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Technology Acceptance Model for 3D Virtual Reality System in Luxury Brands Online Stores

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ABSTRACT This paper presents an evaluation of a 3D semi-immersive virtual reality (VR) system for online luxury product visualization and customization service. This paper's objective is to present the results of the survey-based analysis using a technology acceptance model with ease of use, usefulness, perceived experience value, and perceived presence as independent variables, in testing the attitudes toward the system. The impact of product customization and personalization features on the perceived experience value and the attitudes toward the system was also tested. The result shows that the perceived presence, usefulness, ease of use, and the perceived experience value have a significant positive effect on the attitudes toward the 3D VR semi-immersive system. The result also revealed that utilizing the advantage of 3D VR systems with regard to real-time manipulation of the product and the flexibility in customizing the 3D models' features in real time has elevated the attitudes toward the aforementioned emerging technology within this specific context.

INDEX TERMS Virtual reality, technology acceptance model, luxury brands, product customization.

I. INTRODUCTION

Online retailing is one of the activities that require rich data representation and realism imitating user-experience capacity. In order to compensate for the non-physical presence of a product, a functional web application that provides useable and clear information, as well as a high level of interactivity, is deemed essential. The latter can be achieved with the use of intuitive interaction between consumers and virtual products. However, the typical methodologies applied for the presentation of items in digital stores do not go beyond two-dimensional (2D) images and, exceptionally, some animation or video-footage/catwalk. This existing technology is inherently deficient in information provision and does not permit sufficient interactivity; at least when compared with what a three-dimensional (3D) virtual model can offer. The necessity of advanced Human-Computer Interaction (HCI) strategies is more salient in the context of the online product customization service, where the customer has control of modifying and integrating the product's characteristics. The luxury concept is associated with the experience. The main stimulus behind purchasing luxury products is the perceived experience value [1]. In online stores, the experience takes on a different aspect due to the fact that the interaction is mediated by technology. The attitudes towards the online luxury store are determined by different aspects, which could be task-related, such as product information, convenience, and time and effort exerted, as well as aesthetic and experiential-related such as web design [2].

Hence, there is a challenge for the experience design and the interface design to compensate for the lack of direct interaction and explicit luxury experience. This dictates the need for exceptional facilities that are not readily available through conventional technology. This is consistent with prior research, which suggests that in order for luxury brands to thrive on the online platform, a multisensory experience has to be delivered [3]. This multisensory experience should involve high-task and low-task related factors to satisfy the customers' demands in the online stores. To this end, integrating VR technology into online luxury stores for product visualization and customization is expected to elevate task-related factors in addition to factors related to the perceived experience value.

Offering services such as personalization or bespoke customization would enhance client self-expression. In fact, luxury brands' customers, particularly mature consumers,

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seek to have made-to-measure and customized items [4]. About 34% of luxury brands' customers believe that products and services should be customized to their needs and desires [5]. Even more, 39% of luxury brands' customers buy luxury goods to enjoy a customized custom-made service [6]. Burberry's chief executive posits that providing online product customization aims to engage customers, disregarding how that could increase sales [7].

To this end, VR technology provides the user with immersive experience when interacting with the products online, unlike conventional methods. Furthermore, VR enhances customer involvement in the product design process due to capacities such as real-time product design updates, real-time interaction, and comprehensive output product visualization [8]. A previous study suggested that vivid, involving, affective and active are the main psychological conditions that users could experience during their interaction with a 3D object in a virtual environment [9].

Our current study proposes an HCI interface that employs three-dimensional VR environments and presents fully detailed photo-realistic 3D products. The proposed interface enables the user to perform all the customizations currently offered on the real products either within the shop space or from the comfort of the user's home. The use of the proposed system reduces the need for large stocks of different product variations and makes the customization a timely, efficient and enjoyable process either within a shop or from home. The immersion and photorealism of the products further enhance the user-experience in contrast to existing online brand applications. The proposed system has been evaluated by 42 users. Their feedback has been analyzed with a Technology Acceptance Model customized for Virtual Reality systems in luxury brands' online stores and offered encouraging results for the adoption of this technology as will be presented and discussed in the following sections. This paper aims to offer a twofold contribution. Firstly, to present an innovative approach for an online or standalone VR application that could offer a semi-immersive, photorealistic and full manipulation of life-size items of luxury brands. Secondly, as this type of system poses a number of issues for the evaluation and extrapolation of results in the larger population, this study offers a customized Technology Acceptance Model (TAM) that could offer valuable information regarding user acceptance and create a tool framework for future studies in the field of luxury and fashion brands [10].

II. PROPOSED SYSTEM RATIONALE

Adhering to the aforementioned observations and studies, it is evident that current high-street luxury brands suffer due to the online competition and price comparison which typically is in favor of online stores [12]. The latter do not require expensive maintenance of facilities and as such are more cost-efficient. Yet the customers that buy items from the luxury brands appreciate the user experience both in an online environment and in real-life stores. Adhering to this observation, this work offers a new interaction approach based on a prototype

FIGURE 1. VR interface design of the customization feature (Style sub-menu options).

interface and gesture recognition VR system. The proposed system is in contrast to previous studies which utilized VR in conjunction to typical interaction methods, such as a mouse, and interfaces heavily relied upon existing online webpage designs of luxury brands [8] and [11]. The proposed system is designed to be easily deployed in a small space within a luxury brand shop or in the customer's home. Any projection or television device that could produce stereoscopic 3D visuals could facilitate the system which could be provided as a stand-alone application. The interaction with the proposed system could either use typical game controllers, mouse or gesture recognition for a natural interaction with the real-life size and photorealistic VR items. The system provides product customization and personalization features as illustrated in Figure 1.

With the intention of providing the user with a more holistic experience and capitalizing on the unique features of a stereo-capable monitor, the system is designed for 3D monitors or high-resolution 3D projection systems that have the advantage of presenting realistic output. To this end, the use of gesture recognition is considered to be the most efficient and intuitive method for direct manipulation and interaction with the VR objects in a large-scale display scenario [11]. The flexibility and realism of the aforementioned system and its impact on perceived experience value presents new prospects for e-commerce systems, particularly for high-end markets.

III. INTERFACE DESIGN AND OPERATION

The interface design follows primarily the design aspects of the brand's visual cues whilst being developed with a small number of large and accessible buttons, spread across the screen-estate. The latter was deemed ideal as it simplifies the use of gesture recognition and reduces dramatically accidental button selections as presented in Figure 2. Additionally, the proposed minimalistic interface does not overload the customer with unnecessary visual information which could retract his/her attention from the main item.

Furthermore, if the customer utilizes a gaming controller they could easily perform any customization to the preferred item without the navigation issues encountered in cluttered online applications as illustrated in Figure 2.

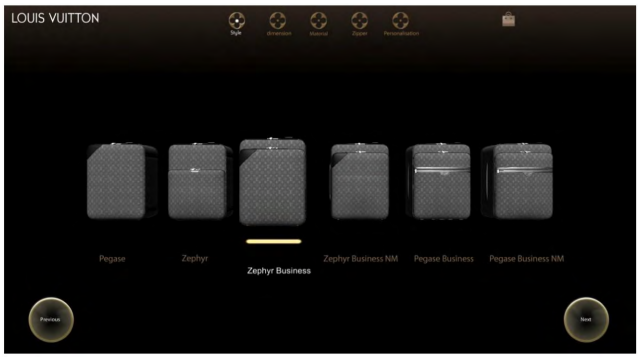

FIGURE 2. The proposed VR system offers a minimalistic and easily accessible interface for both gesture recognition and traditional controller conduits.

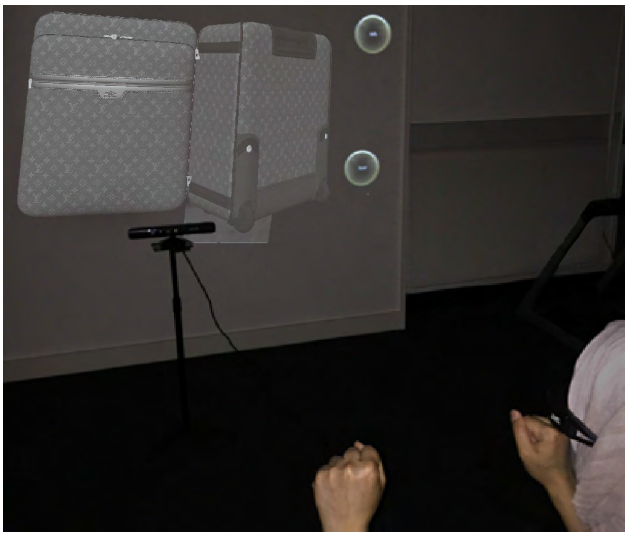

FIGURE 3. Life-size and photorealistic 3D models of the bags used in the proposed system.

The proposed system enables the customer to operate a number of interactions following a typical real-life shopping process. As such the customer could select one of six different 3D photorealistic, luggage bag models as illustrated in Figure 3. In turn, the customer could manipulate (rotate, pan and zoom) the luggage bag in three dimensions and investigate all the exterior features. In order to examine the interior bag compartments, the user could virtually unzip and/or unclip the different bag compartments and reveal the bag's interior. For both exterior and interior, the customer could change materials, colors, and various details currently provided by the particular brand. The bag could be further customized with the provision of a personalized monogram which could be operated and applied through the VR interface.

IV. SYSTEM EVALUATION

The experiment used a front projection system in stereo mode produced by a professional level 3D/HD JVC projector. The projection screen was 3m (W) x 2.5m (H) in order to provide sufficient space for real-scale presentation of the 3D luxury objects. The users were standing approximately 2.5-3m away

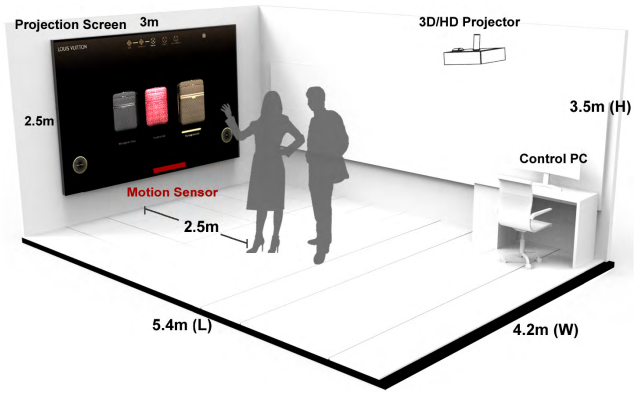

FIGURE 4. 3D Visualization of the VRS Lab environment used for the evaluation of the proposed VR system.

from the projection screen. This distance offered the best results in gesture recognition and the items appeared in life-size dimensions. Furthermore, these space dimensions could be accommodated easily in luxury brand stores. The projection could be further improved and/or disguised with the use of an ultra-short-throw projector or rear projection set-up. The dimensions of the experiment/projection room, namely Virtual Reality and Simulation Laboratory (VRS Lab), were 5.4m (L) x 4.2m (W) x 3.5m (H) and based on Glasgow Caledonian University, illustrated in Figure 4. Arguably the selection of a Head-Mounted Display (HMD) would have been a more cost-efficient option. However, this could have caused numerous issues that would have prevented the clients from using this technology [13]. In particular, the process of wearing, fixing the size of the HMD tensioners and in turn manipulating the different interaction conduits is time-consuming and poses an element of embarrassment for a large number of clients uninitiated to VR. As stated previously, the majority of the potential customers are mainly mature and unwilling to experiment in such processes whilst they are on a shopping trip [11] and [12]. In addition, the use of HMDs forces the user to lose eye-contact with the salesperson and is disassociated with the real environment, which creates communication and mobility issues.

As such the stereoscopic projection was deemed as the easiest and safest presentation method to apply and use. The user is still semi-immersed due to the size of the screen and the photorealism of the VR objects, yet is capable of communicating and moving freely. Similarly, the use of large size 3D TVs (>65 inches) could have identical usability and overall application effect with the projection screen.

During the system development, the user's motion was originally tracked by proprietary motion trackers, although the system performs equally well with off-the-shelf technology such as different gaming and camera tracking available in contemporary consumer electronics.

For the particular user-trial, it was deemed essential to employ an off-the-shelf gesture recognition/controller device such as Kinect by Microsoft as presented in Figure 3. The latter device offered a cost-effective, customizable and adequate

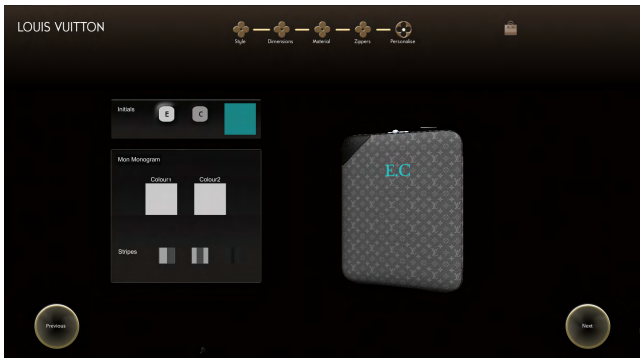

FIGURE 5. Screenshot of the customization process required for the completion of the task during the user experiment.

motion tracking and depth scanning for the particular experiment. As stated above, the visual interface was designed based on a minimalistic representation of the required functions and offered large buttons, positioned wide apart in order to accommodate a fast and easy interaction. As such the skeleton tracking and hand tracking granularity of the selected device was sufficient.

In order to evaluate the proposed system, 42 users that are frequent luxury brands' customers volunteered to perform a number of activities in order to investigate the 3D bag and customize it in accordance with a preset scenario that required specific features to be applied on the final product. The users filled a pre-questionnaire which was designed to acquire personal preferences and demographic information. In turn, the users experienced the VR system and the various features.

The features defined by the scenario were selected with the view to challenging the users to navigate through a number of customization options and effectively explore the majority of interactive systems and options.

During the process, the users were familiarized with the 3D direct manipulation of the life-size items in order to select the required options for the exterior and interior of the luggage bags in order to complete the scenario task.

In particular, the subjects were asked to perform a scenario based customization for one of the luggage bags as illustrated in Figure 5. The evaluation replicated a 20-step process which is indicative of the investigation, customization and selection process. The steps are the following:

1. Navigation through the 6 different bags
2. Selection of the correct luggage bag
3. Inspection of the exterior of the bag
4. Inspection of provided exterior colors
5. Selection of required color (grey pattern)
6. Selection of black leather protective corners
7. Selection of silver studs
8. Selection of silver pad-lock
9. Selection of silver zip
10. Open/Unzip the bag and all the pockets
11. Inspect the interior
12. Select the linen pattern for the interior (dark grey)
13. Select the interior material
14. Find and operate the monogram interface
15. Select 2 initials (user's initials) for the monogram
16. Select the color of the monogram letters
17. Select the font of the monogram letters
18. Inspect the final customized item
19. Approve selection
20. Proceed to order the customized luggage bag.

A screenshot of the customization process during the experiments is presented in Figure 5. The users finally completed a post-questionnaire which aimed to acquire information and subjective feedback in accordance with the customized TAM presented below. This was required for the evaluation and indicative understanding of the users' acceptance and future use of the proposed emerging technology in the e-commerce environment for luxury brands.

The current study aims to evaluate the effectiveness of the system for this particular scenario and understand the factors that influence the users' perception. Using theoretical frameworks enables researchers to understand users' attitudes and the relationships between research variables and constructional factors. Hence, developing a framework to identify and understand the factors that affect the attitudes to a 3D VR system for the luxury e-commerce sector is essential.

V. TECHNOLOGY ACCEPTANCE MODEL

Extensive empirical implications of TAM in online shopping technology have suggested its reliability and validity as a theoretical model that helps in understanding users' acceptance of a technology [14], [15] and [16].

Both the perceived ease of use "the degree to which a person believes that using a particular system would be free of efforts" and usefulness "the degree to which a person believes that using a particular system would enhance his/her job performance" as positioned by TAM, have a direct impact on the attitude towards using a particular emerging technology, which in turn influences the behavioral intention to use the system and then the actual use of the system [17]. These factors are also fundamental in evaluating a VR system [15], [18]. Thus, the following hypotheses are proposed:

H1: The perceived ease of use of the 3D VR system affects attitudes positively

H2: The perceived usefulness of the 3D VR system affects attitudes positively

H3: The perceived ease of use of the 3D VR system affects usefulness positively.

A. VR SYSTEM EVALUATION

In the context of luxury brand e-commerce experience, the ease of use and usefulness factors only would not give a sufficiently comprehensive insight into revealing the actual influence behind the prototype VR application attitudes and acceptance. The perceived presence is recognized as an influential factor in achieving optimal customer attitudes towards VR online shopping technology [9], [20], [21] and [22]. The perceived presence is defined as "the degree to which

a medium can produce seemingly accurate representations of objects, events, and people representations that look, sound, and/or feel like the real thing'' [19]. A previous study observed that presence is generated when interacting with sensory enabling environmental factors that promote involvement and enable immersion [23]. Another study stated that the human mind, the technology and the environment all share in the perceived immersion when experiencing a medium [28]. Immersion is defined as ''the degree to which a virtual environment submerges the perceptual system of the user'' [25]. The perceived presence serves as an intermediate factor between the VR system characteristics and the attitudes and behavior of the target users; therefore, it is expected to have a direct effect on the perceived VR experience [9]. On the basis of this, the following hypothesis is developed:

H4: Perceived presence within the 3D VR system affects attitudes positively

B. LUXURY E-COMMERCE EXPERIENCE EVALUATION

Studies in luxury brands and user experience have suggested that the factors determining the customers' attitudes and motivations towards services provided by luxury brands are distinct from those in customers of mass brands, as luxury brands provide their customers with more than functional value [26]. Experience and luxury are closely-related values, as the luxury value is achieved in an experiential manner. Customers tend to be attracted by the experience luxury brands provide online [4]. The perceived value of the experience or customer value is defined by ''interactive relativistic preference experience'' [27]. This means that the experience value results from the interaction with the brand and service provided and generates user preferences. This preference is represented in the perception of the hedonic, emotional and aesthetic values as well as the cognitive and physical ones [28] and [29]. Based on the aforementioned, the current research proposes the following:

H5: Perceived experience value of a 3D VR system for luxury brand e-commerce affects attitudes positively

Also, the ease of use and efficiency of the system have a direct effect on the user experience [30]. Therefore, the current study proposes:

H6a: Perceived ease of use of 3D VR system affects perceived experience value

H6b: Perceived usefulness of 3D VR system affects perceived experience value

The TAM was used in a previous study to examine the acceptance of the augmented reality system, which indicated that the perceived presence has a direct and significant influence on ease of use, usefulness and experiential value [31]. Accordingly, the evaluation of VR systems, as stated earlier, is based on the perceived presence; thus, the study hypothesizes:

H7: Perceived presence within the 3D VR system affects perceived experience value

The current study proposes a VR system for product visualization and customization. Therefore, the product

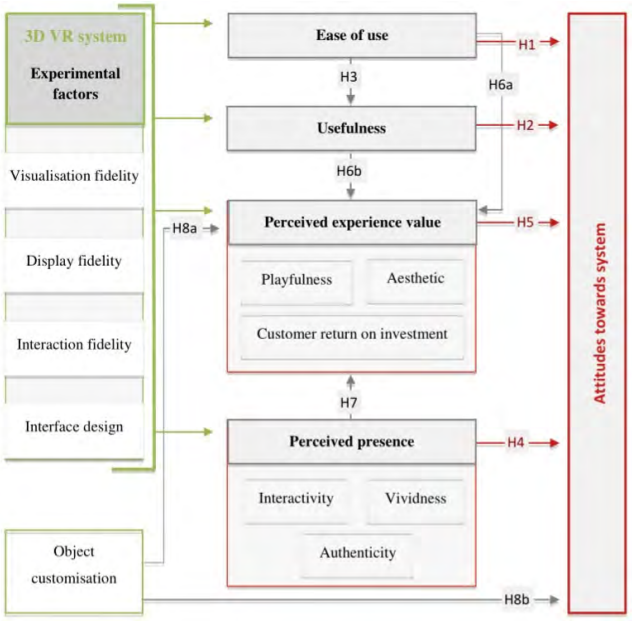

FIGURE 6. Research model: TAM for 3D VR system for luxury brands e-commerce.

customization features are also expected to influence the perceived experience value:

H8a: Object customization capacity in 3D VR system affects perceived experience value positively

H8b: Object customization capacity in 3D VR system affects attitudes positively

A schematic representation of the aforementioned values are depicted below in Figure 6.

VI. RESEARCH MEASUREMENTS DEVELOPMENT

The system evaluation procedure was based on the TAM. Besides the ease of use, and usefulness, additional constructs were intergraded within TAM in order to evaluate the system, taking into consideration the factors expected to influence the evaluation of the system for this particular context. Representative users participated in the user trials. Observations of the users during the session as well as pre- and post-study questionnaires were carried out for data collection.

A. MEASURING PERCEIVED EASE OF USE, USEFULNESS AND ATTITUDES TOWARDS THE SYSTEM

The ease of use, usefulness and attitudes towards the system measurement items have been developed by a previous study and have been used extensively as a guide by scholars [32]. These items were used in the current study with slight alterations to correspond to the system's characteristics.

B. MEASURING PRESENCE

The variables of detecting the perceived telepresence in the VR environments were identified in a previous study based on a consideration that sees telepresence as a function of both technology and perceiver [19]. The variables are vividness

TABLE 1. Presence antecedents.

Presence (PR)		
Interactivity (PRI)		
Speed (PRIS)	*Range (PRIR)*	*Mapping (PRIM)*
Vividness (PRV)		
Breadth (PRVB)	*Depth (PRVD)*	
Authenticity (PRA)		

TABLE 2. Experience value antecedents.

Experience Value (E)	
Aesthetic (EAE)	
Visual appeal (EAEV)	*Entertainment (EAEE)*
Playfulness (P)	
Escapism (EPEC)	*Enjoyment (EPEN)*
Customer Return on Investment (RI)	
Efficiency (ERIE)	*Economic value (ERIC)*

and interactivity, with interactivity defined as ''the extent to which users of a medium can influence the form or content of the mediated environment'', and vividness as ''the representational richness of a mediated environment as defined by its formal features, that is, the way in which an environment presents information to the senses''.

There are two factors that determine vividness; the sensory breadth, i.e. ''the number of sensory dimensions simultaneously presented'' and the sensory depth, which refers to ''the resolution within each of these perceptual channels''.

These two factors are dictated to a large extent by the nature and the features of the medium, which renders vividness stimulus-dependent. Sensory breadth and depth are key functional elements that determine the extent to and clarity with which a communication medium can reach the senses [19].

When studying interactivity, three factors can be considered: mapping, which refers to the ability of the system to map its control to alterations accordingly in the mediated environment, predictably and naturally; speed, which refers to the rate by which input is integrated into the medium, and range, which is represented by the number of possible actions in any time during the experience [19] (Table 1). Although a study suggested that the notion of Authenticity is more efficient than presence in e-commerce [33], another study considered authenticity as a variable in determining presence beside interactivity and vividness [22]. Authenticity was also defined as ''a psychological state in which virtual objects presented in 3D in a computer-mediated environment are perceived as actual objects in a sensory way'' [33]. Drawing on these, the perceived presence in the current study is measured via three variables: authenticity, interactivity and vividness (Table 1).

The current study adopted elements for the interactivity and vividness antecedents from a presence questionnaire, which was widely utilized by scholars in evaluating VR environments [23], while the authenticity antecedents were adopted from another study interested in luxury value perception [33].

C. MEASURING PERCEIVED EXPERIENCE VALUE

Customer perceived experience value is defined as ''the customer's cognitive and affective assessment of all direct and indirect encounters with the firm relating to their purchasing behavior'' [34]. Designing the user experience for online stores takes into consideration all the interface elements including the brand, interface layout, text, sound, visual designs and interaction methods [30]. In fact, the perceived user experience is a multi-dimensional construct [35]. A previous study in this field argues that the experiential value generates extrinsic benefit, which derives from utilitarian shopping, and intrinsic benefit, which derives from the appreciation of the experience irrespective of the utilitarian outcome [30]. This is partly consistent with another similar work, which found that emotions played a significant role in user experience [30]. It was concluded that the perceived experience value is highly subjective; it is a consequence of fun and playfulness rather than task completion [30] and [36].

The current study adopts a similar method to the aforementioned previous studies in evaluating perceived experience value that categorized experience desirable outcomes into intrinsic (hedonic) and extrinsic (utilitarian) values [35]. Intrinsic values are represented in playfulness and aesthetics, and extrinsic values are represented in consumer return on investment and service excellence [35]. Since this study considers a 3D VR system for the visualization and customization part of the e-commerce service, service excellence should focus only on the factors related to this part. Therefore, service excellence is substituted for perceived usefulness and ease of use. Hence, the perceived experience value is evaluated through three antecedents: playfulness, aesthetics and customer return on investment, while the roles of ease of use and usefulness are considered in hypothesis H6a and hypothesis H6b. The playfulness construct is defined by means of the intrinsic enjoyment and escapism, with enjoyment defined as the potential entertainment of the experience and escapism referring to the psychological state of being absorbed in the experience [35]. The aesthetic construct is represented in the prominent visual element of the store environment and the dramatic or entertaining nature of the service performance. Thirdly, there is the customer return on any form of investment, be it financial, time-related, behavioral or psychological (Table 2).

D. MEASURING OBJECT/PRODUCT CUSTOMIZATION CAPACITY

Product customization is a feature developed in the VR system to utilize the capacity of the system in terms of the level of product visualization, manipulation and real-time features changes (Table 3).

The impact of the product customization capacity on the attitudes towards the system was evaluated as mentioned previously while the indirect effects of the experimental variables on the attitudes towards the system mediated by

TABLE 3. Object customization capacity.

Object customization capacity (OC) questions	Experimental variables
The real-time interaction with the bag allows me to understand the features I choose in the bag	System
The 3D model of the bag allows me immediately to visualize the features I choose in the bag	Visualization
The 3D display gives me an accurate representation of the features I choose in the bag	Display
I feel in control over the product features	System

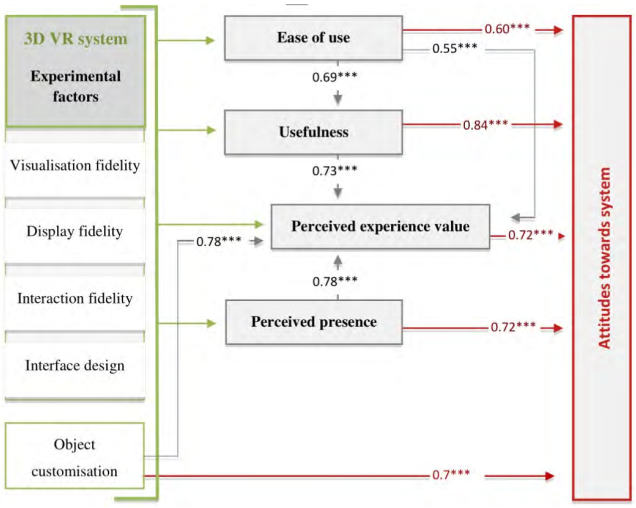

FIGURE 7. The result of the extended TAM model shows the path and R coefficient value.

the ease of use, usefulness, perceived experience value and perceived presence were studied. The experimental variables included visualization, display, interaction fidelity and interface design, presented in Figure 7.

VII. EXPERIMENT RATIONALE

To measure the reliability of the questionnaire, the means of each construct in the questionnaire were assessed for reliability using Cronbach's Alpha. It measures the internal consistency among scale group items [37].

The items of each sub-construct were also assessed for reliability using Cronbach's Alpha (Table 4).

In general, all of the items showed good to excellent reliability (over 0.7 α values), which indicates a good level of internal consistency. Three items were deleted, one from the ease of use and two from the usefulness to increase the values. Table 4 shows the results after the deleted items.

Forty-two volunteer users were recruited to participate in the trials independently. After conducting the trials, the users provided their feedback on a survey and were asked to rate each statement on a 5-point Likert scale of attitudes.

Demographic information was collected; The age of the participants ranged between 18 and 44 (30.73 $\pm$ 6.03); 40% per cent of them aged between 31 and 35 and there is a slight female group bias (8 more females than males). The survey used a 5-point Likert scale ranging from strongly agree to

TABLE 4. Cronbach's Alpha value for the VR system (after deleted items).

Construct	Item No.	Cronbach's Alpha
Attitudes (A)	**6**	**.841**
Ease of Use (EOU)	**3**	**.654**
Usefulness (U)	**3**	**.869**
Presence (P)	**12**	**.875**
– Presence - Interactivity (PI)	4	.823
– Presence - Vividness (PV)	5	.779
– Presence - Authenticity (PA)	3	.766
Experience Value (E)	**15**	**.927**
– Experience - Playfulness (EP)	5	.760
– Experience - Customer Return on Investment (ER)	2	.856
– Experience - Aesthetic (EA)	8	.923
Object Customization (OC)	**4**	**.879**

TABLE 5. Test of normality (SPSS).

Construct	Shapiro-Wilk		
	Statistic	df	Sig.
OC	.911	33	.010
EOU	.947	33	.109
U	.946	33	.104
A	.892	33	.003
P	.975	33	.622
E	.929	33	.033

TABLE 6. Mean, kurtosis, skewness and z-value for the mean of constructs including both interaction method items.

Construct	Mean	Std. D	Kurtosis		Skewness		z-value
	Statistic	Statistic	Statistic	Error	Statistic	Error	
OC	3.3214	.60306	-1.003	.717	-.353	.365	-0.96
EOU	2.6028	.56355	-.632	.717	.349	.365	0.95
U	3.1810	.61495	-.751	.717	-.329	.365	-0.90
A	3.3503	.58196	-1.138	.717	-.494	.365	-1.35
P	3.0746	.57705	-.787	.717	-.280	.365	-0.76
E	3.4415	.47853	-.272	.717	-.746	.365	-2.04

strongly disagree with the statement. The procedure adopted in this study to assess data normality was the Shapiro-Wilk test [38].

Also, the calculation of the z-value is based on the skewness and kurtosis values. Although some of the variables did not seem to be normally distributed according to the Shapiro-Wilk test, the z-values showed different outcomes.

The z-value of all the constructs including the hand gesture and the mouse interaction methods were between -1.96 and $+1.96$ except for one construct (E), which returned a value of -2.04.

VIII. HYPOTHESIS TESTING

The study conducted a linear regression analysis to test the research hypotheses. The final model was proposed with structural path coefficients (R) as highlighted in Figure 6. All the hypotheses of the conceptual model were statistically supported ($p < 0.01$).

TABLE 7. Model testing: Correlation and regression analysis.

Regression path		B	β	R2	p-value	Result
Perceived experience value predictors						
H6a	EOU → E	.471	.554	.307	.000	Supported
H6b	U → E	.572	.735	.541	.000	Supported
H8a	OC → E	.625	.788	.620	.000	Supported
H7	P → E	.653	.788	.621	.000	Supported
Perceived usefulness predictors						
H3	EOU → U	.758	.695	.483	.000	Supported
Attitudes towards the system predictors						
H1	EOU → A	.626	.607	.368	.000	Supported
H2	U → A	.796	.841	.707	.000	Supported
H4	P → A	.728	.722	.521	.000	Supported
H5	E → A	.872	.717	.514	.000	Supported
H8b	OC → A	.674	.699	.488	.000	Supported

In the first section of Table 7, it can be seen that the perceived experience value was used as a dependent variable, and the ease of use, usefulness, presence and object customization were used as independent variables (predictors) with the aim of testing hypotheses H6a, H6b, H8a, and H7.

The results show that the level of perceived presence (H7) and object customization (H8a) can both predict the perceived experience value according to the regression line with high R values (0.788) and (R2 = 0.62) for both. ANOVA was used to carry out the regression analysis with a total degree of freedom (de = 41) and low p-value (0.000) and showed that the variations between variables were totally insignificant (accepting the null hypothesis) and the sample obtained was consistent.

Furthermore, the perceived experience value can be predicted also by the perceived usefulness (H6b) with high R-value (0.73) and (R2 = 0.541). The ANOVA test with (df = 41) shows an entirely insignificant variation between the dependent and independent variables (p = 0.000) and provides enough evidence to accept the null hypothesis.

On the other hand, the perceived ease of use (H6a) can predict 30% of the perceived experience value (R2 = 0.307), with R-value of (0.5). The relationship is statistically significant at the 0.001 level (p = 0.000).

Finally, the last row of the first part of the table testing H3 shows that the level of the perceived ease of use can predict the usefulness with (R = 0.695), (R2 = 0.483) and p-value = (0.000).

In the third section of Table 7, it can be seen that the attitudes towards the system were used as dependent variables and the perceived experience value as independent variable (predictor), in addition to ease of use, usefulness, presence and object customization, with the aim of testing hypotheses H1, H2, H4, H5, and H8b. Of all the predictor variables, perceived usefulness represented the strongest effect on the attitudes towards the system (0.841), followed by the perceived presence (0.728), perceived experience value (0.717), object customization (0.699) and finally, perceived ease of use (0.607). The above results illustrated that the users perceived the utilization of the proposed VR system primarily as a useful tool (0.841) to experience, customize and purchase the complete luxury product. In turn, this reveals that the interaction with the semi-immersive virtual environment and object was enjoyable and did not create any cognitive overload to the users. This outcome reinforces the view that emerging technologies such as VR could assist and enhance significantly the digital user experience resulting in the more successful commercialization of luxury items.

IX. DISCUSSION

The results of the study provide empirical support for the significant impact of the perceived presence, perceived usefulness and perceived ease of use on the perceived experience value. The perceived presence has the strongest influence on the perceived experience value. This result agrees with previous studies in the online commerce sector [20], [30] and [31]. Customers of luxury brands appreciate the interaction with the products in the physical stores similarly as in online shopping [26], which is highly supported in a 3D VR real-time interactive environment. The more the system features absorb the users in a way that engages them in a flexible experience, the more valuable the users perceive the experience to be.

The perceived ease of use has a significant influence on the usefulness of the system as proposed. Both the perceived usefulness and ease of use are also predictors of the perceived experience value for VR luxury brand e-commerce. This finding is consistent with studies [39], [40] and [32]. About 57% of the variance in the perceived experience value can be accounted for by the perceived usefulness of the system. In luxury online stores, the efficiency of the provided service is a principal factor in determining the quality of the service [27].

The relationship between the ease of use and experience value was not exceptionally high (B =.47, P<.001) compared to the perceived presence, albeit positively significant. In a relatively uncommon system assessed in prototype form, it was expected that the ease of use would improve through practicing and familiarization with the technology. This was observed during the user trials, with user speed, adoption and accuracy increasing progressively within the session. This assumption of increased perceived ease of use with increased system familiarity is supported by a previous scholar, who found that familiarity and previous experience with the technology affected not only the ease of use but also the cognitive absorption and the attitudes towards the system [41].

In terms of attitudes towards the 3D VR system, the results of the study provided empirical support for the significant impact of the perceived presence, usefulness, ease of use and the perceived experience value on the attitudes towards the technology. The finding of the study asserts that the perceived usefulness is the main predictor for users' attitude. The 3D VR system is useful for a comprehensive product investigation with the potential to investigate the fine exterior and interior details. This finding is supported by [14].

On the other hand, the perceived presence during the interaction with the 3D VR system had statistically significant influence on the attitudes towards the 3D

VR system. This result is in accordance with a previous study in a VR e-commerce context [20] and another similar study in e-commerce in general [3]. The later study concluded that the higher the image interactivity in the online store, the higher the users' perceived presence and the higher the likelihood that the customer would behave similarly to the real world [42], and therefore, the greater the impact on the luxury brand customers [30]. The findings of the study suggest that the product customization feature in a 3D VR system has a strong influence on the perceived experience value in luxury brands' online stores. Luxury brands' customers look for the uniqueness of products and uniqueness of experience [4]. Notably, about 81% of luxury brands' customers, represented by the study users, prefer to customize the features of a product whilst preserving the brand characteristics (within the brand style). On the other hand, the product customization feature in luxury brands' e-stores affects the attitudes towards the 3D VR system in a positive manner. Utilizing the advantage of 3D VR systems with regards to real-time manipulation of the product and the flexibility in customizing the 3D models' features in real time has elevated the attitudes towards the aforementioned emerging technology within this specific context.

X. CONCLUSION

The paper presented a prototype VR system, which enables the customers of luxury brands to view, interact and customize life-size and photorealistic VR models of items prior to proceeding to purchase. The system was evaluated by 42 users offering positive and encouraging results. The analysis of the derived data and the attitudes to the system in the context of luxury brands' e-commerce data were tested based on an extended TAM explicitly customized for this purpose. The results indicated that the perceived experience value, presence, ease of use and usefulness influenced the attitudes towards the system significantly. Notably, the derived results on the predictor variables highlighted that the users considered this emerging technology as useful (0.841) and enjoyable to operate (0.717). The aforementioned results are encouraging for further experimentation and system development based on such technologies that could enhance e-commerce expansion for luxury brands not only based on the existing luxury brands customer pool but also on new generations of potential customers that are more familiar with emerging technologies. This commercialization avenue, based on online or standalone VR systems could be deployed both in stores or the home environment. Notably, the perceived presence and experience findings support further the view that photorealistic VR visualization and bespoke interfaces could offer a viable alternative or complement current commercialization methods. As such, the implementation of 3D-VR systems for in-store scenarios, for product visualization and customization would be a further area of interest meriting future investigation. In addition, the perspective of the user, as well as that of the store advisor (designer or salespersons), could be further examined. Finally, this prototype VR system could be further applied and evaluated with other customizable luxury goods such as watches, accessories and home furnishings. Fine-tuning the customized TAM and making a comparative evaluation could assist in highlighting the system's potential efficiency and provide the framework for other studies in the field.

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