In-Store Shopping Experience Enhancement: Designing a Physical Object-Recognition Interactive Renderer

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Abstract. Following the rapid spread of online-shopping services on both internet and smart devices, the traditional way of promoting and trading in physical retail stores has been challenged. To increase sales, retailers have spent an enormous amount of resources to maintain the attractions of 'traditional' physical store in a digital shopping behaviour dominated world. Unfortunately, the outcome leaves much to be desired.

This study discusses the need of such hybrid-shopping style through an integrated process of customer investigation, observation and user testing. This paper using footwear shopping as a case study. The authors proposed an inventive installation to re-strengthen the inter-connections among customers, products and retailers using physical object recognition and 3D projection mapping technologies. This interactive installation allows customers to personalize their preferences through manipulating the physical products with Augmented Reality (AR) rendering effects. Furthermore, this system also provides an alternative solution to reform the product-promotion and production progress. This design can be applied to the promotion of many other kind of products.

Keywords: Innovative design · Interaction design · Experience design
Shopping behaviour · Physical component recognition · Projection mapping
Tangible interactivity

1 Introduction

Due to the rapid development of on-line shopping for nearly two decades, the consumers' shopping behaviour has been fundamentally changed. When thinking of shopping, the first action most people would take is to browse the shopping item(s) online, browse the reviews, compare the prices, and often may even purchase the item(s) through the internet. Certainly, such online shopping behaviour is the direct consequence

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of the fast-spreading high-speed internet services; there are certain benefits to consumers by implementing such shopping behaviour. However, a huge negative impact has occurred on the retailer stores. According to The Fiscal Times (TFT) news, there is an incredibly rapid decline in American retail stores [1]. Some data illustrated that this situation has occurred since 2010 but is now getting faster [2, 3].

Following this trend, some valuable relationships during the traditional shopping process have already been lost, for instance, the traditional connection in product manufacturing has been pushed to the limit [4]. Losing the direct interaction with the real products and physical store atmosphere is the key factor which has significant influence on customer's behaviour, satisfaction and expenditures [5]. Furthermore, regarding the 2015 Time-Trade State of Retail Report, most consumers prefer to shop in stores rather than online or digital shopping because they like being able to actually touch and feel the products during shopping [6]. From the producers' perspective, thousands of manufacturers have to shift their strategies to answer such changes in customer thinking, shopping behaviour patterns, crowd feed & evaluations, and expectations in various sections.

Globally, there is also much effort to attract consumers back to the physical retailer stores. Even the online shopping giants are opening physical stores and have been implementing the latest technologies to enhance in-store shopping experience, such as Alibaba's supermarket stores in Beijing and Shanghai, and the Amazon's physical stores in New York, Washington and several US major cities.

In this paper, the authors have studied the factors which affect or potentially affect the customer shopping behaviour. These factors help in formulating design principles and in generating new concepts to achieve a richer shopping experience. Specifically, the main focus is on:

- User research on purchasing behaviour (use 'footwear purchasing behaviour' as a case study)
- Physical (touchable and wearable) components based recognition and communication system development
- Real-time spatial augmented realty
- Future development possibilities.

The paper proceeds as follows: Sect. 2 investigates the current market and consumer requirements. Section 3 presents the rationale of this design. Section 4 describes the technology and features of the design. Finally, Sect. 5 discusses the findings and also potential future development.

2 Research and Investigation

From a general viewpoint, a good design must engage consumers and create behaviour changes with a full understanding of users and their context [7]. Likewise, the way the user interacts with devices is strongly affected by the way the devices are designed [8]. Thus, it is crucial for designers to create and solidify the concept based on a deep understanding of shoe buyer behaviour patterns. In this study, the authors present design to support in-store footwear shopping behaviour as a case study. Compared with

online shopping, what is the motivation for consumers to come to retail stores? Which inherent characteristics of current physical retailers still benefit consumers, and which are expected to change?

2.1 Market Research

As the first step, a US market review was implemented with a focus on both market and user-related statistical data to obtain a clearer grasp of the trends of consumers' shopping behaviour and then to identify the gap between consumers' expectations and existing services in the conventional footwear stores. Looking at the US market, the growth of e-commerce is still outpacing the overall growth of retail sales; retailers are continuing to close brick-and-mortar outlets. While total US retail sales grew 3.7% in the fourth quarter of 2014 compared with the same quarter in 2013, e-commerce sales jumped 14.6% in the fourth quarter. One year earlier, total sales grew 3.8% year-over-year, while e-commerce sales increased 16.0%. In fact, all kinds of traditional stores are urgently facing the need to adapt to new technology, including the Internet of Things [9]. However, according to the Omni Channel Shopping Preferences Study, most people are willing to combine online shopping and physical store together to complete their purchase. Also, interestingly, the 2015 Time Trade State of Retail Report found that eighty-five percent of customers say they prefer to shop in physical stores [6]. Furthermore, most of them suggested that they would even prefer to shop at an Amazon store over Amazon.com if possible [6]. Essentially, people shift their shopping method but physical stores still play an irreplaceable role in our life. Meanwhile, customers have higher expectations for the in-store shopping environment than ever before [10]. The Internet enables e-retailers to better understand each customer's needs, which facilitates provision of specially tailored offers and preference promotions [3]. If the retailers cannot entice customers in their stores and keep them interested, they will choose to stay home and shop online [1].

2.2 Consumer Survey Findings

Secondly, a survey study on the shoe purchasing behaviour was implemented. A total of 62 subjects participated, including 30 males and 32 females. Of these, 56 respondents are from age 18–27, four from 28–37, two from 38–54. The key findings are:

(A) 54.8% (34) of the respondents were willing to pay $100–$199 for purchasing a pair of customized shoes. Interestingly, a group with four people (with three females and one male) expected to spend less than $49; in contrast three people (all males) were willing to spend more than $250.

(B) When a customer intends to purchase a pair of shoes, 85.5% of the total participants (53 subjects) suggested that they prefer to use a physical retail store to be able to physically hold and check the real shoe products, and 13 of these subjects suggested that they need further assistance to purchase shoes even using the physical stores. Only 9 subjects suggested that they are happy with online-shopping environment mainly due to time-consumption reasons.

(C) Regarding the most important factors affecting their decision-making for shoe purchasing, 69.3% of the respondents (43 subjects) considered *Comfort*; which compared to 38.9% (21 subjects) selected *Brand*, 30.6% (19 subjects) chose *Price*; and 25.8% (16 subjects) chose *Colour Scheme and Shape* respectively.

Other findings were based on a series questions related to *Customization (pre-designed order)*. The authors found out that 56.5% (35 subjects) of the total respondents were willing to complete their shoe design through an online website or smart device and then be able to try them on in the physical store; 25.8% (16 subjects) prefer to design their shoes in an in-store environment with assistance from the shop staff, and only 19.4% (12 subjects) were willing to complete their design with the online shopping tools only. Interestingly, 45.2% (28 subjects) of the respondents were willing to pay a part of the price as a deposit before they get the actual product and 38.7% (24 subjects) were willing to pay the full payment before they get the actual product. Only 9.7% (6 subjects) consider the question of 'if I cannot get the actual shoes at the first time in the store why should I have to come into the physical store?' as a serious issue.

Considering the time consumption in the design and production process of a customized order, the survey found that 85.5% (53 subjects) of the respondents were more than satisfied if the time span could be limited to less than a week from ordering to receiving the actual products. Further details are shown in Table 1.

Table 1. Satisfaction for delivery time after your design

	Disappointed	Normal	Satisfied	Very satisfied
Less than a week	0	7	19	**34**
One to two weeks	5	14	**25**	13
Two to three weeks	**19**	17	17	3
Three to four weeks	24	**25**	9	1
Four to five weeks	**38**	18	1	0
Five to six weeks	**56**	5	1	0

Furthermore, respondents were mostly interested in modifying and redesigning 'sneakers', which occupied 67.8% (42 subjects) of the respondents, including 25 male subjects. The secondary type was 'boots' with a percentage of 38.7% (24 subjects), including 14 female subjects in this group. It is worth noting that over 60% of the respondents were interested in adding personalized patterns and viewing it both digitally and physically.

Through this survey study, it has become clear that:

1. Tangibility drives customers to visit a physical retailer store, as they want to try on the actual footwear;
2. Customization answers customers' passion to create their own shoes, responds to their unique expectations. Even in the situation they cannot take their customized request away immediately, they still prefer to view it both digitally and physically;
3. Waiting period is an inevitable issue for delivery, but, in general, customers prefer to receive the ordered goods as soon as possible, preferably 'now';

4. Information exchange, especially for the youth generation, smart device access has been considered as one of the most crucial items in their daily activities. Using smart devices as a linkage to connect people with products might be an attractive approach to engage people in the customization process.

The shopping experience typically aims to maximize either efficiency or entertainment according to retail management theory [11]. The online market maximizes the advantage of convenience that motivates consumers to shop online through the internet [12]. People collect information and compare goods in a much faster way compared with the current way of in-store shopping. Thus, based the above investigations, we could see that the physical stores have not been improved in an adequate manner to satisfy the changes of customers' expectations.

3 Design Rationale

Based on our market research and user studies, it is clear that in-store retailers have a significant potential to maximize benefit by enhancing the physical environment and customizing services. With this design concept, it is possible to enhance in-store shopping experience with higher product browsing efficiency, richer interactivity and visualization. The target product is shoe manufacture, the target end-users are young people from sixteen to thirty-years old who intend to purchase a pair of shoes. The features of interactive renderer developing based on consumer research allows customer to participate in a design process, to preview shoes in real-time mode. Choosing real shoes as rendering object meets the needs that were identified from the user research. Use tangible physical manipulation tool as rendering controlling input device rather than merely virtual digital buttons on screen is aiming to increase the usability and able to customer to preview materials physically [13, 14].

3.1 Design of Tangible Components

Generally, the design contains two main parts. One is wearable pure white shoes. The customer is able to touch and put them on as with normal shoes. Before rendering, they are able to put them on and check the conformability. The second part consists of tangible controllers. To recognize the rendering effects that will apply to the shoe, all controllers' materials are made with real materials, the same as the shoes (Fig. 1).

Fig. 1. Tangible controllers

Moreover, using tangible controllers as an input method rather than a multi-touch screen not only avoids misunderstanding of interface design but also provides the possibility for several people to play with it and exchange their markers to share their design template. To communicate with the physical components recognition system, all tangible components including shoes and controllers are attached with a unique fiducial marker at the bottom which are used for physical components recognition.

3.2 Physical Components Recognition

Physical components recognition is a key feature leading innovation to close the gap. Once customers put controllers on a table, the markers will be detected by the camera underneath. Every fiducial stands for a different instruction used for sending messages to physical components recognition system. The markers were designed as two main types (Fig. 2). One is for shoe models. Another is for controllers, which stand for different types of shoe deign template. Theoretically, only two kinds of markers put on the table together will enable shoe objects will be rendered. In addition, all controller's fiducial design is also working for smart device MYSHOE App. Users can use an iPad, tablet or smart phone through the application to discover possible shoe designs, modify them and preview them digitally.

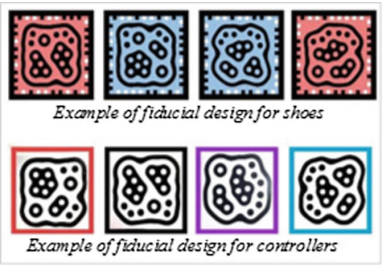

Fig. 2. Example of fiducial designs

3.3 3D Projection Mapping

Also known as video mapping or Spatial Augmented Reality (SAR) [15] the projection mapping technique is used for adding a variety of layers to a physical object in order to augment the object with digital content [16]. In this case, 3D projection mapping effects applied to the shoes model (Fig. 3) and it can be modified by replacing tangible controllers. To maximize the physical feature, 3D projection mapping techniques are the optimal choice for this project. First, it retains a touchable physical product, which is essential to physical shopping. Compared with augmented reality (AR) and virtual reality (VR), SAR allows the customer to put on the actual product and touch real materials and goods rather than in a virtual world play with a well-designed digital image. Second, it offers a chance for the customer to participate in design process, to create personalized products and to render them in real-time mode. It also saves plenty of inventory space, thus reducing the operating cost. However, it does have a

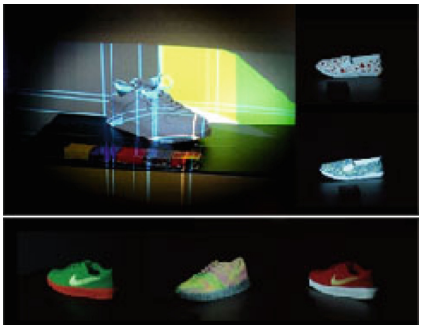

Fig. 3. 3D projection mapping calibration

drawback, which is lighting interference. According to the final prototype user testing, this technique pretty much relies on the environment. If strong light surrounds it, it will seriously affect the rendering results. To ensure getting an optimized rendering in a public place, it is necessary to create a light-block space for demonstration.

3.4 Intangible Components

The design also includes a smart device application, which allows the customer to discover shoe information in or out of a store through an App called MYSHOE. Essentially, it includes two modes, the in-store and the online modes. System structure is shown in Fig. 4.

The in-store mode allows customers to preview and modify the 3D rendering effect virtually through the smart device. Once the customer is satisfied with their selected favourite colour, pattern and shoe model, it will show all the details about purchasing,

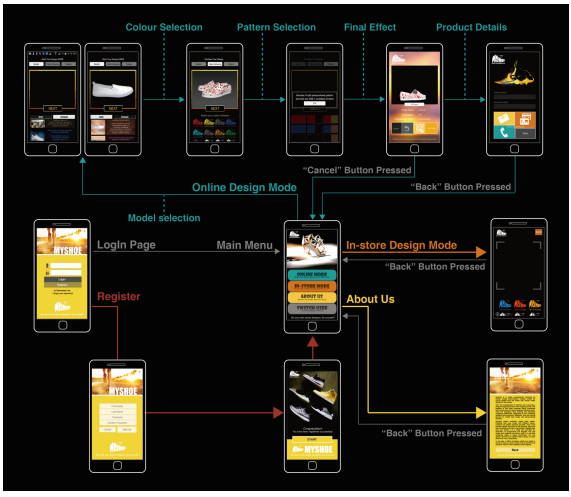

Fig. 4. MYSHOE application user flow

such as introduction, recommendation, price and payment option etc. Most importantly, the purchaser can find the marker ID that stands for corresponding controllers and shoe. Then users are able to real-timely observe their design through interactive rendered results (Fig. 5).

Fig. 5. Online mode discovery

The online mode provides an interface as the crucial part that brings together the online retailer and consumers [3] and also a chance to encourage them back to the store to physically make their shoes. Through that mode, the customer is able to browse and select shoes, then modify the colour, add patterns, and finally preview it digitally with 2D and 3D rendering effect, and make the payment as with e-retailers.

4 Technology

The latest prototype contains an interactive rendering table and a smart device application. The interactive rendering table (Fig. 6) is based on Adobe Flash, enabling it to receive a UDP message from the detecting software (reacTIVision), then send a

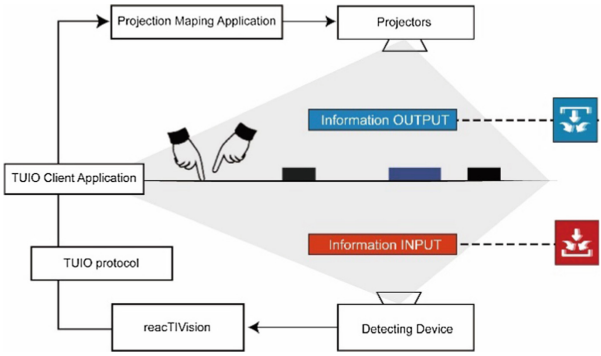

Fig. 6. Overall system structure

message to projection mapping software (TouchDesigner). Finally, it can present the designed shoe model through projected images which are overlapped on a blank (white) shoe model. The App named MYSHOE is based on Unity3D and Vuforia SDK, and uses the physical recognition system to find the corresponding digital images or models, then show the 2D and 3D digital effect to the users.

5 Discussion and Potential Development

With the global popularity of online shopping proceeding at an incredible speed, many business institutions and services have noticed the significant impact of online-retail sales by adjusting their business processes [4]. The traditional physical retailer business model may be replaced by a hybrid one due to the trend of integration of internet and physical store shopping. Through enhancing the tangible interactivity between customers and products, retailers could have the ability to provide consumers with a more enjoyable in-store shopping experience.

In this study, a 3D projection-mapping technique has been implemented to provide an alternative in-store shopping solution which enables multiple users to participate. A higher level of service customization leads to higher customer satisfaction [17], and the aims of customization are to satisfy as many needs as possible for each individual customer [18]. Thus, this tangible SAR-enabled product display and ordering system was designed for the customer to further explore the features of the products and intuitively customize their orders.

One of the most direct benefit of this technology is that users can experience an Augmented Reality product presentation, which can be more readily shared compared with a Head-Mounted VR technology [19]. For instance, people's position can be more flexible, and users can view the displayed products from various angles simultaneously. In responding to a 360° display need, multiple projectors also could work together (with additional projection edge-blending technologies) to achieve an omnidirectional vision. Furthermore, seeking peer opinions and having discussions are common behaviour needs during purchasing shoes, which requires the installation with multi-user participation capacity. Responding to this need, the authors have integrated the functions of *feelings sharing*, *opinions of similar idea* and *specific design requirements* before place orders.

Regarding the prototype user testing, the authors have found the following three main drawbacks.

Firstly, tangible components design must follow the design principle of 'less is more' to keep it simple and support intuitive operations. However, using 'tangible controllers' as the only input method could make the users feel that it 'lacks interactivity'. Users nowadays expect much richer interactive experience to enhance their explorations and customization (design) possibilities.

Secondly, the visual feedbacks (rendered AR effects) which based on SAR technology is sensitive to the environmental lighting. Any kind of strong light source will have a significant impact on the rendering effect.

Finally, the software selected (Adobe Flash in this study) as a tool receiving and sending messages was not a stable solution, which has randomly caused entire system crashes. It's necessary to explore a better alternative solution to process the input data.

A video demo is available at YouTube; the link is shown below.

- Interactive Renderer 1.0: https://www.youtube.com/watch?v=T9dcOa08Jfk
- Interactive Renderer 2.0: https://www.youtube.com/watch?v=oFt1dc5SkI4&t=49s.

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