have experience with the events and a virtual life in early days of Berlin. It also shows the major events happened in Berlin in 1920s, the weather conditions, celebrations, major riots etc[59, 60].

3.3.3 City of Uruk

The book "Virtual Agents and 3D Virtual Worlds for Preserving and Simulating Cultures " aims at developing elements that are associated with learning and preserving cultures [61]. Even if the main objective of this paper is to specify virtual

agents for preserving and simulating virtual cultures, it also explains that preservation of culture can be done through 3D virtual technologies, that can be used for educational purposes for teaching the culture to the visitors. Visitors at City of Uruk in SecondLife, can learn about the culture of the people in the Uruk City through exploration of virtual world and through interactions with its virtual inhabitants [61]. "The City of Uruk prototype illustrates the use 3D Virtual Worlds and Artificial Intelligence in the domain of Cultural Heritage. The main aim of this project was to recreate the ancient city of Uruk from the period around 3000 B.C. in the Virtual World of Second Life letting history students experience how it looked like and how its citizens behaved in the past. The prototype currently features 4 autonomous agents re-enacting the daily life cycle of 2 fisherman families. The recreation of the city and agent behaviors are being modeled under supervision of subject matter experts and based on the results of archaeological excavations and available historical data "[62].



Figure 3.3: City of Uruk

3.3.4 City of Paris

City of Paris in SecondLife is a historical representation of time in 1900. Here there is visualisation of major places in Paris at that time such as Theatre Sarah Bernhardt, Moulin Rouge, Eiffel Tower, Notre Dame Cathedral etc. There are virtual humans standing in the streets and parks wearing, old style of clothing. Art galleries and theatres for entertainment and fun, the transport system at that time, shopping streets etc are shown in this island of Paris. This can give us an idea about the past Paris [63, 64].

Eiffel Tower in Paris : This is a replica of the real Eiffel Tower in the City of

Paris, in Second Life. This location is very attractive, not exact replica of real eiffel tower and its surroundings with proper scaling, but it is designed similar to real tower but with some more attractive texture ."Like the real thing, the SL tower is proportioned to impress by its beauty. It is not the breathtaking icon that which is the real eiffel tower and nor is it even a scale model, but it seemed a nice quiet spot in the virtual world" [65].



(a) Street in City of Paris



(b) Eiffel Tower in City of Paris

Figure 3.4: City of Paris in 1900

3.3.5 London City

This is one of the popular tourist destination that supports socialisation such as participation in events, competitions, concerts and meeting with friends. In London city North we can see Clubs and Pubs, Big Ben, Urban, At.paul's Cathedral etc [66]

St.Paul's Cathedral London: This is a representation of real St.Paul's Cathedral in London. The major objective of this project is to show the real cathedral and its interior It is a touristic destination and we can see so many contents such as traditional vehicles to travel, representations of inhabitants , cafe and some information boxes that we can buy to use in SecondLife. "This virtual world reproduction of the famous central London cathedral, originally designed by Sir Christopher Wren in the 17th century, maintains some of its real world counterpart's splendor inside and out" [67]

Big Ben: This is one of the famous touristic destination in SecondLife where we can see so many visitors in the island. In this island there are provisions to animate our own avatar to dance. Also we can see vehicle for travelling inside the land, various buildings in London like offices, shops, old buildings etc and also the big clock called as Big Ben clock in London. The visitors can walk to the tower and fly up and it is possible to hear the bells ringing hour basis [68].



(a) St.Paul's Cathedral



(b) Big Ben London in SecondLife

Figure 3.5: City of London

3.3.6 New York City

This project have the major goal to have as many virtual tourist to this New York City which is called as the "fashion capital in SecondLife". Here we can roleplay to have new modern city life in New York City in authentic NYC Soho duplexes, but here the users should pay some linden dollars to experience the city life. According to The Avenue magazine, this "is a clean, safe New York, brimming with energy and potential, replete with chic commercial builds, hosting glamorous design houses, adorned by elegant ornamental entrances and, of course, sophisticated brownstones, ideally suited for urban living, situated along tree-lined avenues." [69]. In this island we can see modern city's "post colonial architecture", most modern and attractive living spaces and buildings, different shoppes that sell modern and classic items. In this city residents can have a metropolitan city life. Here we can see employment opportunities too that can provide an experience of job in the city [70].



Figure 3.6: Newyork City in SecondLife

3.3.7 Major trends in Virtual Cities

During my studies on similar projects in SecondLife, it was perceived that typical trends in the virtual cities are representations of major tourist attractions of the place, virtual inhabitants, major traditional events, role play as citizens of the city, entertainment programs such as musical concerts and gaming in the island and facilities such as transportation systems. Also in all the cities we can see that information about a specific creation was provided in the form of notecards or as IM to the visitors. Some cities were only for educational purposes, some others for tourism purposes and some for entertainment. In order to use some of the facilities provided in the city it is required to pay some pennies or we need to join in some communities or groups in that island. In most of the virtual cities there are representations of virtual inhabitants either the past or the present. These virtual inhabitants have different functions such as, some shows the tradition and culture of the city, some carry information that will be valuable for the visitor etc.

3.4 Major analysis from Literature Review

From the theoretical studies, it was identified that virtual reality techniques are useful for educational purposes. It is helpful to eliminate the physical barrier between the students and the instructor to some extent with the characteristics of immersion into the environment. It does not depend on physical location and helps in e-learning. It helps to understand the context very well. It is helpful for students to concentrate in their studies by engaging more through VR mechanism with fun and learn by play. Also the students have good communication possibilities with virtual environments.

The VR is helpful in the field of History and it has possibilities with learning of traditions and cultures in different place and also have potentials for heritage preservation. It also helps for training purposes with its possibilities of immersions and engagement in the context.

Furthermore this can be used in tourism field for different purposes such as marketing the place, to understand and evaluate the place before a real visit. Also identified that virtual reality have different applications in tourism field such as in planning sectors, for entertainment by giving a sense of presence, to educate

tourists and to act as an information source for the tourists. Also it can be useful for people with disabilities and also those who have difficulties in visiting the places physically due to personal reasons. Also these type of systems can increase the visitors' knowledge and satisfaction with the availability of information about the places. Virtual worlds have great potential in the future. It is possible to use virtual worlds for education and tourism and there are possibilities in virtual tourism as well. In addition it was found that there are several virtual cities in SecondLife virtual world that support education, entertainment and tourism. Also it was found that virtual reality devices such as Oculus Rift can provide potential uses for learning and training by the characteristics of immersion that helps users to engage more in the environment.

Virtual world of SecondLife have so many destinations for virtual cities that are applicable in education and tourism. In most of these type cities we can see popular attractions of the place, major events, role playing communities, inhabitants of the place, past life, traditions and culture in the past. Also modern cities with modern lifestyles and role playing are present. Also cities for educational purposes with major institutions are also available in SecondLife virtual worlds.

Chapter 4

Background

In this chapter the concepts and tools used in this thesis work are presented. In the following sections an explanation about the key concept, Virtual world of SecondLife by which the thesis is based upon and about the system on which the work has got more influence are included. In addition, some tools used for the thesis work are presented.

4.1 Second Life

Second Life is an open platform technology where the users can create contents of virtual worlds that are of interests. It was established by a Californian based firm Linden research,Inc, commonly known as Linden Lab[16]. It is a massive multiplayer online virtual environment. The users are the participants of this virtual environment, which are generally called as Avatars. The Avatars are the residents of the environment, which can be customised using the utilities provided in the framework, can interact each other and socialize with communication tools such as text chats or voice chats using Internet after joining in groups or becoming friends [71, 72]. For this project, open platform SecondLife was used.

Here the users can create their own contents in a variety of destinations such as educational destinations, tourist destinations, entertainment destinations like music, art and games. "Avatars can explore the virtual world by registering as a user, meet other residents, socialize, participate in individual and group activities, build, create, shop and trade virtual property and services with one another. It is a platform that principally features 3D-based user-generated content"[71]. See figure 4.1 for a representation of Second Life virtual world, the city of Dublin, a popular island that

was built by some residents.



Figure 4.1: Second Life virtual world: City of Dublin

In this virtual world, users can build models in the allowed virtual space called as islands, according to their creativity and concern. Interested people can login to SecondLife, create an account and buy some land to build the 3D models. SecondLife engine provides some tools and utilities to build the contents in the island. Also it is possible to edit the terrain that suits various needs such as edit terrain with rocks or with snow etc. For this project 3D models of Trondheim city were built in the virtual space of NTNU island.

4.2 Existing system of Virtual Trondheim

The project Virtual Trondheim started in Fall 2014 [20]. In the virtual space of NTNU island, 3D models were created that are of major touristic attractions such as Nidaros Cathedral, Vår Frue Kirke and Trondheim Royal palace as per the primary requirements obtained from the interviews conducted at Trondheim Tourist office with the visitors and with employees there in autumn 2014. See Figure4.2 for Virtual Trondheim. Also there was a detailed study with demonstrations and questionnaires done with NTNU students who took the course Cooperation Technology and Social media in their Academic Semester Fall 2014 with the project "Virtual Campus of NTNU" where there are representations of NTNU campus buildings, Studentersamfundet, various students projects and virtual research arena [31].

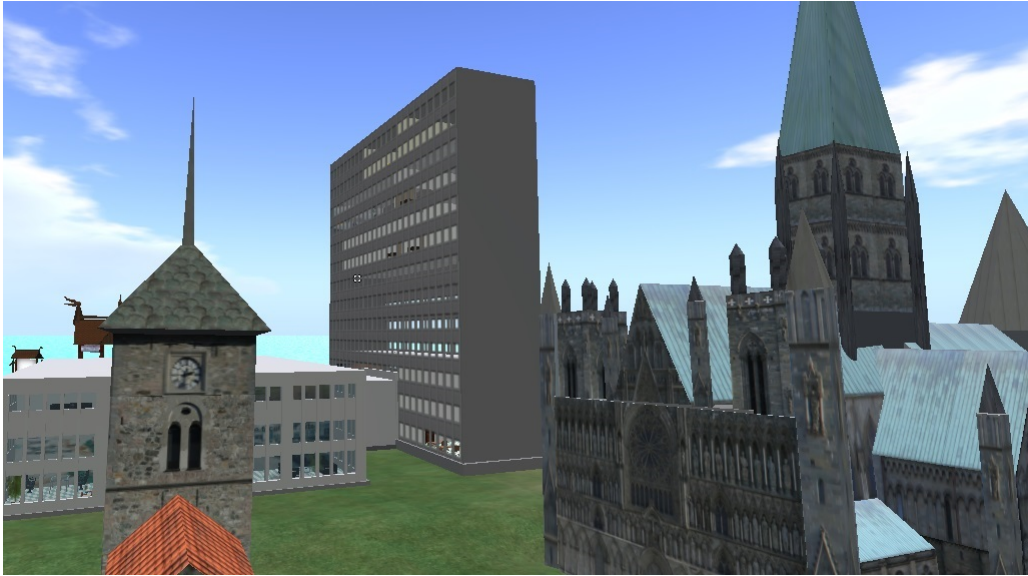


Figure 4.2: Virtual Trondheim

4.2.1 Major Studies

The major studies done on Fall 2014 as below:

- Open Interviews and identifying the requirements needed for Virtual Trondheim with tourist office employees
- Evaluation with questionnaire and identifying the requirements
- Demonstrations on Forskningsdagene and observing the attitude towards the technology
- Evaluation of the system with NTNU students and identifying the improvements needed for the new system

4.2.2 List of Requirements emerged from the studies

Here are the list of major requirements emerged out from the studies conducted on Fall 2014 among employees at tourist office, public from Forskningsdagene and students at NTNU

Responses from the employees of Tourist office

- The main tourist attractions include Old buildings, Museums, Nidaros cathedral and some old churches in the city and historical places like Munkholmen and Kristiansten fortress

- It is helpful if there is proper map of the city. People are interested to get an overview of what possibilities the city can offer and major features of the city that can make the visitors more attracted to for e.g. tradition and culture
- The people will look for events (technical and cultural) occurring in the city, unique shops ,museums, city centre, Park or area that can display the major attractions of the city
- Normally the people plan visit to a city by an initial overlook at the city centre for directions, signs for shops and main attractions and the shopping possibilities. The virtual city can act as an information source for the visitors those who visit the city in real life. So if we are able to create a realistic model of the Trondheim with specific details then it might be very useful in the field of tourism.
- The system should be designed in way to be beneficial to the users so that it can form as an information source to plan the tour and hence time consuming searches for the tour can be reduced
- Models should be realistic, and the buildings and places should be able to recognise by the users during their real visit

Responses from Forskningsdagene 19.-20. September 2014

- People love the technology, they were looking forward for improved versions with better resolution
- They were interested to walk around in Trondheim, and enjoyed walking inside known buildings like Studentersamfundet and Main building at Gløshaugen. Some people responded that Main building is unfinished inside, so should be redesigned with exact replication as the interior of real Main Building.
- People asked for Nidaros Cathedral and Tyholt Tower.
- Also requested for more to do in the world, like drive the small cars, Quest or objectives anything to do rather than just walk around, Non playable characters walking around etc.

- Also it was found that kids love to see attractive stuffs rather than simple buildings, especially the Ant Model, the museums etc. They were asking to add more attractive elements in the island
- Further some people find it very useful since it give an awareness about the area for those who visit Trondheim for the first time. So they need more detailed descriptions regarding the city and its potentials that helps to act as an information source.
- Also while inside the building they need immediate exit and they don't want to go all the way back through the buildings to exit from the buildings. But in the current set up of SecondLife this cannot be achieved.

Responses from Students of NTNU

- More historical buildings, places and old city streets as they indicated in their purpose of visit to learn more about Trondheim history and culture.
- Museums and Campus buildings that helps them to know about the educational possibilities of NTNU and Trondheim
- Major shopping centres, social events (Cultural and technical events) can be helpful for those who are unaware of the city
- Facilities like Maps, more interactive interfaces and virtual Human guide can be included
- Tools like Oculus Rift and MS Kinect with its improved newer versions

From these responses, the requirements were formulated, analysed the data qualitatively and quantitatively and the contents that are of more interest were implemented in NTNU island.

4.2.3 Virtual Trondheim

The main buildings were implemented as per the requirements from the client in the NTNU island for the Virtual Trondheim project such as Nidaros Cathedral, Vår Frue Kirke and Trondheim Palace.

4.2.4 Major conclusions with Virtual Trondheim

After the implementation, a further evaluation was done with the help of questionnaire given to tourists coming to Trondheim tourist office. The outcomes from evaluation were as follows:

- People visit Trondheim to know more about the major attractions in Trondheim like Nidaros and Museums
- It can help many of those who are not able to visit the cities like Trondheim due to age, money and health related problems
- People prefer to visit the campus and to use the educational possibilities promised by the virtual island
- The aspect of social events visualisation can add more value to virtual community, further in tourism sector
- The Virtual Reality hardware device Oculus Rift, have a promising field in both educational and tourism sector
- Virtual Trondheim can be used to learn and understand the potentials of Trondheim in the field of tourism and education, further it can educate tourist about culture and tradition of the people here and historical aspects of Trondheim city
- The students and people from outside can use it as an information source for their real visit, by familiarising themselves, with the buildings found in the island
- The interesting contents to add in the island were more historical buildings and places, virtual humans, information about the buildings and places, games and interactive maps.

4.3 Blender

Blender is an open source 3D Modelling software that can be used to create three dimensional mesh models and animations with a realistic visual effects[73]. For this

project the contents needed to create and import in Second Life were created in Blender 2.71. With this software it is possible to build several geometric primitives like polygon meshes, subdivision surface modelling, sculpting etc. Also there is a rendering engine associate with it. It is possible to apply game physics, UV unwrapping and texturing with Blender Software. Also a new addon "Object:Avastar" was separately added to the Blender 2.71 in order to create and do the animations of the virtual humans.

4.4 Oculus Rift

It is a virtual reality head-mounted display that is used in virtual worlds and gaming to get three dimensional experience and more immersive effects. Figure 4.3 shows Oculus DK1 which was used for the case studies with Virtual Trondheim. It provides precise ultra-low latency 360 degree head tracking, that allows us to look around the virtual world as we would see in real life and give a natural and intuitive experience [74]. The new version of Oculus dk2 uses a low persistence OLED Display to reduce the motion blur and judder that are the contributors of sickness [75]. This helps to see the island in 3D more effectively providing a high immerse effect.



Figure 4.3: Oculus Development Kit

Chapter 5

Prestudy

This chapter focuses on the empirical studies conducted during the initial phase of the project. A detailed explanation about the demonstration of the system with different participants together with interviews and questionnaire forms for the feedbacks, are presented along with the graphical analysis of the data.

5.1 Existing Prototype: Virtual Trondheim

This section presents a prestudy with the existing prototype 'Virtual Trondheim' which was developed on Fall 2014 in order to accomplish the research objectives and for the requirement acquisition to improve Virtual Trondheim in a way such that it can be used by both tourists and the tourism professionals. Procedure of the prestudy was as follows:

- Demonstration of the system to tourist guide course instructor followed by the interview.
- Demonstration of the system to visitors of tourist office.
- Demonstration of the system to guides from tourist guide training program, Trondheim.
- Demonstration of the system to employees at Trondheim kommune.
- Demonstration of the system to employee at Vitensenteret

Virtual Trondheim in Second Life was a representation of real city of Trondheim that contains some major tourist attractions such as Nidaros Cathedral, Vår Frue

Kirke and Royal Palace in the island of NTNU. In addition to these, there are buildings associated with NTNU campus and various student projects. Avatar can explore the buildings and communicate with other residents those who are online and are in same group using text chat or voice chat facilities.

5.2 Interview with Tourist Guide course Instructor

An interview was arranged with tourist guide course instructor at the initial phase of the project. The instructor has been working as Tourist Guide course Teacher from the last few years. She is a well experienced person in the field of tourism in Trondheim and she knows better about the interests of tourists visiting Trondheim. Since she is a guide instructor, she had a better idea about how is it possible to use these type of systems in educational perspective and also in professional tourism. Before the interview, a detailed description about the Second Life platform, Virtual Trondheim and NTNU islands had given to the instructor that helps her to understand the scenario. Major goal of this interview was to gain the requirements in order to improve Virtual Trondheim so that it can be used by tourism professionals and tourists.

The interview was a semi-structured type where the interviewer has a list of questions or key points to be covered and worked through them in a methodical manner. The instructor can responded how she likes and supplementary questions were asked accordingly [76]. Some questions were formulated before the interview in order to obtain clear answers from the instructor so that there was no chance to slip away from any kind of information that is relevant for the thesis. The general questions that were asked for the interview was divided into two major categories

- Virtual Trondheim from the perspective of tourists
- Virtual Trondheim from the perspective of tourism professionals

The questions from the perspective of tourists were as follows:

In general, what is your opinion, about the purpose of peoples' visit to Trondheim, what might be their intentions and interests?

The supplementary questions asked appropriately as per the response from the client

was :

- In your opinion, what all contents we need to include here, that will be useful for tourist
- Will the tourist be interested in more historical buildings, streets and places e.g churches, Kristian fortress, Munkholmen, Old street, Tyholt tower etc
- Will it be useful if recreate historical events that are relevant for the nation ?
- Will it be interesting to implement representation of virtual inhabitants from the past and the present Trondheim?
- What might be the useful creations and how can I improve on this ?
- Will it be interesting to implement Modern Trondheim with current news and research possibilities. for e.g. Moser's Nobel prize, NTNU research areas etc

The questions from the perspective of tourism professionals were as follows:

What might be the possibilities that you can find, to use this framework as a part of your guidance course ?

The supplementary questions asked spontaneously as per the response from the client were :

- Is it possible to use this as a tool for the guide course?
- How can we make it suitable for helping in course guidance?
- What might be the useful contents and how can I improve these?
- Are you interested in Gaming elements such as Quest or quizzes or any other thing to do rather than just walking around?
- Will it be useful if we have a separate virtual human that can act as a guide for exploration of this land?

A separate question about using Oculus Rift in Virtual Trondheim was asked in general, in order to obtain the opinion from both perspectives, of tourists and of professional tourists.

The interview questions are also given in Appendix A.5

5.2.1 Summary of Responses from Tourist Guide Course Instructor

The instructor had given a quick overview about the normal routes of the tourists in Trondheim. If the tourists are routed by bus, it will normally be like, they begin from the harbour area, then passing to the city view point, then to university area, then to Kristiansand fort and back to harbour again. If it is by walk, there might be different routes, but normally same route as the bus route and also will cover the cathedral area. After the overview about the routes they normally follow, she tried to answer the questions that mentioned above. The comments from the instructor were as follows: The tourists normally show interest in all the buildings, but the main attractions are old bridge town and wooden houses.

Major Interests of Tourists are as follows:

- wooden houses at city streets from 19th century
- Old town bridge
- Warehouses from 18th century
- The bicycle lift
- Sverresborg museum
- Nidaros cathedral
- oldest churches, music museum at lade
- old bunkers
- NTNU Main building and Modern city

Major points about the Virtual inhabitants: Virtual inhabitants who can act as informational source is another type of content that benefits to both tourist and student guide. If Virtual inhabitant at a specific time period can give his view to the visitor then it might be more interesting to the public visitor. It will be interesting if the virtual inhabitant staying in front of each building can vary depending on the type of building. for e.g: in front of cathedral - archbishop or

person associated with the Cathedral; in front of royal palace - the king and queen in their official dress, some beggars in the street, masons at Vår Frue Kirke; in front of old town bridge-person from 19th century, a big town planner or somebody that can provide information about the Bridge and its history.

Some general views: It will be nice if practical information regarding each building is available. for e.g : tickets sold at some specific place, information regarding Museums, pass for entry to cathedral, Opening hours of each buildings etc. Also the people might be interested to see the buildings from outside only, they don't prefer to go inside each building. They might also be interested in historical events visualisations that can be placed at the corresponding locations. For e.g. Archbishop escape event, Old monk arrested by fellows event in front of Cathedral, Battle events, St.Olav possession around the city, St.Olav fest etc. In addition, for the tourist, the cultural understanding is also important. They are eager to know more about the history related to Trondheim. Tourist usually asks about St.Olav hospital and modern Trondheim facilities. The instructor tried to view the virtual space of Trondheim with the Oculus Rift. Even though she was quiet dizzy with the Oculus Rift, she had the opinion that it can provide a high immerse effect to the visitors and they may get the feeling that they are inside the real city. Also it can provide an excitement for youngsters particularly.

Use the system as a tool: For the guide students it will be very useful if it is possible to provide sufficient information about the historical places and buildings. Also it will be more efficient if we implement quiz in the island so that they can answer the questions and win the pilgrim certificate. The most important point is that the buildings currently in the island is quite confusing with their locations. So should try to keep the buildings same as that in the real city. Then this island can be used as a tool for the guide course. The framework can also be used as a tool for the guide students courses, if we can do role play with tourist and the guides and can provide an overview of the city. The students those who are unable to attend sessions, can use it for their studies. Also if there is a mock up virtual tour i.e. Virtual tour through a predefined path can be created, then it will be helpful for the students. It will be helpful for guide students for their preparation in exams and real time guidance. With above mentioned modifications, this system can be

used in guide course, which can make the guide course doable since the problem of inability to attend the long sessions for students could be eliminated.

5.3 Demonstration of the system to visitors of tourist office

In order to acquire requirements for the new improved version of Virtual Trondheim a demonstration of the system was conducted at Trondheim tourist office with the visitors. One tourist Outside Norway and another tourist from Norway, but outside Trondheim participated in that particular demonstration and answered the questionnaire which was distributed along with demonstration of the existing system. The visitors were also asked to use the Oculus rift in order to have a high immerse effect using the 3D model of Virtual Trondheim. Both of the visitors were between the age 20 and 30 and they were quiet interested to use the Oculus Rift and have fun with the system. In this study, only two visitors participated at the tourist office since it was winter and only very few people arrived at tourist office on that day. Also most of the visitors were quite busy so that they refused to try the system with Oculus. With two visitors one kid also tried the system, but he was not old enough to fill out the questionnaire form. But from the direct observation it was found that he was very excited in using the system.

5.3.1 Responses of Visitors at Trondheim Tourist Office

A questionnaire was distributed along with the demonstration of the system. The main goal of this demonstration with the questionnaire was to gather requirements for Virtual Trondheim that would be of more interest to the tourists. In the questionnaire form there were mainly 3 questions as follows:

1. If you are to visit Virtual Trondheim, what would be most probably the purpose of your visit?

The objective of this question was to identify the reason to visit Virtual Trondheim by the tourists. This also helps to understand the aim of different tourist to visit particular places.

- To learn more about Trondheim history and culture
- To learn about local events (cultural, sports etc)

- For socializing and fun
- To prepare for a real visit
- To learn more about research and educational possibilities in Trondheim, e.g. at NTNU

For this question it was given a 5 point probability scale as Very probable, somewhat probable, Neutral, Somewhat improbable and Not probable was given. The person outside Norway responded to this question as follows: He choose the option, To learn about Trondheim history and culture, as 'Somewhat probable' purpose and he had a neutral opinion about the probability to learn about local events(cultural ,sports etc). But he choose the option, To socialize and fun, as very probable purpose. Also for the option, To prepare for a real visit, he selected as 'somewhat probable' purpose. But for the last option, To learn more about research and educational possibilities in Trondheim e.g at NTNU, he had the opinion that it is somewhat improbable. The person outside Trondheim responded to this question as follows: For the option To learn about Trondheim history and culture, he selected as somewhat probable purpose, and he had a neutral opinion about the probability to learn about local events(cultural ,sports etc). But he mentioned it as neutral for the option, to socialize and fun. And for the options, To prepare for a real visit and To learn more about research and educational possibilities in Trondheim, e.g, at NTNU, he had the opinion that it is somewhat probable.

2. What should Virtual Trondheim contain?

This question helps to find out the interesting contents to add in Virtual Trondheim so that it can be beneficial, fun and attractive for them to visit the island.

- More historical buildings and churches
- Virtual city inhabitants from the past (e.g. vikings)
- Information about buildings and sights
- Reconstruction of historical events

- Presentation of latest advances in science and research (e.g. by Trondheim's Nobel prize winners)
- Virtual city inhabitants (modern)
- Live events (e.g. lectures, parties)
- Buildings and streets the way they were in the past

For this question the likert scale was given as Very much interested, Somewhat interested, Neutral, Not really interested and Not at all interested. The person outside Norway was very much interested in More historical buildings and churches, Virtual city inhabitants from the past and virtual city inhabitants (modern). And he was neutral in the options, Information about buildings and sights and the Live events (e.g. lectures, parties). But he was not really interested in the given options such as Reconstructions of historical events, Presentation of latest advances in science and research (e.g. by Trondheim's Nobel prize winners) and Buildings and streets the way they were in the past. In his opinion this 3D visualisation can be used to have fun with other residents in the city. The person from Norway, but outside Trondheim responded as follows: He was very much interested in More historical buildings and churches, Virtual city inhabitants from the past (e.g. vikings) and Information about buildings and sights. He was neutral in his interest to include Virtual city inhabitants (modern) and Presentation of latest advances in science and research (e.g. by Trondheim's Nobel prize winners). Also he was somewhat interested in reconstruction of historical events and buildings and streets the way they were in the past. But he was not really interested in Live events (e.g. lectures, parties). In his opinion this is something interesting and exciting for the kids and the youth to have a journey through the island by flying and to have some idea about the place.

3. The following facilities or technological solutions would make your Virtual Trondheim visit more enjoyable

For this question some options are given as facilities to enjoy in Virtual Trondheim so that it can be used for tourists in their tour plan or to have some fun with the city.

- A virtual guide that provides information and helps with navigation
- Interactive map
- Oculus Rift
- Gaming elements such as quests and quizzes

For this question the likert scale was given in a form of degree of agreement, with the possibilities given as Strongly agree, Agree, Neither agree or disagree, Disagree and Strongly disagree. The person from Outside Norway has a strong agreement with the option of interactive map, agreement with use of Oculus Rift and have neither agreement or disagreement with the options for the facilities such as A virtual guide that provides information and helps with navigation and Gaming elements such as quests and quizzes. For the person outside Trondheim, but inside Norway agreed with the options for the facilities such as Interactive map, Oculus Rift and Gaming elements such as quests and quizzes, and he neither agreed or disagreed with the option 'A virtual guide that provides information and helps with navigation' since he had the comment that he know how to navigate through the place without any help from outside source.

5.4 Demonstration of system with guides from tourist guide training program

For the prestudy, a demonstration of the system, with guides of Trondheim who are completing tourist guide training program, was conducted along with the explanation of the system from its minor details to its utmost. A total of 9 students of different ages and from different places attended the presentation. Almost all of them were between of age 35 and 45 and 2 guides were of age above 50. The guides cooperated through out the presentation and clarified their doubts about Second Life and Virtual Trondheim.

5.4.1 Responses of guides during discussion

Initially a detailed explanation about virtual reality systems and virtual worlds together with the existing system of virtual Trondheim and virtual campus were given. Also some virtual cities such as Roma, Berlin and Paris were shown in order to get some idea about similar systems. After the demonstration a discussion was

started together with semi-structured interviews. The interview questions are given in Appendix A.6. A summary of the discussion is given below.

Opinions and suggestions about the system

It can act as an information source. It can be useful for the tourist to have some idea about the city if add more tourist attractions and the places with proper information about the city. It helps to explain about the city and no need to pay money to visit the places with this type of expanding technology. It is really an interesting concept of exchanging information and culture between people from different places with this virtual reality environment. Furthermore it is easy to memorize the buildings using this type of environment. In addition, it is good to have the system in iphone. The system is cheaper and can use it by sick people and also who do not have money to travel.

Moreover it can be used for advertising of the place by showing highlights of the city and by providing practical information. It will give an awareness about the place for the tourists and help to prepare for a real visit. As of now, the buildings are placed in random order and it will be confusing with buildings and their locations with this kind of arrangement. But have somewhat real textures for some buildings which can be identified without explanation. If it is doable to create a full city model by providing specific resources and time, then this can be very useful for the future.

Also it is good to have some pop-up mechanism while searching for the places in the island and help the tourist with the directions. This type of systems can be useful as school projects to educate the students. If the visitor can walk through the virtual city as that in real life then it will be amazing.

More realistic images need to apply as textures for the buildings. The system is not a substitute for the original tour through the city. Also some guides were having doubt that these type of systems can have negative impact in the tourism industry as well. They fear that if the place is not properly represented in the environment and provide any wrong information then tourist would have a negative impression about the place and they may refuse to visit the place. In the other way if the place is represented accurately in all its details then also they may refuse to visit since they already have a visit via online. So it is better to have representations of the

past and also some information about the present for promotion of the place.

The guides have the opinion that it can be useful for training activities but then it is required to have the proper city plan with routes and the original city structure. As of now, the island is having city buildings placed in random order and also the buildings are textured that seem to be artificial and are more beautiful than the original. The layout of virtual city is rather different from the real city. It can act as more efficient system if this can be restructured same as that in Google maps.

In addition, it is not a good idea to have this system for guide training without real interaction with the people. So it is required to have some representations of inhabitants and to interact with them so that guides can get a knowledge of how to behave with the tourists. If there are contents in the island such as information about the buildings, the visualisation of how to respond to tourists, how to go to different places, how to interact with Norwegians explaining their way of behaviour etc, it can serve as an educational aid for tourist professionals and can provide extra training or tuition for the guide students. It is good to have some quiz or puzzles in the island so that the tourist can test their knowledge and to study about the places in a challenging way, incorporated with fun. It will be good to have representations of historical places that are difficult to explain orally.

There were different opinions put forward by the guides. Some responded that if it is possible to show Trondheim's past life and history, it can make more sense. Also it is really better if there is a representation of more historical events, how the buildings evolve in the history and more information about the places. Also they love to see the representation of people from the past centuries. Also it is better to show some virtual inhabitants that can interact with for acquiring information about the place. But some of the guides were confused about the usage of system for using to show the tradition and culture.

For the demonstration an old laptop with limited capacity and a limited Internet facility were used. So while accessing the contents via online the system was getting slow while teleporting to islands and contents were not properly downloaded. Hence some limitations were identified by the guides with SecondLife Game engine. It is not much efficient to visualize the whole city model with all its corners in high graphics definition and also it gets heavy and computer is getting slow while downloading

contents. So it is required to have high definition systems for these type of systems to work efficiently which is rather quite difficult to acquire for the tourists and also for general public. The guides preferred to use the system without Oculus since most of them got dizzy while using it. Also many of them found uncomfortable to use the headset together with laptop keys for navigation. They commented that the system would be more useful for young aspirants and it is mostly difficult to use the headset for elders even though it is quite individual.

5.4.2 Responses from the Questionnaire

Here there were 9 tourist guides from Trondheim of age between 30 and 50 participated in the discussion.

1. In the tourist perspective, for what activities would Virtual Trondheim be most useful?

In order to check the usefulness of this type of system before implementation, it was required to gather the opinion about the same from the experts. During the demonstration, the possibilities of these type of systems were described and the guides got an idea about virtual reality systems. For this particular question 5 possibilities were given as choices.

- To learn more about Trondheim history and culture
- To learn about local events (cultural, sports etc)
- For socializing and fun
- To prepare for a real visit
- To learn more about research and educational possibilities in Trondheim, e.g. at NTNU

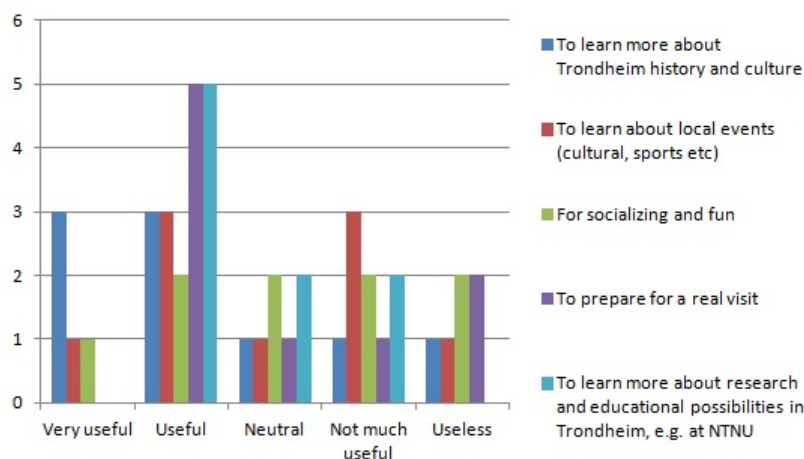


Figure 5.1: Degree of usefulness in a tourist perspective

The graph in Figure 5.1 shows the degree of usefulness of Virtual Trondheim for each of the given activities responded in a tourist perspective by the tourist guides from Trondheim. A 5-point scaling, Very useful, useful, neutral, not much useful and useless, was used.

For the studies, there were 9 tourist guides from Trondheim origin. Three of them had the opinion that it is very useful to learn about Trondheim history and culture, another two suggested that it is useful for the same and one was having a neutral opinion. But other two has the opinion that it is not much useful for the same. When considering the second choice, to learn about local events such as cultural, sports etc, only one has the opinion that it is very useful, and three of them have the opinion that it is useful for the same, but not much useful lo learn about social events. For the next choice, for socializing and fun, also one guy had the opinion that it is very useful, another one voted for useful, two voted for neutral, two others felt that is not much useful and another two felt that it is Useless. For the fourth option, to prepare for a real visit, five of them considered it as useful, one considered it as neutral and two of them considered it as useless.

For the last choice, To learn about research and educational possibilities in Trondheim, e.g. at NTNU, five people had the feeling that it is useful, and two were opted for neutral and for two others it was not much useful.

Comments: For this first question, some extra comments were also added by

some of the tourist guides. The first one was "If you could simulate historical periods(go back in time), it must be useful, seeing the development through time". One person commented that "May be it can be used to prepare for a real visit, after it is developed fully". Another comment was "My opinion, the Second Life would be great to :Train a sightseeing. To prepare tourist for a visit, to show a time line and how Trondheim has developed. For me as a guide, I cannot use it in my daily work". Another comment was that "It may be useful when it is fully developed."

2. In the perspective of a tourist, what should Virtual Trondheim contain?

This second question was about the content that need to be added in Virtual Trondheim, from the perspective of a tourist. This was aimed at the most preferable contents for tourists since it would be the tourist guides who know more about the major tourist attractions that might be asked by the tourists. For this question a total of 8 choices were added and also a separate column to fill out any other special preferences from the tourist guides, that the tourist might ask for. The choices were as follows:

- More historical buildings and churches
- Information about buildings and sights
- Reconstruction of historical events
- Virtual city inhabitants (modern)
- Live events (e.g. lectures, parties)
- Buildings and streets the way they were in the past
- Virtual city inhabitants from the past (e.g. Vikings)
- Presentation of latest advances in science and research (e.g. by Trondheim's Nobel prize winners)

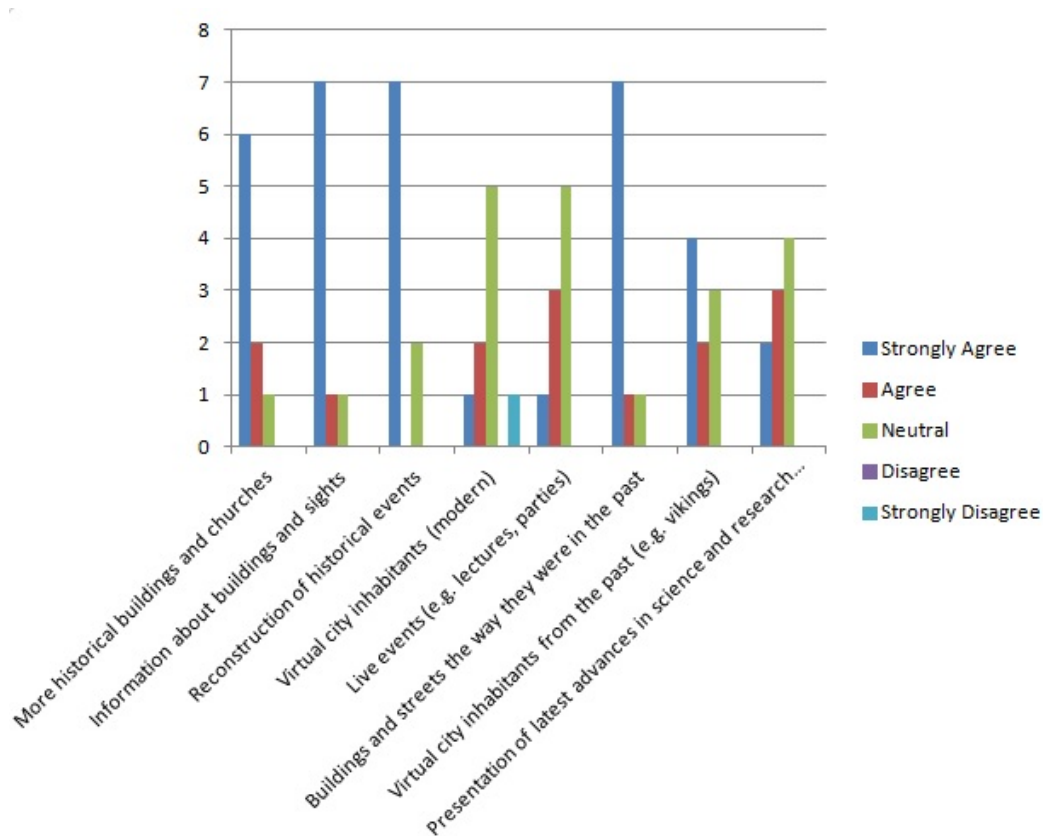


Figure 5.2: Likert scale for the contents to include in Virtual Trondheim

The Figure 5.2 shows the likert scale in terms of agreement that need to be included in virtual Trondheim from the tourist perspective. The first 3 choices and the choice of 'Buildings and streets the way they were in the past' got Agreed strongly by the seven persons. All of the choices were either agreed by the tourist guides or was given a neutral opinion. But for this particular question the preference was for 'More historical buildings and the information about buildings and sights'. Also the past life situations were opted by most of them such as, the streets the way they were in the past and the virtual city inhabitants from the past. A comment from a tourist guide was rather interesting. "All highlights of Trondheim should be included. People can choose what to learn more about, whatever, Cathedral, city centre etc". All the opinions took into consideration while doing the implementation.

3. In the tourist perspective, what facilities/technological solutions would make the Virtual Trondheim visit more enjoyable?

This question was formulated based on the solutions that can be implemented

in SecondLife. Four possible facilities were added as choices, and the tourist guides answered in a tourist perspective. The choices of facilities given with this question were :

- A virtual guide that provides information and helps with navigation
- Interactive map
- Oculus Rift
- Gaming elements such as quests and quizzes

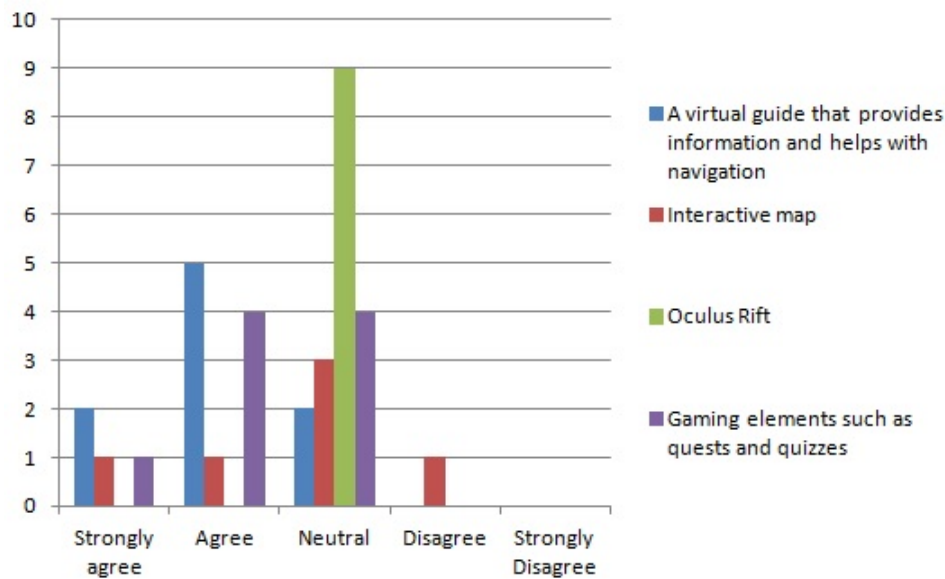


Figure 5.3: Agreement scale with the facilities in tourist perspective

The Graph shown in Figure 5.3 shows the degree of agreement for each of the given facilities, in a tourist perspective as responded by the Tourist guides from Trondheim. For the facilities five of them were agreed, two strongly agreed and another two were neutral to the first choice about the virtual guide that provide information and helps with navigation. But for the second choice The interactive map, one of them strongly agreed, another just agreed, six were of having a neutral opinion and last one was in a strong disagreement with the idea of Interactive Map. And also it was found that all of them were having a neutral opinion about the Oculus rift which can be used to view the city in a 3D view. For the last choice, about the gaming elements such as quests and quiz, four of them agreed, four were having a neutral opinion and one strongly agreed for the same.

4. To what extent could Virtual Trondheim be useful in Guide training?

This particular question was asked in reference to the existing system that was under development. It was asked to know the importance of the same in tourist guides education program. They were asked to give their opinion after the whole presentation of the system, which explains all the possibilities of Second Life. Here four of the tourist guides responded positively and had a view that it is useful. But another four were quite uncertain about the same. And one was having the opinion that it is not much useful for Guide training.

5. For what guide training activities could Virtual Trondheim be most useful?

During the demonstration about SecondLife and virtual Trondheim, the possibilities were discussed and also about the contents that can be added in virtual Trondheim, so that it can be used as an educational tool for the tourist guides and for the instructors. The choices include :

- Role playing and rehearsing tours
- Guiding online visitors
- Communicating with fellow students
- Getting better understanding about different places and historical events
- Preparing for exams
- Doing online training when unable to come to sessions/lectures physically
- Preparing/rehearsing presentations of different sights

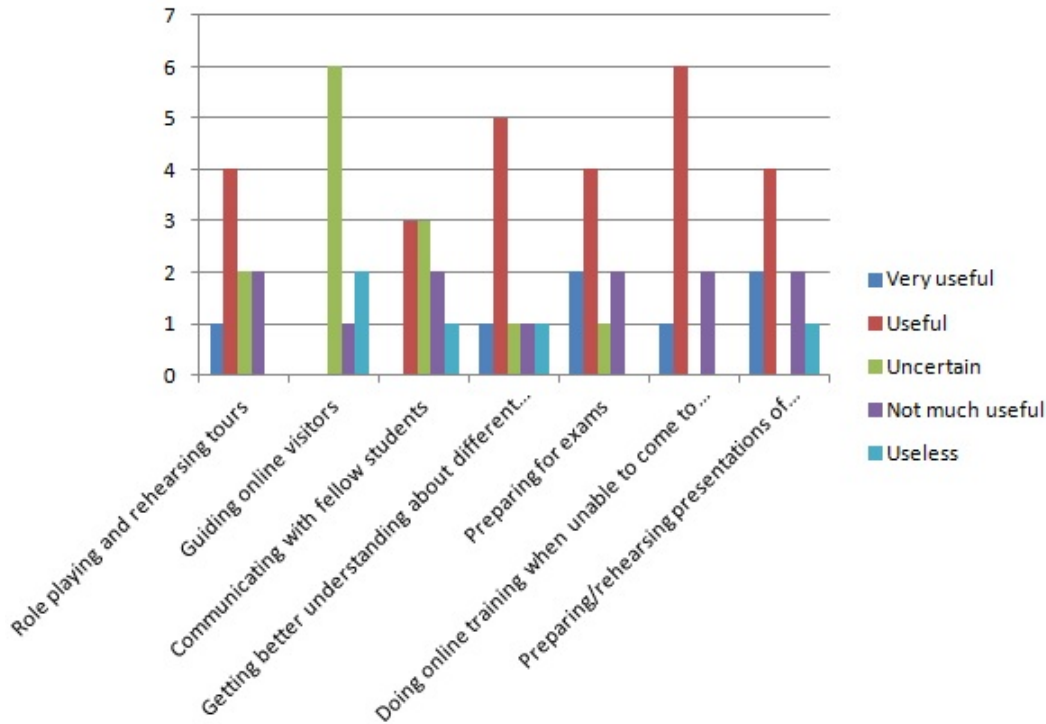


Figure 5.4: Usefulness in Guide Training activities

The Graph shown in Figure 5.4 gives an idea about the response of the tourist guides towards the usefulness of the system for guide training activities. For this particular aspect the tourist guides had different opinions and some were uncertain about the same. For the first aspect of role playing and rehearsing tours, one of them found it very useful, four of them found it useful, two were uncertain, and two others were having the opinion that it is not much useful. But for the second and third options such as guiding online visitors and communicating with fellow students, they were quite uncertain about the usefulness of the system.

Meanwhile all the following options such as Getting better understanding about different places and historical events, Preparing for exams, Doing on-line training when unable to come to sessions/lectures physically and Preparing/rehearsing presentations of different sights they had positive opinion and most of them found it as either very useful or useful.

Comments: One of them commented that "Virtual tour guide would be very useful" and another comment was "I believe a virtual tour programme would be

expensive and demand PC power, which some of us might not have. However I like the idea of being able to have a presentation of a place I am going to visit".

6. In the perspective of a tourist guide, what should be improved/added to Virtual Trondheim?

This question was asked to collect some new requirements that can be useful for tourist guides to use it for their own curriculum. Here the options were given preferably to tourist guides. The choices were as given below:

- As accurate as possible replication of the real city
- PowerPoint presentations and other materials
- Virtual humans
- Maps and directions
- Virtual tour through a predefined path
- Online tests and quizzes
- Detailed information about the buildings
- Communication possibilities with tourists (e.g. social media and networks)
- Reconstruction of historical events
- Buildings and streets the way they were in the past
- Presentation of latest advances in the city (e.g. scientific)
- Virtual reality interface (such as Oculus Rift)

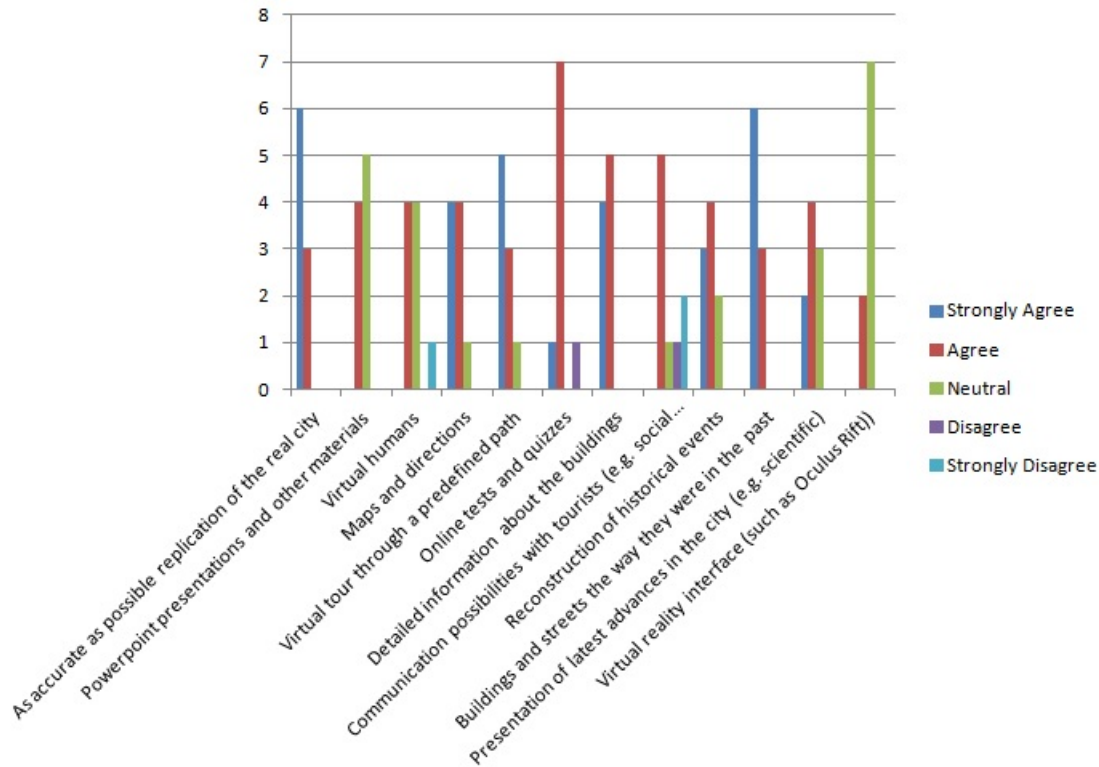


Figure 5.5: Agreement scale for the contents need to add in the island

The graph in the figure 5.5 shows response for the contents that need to be added in Virtual Trondheim in the perspective of tourist guides. The first option of 'As accurate as possible replication of the real city', six of them Strongly agreed and three of them agreed. Also four of them agreed that PowerPoint presentation and other materials will be useful for them. But for the option of virtual humans four of them agreed, four of them had a neutral opinion, but one had a strong disagreement with the same. About the maps and directions four strongly agreed, one had a neutral opinion and four of them agreed. Also for the Virtual tour through a predefined path option five strongly agreed, four agreed and one was having a neutral opinion about the same.

Regarding the option of Detailed information about the buildings, four were in strong agreement and the other five agreed. For the option of Online tests and quizzes, one strongly agreed, seven of them agreed, but one had a disagreement for the same. But regarding Communication possibilities with tourists (e.g. social media and networks) five agreed and one had neutral opinion, but others

had disagreement with the same. The option for Reconstruction of historical events, three strongly agreed for the same, four agreed and two had a neutral opinion for the same. Besides the choice of Buildings and streets the way they were in the past got six positively responded as strongly agreed, and three agreed. And for the options of Presentation of latest advances in the city (e.g. scientific), three were having the neutral view, two had a strong agreement and four agreed.

Furthermore for this particular question one of the tourist guide had given a comment as "For me It would be fine with this programme to train for a sightseeing . However necessary to include all sights I will present". About the Virtual reality interface Oculus Rift option seven guides were having neutral opinion and two were having an agreement opinion.

Suggestions: In addition to these questions one column was given for suggestions. Comments: "As it is now, it would have to be improved greatly to have any use for tourism. As it is now it is more like a wonderful folk museum with buildings from different locations standing together". Also got one suggestion about virtual Trondheim as "I am not experienced with computer games, so I have not much to say. I believe this is something for the future and tourist of tomorrow might expect a virtual presentation to be interested in visiting Trondheim. For disables it would probably be great, but also perhaps disappointing. I believe real life or first life is best, even if I can see positive effects also. May be I am too old." The guides believe that this project is very much useful with education program for school students. Also this system can be used for advertising the place since the presentation of the place in 3D online is quite interesting. It will be very helpful if it is possible to have a historical view about the place, more information and how buildings evolve in the historical periods of Trondheim.

5.5 Demonstration to employees at Trondheim kommune

A demonstration of the system was given to employees at Trondheim kommune together with detailed explanation about the system. These employees were working with 3D systems that visualise the city of Trondheim for city planning. They

also have some plans to implement 3D systems that can be useful for students for educational purposes. So they were interested to have a representation of the past Trondheim city with historical events, old city streets and information about the past centuries that helps to educate students to understand about the traditions and culture from the past.

5.6 Demonstration to employee at Vitensenteret

An explanation and demonstration of the system with the director of Vitensenteret was given. Vitensenteret is the museum where exhibitions are conducted and also have hand-on experiences with the models displayed. Here visitors are eager to try out new technologies and scientific workshops. The director was curious about the system and he had the comment that this type of new systems will be exciting for visitors at Vitensenteret.

Chapter 6

Requirements Specification

This chapter describes about the requirements emerged out from the prestudies and the literature studies executed at the beginning phase of the project. The major requirements emerged out from the discussions obtained from tourist guide course instructor through demonstration of the systems and with semi-structured interview. Also feedbacks were obtained from the evaluation of Virtual Trondheim with tourist office visitors in the beginning phase of the project. In addition to this a major empirical study was done with students of tourist guide course who were of age above 30. Also the potentials of VR was identified through the literature studies about the virtual reality systems and virtual worlds like SecondLife. The feedback obtained from the evaluation of Virtual Trondheim in Fall 2014 was also considered for the improvements. In addition to this comments from employees at Trondheim kommune and from director at Vitensenteret were also considered.

Initially the feedback and comments obtained from the evaluation of Virtual Trondheim in December Fall 2014 was considered for the improvements. As per this feedback the designing works were started. From the feedback it was confirmed that the working on improvements were started by designing more historical buildings. Some requirements were also obtained from the demonstration of the system along with questionnaires, with some visitors at Trondheim tourist office in February, in the early phase of the project.

Since the interviews with the clients have to be arranged as per their availability, there was some delay occurred and a semi-structured interview with tourist guide course instructor was done after one month, in March, since when the project start.

Before this interview a complete demonstration of the existing prototype was given and the instructor tried Virtual Trondheim with Oculus Rift too. From this discussion many suggestions were emerged out and a suggestion to use this as for the guide course was put forward by the instructor.

Also a presentation of the system was arranged at Grand Olav hotel with students of tourist guide course in the mid of March. There were total 9 students of age above 30 and a major collection of prioritised requirements were obtained.

Results from all these sources were triangulated and explained briefly in this chapter. Major Requirements emerged from demonstrations are given below:

6.1 Wooden Buildings

One of the major attraction of Trondheim city is the wooden buildings in different colours along the narrow streets like Bakklandet and the buildings along the Nidelva River. Also as per the guide course instructor most of the tourists ask for a walk through the streets with wooden buildings and through harbour side. Also normally the guided tour through the place starts with the harbour side where we can see so the most beautiful wooden buildings along the river side. Due to these reasons wooden buildings form one of the major requirement of Virtual Trondheim. Besides tourist guide students also pointed out the importance of wooden buildings in the streets.

6.2 Old Town Bridge

Another major tourist attraction of Trondheim is the Old Town Bridge which has a strong historical background along with it. So the instructor specified this particular requirement as of prime important. Also most of the tourists love to visit this place since it has very beautiful view from the bridge with buildings . This bridge goes over the Nidelva river starting from south of Kjøpmannsgata and connects to Bakklandet which are famous old streets in Trondheim. We can see unique shops and cafe in Bakklandet that are special to Trondheim city. The Old Town Bridge is one of Trondheim's attractions and a famous landmark, and have a great view from NTNU and the Navy on one side and the Trondheim Fjord on the other side.

6.3 Historical buildings

This is one of the major requirements that was asked by most of the people that participated in the preliminary studies. In Trondheim most of the buildings are quiet old and looks very beautiful and also these are Trondheim's one of the identity.

6.4 Information about places

Another important requirement was to include as much detail about the places and sight of Trondheim along with the buildings. It is also good to have practical information regarding the buildings so that it will be helpful for the tourists to plan their tour. Also it is useful for tourist guides to have a small description about the buildings that include history of the buildings so that they can easily explain it to the tourist in their guide activities.

6.5 Virtual Inhabitants

Virtual inhabitants that act as informational source is another type of content that benefits to both tourist and guides. If Virtual inhabitant at a specific time period can give his view to the visitor then it might be more interesting to the public visitor. It is more attractive if the island contains virtual inhabitants with some traditional dress. One of the visitors at tourist office asked for modern inhabitants and the guide course instructor and students asked for virtual inhabitants that lived in the past and inhabitants in traditional costumes. It is also good to have some information along with these inhabitants that helps for tour practises. The virtual humans in front of each building should be different for example, a town planner in front of Old town bridge, a representative of church in front of nidaors cathedral etc.

6.6 Online presentations, quests or Quizzes

This is another requirement from the public and also from the instructor. It is identified that something to perform in the island rather than just a walk around will be more interesting for most of participants. The quiz can help to test the knowledge about the place and also it might be a fun and challenging experience for the visitors. In addition the quiz will be an interesting item for the tourist guides

too as per the instructor. Also it is good to add some PowerPoint presentations or some slide shows in the island about the major attractions so that it can be useful for both the tourists and the guide students and will act as an educational source.

6.7 Replication of the real city

This is one of the prime requirement that was asked by most of the participants. It will be very helpful for the tour guides to practice their tour if there is proper replication of the real city with routes and streets. It is required to have a proper plan of the city with maps. Then this can be used as an educational tool for the guide course. The students those who are unable to attend sessions, can use it for their studies. Also this can help the tourist to have a view about the city so that it will be helpful to plan their visit and it helps to give some idea about the places and how to reach their preferred destination easily.

6.8 Reconstruction of historical events

This is something that might be interesting for the tourists. The tourist guide course instructor and the students had the opinion to include major historical events in the city that occurred in the past centuries. This can be can act as a good educational source for those who are interested to learn about the historical events and also for the school students. It will help to show the historical evolution of Trondheim through the centuries. Also it is good to have a representation of buildings and the streets the way they were in the past.

6.9 Map

It will be helpful if there is proper maps and directions of the city. For visitors who are not aware of important places of the city, the map can help them for easy navigation. Also some were asked for interactive map in the island.

6.10 Role playing and Rehearsing tours

This is another requirement that got some votes from the participants. It is beneficial for the tourist guides to have a role play of tourist and the guides through the city streets by providing a city overview with explanations about the places. This can act as a educational source for guide tour practices for the students. Also it will be helpful for the guide students if there is mock up tour or a virtual tour

through a predefined path can be created. This can reduce the confusions about the routes of the virtual city and make it easy to visit all the constructions in the island.

6.11 Oculus Rift

Oculus Rift can be used effectively to provide a rich immersive effect for a high quality 3D virtual world. Most of the participants were interested to use Oculus rift and they found it as an exciting tour experience with Oculus rift.

Chapter 7

Implementation

This section gives a detailed explanation of the implementation phase of virtual Trondheim as per the requirement specifications. After the prestudy data analysis, it was found that for implementing virtual Trondheim in SecondLife, 3D Models should be created that resemble the real city buildings structure. So specific tools have to be used to attain this realistic view in SecondLife environment. Searches on new techniques for the tools to model 3D structures directed to the use of a tool called Blender which is a 3D modelling software. Also the SecondLife interface tools and techniques are considered for importing mesh models into the island that are created in Blender. Also a study on scripting with mesh models in SecondLife are done in order to create animations which was one of the important section in implementation phase.

7.1 Mesh Modelling

In order to add contents specified in the requirements, 3D modelling of the buildings and virtual humans have to be done with the 3D modelling software Blender 2.71. With the help of Blender tools and interfaces modelling was done so that the models appeared realistic in shape and texture. Modelling was done by base model creation, applying materials and textures to the particular slots assigned, adjusting the model with proper lighting, and finally by baking of model to test that it looks realistic in Second Life. The finalised baked model with proper textures was then imported into SecondLife.

7.1.1 Mesh Model creation

In order to follow the original architectural pattern of the buildings of Trondheim, meshes were moulded with Blender 2.71. The original pattern of the Old Town Bridge and Archbishop's museum was identified from Google maps Street View online [77] and followed the same structure. The Buildings along the Nidelva riverside were constructed with the help of online resources of 3D warehouses of Trondheim [78] and Google Maps [79]. From those 3D warehouses the structure of the buildings were captured and be familiarised with shapes of each building component. Then modelling had done in Blender with similar structure and shape as that in sketch up models.

Buildings' Meshes

The base models of the buildings were done from the scratch with the help of tools available in Blender. The shapes of buildings were done with basic mesh in Blender such as Cubes and Cylinders. With Blender tools the basic meshes were transformed to original buildings meshes and structures with proper scaling and dimension. Even though this method of development from the scratch was quite difficult, it was compelled to do since there was no other alternatives. The Models of Brygge along Nidelva river side, Old town Bridge, some wooden houses and Archbishop's museum were created in Virtual Trondheim island.

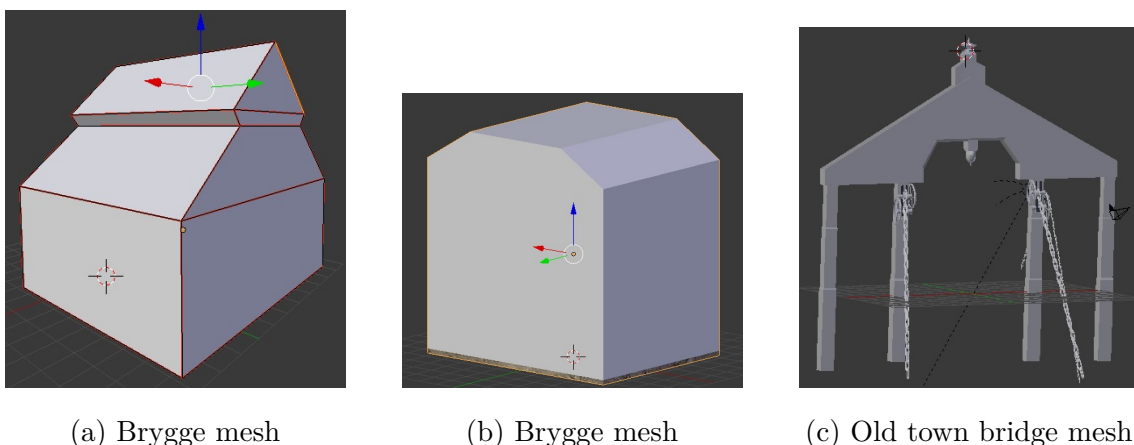


Figure 7.1: Building Mesh models

The Figure7.1 shows parts of big mesh objects such as Brygge and old town bridge. These parts were created with basic mesh models shown in Figure 7.2a

and some parts of old town bridge such as the big chains and wheels attached to the chain shown in Figure 7.2b and Figure 7.2c were created by basic mesh models edited, scaled and manipulated appropriately with blender interface tools.

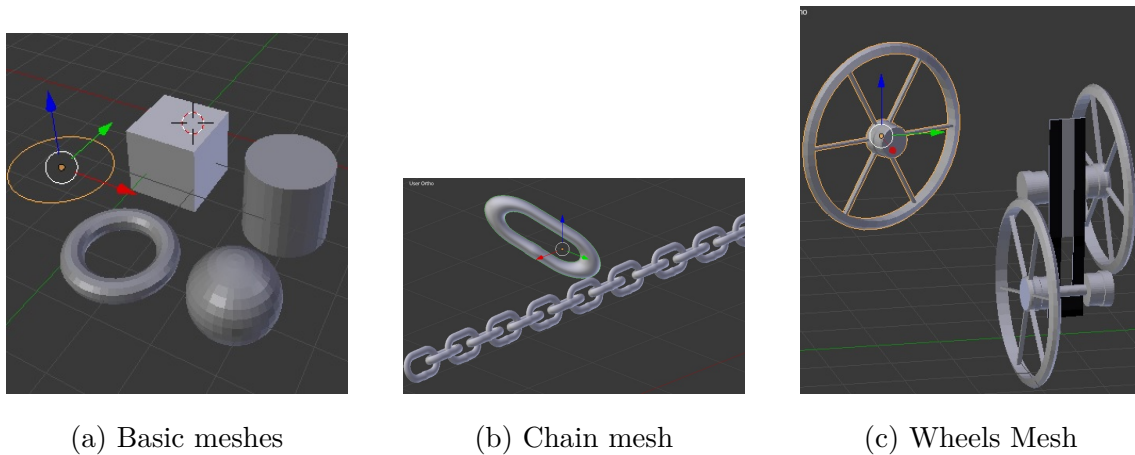


Figure 7.2: Element Mesh models

Human Modelling

Creating 3D model of a human and his clothes from scratch requires a lot of time and effort since a human modelling with basic mesh tools such as cubes and cylinders requires much manipulation with edges and vertices to get a perfect shape of a real human body. So a basic human add-on in Blender called as Avastar was purchased so that the time needed to create humans can be get reduced much efficiently. The Mesh model creation of humans was done with this add-on in Blender known as Avastar [80]. Figure7.3 shows a basic Avastar Mesh.

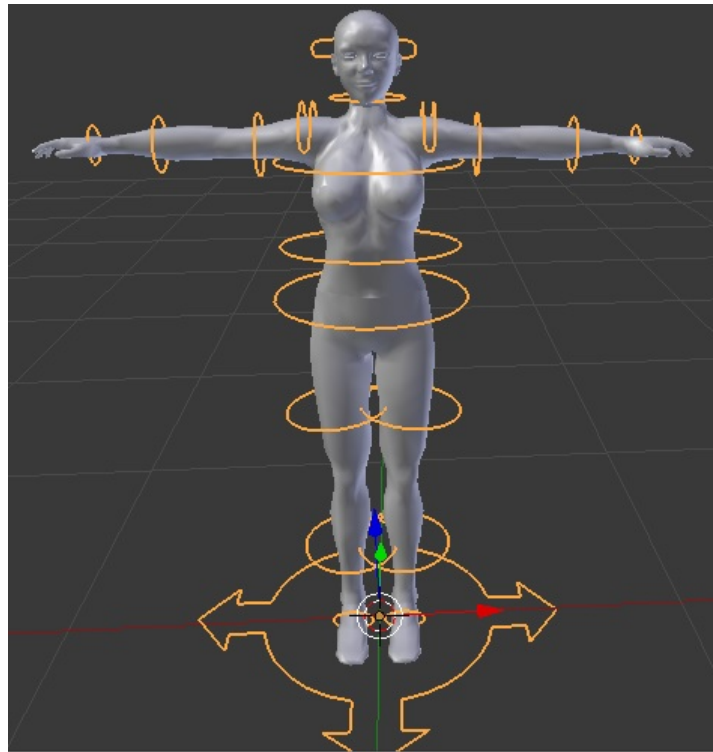
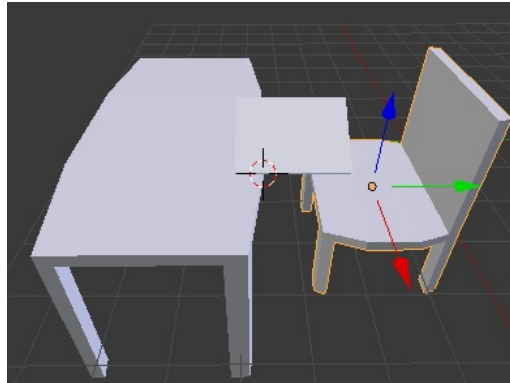
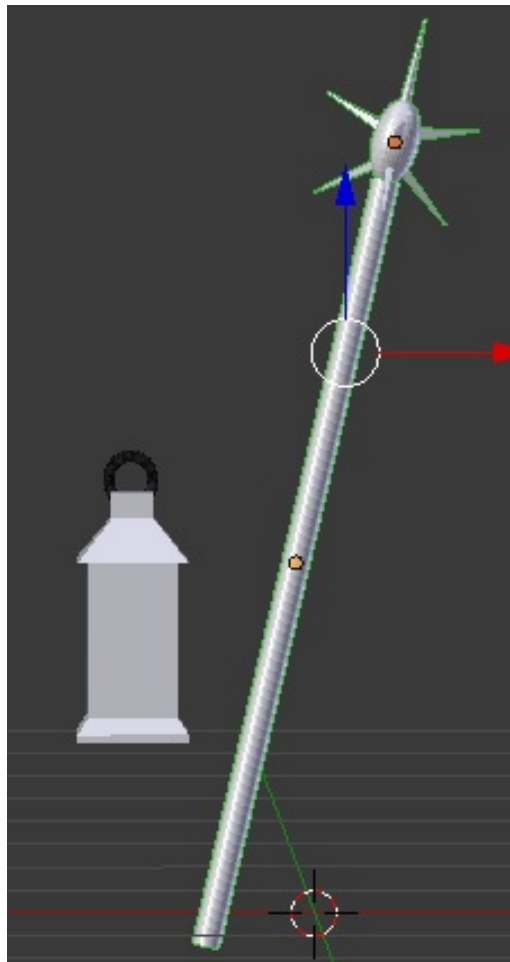


Figure 7.3: Basic Avastar Mesh

With the Avastar add-on mesh, the human modelling became quite easy to create a basic shape of the Virtual Human in Blender. The Avastar mesh was modified appropriately using shape sliders in Blender to create different character meshes such as Nidaros Choir lady, Town planner and Vektervandring. The Choir lady in front of the Nidaros Cathedral was created as she is sitting in a chair with one book on her table. She can provide some information about the same if we touch on her book. Also two more characters, a town planner standing in front of old town bridge with a book of town plan and Vektervandring with his stick and a lantern from Røros in front of Archbishop's museum were also created as inhabitants in Virtual Trondheim. Some information about the buildings were provided along with these Virtual inhabitants so that the visitor can touch and have some knowledge about the buildings such as opening hours, history of the buildings etc. These humans were having large number of vertices and edges which can lead to high land impact on the island. So while uploading the human meshes the number of vertices were reduced to its minimum in order to reduce the land impact. The basic avatar mesh character was edited accordingly, for male and female characters and for different poses of the humans using the shape sliders.

Human accessories

(a) Choirlady accessories



(b) Vektervandring accessories

Figure 7.4: Virtual Human accessories

In addition to the humans and buildings, more additional items such as table and chair meshes, books and sticks meshes that can make sense with real humans were

also created. Those meshes help to give a realistic appearance for the virtual humans stay in the island. Figure 7.4a shows a table with one book and a chair to sit for the virtual Human who is staying in front of Nidaros Cathedral which is a representation of a choir lady. Figure 7.4b shows the accessories of Vektervandring from Rorøs who has the function to help the tourist.

7.1.2 Texturing

Texturing is the process of applying different textures such as images, movies or some patterns on to the faces of a mesh object in order to get intended appearance to the particular object. For e.g. for buildings walls, it is possible to apply a texture of a brick so that building looks, as it is build up with different bricks.

Buildings Texturing

The faces of the meshes were textured same as that of the original buildings in order to mimic real buildings. Basically all meshes can have up to 8 texturizable areas or material slots that can apply textures. So texturing was done on each building by grouping the mesh faces in eight material slots. For those faces that need identical textures were grouped and marked seem on the mesh object. For each marked seem, material slots were created and assigned separate texture to each slot. The material slots were then UV mapped and render the mesh model with the texture or bake it so that the whole model looks similar to the real buildings. UV mapping can be explained as a mapping procedure in blender to wrap a 2D image texture onto 3D mesh. Image mapping procedure on 3D mesh faces helps models to have a realistic looking surfaces with derived textures from these images [81]. The images used for texturing were acquired from another project named Travel in Europe which was already completed some years ago [21] since those images were captured in perfect angle that can apply to each of faces of the mesh model. Also some pictures were taken by the author itself from the original buildings because of the unavailability of pictures from the other project. Images that need to apply on mesh models were processed in paint program so that it should fit well with the faces of the mesh models. Also in blender there are tools to modify the image to make it more realistic. Image sampling, Image mapping, shading and colouring are some examples of these tools. Figure 7.5a, Figure 7.5b, and Figure 7.5c shows parts of textured buildings

in Blender software. A complete model of Old town Bridge was not able to create in a single workspace of the Blender since it was really a very big structure. So parts of the model were created separately such as the top portion of the bridge, the chains, wheels, the pillars, the road and the fence in different workspace and imported separately into the SecondLife. Also the Archbishop’s museum and the Buildings along the river side were also created separately in separate workspace and imported separately into SecondLife. After importing the meshes to the land, the textures associated with them were also uploaded. Then the textures were dragged on to the faces of meshes to get the intended appearance to the buildings. It is important to note that while editing mesh there are chances to have duplicated edges, faces and vertices. So after the whole model creation the duplicates should be removed before applying textures else it cause several errors while importing to SecondLife. The created mesh model should be saved in .dae or COLLADA format which is the only file format that can be used to import into SecondLife.

Buildings Physics

For each mesh that upload into SecondLife there should be a physics incorporated with it, either by the SecondLife engine or by manual creation of physics with the mesh. This has to be done in order to achieve a realistic behaviour for the objects. For Building meshes a separate simplified physics model was created and uploaded with the original mesh into the island. Buildings Physics was done in Blender with a collision detection mechanism by making the mesh as passive rigid bodies. It was a good mechanism rather than automatic physics creation by the Second Life engine that can cause some unexpected behaviours.

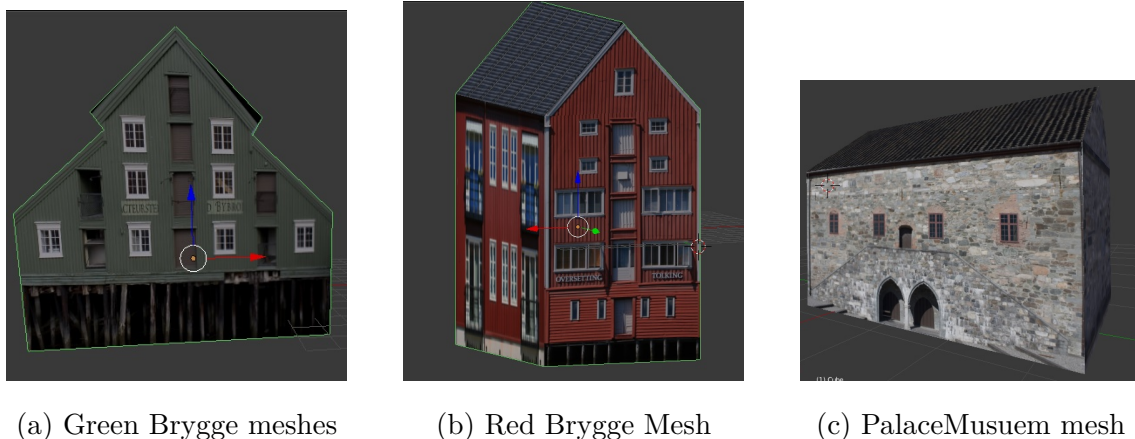


Figure 7.5: Element Meshes of Buildings

For this particular project 3D models of wooden buildings along the river side, A river flow model, old town bridge with fence and Archbishop's museum were created in Blender and imported to Second Life. Also a rotating quiz mesh was created in order to show a quiz module in NTNU island by which a resident can test his knowledge about Trondheim.

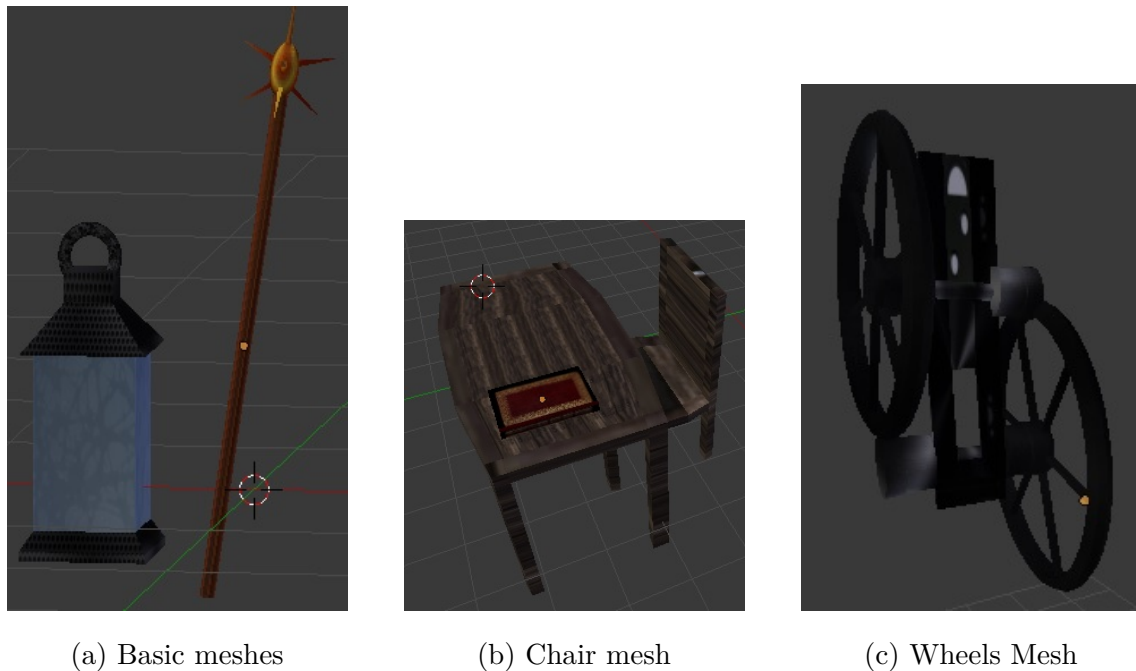


Figure 7.6: Element Meshes of accessories

Avatar accessories meshes were also created and textured in Blender and exported to SecondLife. Some basic meshes like chain meshes and wheels meshes for the old town bridge was quite complicated to mend it together in SecondLife since for the chain mesh, each chain hook was positioned manually which was rather a time consuming and hard job to complete it perfectly.

Avastar Texturing

The clothes, head and the hair meshes have to be textured appropriately to get a real human appearance in Second Life. The texturing of the human was done in-world after exporting the UV layout of the mesh body of the Human from Blender to a GIMP Program. Since the Avastar mesh was having so many vertices and edges, a simple UV layout exported from Blender cannot help to make the clothes textures or face textures. Instead Avastar UV templates provided by Linden Lab were used to make the Skins and clothing. An edited Avastar template available online was

used to make as a reference to paint the clothes, head and body parts [82]. On this UV template the painting of Clothes and skins were done using GIMP software and the layouts were saved in a .xcf format files and then exported as .tga format. This exported image files in .tga format were used to apply on the Avastar mesh body to get a virtual human textured in clothes, with perfect face and skins. But for the Hair texture, the hair UV layout was exported from Blender and painted in GIMP program. The UV templates is shown by the Figures 7.7a, 7.7b and 7.7c.

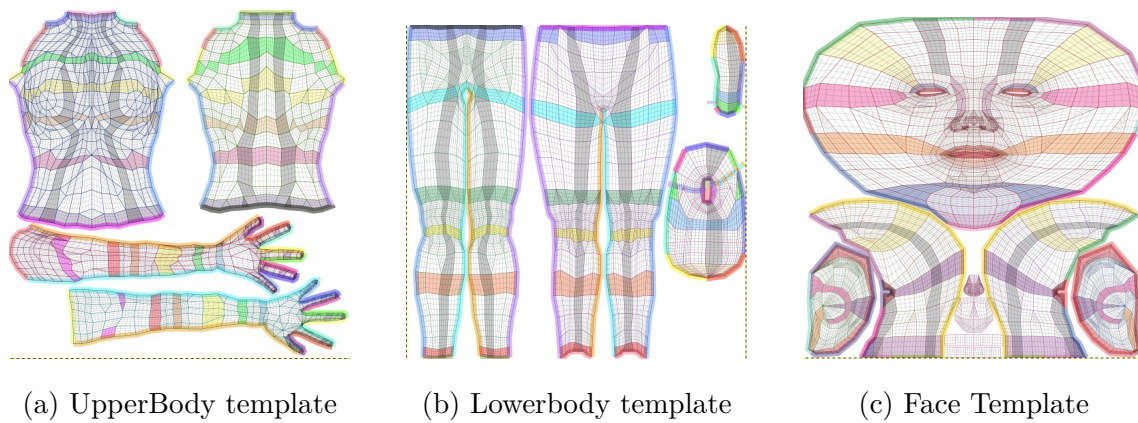


Figure 7.7: UV templates

This UV templates shown in Figure 7.7 were exported into GIMP and painted appropriately to get the desired textures for the Virtual Humans. The textured upperbody part, lowerbody part and the face are shown in Figure 7.8.

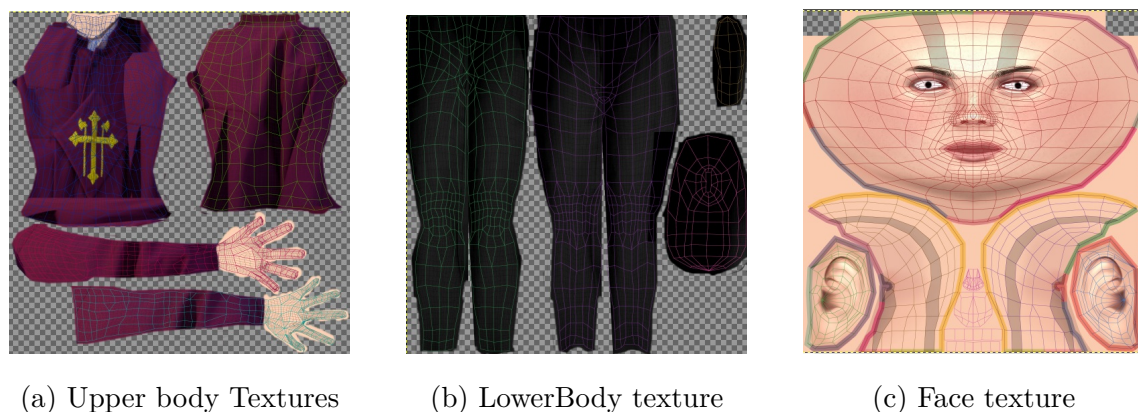


Figure 7.8: Textures of the Human Body

Also the skirt layers of female humans are shown inFigure 7.9.

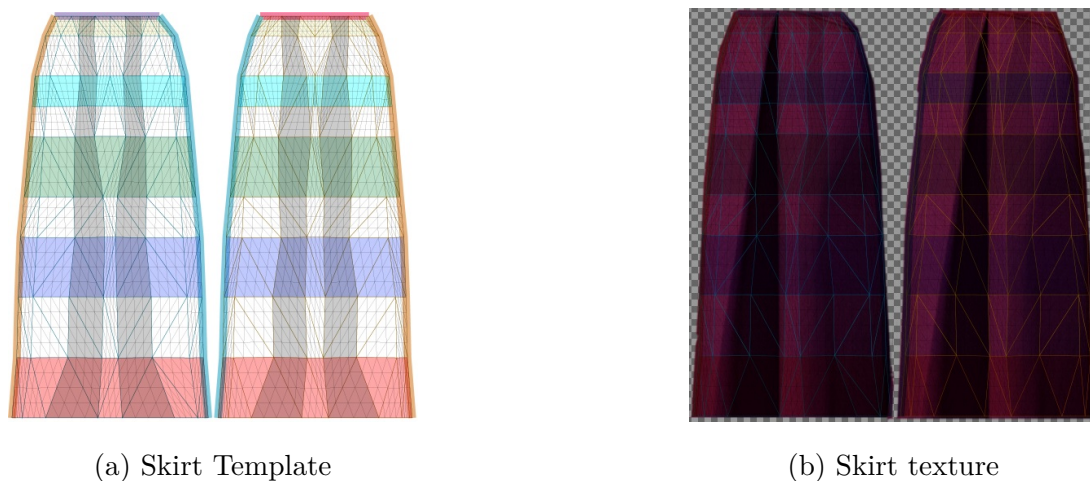


Figure 7.9: Textures of Skirt

The Head template and textured files in .xcf format shown in Figure 7.10.

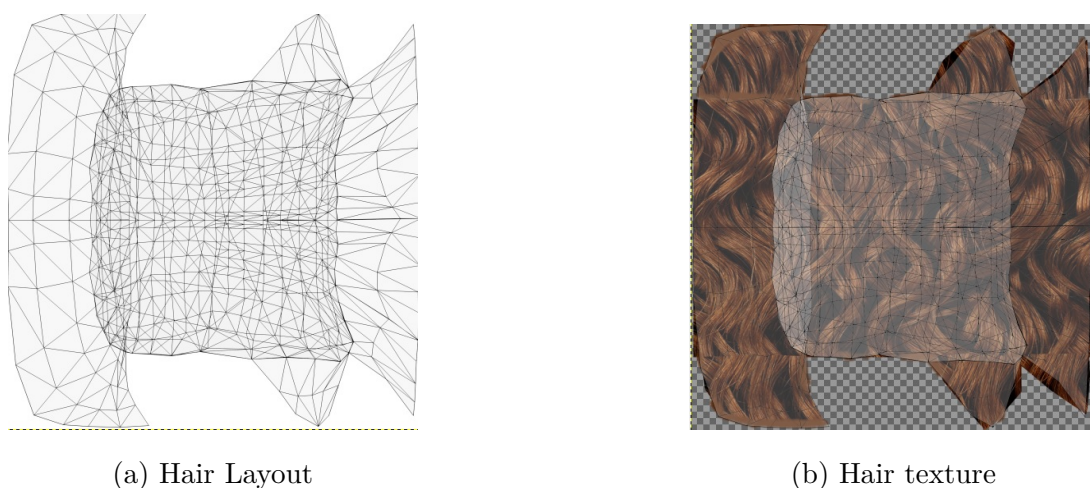


Figure 7.10: Hair Textures

7.1.3 Avastar Animation

Avastar add-on in Blender have so many features so that it is possible to make different pauses for the virtual humans and to animate it smoothly. It is a fully rigged mesh with IK controls, bone weights and physics. Animatable human models can be created with Avastar. Therefore this tool in Blender have various elemental user interfaces and functions [83]. After adding the Avastar add-on to the workspace, the shape was modified as that required for male and female characters using Avastar Materials tools. Since the human character created with Avastar add-on was fully rigged and weighted, it was easy to make different pauses for the animation. Ini-

tially the mesh status changed to pose mode and then the connected bones were grabbed using shape sliders to get different pauses, from the default T-pose mode of Avastar mesh. Then selected the bones that were changed and created a Key Frame in blender with the finished pause. In this way each pause for a specific type of animation was key-framed and saved in .obj format. So for a continuous movement a series of frames were created and saved in .obj format.

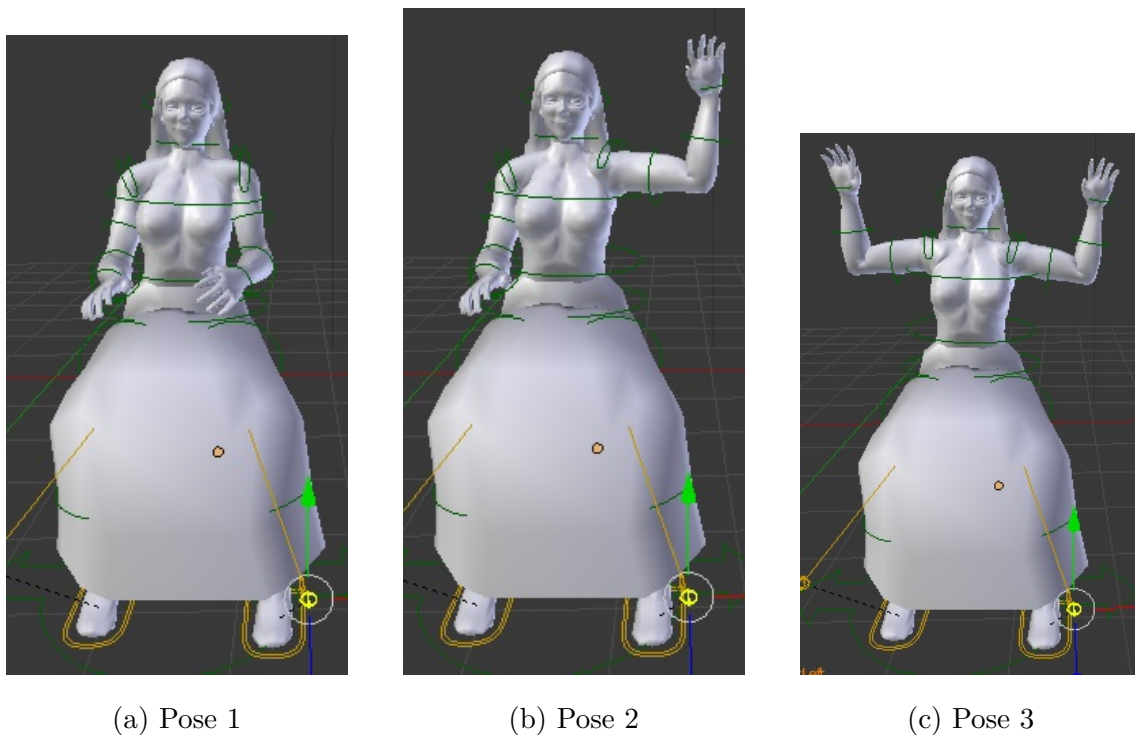


Figure 7.11: Different Poses of Choir lady

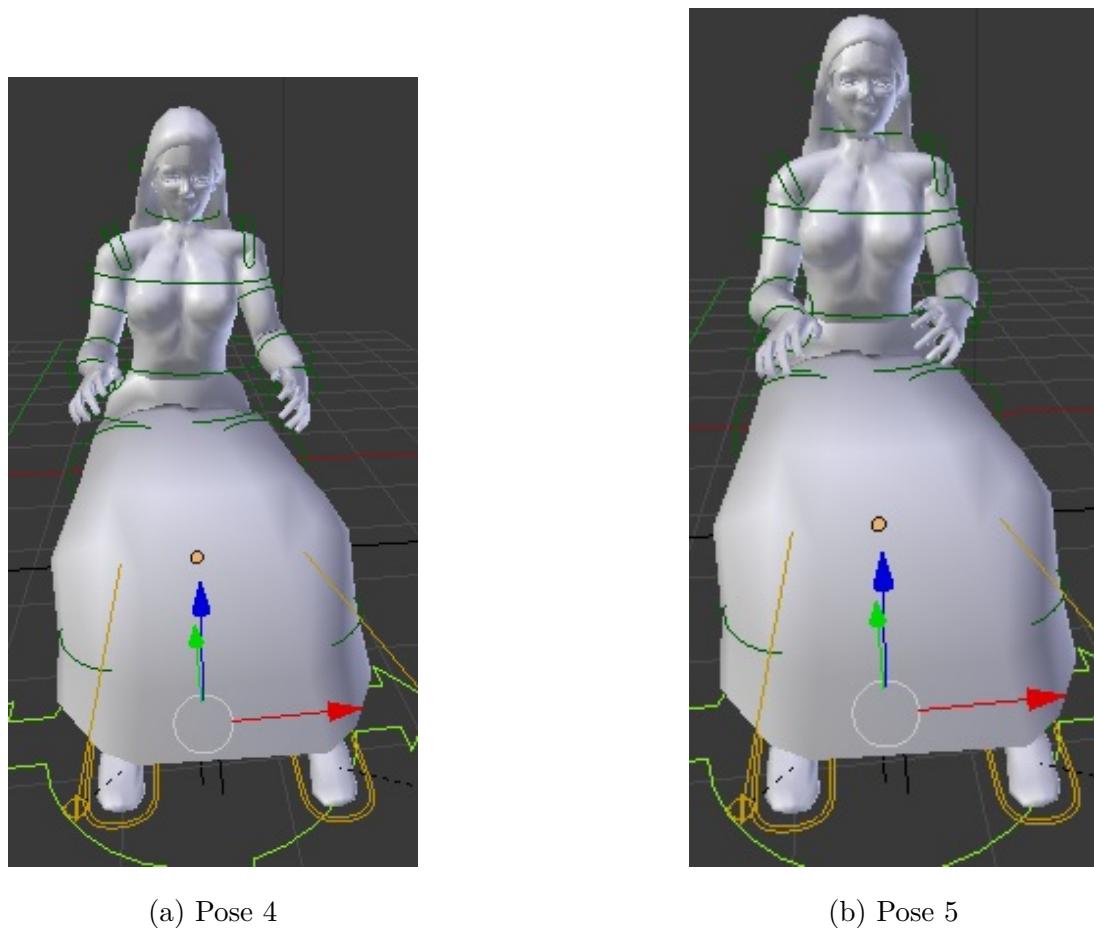


Figure 7.12: Different Poses of Choir lady

The different pauses of animation for waving the hand to say Hi to the visitors by Nidaros Choir lady is shown in Figure 7.11 and Figure 7.12. A total of five different pauses were created and saved in .obj format. These poses were saved in frames using timeline section in Blender. Also set the time for each pose by setting the number of frames between each pose. The first pose and last pose were set as same in order to get a continuous movement and all the poses were saved in .obj format and exported.

7.1.4 Exporting Meshes

After the animation has got finished in Blender, the poses which were saved as Wavefront (.obj format) files were exported and then again re-imported to another Blender file. While exporting as .obj file, "the Selection Only" and the "Animation" options in Export tab should be checked to export only the selected poses and its animations.

All the poses should be re-imported into the same Blender file. Since in each pose Avastar body meshes will import separately by default. So mesh body parts were be joined to get one complete pose of Avastar. Then these poses were re-exported as a single Avastar Collada file (.dae format) into SecondLife. In this collada file all the poses were linked together and it can be easy to import and unlink to apply the textures to Avastar in SecondLife. It is important that after reimporting the whole mesh Avastar to a new Blender file, all the meshes such as upperbody mesh, lowerbody mesh, head mesh, eyes mesh and hair mesh should be linked together to get a whole Avastar shaped mesh. Another important fact to remember is that while re-importing the option for "Keep Vertex order" needs to be checked so that the linked set would be in same order as it is animated, so that the Avastar meshes will show up in SecondLife as expected.

The buildings' meshes created in Blender were exported directly as normal collada file (.dae format) and imported into Second Life. While exporting it is important to make sure that "Selection only" and "Apply Modifiers" option are checked and the operator presets should be the "static meshes SL+ OpenSim Static" in Blender.

7.2 Import Meshes into Second Life

The meshes that were saved in .dae format (collada) in Blender can be imported to Second Life and rez those on the island. Here under Build tab, file upload option can be found and meshes can be uploaded to SecondLife. The major steps before get the mesh uploaded to island as per SL tutorial were as follows: [84].

- Choose the .dae file of mesh that stored on computer by choosing Build > Upload > Model.
- Preview the "mesh's automatically generated levels of detail on the Level of Detail tab by clicking High, Medium, Low, and Lowest".
- Select the Physics tab and choose the physics model associated with the mesh that need to upload
- Select the Upload options tab and check the boxes for some additional features on model, such as textures, Edges.

- Click on Calculate weights and fee, and examine the mesh weight, land impact, and Upload cost in Linden dollars.
- Click on Upload button to upload mesh model to Second Life.

While uploading it was required to reduce the Level Of Detail to its minimum in order to reduce the download weight and Land impact.

7.2.1 Level Of Detail

While uploading, we can find four levels of details, by which the user can have choice for any level of detail to choose as per the wish. One of the major factor that determines the land impact of the mesh Objects uploaded in SecondLife islands is LOD. There is an LOD generator that shows Four levels of uploading mesh i.e Lowest, Low, Medium and High. With this generator we can change the number of triangles and vertices and hence the object's complexity can be changed [85].

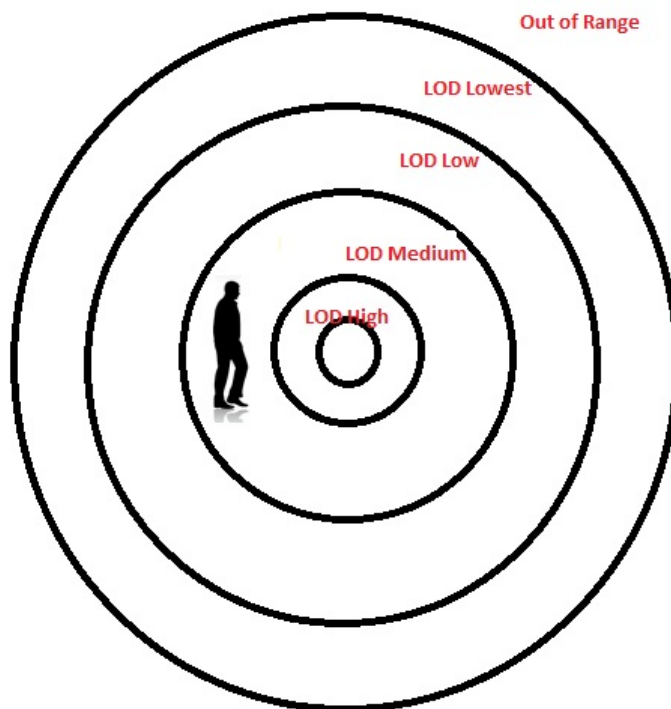


Figure 7.13: Level Of Details

This LOD Mechanism help to change the visual details in four different levels. Also it is better to reduce LOD so that the amount of power needed to display mesh objects can be reduced to a certain extend and hence the efficiency can be

increased [85]. For the Virtual Humans created in the island, the LOD for the first version was set as High and for the subsequent versions each with less detail than the one before, so that the Calculated weight was reduced to minimum. For Buildings meshes the weights were kept at its minimum so that the meshes got only minimum land impact.

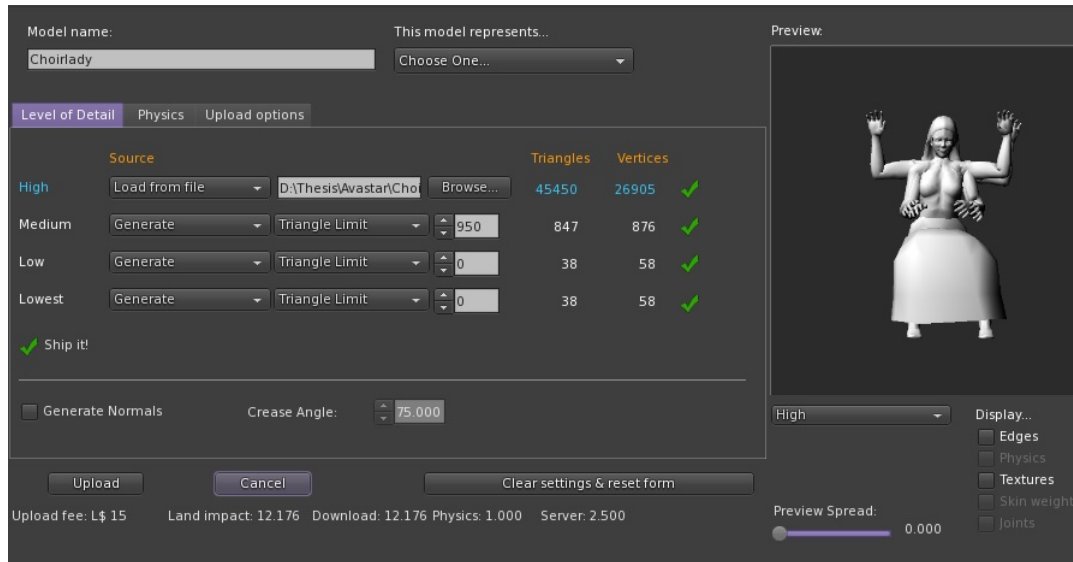


Figure 7.14: Avastar mesh with linked poses. LOD set to minimum so that Land impact and Download weight is minimum

7.2.2 Land Impact

"Land impact is Second Life's mechanism for calculating the computational weight of an object against land usage limits. All mesh objects, and all objects with a physics shape type other than Prim, use an algorithm for determining land impact that is not dependent upon the number of prims in the object. By using an algorithm that considers each object's impact on Second Life's performance, we make sure that mesh objects and traditional prim objects receive fair shares of Viewer and server resources, encouraging content creators to continue designing performance-efficient objects even if they're working with uploaded meshes "[86]. In the Figure 7.14 the avastar mesh component LOD is set to minimum so that land impact and download weight is reduced to a large extend. In an educational island like Virtual Trondheim that have limited capacity, it is important to reduce the land impact of the uploaded models for better performance.

While implementation one major problem encountered due to the high land impact.

Since the island has got so many students projects, the part of ntnu island which was kept for Virtual Trondheim has got the region capacity reached to its maximum and some of the mesh components were automatically deleted from the island by LindenLab. So due to this reason the mesh component LOD was set its minimum in order to overcome this problem and get rid of the issue of automatic deletion from the island without any warning.

7.2.3 Models Of Virtual Trondheim

After the meshes get uploaded successfully to the Second Life inventory, those were rez on the land, scaled and edited it appropriately and got it rearranged to form complete model of the buildings. The textures for buildings were also uploaded in SL as Build > Upload > image. The images that need to upload to SL should be of size less than 512MB. Since UV wrapping was already done at the time of model creation in Blender, it was possible to drag the texture to the appropriate faces of the buildings in the island. The texture fit into the faces without any distortions at the intended locations of the buildings or Virtual Humans and had resembled exactly as designed in Blender. After placement of each building component with separate physics model, the mesh was edited and on Features tab make Physics shape type as Prim, so that it should behave as expected in terms of applied physics on the mesh component. Here there are some pictures of mesh models in Virtual Trondheim. Figure 7.15 shows an overview of the buildings along the Nidelva river side in Trondheim.



Figure 7.15: Brygge (Buildings) along Nidelva River

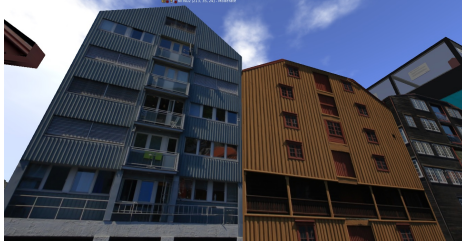


Figure 7.16: Bryggene Trondheim In Second Life

Figures 7.16 shows a close view of some of the buildings along river side and Figure 7.17 shows the pictures of Old town bridge in Trondheim

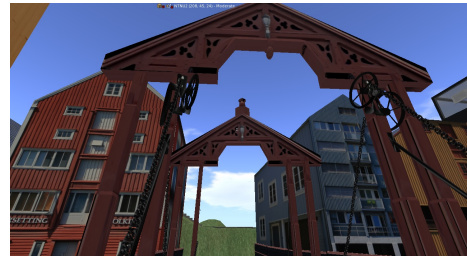
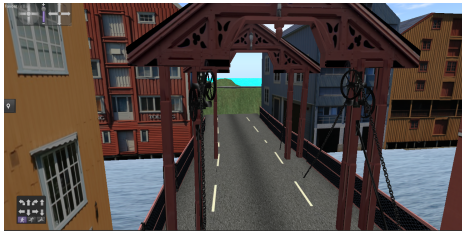


Figure 7.17: Old Bridge Town Trondheim In Second Life

Figure 7.18 shows some of the wooden houses in Baklandet gate in Trondheim. Baklandet is one of the small streets in Trondheim with many wooden houses and it is situated east side of the River Nidelva



Figure 7.18: Baklandet Trondheim in SecondLife



Figure 7.19: Parts of Archbishop's Museum In Second Life

Figure 7.19 shows pictures of some parts of the Archbishop's Museum situated near to Nidaros Cathedral Trondheim.



(a) Town planner

(b) Accept NotecardCard

(c) Notecard Info

Figure 7.20: Townplanner with some information

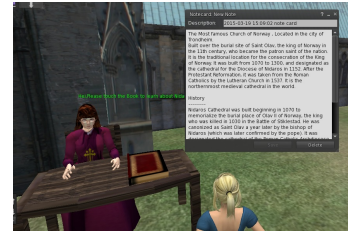
The Figure 7.20 shows a representation of virtual inhabitant in the island. She represents a town planner standing in front of Old town bridge. Any resident who visit Virtual Trondheim can Touch the book in her hands and can read about old town bridge history. The resident should Accept the given Notecard in order to read the details written in the Notecard. This given Notecard was implemented using Notecard giver script in Second Life which is explained in Section 7.3 Scripting. In the same way a virtual Choir lady in front of Nidaros Cathedral and Vektervandring in front of Archbishop's Museum is also implemented in the island.



(a) ChoirLady



(b) Accept NotecardCard



(c) Notecard Info

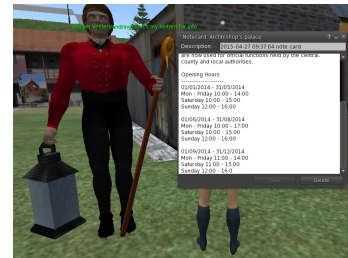
Figure 7.21: Choir Lady in front of Nidarorsdomen with some information



(a) Vektervandring



(b) Accept NotecardCard



(c) Notecard Info

Figure 7.22: Vektervandring at Archbisop's Muesum with some information

Vektervandring is having some practical information about the buildings and Choir lady is having some details about the Nidaros cathedral for the tourist.

7.3 Scripting

This section discusses about the scripting works done for the animation of Virtual Inhabitants such as Choir lady sitting in front of Nidaros Cathedral and the lady town planner standing in front of Old town Bridge. In addition to that there are scripting works done for the implementation of a Quiz for the residents, script for river flow, rotation script for the Quiz mesh, the Notecard giver script and floating text scripts associated with Virtual Humans in the island.

7.3.1 Virtual inhabitant animations

Initially the Avastar mesh poses were rezed to island. Then the poses were unlinked and apply the textures to all the poses by dragging the textures from inventory. Again linked the poses together to form single Avastar and the whole mesh Avatar looks similar to a real inhabitant. Then a basic program or script was added to the mesh content tab to animate in-world in the specific order of its movements.

By using Alpha animation script in Linden Scripting (lsl) it is possible to animate the virtual human meshes. `llSetLinkAlpha` function in linden scripting was used here in order to show link sets meshes in a specific sequence. With `llSetLinkAlpha` the poses saved in frames were shown in particular timing intervals which simulates the animation or movement of the humans. This is a frame-by-frame animation and also uses `llSetLinkPrimitiveParamsFast` function to set the prims parameters according to rules. The source code for Virtual human animation in-world is shown in Appendix A.10 The pseudoscript for Choir lady movements in front of Nidaros Cathedral and Town planner in front of Old town bridge was as follows:

```
Declare total prims, link counter;
While default State
{
do
{
Get Number Of prims in the linkset
Set linkset visible all sides using llSetLinkAlpha();
Set timer event;
}
timer trigger()
{
increment linkcounter;
linksets toggle their alphas in the same same execution frame using llSetLinkPrimitiveParamsFast() and uses short time intervals;
set link counter;
}
}
```

7.3.2 Quiz

As per the requirement of having something to perform in the island rather than just a walk around through the island, a quiz was implemented so that the residents can test their knowledge about Trondheim to some extent and can learn by play. The Quiz was implemented with a script that read multiple choice questions and answer choices from a notecard and present it in a dialog box. It is an open source code available from SecondLife wiki created by a Senior Helper [87]. The multiple choice questions were available from another project named Travel In Europe that also aimed at developing a 3D virtual environment that supports user to perform adventures similar to that in video games. [21].

The script for the Quiz is shown in appendix A.11. There are some changes made for the original quiz code such as the time that can take to complete a quiz for the resident was extended to 2 hours. This helps the quiz taker to learn the right answers if he got wrong answers or he don't know which one is the right answer from the choices given. It allows only one resident to take part in the quiz at a time and gives immediate feedback when a dialog button named submit is pushed. This is for one time submission and it is not possible to retake the quiz. The result will be stored and also displayed immediately after the quiz. Further if the owner of the quiz want to check the result of each person who took part in the quiz, it is possible by typing report /24 channel chat [87]. For the implementation of Quiz, a Cube Prim was first created in the island and apply some textures on it related to Trondheim tourist attractions. Then a rotating script was added to this prim so that it seems rotating continuously. Also a floating text above the Quiz prim saying "Touch this rotating cube to take part in the Quiz" was created so that any resident who happens to see the rotating structure can immediately understand what should do with the Rotating cube. The multiple choice questions for the quiz were added into the content tab of the prim in a Notecard. This notecard and the scripts were saved in the prim's content tab. The Figure 7.24 shows a resident participating in Quiz.



(a) Rotating Quizmesh



(b) user touch the mesh



(c) Answering questions



(a) Completed the quiz



(b) Quit the quiz



(c) Retake quiz-notify

Figure 7.24: User take part in the Quiz

7.3.3 Notecard giver

Notecards are a way to deliver detailed information about something that does not fit in a single IM (Instant Message) in Second Life. It is possible to create notecards in the user inventory. Also it is possible to share the notecards with recipients in the user's Friends list. There is one more possibility in SecondLife islands to give notecards automatically to anyone who visit the island that accepts IM about the same [88]. Here notecards are given when the user touches some particular objects of the island. This was accomplished by notecard giver script in SecondLife [89]. The information given in the notecards are adopted from the sites [90, 91, 92]. Pseudocode for giving notecard when user touches the object is given below:

```

Declare string notecard;
while in default state do
{
get notecard name from inventory;
if type not equal to notecard
{

```



```
ownersay "no notecard found in inventory "  
}  
else  
{  
display notecard name;  
}  
end while;  
touch start event trigger  
{  
if notecard found  
{  
Inventory notecard opens;  
}  
}  
}
```

After the creation of object such as book mesh or lantern meshes, the script was saved in content tab of the object and the notecard was also saved in content tab. The Notecard giver source code can be found in Appendix A.12.

7.3.4 River flow

For the river a model was created using prims and burying the prims in a depression on the island. The river flow texture was applied to the prim. The flowing water was accomplished by animating the river image by changing the offset of the image in one direction, so that the texture seemed to be flowing from one side of the prim face to the other. This was done by adding a script to the prim which is `llSetTextAnim()` function found in SecondLife inventory. The other faces of the prim are set to a 100% alpha texture, so it is possible to see only the one prim face that is the animated water [93]. The animated river flow script can be found in Appendix A.13

7.3.5 Rotating Cube Mesh

The quiz mesh was a rotating cube upon which the Avatar can touch and start in taking part the quiz. The script was from the Inventory folder in SecondLife and the function `llTargetOmega()` makes the cube to have a rotation effect. Rotation

Script is shown in Appendix A.14

7.3.6 Hover text over the Prim

Above the rotating cube mesh a floating text saying "Touch on rotating cube to take part in Quiz" was implemented, associated with Nidaros Choir lady a floating text saying "Hei, Please touch the book to learn about Nidaros" and same type of floating text associated with Veketervandring and Town planner in front of Old town bridge was implemented . These floating scripts were done as follows :

1. Create a prim and make it transparent using the script
2. Edit the same prim again and create a new script

Make the prim invisible using the function `llSetPrimitiveParams(parameters)`, with appropriate parameters [94]. A text will be displayed that hovers over the prim with specific color using the function `llSetText(parameters)`, with appropriate parameters [95]. The scripts for both can be found in Appendix A.15

Chapter 8

Evaluation

This chapter discusses about the evaluation of the project works done and the results obtained through the questionnaires and open interviews. A total of five different evaluations were done on this project in order to prove the research question and its objectives. Evaluation with high school students was done in order to prove that this can be useful for educational purposes. The evaluation with visitors at tourist office was done to prove that it will be useful for the tourists for their different tourist activities. An evaluation was done at Vitensenteret in order to get an evidence that this has potential in the future since visitors over there are people who are interested to try new technologies. An expert evaluation was done with tourist office employees to prove that this can be used a tool in tourism industry by the tourism professionals. Also one more evaluation was done with some NTNU students to get more comments about the implementations in order to strengthen the objectives of the research question.

One evaluation was done on Åpendag at NTNU with the High school students who visited the stand of Virtual Trondheim with Oculus rift. The reason for this project to be evaluated with the school students was that, during the presentation of the project with the tourist guides they mainly stressed the importance of these type of systems for educational purposes for the school students and for the young aspirants. On 29 April 2015, Åpendag at NTNU, 40 high school students visited the stand of Virtual Trondheim with Oculus Rift and filled out the questionnaire form after the demonstration. All the students were of age between 15 and 20 and seemed that it was interesting for them to try with the Oculus and have fun with

the virtual tour through the Virtual Trondheim in NTNU island. Figure 8.1a shows the evaluation conducted with high school students on Åpendag at NTNU.

Another evaluation was done with the visitors at the Trondheim tourist office. This has to be done since one of major users of this system would be the tourists and the tourism professionals. Even if they might not be familiar with these type of systems, they have curiosity in knowing more by travelling and are really interested in visiting different places, know more about other cultures and traditions, and to have a diverse experience. Also the developed system is intended to be used by visitors of tourist office too. The visitors at the tourist office were from different places and the age ranges between 10 and 60. The evaluation was done in two Saturdays, on 2 May and on 9 May 2015 in order to get maximum number of visitors to try Oculus and Virtual Trondheim. Figure 8.1b shows demonstration of the system with visitors at Trondheim tourist office.

In addition to this one more evaluation was done with visitors at the Science Museum Trondheim who are interested in Science and technologies. Here the visitors can have a hands-on experience on the displayed models. Most of the visitors at Vitensenteret were kids between age 5 and 10. Also there were grownups interested to try Oculus and have a virtual tour. Figure 8.1c shows the evaluation of Virtual Trondheim with visitors at Vitensenteret Trondheim.



(a) Åpendag at NTNU

(b) Tourist office visitors

(c) Vitensenteret visitors

Figure 8.1: Evaluation of Virtual Trondheim

Further an expert evaluation was done with some employees at the tourist office and also another evaluation was done with some students of NTNU who can provide valuable opinions through detailed explanations and open interviews.

8.1 Evaluation with Questionnaires

A quantitative data analysis was done through the demonstration of the system together with the distribution of questionnaires. The questions with the answer

options are given below and a further analysis with the graph is also shown.

8.1.1 Response of the people about the usage of Virtual Trondheim

1. What is your opinion about using Virtual Trondheim ?

This question was about the usefulness of Virtual Trondheim for the visitors to the island. Some options are given as choices with a 5 point agreement scaling. The options are given below:

- It helps to learn about NTNU and the campus facilities
- It helps to learn about history and culture of Trondheim
- It can act as an advertisement of Trondheim
- It can help to prepare for a real visit
- It helps to get some idea about major tourist attractions
- It provides information about major places and buildings of the city
- It presents scientific and research activities in the city

Appendag Students

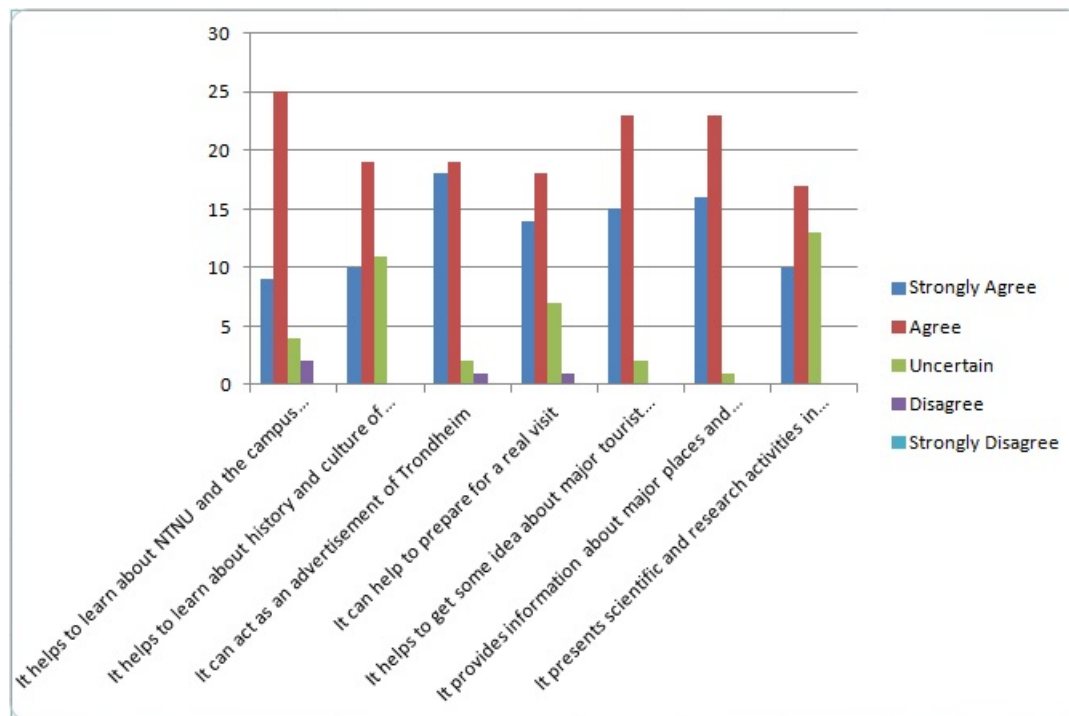


Figure 8.2: High School Students response to usefulness of Virtual Trondheim

A total of 40 high school students participated for the evaluation on Åpendag. Out of this nine strongly agreed and 25 agreed that it is helpful to learn about NTNU and the campus facilities. But four were uncertain about the same. Also 10 strongly agreed and 19 agreed to the option that It helps to learn about history and culture of Trondheim. But 11 were uncertain about the same. 18 students strongly agreed, 19 agreed and seven were uncertain about the option that it can act as an advertisement of Trondheim. Likewise 14 strongly agreed, 18 agreed and seven were uncertain about the option that it helps to prepare for a real visit. In addition 16 students strongly agreed and 23 agreed upon the options such as it helps to get some idea about major tourist attractions and It provides information about major places and buildings of the city. Only ten students strongly agreed and 17 agreed on the option that It presents scientific and research activities in the city and rest of the students were uncertain about the same. But two students were having a disagreement about the options such as It helps to learn about NTNU and the campus facilities, It can act as an advertisement of Trondheim and It can help to prepare for a real visit.

Visitors at Tourist office

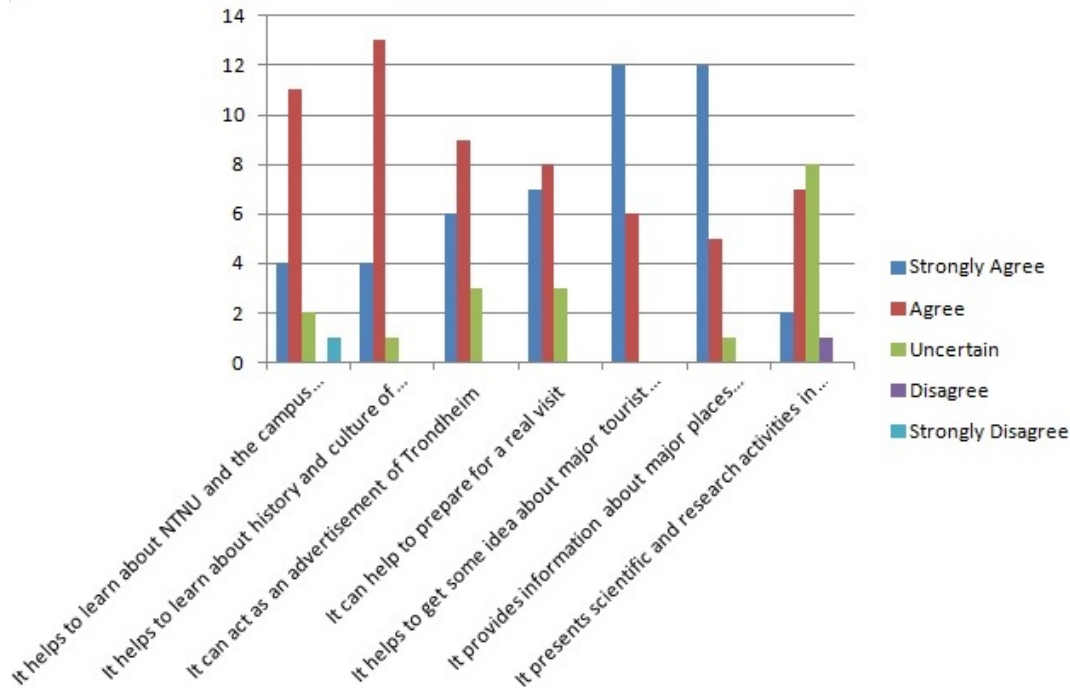


Figure 8.3: Tourist Office visitors response to usefulness of Virtual Trondheim

At tourist office, from two days of demonstration, a total of 18 visitors took part in the evaluation. Out of this four strongly agreed and 11 agreed that it is helpful to learn about NTNU and the campus facilities. But two were uncertain about the same. Also four strongly agreed and 13 agreed for the option that It helps to learn about history and culture of Trondheim. Only one of them was uncertain about the same. Six students strongly agreed, nine agreed and three were uncertain about the option that It can act as an advertisement of Trondheim. Likewise seven strongly agreed, eight agreed and three were uncertain about the option that It helps to prepare for a real visit. In addition 12 students strongly agreed and six agreed upon the options such as It helps to get some idea about major tourist attractions and It provides information about major places and buildings of the city. Only two students strongly agreed and seven agreed for the option that It presents scientific and research activities in the city and rest of the students were uncertain about the same. But one or two students were having a disagreement about the options such as It helps to learn about NTNU and the campus facilities and It presents

scientific and research activities in the city.

Visitors at Vitensenteret

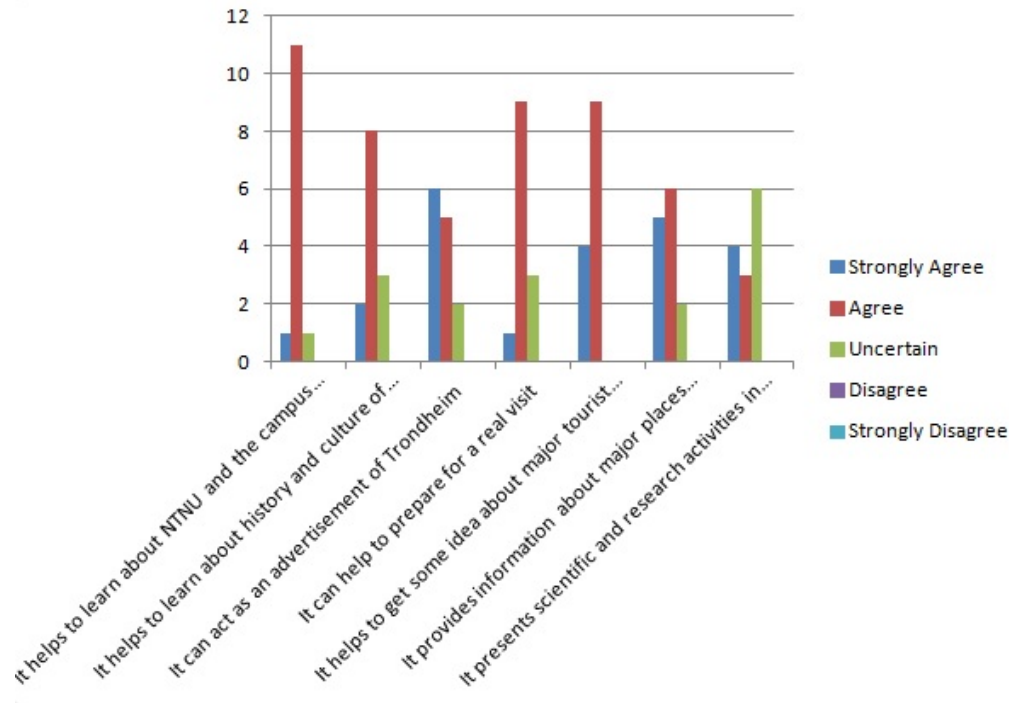


Figure 8.4: Vitensenterent visitors response to usefulness of Virtual Trondheim

At Vitensenteret, from two days of demonstration, a total of 13 visitors participated for the evaluation excluding the kids. Out of this one was strongly agreed and 11 were agreed that it is helpful to learn about NTNU and the campus facilities. But one was uncertain about the same. Also two strongly agreed and eight agreed for the option that It helps to learn about history and culture of Trondheim. And three of them were uncertain about the same. Six visitors strongly agreed, five agreed and two were uncertain about the option that It can act as an advertisement of Trondheim. Further one strongly agreed, nine agreed and three were uncertain about the option that It helps to prepare for a real visit. In addition four visitors were strongly agreed and nine agreed upon the option that it helps to get some idea about major tourist attractions. And five strongly agreed and six agreed for the option that It provides information about major places and buildings of the city, but two were uncertain about the same. Again four visitors were strongly agreed and

three agreed for the option that It presents scientific and research activities in the city and rest of the six were uncertain about the same.

8.1.2 Response to use of Oculus Rift



Figure 8.5: Person with Oculus

2. Do you prefer to explore Virtual Trondheim with Oculus Rift

This second question was about the preference of using Oculus Rift which was rated with the agreement scaling such as strongly agree, agree, uncertain, disagree and strongly disagree.

Appendag Students

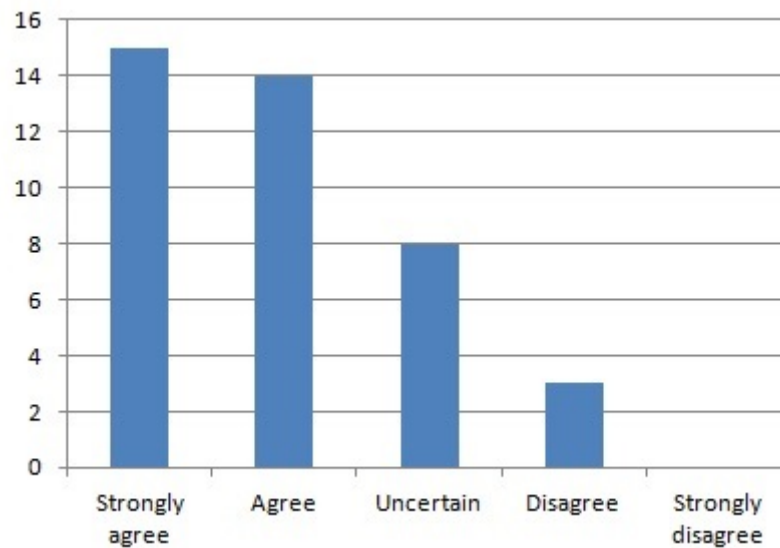


Figure 8.6: High School Students response to preference in using Oculus

Here from the Figure 8.6, we can see that out of 40 students 15 strongly agreed and 14 agreed for using Oculus rift. Only eight of them were uncertain about the same since they found some difficulties in moving around with the head set and using the laptop keys. And some were sick with it usage. So three students disagreed to use the Oculus Rift for a virtual tour with Virtual Trondheim. Most of the students were excited in using virtual Trondheim with Oculus Rift. From the direct observation, their attitudes can be identified easily. But some students had difficulties in using Oculus, they were mostly of girls those who were sick with the system.

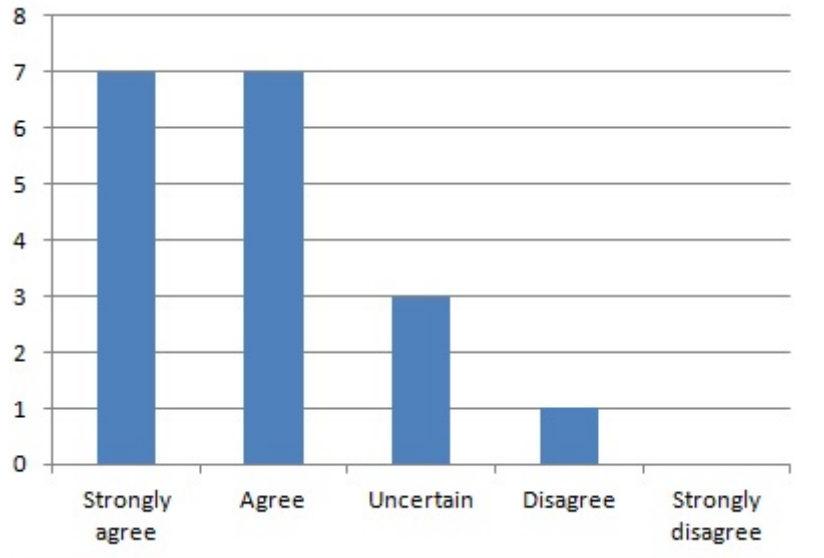
Visitors at Tourist office

Figure 8.7: Tourist Office visitors response to preference in using Oculus

From the Figure 8.7, we can see that out of 18 visitors seven strongly agreed and seven agreed to use the Oculus Rift. But three of them were uncertain about its usage since they were old people and had some difficulties in using the headset with the laptop keys. Also one disagreed about using the same and she was quite uncomfortable with Oculus. Also some kids tried to use Oculus Rift and were really enthusiastic with the same. They found it very enjoyable and were very eager to use the Oculus headset and explore the land. Also they did not seem to get dizzy or sick on use of the headset. They were interested to fly over the land and to see buildings and creations in the island. The visitors between age 15 and 35 were quite interested to use the technology and the 3D graphics and some of them commented that it is the future. Some commented that it is interesting to have some knowledge about the place.

Visitors at Vitensenteret

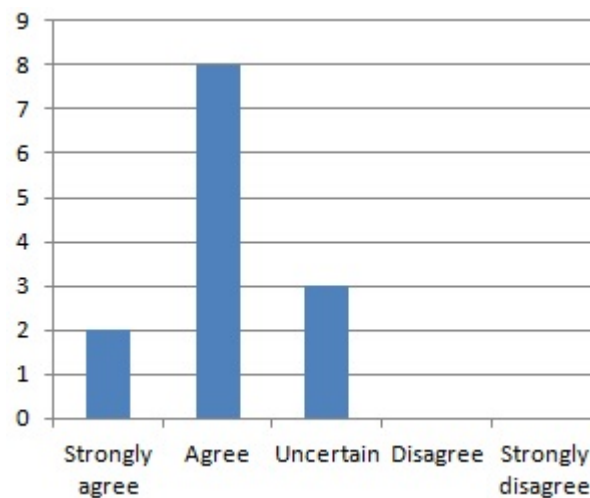


Figure 8.8: Vitensenteret visitors response to preference in using Oculus

At Vitensenteret the grownups who accompanied the kids also tried with Oculus Rift. From the Figure 8.8, we can see that out of 13 visitors, two strongly agreed, eight agreed and three were uncertain about the usage of Oculus Rift. Some of them were quite dizzy with the system and had some uncertainties in using it since they were unable to control the movement with laptop keys wearing the head set at the same time. But most of them enjoyed the Virtual tour and had commented that it is interesting to see the City of Trondheim in 3D with Oculus Rift.

8.1.3 Response to the Constructions in the island

3. How will you rate the constructions in the Virtual Trondheim? (Especially Nidaros, Gamle Bybru, Bryggene, Virtual Humans)

The objective of this question was to evaluate the created 3D models on the basis of its resemblance to the real buildings in the city of Trondheim. For this question the rating was given with a realistic scaling such as Very realistic, Realistic, Neutral, Unrealistic and Very unrealistic.

Åpendag Students

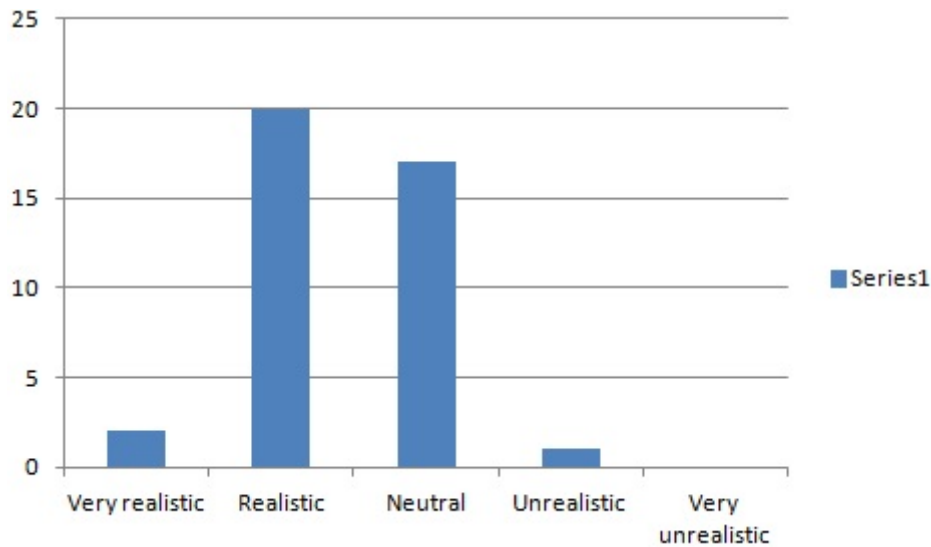


Figure 8.9: High School Students response to contents in Virtual Trondheim

From the Figure 8.9, we can see that out of 40 students two had the opinion that the constructions are very realistic, 20 said that it is realistic and 17 had the opinion that it is neutral when considering the real Trondheim city and the inhabitants. One had the opinion that constructions are unrealistic.

Visitors at Tourist office

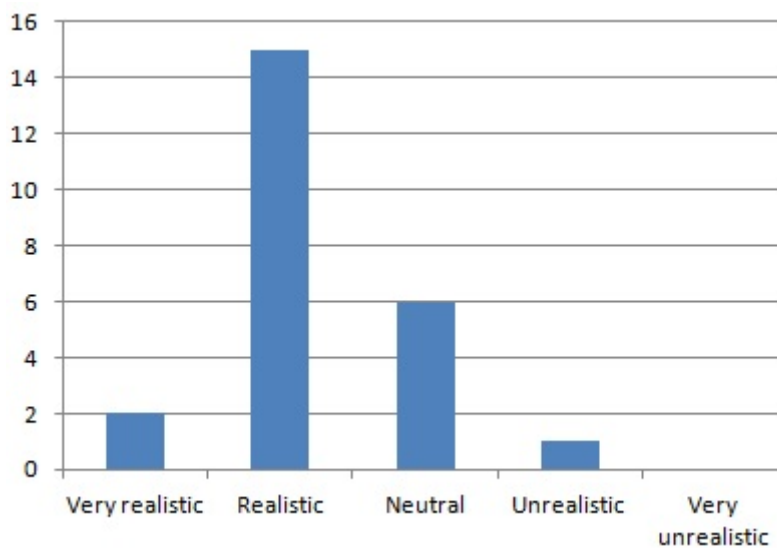


Figure 8.10: Tourist Office visitors response to contents in Virtual Trondheim

From the Figure 8.10, we can see that out of 18 visitors one had the opinion that the constructions were very realistic, 13 said that it is realistic and three had the opinion that it is neutral when considering the real Trondheim city and the inhabitants. Here also one had the opinion that constructions are unrealistic.

Visitors at Vitensenteret

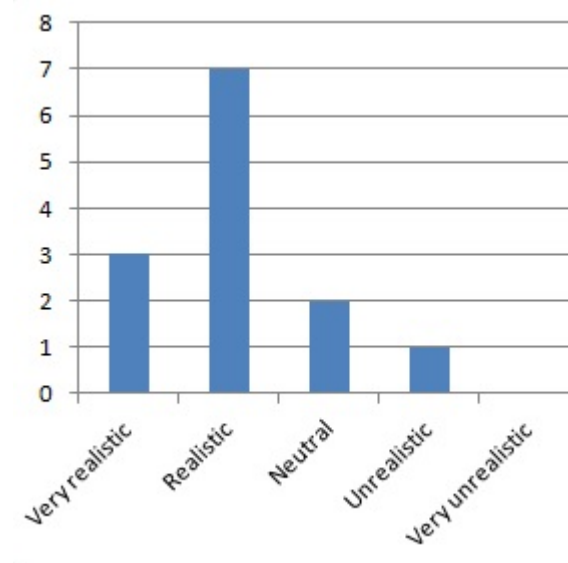


Figure 8.11: Vitensenteret visitors response to contents in Virtual Trondheim

From the Figure 8.11, we can see that out of 13 visitors three had the opinion that the constructions are very realistic, seven said that constructions are realistic and two had the opinion that it is neutral when considering the real Trondheim city and the inhabitants. Here also one had the opinion that constructions are unrealistic.

8.1.4 Characterisation about experience with Virtual tour

4. How would you characterize your experience in Virtual Trondheim?

This question helps to evaluate the system with respect to the characteristics of Virtual Trondheim with a scaling in the degree of agreement. The options for this question were given as below.

- I felt immersed in the environment
- Navigation was difficult
- Informative and having fun
- Provides a learning experience

The scaling was on agreement basis such as strongly agree, agree, neutral, disagree and strongly disagree.

Appendag Students

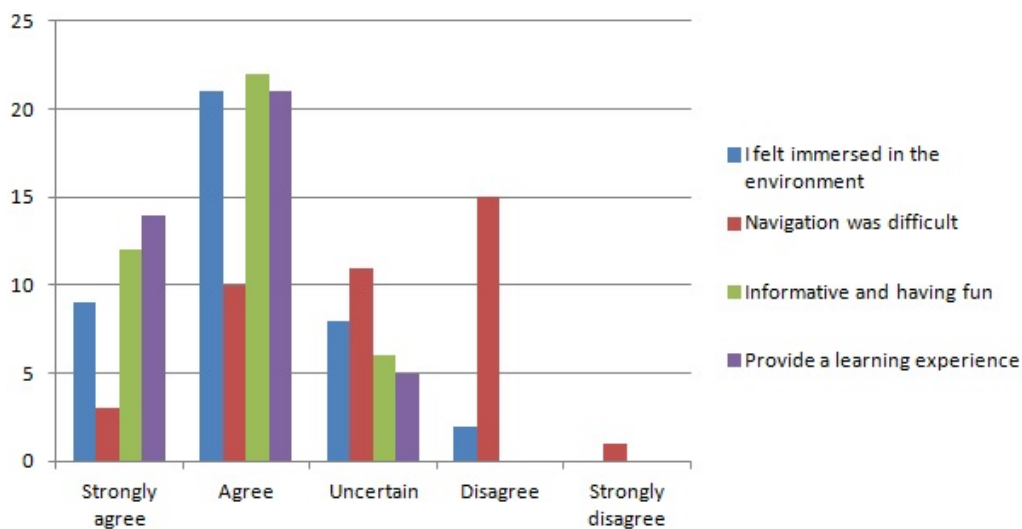


Figure 8.12: High School Students response to Characterisation about experience of Virtual tour

After the virtual tour with Oculus rift, out of 40 students, nine had a strong agreement and 21 had an agreement that they felt immersed in the environment. But eight students were uncertain about the same and two had disagreed with the condition of immerse feeling with the virtual tour. In the case of navigation through the island, three of them felt that it is really difficult to move through the island and 10 of them also agreed that the navigation is difficult. And 11 were uncertain about the same. But one was strongly disagreed and 15 students disagreed to the case and had the feeling that the navigation is quite easy through the environment with the Oculus rift and laptop keys simultaneously. In the case of the option Informative and having fun, 12 strongly agreed , 22 agreed and six were uncertain about the same.

Also 14 strongly agreed and 21 agreed that the environment provide a learning experience for the visitors to the island. But five of them were uncertain about this characteristics.

Visitors at Tourist office

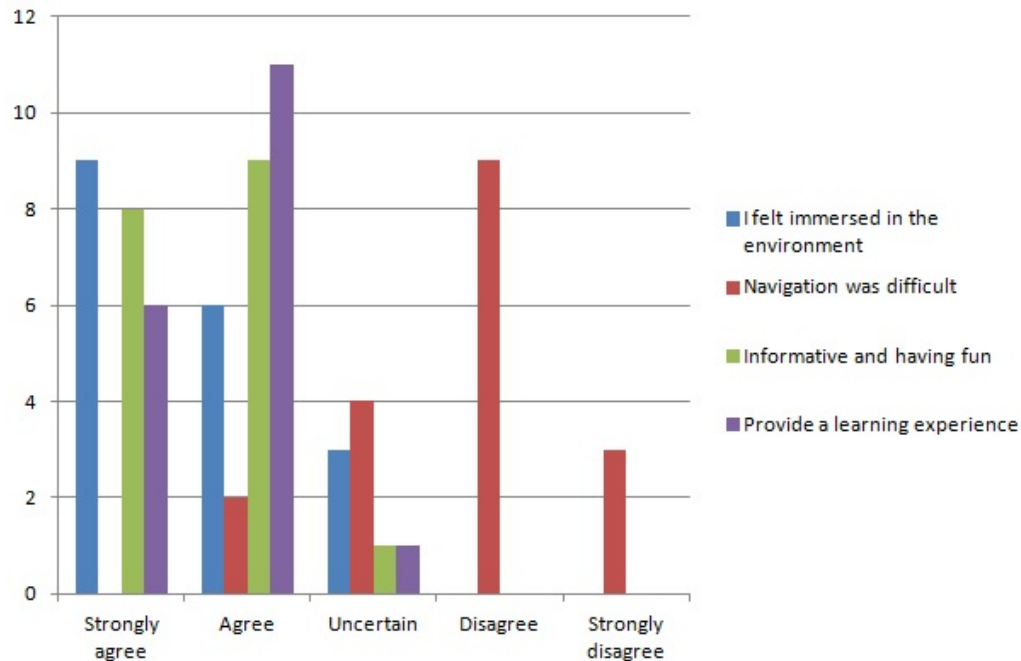


Figure 8.13: Tourist Office visitors response to Characterisation about experience of Virtual tour

After the virtual tour with Oculus rift, out of 18 visitors, nine had a strong agreement and six had an agreement that they felt immersed in the environment. But three visitors were uncertain about the same. In the case of navigation through the island, two of them agreed that the navigation is difficult. And four were uncertain about the same. But three strongly disagreed and nine visitors disagreed to the case and had the feeling that the navigation is quite easy through the environment with the Oculus rift and the laptop keys. In the case of the option Informative and having fun, eight strongly agreed, nine agreed and one was uncertain about the same. Moreover, six strongly agreed and 11 agreed that the environment provide a learning experience for the visitors to the island. But one of them was uncertain about this characteristics.

Visitors at Vitensenteret

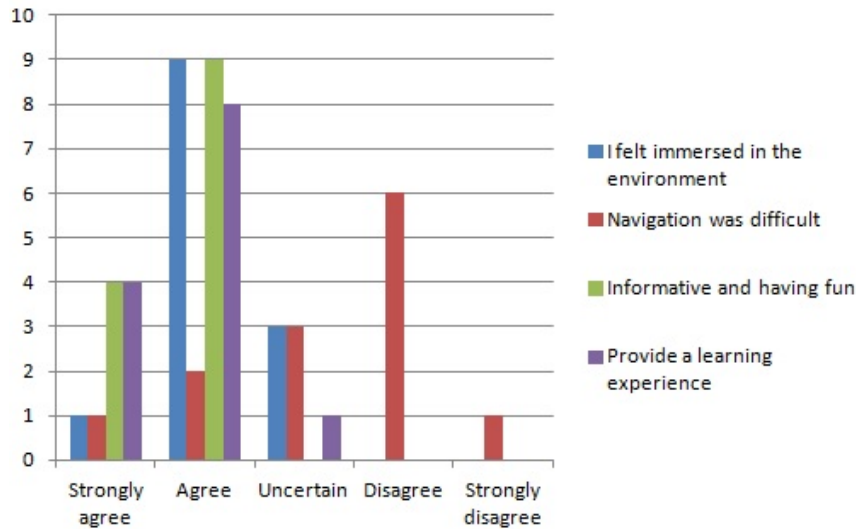


Figure 8.14: Vitensenteret visitors response to Characterisation about experience of Virtual tour

Out of 13 visitors, one had a strong agreement and nine had an agreement that they felt immersed in the environment. But three visitors were uncertain about the same. In the case of navigation through the island, one of them felt that it is really difficult to move around the island and two of them agreed that the navigation is difficult. And 3 were uncertain about the same. But one was strongly disagreed and six visitors disagreed to the case and had the feeling that the navigation is quite easy through the environment with the Oculus rift and the laptop keys. In the case of the option Informative and having fun, four strongly agreed and nine agreed about the same. Four visitors strongly agreed and eight agreed that the environment provide a learning experience for them. But one of them was uncertain about this characteristics.

8.1.5 Suggestions for Improvements

5. How would you like to improve Virtual Trondheim

The objective of this question was to acquire some valuable suggestions about virtual Trondheim from the visitors. Also it can help to get more requirements in order to improve the system and also for further research activities.

- More historical buildings and places in Trondheim
- More Virtual humans
- More information about Buildings and places
- Games
- Social events
- Interactivity
- Maps

This particular question was given in order to get an assurance about the interesting contents of the people to view in NTNU island or Virtual Trondheim.

Åpendag Students

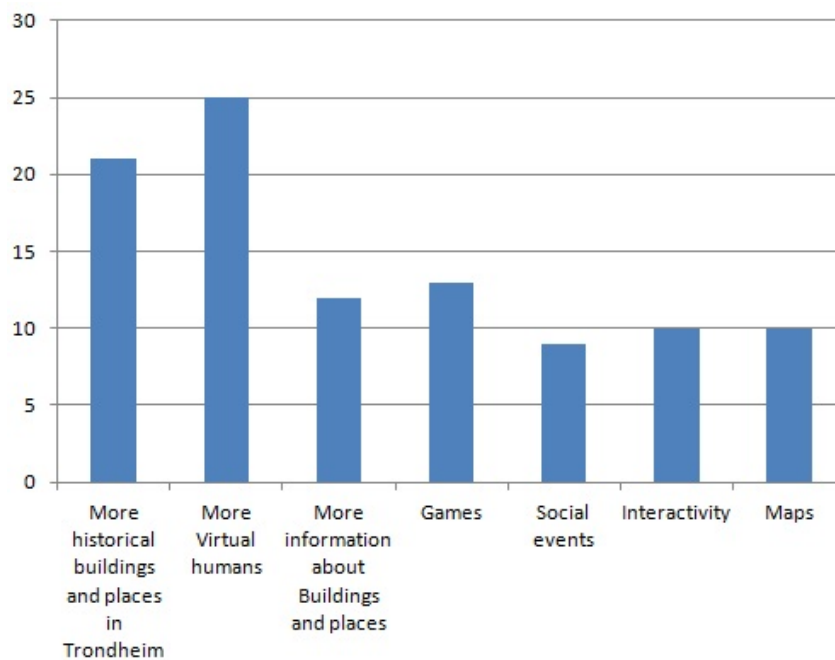


Figure 8.15: High School Students response to suggestions for Improvements

From the Figure 8.15, we can see that 25 students interested in more virtual humans, 21 interested in more historical buildings and places in Trondheim. Also 12 to 13 interested to have more information about buildings and places in Trondheim and having some games in the island. But only 10 students interested to have more interactivity and maps and nine interested to have

Social events in the island. So from this we can analyse that the students are more interested to see more buildings and virtual humans or inhabitants in the island and they need more information about the place.

Visitors at Tourist office

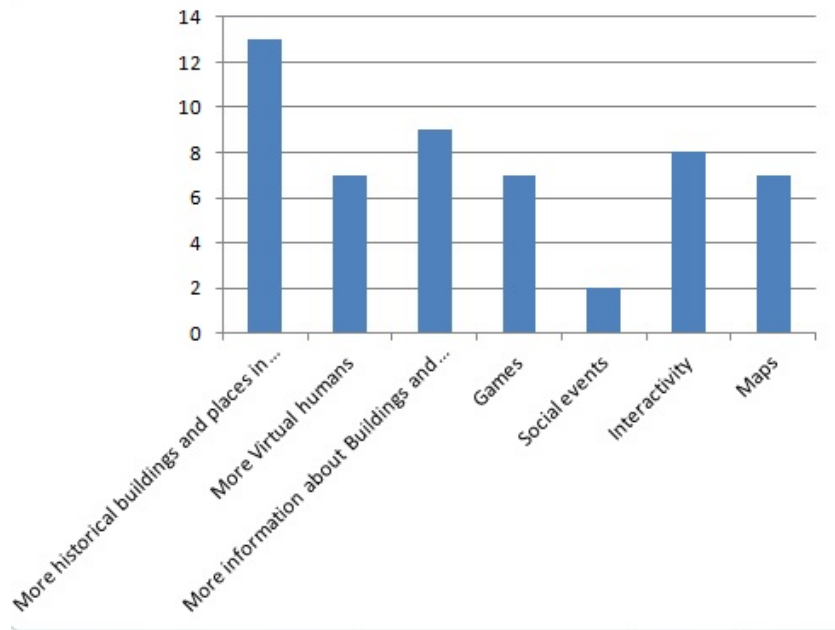


Figure 8.16: Tourist Office visitors response to Interested Contents for Improvements

From the Figure 8.15, we can see that most of the tourist, about 13 interested in more historical buildings and places in Trondheim. Only seven visitors were interested in more virtual humans or inhabitants representations in the island. Also eight tourists were interested to have more information about buildings and places in Trondheim and having some games in the island. Also eight visitors were interested to have more interactivity and seven interested to have a map of the Trondheim island. Only two interested to have Social events in the island. So from this we can analyse that the visitors interested to see more buildings and place in Trondheim. Also they need more information about the places and maps or directions in Trondheim island so that it might be helpful for them for their real visit through Trondheim city.

Visitors at Vitensenteret

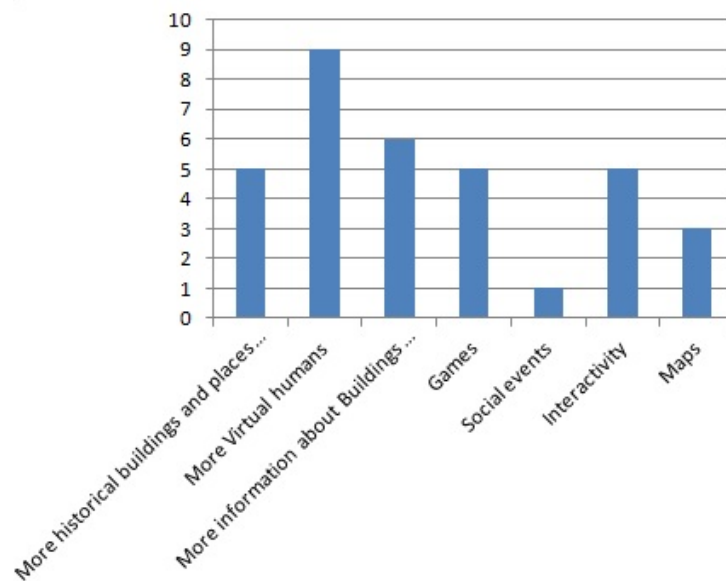


Figure 8.17: Vitensenteret visitors response to Interested Contents for Improvements

From the Figure 8.17, we can see that most of the visitors, about nine interested in having more virtual humans in the island and also six interested to have more information about buildings and places in Trondheim. Moreover five interested to have more historical buildings and places in Trondheim, games and interactivity in the island. Only three interested in Maps and one interested in social events. Since most of the visitors at Vitensenteret have keen interest in Science and technology they were interested to have a city with more information and have more inhabitants so that they can learn something from the city with a live atmosphere, crowded with more interactive inhabitants.

8.2 Response from Kids

For the kids between age 10 and 15, a small response sheet was prepared in order to from them an evaluation to know effect of the system in Kids. The Response sheet can be found in Appendix A.4

Two questions were asked such as whether they like the system and Is the system exciting?. Also a comment section included. A total of nine responses were there and all of them like the Virtual tour with Oculus Rift. And six of them responded

that it was an exciting tour in 3D world. But rest three responded as interested but it does not seemed to be exciting for them. Two comments were also there, one commented "litt rare kontrollor, men morro" and another commented as "bra.."

8.3 Evaluation with tourism professionals

A qualitative evaluation was done through interviews with three employees at Trondheim tourist office. Initially an explanation about the new contents implemented in the island was given to the employees. Then a virtual tour with Oculus rift through the island was done. A brief description of the interview is explained below. The interview questions are shown in Appendix A.7.

Before the interview a detailed explanation was done about virtual Trondheim and the contents created such as Old town bridge, Buildings along the Nidelva river, Archbishop's palace, Virtual Humans and the Quiz. Then tourist employees tried out a virtual tour with Oculus Rift, except one since she was quite dizzy with the Oculus, but she had virtual tour without the Oculus rift. Two employees were very much interested to use the Oculus Rift.

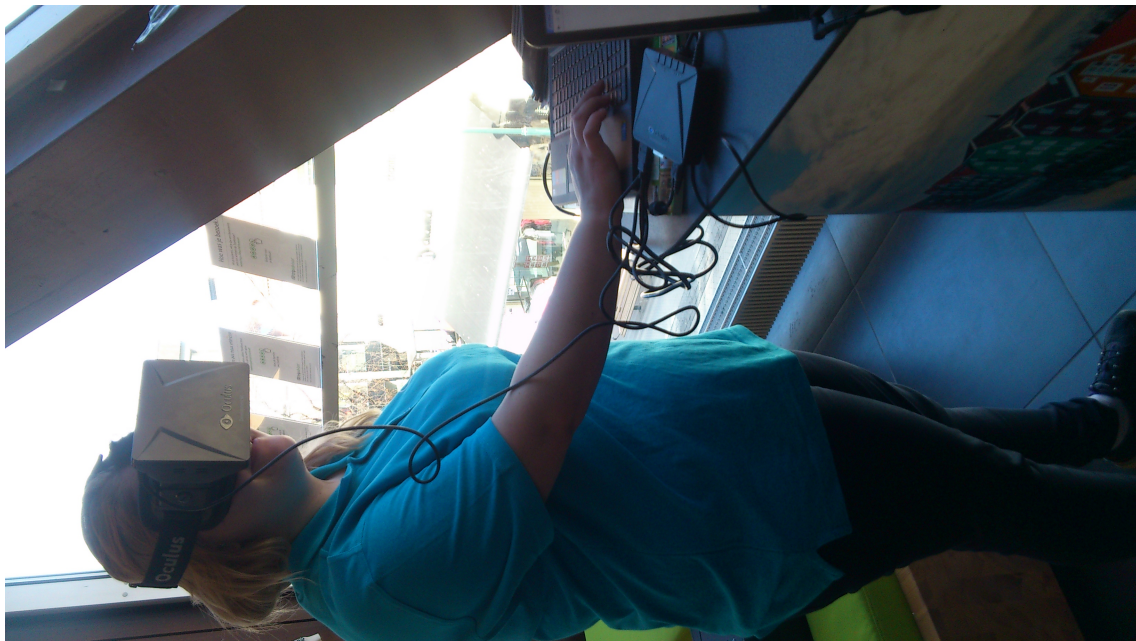


Figure 8.18: Tourist Employee with OculusRift

The Interview questions and the response to each question are described below. The sentences or the sentence fragments, shown with quotes, are employees' own use of phrases.

- What is your opinion about this Virtual representation Trondheim city and In your opinion how is it useful for the tourist and the tourism industry?

One employee commented that "It is a good idea to have these type of 3D representations. The buildings looked realistic, but the problem here is that, the buildings are placed in random order, not exactly same as that in the real city". Employees had the feeling that if the buildings can be placed exactly the same as that in the real city, then this can be used as an information source and it helps to get a better idea about the place. All the constructions such as Cathedral, old bridge town an river, Bryggene and virtual humans, looks like realistic and it can give a sense to the public. One employee was new to the industry, but she had the opinion that "it can be used to provide some idea about the city. It is cool to have a system like this since the tourists do not know what they want to see in Trondheim". She had the opinion that it will be helpful to have an idea by representing the city in 3D and providing some information for them. The presentation of buildings and places were quite interesting, informative and provide a learning experience. Normally the tourist might not know what are the possibilities of the city, so it is good to have something like this so that before the real visit they can visit Virtual city and have some knowledge about the place. The third employee, since she was really sick with Oculus, she had a virtual tour through the city, without Oculus. She had the comments as follows: "It is can provide an idea about tourist attraction about the place and can provide information to them. It is good for younger people who can try with this kind of modern graphics without any problems of sickness. It is a fun way to explore a place without even leaving a place where you are standing". Also employees agreed that this can be used for the people to prepare for a real visit.

- Will it be possible to use the system as an advertisement about the place or to promote the place?

It can be used to show the people how the city looks like and what are the major tourist attractions of Trondheim. Since the buildings looks realistic it will be helpful for the tourist to have a picture about the same before their actual visit. But the main concern here is to have the proper plan of the city.

All the three employees agreed with this idea of promoting the Trondheim with Virtual Reality techniques and Virtual Trondheim in SecondLife.

- What is your opinion about the implementation of Quiz in the island. Will it be helpful for the Tourist and the Tourist guides ?

It is a good idea to have something like Quiz rather than just walking around through the city. One employee commented as "It can provide some knowledge to the visitors and to have a quick introduction about the city. For tourist guides and for the students it is good to get a quick introduction. Normally we need to read a lot about the history and it is really hard to learn something fast. But the quiz help to have some quick idea without reading much". Also one employee had the comment that, "it is good to have a lucky game like Quiz", so that the visitors can learn about the city in a fun way.

- Will this can be used for future or otherwise for heritage preservation ?

It is possible to use for heritage preservation or for the future purposes, but then "need to do a lot more about the history of Trondheim and about the culture and traditions", how the city of Trondheim in early centuries and about the evolving events from the past to the present.

- What is your opinion about the Virtual Humans residing in the island?

It will be helpful for the tourists to have some practical information to plan their tour, but "they really don't prefer too much explanations" about the buildings such as the history, but it is a good idea to have some information that are most relevant related to the buildings. Also one employee is interested in virtual humans, like "town planner in front of old town bridge, that can stand at the harbour side, deliver to the tourist, cards and stuffs that can guide to different places". Also they commented that "the part of giving information with Virtual Humans is interesting. It is cool to have the virtual humans with old costumes, but the modern humans are not necessary in the island".

- Is it possible to use this system as an educational tool for students and for tourist guides?

The employees had the opinion that it will be helpful for the students to have some idea by experiencing a virtual tour since the realistic representations of

the buildings and associated information helps them to learn easily and also this can give a feel that the person is inside the real city. "It is possible to use as educational tool for tourist guides, but then everything should be in correct proportion and the buildings should be placed same as that of the real city map. But this can provide some quick idea about the city and it is easy to memorize everything before the real tour". The tourist guides can record the buildings and places in their mind easily. "It is good idea that major tourist attractions are placed in such a small area that can be accessible by Internet". Also employee is guessing that it can be used for practising for tourist guides. "It is good to have information about the attractions in modern digital way".

8.4 Online SecondLife interview

An interview with two NTNU students was conducted online through SecondLife. The interview was conducted by online text chat, which is a type of communication mechanism available in SecondLife frameworks itself. Both the students joined in SecondLife and logged in to the NTNU island to visit Virtual Trondheim for the evaluation purposes. Both of them are doing International masters in Electrical engineering. The comments from them are summarized below. The students own phrases are shown in quotes.

- Regarding the Virtual tour

"It is a future technology. There is having some fun to fly around and act as an avatar player as that in games". It is really interesting and have got an exciting experience with the virtual tour. This system is helpful "for the school students in their learning, especially about the history of Trondheim" and also for the people who concentrate in historical science. It is also helpful for the people who wish to visit different places and if they cannot visit Trondheim in real life, at least they can visit virtually. "The buildings looks realistic, just as that in real city but it is placed in random order".

- The Quiz in the island

It can provide some knowledge quickly or some view about the Trondheim. "It is challenging" and the idea of quiz is good since it helps to "test knowledge about Trondheim" and also can provide some new knowledge for visitors who

do not have idea about the history of Trondheim. It is good if it possible to take the quiz at least two times for a visitor. It is good to show the answer itself not just the right answer option as 1, 2 or 3. Also "it is fun to have one vehicle, a helicopter, to fly around the island".

- Virtual Humans

"Very cute representation and looks somewhat realistic". The Nidaros choir lady looks realistic and is interesting the way she says 'hi' to visitors and "it is fun to touch on" and have some knowledge from a human itself that seems interactive. Vektervandring was a new information to one student. It is good to have it because it provide some "cultural understanding about the Norwegians", since vektervandring is a person who is dressed in special clothes with a lantern and a stick in hands and give help to tourists especially in Røros.

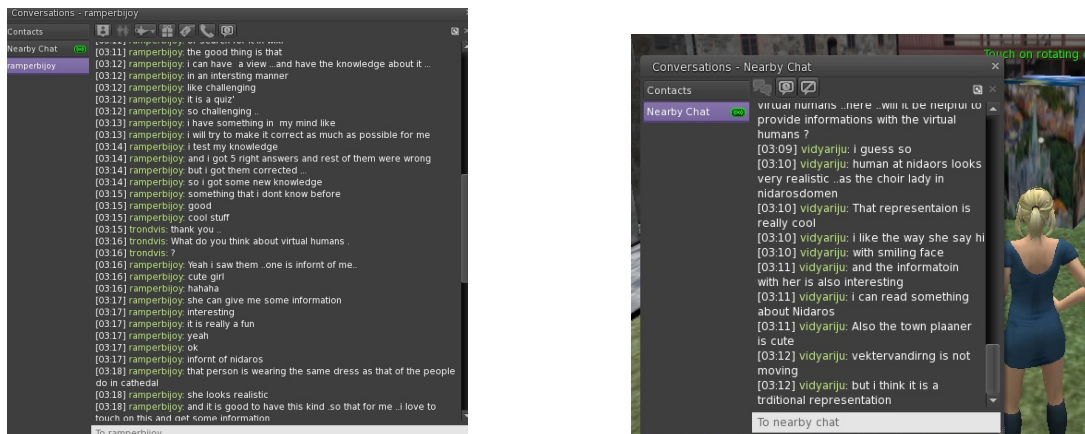


Figure 8.19: Online SL Evaluation

8.5 Structured Interview with Students

A structured written interview in the form of written assignments was done with two NTNU students. This was done using Google forms by writing answers to the questions. One of them was an NTNU student taking International Masters and have experience in SecondLife and another student was doing the Course Norwegian for Foreigners at NTNU, but do not have experience with SecondLife. The Interview questions with the answers are described as follows:

- What is your opinion about using Virtual Trondheim for tourist activities (Hint:Provide idea about tourist attractions, give information , learn from this , prepare for real visit)
"I think it is a good idea, especially for who had no idea about Trondheim before the visit."
"A virtual visualisation of Trondheim to decide a visit and gather practical information related to the tourist attractions."
- Will it be helpful to advertise about the place or for the promotion, by the virtual tour ?
"Yes. To a certain extent. Especially with interactive information e.g. videos, promote slides, interactive objects."
"Certainly, it can be used as a promotional tool for highlighting the historical or other places of tourist interest. Virtual platform can evoke much interest, and can reach much more than using any simple audio video demonstrations."
- Is the quiz interesting, can it provide some knowledge for the visitor or to test his knowledge about Trondheim ?
"Yes. It could be better if it has a progress such as question 1 of 10, question 2 of 10 or a visible way to know when it should end."
"The quiz can be a fun and interesting way of passing new information at the same time reminding the importance of Trondheim and its historical presence."
- Will the virtual humans residing in the city are realistic? Your opinion
"I think they should have gestures more randomly, and slower movement. Probably some walking around a small area also is interesting."
"Yes, in terms of their overall appearance, particularly their attire. But it would be interesting to see more virtual humans around in their respective uniforms or costumes to make a clear distinction."
- Does the Virtual Human resemble real human ?
"Yes, to a certain extent."
"Yes, Nidaros lady is in the same dress code, resembles quite well."
- What is your opinion on using this for heritage preservation , i.e to use this as

a record about Trondheim, a 3D digital record, to be used for the future ?

"I think its an interesting idea. It can also be used with videos of recording the actual locations in real time (if still exists) or pictures from books. Combination between 3D version and real life version can be more useful and interesting, for example to history class or architecture class."

"To a great extend it can be used as a 3D digital record, mimicking the activities, buildings, streets, places than written explanations. Then the virtual tour should be carefully reviewed to make sure that it is accurate. It should be supported by real videos or pictures of the place."

- Is it possible to use this an educational tool for e.g : to educate tourist guides, to educate students of historical science

"yes, useful for students and tourist guides

"It is a simple and fast way to teach interested or concerned people about the place. It is an easy medium with notifications(text/audio) as and when visitor tour around."

- Your suggestion for improvements

"More gestures for virtual humans, observe the tourist guides in real life for ideas. The city seems to be filled with a lot of architectures which made it narrow space for visitors to navigate around, probably better to extend the distance between the buildings and place in some flowers, small plants in between. Quiz should have progress bar. Some background sound when you go close to a building (for example, the Nidaros cathedral, could have bell sound when you approach near it)".

"It can be helpful if different modes can be set such that for example a research student get much detailed explanation and a normal visitor gets rather a general information. 3D TVs are common these days,If we can get rid of Oculus and can be visualised through normal 3D glasses, it can be helpful for people with motion sickness."

- Applications of this virtual representation of city (Hint:Education and training ,Tourist guidance , school students, marketing of the place etc)

"I think mostly this virtual city could be used in education purpose and tourist

general pre-tour purpose."

"Tourism, research guide, trailer of museums and other places as a piece of advertisement."

Chapter 9

Discussion

In this section, there is a brief discussion about the prestudies and poststudies conducted and the evaluation of the results obtained in this period of project work. Also included the limitations experienced during the prestudies. Another important aspect explained here is how the research question was accomplished with the implementation of the system, about the requirements that fulfilled and those that are not able to implement in the system during this period. It further explains the future work.

9.1 Prestudies

The major study was the pre study with the existing prototype of Virtual Trondheim. Interviews were conducted with tourist guide instructor and with tourist guides along with the demonstration of the system. Also another demonstration was done with the visitors at Trondheim tourist office. The data obtained with these studies were one of the major source for the implementation of new improved version of Virtual Trondheim. Also the Literature review and theoretical considerations was another source for the implementation. Also there was a support with some background details of Virtual Trondheim which was explained in section 4. These studies reflected back to literature review when considering requirements emerged out after the data analysis in terms educational activities in tourism sector. For the prestudies with tourist guides and visitors at tourist office and for the interviews, Oculus Rift DK1 connected with laptop was used in order to get an immerse effect with the environment. As per the prestudies, implementation was done.

9.2 Post studies

After the implementation of the Virtual Trondheim on the basis of prestudies, a further evaluation was done with the new improved version of Virtual Trondheim. For this evaluation some interviews were done with three tourist office employees and with four NTNU students. Also a demonstration of the system was done at tourist office, at Vitensenteret Trondheim and at NTNU Åpendag. For all these post study evaluations, same Oculus Rift DK1 together with laptop was used.

9.3 Comparison between pre and post studies

For both the studies same NTNU island and Oculus Rift DK1 was used. For the prestudy, used a prototype of Virtual Trondheim which was developed in Fall 2014. For the post study the new improved version of Virtual Trondheim was used which was developed based on the prestudies. Prestudies were conducted in order to gather requirements for the new version of Virtual Trondheim and post study was conducted in order to get the new system evaluated to check whether it can be used for educational purposes, whether it can be used for tourists and for professional tourism in tourism industry. These evaluations helped to prove the research question. The tourist guides for prestudies were of age above 30 and so some of them found difficulties in using the Oculus Rift and commented that this technology is useful and more interesting for younger generations. For post studies the participants were mostly of age from 15 to 35 and so most of them did not find any difficulty in using the Oculus Rift.

9.4 Implemented Requirements

In this thesis work, the major requirements that were queried by majority were implemented. It includes Wooden Buildings that can see along the narrow roads of Trondheim, Old town bridge, the wooden buildings along the river side together with the river, parts of Archbishop's Museum, two animated virtual humans that give notecard having some information about the places, one in front of Nidaros Cathedral and one in front of Old town bridge and a static virtual human known as Vekturvandring in front of Archbishop's museum. In addition a Quiz represented as a rotating mesh was implemented to test knowledge about Trondheim. Also it is possible to implement more in the island as per the suggestions during the evaluation

but due to shortage of time those were marked as future works.

9.5 Problems encountered:

One of the major issue found during the implementation was the difficulty in creating a proper replica of the real city. As of now this real replication of the city is impossible since in the NTNU island there are various student projects ongoing and it is not possible to rearrange all of them by the author since the author of this project is only a member of the NTNU island with limited rights in the island. Another reason for this was, Virtual Trondheim was allowed to create only in specific portion of the ntnu island which was already crowded with various student projects with different requirements. In addition to difficulty in reordering the ongoing projects there were some issues with land impact and region capacity. So some portions of Virtual Trondheim was implemented in ntnu1 island and other portions were implemented in ntnu2 island. Another issue encountered during the implementation due to high land impact. When region capacity reached to its maximum because of large number of parcels, some of the meshes got deleted from the island without any notification or warning. So the meshes rezed to the island again by setting the LOD to minimum to have reduced land impact.

9.6 Discussion of the Evaluation

The evaluation was conducted with regard to accomplish the research objective of investigating how educational activities in tourism can be supported by virtual worlds and virtual reality. Here the investigation was conducted to support educational activities for tourism professionals and tourists.

First evaluation was done on three contexts, with qualitative study with the developed system, one with high school students on Åpendag, second with the visitors at the tourist office and the third with the visitors at Vitensenteret. During the data analysis the percentage of participants who were agreed and strongly agreed are combined to get a final percentage of agreed participants. Same was done for disagree and Strongly disagreed percentages. In the same way, for the question to rate the constructions, the percentage of participants who felt the contents as very realistic and realistic are combined to get a final percentage of participants who felt that the contents as realistic.

9.6.1 Åpendag

For the question about the use of Virtual Trondheim, 7 different options were given. From the data analysis it was identified that about 93% of students agreed that it can act as an advertisement of Trondheim, 95% agreed that it helps to get some idea about major tourist attractions and 97% agreed that it provides information about major places and buildings of the city. In addition 85% agreed that it helps to learn about NTNU and the campus facilities and 80% agreed that it can help to prepare for a real visit. Also 73% agreed that it helps to learn about history and culture of Trondheim and 68% agree that it presents scientific and research activities in the city.

A tabular representation of Response to applications of Virtual Trondheim is shown in A.1 in Appendix A.9.1

It was found that 73% of students preferred to use Oculus Rift with Virtual Trondheim and they enjoyed the tour with virtual Trondheim, but 20% found some uncertainties with the Oculus Rift since some were quite dizzy with the system which was personal and 1% were found difficulty in using both headset and laptop keys together for the navigation.

Also regarding the constructions in the island, 73% found those as realistic and 43% felt as neutral when considering the real city of Trondheim. But a few, about 2% found the constructions as unrealistic.

For the question about the characterisation of experience in Virtual Trondheim, 75% students felt that they got immersed into the environment and had an exciting exploration with the virtual Trondheim. But in the case of navigation through the virtual Trondheim, 40% felt that it is easy to navigate around the virtual world and but 32% agreed that it was difficult to navigate and 27% felt some uncertainties with the navigation. In addition 85% agreed that it is informative and having fun and 88% had agreed that it can provide a learning experience.

The last question was about the suggestions to include more contents in the environment. There were many options given and 63% interested for more Virtual Humans, 53% interested in more historical buildings and places, 30 % to 33% liked to have more information about buildings and places and to include games in the island. 23 % to 25% shown interest in maps, interactivity and social events

Comments: Also suggestions were asked and some students commented about the island and the constructions in general. One found the system as awesome. Another had commented that "Ramp up the Graphics and may be make it so that you can interact more with the environment". Another student had opinion that "it need better High Definition graphics resolution". Also comments about Oculus such as it causes much "nausea and so difficult to navigate" around the island, make it more easier to move since it is difficult to control with arrow keys of the laptop together with Oculus Rift headset. One of the students "need better controls and improved focus and visuals". Another wished for "Better scale and sky box".

9.6.2 Visitors at Tourist office

At tourist office, the visitors were of age ranging from 10 to 50 and from different places Outside Trondheim and Outside Norway, and so the opinions were rather different. But from the analysis it was identified that most of them prefer to use Oculus Rift and mostly younger people, of age below 35 found it more exciting and interesting. For the question about the use of Virtual Trondheim, all of them (100%) were agreed that it helps to get some idea about major tourist attractions. Further 95% agreed upon the options such as It helps to learn about history and culture of Trondheim and It provides information about major places and buildings of the city. Moreover 84% agreed to the options such as It helps to learn about NTNU and the campus facilities, It can act as an advertisement of Trondheim and It can help to prepare for a real visit. But only 50% was sure that it presents scientific and research activities in the city.

A tabular representation of Response to applications of Virtual Trondheim is shown in A.2 in Appendix A.9.1

Also 78% of the visitors preferred to use Oculus Rift but rest of them found some difficulties in using it and got some uncertainty in the virtual tour.

About the constructions of the island, 78% found it as realistic and 16% visitors had felt that the constructions as Neutral when compared to real city.

For the question about characterisation of experience in Virtual Trondheim, 95% found that it is informative and having fun and provide a learning experience. Also 83% felt immersed in the environment and 67% found that the navigation is easy. For the last question about the suggestions to include more contents in the island,

some choices were given. 77% interested in more historical buildings and places in Trondheim, 44% interested in interactivity, 50% interested in more information about buildings and places and 39% interested in the options such as More Virtual humans, Games and Maps.

Comments Some comments from visitors: "We are from Barcelona, thank you very much". "Certainly upgrade to a better engine and a better pair of goggles like DK2 or better". From the comments we can conclude that the people are interested with the system and they are interested to use goggles but with its improved version and also need good graphics engine.

9.6.3 Visitors at Vitensenteret

The visitors at Vitensenteret had more interest in Science and technologies. During the demonstrations it was found that most of them like the idea of Virtual tour through the city with Oculus Rift since they had the opinion that it had potentials in future. For the question about the use of Virtual Trondheim, from data analysis, it was found that all of them (100%) had agreed to the opinion that It helps to get some idea about major tourist attractions. Moreover 92% agreed that it helps to learn about NTNU and the campus facilities. Also 85% agreed to the options such as It can act as an advertisement of Trondheim and It provides information about major places and buildings of the city. Further 77% was in agreement that it helps to learn about history and culture of Trondheim and it can help to prepare for a real visit. Also 54% found that it is useful to present scientific and research activities in the city.

A tabular representation of Response to applications of Virtual Trondheim is shown in A.3 in Appendix A.9.1

Here also 77% preferred to use Oculus Rift but the rest of them had some uncertainty in using it. Also 77% agreed that the construction are realistic and rest found it as neutral.

Also for the question about the characterisation of experience in Virtual Trondheim all of the visitors (100%) had the opinion that it is informative and having fun. Also 92% found that it provide a learning experience. 77% felt immersed in the environment and 54% found that navigation was easy through the island. But here also some 23% found some uncertainty and difficulty to navigate through the

island.

For the last question about the suggestions to include more contents in the island, 69% interested in more virtual humans, 46% interested in more information about buildings and places, 38% interested in options such as More historical buildings and places in Trondheim, Games and Interactivity. And 23% interested to have Maps in the island.

Comments: Also there were suggestions about the island as follows: "Communicate complex information easily and faster by immersing into realistic 'virtual world' which is interesting. Free navigation into the buildings are more interesting. Text information about history and other details of the attractions are more informative. Its much better than abstract information and navigation using goggle earth street view. It can also help authorities with city planning and development and also effect on changes on community. Implement the city same as that in real city. GRAPHICS ..COOL ... it can be very helpful for to get information." Here from the comments we can conclude that the system is interesting. It has cool graphics and it can be used to get information about the place and also for future purposes such as city planning. Also it is required to implement the city same as that in real.

A tabular representation of Response to preference to use Oculus Rift is shown in A.4 in Appendix A.9.2 .

Tabular representation of rating of constructions in Virtual Trondheim given by the participants is shown in A.5 in Appendix A.9.3.

Tabular representation of response to characterisation of the experience with virtual tour given by the participants is shown in A.6 in Appendix A.9.4.

Tabular representation of rating for the suggestions to include more contents in Virtual Trondheim is shown in A.7 in Appendix A.9.5.

9.6.4 Summary of improvement and suggestions from comments

During the evaluation of the Virtual Trondheim, some ideas were emerged out for the improvements. A brief explanation about the improvements from the comments are as follows: It is better to have the virtual city same as the real city of Trondheim. So it is required to place the buildings same as that in the real city with proper city

plan and the routes so that it can be used as an efficient educational tool for the tourist guides. Also most of people had the opinion that the models are realistic but the only issue was they are placed in random order. It is also good to present Virtual humans at a specific time period giving his view to the visitor. It will be interesting if there are visualisations of historical events. In the quiz it is good to show the right answers itself rather than showing the right answer option number. Also it could be better to have a progress bar. It is better to have more virtual humans in the island with traditional costumes and with more gestures. It can be used for heritage preservation if it is designed at its most accuracy supported with real videos and pictures of the place. It is good to have some background sounds when go close to buildings and also it seems congested and good to have spaces between buildings with plants. Also it will be helpful if it is possible to set different modes or versions for e.g. for a student with much detailed information and for a tourist with some general or practical information. It is good to use improved version of 3D glasses such as Oculus so that it can reduce motion sickness to a great extend. It is good if there is a better graphics engine.

9.6.5 Evaluation with Tourist professionals

This section describes the concluded results of the evaluation done with the tourist office employees. The virtual tour was interesting, exciting and having fun for the employees. The constructions are realistic. It helps for educational purposes such as to educate the students and to educate tourist guides for practising even if it need to be get completed as same as in the real city. Also it is helpful for the tourists to learn about the place for the visitors before the actual visit. Also this can be used as a promotion tool with more information. The virtual humans were implemented as realistic and more interesting is that they can provide some information. In addition it is interesting to have virtual inhabitants from the past. The Quiz is fun and challenging, and it can provide a quick introduction or knowledge about the place. The buildings are placed in random order, so it is required to place the buildings same as that in the real city. Also there was a comment that this system is useful for younger people and for those who do not have any health issues in using Oculus Rift since it cause sickness which is quite personal.

9.6.6 Evaluation with NTNU students

The technology is quite interesting and having fun. It is possible to take decisions about visiting the place and to gather practical information about the attractions of the city. It can be used a promotional tool for highlighting the historical or other places of tourist interest. Also it would be interesting to have more virtual humans with traditional costumes so that they can provide cultural understanding. The implementation of quiz is also good idea so that there is something to perform in the island rather than just a tour by walk or fly. Also this is applicable in educational purposes, tourist general pre-tour purposes, tourism industry and for advertisement of the place. It is possible to use for heritage preservation but virtual tour should be carefully reviewed to make sure that it is accurate. It should be supported by real videos or pictures of the place.

9.6.7 Tabular form of evaluations

A summarised result of quantitative evaluation is shown in this table.

Applications	Agree	Uncertain	Disagree
To learn about NTNU and campus facilities	87 %	10 %	3 %
To learn about history and culture of Trondheim	82 %	18 %	0 %
Acts as advertisement of Trondheim	87 %	12 %	1 %
To prepare for a real visit	81 %	18 %	1 %
To get idea about tourist attractions	98 %	2 %	0 %
Provide information about places and buildings	92 %	8 %	0 %
Presents scientific and research activities	57 %	41 %	2 %
Preference of Oculus Rift	77 %	19 %	4 %
Feel immersive in the environment	78 %	18 %	4 %
Easy Navigation	54 %	24 %	22 %
Informative and having fun	98 %	2 %	0 %
Provide a learning experience	92 %	6 %	2 %

Table 9.1: Responses in evaluation for the applications with Virtual Trondheim

Rate Contents	70 %(Realistic)	26 %(Neutral)	4 %(Unrealistic)
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Table 9.2: Response to contents in Virtual Trondheim

Suggestions	Interested visitors
More historical buildings and places in Trondheim	60 %
More Virtual Humans	62 %
More information about Buildings and places	52 %
Games	37 %
Social Events	15 %
Interactivity	36 %
Maps	29 %

Table 9.3: Suggestions to add Contents in Virtual Trondheim

9.7 Results of the evaluation

The results of the evaluation conducted are summarised below.

Quantitative evaluation summary:

- Purpose of visit: From my studies it was identified that the purpose of the tourists to visit the places is to learn about major tourist attractions and to learn about history and culture of Trondheim. The tourists would visit a system like Virtual Trondheim in order to plan their real visit and also to learn more about the place so that they can evaluate place before their travel and helps to have some prior information.
- Preferences of tourists in Virtual Trondheim: Tourists prefer major tourist attractions and more information about the city. Also tourist guides mainly stressed its usage in education for the school students. So they prefer to add more historical attractions from the past and the past life with virtual inhabitants from the past and the past events. Also the most queried contents to add in the island were more historical buildings and places of Trondheim, on-line tests and Quizzes, Virtual city inhabitants, the old city streets. Moreover

most of the tourists need more information about the buildings and places. Also they preferred the exact replication of the real city with proper city plan and routes. Also tourists were attracted in adding games and more animated characters inside the island as virtual inhabitants.

- **Helps to learn :** This system can be helpful to educate tourist. Also it can be applied for education since it will be helpful for students those who are interested to learn historical science. Also from the discussions with tourist guides it was recognized that Virtual Trondheim will be most useful for the tourist to learn about the place and to prepare for a real place. It helps to get some idea about major tourist attractions and provides information about major places and buildings in the city. Also the system have the characteristics of providing a more interested mechanism to learn i.e learn through immersive experience. In addition, Virtual Trondheim can also be used for school students to educate themselves about history of the place, from the information associated with the buildings and with the Virtual Humans. Also this can act as an information source for the tourists. This is something that communicate complex information easily and faster by immersing into realistic 'virtual world.
- **Age:** During the demonstration of the system with tourist guides, it was identified that this type of systems can be useful for young aspirants. It will be difficult for elderly to handle the system easily. Also from the age section in the questionnaire forms, it was found that young people are excited to use the system and elder people are not shown much interest in using Oculus since they have uncertainties and find difficulty to use the system.
- **Visualised information source :** Since the virtual island contains buildings and place that resemble real buildings in the city of Trondheim, this system helps the tourists to prepare for a real visit. Also this system can be considered as an advertisement by which the tourists can look into for information. From this island tourists can gather major information provided which can help them to plan their visits.
- **VR Oculus Rift :** Most of the participants in the evaluation were excited to use Oculus. Particularly kids and youngsters showed more interests with the

device. They had an immersive feeling in the environment and the navigation through the island were seemed to be easy for youngsters. Some of the elders got nausea with the system. Also some were quite uncertain with the navigation and experienced a discomfort during the navigation. Also a few found difficulty in using both Oculus and laptop keys together for the navigation and commented that they need some kind of navigational tool instead of laptop keys.

Qualitative evaluation summary : The summarised description of interviews conducted to tourist office employees and NTNU students are explained here.

- Virtual Trondheim can be applied for marketing: The system can be used as an advertisement or for the promotion of the place since it provides information about major places and buildings of the city. Furthermore the system has buildings that resembles the real buildings in the city. The system has an attractive way of its presentation of the city by which the tourist can be attracted more easily to the place. Tourist professionals can show tourists how the city looks like and what are major tourist attractions. It can be used as a promotional tool for highlighting the places that are of tourist interest. Virtual platforms can evoke much interest compared to simple audio video demonstrations.
- Virtual Trondheim can be used as educational aid for tourist professionals: It can be helpful for educational purposes of tourist guides with buildings resembling the real city. From the tourist guide perspective, it is mostly useful when the guides are unable to attend sessions and it can be used for practising after it is fully developed with proper city plan. In addition it can be used as an educational aid for tour practices of the guides and as a tool in the guide course. As per the comments from the interviews with tourist employees, since the constructions in the island look realistic, it can help for guides for practising the tour guidance. It will be more efficient if the buildings can be placed in proportion same as that of the real city. It helps to memorize things about the place easily.
- Quiz: The Quiz implemented in the island acts as a quick introduction about

the place for the visitors. Also it is a good idea to do something in the island rather than just a walk around the city. Also it is a fun and challenging way of learning. Quiz can also pass new information about the importance of Trondheim and its historical presence.

- Useful to show History: This type of systems can be useful to show the traditions and culture. Also there are historical information provided associated with buildings which helps to know more about the same for those who are interested. Also it can be useful for heritage preservation with more historical buildings, places and events, with accurate text and video information. The text information with the virtual human are also attractive and it can be helpful to study about the history of Trondheim to a certain extend.
- Virtual Humans: This virtual inhabitants present in the island are attractive and more interesting is that it can provide practical information and knowledge related to history of buildings in the place, to the visitors. Also those with traditional costumes can show culture and traditions of the place, and are of much interesting for the visitors. Virtual inhabitants can show the Norwegian culture with their costumes and provide some knowledge about the history to the visitors.
- VR Oculus Rift: Virtual Trondheim with Oculus Rift will be exciting for younger people and it is not much handy for elderly. This can provide a high immerse effect and most of the people are really interested in this kind of new 3D systems. Most of the people find tour with Oculus as exciting and fun. It is a fun way to visit a place without even leaving the place where the person is standing.
- Ambiguities: During the discussion with guides there were comments from some of the tourist guides about their confusions in using these type of systems for tourism purposes. They have the feeling that if the system shows wrong information it can affect tourism negatively.

Individual responses during the evaluation are given below.

- For planning : It can also help authorities with city planning and development and also will have effect on changes in community in the future.
- Communication : Communicate complex information easily and faster by immersing into realistic 'virtual world'.
- For Disable : One person commented that for disables it would probably be great, but also perhaps disappointing.
- System for future : Two persons commented that this type of Virtual reality systems might be something for future.

Reflections: Evaluation results reflects on literature studies too. The usefulness of virtual Trondheim in terms of learning aspects for the school students, for tourists and for people who are interested to advance with new technologies reflects back to the literature analysis that virtual reality systems can be useful for learning purposes [8, 17, 44]. Also the usefulness of virtual Trondheim for tourism purposes such as for marketing and for advertising the place reflects back to the literature studies conducted on the papers [17, 96, 18, 48].

- For learning: As per the literature review in papers [8, 48, 36], Virtual reality systems like Oculus Rift and virtual worlds like SecondLife can be useful for education which has been confirmed through the evaluation of Virtual Trondheim which uses Oculus Rift VR technology and SecondLife virtual world.
- For marketing: As explained in the papers [49, 50, 17, 51] virtual reality systems have potentials in tourism for marketing and for the promotion of places which is also confirmed through the results obtained during the evaluation of implemented system of Virtual Trondheim in SecondLife with Oculus Rift used as VR technique.
- Information source accessible over Internet: This virtual Trondheim in SecondLife virtual world can be easily accessible through Internet by general public which in turn reflects on the literature studies on e-learning in the paper [34]. In addition, this island can serve as an information which reflects back to paper [48].

- For planning, communication enhancement, For disabled people: From the comments obtained during the evaluations, it was identified that this type of system can be used for city planning, for communicating complex information easily and for usability of the system for disabled person which in turn also reflects on papers [17, 12, 53].

9.8 How does the research question satisfied with the Project work?

The case studies, interviews and the evaluations conducted after the implementations helped to arrive at a conclusion that Virtual Trondheim and the VR Oculus Rift can have a potential in the future. It can be applied both in tourism and the educational fields incorporated with fun and knowledge. Also it will be helpful in professional tourism too. From the discussions on pre and post studies, it was confirmed that the research to investigate on how could the educational activities in tourism can be supported by Virtual reality systems, in the context of Trondheim, had fulfilled its objectives. And hence proved that the NTNU island for Virtual Trondheim can be used as an educational cum touristic destination, that can be useful for both educational and tourism purposes.

9.8.1 Fulfilling the Research Question

In this thesis work the research objectives were fulfilled by implementation of the requirements emerged out during the prestudies and by doing a further evaluation on the implemented items in Virtual Trondheim.

The important feature of Virtual Trondheim in virtual world of SecondLife is that, Virtual Trondheim is an island developed for fulfilling educational activities for both the tourists and tourism professionals and it can support tourism industry.

Virtual Trondheim supports educational activities of tourists and tourism professionals : By the implemented contents as per the requirements such as wooden buildings, The buildings along the river side, old town bridge and Archbishop's Museum, it is possible to learn about the place for those who do not have an idea about the place or about the major tourist attractions which was confirmed through the evaluation at visitors at Trondheim tourist office and with the employ-

ees there. It can be used by tourist guides for their guide practice and can use it as an educational aid for the tourist guides also if all the buildings are placed as per the real city plan. Also the text information associated with the Virtual humans or the notecards given by the virtual humans helps the tourist and the visitors to the island to gather some information about the place. The practical information associated with notecards can act as an information source to tourist so that they can plan their tour in the real city. The Quiz can help to give a quick introduction to the tourist about the history of buildings and also is challenging. It is helpful for the students to study about the place and about the history and culture. It is also helpful for those who are interested to study about new technologies which was confirmed through the evaluation at Vitensenteret. In addition it is agreed with its usefulness for learning about the place incorporated with fun. It can be used as an educational tool for the guide training course if it is developed fully with proper city plan and with appropriate information contents.

Virtual Trondheim supports tourism : From the evaluations and interviews it was confirmed that the realistic buildings and the information associated with the system help to promote the place or to advertise the place in tourism industry. Also it can act as information source for the public.

From the evaluations it was confirmed that the contents needed to fulfill the research question was done successfully and the whole research question of investigating how could the educational activities in tourism can be supported by virtual reality and virtual worlds, in the context of Virtual Trondheim, was proved both in terms of tourism and of professional tourism.

9.9 Limitations

The implemented system of Virtual Trondheim can only be used in SecondLife framework. It is not possible to directly operate or transfer the whole system in another game engine such as Unity, but some findings could be transferred to different systems. Another fact is that it is not possible to operate in mobile devices since mobile version has not implemented yet. It is not possible to access this SecondLife island simply via online without installing the SecondLife game engine. Also during the evaluations with students on Åpendag, visitors at tourist office and visitors at Vitensenteret, the availability of time to explain all the concepts about

Virtual Trondheim was limited. So some aspects about virtual humans and about the implementation of Quiz was not considered during those evaluations. Hence the concepts about virtual humans and Quiz were only evaluated by tourist office employees and the NTNU students. Also the social aspects of Virtual Trondheim was not considered during the evaluation due to time limitations of participants. Also a criticism arose from tourist guides during the studies, of being negative impacts on tourism with this kind of new technologies. So need to do further research on the same. For the evaluation, the aspect of VR for disabled persons were not considered specifically, but some comments related to it emerged out from the tourist guides as it might have some impacts on disabled people but need to do further research on this particular aspect.

Chapter 10

Conclusion and Future works

This thesis work investigated the possibilities of virtual reality technologies in educational touristic activities and professional tourism in the context of virtual city of Trondheim. Prestudies were conducted by interviews with tourist guides and tourist guide course instructor and also gathered data using questionnaires with visitors at tourist office and the tourist guides in order to implement a new improved version of Virtual Trondheim. A study on the related works in the same field was conducted. From the feedback obtained during the studies, data got evaluated and requirements were formulated. As per the requirements, implementation of Virtual Trondheim was done. The new system was further evaluated with tourist office employees, visitors at tourist office, visitors at Vitensenteret and with some NTNU students.

From these evaluations it was confirmed that virtual reality technology have a promising future. It is possible to use virtual Trondheim for educational activities of tourists and tourism professionals. It can be used in tourism industry for marketing too. The people are really interested in new technologies like 3D and learn through experience incorporated with fun. The technology can act as educational resource for those who are interested to learn by experience. It is an interesting media for educating the students. Also it can be used by tourist for planning their real tour by having an experience with the virtual tour before their travel. With this it is possible for the tourism professionals to advertise or promote the place. Also in the future it can be used as an educational tool for tourist guides with its completed model with proper city plan.

10.1 Contributions

Through this research work it was identified that virtual worlds can be effective for general public, tourist and tourism professionals for learning, and it can act as an information source for them. Also virtual worlds can be favourable for professional tourism such as for marketing and for the promotion of the places, as educational tool for using it for tour guide students in their course and for the guides for virtual tour practises. Also virtual worlds can be beneficial for school students to learn about the place.

10.2 Future works recommended for this specific project

Due to shortage of time some requirements that were not implemented are kept for future works. The main future work is the reordering of the buildings as per the real city. Also proper routes of the city should be shown so that it can be used by tourist guides for practising virtual tour. The land should be edited appropriately to get the real terrain of Trondheim.

Also more virtual inhabitants with traditional costumes are quiet interesting for the people. In addition to this, role playing communities that represent past and present life in Trondheim can also be implemented.

More historical buildings, churches and historical places of Trondheim can also be a focus.

In addition, it will be more efficient for educational activities if we implement educational tools such as Powerpoint presentations, puzzles to solve which relate with historical events that can provide some fun, so that both education and entertainment can be accomplished in the island.

It would be rather interesting if there is visualisation of historical events in front of buildings and places that have long history.

It is a better idea to implement a Virtual Tour through a predefined path so that Avatar can just follow that path and it will be easy for the visitors to explore the whole island without confusions and without missing any details.

It is also easy for the visitors if possible to implement an interactive map to ask for places and it will pop up the directions specific to the place.

A virtual human guide can be implemented in the virtual environment for guidance, who can welcome the visitors to the land and interact with them. But for this, different scenarios have to be implemented with virtual human such as a human guide who welcomes the visitors and then start travelling through the island after asking acceptance to the visitor whether he/she likes to follow her through the land. If visitor do not wish to follow the guide then guide will stay there, else the visitor can follow the guide through a predefined path to have a virtual tour through the land. Also with this virtual guide, other scenarios have to be incorporated such as the visitor can hear the guide to accomplish different tasks in the land.

Besides, it is good to use any devices for easy navigation rather than just keys on laptop for example an Xbox controller.

It is important to increase the land capacity for the future in order to implement extra models and facilities, since the land capacity has reached its maximum in the island.

10.3 Future works recommended in general

Based on the literature studies and prestudies mentioned in Chapters 3 and 5, some ideas for future works in general in virtual tourism are explained below.

There are possibilities for VR in heritage protection. It is very interesting to show the evolution or major steps of the historical periods of a place so that we get a clear pictorial view from the past til present. The historical evidences with real videos and photos helps to improve the accuracy of the system to use it for educational purposes.

For education, it is good to consider social aspects of virtual worlds in more detail. So it is better to create an environment for the university campus for coordination between different departments, for discussions, for online trainings, for publishing and presenting the research works etc. Also it will be interesting if there are virtual games or activities which are challenging such as puzzles, that operate in a virtual interactive environment. Furthermore, virtual exhibitions related with science and technologies might be demanding for high school and university students. Also it might be interesting to have virtual worlds for training for general purposes which are important for common people . Some examples are how to manage or adapt in different climatic conditions such as in winter, how to train pets, how to escape

from fire, how to do first aid immediately after an accident.

VR can be useful for planning of the city. For e.g it is better to implement an island, where the city planners can login and discuss about different plans of city routes and buildings. They can share and work collaboratively to plan new things or to restructure city.

To include more entertainment with VR elements in virtual environments, it is better to have vehicle for virtual tour such trains, aeroplanes, ride a bike or sports car etc. Also it is better to have concerts, events, or shows which are specific to countries and are most popular.

Introduction of VR facilities that can provide entertaining, educating and immersive experiences in tourists sites can help tourists, will be interesting. For example to have an experience of being in a jungle while tourist is visiting a zoo in a particular tourist site.

Appendix A

Appendices

A.1 Questionnaire for Visitors at Tourist office

Virtual city of Trondheim

Where are you from?

- Trondheim
- Outside Trondheim (Norway)
- Outside Trondheim (International)

Age

- Below 10
- 10 - 15
- 15 - 25
- 25 - 35
- Above 35

Gender

- Male
- Female

If you are to visit Virtual Trondheim, what would be most probably the purpose of your visit?

	Very probable	Somewhat probable	Neutral	Somewhat improbable	Not probable
To learn more about Trondheim history and culture	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
To learn about local events (cultural, sports etc)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
For socializing and fun	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
To prepare for a real visit	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
To learn more about research and educational possibilities in Trondheim, e.g. at NTNU	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Any Other purpose

What should Virtual Trondheim contain?

	Very Much Interested	Somewhat Interested	Neutral	Not really Interested	Not at all Interested
More historical buildings and churches	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Virtual city inhabitants from the past (e.g. vikings)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Information about buildings and sights	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Reconstruction of historical events	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Presentation of latest advances in science and research (e.g. by Trondheim's Nobel prize winners)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Virtual city inhabitants (modern)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Live events (e.g. lectures, parties)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Buildings and streets the way they were in the past	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

The following facilities/technological solutions would make your Virtual Trondheim visit more enjoyable

	Strongly agree	Agree	Neither agree or disagree	Disagree	Strongly disagree
A virtual guide that provides information and helps with navigation	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Interactive map	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Oculus Rift	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Gaming elements such as quests and quizzes	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Your suggestions to improve Virtual Trondheim

Submit

A.2 Questionnaire for Tourist Guides

GuideQuestionnaire

The goal of this questionnaire is to improve the virtualization of Trondheim and NTNU area by assessing the opinion of Tourist guides on different aspects. Thank you!

Where are you from?

- Trondheim
 Outside Trondheim
 Outside Norway

Gender

- Male
 Female

Age

- Below 20
 20 - 30
 30 - 40
 40 - 50
 above 50

From the tourist perspective, for what activities would Virtual Trondheim be most useful?

	Very useful	Useful	Neutral	Not much useful	Useless
To learn more about Trondheim history and culture	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
To learn about local events (cultural, sports etc)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
For socializing and fun	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
To prepare for a real visit	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
To learn more about research and educational possibilities in Trondheim, e.g. at NTNU	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Other

From the perspective of a tourist , what should Virtual Trondheim contain?

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
More historical buildings and churches	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Information about buildings and sights	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Reconstruction of historical events	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Virtual city inhabitants (modern)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Live events (e.g. lectures, parties)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Buildings and streets the way they were in the past	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Virtual city inhabitants from the past (e.g. vikings)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Presentation of latest advances in science and research (e.g. by Trondheim's Nobel prize winners)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Other contents that can be added

From the tourist perspective, what facilities/technological solutions would make the Virtual Trondheim visit more enjoyable

	Strongly agree	Agree	Neutral	Disagree	Strongly Disagree
A virtual guide that provides information and helps with navigation	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Interactive map	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Oculus Rift	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Gaming elements such as quests and quizzes	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Other facilities

To what extent could Virtual Trondheim be useful in Guide training?

- Very useful
- Useful
- Uncertain
- Not much useful
- Useless

For what guide training activities could Virtual Trondheim be most useful?

	Very useful	Useful	Uncertain	Not much useful	Useless
Role playing and rehearsing tours	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Guiding online visitors	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Communicating with fellow students	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Getting better understanding about different places and historical events	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Preparing for exams	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Doing online training when unable to come to sessions/lectures physically	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Preparing/rehearsing presentations of different sights	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Other Activities which are useful

From the perspective of a tourist guide, what should be improved/added to Virtual Trondheim?

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
As accurate as possible replication of the real city	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Powerpoint presentations and other materials	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Virtual humans	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Maps and directions	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Virtual tour through a predefined path	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Online tests and quizzes	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Detailed information about the buildings	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Communication possibilities with tourists (e.g. social media and networks)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Reconstruction of historical events	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Buildings and streets the way they were in the past	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Presentation of latest advances in the city (e.g. scientific)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Virtual reality interface (such as Oculus Rift)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Other

Please add your suggestions about the features and contents that can be implemented in Virtual Trondheim , which can be used by either tourist or tourist guides

Submit

A.3 Questionnaire for Evaluation

Evaluation form Virtual Trondheim

Where are you from?

- Trondheim
 Outside Trondheim (Norway)
 Outside Trondheim (International)

Gender

- Male
 Female

Age

- Below 15
 15 - 20
 20 - 35
 35 - 50
 Above 50

What is your opinion about using Virtual Trondheim

Please choose all that applies

	Strongly Agree	Agree	Uncertain	Disagree	Strongly Disagree
It helps to learn about NTNU and the campus facilities	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
It helps to learn about history and culture of Trondheim	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
It can act as an advertisement of Trondheim	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
It can help to prepare for a real visit	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
It helps to get some idea about major tourist attractions	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
It provides information about major places and buildings of the city	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
It presents scientific and research activities in the city	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

I prefer to explore Virtual Trondheim with Oculus Rift

- Strongly agree
- Agree
- Uncertain
- Disagree
- Strongly disagree

How will you rate the constructions in the Virtual Trondheim?

Especially Nidaros, Gamle Bru , Bryggene , Virtual Humans

- Very realistic
- Realistic
- Neutral
- Unrealistic
- Very unrealistic

How would you characterize your experience in Virtual Trondheim

Please choose all that applies

	Strongly agree	Agree	Uncertain	Disagree	Strongly disagree
I felt immersed in the environment	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Navigation was difficult	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Informative and having fun	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Provide a learning experience	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

How would you like to improve Virtual Trondheim

You may choose several options

- More historical buildings and places in Trondheim
- More Virtual humans
- More information about Buildings and places
- Games
- Social events
- Interactivity
- Maps
- Other:

Your Suggestions to improve and Opinions about this Virtual Trondheim

A.4 Kids Response

Kids

Liker du?



- Ja
 Nei

Er det spennende ?

- Ja
 Nei

Kommentarer

Submit

A.5 Interview Questions with Guide Course Instructor

- In your opinion, what all contents we need to include here, that will be useful for tourists?
- Will the tourist be interested in more historical buildings, streets and places eg churches, Kristian fortress, Munkholmen, Old Streets , Tyholt tower etc ..?

- Will it be useful if I recreate historical events that are relevant for the nation?
- Will it be interesting to implement representations of virtual inhabitants from the past and the present Trondheim?
- What might be useful creations and how can I improve on this?
- Will it be interesting to implement Modern Trondheim with current news and research possibilities . for e.g Moser's Nobel prize, NTNU research areas etc..?
- Is it possible to use this as a tool for the guide course?
- How can we make it suitable for helping in course guidance?
- What might be the useful contents and how can I improve these?
- Are you interested in Gaming elements such as Quest or quizzes or any other thing to do rather than just walking around?
- Will it be useful if we have a separate virtual human that can act as a guide for exploration of this land?
- How is your experience with Oculus Rift and what is your opinion about this?
- What are your expectations ?
- What might be the useful creations and how can I improve on this ?
- Is it helpful if I create more historical buildings, streets and places that shows the real Trondheim history and culture ?
- Is it helpful for the course if I create representation of inhabitants in the past ?
- Will it be useful if we have a separate virtual human that can act as a guide to the students for exploration of this land ?
- What might be the student's preference , self navigation through the island or the navigation with the help of a virtual human guide?
- How should be the representations of virtual human guide ?

- What might be the other facilities that we can include in this virtual Trondheim, your suggestions ?
- Is there any other suggestions, about the contents that we need to include that help in your course ?

A.6 Interview with tourist guides

- How can we put this system in training activities of guide students?
- Do you think in this system more traditional items have to be included ? What is your opinion on this ?
- Do you think this system can be useful for promotion of the place?
- How can we improve the system for using it as a tool for tourists?
- How can we improve the system so that it can be useful for guide training activities?
- In tourist guide perspective what all contents need to be included here for using it as a tool for guide course?
- Can we use the system for advertising the place?
- Do you think that this type of technologies have potentials in the future?
- What might be the impacts of VR technologies on tourism, in your point of view?
- What are your suggestions to use it for educational purposes?
- In which all ways this type of system can affect tourism in Norway?

A.7 Interview Questions with tourist office employees

- What is your opinion about using this for tourist activities for e.g : Can this provide some idea about major tourist attractions ?

- Will it be helpful to provide some information regarding the place for tourist ? (practical info , history about the old buildings constructed)
- Can this be used to advertise about the place or for the promotion by the virtual tour through the place ,in tourism ?
- Will it be helpful to give some knowledge about the place ?
- Will it be helpful to prepare for a real visit ?
- Will it be helpful to learn about Trondheim history , historically important places , to learn about the past for e.g about Nidaros and history that related to the building ? Archbishop's palace , Bryggene, gamle Bybru, the history related to these buildings and place ?
- What is your opinion about the quiz , is it interesting , can it provide some knowledge for the visitor or to test his knowledge about Trondheim ?
- What is your opinion about the virtual humans residing in the city?
- Is it possible to use this an educational tool for e.g : to educate tourist guides, to educate students of historical science
- What is your opinion on using this for heritage preservation, i.e to use this as a record about Trondheim, a 3D digital record, in order to use it for the future?

A.8 Interview with NTNU Students

- What is your opinion about using Virtual Trondheim for tourist activities?
- Will it be helpful to advertise about the place or for the promotion, by the virtual tour through the place, in tourism ?
- Will it be helpful to advertise about the place or for the promotion, by the virtual tour through the place, in tourism ?
- Is the quiz interesting, can it provide some knowledge for the visitor or to test his knowledge about Trondheim?

- Will the virtual humans residing in the city are realistic? Your opinion?
- Does the Virtual Human resemble real human ?
- What is your opinion on using this for heritage preservation , i.e to use this as a record about Trondheim, a 3D digital record, to be used for the future?
- Is it possible to use this an educational tool for e.g : to educate tourist guides , to educate students of historical science?
- Applications of this virtual representation of city? (Education and training ,Tourist guidance , school students, marketing of the place etc)

A.9 Evaluation Summary

A.9.1 Applications of Virtual Trondheim

Applications	Agree	Neutral	Disagree
Helps to learn about NTNU and campus facilities	85 %	10 %	5 %
Helps to learn about history and culture of Trondheim	73 %	27 %	0 %
It can act as an advertisement of Trondheim	93 %	5 %	2 %
Helps to prepare for a real visit	80 %	17 %	3 %
Helps to get some idea about major tourist attractions	95 %	5 %	0 %
Provides information about major places and buildings in city	97 %	3 %	0 %
Presents scientific and research activities in the city	68 %	32 %	0 %

Table A.1: Response of Students to applications of Virtual Trondheim

Applications	Agree	Neutral	Disagree
Helps to learn about NTNU and campus facilities	83 %	11 %	6 %
Helps to learn about history and culture of Trondheim	95 %	5 %	0 %
It can act as an advertisement of Trondheim	84 %	16 %	0 %
Helps to prepare for a real visit	84 %	16 %	0 %
Helps to get some idea about major tourist attractions	100 %	0 %	0 %
Provides information about major places and buildings in city	95 %	5 %	0 %
Presents scientific and research activities in the city	50 %	45 %	5 %

Table A.2: Response of Tourist office visitors to applications of Virtual Trondheim

Applications	Agree	Neutral	Disagree
Helps to learn about NTNU and campus facilities	92 %	8 %	0 %
Helps to learn about history and culture of Trondheim	76 %	24 %	0 %
It can act as an advertisement of Trondheim	85 %	15 %	0 %
Helps to prepare for a real visit	77 %	23 %	0 %
Helps to get some idea about major tourist attractions	100 %	0 %	0 %
Provides information about major places and buildings in city	85 %	15 %	0 %
Presents scientific and research activities in the city	54 %	46 %	0 %

Table A.3: Response of Vitensenteret visitors to applications of Virtual Trondheim

A.9.2 Preference to use Oculus Rift

Preference	Åpendag students	Tourist office visitors	Vitensenteret visitors
Agree	73 %	78 %	77 %
Uncertain	20 %	15 %	23 %
Disagree	1 %	7 %	0 %

Table A.4: Response to Preference to use Oculus

A.9.3 Rating of constructions in Virtual Trondheim

Rate contents	Åpendag students	Tourist office visitors	Vitensenteret visitors
Realistic	55 %	78 %	77 %
Neutral	42 %	21 %	15 %
Unrealistic	3 %	1 %	8 %

Table A.5: Response to Constructions in Virtual Trondheim

A.9.4 Characterisation of experience with Virtual Tour

Characterize experience	Åpendag students	Tourist office	Vitensenteret
Felt immersed in the environment	75 %	83 %	77 %
Navigation was easy	40 %	67 %	57 %
Navigation was uncertain	28 %	22 %	23 %
Navigation was difficult	32 %	11 %	23 %
Informative and having fun	85 %	95 %	100 %
Provide a learning experience	88 %	95 %	92 %

Table A.6: Response to Characterisation about experience with Virtual Tour

A.9.5 Suggestions to include contents

Suggestions	Åpendag	Tourist office	Vitensenteret
More historical buildings and places in Trondheim	53 %	72 %	38 %
More Virtual humans	63 %	39 %	69 %
More information about Buildings and places	30 %	50 %	46 %
Games	33 %	39 %	38 %
Social events	23 %	13 %	10 %
Interactivity	25 %	44 %	38 %
Maps	25 %	33 %	29 %

Table A.7: Response to Suggestions to include contents

A.10 Virtual Humans Animation

Source code for animating the virtual human mesh models residing in the city

```
integer total_prims;
integer link_counter;
default
{
    state_entry()
    {
        total_prims = llGetNumberOfPrims();
        llSay(0, (string) total_prims);
        llSetLinkAlpha(LINK_SET, 0.0, ALL_SIDES);
        llSetTimerEvent (0.2);
    }

    timer()
    {
        integer next_link_counter = (link_counter % total_prims) + 1;
        llSetLinkPrimitiveParamsFast( link_counter,
```

```

    [ PRIM_COLOR, ALL_SIDES, <1.0, 1.0, 1.0>, 0.0
      , PRIM_LINK_TARGET, next_link_counter
      , PRIM_COLOR, ALL_SIDES, <1.0, 1.0, 1.0>, 1.0
    ]);

    link_counter = next_link_counter;
}
}

```

A.11 Quiz

Source Code for Quiz

```

//A Dialog-driven quiz, using text from a notecard -- Rolig Loon -- October 2009
//
// Free for public use -- please don't do something crass like selling my script.
// Modify if you must, but please keep these header lines intact. Be nice.
//
// Notecard format:
// A line beginning with a "Q" is part of a question
// A line beginning with an "A" is a string of comma-delimited zeros (wrong)
// and a one (right) to identify the answer
// A line beginning with a "#" is a comment
// Blank lines are ignored
//
// Dialog boxes are limited to 512 characters, so make each question
// (including choices) short enough to fit.
// There is no limit to the number of questions in a quiz,
// and you may //have up to 12 answer choices per question
//
// ===== sample notecard =====
//# Lines starting with Q appear verbatim in a dialog box
//# You may have as many Q lines as you want per question, but only one A line
//# Interpreted data begins immediately after the lead character in a line
//QWhat is the capital of Minnesota?

```

```
//Q1. St. Paul
//Q2. Minneapolis
//Q3. Iowa City
//Q4. Boston
//A1,0,0,0
//QHow many fingers are on my right hand?
//Q1. One
//Q2. Two
//Q3. Three
//Q4. Four
//Q5. Five
//A0,0,0,0,1
// ===== end of sample =====
//
// Instructor types "results" in channel 24 to get a
// report of all student scores

string gCard; //Notecard name
integer gLine; //Current line being read
key gQID; //Datasever key
integer gtouch; //Activates/deactivates touch_start event
list gAvList = []; //Cumulative list of people who have taken this quiz
string gAv; //Name of the current quiz-taker
key gAvKey; //Key of the current quiz-taker
integer CHAN; //Channel for dialog communication
integer Handle; //Listen handle for dialog
integer gScore; //This quiz-taker's score
string gQuestion; //Text for the current question
list gAnswers; //Answer key for the current question
list gAllScores = []; //Cumulative list of scores for quiz-takers
integer Timespan = 120;
// This is the maximum time allotted for the quiz, in minutes.
```

```
//Change here if needed.

integer IsNameOnList(list namelist, string name)
//Verifies whether av has already taken the quiz
{
    integer i;
    integer len = llGetListLength(namelist);
    for (i=0; i<=len-1;++i)
        if(llList2String(namelist,i) == name)
            {
                return TRUE;
            }
    return FALSE;
}

init() //Resets parameters for the next quiz-taker
{
    llSetTimerEvent(0);
    gtouch = 0;
    gAv = "";
    gAvKey = NULL_KEY;
    gLine = 0;
    gAllScores += gScore;
    gScore = 0;
    llListenControl(Handle,FALSE);
}

list order_buttons(list buttons)
{
    return llList2List(buttons, -3, -1) + llList2List(buttons, -6, -4)
    + llList2List(buttons, -9, -7) + llList2List(buttons, -12, -10);
}
```

```
default
{
state_entry()
{
    gCard = llGetInventoryName(INVENTORY_NOTECARD,0);
    gAvList = [];
    CHAN = (integer)(llFrand(100000000))* (-1);
    Handle = llListen(CHAN,"","","");
    llListen(24,"",llGetOwner(),"");
    init();
}

touch_start(integer total_number)
{
    if (gtouch == 0) // Starting quiz with a new person
    {
        if(IsNameOnList(gAvList,llDetectedName(0)))
        {
            llInstantMessage(llDetectedKey(0),"Sorry, "+ llDetectedName(0) + ".
                You have already taken the quiz. You cannot take it twice.");
            return;
        }
        else
        {
            gAvList += llDetectedName(0);
// Add av to the list of people who have attempted this quiz
        }
        gAv = llDetectedName(0);
        gAvKey = llDetectedKey(0);
        llInstantMessage(gAvKey,"Hello, "+ gAv+ ".
You will have "+(string)Timespan+" minutes to finish this quiz.
```

```

Respond to questions as they appear in blue dialog boxes on your screen.");
llInstantMessage(gAvKey,"Touch this panel again to stop the quiz.");
llSetTimerEvent(Timespan*60);
}
if (gAv != llDetectedName(0))
//Only accept touches from this av until the quiz is finished
{
llInstantMessage(llDetectedKey(0),"Someone else is taking
the quiz now. Please wait.");
return;
}
if (gtouch >=1) // This is the emergency stop.
//Av wants to stop taking the quiz before the last question
{
llListenControl(Handle,TRUE);
llDialog(gAvKey,"If you stop now, you may not restart later.
\nDo you want to QUIT now?", ["YES", "NO"],CHAN);
return;
}
// An av should only reach this point if it is the first touch
gQID = llGetNotecardLine(gCard,gLine);
//Read the first line of the notecard
++gtouch;
}

changed(integer change)
{
    if(change & CHANGED_INVENTORY)
    {
        llResetScript();
    }
}

```

```
timer()
{
    llInstantMessage(gAvKey,"Your time is up.
    Thank you for taking the quiz. Your score is "+ (string)gScore);
    init(); //Restart the quiz for the next person
}

dataserver(key query_id, string data)
{
    if(query_id == gQID) //If the data request came from this script
    {
        if(data != EOF) //If there is still data to be read
        from the notecard
        {
            if(llGetSubString(data,0,0)
            == "#"||llGetSubString(data,0,0) == "")
            //Ignore comment lines and blank lines
            {
                ++gLine;
                gQID = llGetNotecardLine(gCard,gLine);
            }
            else if (llGetSubString(data,0,0) == "Q")
            //Read the question and all answer choices
            {
                gQuestion += llGetSubString(data,1,-1) + "\n";
                //Format each "Q" line as a new line in the dialog box
                ++gLine;
                gQID = llGetNotecardLine(gCard,gLine);
            }
            else if (llGetSubString(data,0,0) == "A") //Read the answer key
            {
```



```

gAnswers = llParseString2List(llGetSubString(data,1,-1),[","],[]);
integer len = llGetListLength(gAnswers);
integer i;
list buttons = [];
for (i=1;i<=len;++i)
//Create a numbered button for each choice
{
    buttons += [(string)i];
}
llListenControl(Handle,TRUE);
llDialog(gAvKey,gQuestion,order_buttons(buttons),CHAN);
//Display the question in a dialog box
}
}
else // If there are no more lines on the notecard
{
    llInstantMessage(gAvKey,"You have finished the quiz. Congratulations.
Your score is "+(string)gScore);
    init(); //Restart the quiz for the next person
}
}

listen (integer channel, string name, key id, string message)
{
if (channel == 24) //Teacher said something on channel 24
{
if (llToLower(message) == "results") //and the message was "results"
{
integer len = llGetListLength(gAvList);
integer i;
for (i=0;i<=len-1;++i)

```

```
{
l1OwnerSay(l1List2String(gAvList,i) +
"Score = " + l1List2String(gAllScores,i+1));
    }
}
}

    else if (message == "YES")
// Av has touched the panel and wants to quit
{
        l1InstantMessage(gAvKey,"You have left
        the quiz with a score of "+(string)gScore +" . Goodbye!");
        init();
}
else if(message == "NO") // Av has touched the panel and does NOT want to quit
    {
        return;
    }
else // A question has been displayed in a dialog box
{
        integer pos = l1ListFindList(gAnswers,["1"]); //Search the answer key.
The correct answer is pos+1
        if(message == (string)(pos+1))
{
++gScore;
l1InstantMessage(gAvKey,"Correct! Your score is now "+ (string)gScore+ " . Next");
        }
        else if (pos != -1)
{
l1InstantMessage(gAvKey,"Wrong.The correct answer was "+ (string)(pos+1)+" Next");
}
        else if (pos == -1)
//The teacher screwed up and didn't code a correct answer
```

```
{
  llInstantMessage(gAvKey,"Oops! There is no right answer
to this question. Let's move on....");
}
  gQuestion = ""; //Erase the current question
  gAnswers = []; //And its answer key
  ++gLine;
  gQID = llGetNotecardLine(gCard,gLine); // Get the next question
}
}
}
```

A.12 Notecard Giver

Source code for giving notecards to the user who touches the object.

```
string strNotecard;
default
{
  state_entry()
  {
    //state entry runs once, when the script starts
    strNotecard = llGetInventoryName(INVENTORY_NOTECARD,0);
    if(llGetInventoryType(strNotecard)!=INVENTORY_NOTECARD)
    {
      //sanity check -- "if there is no notecard in the prim's inventory"
      llOwnerSay("There is no notecard in my inventory!");
    }
    else
    {
      //confirm to my owner that I know what I'm supposed to be doing.
      llOwnerSay("I have found a notecard called "+strNotecard+"
and I will give that to whoever touches me.");
    }
  }
}
```

```
}  
}  
  
touch_start(integer num_detected)  
{  
  if(strNotecard)  
  { //shorthand for "if a value has been assigned to strNotecard"  
    llGiveInventory(llDetectedKey(0), strNotecard);  
    //give a copy to whoever touches me  
  }  
}  
  
changed(integer change)  
{  
  //something has changed! I wonder what  
  if(change & CHANGED_INVENTORY)  
  { //something in my inventory has changed!  
    llResetScript();  
    // to make sure the value of strNotecard is kept current.  
  }  
}  
}
```

A.13 River flow

Animated river mesh

```
// anim SMOOTH Script  
// By Doug Linden (I think)  
//  
  
// If you are interested in scripting, check out  
// the Script Help under the help menu.
```

```
// The double slash means these lines are comments
// and ignored by the computer.

// All scripts have a default state, this will be
// the first code executed.
default
{
    // state_entry() is an event handler, it executes
    // whenever a state is entered.
    state_entry()
    {
        // llSetTextureAnim() is a function that animates a texture on a face.
        llSetTextureAnim(ANIM_ON | SMOOTH | LOOP, ALL_SIDES,1,1,1.0, 1,0.05);
        // animate the script to scroll across all the faces.
    }
}
```

A.14 Rotating Cube

Rotation script for the rotating Cube Mesh of the Quiz

```
default
{
    state_entry()
    {
        llTargetOmega(<0,0,0.5>,PI,1.0);
    }
}
```

A.15 Floating text over the objects

A.15.1 Make transparent prim

```
default
{
```

```
state_entry()
{
llSetPrimitiveParams([ALL_SIDES, PRIM_SHINY_NONE, PRIM_BUMP_NONE, PRIM_COLOR,
ALL_SIDES, <1.0, 1.0, 1.0>, 1.0, PRIM_TEXGEN, PRIM_TEXGEN_DEFAULT,
PRIM_TEXTURE, ZERO_VECTOR, ZERO_VECTOR, 0.0]);
// Delete ourselves from the prim; we are no longer needed.
llRemoveInventory(llGetScriptName());
}
}
```

A.15.2 Floating text

```
default
{
state_entry()
{
string text;
vector COLOR_GREEN = <0.0, 1.0, 0.0>;
float OPAQUE = 1.0;
llSetText("Click on this person to have more info", COLOR_GREEN, OPAQUE);
// Displays text hovers over the prim with green color and float value one.
}
```

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