Article

Technology Behavior Model—Beyond Your Sight with Extended Reality in Surgery

Xiaoxue Gong [1,*] and Poh Soon JosephNg [2]

1 Institute of Computer Science & Digital Innovation, UCSI University, UCSI Heights, Cheras 56000, Kuala Lumpur, Malaysia
2 Faculty of Information Technology, INTI International University Persiaran Perdana BBN, Nilai 71800, Negeri Sembilan, Malaysia; joseph.ng@newinti.edu.my
* Correspondence: klyydts@126.com

Abstract: Extended Reality Smart Glasses is a new pattern that uses extended reality technology to present a visual environment that combines the physical and virtual worlds. However, the surgical technique using Smart Glasses implementation is still unknown, to the infancy in clinical surgery, derived to the limits of existing technology. This study researched the acceptability and possibility of XRSG for medical experts. It combines human seen behavioral control with information technology research to construct a new "Extended Reality Technology Behavior Model" using method Technology Acceptance Model and Theory of Planned Behavior. To improve the accuracy of the study, statistical analysis, exploratory analysis, and cross-sectional research triangulation were used to collect data in five hospitals in Malaysia using a convenience sampling method and a questionnaire on behavioral influences. From the collected data, PLS-SEM analysis was used to reflect the relationship between variables. The strong positive results suggest that using XRSG by medical experts helps to improve the composition, interactivity, standardization, and clarity of medical images, resulting in increased efficiency and reduced procedure time and felt the usefulness and ease of use of XRSG through their behavior, providing a basis for technology acceptance in surgery.

Keywords: extended reality smart glasses; medical image modeling; interactive technologies; technology behavior model

1. Introduction

During clinical surgery, surgeons need to monitor and view multiple visualization instruments, including endoscopes, laparoscopes, cardiac monitors, and others [1]. The surgeons always observe the display data and images by means of rotating their head, as far as to result in torso distortion due to of maintaining a fixed position for long periods of time [2]. Data and images are transmitted to the glasses through WIFI when using smart glasses for surgery [3]. Their eye does not move and focus on the surgical operation. In some delicate surgeries the clarity of human eyes cannot meet the demand, and surgeons need to use a microscope to perform the surgery [4], for instance, vestibular schwannoma of the brain [5], dental pulp nerve endings [6], and intracranial dural arteriovenous fistulae [7]. Nevertheless, the microscope is too bulky and has a small operable interface which is not conducive to surgical operations. Smart Glasses have high-definition cameras with adjustable focal lengths to improve the clarity of the human eye [8]. Meanwhile, the surgeon's hands are freed and facilitate flexible manual operation.

Extended reality is a deep immersion experience that generates a comprehensive, three-dimensional reality-virtual continuum through computer systems. Through Virtual Reality (VR) to provide users with a virtual environment, combined with digital overlay enhanced images in Augmented Reality (AR), and use of Mixed Reality (MR) to form three-dimensional imaging, to achieve a perfect combination of physical reality environment

and virtual reality environment, as shown in Figure 1 [9]. It promotes regional innovation and opens up new visualization avenues of application. The human body is complex and mobile, moving the internal organs of the body between exhalation and inhalation [10]. Each part is a relatively independent and complex structure. During the operation, it can overlap with the patient entity, which is convenient for the surgeon to recognize and operate [11,12]. XRSG uses Expanded Reality Technology (XRT) that can create images of such sensitive images. Most important is the visual experience, which combines real and virtual human structures to create a three-dimensional, realistic medical image of the human body [13]. Past works of literature on XRT in surgery have been insufficiently discussed.
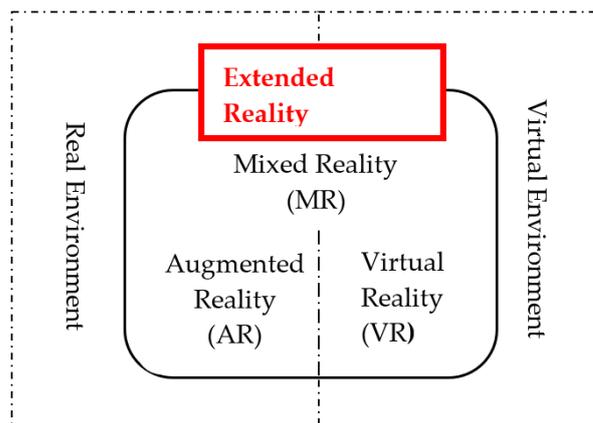

Figure 1. VR, AR, MR, and XR distinction.

However, from the point of view of theoretical development, the XRSG technique has met the needs of surgical procedures, such as trials in dermatology [14], neurosurgery [9], and urological procedures [15], but has not yet been applied to clinical procedures [16]. In this study, the acceptability and feasibility of the use of XRSG for surgical operations by medical specialists were tested. The XRT was studied using the Technology Acceptance Model (TAM) to explore people's acceptance of innovation through their perception of its usefulness and ease of use [17]. It also requires the acceptance and use of subjective consciousness leading to behavioral change suitable for the Theory of Planned Behavior (TPB) through the medical expert's experience of the procedure [18]. The current study proposes a new theoretical framework with a combination of TAM and TPB, the Technology Behavior Model (TBM). In this model, extended reality technology is added to make it more suitable for this study. Currently, XRSG is mainly used to improve visual effects and is not as popular as cell phones. Therefore, people's subjective perceptions are the basis of their behaviors. In this study, the triangle mixed research method was used to collect data through an online Google questionnaire and conduct statistical analysis on the data using SmartPLS. PLS-SEM has a multiplanar structure and sophisticated model manipulation software that allows for multivariate mixed cross-tabulation analysis, which facilitates the study of the data [19]. The structure of this paper is as follows. First, the theory and hypotheses of this study are presented by examining the previous literature. The second part presents the research methodology, data analysis, and conclusions of this study. Third, the contributions of this study are discussed, including the proposed new technical-behavioral model for medical image modeling by using Extended Reality Technology, which improves the Usage Perspicuity, standardizes the operation of medical experts while allowing the use of multiple interaction methods for viewing images and data, and avoids cross-contamination in the surgical environment. This provides a better patient-to-surgical experience, ensures a successful surgery, and reduces surgery time. This paper ends with the conclusion section, to confirm the acceptance and use of smart glasses surgery by medical experts and to provide an outlook for after research.

2. Literature Review

2.1. Study Context

Smart glasses are hands-free interactive computing devices that include real-time remote command and monitoring. Wearability and hands-free are the main advantages of SG. XRSG can be used in different areas of the healthcare industry [20]. There are a few types of XRSG available in the market. The commonly used ones are Google Glass, Eyewear, and PicoLinker, which are mainly used for live surgical video communication [21–23]. PicoLinker has been used commercially in the Japanese industry for two years [23]. Surgeons started using SG for surgical observation, such as vision correction, skin surgery, and plastic surgery. However, Google Glass is not widely used because it is expensive [21]. Therefore, most medical professionals do not use XRSG in general surgery.

XRSG are devices that can support medical experts. During surgery, the surgeon needs to view various visualization devices to overlook the patient's signs [22]. This information is displayed on a display. In research and exploration, it was found that medical experts can detect information about the patient during surgery with SGs without the need to consult the case book or the pathology records at the computer terminal. Realistic images are obtained by superimposing 3D anatomical composite images inside the lens [24]. These navigational images can be displayed to the surgeon through the XRSG display. The displayed images include vital signs, computer navigation, and conventional images (X-ray images, computed tomography, color ultrasound, MRI, and other instrumental images.) The PicoLinker allows the surgeon to focus on the surgical task without leaving the scene [23]. In some literature, the authors report that the use of the extended reality smart eye can improve accuracy, reduce radiation, and shorten surgery time. Minimally invasive surgery is not new to people, but with the help of visualization and fluoroscopic navigation, the extended reality smart eye can monitor surgical data projected into the surgeon's field of view [25].

Based on the studies in the relevant literature, the future technological route of XRSG in clinical surgery has been prospected. As shown in Table 1, future tracking technologies and image processing will be more intelligent, and displays and sensors will be closely related to the perception of human organs [3,26,27]. Realization of highly intelligent technologies offer more freedom of operation.

Table 1. XRSG technology in the future.

	Past	Now	Future
Environment Awareness Technology	−	High-definition camera	
	Fixed label	Computer graphics	Deep learning
Motion tracking	Magnetic markers, visual markers	GPS, inertial navigation system	An optical system, depth of field camera
Display technology	Handheld projector	Head-mounted display	Virtual retina display
Interactive technologies	Flat user interface	A 3D user interface, gesture and pose capture, speech recognition	Touch, eye tracking, and man-machine symbiosis
Medical image modeling	Solution of the plane model	Surface shading technique, volume roaming technique, and surface reconstruction technique	CT model reconstruction + real-time deep learning calibration

2.2. Theoretical Foundation

2.2.1. Technology Acceptance Model

The technology acceptance model is Davis's rational behavior in studying the acceptance of information or technology systems by users. Ooi et al. [28] argued that TAM is one of extensive recognized and commonly used models to study the willingness to use

new technologies [24]. The use of this model in this study can help medical experts to perceive the usefulness and ease of use of XRSG by using XRSG in clinical operations. Medical experts actively use XRSG in clinical operations to change user behavior. Through subjective perception, good impression, and active choice, people's acceptance of using extended reality smart eye is developing. According to the current understanding of relevant information, SG can play an important role in clinical surgery, facilitate doctors to operate, and improve the success rate of surgery, thereby changing people's behavior and approving the use of SG in surgery.

2.2.2. Theory of Planned Behavior

The Theory of Planned Behavior, developed by Icek Ajzen, helps us understand how people change their behavior [29]. It includes five elements: attitude, subjective norms, perceived behavior control, behavior intention, and behavior [30]. The more positive the individual's attitude towards a behavior, the stronger the individual's behavior intention [18]. The more positive the subjective behavior norm, the stronger the individual's behavior intention. The more positive attitudes and subjective norms, the stronger the perceived control of behavior, and the stronger the individual's willingness to act. Attitudes, subjective norms, and perceptual behaviors are all mutually independent and interrelated identification behaviors [31].

Both the Theory of Planned Behavior (TPB) and the Technology Acceptance Model (TAM) is derived from the Theory of Reasoned Action (TRA) [32]. TAM focuses on the adoption of information technology, while the city planning committee is used to explain individual behavior. TAM and TPB both aim to study actual behavior, so a new theoretical framework-Technology Behavior Model (TBM) is proposed. According to TPB, it analyzes perception and behavior control, focusing on the impact of human autonomous perception and cognition on actual behavior, which can be used in medical investigations, while TAM changes the perceived usefulness and ease of use through some external variables to affect actual actions. Applicable in this research for the technical analysis of SG. Therefore, this research can use a new theoretical framework to comprehensively analyze the performance of human consciousness and perceptual behavior in practical actions.

2.3. Determinants of the Adoption of XRSG in Surgery

Determinants of the use of XRSG in surgery include the usefulness and ease of use of extended reality, medical framing methods, interactive technology, operational specifications, and clarity of use.

2.3.1. Extended Really Usefulness (XRU)

XRU refers to the ability to help medical experts perform better in clinical operations. Medical experts can learn and use XRSG during surgery to perceive their role in the procedure and whether it contributes to the procedure the efficiency of surgery by using the use of extended reality technologies, including human-space imaging, visualization enhancement, and eye-tracking human-computer exchange technologies. XRU stems from changes in perceived usefulness (PU) in TAM, which affects the use of behavioral intention in TPB. This is mainly based on preoperative pictures, data, and own experience to estimate the surgical approach. Existing extended reality technologies can improve surgeon's ability to recognize the vision, imaging, and localization for surgical purposes. These studies suggest that the use of XRSG by medical experts can help improve the success rate of surgery. Therefore, the hypothesis is as follows:

Hypotheses 1 (H1). *XRU has a positive effect on the intention to adopt SGs (ITASG) surgical behavior of medical experts.*

2.3.2. Extended Reality Ease of Use (XREU)

XREU is the use of XRSG by the operator to simplify operations and thus reduce operation time. This suggests that by using new things and technologies to reduce user

work, users will be willing to move forward and embrace the use of technology. The concept of perceived ease of use guides the acceptance and use of user payment behavior [33]. Studies have found that healthcare professionals using XRSG can avoid looking at multiple visual monitoring devices and maintain the attention of the human eye. Perceptual ease of use (PEU) changes the operator's use for habit (ITASG) and willingness to use XRSG in surgery. Operators respond positively to this behavior. Therefore, the hypothesis is as follows:

Hypotheses 2 (H2). *XREU has a positive effect on the intention to adopt SGs (ITASG) surgical behavior of medical experts.*

2.3.3. Image Modeling (IM)

IM refers to the construction of virtual 3D imaging based on human body systems through XRSG's extended reality technology. It can be integrated with the patient's entity during surgery, facilitating observation and manipulation by medical experts. It reflects the practicality and ease of use of user perception, and changes the operator's behavior through perception, reflecting the change of XRTBM usage behavior. In clinical procedures, minor errors can have serious consequences for the life and health of the patient, as each patient is different. Medical experts primarily use existing imaging equipment to perform procedures, which requires a high level of expertise. XRSG 3D medical mapping addresses existing surgical imaging needs and eliminates the need for medical experts to assess lesions at a technical level. It facilitates operator positioning and measurement of bearings. The use of XRSG is positively influenced by the desire of individuals to use them. Therefore, the hypothesis is as follows:

Hypotheses 3 (H3). *IM has a positive effect on medical experts operating XRU.*

Hypotheses 4 (H4). *IM has a positive effect on medical experts operating XREU.*

2.3.4. Interaction Design (ID)

ID refers to the interaction technology of XRSGs, which mainly includes voice, gesture, and eye-tracking. The operating room is a special sterile and closed environment to ensure a safe surgical environment. Medical specialists can use voice interaction to guide and teach surgery remotely. It can help inexperienced surgeons to learn. Interactive technology facilitates dissemination and communication, making it easier to use in surgery. It attracts users to choose XRSG and allows them to pay based on actual behavior. Reducing unnecessary display control during surgery, improving the quality of surgery, and ensuring zero cross-contamination can change the behavior of medical experts. During the operation, interactive operations such as gestures and eye-tracking allow easy access to patient information and data, real-time monitoring of patient physiological changes, and image monitoring. At the same time, it avoids contaminating the operating environment by manually touching the keyboard and mouse. Therefore, the hypothesis is as follows:

Hypotheses 5 (H5). *ID has a positive effect on medical experts operating XRU.*

Hypotheses 6 (H6). *ID has a positive effect on medical experts operating XREU.*

2.3.5. Operation Norm (ON)

ON means that XRSGs can use the camera to measure the surgical site, avoiding the operator's body movement, and conducive to visual focusing on the surgical site. Standardized operations can supervise the operations of medical experts, and reduce operational risks caused by accidental errors. Operators are reminded by XRSGs to recognize the standardization of implementation behaviors, thereby perceiving usefulness and ease of use, and improving the success rate of surgery. In clinical practice, the position and size of human organs always change with breathing and movement. The exact matching of real and virtual organ models is a huge challenge. In practice, doctors can use XRSGs to free their hands and keep the operator's eyes within a certain range, so the surgeon

can standardize the doctor's operation and avoid accidental human error. Therefore, the hypothesis is as follows:

Hypotheses 7 (H7). *ON has a positive effect on medical experts operating XRU.*

Hypotheses 8 (H8). *ON has a positive effect on medical experts operating XREU.*

2.3.6. Usage Perspicuity (UP)

UP means that XRSG can replace the human eye and improve the visual clarity of the human eye. During surgery, doctors often need to use their hands to perform operations, with their eyes focused on the computer monitor and handheld video monitor. The Head-Mounted Projection Display (HMPD) of SG connects the instrument to the Internet to convert the data into a three-dimensional image displayed by the HMPD. XRSG can make the operation interface clearer and ease operation. This actual change is conducive to the surgeon's opinion of subjective behavior. During the operation, XRSG is used to view the surgical site, monitor the patient's physiological state and internal organ changes. XRSG can use suitable camera pixels and connect the inner lens to increase the image and improve the clarity of the field of view. Therefore, the hypothesis is as follows:

Hypotheses 9 (H9). *UP has a positive effect on medical experts operating XRU.*

Hypotheses 10 (H10). *UP has a positive effect on medical experts operating XREU.*

2.4. Theoretical Framework

This research expands the possibilities of using realistic SG during surgery. The application of extended reality technology is achieved using human behavioral awareness. As shown in Figure 2, based on the proposed new Technology Behavior Model (TBM), combined with the extended reality hypothesis, it is renamed the Extended Reality Technology Behavior Model (XRTBM).
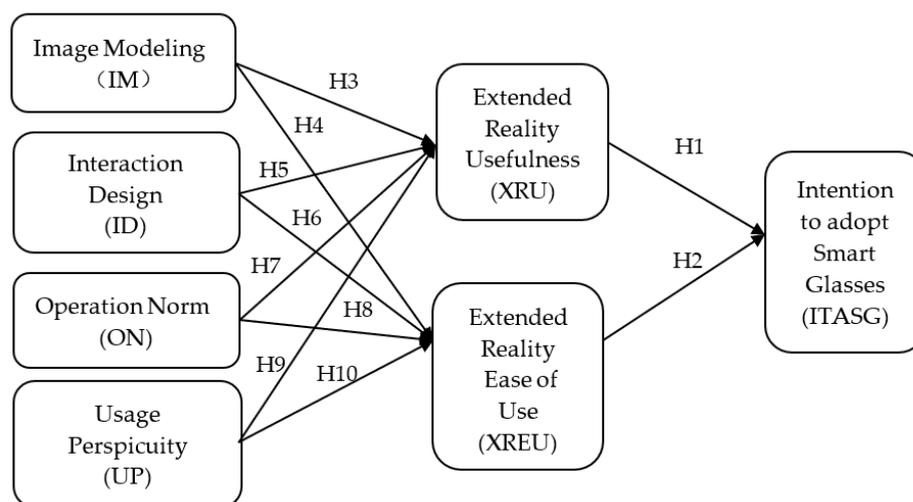
Figure 2. Proposed Conceptual Framework.

3. Methodology

3.1. Research Design

Research design is a research strategy that combines different elements of logic [33], research objective questions, and data analysis processes to test the validity of objective hypotheses and obtain research results [34]. To better answer and address the questions of this study, quantitative research, exploratory research, and cross-sectional research methods were used. First, quantitative research can use mathematical methods to analyze the collected data and perform logarithmic operations and statistical analysis [35]. This study will collect primary data. Quantitative research can help researchers to analyze the

data systematically. Secondly, exploratory studies are innovative and discovery studies [36]. Although XRSGs have been used in medicine, they are mainly used in communication and telemedicine. The role of XRSGs in surgery is lesser-known and understood, and the reference material for this study is limited, so the study plan to use an exploratory study for this study. Third, cross-sectional studies can facilitate data collection by researchers without affecting other variables, save data collection time, and determine possible relationships. This research method was conducted over a short time, and the data collected in this study was for a period of two weeks.

3.2. Sampling Design

In this study, the researcher used non-probability sampling. As the population in this study is a cohort, it was not possible to use probability sampling because the sample size was not uniformly distributed. Based on the need of the study, the researcher chose convenience sampling as the sampling method for this study. This sampling method is simple, convenient, quick, and low cost. The target population of this study was medical specialists in five hospitals in Malaysia. This is because they need to improve the efficiency and safety of their procedures. Collecting their opinions can directly reflect their needs for XRSG. A total of 300 pieces of data were collected, which exceeded the minimum sample size of the effect size of 0.5, an alpha level of 0.05, and a power of 0.90 for the collection of 273 to meet the needs of the study data.

3.3. Measurement

To test the authenticity of the theoretical construct, a questionnaire survey was conducted among hospital medical experts in Malaysia. The questions of the questionnaire survey are based on literature and studies published in relevant peer journals and articles. This survey will investigate the impact of XRSG, whether it can help medical experts to perform better in surgery, whether it can improve the confidence of successful surgery, and other related questions. This questionnaire is completed in English.

The questionnaire is divided into two parts. The first part was demographic characteristics, including gender, age, education level, income, and occupation. The second part was the correlation between the independent and dependent variables. Each independent variable consisted of three questions to ensure that the questions were simple and easy to understand. All questions were expressed by a seven-point Likert scale with different levels and only one option for everyone.

3.4. Data Collection Method

As mentioned above, this study of the relationship between the dependent and independent variables requires the use of primary data [37]. Due to the impact of COVID-19, the questionnaire was created using Google Forms. Respondents were sent a link and invited to fill it out. To better reach the target sample size, the questionnaire was sent through various social media platforms, such as Facebook, Whatsapp, and WeChat, and we asked the invitees to answer the questions within 10 min. Additionally, we conducted online interviews with 10 academics in the field through Zoom and Teams regarding the advantages and disadvantages of using XRSG in surgery. In addition, Google Forms was used to automatically generate results after respondents submitted their data and store the data in a database to form a data report. Researchers could view it in real-time to understand the progress, results, and distribution of the questionnaire.

4. Data Analysis

The PLS-SEM method requires a sufficient sample size, the existing literature, and data lack a clear consensus on sample size. A total of 298 valid questionnaires were collected within the period of data collection, while 2 questionnaires were invalid or missing data. This primary data collection meets the requirement of the PLS-SEM sample size proposed by Hair et al. [19]. Missing values are an inevitable problem in questionnaire research,

which makes it difficult to analyze the factors of behavioral research in social sciences. The acceptable range of lost data is 5%, and the loss of data this time is only two respondents, or 0.77% of the sample size of 300, which will not lead to any possible error results. By using SmartPLS, the method of mean replacement was adopted for the lost data to ensure the maximum benefit of the research data, and the mean value of the variables remained unchanged [38].

4.1. Demographic Analysis

In this study, male respondents accounted for 59.06% and female respondents accounted for 40.94%. This study does not consider people under the age of 20. Respondents aged 20–45 accounted for 84.9% of the total number of people in this survey. At the same time, the respondents have generally higher education levels, of which 62.42% have a university degree and 37.58% have a postgraduate degree. From the income analysis in Table 2, more than one-third of the respondents have incomes between RM 5000–8000, and most of them are people aged 36–45. They can better reflect the new generation's views on XRSG.

Table 2. Demographic Analysis.

Demographic Characteristic	Option	Counts	Percentage (%)
Gender	Male	176	59.06%
	Female	122	40.94%
Age	20–35	103	34.56%
	36–45	150	50.34%
	46–55	37	12.42%
	More than 56	8	2.68%
Marital status	Single	102	34.23%
	Married	196	65.77%
Education	Undergraduate	186	62.42%
	Postgraduate	112	37.58%
Income	Less than RM 3000	4	1.37%
	RM 3000–5000	20	6.71%
	RM 5000–8000	120	40.27%
	RM 8000–10,000	98	32.88%
	More than RM 10,000	56	18.78%

4.2. Statistical Analysis

The partial least squares variance method (PLS-SEM) of SmartPLS 3.3.3 was used for structural model analysis, which is the most commonly used method in current research [39]. The main reasons for using this method in this study include: First, it is suitable for unconventional studies. The target population of this study is large, and the data cannot be averaged [40]. An unconventional study can avoid data errors. Second, this study used an exploratory theoretical study, which illustrates, through other research links, that the variance of endogenous constructs is closely related to the theoretical basis of exploratory studies [41]. Third, PLS-SEM is used to deal with mixed and complex model studies [37], and a new theoretical framework, XRTBM, is used in this study. Therefore, using PLS-SEM statistical techniques, this study can satisfy the use of different computational methods to detect internal and external effects between variables, including common method factors (CMF), moderating validity, internal and external structural models, model applicability, effect sizes, and predictive power of the studied models.

4.2.1. Common Method Bias

Common method bias (CMB) occurs because the data is collected through a single online questionnaire survey method [42]. This is because the common method deviation is the common deviation variation caused by the measurement model (factor), rather than

the variance variation caused by the structural measure [39]. This problem is particularly prominent when the independent and dependent variables come from the perception of the interviewee [37]. The CMB experiment measures the real factor load (Ra) and method factor combination (Rb). According to the study of Hair et al. [19], the variance of the method factor load is not significant, and the variance of the substantial factor load is much higher than 39:1, indicating that the data is not affected by CMB. It can be seen from Table 3 that the ratio of Ra^2 to Rb^2 is 91.6:1, which is much larger than the method variance, so CMB does not exist.

Table 3. Common method Factor.

Latent Construct	Indicators	Substantive Factor Loading (Ra)	Substantial Variance Square (Ra^2)	Method Factor Loading (Rb)	Method Variance Square (Rb^2)
ITASG	ITASG1	0.89	0.7921	−0.059	0.003 [NS]
	ITASG2	0.938	0.879844	−0.075	0.005625 [NS]
	ITASG3	0.935	0.874225	0.05	0.0025 [NS]
ID	ID1	0.928	0.861184	0.025	0.000625 [NS]
	ID2	0.918	0.842724	−0.112	0.012544 ***
	ID3	0.932	0.868624	0.109	0.011881 ***
IM	IM1	0.9	0.81	−0.002	0.000004 [NS]
	IM2	0.941	0.885481	0.054	0.002916 [NS]
	IM3	0.91	0.8281	0.093	0.008649 [NS]
ON	ON1	0.935	0.874225	−0.148	0.021904 **
	ON2	0.946	0.894916	0.06	0.0036 [NS]
	ON3	0.925	0.855625	0.026	0.000676 [NS]
XREU	XREU1	0.9	0.81	−0.128	0.016384 ***
	XREU2	0.917	0.840889	0.069	0.004761 [NS]
	XREU3	0.943	0.889249	0.032	0.001024 [NS]
XRU	XRU1	0.926	0.857476	−0.055	0.003025 [NS]
	XRU2	0.929	0.863041	0.24	0.0576 *
	XRU3	0.895	0.801025	−0.189	0.035721 **
UP	UP1	0.928	0.861184	−0.002	0.000004 [NS]
	UP2	0.925	0.855625	−0.031	0.000961 [NS]
	UP3	0.903	0.815409	0.032	0.001024 [NS]
	Average	0.922095238	0.850521238	−0.00052381	0.009281381
	Ration	91.63735897			

Notes: ITASG = Intention to Adopt Smart Glasses; ID = Interaction Design; IM = Image Modeling; ON = Operation Norm; XREU = Extended Reality Ease of Use; XRU = Extended Reality Usefulness; UP = Usage Perspicuity. b. *** $p < 0.001$; ** $p < 0.01$; * $p < 0.05$, [NS] insignificant.

4.2.2. Assessing the Outer Measurement Model

In more related research, reliability and validity tests are usually needed to evaluate external measurement patterns. Reliability means that the measured structural reliability is generally required to be greater than 0.7 [19]. It is determined by estimating the ROH A value. It can be seen from Table 4 that the ROH A of all studies is greater than 0.9, far exceeding the standard threshold. It can be seen that the data in this study has high reliability. In terms of validity, convergent validity and discriminant validity tests are used. Convergent validity refers to the degree of correlation between items within the same concept. Discriminative validity refers to the degree of difference between items in different concepts. When calculating the convergence validity, the variable factor load exceeds 0.7 [43], and the average variance extraction (AVE) of the convergence validity testing standard exceeds the 0.5 thresholds [44]. The comprehensive reliability of Table 4 is greater than 0.9, and the average AVE is greater than 0.85. In the calculation of discriminant validity (DV), the Hetero-Trait-Mono-Trait (HTMT) correlation ratio is usually used to

evaluate discriminant validity with a standard value of HTMT < 0.85. The HTMT for each loading factor in Table 5 is all combined standard value. The HTMT in Table 6 inferred that combined with 5000 samples, the deviation correction, and acceleration (BCa) were all within the normal range. As both the 2.5% and 95% confidence intervals did not reach 1, the DVs of the research variables in the structural model were different, so the validity was established.

Table 4. Convergent Validity and Construct Reliability.

Latent Construct	Items	Loadings	Standard Deviation	RhoA (ρA)	Composite Reliability	Average Variance Extracted (AVE)
ITASG	ITASG1	0.892	0.385	0.914	0.944	0.849
	ITASG2	0.933				
	ITASG3	0.937				
ID	ID1	0.928	0.377	0.921	0.948	0.857
	ID2	0.923				
	ID3	0.927				
IM	IM1	0.903	0.397	0.908	0.941	0.841
	IM2	0.941				
	IM3	0.906				
ON	ON1	0.933	0.384	0.929	0.954	0.875
	ON2	0.944				
	ON3	0.928				
XREU	XREU1	0.893	0.389	0.917	0.943	0.846
	XREU2	0.923				
	XREU3	0.943				
XRU	XRU1	0.928	0.397	0.907	0.941	0.841
	XRU2	0.927				
	XRU3	0.895				
UP	UP1	0.923	0.395	0.910	0.942	0.844
	UP2	0.922				
	UP3	0.910				

Notes: ITASG = Intention to adopt Smart Glasses; ID = Interaction Design; IM = Image Modeling; ON = Operation Norm; XREU = Extended Reality Ease of Use; XRU = Extended Reality Usefulness; UP = Usage Perspicuity.

Table 5. Hetero-Trait-Mono-Trait (HTMT).

Latent Construct	ITASG	ID	IM	ON	XREU	XRU	UP
ITASG							
ID	0.642						
IM	0.654	0.678					
ON	0.601	0.665	0.541				
XREU	0.642	0.650	0.570	0.622			
XRU	0.772	0.743	0.649	0.638	0.662		
UP	0.684	0.624	0.625	0.436	0.519	0.597	

Notes: ITASG = Intention to Adopt Smart Glasses; ID = Interaction Design; IM = Image Modeling; ON = Operation Norm; XREU = Extended Reality Ease of Use; XRU = Extended Reality Usefulness; UP = Usage Perspicuity.

Table 6. Hetero-Trait-Mono-Trait (HTMTinference).

Latent Construct	Original Sample (O)	Sample Mean (M)	Bias	2.50%	97.50%
ID -> ITASG	0.252	0.249	−0.003	0.171	0.340
ID -> XREU	0.243	0.238	−0.004	0.119	0.374
ID -> XRU	0.346	0.342	−0.003	0.244	0.461
IM -> ITASG	0.134	0.135	0.002	0.050	0.212
IM -> XREU	0.153	0.154	0.000	0.025	0.277
IM -> XRU	0.171	0.173	0.001	0.048	0.285
ON -> ITA	0.198	0.201	0.003	0.126	0.265
ON -> XREU	0.291	0.292	0.001	0.185	0.401

Table 6. *Cont.*

Latent Construct	Original Sample (O)	Sample Mean (M)	Bias	2.50%	97.50%
ON -> XRU	0.223	0.227	0.004	0.123	0.319
XREU -> ITASG	0.263	0.263	0.000	0.138	0.391
XRU -> ITASG	0.544	0.544	0.000	0.420	0.663
UP -> ITASG	0.123	0.123	0.000	0.051	0.197
UP -> XREU	0.136	0.136	0.000	0.033	0.248

Notes: ITASG = Intention to Adopt Smart Glasses; ID = Interaction Design; IM = Image Modeling; ON = Operation Norm; XREU = Extended Reality Ease of Use; XRU = Extended Reality Usefulness; UP = Usage Perspicuity.

4.2.3. Inspecting the Inner Structural Model

Standardized root means square residuals (SRMR) were used to evaluate the overall saturation of the XRTBM and the fit between the factors. The results showed that the saturation model was 0.022, while the estimated model was 0.058, both less than 0.08, indicating a good model fit [37]. The structural variance inflation factor (VIF) values assessed by the collinearity test were all between 1.5 and 2.3, below the threshold of 5.0 [45,46]. There was a highly correlated structure. The internal structure model was tested on a bootstrap subsample of 5000 with unsigned options using bias correction and the BCa bootstrap method. Differences were compared at the 0.05, 0.01, and 0.001 significance levels. The results of the PLS-SEM hypothesis tests are presented in Table 7 and Figure 3. For XRU, XREU (H1: B = 0.544, *p*; 0.001; H2 = 0.263 B, *p*; 0.001) was positively correlated with the hypothesized ITASG. Additionally, hypothesized ID, IM, ON, and UP had highly significant p-values for XRU, XREU, and ITASG, respectively, with *p*-values less than 0.01. Except for IM, UP values for XREU were slightly greater than 0.01, but all were less than 0.05, also consistent with good significant relationships.

Table 7. The outcome of the Structural Model Examination.

	PLS Paths	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	T Statistics (|O/STDEV|)	*p* Values	2.5%	97.5%	Remarks
H1	XRU -> ITASG ***	0.544	0.544	0.061	8.909	0.000	0.033	0.134	Yes
H2	XREU -> ITASG ***	0.263	0.264	0.064	4.137	0.000	0.137	0.391	Yes
H3	IM -> XRU **	0.171	0.172	0.061	2.823	0.005	0.048	0.288	Yes
H4	IM -> XREU *	0.153	0.152	0.064	2.4	0.016	0.026	0.274	Yes
H5	ID -> XRU ***	0.346	0.343	0.056	6.12	0.000	0.235	0.457	Yes
H6	ID -> XREU ***	0.243	0.238	0.064	3.769	0.000	0.122	0.375	Yes
H7	ON -> XRU ***	0.223	0.226	0.051	4.366	0.000	0.126	0.326	Yes
H8	ON -> XREU ***	0.291	0.292	0.055	5.289	0.000	0.187	0.404	Yes
H9	UP -> XRU **	0.160	0.158	0.051	3.134	0.002	0.061	0.258	Yes
H10	UP -> XREU **	0.136	0.137	0.055	2.489	0.013	0.034	0.247	Yes

Notes: ITASG = Intention to Adopt Smart Glasses; ID = Interaction Design; IM = Image Modeling; ON = Operation Norm; XREU = Extended Reality Ease of Use; XRU = Extended Reality Usefulness; UP = Usage Perspicuity. * Significant at 5% level, *p* < 0.05. ** Significant at 1% level, *p* < 0.01. *** Significant at 0.1% level, *p* < 0.001.
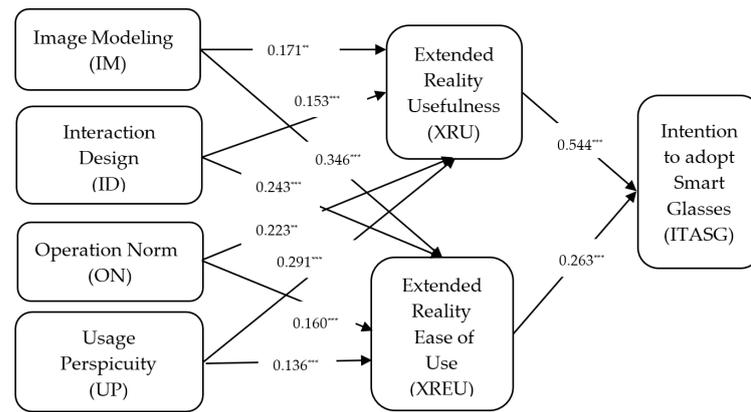
Figure 3. Result of hypotheses testing.

4.2.4. Predictive Relevance and Effect Size

Calculating the predicted relevance through Stone-Geisser's Q^2 value provides an objective indication of whether the endogenous variables are consistent with the structural model [19]. When Q^2 is greater than 0, it indicates that the structural model has predictive relevance and vice versa. ($Q^2 = 1 - SSE/SSO$) in Table 8 shows that the final value of Q^2 for cross-validation under each variable is greater than 0, indicating that the predictive relevance of the structural model has been established. However, this approach ignores data points due to the rigor of the study. According to Sarstedt et al. [37], this value does not fully fit the predictive power of the surface structure model. Meanwhile, the predictive power of PLS-SEM was solved using Plpredict software. It can be seen from Table 9 that the factor variables of Q^2 in the PlS-SEM and ITASG linear regression models are both greater than 0, and the Root Mean Square Error (RMSE) is relatively high. The structural model has high predictive performance.

Table 8. Predictive Relevance.

Endogenous Construct	SSO	SSE	Q^2 (=1 − SSE/SSO)	Predictive Relevance
ID	900.000	436.140	0.515	$Q^2 > 0$
IM	900.000	422.971	0.530	$Q^2 > 0$
ITASG	6300.000	3761.205	0.403	$Q^2 > 0$
ON	900.000	405.964	0.549	$Q^2 > 0$
UP	900.000	437.587	0.514	$Q^2 > 0$
XREU	4500.000	2732.652	0.393	$Q^2 > 0$
XRU	4500.000	2669.201	0.407	$Q^2 > 0$

Notes: ITASG = Intention to Adopt Smart Glasses; ID = Interaction Design; IM = Image Modeling; ON = Operation Norm; XREU = Extended Reality Ease of Use; XRU = Extended Reality Usefulness; UP = Usage Perspicuity.

Table 9. PLS Predict Results.

ITASG	PLS-SEM			Linear Model Benchmark		
	Q2_Predict	RMSE	MAE	Q2_Predict	RMSE	MAE
ITASG1	0.443	0.778	0.652	0.576	0.678	0.549
ITASG2	0.404	0.833	0.687	0.45	0.8	0.654
ITASG3	0.384	0.796	0.663	0.526	0.698	0.579

Notes: ITASG = Intention to Adopt Smart Glasses.

On the other hand, the relationship between the influence of exogenous variables on structural variables (f^2). The effect variable refers to the difference caused by various factors. It is an index to measure the size of the treatment effect and is not affected by the sample size. For strong, medium, and weak, the effect size is above 0.35, 0.15, and 0.02, respectively. It can be seen from Table 10 that the influence relationship of each variable is far greater than 0.02, and the influence of XRU on ITASG is as high as 0.544. The UP,

ON, XREU, and F^2 of XRU and ITASG are the lowest among the four sets of data. It can be seen that the use of XRSG behavior by UP is weaker than that of ID, IM, and ON. However, according to research needs, there are significant effects among variables.

Table 10. Effect Size (f^2).

Predictor Construct/Dependent Construct	ID	IM	ITASG	ON	UP	XREU	XRU
ID			0.252			0.243	0.346
IM			0.134			0.153	0.171
ON			0.198			0.291	0.223
UP			0.123			0.136	0.16
XREU			0.263				
XRU			0.544				

Notes: ITASG = Intention to Adopt Smart Glasses; ID = Interaction Design; IM = Image Modeling; ON = Operation Norm; XREU = Extended Reality Ease of Use; XRU = Extended Reality Usefulness; UP = Usage Perspicuity.

4.2.5. Importance Performance Map Analysis

Importance Performance Map Analysis (IPMA) is a useful method in PLS-SEM to examine the average dimensionality of latent variables, path coefficients, and other reported standard results [39]. In other words, IPMA compares the overall effect of the structure with the mean scores of the latent variables. As seen in Table 11 and Figure 4, the overall effect is higher than 0.02. Additionally, XRU and XREU have a high positive effect on ITASG. From the performance point of view, all data are greater than 67, with ID being the highest, followed by ON, IM, and UP. the mean value of each variable is 67.952, which is at a relatively high level. This indicates that each variable has a direct impact on user behavior.

Table 11. Importance Performance Map Results.

	Importance (Total Effect)	Performances (Index Value)
ID	0.222	77.533
IM	0.140	71.042
ON	0.184	73.921
UP	0.115	67.941
XREU	0.241	68.576
XRU	0.493	71.502
Mean Value	0.252	67.952

Notes: ID = Interaction Design; IM = Image Modeling; ON = Operation Norm; XREU = Extended Reality Ease of Use; XRU = Extended Reality Usefulness; UP = Usage Perspicuity.
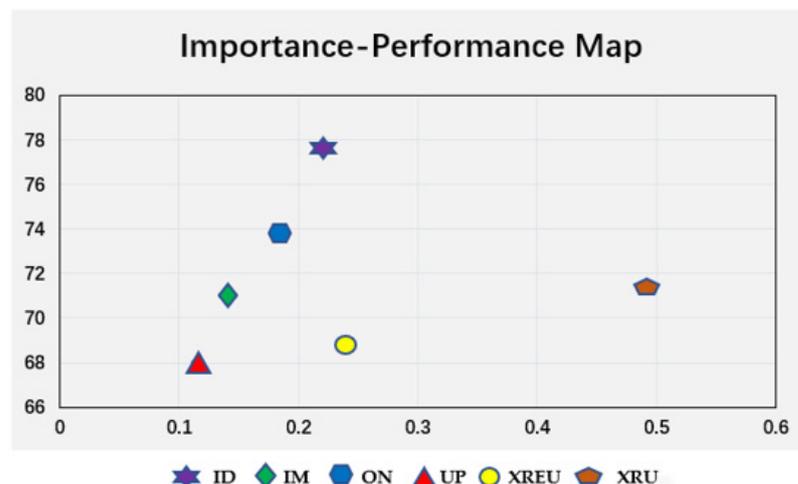

Figure 4. XRTBM for ITASG.

5. Finding and Discussion

XRU and XREU have a significant impact on the medical experts' use of XRSG for surgery. Ghaednia et al. [23] reiterated that the use of SG by surgeons in the application of spinal surgery can be effective in helping the surgeon to perform the procedure better and Vasarainen et al. [25] used SG in urological surgery. Zeng et al. [13] confirmed in their study that XR technology can help medical experts quickly and accurately locate patients' blood vessels and nerves and found that the usefulness and ease of use of XRSG had a significant positive impact on medical experts' behavior in using XRSG. For example, surgeons can use the XRSG to connect internal lenses to improve the visual clarity of the human eye through the AR system of eyeglasses, expanding the surgical field and facilitating the performance of surgery [47]. Therefore, H1 is supported and H2 support is confirmed. A wide and clear field of view can improve the efficiency of surgery, reduce the surgeon's work pressure, and reduce the operation time and the time affected by radiation. Thus, it reflects that users can easily use XR technology for clinical operations.

On the other hand, IM is a 3D image based on the combination of XR technology and human system structure to simulate surgical practice and teaching. Due to the systematic and kinesthetic nature of the human body structure [48], the use of stereoscopic medical image composition can clearly show the internal structure of the human body. Lee et al. [49] found that medical experts could locate the patient's blood vessels by image overlap and perform suturing during surgical vascular suturing. This demonstrated that the H3 hypothesis is feasible and that rapid localization simplifies the surgeon's search in favor of H4. ID has positive interactions with both XREU and XRU. It was found that the joint use of multiple interactive technologies can better serve the communication and usage switching of medical experts during surgery [10]. Good voice communication facilitates remote communication for surgery, and gesture recognition facilitates freeing the surgeon's hands. Eyeglass tracking facilitates switching and viewing of monitoring visualization data and images. Enhancing the utility and ease of use of the XRSG, the operator's behavior is subjective. Therefore, H5 and H6 are supported.

From the above discussion, it is clear that the XRSG allows the surgeon to operate surgical instruments and instruments with both hands, avoid viewing multiple visual inspection displays, standardize operational actions, and avoid unintentional human errors; therefore, H7 and H8 are supported. The built-in high-definition camera of the XRSG can replace the human eye to enhance visual clarity and make the visual images larger [16]. In a study by Nag et al. [50] medical experts used PicoLinker Smart Glasses to improve wire insertion under fluoroscopy. The wires were inserted exactly at the set position for ease of use. The use of the reflective SG is useful and reflects the ease of operation. Therefore, H9 and H10 are supported.

The study shows that IM, ID, ON, and UP support perceived usefulness and ease of use, change the operating habits of medical experts during surgery, and have a positive behavioral impact on surgical operations. This demonstrates the feasibility of the proposed XR technology acceptance and behavioral theory.

6. Implications

With the global spread of COVID-19, healthcare systems in many places are collapsing due to the dramatic increase in patients and to protect medical experts and reduce work stress. Extended reality devices are important to technology development units around the world [51]. Smart healthcare has been explored in-depth and smart glasses have become a prominent representative of many smart products. It can be used in all phases of the healthcare system, including remote consultations, room visits, monitoring, and surgery. In particular, there is a need to ensure contact-free contamination during surgery due to the sterile environment to improve the surgeon's eyesight, free up the surgeon's hands, and better complete the surgery. Specific contributions are illuminated in the following subsections.

6.1. Theoretical Implication

This study establishes a new theoretical framework, the Technology Behavior Model (TBM) based on the Technology Acceptance Model and the Theory of Planned Behavior, which is one of the main contributions of this paper. The new technology is perceived through the human subjective consciousness experience to simplify the operation and improve the efficiency of the existing work. This leads to subjective changes in user behavior changes. The flexibility of the model changes to facilitate the comprehensiveness of the research, as relevant theoretical structures can be added according to the actual needs of the new technology under study [52]. Based on this model, the "Extended Reality Technology Behavior Model" is designed by combining the extended reality smart glasses. Furthermore, this study shows that the new research theory is valid and suitable for studying the relevance of XRSG to extended reality. As it focuses on extending technology to actual changes in human behavior, extended reality technology enables changes in human behavior that are based on perceptions of human experience, using the technology acceptance model and the theory of planned behavior [29,53]. Based on the current models, relevant models can be freely added to make the existing models more detailed and beneficial for future studies. This study introduces the concepts of vision, composition, and validity from which the real experiences of medical personnel using XRSG in surgery can be understood.

6.2. Managerial Implication

In this study, for the first time, the use and perception of extended smart glasses for medical specialists is presented. The medical expert's view is more authoritative in the use of clinical smart surgery. It is also the first time that the human body structure image composition is proposed, and the physical and virtual environment is unified by the existing extended reality technology combined with the visualized detection instrument images to build a three-dimensional image [54,55]. Secondly, the smart glasses system adds device identification and operation rules, which can effectively remind the operator of the correct usage. Again, the self-contained high-definition camera, not only in limited to recording and accessing images, but also has enhanced human eye vision, which can replace the use of microscopes. Finally, it adds eyeglass tracking to the existing interaction technology. Although this technology is still in the early stages of development, it can better assist medical experts in completing surgical operations by combining mature voice and gesture technology. These new changes above provide medical experts with the convenience of completing surgery and effectively improve the success rate and efficiency of surgery.

6.3. Methodological Implication

The three analytical methods used in this study were quantitative analysis, exploratory analysis, and cross-sectional analysis. The main reason for this is that there is less information and trial data related to smart glasses research and the information is mainly about telesurgery, and surgical teaching [56,57]. This makes the available information related to clinical surgery more difficult to find, so this makes it more difficult for this study. Single quantitative analysis lacks empirical, and judgment of the nature, characteristics, and developmental patterns of the subjects analyzed, resulting in inaccurate data. For the lack of reference materials and unknown problems, an exploratory study was conducted to be able to ensure the comprehensiveness of the study data. Combined with the cross-sectional analysis method, data bias can be controlled more systematically. The triangular mixed study can effectively improve the accuracy of the collected data and ensure the authenticity and controllability of data collection.

6.4. Social Implication

The use of XRSGs in clinical surgery can lead to a better surgical experience, increase the success rate of surgery and save more patients [58]. Changing the way medical experts operate can lead to a better surgical experience for patients. The use of XRSG is a step

forward in the development of smart surgery, a paradigm shift from relying solely on medical experts to embracing artificial intelligence. This has changed the development of existing surgical systems. It solves the problem of social trust stigmatization of patients with high medical difficulty and high surgical risk. The application of telemedicine systems can help patients in remote areas with remote consultations and remote surgery. It also allows for international medical online surgical collaboration; the promotion of surgical research and learning in hospitals, institutions, and countries; higher chances that patients achieve the best surgical results; and the improvement of the technical professional ethics of medical experts.

7. Conclusions and Future Works

The study avoids the errors and mistakes that arise from using a single research method by using a mixed-mode approach to data collection. Especially for the early stages of the development of the extended reality technology, there is no more reference material on which to base the study. This study proposes a new theoretical framework smart glasses extended reality technology behavioral model that expands the acceptance of the technology in reality and investigates the surgical behavior of medical specialists using XRSG in terms of human psychological characteristics and environmental demands. PLS-SEM was used in the data analysis, and multiple composite methods were used to compare the external and internal validity and credibility of the variables to make the results more accurate. The study showed that the total effect of XRSG in terms of image modeling, interaction design, operational specification, and clarity of use was 0.14, 0.222, 0.184, and 0.115 (Table 11), respectively. This indicates that they can be effective in helping medical specialists to perform procedures better. Four variables were confirmed for medical specialists' agreement with smart glasses surgery. This study has important social implications in those smart glasses surgery improves the success rate of surgery and can be effective in saving more lives, and also provides a reference for the development of future smart surgery in clinical applications. However, this study has some limitations that should be addressed in future studies. First, this study was limited to Malaysia and could not measure other countries. The influence of people's education and culture on the acceptance of XRSG cannot objectively reflect the behavioral awareness of people in other regions. Second, the available technology places greater demands on the integration of extended reality technologies. How does XRSG ensure that the constructed human models are consistent with the movement of human organs? The technology is still immature in terms of facilitating auditory, tactile, and sixth senses. This requires further investigation by researchers. Third, although the technical features of XRSG have been improved, as the world population ages and the demand for surgery increases, more durable visualization techniques need to be developed to ensure effective demand for clinical procedures.

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