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COMPARISON OF USER EXPERIENCES BASED ON WATCHING 360° IMMERSIVE VIDEO AND REALITY – A CASE STUDY OF A SCOOTER RIDE

ABSTRACT

This paper compares the user experiences (UXs) while riding a scooter on the road to watching a 360° immersive scooter ride video in a laboratory using a Head-mounted Display (HMD) projection system. The aim of this study is to determine whether watching through an HMD projection system produces similar feelings of attractiveness, practicality, and enjoyment for the riding experience as riding on a real scooter. The data were collected from an experiment involving a total of 59 individual scooter commuters. The participants were asked to watch a 360° immersive video and to complete a user experience questionnaire (UEQ). The results verified that a virtual reality (VR) service with an HMD and panoramic scooter riding video content may be used as an experience tool to create reality-like scooter riding experiences for the users. Furthermore, the important factors that influence a user's continued usage of watching 360° immersive video services were found to be attractiveness and pragmatic quality. Based on these results, a number of suggestions are proposed for the design of related VR services to strengthen the advantages of 360° immersive video in simulated two-wheeler ride experiences and providing road safety education.

KEY WORDS

riding experience; traffic experience; immersive environment; 360-degree panoramic videos;

1. INTRODUCTION

The elevated fine particulate matter (PM2.5) concentration is an important environmental issue in Taiwan. Two-stroke scooters, cars, and trucks, particularly diesel vehicles, are the main vehicular pollution sources that emit more than 17,000 tons of PM2.5. The PM2.5 value was estimated from the 2013 Taiwan Emission Inventory Data System, version 9.0 [1]. In Taiwan, there are approximately 13,764,229 two-stroke scooters. To improve the air quality and public health, one of the aims of an eco-friendly environmental protection policy announced by the Taiwanese government is to replace scooters with electric two-wheelers (E2Ws) in the Taiwanese two-wheeler market. However, E2Ws are still not widely adopted in the Taiwanese market. Taiwanese E2W sales figures showed that 63,274 electric scooters (e-scooters), 152,535 electric bikes (e-bikes), and 80,504 electric-assist bikes were sold between 2009 and 2016. The related E2W promoting programs introduced by the Taiwanese government has verified that providing E2W trial ride services, has a positive impact on the user's acceptance level of the E2W product [2-4]. There is strong evidence that shows that purchases based on experience provide more satisfaction, [5, 6] because experiences are considered to be aligned with self-identity [7]. Experiential benefits generally correspond to product-related attributes, and the experience of using the product or service, and satisfying the needs such as sensory pleasure, variety, and cognitive stimulation [8]. This underlines the importance of hedonic advantages. Therefore, E2Ws industries are becoming increasingly interested in applying experiential marketing, to positively stimulate people's willingness to accommodate E2Ws. Thus, an experience system using virtual reality (VR) devices and applying 360-degree panoramic formats for the experiential service of vehicle is proposed. Since Taiwan has the highest density of scooter users, this study set up a scooter riding VR system. In this initial experimental study, the research goal is to analyse the effectiveness of using HMD VR devices and applying 360° panoramic formats in eliciting positive user experiences (UXs) and to compare these to UXs evoked in physical scooter ride settings. To address the lack of empirical evidence, the user experience questionnaire (UEQ) was adopted, which is designed to help a researcher understand the overall impression of a user when they interact with a product, i.e. cover both pragmatic and hedonic quality aspects [9]. This questionnaire is designed to allow a fast and immediate measurement of the UXs of interactive products. It measures not only the usability aspects, but also the user experience aspects [9]. We investigated paths through which VR and 360° panoramic video technologies impacted the users' UXs and usage intentions. The 360° immersive video service presented actual situations of riding scooters on the road, which made it possible to make valid comparisons. The responses from the participants were collected to understand the user's UXs, both in using 360° immersive video service and riding a scooter on the road.

2. LITERATURE REVIEW

Virtual reality technology

Virtual reality (VR) has been defined as the "use of interactive simulations created with computer hardware and software to present users with opportunities to engage in environments that appear and feel similar to real-world objects and events" [10]. Computer hardware and software and its peripheral devices, that are used to create a VR system, are designed to replicate the information available to the sensory/perceptual system in the physical world and to produce outputs that impinge upon the body various senses, resulting in convincing illusions for each of these senses and thus a rich, interactive multimedia facsimile of real-life [11]. Therefore, the key to defining VR in terms of human experience is through the concept of presence. The goal of designers and users of VR environments is to create a computer-generated simulation that is indistinguishable to the user from its real-world equivalent. Reaching toward this goal has already enabled us to realize some of the VR's potential uses in training, engineering, scientific research, and for providing uniquely gratifying entertainment experiences [12, 13]. VR is a set of tools and techniques that supports seamless human-contents-environment interaction and provides a simulated means of creating a sensory and psychological experience for users as an alternative to reality. The contents are realistic multimedia contents that are used to stimulate the five senses of a human being, namely the basic orientation system (which is responsible for maintaining body equilibrium), the auditory system, the haptic (touch) system, the taste–smell system, and the visual system [14].

Experiences created by the VR system, are expected to provide sensory, emotional, cognitive, and behavioural values that replace functional values. Related simulations have been verified to evoke user responses, similar to those in physical environments [15]. The most deeply compelling VR experiences are associated with high levels of immersion. Immersion, defined as "a psychological state characterized by perceiving oneself to be enveloped by, included in, and interacting with" a virtual environment (VE). "The term immersion is used to refer interchangeably to either physical inputs or psychological presence." Presence is defined as the sense of being in an environment; this points to the psychological sensation of being in a virtual place [16]. Presence is also sometimes used to describe the mediated experience of a physical environment [17]. Immersion refers to the extent to which high fidelity physical inputs (e.g. light patterns, sound waves) are provided to the different sensory modalities (vision, audition, and touch) to create strong illusions of reality in each. The most compelling VR environments are implementations that literally envelop the user in a virtual world, surrounding the user with stereoscopic visual imagery and sound, tracking body motion, and responding to behaviours in the environment. The user experiences the sensation of having entered a computer-generated landscape that surrounds them in all directions.

Two major types of VR content are realistic images or videos, in 360-degree and three-dimensional (3D) digital representations. In the past, the format most used was 3D. The 3D format is created digitally through computer vision software, the navigation is continuous, and it must be connected to a computer. "The 3D scene specification is divided into three parts: geometrical, behavioural, and aural" [18]. The 360-degree panoramic format is gaining popularity due to smartphones such as the Samsung Gear. The panoramic format, which is cheaper than 3D format, is based on videos of real situations and navigation is limited to a 360° view of each photogram [19]. Panoramic videos are a new and rapidly growing approach that can display the power of sight, sound, and motion in an entirely new way, and allows viewers to sense action from all angles and directions. Videos can provide highly realistic imagery, they are convenient to watch and share, and are comparatively easy to produce, due to the advancement of low-cost camera equipment. In addition, VR systems can be classified as fully immersive, semi-immersive, or non-immersive [20]. VR devices for fully immersive human-machine interfaces require a Head-mounted Display (HMD), which is a device that brings a computer-simulated content in front of your eyes, imitating presence in real environments. The most popular headsets so far are Google Cardboard, HTC VIVE, Oculus Rift, Sony PlayStation VR, and Samsung Gear. Another type of headsets are mobile VR headsets that connect to smartphones, such as the Samsung Gear VR. The headset serves two purposes: tracking user pose (including both 3D position and 3D orientation) and presenting the VR content to the headset display for user viewing. Such VR headset systems have to meet three critical performance criteria, i.e. responsiveness, high-quality visual effects, and mobility [21]. Any performance degradation can result in user discomfort or motion sickness owing to the near-eye display characteristics of VR systems [22]. The headset via a cable limits the mobility of the users. Thus, the VR experience creates a safety hazard as the user may trip and fall. Therefore, high-quality immersive VR on mobile devices is the currently developed technology. VR devices for semi-immersive experiences, use large projection screen or ultra-high-resolution screen, such as powerwalls and CAVE. Interfaces for the non-immersive experiences use desktop-based or mobile-based VR. Vividness and interactivity are two major dimensions associated with VR technology in creating an environment that appears and feels similar to the real-world; vividness refers to the ability of a technology to produce a sensorially rich mediated environment, while interactivity refers to the degree to which users of a medium can influence the form or content of the mediated environment. Two factors that contribute to vividness are sensory breadth, which refers to the number of sensory dimensions simultaneously presented, and sensory depth, which refers to the resolution within each of these perceptual channels. It is important to accurately portray a sense of depth across parts of a visual field, while immersive visual displays, such as stereoscopic head-mounted displays, create a sense of presence by presenting a visual environment that moves with the viewer. Three factors that contribute to interaction are speed, which refers to the rate at which input can be assimilated into the mediated environment, range, which refers to the number of possibilities for action at any given time, and mapping, which refers to the ability of a system to map its controls to changes in the mediated environment in a natural and predictable manner [17].

Nowadays, VR technologies have reached the level of maturity needed to make use of them in diverse areas of real-life applications. As VR technology becomes more accessible and affordable, VR is also likely to become widely used in various industrial exhibition settings. Hence, an on-site VR facility is being considered to be introduced, to provide a more convenient E2W trial ride experience and safe riding education services. The trial ride service is used to positively stimulate the willingness of trial riders to accommodate E2Ws. In addition, the riding education service is used to establish the user's road safety. In real world, road traffic injuries claim more than 1.2 million lives each year and have a huge impact on health and development [23]. Considering Taiwanese e-bikes as an example, the e-bikes are designed such that the speed limit is less than 25 km/h. However, the number of traffic crashes continues to increase every year. The annual sales figures of e-bikes from 2013 to 2016 are shown in *Figure 1*. As the Taiwanese government provided consumers with e-bike subsidies before 2016, the sales figures of e-bikes are only counted from 2009 to 2016. In addition, the annual number of accidents related to e-bikes from 2013 to 2018 is shown in *Figure 2*. The critical factors that cause traffic injuries include inattention, distraction, blind spots, traffic violations, and the modification of e-bikes by some owners to increase the speed. This made the Taiwanese government more attentive toward safe riding education and to further develop e-bike driving license specifications. This emphasizes the importance of having the appropriate riders' road safety information while promoting E2Ws.

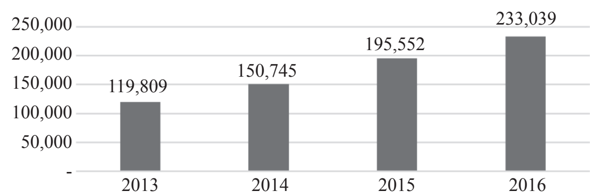

Figure 1 – Annual sales figures of e-bikes

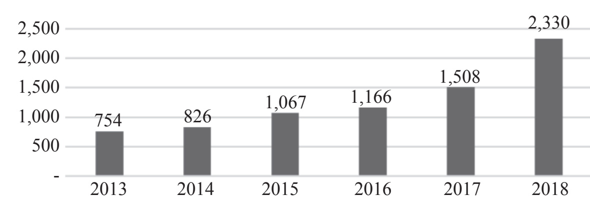

Figure 2 – Annual number of recorded e-bike accidents

User experiences

The E2W trial ride service or safe riding education service may be turning into an E2W VR service as an alternative way of delivering real environments. Applying VR technology to the experience of an E2W ride, is one of several innovative experience services. The E2W VR service is designed for riding experience and safe riding education purposes. VR provides a simulated means of creating a sensory and psychological experience for users as an alternative to reality; experiences are expected to provide sensory, emotional, cognitive, and behavioural values that replace functional values. Related simulations have been verified to evoke user responses, similar to those in physical environments [15]. In VR environments, objects provide the user with visual feedback, which may be presented through an HMD projection system, or flat screen. Feedback can also be provided through the hearing senses. However, user experiences (UXs) created by VR applications in virtual product experiences and the UXs through which VR elicits usage intentions has not been analysed and needs further investigation. UX encompasses "a person's perceptions and responses resulting from the use or anticipated use of a product, system or service [24]." UX is a subjective feeling. Furthermore, the experience of each user could depend on a variety of external factors. "Measurement is the first step that leads to control and eventually improvement. If you can't measure something, you can't understand it. If you can't understand it, you can't control it. If you can't control it, you can't improve it [25]." There are many related UX evaluation methods, e.g. usability testing, self-determination theory (SDT) [26], positive and negative affect schedule (PANAS) [27], OCC emotion model [28] Technology Acceptance Model (TAM) [29], Unified Acceptance and Use Technology Theory (UTAUT) [30], and UEQ [9]. Most of UX evaluation methods are based on questionnaires designed to collect quantitative data from an assessment done by the users of a product. This can be a useful addition to methods that allow a sophisticated assessment of the strengths and weaknesses of interactive products [31].

3. METHODOLOGY

Considering that scooters are a means of transportation in the Taiwan two-wheelers market, a scooter VR service is used in this initial study. The VR services are designed with an HMD and 360° panoramic video content for the experimental scenario of a scooter ride. The scenario uses two of the five senses to present a scooter ride, involving users observing the Yangde Avenue go by, hearing the roar of the scooter, and sounds of the Avenue.

Fifty-nine individual scooter commuters took part in the experiment and completed the surveys. There were 38 males and 21 females aged 18-62 years ($\bar{X}$=23.37; σ=7.16). Their mean riding experience was 4.12 years (σ=4.96). No participant experienced simulator sickness or had technical difficulties with the VR system.

In order to measure the user's riding experiences and viewing experiences via the VR system, each subject experienced the riding of their own scooter on the road, and watched a 360° video of riding a scooter on the road. The virtual environments were run on a personal computer (Intel Core i7-7700 3.6 GHz), with Microsoft Windows 10 Professional, a video card TURBO-GTX 1080 8 GB (Active Fan), and 16 GB of RAM. A VIVE VR system was used. Environments were visualized using an immersive HMD (1080×1200 pixels per eye, the refresh rate of 90 Hz, and field of view for 110 degrees) with head tracking.

For each participant, two paper-and-pencil questionnaires for user experience evaluations were used. One pre-experimental subjective rating was designed to explore the participants' riding experiences. It contained three sections - (1) personal information: three items designed to collect socio-demographic data on gender, age, and riding experiences; (2) UX: twenty-six items designed to measure attractiveness, pragmatic quality, and hedonic quality. The items were adopted from the UEQ to measure the subjective response to scooter usage, this was assessed by using a 7-point semantic differential scale. The UEQ allows a fast evaluation of the user experience of interactive products. For the English version of the UEQ, please refer to the paper by Rauschenberger et al. [7]; (3) satisfaction: one item was designed to collect quantitative data on what users perceived as self-satisfaction, in riding a scooter, this was assessed by using a 7-point Likert scale ranging from extremely agree to extremely disagree.

One post-experimental subjective rating was designed to explore participants' viewing experience; it contained two sections - (1) UX: twenty-six items were adopted from the UEQ to collect quantitative data, this was assessed by using a 7-point semantic differential scale; (2) satisfaction: four items were designed to collect quantitative data on whether the user perceived that using the VR system, to watch the scooter riding video achieved the purpose of having a realistic riding experience, had satisfaction with themselves, had improved related knowledge, and had an enhanced willingness to continue using VR in watching 360° panoramic videos; this was assessed by using a 7-point Likert scale ranging from extremely agree to extremely disagree.

At the beginning of the experiment, the participants were required to read and sign an IRB-approved consent form, which provided details regarding the experiment. They were allowed to opt out of the study at any time during their participation. Then, the participants were requested to complete the pre-experimental subjective rating to measure their riding experience. After completing the pre-experimental subjective rating, the participants were instructed regarding the use of the VR equipment. In the experiment, the participants experienced a scooter ride on the road at a speed of 40 km/h, which lasted for approximately 2 minutes. The overall experience of the participant is based on the VR using HMD of VR for transmission of panoramic video data. At the end of the experiment, the participants completed the post-experimental subject rating to measure their experiences from watching the scooter ride.

Analyses were conducted using SPSS software, Version 22.0. Variables were assessed by factor analysis, reliability analysis, Wilcoxon signed-rank test, T-test, and multiple regression analysis. The two-tailed significance level was set at $p<.05$.

4. RESULTS

Descriptive statistics

The items of the UEQ are scaled from -3 (the most negative answer) to +3 (the most positive answer). The means of each UEQ factor, for both riding a scooter and using the VR system are shown in *Figure 3*. It can be seen that the scale shows the mean of the attractiveness, perspicuity, efficiency, stimulation, and novelty factors for using the VR system, and the attractiveness, perspicuity, and efficiency factors for riding a scooter are near +2. A value near +2 represents a very positive response and it is a near-optimal impression. The scales mean of the dependability factor for using the VR and the dependability, stimulation, and novelty factors for riding a scooter are in the range from +1.2 to +1.6. These values represent a positive impression. The error bars represent the 5% confidence intervals for the scale means, i.e. the probability that the true value of the scale mean lies outside this interval is less than 5%.

With regard to satisfaction, the items are scaled from -3 (extremely disagree) to +3 (extremely agree). The data are shown in *Table 1*. Most of the agreement levels related to using VR in achieving riding experience purposes, self-satisfaction, and increases in the knowledge of a scooter product tended to be neutrally agreed. Most of the agreement levels related to the intention of continued use for both riding a scooter and using VR to watch scooter riding videos tended to be strongly agreed.

Factor analysis and reliability analysis

Please refer to *Table 2* for factor loadings and scale reliabilities. The internal consistency of the attractiveness, efficiency, perspicuity, and stimulation scores were high. However, the dependability and novelty scores had low internal consistency (Cronbach's α on the pooled values of riding a scooter: Dependability, α=.49; Novelty, α=.27. Cronbach's α on the pooled values of using VR: Dependability, α=.25; Novelty, α=.067). Therefore, these items were not included in the subsequent analyses. The sampling for riding a scooter (Kaiser-Meyer-Olkin

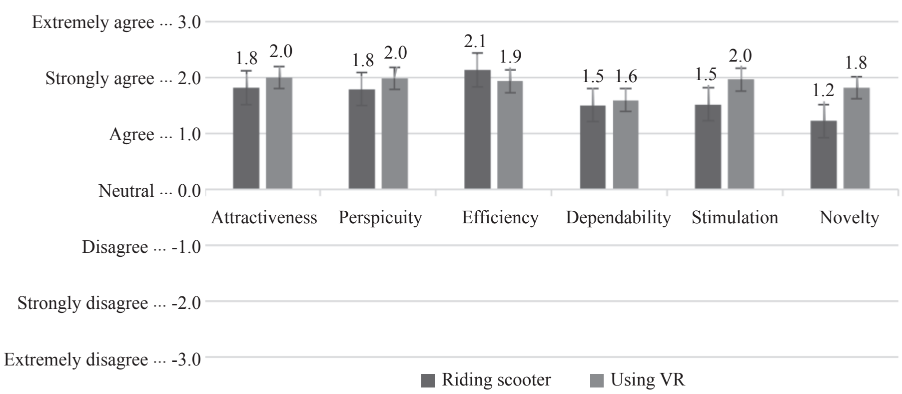

Figure 3 – Comparison of riding a scooter and watching a 360° immersive video concerning the UEQ scales

Table 1 – Mean and standard deviation for satisfaction

Construct	Item	$\bar{X}$	σ
Riding a scooter	Q1: I perceived high self-satisfaction when riding a scooter	0.71	1.13
	Q2: I am willing to continue riding a scooter	1.49	1.61
Using VR system	Q1: It can achieve the purpose of providing a riding experience	0.32	1.73
	Q2: I perceived high self-satisfaction when viewing scooter ride via VR system	0.29	1.31
	Q3: It can improve the related knowledge of the user	0.17	1.38
	Q4: I am willing to continue using VR for watching scooter riding videos	1.22	1.63

Table 2 – Factor loadings and reliabilities for UEQ measures

Construct	Item	Factor loading		Cronbach's α	
		Riding	Viewing	Riding	Viewing
Attractiveness	A1: annoying/enjoyable	0.654	0.692	0.79	0.62
	A2: good/bad	0.688	0.710		
	~~A3: unlikable/pleasing~~	~~0.556~~	0.673		
	A4: unpleasant/pleasant	0.683	0.628		
	A5: attractive/unattractive	0.835	0.756		
	A6: friendly/unfriendly	0.801	0.749		
Efficiency	~~E1: fast/slow~~	~~0.429~~	0.930	0.69	0.90
	E2: inefficient/efficient	0.858	0.749		
	E3: impractical/practical	0.826	0.689		
	E4: organized/cluttered	0.609	0.670		
Perspicuity	P1: not understandable/understandable	0.644	0.758	0.71	0.92
	P2: easy to learn/difficult to learn	0.899	0.726		
	~~P3: complicated/easy~~	0.757	~~0.582~~		
	~~P4: clear/confusing~~	~~0.552~~	0.649		
Stimulation	~~S1: valuable/inferior~~	0.613	~~0.540~~	0.73	0.90
	S2: boring/exciting	0.850	0.761		
	S3: not interesting/interesting	0.877	0.806		
	S4: ~~motivating/demotivating~~	~~0.447~~	0.727		

(KMO) value=.798, Bartlett's test Chi-sq=606.321, *p*=.000) and using VR (KMO value=.866, Bartlett's test Chi-sq=786.217, *p*=.000) is adequate.

To ensure that the four UEQ dimensions were distinct, a factor analysis using principal component extraction and oblimin rotation was conducted. For riding a scooter, a Cattell's screen plot showed four clear factors emerging, explaining 67.33%, 54.95%, 41.90%, and 24.09% of the variance, respectively, for using VR, the factors explained 72.58%, 64.25%, 52.51%, and 27.70% of the variance, respectively. In addition, the factor loading should be >0.6 [32-33]. See *Table 2*, it is clear that items A3, E1, P3, P4, S1, and S4 did not load appropriately onto the attractiveness, efficiency, perspicuity, and stimulation scales. These items were therefore not included in the subsequent analyses.

Wilcoxon signed-rank test

The Shapiro-Wilk test revealed an acceptation of normality assumption on riding a scooter (0.41, p>0.05) and the scores in using VR (0.92, p>0.05). In addition, the Wilcoxon signed-rank test revealed a significant difference between the acceptances of riding a scooter and using the VR system (please refer to *Table 3*). There was no statistically significant difference for the perceived perspicuity or stimulation ($P \geqq 0.05$). These results indicate that:

- the users perceive the riding of a scooter to be as perspicuous as using the VR system;
- the users perceive the riding of a scooter to be as stimulating as using the VR system;
- the users are more self-satisfied when riding a scooter (Mdn = 0) than when using the VR system (Mdn = 0) (Z = -2.06, p = 0.039, r = 0.30);

Table 3 – Analysis of UEQ factors and satisfaction

Item		Mean	S.D.	*Z* value	*p* value	Effect size (*r*)
A1: annoying/enjoyable	Riding scooter	0.47	1.87			
	Using VR	1.07	1.31	-1.996	0.046	0.27
E4: organized/cluttered	Riding scooter	0.64	1.47			
	Using VR	1.14	1.01	-2.042	0.041	0.28
E3: impractical/practical	Riding scooter	1.54	1.58			
	Using VR	0.83	1.45	-2.71	0.007	0.36
Self-satisfied	Riding scooter	0.71	1.13			
	Using VR	0.17	1.38	-2.06	0.039	0.30

- the users perceive riding of a scooter (Mdn = 2) to be more practical than using the VR system (Mdn = 1) ($Z = -2.71$, $p = 0.007$, $r = 0.36$);
- the users enjoy more using the VR system (Mdn = 1) than riding a scooter (Mdn = 1) ($Z = -1.996$, $p = 0.046$, $r = 0.30$);
- the users perceive that using the VR system (Mdn = 1) is more organized than riding a scooter (Mdn = 1) ($Z = -2.042$, $p = 0.041$, $r = 0.28$).

T-test

The T-test results indicated that UEQ factors of attractiveness for riding a scooter had significantly different findings for good/bad ($t = 2.10$, $p < .05$) between men ($X = 1.37$, $\sigma = 1.00$) and women ($X = 0.71$, $\sigma = 1.38$).

Multiple regression analysis

A multiple regression analysis was performed to predict the usage intention (Y) from the survey data. The results indicated that the variables precisely predicted whether the users intended to use 360° immersive video service ($F(5,53) = 44.55$, $p < 0.000$, Adjusted $R2 = 0.81$). These variables included pleasant ($\beta = 0.54$, $t = 4.46$, $p = .000$, $VIF = 1.95$), attractive ($\beta = 0.36$, $t = 3.82$, $p = .000$, $VIF = 1.82$), practical ($\beta = 0.55$, $t = 6.07$, $p = .000$, $VIF = 1.71$), and easy to learn ($\beta = -0.40$, $t = -3.73$, $p = .000$, $VIF = 1.52$). All the variables significantly contributed to the prediction, $p < .05$.

5. DISCUSSION

In this study, a quantitative analysis of the UXs while riding a scooter and UXs while using a 360° immersive video service was carried out using a UEQ scale. The UEQ scale was based on attractiveness, pragmatic quality, and hedonic quality. Pragmatic quality considered efficiency, perspicuity, and dependability, whereas hedonic quality focused on stimulation and novelty. Based on the research results, the UXs and usage intentions are further discussed.

UXs comparison between VR and reality

The results revealed that riding a scooter created a near optimal impression concerning attractiveness, perspicuity, and efficiency and a positive impression concerning dependability, stimulation, and novelty. It means that riding a scooter may allow most of the riders to perceive positive UXs, with involved positive attractiveness, pragmatic, and hedonic qualities. On the other hand, the results revealed that using an immersive service in watching a 360° scooter ride video created a near optimal impression concerning attractiveness, perspicuity, efficiency, dependability, and novelty, and a positive impression concerning stimulation. It means that using 360° immersive video service may allow most of the users to perceive near optimal UXs. In this study, the dependability and novelty scales of the UEQ were excluded because these scales had a low internal consistency. Furthermore, A3, E1, P3, P4, S1, and S4 were excluded because these items did not load appropriately onto the attractiveness, efficiency, perspicuity, and stimulation scales. In this regard, the UEQ has been revised to measure the UXs while riding a two-wheeler product and while using a 360° immersive video service. The dependency of the revised UEQ scale is presented in Figure 4. In addition, the results of comparing the attractiveness, perspicuity, efficiency, and stimulation scales, found that there was no significant difference between riding a scooter and using a 360° immersive video service. Moreover, the results of satisfaction verified that most of the participants had a high agreement level of continued usage intention on using an immersive service in watching a 360° scooter ride video. These results revealed that providing a 360° immersive video service may assist

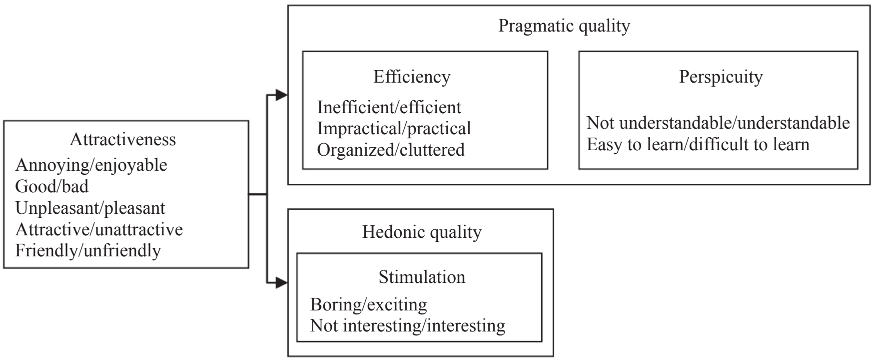

Figure 4 – UXs scale structure for a user while riding a two-wheeler

the users to successfully create riding experiences that are similar with riding a scooter. Furthermore, in terms of UXs, the integrated application of VR and panoramic audio and video technologies may be used as an experience tool to create a reality-like scooter riding experience for the users.

There is a gender-based variation in the UXs while riding a scooter, which is not the case while watching a 360° scooter ride video. This gender-based difference has been found to be due to the user's general response toward the scooter as a product. The results indicated that both female and male participants liked the scooter product. However, most of the male participants tended to have very good feelings for the scooter product, while female participants tended to have slightly good feelings. This means that male users have a better response toward the scooter as a product than female users. Contrary to the case of a scooter, the response to a 360° immersive video service is not gender dependent. Therefore, providing 360° immersive video service can avoid the possibility of individual differences.

The results of the analysis with each question item revealed that there were significant differences in enjoyable, organized, practical, and self-satisfaction between the riding of a scooter and using a 360° immersive video service. Compared to the riding of a scooter, the participants tended to have higher agreement levels related to enjoyable and organized, in using the immersive video service. The results verified that most of the participants may experience significantly higher joy and organized feelings in using a 360° immersive video service, than riding a scooter. In contrast, compared to using the immersive video service, the participants tended to have higher agreement levels related to practical and self-satisfaction feeling for riding a scooter. The results verified that most of the participants may experience a significantly higher practical and self–satisfaction feeling in riding a scooter, than in using a 360° immersive video service. These results also indicate that both riding a scooter and using a 360° immersive video service in creating a user's riding experience, have their own significant advantages. For designing a successful two-wheeler trial ride and road safety education VR system for users to have deep and positive user experiences, the designers oriented themselves toward how to enhance user enjoyment and provide organized content are suggested.

Usage intentions towards the 360° immersive video service

The influence of immersive video services on the viewers' experiences and usage intentions in watching a 360° scooter ride video was investigated. The results revealed that the immersive experiences may lead 71.2% of the participants to have the intention to be frequent users in riding a scooter. Significant support was found for the model and for the goodness-of-fit. Results indicate that the model was successful in predicting continuance usage intentions towards the 360° immersive video service, accounting for 81% of the variance.

Four of the model predicted relationships were supported, with pleasant, attractive, practical, and easy to learn all contributing uniquely to users' continuance usage intentions towards the immersive video service. These four items can be defined as: (1) pleasant is the degree of a sense of satisfaction associated with an impression of the immersive video service; (2) attractive is the degree to which the impression of the immersive video service is truthful, beautiful, and motivates an intrinsic desire to know and use; (3) practical is the degree of understanding the characteristics of the scooter product associated with the immersive video service use;

and (4) easy to learn is the degree of initial orientation and deepened learning associated with the immersive video service support. Of these factors, pleasant, attractive, and practical positively influence the user's usage intentions, while easy to learn has a negative influence.

To increase the appeal of the two-wheeler trial ride and educate the individuals on road safety using an immersive video service, it is recommended that the designers consider enhancing user attraction and enjoyment and provide them with practical content. Adding challenging tasks to the content increases the user's willingness to interact with the immersive video service. Specifically, content capture using current panoramic photography technology increases the user's satisfaction. To further increase the user's willingness to use the panoramic VR service, selecting a beautiful and unique riding scenery is recommended. In addition, in order to improve the practicality and further challenge the users, designing special riding events to create a variety of riding experiences is recommended, such as traffic accidents, speeding events, and traffic violations.

Study limitations and future work

Results should be interpreted with caution, due to inherent survey data limitations. This paper presents the case study of the 360° immersive scooter ride video service in Taiwan, the VR service with a panoramic scooter ride video that was an early adopter in this country. Sampling was limited to the New Taipei area of Taiwan. Culture and lifestyle may differ among countries. Moreover, the experimental equipment only provided audio-visual stimulation, and no user-controlled functions.

Future research should add control technology to allow users to control their relationship to the virtual environment; the results can also be generalized by extending the questionnaire content to virtual world contexts. Regarding safe riding education, upcoming studies should verify the benefits of educational content being applied to 360° immersive video services.

6. CONCLUSION

The main aim of this study was to use the items and scales of the UEQ to investigate the factors of Attractiveness, Pragmatic quality, and Hedonic quality that influence a user's acceptance of a 360° immersive video service and a user's willingness to use the immersive video service to experience the riding of a scooter.

Results of the experiments and surveys provide evidence of the UEQ for increasing the understanding of the public acceptance of immersive scooter ride video services. The results also revealed that using an immersive video service may allow most of the users to perceive a near optimal UX. Furthermore, the study successfully compared UXs of riding a scooter to a 360° immersive video service for experiencing scooter riding. The results verified that using a 360° immersive video service may create a reality-like scooter riding experience for the users. The 360° immersive video service may also provide a more appealing and organized riding experience than traditional environments.

Moreover, providing people with a immersive video service in watching panoramic scooter riding videos can yield positive influences on the users' continuance usage intentions. In particular, the user-perceived Attractiveness and the Pragmatic quality of the 360° immersive video service play a big part in their continuance usage intentions, while "pleasant," "attractive," "easy to learn," and "practical" all appear to be important factors. It is to be hoped that in order to maximize service uptake, the developers and providers of such 360° immersive video services will consider the above issues when implementing more permanent versions of the public 360° immersive video services.

In addition, in this study, it was desirable to have the user feel visually immersed in the virtual reality scene corresponding to a video of real-life objects. In order to enable widespread use of VR in real life applications, it is desirable to provide the user with a sense of natural interaction with features displayed within the virtual reality scene in the near future.

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探討*360°*全景服務與實際駕駛間的使用者體驗差異：以機車駕駛為例

摘要

本實驗研究探討頭戴式顯示器與*360°*全景技術整合應用於機車駕駛虛擬服務能創造的使用者體驗。本研究目的以證實頭戴式投影技術應用於機車駕駛服務是否能創造與實際機車駕駛相似的體驗，使用

者體驗評估要項包括：吸引力、實用、以及愉悅品質。本實驗提供參與者於頭戴式顯示器上觀看360°全景影片，並於觀看後填寫用戶體驗調查表；最後，共取得*59*位實驗參與者有效回饋。研究結果證實，整合頭戴式顯示器和*360°*全景技術所提供的機車駕駛虛擬實境服務可為使用者創造類似於實際機車駕駛的體驗。其中，吸引使用者持續使用機車駕駛虛擬實境服務的重要因素為服務能帶給他們的吸引力和實用品質。最後，本研究針對虛擬實境服務相關設計提出建議，進一步增加*360°*全景技術於創造二輪車駕駛體驗中的優勢及應用虛擬實境技術於未來道路安全教育訓練。

關鍵詞

電動二輪車；駕駛經驗；交通經驗；沉浸式環境*; 360*度全景技術

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