Optimization of User Satisfaction on an Augmented Reality Based Guided Tour

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ABSTRACT

This paper reports on work being conducted with the goal of optimizing users' satisfaction on an augmented reality based guided tour. It shows the applied methodology, the metrics used to assess the quality of the user experience and the results obtained from the statistical analysis of the experimental results. We stereotyped users by considering whether or not they had a background related to information technologies, and compared their behavior patterns. Next, we evaluated how social inhibition would affect the way users' interacted with the applications. We then tested for correlations between several measured metrics and users' satisfaction answers, in order to acquire knowledge such as: the influence that the ease of use had in users' satisfaction; whether the time that users spend interacting with the Interactive Installations (I.I.) directly influenced their satisfaction; and others. Finally, we analyzed the influence that the relative visit order of each I.I. in the guided tour had on the users' satisfaction, and found an optimal sequence in which to present I.I.s to visitors, so as to provide them with the most pleasant possible experience.

Author Keywords

User modeling, Behavior Metrics, Augmented Reality, Guided Tour Route Planning, Optimization, User Modeling, Affective Computing

INTRODUCTION

This project was developed by YDreams, SA in collaboration with the Faculty of Psychology of the University of Lisbon. YDreams is a global company that works with the concept of interactivity, with a focus on the field of Augmented Reality technologies. Over the last few years, YDreams has been developing full-scale interactive environments (from stores to exhibitions), products and intellectual property, combining technology and design. This company has a showroom that is frequently visited by customers, schools, and media, among others. These visits are guided by salespeople who present the interactive installations (I.I.), but in an order that changes randomly with each visit. As the users are naturally different from each other, the aim of this project is to study the best way to create an immersive environment in the showroom that adapts the visit according to the different user types, in order to maximize their satisfaction. To achieve that, there are several areas of research that are being studied and applied, such as affective computing [1], storytelling[2], user modeling [3] , intelligent agents and smart objects [4], augmented reality [5], among others. This paper presents a component of the user modeling research. The first section describes the problem we studied and the methodology applied is in the second section. The results obtained with the performed experiments are reported on the experiment results section. Finally the last section contains a short summary, conclusions and the future work.

THE PROBLEM

Ydreams' showroom has several I.I. that are frequently shown to visitants, but the users' behavior on those visits had never been studied. This paper aims to shed light on a set of questions about the way users interact with those I.I.. To achieve that, six I.I. representative of users' behavior were selected. These are YWalk, YReal, Tangitable, YWaterfall, YMagic and YFaces. Three of them show the user's image as he/she interacts with it (YReal, YWaterfal, YFaces); two are entertaining and easy to use (Tangitable, YWalk), and two are new and have a considerable learning curve (YReal, YMagic). YFaces also personalizes users'

interaction, as the application catch them by a camera and places their image, after some transformations, inside a comic book with personalized text in the balloons.

The research questions considered in this study were:

1- If we stereotype users based on whether or not they have an IT background, do we observe any significant difference in their behaviors?
2- When users are publicly displayed in the I.I. with which they are interacting (e.g.: in a video projection), is their behavior influenced by any kind of social inhibition?
3- Can a user's degree of satisfaction with an I.I. be inferred from the time he/she spends interacting with it?
4- How do users evaluate an I.I. they find easy to interact with? Do they consider it a boring experience, or a satisfactory one?
5- Are there any I.I.s that more strongly influence users' global satisfaction with the guided visit than the remaining ones?
6- At which point in the guided tour should those I.I. that provide a personalized experience to the users be presented?
7- How strongly does the relative order in which I.I.s are presented during the guided tour influence the users' satisfaction, and the remaining metrics under consideration?

METHODOLOGY

For this study, a sample of 30 people was selected, with ages between 20 and 30 years old. Part of the sample was composed of university students with a strong technology background (like computer science, aerospatial engineering, among others) and the other part was composed of students from a less technological background (like psychology, nursing, among others). Several visits were scheduled, in groups of 2 people, always with identical academic backgrounds per group. Each visit consisted in presenting those 6 interactive installations and a feedback questionnaire at the end. In order to analyze for each I.I. how much its relative position in the guided tour influenced the users' satisfaction and the other analyzed metrics, 3 different visit orders were tested. Several questions were included on the questionnaire, with the goal of measuring users' satisfaction on this set of tests. In the future the goal is to infer this metric automatically and dynamically during the visit [6]. In order to achieve that, several other metrics were measured with the goal of correlating them (simple or composed) to users' satisfaction answers. These metrics were *latency* (time since the instruction to interact is given until users start to interact), *duration* (time spent interacting) and user *engagement* (time since user stops to interact until the beginning of the next presentation – usually users ask several questions after the I.I. presentation). The variables in analysis for each I.I. were then: *user satisfaction*, *ease of use*, *latency*, *duration* and *engagement*. The global variables analyzed were: boredom of the visit (*boredom*), global satisfaction with the visit (*global satisfaction)*, whether the visit met expectations (*expectations*) and the likelihood of recommendation of this visit to other users (*recommendation*).

EXPERIMENTAL RESULTS

1. *If we stereotype users based on whether or not they have an IT background, do we observe any significant difference in their behaviors?*

In order to answer to the first question, we compare the results from users with an IT background versus users without one. The statistical results obtained considering the users' distinction were: Average of User satisfaction by interactive installation (Fig.1); Average of Ease of use by interactive installation (Fig.2); User satisfaction by interactive installation and by order in sequence presentation (Fig.3). Fig.1 shows that there are differences between the users' preferences. For example, YWaterfall is the most preferred for IT users and the least preferred for the remaining users. The perception of the different interactive installations' ease of use was also different between user types. This fact can be observed in Fig.2 where, for example, YWaterfall was considered the easiest for IT Users and almost the hardest for the remaining users. Analyzing the order in which interactive installations were presented (Fig.3), we see no significant differences between the two types of users. In order to analyze if there are statistically significant differences between the answers given by the two groups, the Friedman Test with Replication [7] was applied. The results obtained were a p-value of 0.62 for users' satisfaction and 0.47 for ease of use, with a 0.05 significance level. Analyzing the results obtained by the Friedman Test with replication, we see no statistically significant differences between answers given by IT Users and Other Areas Users on these two questions. But, in Fig.1 some I.I. seem to have differences. In order to verify this fact, the Kolmogorov-Smirnov Test was applied to each I.I. [7]. The results showed that, at the $\alpha = 0.05$

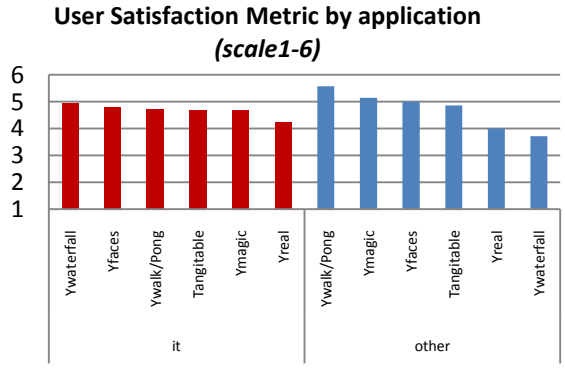

Figure 1. Users' Satisfaction by Interactive Installation and by Users' background.

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Eds. A.J. Spink, F. Grieco, O.E. Krips, L.W.S. Loijens, L.P.J.J. Noldus, and P.H. Zimmerman

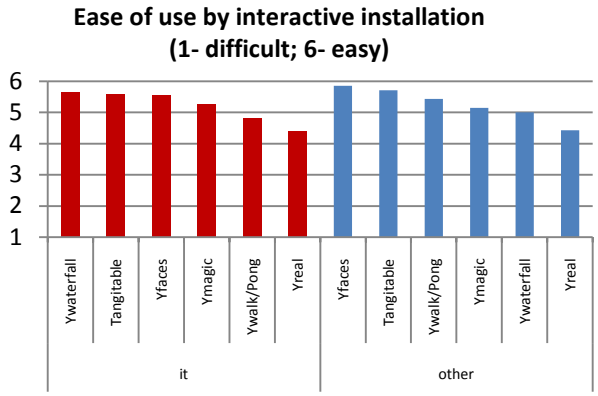

Figure 2. Perception of Ease of Use by Interactive Installation and by Users' background.

level of significance and p-value of 0.004, there exists enough evidence to conclude that there is a difference in user satisfaction for the YWaterfall I.I. between the IT group and Other Areas Group. The users' satisfaction and perception of ease of use for the remaining I.I. don't differ significantly.

There are no major differences between users with an IT background versus users without one. YWaterfall was the only I.I that had presented statistically significant differences between these two users' stereotypes.

2. *When users are publicly displayed in the I.I. with which they are interacting (e.g.: in a video projection), is their behavior influenced by any kind of social inhibition?*

The I.I. that shows users image are YWaterfall, YReal and YFaces. In order to study the social inhibition, we compared latency, duration of interactions and users' satisfactions of these I.I., with the remaining ones. The results showed that YWaterfall and YFaces had the shortest duration, YFaces had the longest latency and YReal were the one that users liked less. Taking these results together with the observations done during the visits, where we could observe that users didn't feel comfortable seeing their images on the screen, we can affirm that these I.I.s promote social inhibition on users.

3. *Can a user's degree of satisfaction with an I.I. be inferred from the time he/she spends interacting with it?*

To investigate this question we applied Spearman correlation [7] to users' satisfaction with each I.I. and the corresponding interaction duration. There was no statistically significant correlation between these two metrics for any I.I.s. Moreover, duration hardly appears in correlation results with other metrics. However, some correlations do give us some degree of information related to this topic. For YReal, *Satisfaction vs Ease* had a

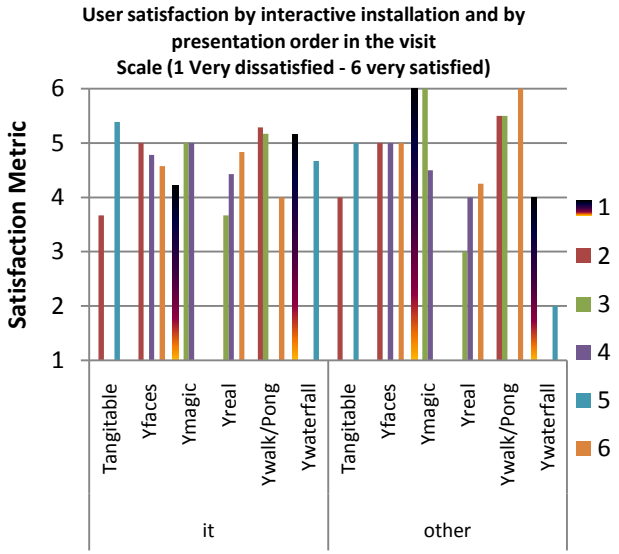

Figure 3. Users' Satisfaction by Interactive Installation order in guided visit, grouped by users' background.

correlation of 0.631, *Ease vs Duration* had a correlation of -0.508, *Boring vs Duration* had 0.437 and *Expectations and Duration* had a correlation of -0.46, at a 0.01significance level. These results shows that, for YReal, the easier users considered it, the better their satisfaction and the shorter would be their interaction duration with it. Also, the longer the duration, the more users found this I.I. to be boring, and the worst would users' expectations about the visit be met. So, although we did not have any direct correlation result that relates duration with satisfaction, we could infer that the shorter the duration, the better users' satisfaction is. As the other I.I. didn't present any information about the interaction duration, we could only say that, with the data obtained with this experiment, the only result is that the shorter the duration, the better.

4. *How do users evaluate an I.I. they find easy to interact with? Do they consider it a boring experience, or a satisfactory one?*

To analyze this fact we applied Spearman correlation [7] to the ease of use, boredom and users' satisfaction metrics. The results showed that for YWaterfall, YMagic, YReal and YFaces ease of use and users' satisfaction had a statistically significant positive correlation (at 0.01 significance level). So, the easier users found these I.I., the higher their satisfaction with it. Also, YWalk, Tangitable and YFaces showed a statistically significant negative correlation (at 0.01 significance level), for *ease of use vs boredom*. So, users like I.I to be easy to use.

5. *Are there any I.I.s that more strongly influence users' global satisfaction with the guided visit than the remaining ones?*

To achieve this result we applied Spearman correlation [7]

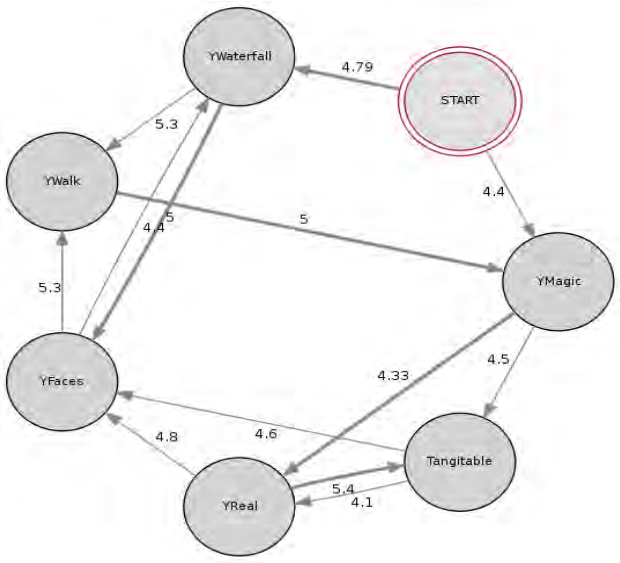

Figure 4. Influence of previous I.I on users' satisfaction for each I.I. (1- very dissatisfied; 6- very satisfied).

to users' satisfaction with each I.I. and their global satisfaction evaluation. The results showed that users' satisfaction with YWalk, YMagic, YReal and Tangitable have influence in their global satisfaction with the whole visit. YWalk had a weak correlation of 0.33 at a 0.05 significance level, YMagic had a 0.433 at a 0.01 significance level, YReal had a correlation of 0.451 and Tangitable had a correlation of 0.514, both at a 0.01 significance level. So, Tangitable is the most influent on global users' satisfaction, followed by YReal and YMagic and, at the end, Ywalk. In future experiments, these I.I. will be given a more central role in the visit, so as to provide users with a more satisfactory experience.

6. *At which point in the guided tour should those I.I. that provide a personalized experience to the users be presented?*

The I.I. that provides a personalized experience to the user is YFaces. This I.I. was tested on the 2nd place, 4th place and 6th place (end of the visit). Although the differences were small, users' satisfaction with this I.I was better if it was presented at the beginning of the visit. Fig.1 also shows that this I.I is one of the preferred by users and is one of the easiest to interact with, so it is a good one to "break the ice" at the beginning of the visit.

7. *How strongly does the relative order in which I.I.s are presented during the guided tour influence the users' satisfaction, and the remaining metrics under consideration?*

Fig. 4 depicts a graph where all the considered interactive installations appear as nodes, and the directed edges represent the measured satisfaction levels (value shown as the edge label) of the I.I. on the destination node when it was visited at some point in the visit after the I.I. on the source node had already been visited. At each node, the thickest of its incoming edges represents the precedence that was observed to give it the highest satisfaction level in these experiments. The short number of tests we were able to perform meant that we could not obtain enough reliable information from which to measure all the possible edges. Instead, we allocated people in the multiple tests over a set of 3 different visit orders that would collectively supply information about an adequate variety of edges. As a result, we can observe that the I.I.s in Fig. 4 all have both in- and out-degrees of 2 (with the exception of YWalk). When the information obtained from these experiments is represented in this way, the problem of identifying the visit order that maximizes the satisfaction levels of all I.I.s is identical to the well known Travelling Salesman Problem [8] in combinatorial optimization. Here however, instead of seeking the shortest tour between cities, we want the tour with maximal satisfaction levels. Optimizing the visit order by taking this goal into account, we come up the following sequence: YWaterfall – YFaces – YWalk – YMagic – YReal – Tangitable. Considering the values measured in our experiments, this would be the optimal visit order for the I.I.s in the company's showroom.

CONCLUSIONS AND FUTURE WORK

The aim of this project is to maximize users' satisfaction in a guided tour environment. To achieve that, some experiments were carried out. The results obtained showed that in general there are no statistically significant differences in behavior between users with an IT background and those without one. Results also showed that users' satisfaction with YWalk, YMagic, YReal and Tangitable have influence in their global satisfaction with the whole visit. Finally, the influence of each I.I.'s relative position in the guided tour on users' satisfaction was also analyzed. The best order in which to visit the multiple I.I.s in the guided tour was inferred, from the feedback data provided by the users in our tests, to be one starting with YWaterfall, followed by YFaces, then YWalk, YMagic, YReal and finally, Tangitable.

The next steps to be done are, at first, to stereotype users based on their information into multiple classes. We will further investigate this topic because we observed, while the test visits were occurring, that users' behavior and interactions with some I.I.s did not follow the same pattern for all users. We then intend to check which metrics could better segment users in order to personalize and adapt the visit to each user type. Afterwards, we will create an optimization algorithm for dynamical selection of the best I.I. sequence to be used in the tour, which takes users' stereotypes into account. Finally, we will implement a virtual agent in the showroom, with the goal of providing users with a more personalized experience. To achieve that, the agent will adapt its behavior by taking into account feedback measured from users' interaction with I.I.s..This agent will function as an interaction unblocker, by showing the user how to interact with each I.I., as well as by

performing other tasks.

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