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Human-Computer Interaction (SIGHCI)

Aug 10th, 12:00 AM

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Emergent Research Forum (ERF)

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Abstract

The advancement in immersive technologies provides online retailers the opportunity to integrate augmented reality (AR) experience for their customers. Using AR, the online product presentation is transformed from the pictorial representation to virtual interaction with the products. The virtual product interaction facilitates online retailers to detect product-related emotion through affective computing. For mobile AR, customers use touch gestures for virtual interaction. Using the theories related to immersive media and affective computing, we hypothesize that the touch movements and touch pressure in AR-based mobile applications are related to positive emotion during product interaction. Moreover, we describe a methodology to establish our hypotheses and to show that these variables can predict the produ ct-related emotion. We expect our research findings to have both theoretical and practical implications. It will explain why touch behavior can predict product-related emotion, and it will also demonstrate online retailers how to implement emotion analytics in AR shopping applications.

Keywords

Predictive analytics, augmented reality, human-computer interaction, emotion analytics, m-commerce.

Introduction

Augmented Reality (AR) technology superimposes the immediate physical environment with virtual features and augments the sense of sight. The AR-enabled product presentation in online stores augments the visual imagery of a product through the superimposition of a 3-dimensional (3D) virtual prototype with the physical surroundings. The technology also allows interactivity with respect to the prototype as well as the immediate physical environment. This leads to immersion in the virtual product experience, and consumers tend to develop a hedonic sensation that incites favorable feelings toward the product (Verhagen et al. 2014). For mobile applications, the AR view of products is facilitated through a mobile camera. The interaction with virtual products can be achieved through touch gestures on the mobile screen. Therefore, the touch interaction is the mechanism to learn affective feedback during virtual product experience in mobile applications. Researchers have investigated the eye movements or gaze behavior to predict consumer interest and consumer emotion in products (Sari et al. 2018). Similarly, the touch movements also predict the emotion elicited during smartphone activities (Mottelson and Hornbæk 2016). Over the years, the need to integrate predictive analytics into information systems research has grown (Shmueli and Koppius 2011). In this context, our research question is as follows:

RQ: Can touch behavior in AR shopping applications predict the product-related emotion?

In studying this question, we contribute to the literature in human-computer interaction (HCI). In particular, we hypothesize the relationship of various touch gestures (including pan, pinch, rotate, and touch pressure) with the positive emotion elicited during virtual product experience. We aim to provide empirical evidence that the touch gestures related to AR activities can predict the level of positive emotion evoked during the experience. Therefore, our study contributes to the research and practice in affective computing (i.e., computing that can interpret, simulate, and process human affects) in ecommerce. It informs the practitioners about the unobtrusive mechanism to detect the product-related emotion during an immersive experience in ecommerce. Moreover, we provide a methodology to understand users' emotion in real time, which enables online stores to devise personalized marketing during shopping activity. Our study gives directions to the future research to analyze the potential of other touch behaviors with respect to different contexts (such as mobile gaming, touch-typing, and so on) to understand the emotive aspects of user experience (UX) design.

Theoretical Foundation

Human Emotion in an Immersive Environment

With the rise of emerging technologies such as multi-media product visualization, virtual worlds, and AR, the concept of a blended space has originated where the digital objects commingle with real objects to create a sense of presence in the mediated environment (Benyon 2012). The blended space is the conceptual space of understanding and making meaning that closely imitates the physical space through technological capabilities. Hence, it creates feelings of immersion in the mediated environment and the illusion of non-mediation, which is called telepresence (Suh and Chang 2006). Telepresence is considered to be a component of flow, which "is an optimal state of experience in which one is completely absorbed and engaged in an activity that nothing else seems to matter" (Nah et al. 2011, p. 734). Due to the influence of flow experience, the sensory inputs and outputs in the mediated environment stimulate human emotions. Since AR offers a higher level of sensory inputs and outputs (such as user control on the 3D products, movements of virtual objects in the real space, haptic feedback, etc.), it exerts greater telepresence and creates increased opportunity for the embodiment of emotions in human actions.

Human emotions are defined as:

"a mental state of readiness that arises from cognitive appraisals of events or thoughts; has a phenomenological tone; is accompanied by physiological processes; is often expressed physically (e.g., in gestures, posture, facial features); and may result in specific actions to affirm or cope with the emotion, depending on its nature and meaning for the person having it" (Bagozzi et al. 1999, p. 184)

The circumplex model of affect has classified emotions along two dimensions – valence and arousal (Russell 1980). The scale of valence ranges from extreme displeasure to extreme pleasure, whereas the scale of arousal ranges from sleep to excitement. Sometimes, another dimension called dominance is also used to measure emotion. Dominance describes the degree of control exerted by a stimulus and ranges from controlled and submissive state to controlling and dominant state (Mehrabian 1980). In this study, we focus on the valence dimension of emotion because it is the prominent emotional dimension related to online shopping tasks (Hibbeln et al. 2017; Tuch et al. 2012). Telepresence in online stores accentuates the human behavior under the influence of valence. Our research attempts to understand such behavior to detect the emotional state of the consumer during product interaction.

Affective Computing through Touch Behavior

In normal human cognition, thinking and feelings are inextricably related. To explain this, Cytowic (1996) argues:

"All sensory inputs, external and visceral, must pass through the emotional limbic brain before being redistributed to the cortex for analysis, after which they return to the limbic system for a determination of whether the highly-transformed, multi-sensory input is salient" (Cytowic 1996, p. 104)

The limbic system is the center for attention and emotion. It plays an integral role in sensory perception. Increased activity in the limbic system leads to external and involuntary sensations like cross-wiring of the senses (Picard 1997). For example, certain music may elicit certain colors in your mind. This phenomenon is called synesthesia. The synesthetic experience leads to various expressive behaviors specific to emotional states, called "sentic" states. The link between the "sentic" states and the expression in the motor system has been explained as:

"The sentic state may be expressed by a variety of motor modes: gestures, tone of voice, facial expression, a dance step, musical phrase, etc. In each mode, the emotional character is expressed by specific, subtle

modulation of the motor action involved which corresponds precisely to the demands of the sentic state" (Clynes 1977, p. 18)

This theory of emotional expression in the motor system (popularly known as sentic modulation) contributes extensively to the field of affective computing. With the help of the theory of sentic modulation, previous studies have established a mapping between the facial expressions or voice features and the emotion space (Picard 1997). Other than face and voice, another form of motor outputs, which is significantly influenced by the emotional states, is the touch behavior in humans (Clynes 1977). In this study, we use the theory of sentic modulation through touch behavior. We hypothesize relationships between touch interaction with AR-enabled products in online stores and product-evoked emotions.

Hypotheses Development

The AR activity in ecommerce mobile applications involves various touch movements such as pan, pinch, and rotate. The pan movement requires one finger to move a digital object in any directions relative to the physical environment viewed through the camera. Therefore, it resembles the user interaction with the physical surroundings. On the other hand, pinch and rotate movements require two fingers to zoom in/out and rotate the digital object, respectively. These movements more generally resemble user interaction with the virtual object. In an AR environment, these touch activities signify consumer involvement in online product evaluation.

We argue that the increase in the frequency of different types of touch movements indicates positive product-related emotion. The active and alert state of mind with an approach behavior towards the product characterizes a condition of positive emotion (Frijda et al. 1989). Therefore, an increase in consumer interaction during flow experience in the AR environment signifies positive emotion towards the online product. If the sensory impressions created by the product is pleasurable, the chances are that the user gets attached and engrossed with the product interaction (Fenko et al. 2010). In that case, an increased number of AR interaction through touch activities with the product can infer positive emotion. Thus, we propose our first hypothesis:

H1: The increase in the number of the pan, pinch, and rotate movements in AR-based mobile applications indicates positive emotion during online product interaction.

In the field of affective science, researchers have found that the duration of tactile behavior facilitates accurate discrimination between emotions (Gao et al. 2012). An increase in the duration of tactile behavior indicates positive emotion elicited during virtual product experience. This is because the intense concentration and a transformation of time in the flow experience implies the condition of positive emotion (Agarwal and Karahanna 2000). The individuals tend to spend ample time to touch and visually inspect the products. Since the pinch movement is the tactile behavior related to the close display and meticulous inspection of the virtual object, the degree of involvement and hence the duration for this touch activity can infer positive emotion. Thus, we hypothesize:

H2: The increase in the average duration for pinch movements in AR-based mobile applications indicates positive emotion during online product interaction.

In the study of sentic expression, it has been found that the transient pressure of the finger carries a dynamic form of emotional message which can distinguish states such as no emotion, grief, hate, love, joy, and reverence (Picard 1997). Researchers have found that the data from the pressure sensors in the touch panel of mobile devices can be used for recognition of emotional states during certain mobile activity (Politou et al. 2017). In particular, for touch-based game interaction, consumer engagement or the state of excitement is reflected through greater touch pressure (Miller and Mandryk 2016). Similarly, Gao et al. (2012) have studied that the best results for valence classification can be obtained through the touch pressure. Therefore, we propose the following hypothesis:

H3: The increase in the average finger pressure for all the touch movements in AR-based mobile applications indicates positive emotion during online product interaction.

Methodology

We plan to conduct a laboratory experiment to understand the efficacy of the touch behavior in AR-based shopping application to infer the level of product-related emotion. We intend to recruit around 80 participants from a university. The participants need not have any experience with AR shopping since they will be trained with the use of AR interfaces before the experiment. However, participants' experience with mobile shopping is strongly desired. A mobile application is developed to closely resemble the IKEA shopping application (with AR features), and similar types of products (i.e., furniture products) will be used in our experiment (Rauschnabel et al. 2019). Participants will be allowed to visually inspect different products (of the same category) in the AR environment while completing the task of product evaluation intended for online purchase. While the user interacts with the virtual products in the AR environment, the application will create a log file stored in an online database. The log file will record the touch movements (such as pan, pinch, and rotate) and the touch pressure corresponding to the touch interaction with each of the online products. We control the experiment in such a way that it does not capture the entire variety of reasons that could have caused specific touch movements of the participants other than generation of positive emotion during product evaluation. After the evaluation of a product, we immediately assess the emotional valence of the participant using the Self-Assessment Manikin (SAM) scale as our dependent variable (Bradley and Lang 1994). SAM valence scale is a nine-point pictorial scale of emotion consisting of facial expressions (expressed by drawing manikins) illustrating the range of emotions from unpleasant to neutral to pleasant. Previous studies have used SAM valence scale to measure a person's emotion during a task related to online product purchase (Hibbeln et al. 2017; Tuch et al. 2012). Finally, the relationship between touch interaction data and the level of self-reported emotion is investigated.

Expected Findings and Expected Contributions

The touch interaction data in our experiment is expected to resemble repeated measures data (also called panel data). For panel data regression, either fixed effects or random effects model is generally used because they account for individual (unobserved) heterogeneity. The random effects model is a suitable choice over a fixed-effects model for panel data regression when the unobserved differences across individuals are random. In such cases, it gives more consistent and efficient estimates (Wooldridge 2010). Therefore, with the assumption that the unobserved differences across individuals are random, we specify a linear random-effects regression model to estimate the relationship between the touch movements/ touch pressure and the positive emotion using the SAM score. The model is:

$$emotions_{it} = \alpha_i + \sum_{k=\{pan,\ pinch,\ rotate\}} (\beta_k\ count_{k,it} + \gamma_k\ avg\ time\ elapsed_{k,\ it}) \\ + \delta_1\ touch\ pressure_{it} + \zeta\ control\ variables_i + \lambda_t + \varepsilon_{it}$$

where i indexes the individuals, t the product number, and λ_t is the product-specific effects. In this specification, α_i is assumed to be independently and identically distributed with expectation α and standard deviation σ_α. Here, $count_{k,\ it}$ represents the number of the pan, pinch, and rotate movements for each individual i corresponding to interaction with product t. Similarly, $avg\ time\ elapsed_{k,\ it}$ represents the average time taken for each of these movements. We consider $avg\ time\ elapsed_{pan,\ it}$ and $avg\ time\ elapsed_{rotate,\ it}$ as additional variables (apart from the variables in our hypotheses) to make our model comprehensive.

We expect to find that the number of touch movements (such as pan, pinch, and rotate), the average time taken for pinch movement, and the touch pressure has positive relationships with the level of emotion. We intend to illustrate that these variables related to touch gestures during human-computer interaction in AR applications can predict product-related emotion. These findings have implications in several research areas, including affective computing, human-computer interaction, emotion analytics using touch behavior, emotion detection through AR interaction, and intelligent system design for personalized marketing. In terms of theoretical implications, this study contributes to the understanding of sentic modulation by showing evidence that the motor forms of expression carry the emotional message from the nervous system. For our experiment, the touch expressions contain behavioral information idiosyncratic to the emotional states (or "sentic" states) of an individual. Therefore, touch behavior on smartphones can distinguish the users' emotion during a particular task. Our research informs the practitioners about how touch gestures during mobile activity can sense the human affect. It helps the practitioners to conceptualize emotional-aware smartphones by exploiting the motor movements on the touch panel of the mobile.

Acknowledgements

This paper is fully supported by CityU Strategic Research Grant (Project Number: 7005379) and CityU Digital Innovation Laboratory.

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