STUDYING USERS' ACCEPTABILITY TOWARDS 3D IMMERSIVE ENVIRONMENTS
Virtual Tours: A Case Study

Karina Rodriguez Echavarria, Craig Moore, David Morris
Watts Building, Moulsecoomb University of Brighton, Brighton, U.K.

David Arnold, A. Delaney, R. Heath
Watts Building, Moulsecoomb University of Brighton, Brighton, U.K.

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Abstract: If information is considered the key in today's information society, then museums and heritage sites are of critical importance as they are places for knowledge to be shared and experienced by individuals. For this reason, presenting and distributing information through ICT forms could play a critical role for the museum in order to empower the public in their understanding of the past. The view of using ICT contextualisation mechanisms, such as 3D immersive virtual environment, in museums and heritage sites is explored in this research. Hence, this paper describes efforts towards exploring the acceptability of the interfaces and interaction techniques for Virtual Tours. We acknowledge the difficulty of the task as 3D immersive environment do not have defined interfaces nor visitor are believed to have replicable experiences. However, we believe that a significant amount of studies of this type might provide some answers to a field full of expectations but not enough experience in the ICT field.

1 INTRODUCTION

The exhibition in a museum or heritage site is mainly a visual environment - both the objects or spaces and their communication forms - for the visitor to deploy their own interpretative strategies. According to museums theory, visitors bring a multiplicity of different attitudes, expectations and experiences to the reading of an exhibition display, so that their comprehension of it is individualized. Hence, visitors focus on those aspects which they are able to recognize and thereby grasp both visually and conceptually. (Hooper-Greenhill, 2000) states that the use of senses, followed by observation, reflection and deduction, and finally the placing of the observation and ideas within a contextual framework, remains the standard method used for object teaching within the heritage places today.

(Falk and Dierking, 1992) studies have demonstrated that visitors tend to be very attentive to objects and spaces and only occasionally to text labels to acquire further knowledge which can inform their interpretation. Thus, the relationship between both the objects and the communication form is critical, as the latter provides additional meaning, in case this is needed, for the visitor to construct his/her own interpretation of the artefact and to fully understand the narrative.

Failure to include or achieve an effective communication form could mean the visitor will be unable to make any sense of the exhibition display. (Vergo, 2000) highlights that the attitude that objects on display were best left to speak for themselves persisted until well into the nineteen century and to some extent it is still with us today. Although, almost all agree that exhibitions address themselves to an audience, and that their aim is, in the broadest term, educational; opinions diverge widely as to how that aim is best achieved. In particular, there is disagreement over the question as to the level of information or explication appropriate or desirable in the context of a given exhibition.

Much of this confusion is attributed to the tendency to treat as synonyms the words "learning", "education" and "school". One manifestation of this confusion is the idea that learning is primarily the acquisition of new ideas, facts or information; rather than the consolidation and incremental growth of existing ideas and information (Falk and Dierking, 1992). This

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causes confusion among concepts of learning cognitive information (facts and concepts), learning affective information (attitudes, beliefs and feelings), and learning psychomotor information (i.e. how to focus a microscope). Learning, many believe, refers only to learning cognitive information, which unfortunately is only one limited dimension as what visitors obtain from an actual museum visit.
Regarding the question of which level of information is required, two polarized views divide the spectrum of opinions; although, exhibitions always achieve an intermediate point or compromise between them. These are (Vergo, 2000):

1. The 'aesthetic exhibition' - where the object itself is the most important. Artefacts are not supposed to be understood but 'experienced'; however, this private process is not very well defined. In this view, any kind of communication form is an intrusion into the 'what is supposed to be' a silent contemplation of the artefact.
2. The 'contextual exhibition' - where the objects and spaces themselves are tokens of a particular age, a particular culture, a particular political or social system, or representative of certain ideas or beliefs. The argument for this contextualisation is that for the uninformed eye, the fragments of other times and other cultures, removed from their original context settings and rituals, are mere curiosities made by unknown people which value cannot be appreciated (Wright, 2000). In such exhibitions objects and spaces coexist, sometimes uneasily, with other kinds of communication forms. Until now, much of it in textural form.

It is the latter view which is of interest for the Information and Communication Technology (ICT) field. If information and knowledge is considered key in today's information society, then museums and heritage sites are of critical importance as they are places for knowledge to be shared and experienced (Wright, 2000). Hence, presenting and distributing information through ICT forms could play a critical role for heritage organizations in order to empower the public in their understanding of the past, but most importantly of the present.
As such, communication forms based on ICT provide the capacity of using a mixture of predominantly non textual material for contextualizing the objects and places in display. Although, the advantages of doing this has been previously suggested, the acceptability and the selection of user interfaces and interaction techniques (in software and hardware) for their use have not yet been completely identified. This work attempts to provide some answers to these questions. In particular to explore the use of 3D interactive virtual environment in a Virtual Tour application for contextualizing historical cities. As such, the paper describes efforts towards evaluating the acceptability of the interfaces using usability methodologies to explore not only the perceived opinions and responses of users, but also their behavior. We acknowledge the difficulty of the task as 3D immersive environments do not have defined interfaces nor visitor are believed to have replicable experiences. However, we believe that a significant amount of studies of this type combined with general guidelines in the usability field might provide some answers to a field full of expectations but not enough experience in the ICT field.

2 VIRTUAL TOUR: XVII CENTURY WOLFENBUTTEL

The Virtual Tour application used for this research recreates Wolfenbuttel as it once stood during the seventeen century. The town sits on the Oker river in Lower Saxony, just a few kilometres south of Braunschweig. Wolfenbuttel became the residence for the dukes of Brunswick in 1432 and in the following three centuries the town was an important centre of the arts. The 3D virtual environment reconstructs the town by using the main buildings from this period, such as the ducal palace, the library and the armoury, as well as a few other areas of interest. Nowadays, the town of Wolfenbuttel still contains many of these buildings; although their functionality has completely changed. In the real place, visitors can walk through the small streets appreciating the beauty of the historical buildings (see figure-1).
For this research, our premise was that only looking

Figure 1: Recreation of streets in the Town Wolfenbuttel.

at the buildings (in the real or in the non-real environment) was not enough for a visitor to understand the historical importance of the place. Hence, the main purpose of the virtual tour was to contextualize the buildings and spaces of the city by providing additional information on their relevance for the town. For this, a female virtual avatar populates the environment acting as a tour guide. This was included with the intention of creating a more engaging

presentation of the information about the town.
The Graphical User Interface (GUI) of the application has different sections (see figure-2). Six locations have been selected for the user to visit in the virtual reconstruction. The user navigates from one to another by clicking on labels 'floating' in the sky in the "Navigation Panel". Once at a location, the user can look around, rotating the view by using the mouse. Free movement is possible only with keys commonly used in first-person shooter games (i.e. Counter Strike). The 'floating' labels have been arranged according to the geographical location of the user in the 3D space. As such, when positioned at any location, the labels for the places to the east/west and north of the current location will appear bigger and clearer, highlighting the fact that to go to another location it is first necessary to pass through the neighbouring locations. The "Location Panel" highlights the name of the location the user is currently located. The user can request more information about any of the six locations in town using the following approaches: i) typing a question on the "Free-Type Questions Panel" or ii) 'pointing&clicking' on one of the predefined questions in the "Frequently Asked Questions Panel". The user also has access to a webpage when arriving at certain locations.

Figure 2: Graphical User Interface (GUI) of 3D immersive application for CH.

3 METHODOLOGY OF THE STUDY

The aim of the study was to explore individuals reactions to the interfaces and interaction techniques as well as the acceptability of the specific Virtual Tour. Further issues the research was interested in addressing were:

- Enjoyment, engagement and understanding of the historical material presented by an individual user.
- Usefulness of including virtual avatars in the environment.
- Learning curve for using the environment by novice and more advanced users.

System acceptability has been described as the combination of practical and social acceptability (Nielsen, 1993). Practical acceptability includes several factors: support, reliability, compatibility, and usefulness of both software and hardware. This can be measured with usability methodologies; where the term usability is understood as the effectiveness, efficiency and satisfaction with which users achieve specific goals in particular environments:

Effectiveness assesses the accuracy and completeness with which users can achieve specified goals in particular environments;

Efficiency assesses the resources expended in relation to the accuracy and completeness of goals achieved; and

Satisfaction is the comfort and acceptability of the system to its users and other people affected by its use.

Previous work on developing interfaces and interaction techniques for 3D virtual environments has been conducted by (Kjeldskov, 2001), (Bowman, 1998), (Poupyrev et al., 1997). Standard usability engineering and Human-Computer Interaction (HCI) evaluation techniques have been adapted to 3D immersive environments in order to be able to address the usability problems introduced by these interfaces. Usability work for 3D immersive environment has been previously researched by (Poupyrev et al., 1997), (Sutcliffe and Kaur, 2000), (K.Deol et al., 2000a), (K.Deol et al., 2000b) and (Bowman et al., 2002). According to this work, the methods for conducting usability studies can be classified according to 3 factors:

- Involvement of representative users, which divides methods between those that require the participation of representative users (such as Formal Summative Evaluation and Post-hoc Questionnaire), and those methods that do not (methods not requiring users still require a usability expert, such as Heuristic Evaluation)
- The context of evaluation, which inherently imposes restrictions on the applicability and generality of results. Conclusions or results of evaluations conducted in a generic context, for example Heuristic Evaluation, can typically be applied more broadly. Results of an application-

specific evaluation method, such as Cognitive Walkthrough, may be best-suited for applications that are similar in nature.

- The types of results produced, which identifies whether or not a given usability evaluation method produces (primarily) qualitative or quantitative results.

Results from previous tests indicate that more natural hardware interfaces, such as wands, rather than the traditional mouse, have more potential for interaction within CAVE-like environments. However, there are no guidelines for others types of set-ups. In addition, it has also highlighted the importance of incorporating features common to computers games into 3D Immersive Virtual Environments. For example: using artefacts as portals to previous times; using avatars to deliver information; using "highlighted" objects as hyperlinks; and using maps.
To add on the experience of this previous research, our work involved studying individual user's behaviors while using the Wolfenbuttel Virtual Tour producing as a result both quantitative and qualitative data. However, it should be noticed that according to museums theory it will be impossible to use representative users as every user will have an individual context on which he/she experiences the environment. The study was based on two combined methodologies: i) *Formative Evaluation* as well as ii) *Post-hoc Usability Questionnaires* (Hix and Hartson, 1993).
Formative Evaluation is an observational, empirical evaluation method that assesses user interaction by iteratively placing users in task-based scenarios in order to assess the design's ability to support user navigation, acting (information seeking) and understanding of subject material. This technique is application-specific and produces qualitative results, such as critical incidents, user comments, and general observations. The results are expected to provide a basis for exploring how visitors engage and interact with this type of environment as it is critical to understand different personality-based interaction styles (i.e. strategic vs. tactic). Post-hoc Usability Questionnaires produce quantitative results, which are useful to improve applications' designs further.
The testing usually lasted one to one and a half hours and had the following format:

1. Introduction
2. Formative evaluation: performing five high level tasks using the software and implementing a 'Think aloud' technique. Tasks ranged from open goals such as exploration and discovery of elements in the environment to more structured tasks. The users were using a head tracker during this part of the test which gave us qualitative and quantitative information of the behaviours of the users towards the environment (see figure 3).
3. Usability questionnaire: based on ISO 9241/10 standard usability questionnaire (Heinz, 1993).

Figure 3: Formative evaluation set-up.

In total, the research involve studying 12 case studies. This sample involved people with different ages, levels of knowledge in ICT and attitudes towards museums and heritage sites. As previously mentioned, the study acknowledged at all stages the sample was limited, however the data produced by this 12 cases produced a better picture of people's attitudes and acceptability of the technology. The highest percentage of the user sample ranged between 27 to 36 years old, while 5 were male and 7 female. Average use of computers ranged between 10 to 20 hours per week.
User's knowledge of computing ranged from intermediate to advanced, but only 2 had advanced knowledge in computer graphics. Three quarters of the sample play or have played computer games. This fact definitely influenced the expectations and interaction techniques with which users were familiar. The majority of users visited museums fairly often as half averaged 2 to 5 visits per year and one quarter averaged more than 6 visits per year. It should be noted that visits to museums were done during traveling, as a high percentage of the answers referred to museums which are not in the local area or even in the UK.

3.1 Testing Users' Data

Head tracker data was stored in a user's log file containing interception point and time stamps for synchronization purposes. In addition, on screen video interaction and user's voice was captured. This provided a video and audio file in an AVI container; which was used to evaluate the users opinions and their thoughts from the speak aloud technique.
The difficulty of using the head tracking data within

this environment is that each case study is completely personal and making comparison between cases is difficult. Users do not have a linear experience, but a 3 dimensional exploratory experience. To overcome this problem, we clustered the data of each user according to the different tasks they performed and then observed the similarities differences between each of them. Observing the head data usually involved looking into the actions of all users, specially the slower and faster subjects to make a comparison. We also listened to the comments of the users while they were performing the tasks. This was not in any way a straight forward task and the results where not always easy to capture and represent.
Typically, a task was performed in an average of three and a half minutes. Hence, the 5 tasks where typically completed in an average time of 18 minutes. The users who had problems understanding the interaction techniques, performed very slowly, with a couple of them taking up to 9 minutes to complete the first task. In addition, variations in time were related to i) some users wanting to explore the environment further, while others were just interested in accomplishing the tasks; as well as ii) users writing down the answers on paper, whilst others would just speak the answers out loud. These factors were taken into account when assembling the conclusions of this exploratory study.

4 DISCUSSION OF RESULTS AND OBSERVATIONS

The results are presented in terms of the main issues that were identified by this research.

4.1 Acceptability

Opinions were divided when discussing the acceptability of such environments, especially for museums and heritage sites. Although their conceptualization potential was appreciated; visitors thought that the Virtual place do not look realistic enough. One could interpret this response suggesting that if ICT is to be used then contextualisation is not enough, but also the virtual authenticity of the object or place needs to be considered.
Regarding the acceptability of the place, not all users were convinced that the 3D virtual environment was an acceptable representation of what the place would have looked like in the seventeenth century, as only half the users agreed with the statement. The users' main concerns were:

- Only the exterior of buildings are shown, and not the interiors. This is a technical limitation of the application that was being used
- The apparent artificiality/sterility of the environment. Users suggested that this could be addressed though the inclusion of people and animals

These responses highlight the desire from users to achieve certain degree of realism. There was a struggle from users to request realism, while not feeling comfortable with realistic interactions techniques, as explained in the navigation section. This dichotomy was highlighted several times during the testing results.
There were also mixed feelings regarding the statement that "the use of 3D virtual environments - like this one - is a credible replacement for reading text labels or audio guides in a museum", with half of the users agreeing but the other half disagreeing, although not so strongly. This highlights the unfamiliarity of users towards new ways of conceptualization; in addition, to the acceptance of using not-so-authentic virtual replicas of real historical objects.
Some of the comments from users were that it was to easy to jump from one place to another without really looking at the buildings and environment; hence, people do not take in much of the information. Another answer, very related to the museum setting highlights the fact that in a place with lots of people crowding around the machine, this type of environment could be very impractical when compared to audio guides unless they too were personalised, which implies their availability on mobile equipment. The fact that audio guides do not distract the visitor from looking at the objects in the museum exhibition is also important to consider. Visual guides might be more applicable in cases where the modern day environment appeared different from the historic environment.

4.2 Enjoyment, Engagement and Understanding of Historical Material Presented

When discussing how people engaged with the experience and found it fun, we find a strong link with computer games. One user, who identified the Avatar as representing herself, saw as a natural interaction to go and ask other characters for the information she was trying to find. She also tried to walk into the building as a natural and enjoyable way

to behave in such environment.
The application provided the user with information in a variety of ways (i.e. web pages, question-answer systems). Users tended to get confused regarding the most suitable mechanisms to get an answer to their questions. They felt very comfortable with searching for information in a webpage, as they were familiar with the interaction paradigm. Even when information was in front of their eyes, using other means, they seem not to find it very easily.
When evaluating differences in performance of tasks, it was noted that slower users were using a more exploratory approach. They took their time to see and grasp the environment instead of just trying to extract the information from it, while others focused only on the movement and the text information presented by the environment.
One of the tasks involved a 'trick' question to see how much attention users were paying to the information provided in text. After a few tests, it was obvious that people also took different approaches to this: those who read and focus mainly on facts (i.e. date of birth, achievements of people, etc.) and those who try to get the main idea from quickly gazing at the text. This result might suggest that just as in labels, users will not be very attentive to the text on an ICT application, but other visual and audio elements should be more suitable for the task.
In general, users felt positive with Virtual Tours engaging visitors with museums and heritage sites. This is the case as the visitors already have an interest in the subject and want to know more. In addition, it has some entertainment value for the user, which can make visiting the museum more fun. This result does contradict the disbelief of many to accept this environments as a credible replacement for reading text labels or audio guides in a museum. This might indicate the conservative view of a museum from the users although they do accept that this type of environments could be more engaging for visitors.

4.3 Usefulness of Including Avatars in the Environment

Users were very critical about including an Avatar that they could not interact with in the Virtual Tour:

- Almost all women tended to think the Avatar was a representation of themselves within the 3D environment rather than as a virtual guide which was providing them with help which it was intended to be.
- Many women found the Avatar to be stressful because her gestures made her looked like if she was bored or confused. One of the users thought she was being pressured to choose something quickly.
- Other users disregarded her, as the Avatar was not directly interacting with them. One user mentioned that he was not paying as much attention to her as to the other parts.

Hence, if including an Avatar it is important to make it interactive and be more involved in welcoming, giving instructions, pointing, or answering questions. There was even a suggestion to write in her shirt the word "GUIDE" to make this fact obvious. These results highlight the importance of interactivity over realism of the characters in a 3D immersive environment. Again, the results highlight that users thought the environment should look realistic, but that finally it was the interactivity of its elements what creates the engagement with it.

4.4 Learning Curve for using the Environment by Novice and More Advanced Users

As previously mentioned, most of the users already had some knowledge on 3D systems. However, some of them took long time to perform some of the tasks, as they could not figure out the interaction technique required. It should be highlighted that a minute for learning a - new - interaction technique is far too long for the 'couple of minutes', museums will expect a user to spend with an application.
In addition, three quarters of users answered that they were not able to use the fundamentals of the software right from the beginning, without having to ask for help. Only one user looked for help immediately, which helped her scoring the shortest time of all. The longest time on this task was achieved by a user who tried different mechanisms for interaction until she found the one suitable to perform the task.

4.5 Usability

General usability issues (many of them obvious but missed previously by the design team) which were highlighted include:

- When using large screens, such as the one used for the test, text in labels has to be large enough to read and the labels should not overlap each other.
- If there are triggers in a 3D environment, these should only be displayed prominently when the

user is able to click on them. There was an example of a big bright yellow-red icon in the 3D environment, which highlighted the fact there was more information available at the location, but to the frustration of the users this could not be clicked.

- The speed of animations must be carefully considered. For example the flying speed was a bit too fast for users to appreciate the environment and see the buildings. Hence, there is a need to give some control to the users to stop, look around or adjust the speed of their movement within the environment.

4.6 Interaction Mechanisms

Initially, the majority of the users had difficulty in identifying the interaction mechanisms used by the application. All users took time to get accustomed to the navigation mechanisms. The lack of common navigation techniques within this type of environment could be a contributory factor to this problem. The head tracking data, demonstrates that most users focus on the area of the screen were most of the movement is happening (as shown in figure-4). As such, they attempt different actions mainly within this space ignoring the other areas. Typically, users attempted to interact by i) clicking on houses, doors or on the virtual Avatar; ii) looking at the applications menu or iii) moving the mouse or the key arrows on the keyboard. None of them actively noticed the fact that most of their interaction techniques have been learned from playing computer games (in their different genres).

The label based navigation mechanism (using labels

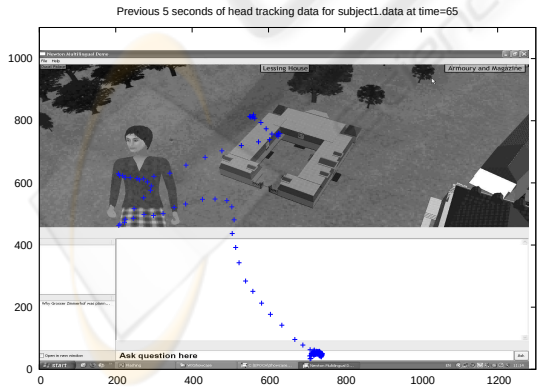

Figure 4: Head tracking data for user while performing a task.

for jumping to locations in the 3D environment) was not well received. Using labels with names of places to navigate around the 3D space made it very contradictory and confusing for users. Two thirds of users failed to understand the geographical logic behind the navigation. Most users would have preferred to use an overview/map of the entire environment and a list of all the places where it was possible to navigate so they can orient themselves easily.

When users identified that they wished to move from one location to another, the system responded by flying to the destination, which is neither consistent with users real-world experiences or those they gain from the majority of virtual 3D worlds. One user commented that it would have been more natural to walk instead of flying to highlight this fact.

Users tried to navigate by typing requests into the "Ask a question here" text field. Providing a non restricted space to "Ask", made them think they could type anything including questions, requests, orders to the system (i.e. "go to library", "most important places in town", "map of town", "how do I move", etc.) This highlights the need to inform the users of the restrictions on the information the system can provide at any time and providing help as soon as entering the environment on what they can do or not within the environment.

5 CONCLUSIONS

The Virtual Tour application presented in this paper represents an example of the type of virtual environments that currently exist to contextualise the communication of heritage. Although their popularity, it has been acknowledge the difficulties on deciding the most suitable interfaces for their use. As a result, the paper has presented ongoing research to explore user's acceptability and behavior towards interfaces and interaction techniques (in software and hardware) for their use. The following observations were found from our study:

- Although museum visitors still have a conservative view on the museum and its contextualization devices; 3D immersive environments might be an engaging way to provide additional information as long as the representations contained are realistic enough.
- To be acceptable, applications must consider their context of use. In museums users may only able to spend a few minutes using a display thus, wherever possible the time required to learn an application must be minimal as must be the time require to explore the key information that it presents.

- The purpose/function of Avatars must be made clear to users. Avatars are only useful if they can operate effectively within the constraints identified above.
- Avatars must meet users' expectations particularly in terms of the gestures and interactivity that they support and the manner in which they engage with users.
- Users should be able to control their speed of navigation and route within the environment. If they want to stop and explore allow them, while still constraint the navigation so they do not get lost.
- Information should be presented in a variety of ways (multimedia, text, etc), but have the same interaction paradigm to be accessed. In this study, users appeared to favor Hyperlinks.
- It is necessary to decide the target audience and take this into account for present historical facts in the most adequate interactive format. Language of information should also be considered.
- Existing best practice interaction and visual design techniques should be utilized. For example: designs must take into account the target display size and resolution as well as the labels should be meaningful and discernible. In addition, the principles of affordance and constraints (Norman, 1988) should be exploited to reduce the cognitive load placed on users.

Although this observations cannot be generalized and are specific to the study we conducted, they can provide an insight into into current and potential museum's users attitudes. There is further debate to be had in the areas of realism of environment above interactivity, and the role of computer games interfaces and interaction techniques.

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REFERENCES

Bowman, D. (1998). Interaction techniques for immersive virtual environments: Design, evaluation and application. In *Human-Computer Interaction Consortium (HCIC) Conference*.

Bowman, D., Gabbard, J., and Hix, D. (2002). A survey of usability evaluation in virtual environments: Classification and comparison of methods. *Presence: Teleoperators and Virtual Environments*, 11.

Falk, J. H. and Dierking, L. D. (1992). *The museum experience*. Whalesback Books, Washington, D.C.

Heinz, W. (1993). Isometricsl, questionnaire for the evaluation of graphical user interfaces based on iso 9241/10. Version: 2.01c March 1998.

Hix, D. and Hartson, H. R. (1993). *Developing User Interfaces: Ensuring Usability through Product & Process*. John Wiley & Sons.

Hooper-Greenhill, E. (2000). *Museums and the interpretation of visual culture*. Routledge, London.

K.Deol, K., Steed, A., Hand, C., Istance, H., and Tromp, J. (2000a). Usability evaluation for virtual environments: Methods, results and future directions (part 1). *Interfaces No 43*, pages 4–8.

K.Deol, K., Steed, A., Hand, C., Istance, H., and Tromp, J. (2000b). Usability evaluation for virtual environments: Methods, results and future directions (part 2). *Interfaces No 44*, pages 4–7.

Kjeldskov, J. (2001). Interaction: Full and partial immersive virtual reality displays. In *Proceedings of IRIS24*.

Nielsen, J. (1993). *Usability engineering*. Academic Press Limited.

Norman, D. A. (1988). *The psychology of everyday things*. New York: Basic Books.

Poupyrev, I., Weghorst, S., Billinghurst, M., and Ichikawa, T. (1997). A framework and testbed for studying manipulation techniques for immersive vr. In *ACM Symposium on Virtual Reality Software and Technology (VRST)*.

Sutcliffe, A. and Kaur, K. D. (2000). Evaluating the usability of virtual reality user interfaces. *Behaviour & Information Technology*, 19:415–426.

Vergo, P. (2000). The reticent object. In *The New Museology*. Reaktion Books Ltd.

Wright, P. (2000). The quality of vistor's experiences in art museums. In *The New Museology*. Reaktion Books Ltd.