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Evaluation of an Augmented Reality Embedded On-line Shopping System

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Abstract

Online shopping has changed customers' purchasing behaviors due to the rapid development of Internet technology. According to the investigation of National Development Council in Taiwan, the number of people using online shopping has increased. Recently, augmented reality has also been introduced to online shopping websites. In this study, a well-known Taiwanese online shopping website was selected to be the experimental platform with an embedded augmented reality function, which allows customers to try on the displayed headwear virtually. In order to evaluate the effectiveness, the same online shopping website without augmented reality function was also used. A total of 30 participants with 10 in each age group (i.e. 20-29, 30-39, 40-49) and with online shopping experience were recruited. At the beginning of the experiment, participants had to take practice session to acquire the augmented reality embedded system and the other one, and then four scenarios would be given randomly. Objective measurements, such as task completion time and mouse performances were recorded during the experiment. System Usability Scale (SUS) and User Experience Questionnaire (UEQ) were used to collect subjective measurements after participants completed each scenario. The results showed that the participants preferred to use the augmented reality embedded system than the other approach. Also the augmented reality embedded system reduced mouse clicking times, mouse speed, and paging frequency, indicating that AR embedded system can help customers to increase the efficiency of making shopping decision.

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Keywords: online shopping, augmented reality, mouse performance.

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1. Introduction

Online shopping is a widely used e-commerce form which can allow users to purchase goods online. According to the report of U.S. retail e-commerce sales for the third quarter of 2012 was $57 billion, which was greater than the third quarter of 2011 [1]. Also from the investigation of National Development Council, Taiwan in 2014, 61.7% of Taiwanese people buying goods online, and many old people had the experience of using online shopping websites.

Goldsmith and Flynn [2] indicated that customers are easily stimulated to buy goods online because of the innovations of online shopping websites, rather than the innovations of clothes or goods. Cunliffe [3] pointed out the three main characteristics of website design are—content, visual appearance, and usability. Thus, the design and innovation of online shopping websites play important roles in facilitating online shopping activities.

Augmented Reality (AR) has been widely used in different areas. AR allows people to experience the virtual product design in real environment. Azuma [4] defined three main characteristics of an augmented reality system including combines real and virtual, interactive in real time, and registered in 3D. Since AR is interactive and intuitive, some applications of online shopping system with AR are also developed. In 2011, Zugara.com used marker-based tracking technique to construct a virtual try-on system, where users can interact with the virtual clothes by a hand-holding marker. In 2010, Metaio.com purposed a virtual try-on websites, which is achieved by displaying fixed 3D models on the screen.

Since augmented reality systems are different from the traditional ones, some special features need to be addressed, including interactivity, immersion, system efficiency, and etc. Bach and Scapin [5] proposed three methods to evaluate AR systems, including interviews, inspection, and usability testing. Dünser et al. [6] applied five assessment methods to evaluate AR systems: objective measurement, subjective measurement, qualitative analysis, usability testing, and informal evaluation. In addition, user experience (UX) is important to a success service. Tullis and Albert [7] indicated that good user experience includes users' perceptions, thoughts, and feelings to services or products.

In this study, an augmented reality embedded online shopping system was constructed. One popular Taiwanese online shopping website—Lativ has been chosen to be our testing platform and a virtual try-on function with markerless-based augmented reality has been added in the system. Objective data were measured in the experiment evaluations, including task completion time, mouse performance, and paging frequency. Besides, subjective measurements are collected to understand users' preference, satisfaction, and feelings to the system. In order to compare the differences, an online shopping website without AR function was also constructed.

2. Material and Methods

In order to evaluate the effectiveness of the AR embedded online shopping system, an experimental task was purposed. The experiment method is presented in the following.

2.1 Participants

Thirty participants including 15 females and 15 males were recruited in this study. They belong to three age groups included—20-29, 30-39, and 40-49 years old, with 10 participants (5 females and 5 males) in each group. The means and standard deviations of the three age groups are listed in Table 1.

Table 1. The means and standard deviations of the three age group participants.

Age	20-29(n=10)	30-39(n=10)	40-49(n=10)
Male(n=15)	25.2(0.75)	33.2(3.19)	44.2(3.71)
Female(n=15)	24.4(1.36)	34.6(2.87)	45.8(2.32)

Note: Unit: years; Mean (Stander deviation)

2.2 Apparatus and materials

There are two main types of online shopping websites in Taiwan, one is operated by companies, and the other is operated by service providers. The first one sells products of its own brand (B2C), and the second one sells products from different suppliers (C2C). In this study, the first type of online shopping websites was considered, and the brand, Lativ, was selected as our reference. Online shopping websites with AR embedded and without AR were constructed in this study. They were compared to find out whether the AR function would affect to users' performance and subjective conceptions.

In order to construct the AR embedded online shopping system, twenty-three 3D models of headwear were constructed by Autodesk Maya 2012. The augmented reality function was powered by Total ImmersionTM D'fusion, and the AR function widow was embedded in the middle of every page of product displays. The selected AR technique was markerless, which can help users to experience the virtual try-on function without other additional marker. The AR embedded online shopping system is illustrated in Figure 1.

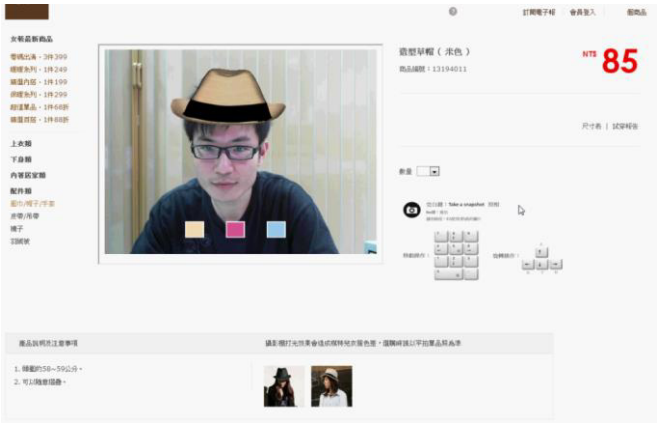

Fig 1. The AR embedded online shopping website.

2.3 Experimental design

A factorial experimental design was employed in this study. The independent variable included systems (with AR and without AR) and age (20-29, 30-39, 40-49). And the dependent variable included task completion time, mouse performance (clicking and rolling time, mouse distance, mouse speed), and paging per second. The task completion time was measured by a timer and the system loading time was excluded.

During the experiment, each participant was randomly assigned to operate one out of the two systems (with AR/without AR), and performed one out of the four shopping scenarios which was also randomly arranged for each participant. Each participant had to complete eight experiment trials within the same procedure.

2.4 Subjective questionnaires

Two subjective assessments were collected using System Usability Scales (SUS) and User Experience Questionnaire (UEQ). The two questionnaires were used to evaluate the usability and satisfactions of using the online shopping systems.

System Usability Scales (SUS) was developed by Digital Equipment Corporation in 1986. SUS is a ten items questionnaire, and the total score is located in 0 to 100, which indicates the usability of the system. User Experience Questionnaire (UEQ) is a questionnaire aims to the end-users [8]. UEQ contains 26 items which are made of adjectives. The purpose of UEQ is to understand how users consider the system by six dimensions: attractiveness, perspicuity, efficiency, dependency, stimulation, and novelty.

2.5 Statistical analysis

On-way analysis of variance (ANOVA) was conducted using SPSS Statistics 17.0 (IBM Inc., USA) with α = 0.05. The age and system effects on objective and subjective measurements were analysed. In addition, correlation analysis was conducted to evaluate the correlations between the objective and subjective measurements.

3 Results

Table 2 provides the summarized ANOVA results of the objective measurements. From the results in Table 2, expect for the paging frequency factor, there is no significant age effect. And the online shopping system showed significant influence in task completion time, mouse click and roll, mouse speed, and paging frequency. There was no interaction between system and age.

Table 2. The summarized ANOVA results

	Task Completion Time	**Mouse Performance**			Paging frequency
		Click and roll	Distance	Speed	
Age	NS	NS	NS	NS	*
System	***	*	NS	***	***
System*Age	NS	NS	NS	NS	NS

Note: ∗p<0.05, ∗∗p<0.01, ∗∗∗p<0.001

Note: NS = no-significant

3.1 Age

In Table 3, the significant age effect was found in paging frequency performance. The Duncan's multiple range test was conducted to identify the differences among three age groups. It seems that the age 40-49 participants had much less frequent page change behavior than the other two groups.

Table 3. The age effect on objective measure.

Age	20-29	30-39	40-49
Paging frequency*	0.933^{A}(0.48)	0.882^{A}(0.44)	0.661^{B}(0.38)

Note: Unit: times/second (SD)

Note: A, B, and C indicate the results of Duncan's multiple range test

3.2 System

In Table 4, the performance of the two systems is presented. The AR embedded online shopping system took longer time to complete, but with reduced mouse clicking and rolling times, mouse speed, and paging frequency.

Table 4. The system effect on objective measure.

	Task completion time***	**Mouse Performance**			Paging frequency***
		Click and roll *	Distance	Speed***	
Web (without AR)	194.36(77.73)	204.40(90.63)	28.78(19.00)	0.15(0.07)	1.12(0.41)
AR embedded	274.07(194.36)	156.97(65.54)	22.24(11.74)	0.07(0.03)	0.53(0.24)

Note: Unit: Task completion time = second; Click and roll = times; Distance = m; Speed = m/second; Paging frequency = times/second.

3.3 Subjective measurements

The subjective measurements results are provided in Table 5. The online shopping system showed significant effects on SUS, UEQ-ATT, UEQ-STI, and UEQ-NOV. The total score of AR embedded online shopping system was 77.32, and the score of Web (without AR) was 70.00, indicating both systems showed "Good" system usability. And there was no interaction between system and age. Figure 2 shows the significant UEQ items in bar charts, the Attractiveness, Stimulation, and Novelty items of the AR embedded shopping system were significantly higher than the system without AR. And the Novelty in web was negative indicating the dissatisfaction about the innovation of the original system.

Table 5. The overall subjective measurements results.

	SUS	**UEQ**					
		ATT	PER	EFF	DEP	STI	NOV
System	**	**	NS	NS	NS	***	***
Age	NS	NS	NS	NS	NS	NS	NS
System*Age	NS	NS	NS	NS	NS	NS	NS

Note: ∗p<0.05, ∗∗p<0.01, ∗∗∗p<0.001

Note: NS = no-significant

Note: ATT(Attractiveness), PER(Perspicuity), EFF(Efficiency), DEP(Dependency), STI(Stimulation), NOV(Novelty)

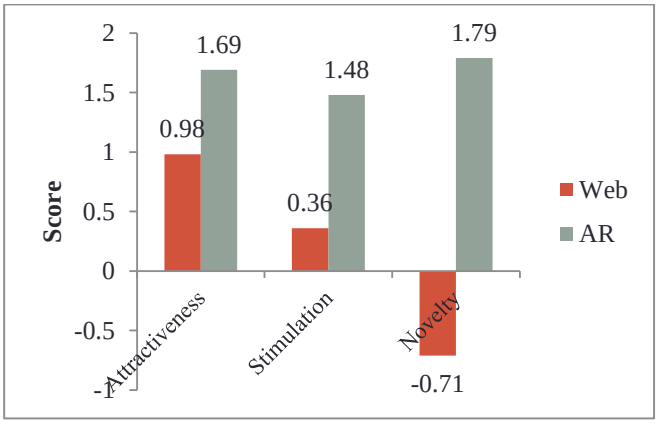

Figure 2. The significant UEQ items

3.4 Correlation analysis

Table 6 shows the result of correlation analysis. As it can be seen, task completion time had positive correlation with the subjective ratings in "Stimulation" and "Novelty". And from the average browsing time correlations, it can be seen that subjects had a habit of spending more time on browsing internet tend to make shopping decision faster.

Table 6. Correlation analysis results.

	Task Completion Time	Mouse Click and roll
(UEQ) Stimulation	0.374**	NS
(UEQ) Novelty	0.345**	NS
(Demographic) Average browsing time	-0.351**	-0.335*

Note: ∗p < 0.05, ∗∗p < 0.01, ∗∗∗p < 0.001

Note: NS=non-significant

Note: r < 0.3 weak; 0.3 ≤ r <0.7 middle; 0.7 ≤ r < 1 strong correction

4. Discussion

4.1 Age

Age effect was found in paging frequency, and the older people tend to make online shopping decision more effectively. As for customers' online shopping behavior, if they stick to each page longer, it indicates that they want to know more information of the product during shopping. It seems that age group 40-49 participants had more shopping experience than the young groups, and resulted in more effective shopping decisions [9].

4.2 System

In here, the AR embedded online shopping system had longer completion time, but significantly less mouse clicking and rolling times, mouse speed, and paging frequency. Zimmermann et al. (2003) indicated that higher paging frequency would make customers become more anxious and irritable [10]. Shim et al. (2002) indicated that high frequent mouse activities imply that shoppers may not find their ideal goods [11]. The implementation of AR based system technique is helpful for users to make decision when doing online shopping [12]. Mouse speed is related to eye movement, and the mouse speed was lower when participants used the website with AR embedded system. The participants tend to have greater eye movement with higher mouse speeds, and it would accumulate eye fatigue for a long time using [13, 14]. Thus, the AR embedded system can reduce mouse operation time and paging frequency, and thus reduce anxiety.

4.3 Subjective measurements

Participants rated the AR embedded online shopping system with higher SUS and UEQ (Attractiveness, Stimulation, and Novelty) scores than the system without AR, indicating the AR can facilitate better user experience. Users feel delighted and spend more time on browsing AR-based web [15]. AR was a better approach for goods online demonstrations [16]. Users tend to have more interests in purchasing goods when they have sensory stimulations [17]. Olsson & Salo (2011) also reported that the subjects had stronger intentions to use AR systems than the traditional ones [18].

4.4 Correlation analysis

Significant correlations were found in "task completion time" and "mouse click and roll." Task completion time increased with the increase of "Stimulation" and "Novelty" ratings. It seems that if participants spent more time on the website, they had more positive feelings about it. On the other hand, the negative correlations indicate that the participants had a habit of spending more time on browsing internet, they would make shopping decision faster. The past shopping experience can lead users to make shopping decisions more effectively [9, 19].

5. Conclusion

In this study, an AR embedded online shopping system was constructed, and it was compared with the original online shopping system without AR function. Thirty participants were recruited in the experiment evaluations, and both objective measurements and subjective measurements were collected.

The AR embedded system received higher scores in both subjective questionnaires (SUS and UEQ), and had better mouse performance. It indicates that the AR embedded online shopping system can help customers to increase the effectiveness and satisfaction of performing online shopping.

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