Servitization through VR Serious Games: From Manufacturing to Consumer Electronics

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Abstract. The provision of services instead of the actual products is becoming a major area of interest for the products provision companies involved in the manufacturing, electronics and construction industries amongst others. Current work in the dissemination of the benefits of this business strategy has highlighted significant issues particular in services that require complex planning and bespoke structure for each client. The provision of such services is gradually migrating from the manufacturing sector to fintech and consumer electronics. The latter is a key part of the automotive industry and the new emerging technologies adopted by the rising market of Electric Vehicles (EV). Based on previous work on gamification of fintech servitization, this work explores the use of gamification to promote and demystify new software services and technologies in the automotive sector. To gauge the impact of gamification for such complex servitization offers, this study employs a case study of a prototype Augmented Reality (AR) – Head-Up Display (HUD) system. The AR-HUD has been evaluated by 15 users in the Virtual Reality Driving Simulation Laboratory (VRDS Lab) aiming to identify user experience (UX) and educate the potential customers on the benefits of these technologies and the value of the relevant software upgrades.

Keywords: Consumer electronics, car software, Servitization, Gamification, User Experience, Augmented Reality, Virtual Reality, Head-Up Display, Simulation

1 Introduction

The current demand for sustainability for resources and products in manufacturing has led to a new business model termed servitization. In this model, the end-user receives the functionality of a product rather than the product itself [1]. Additional maintenance options and output improvements can be included to enhance the product's functionality and lifespan. This business strategy reduces waste and improves profits for the providing company [2]. Servitization has already been utilised in numerous industries with encouraging results [1,2].

Beyond the aforementioned benefits of this strategy, there are also a few drawbacks that could hinder the adaption of servitization offers. The most prominent is the customisation of the required product and services for each user and secondly the subsequent successful explanation of such offers to the customer. These offers can be challenging to comprehend for the majority of potential customers as they typically entail complex and diverse service structures and costings for customers and stakeholders. As a result, this could limit the customers' interest who cannot justify or reflect the services' value to their businesses.

To mitigate this issue various Digitally Enhanced Advanced Services (DEAS) technologies and schemes have been employed. Previous work has presented the use of emerging technologies such as Virtual/ Augmented Reality (VR/AR), 3D, simulations and gamification that could better portray these complex offers. To this end, the use of serious games could entice potential customers to explore in a simple yet enjoyable manner the benefits of servitization offers [3].

The manufacturing arm of particular industries, such as automotive, heavily relies upon the inclusion of consumer electronics in modern vehicles [4-6]. The provision of consumer electronics (CE) and services play a major role in the users' experience (UX) and the decision-making process for the purchase of a vehicle and the subsequent services. This is becoming a major factor in electric vehicles (EVs) that primarily portray the provision of advanced technologies and comforts for the vehicle occupants [7,8].

This paper will initially discuss the current manufacturing servitization process and the use of gamification to present the DEAS offers to the customer based on a real-life example from heavy industry [3-5]. In turn, it will present a prototype AR Head-Up Display (HUD) system that utilises gesture recognition for the interaction with the AR icons to control the vehicle's infotainment system safely [9-11]. As the majority of the future vehicles are expected to have VR/AR capabilities in the cabin, such applications could be downloaded and embedded into the main product/vehicle through a service offer/agreement. The provision of systems that enhance human responses and reduce collisions could further be linked to parametric insurance offers mirroring the selection of applications and systems that support safer driving. The explanation of the system and the related services are presented through a VR simulation serious game that enables the potential customers to experience the benefits of such a product and inform their decision regarding the acquisition of the relevant service.

The AR-HUD system has been evaluated by 15 users in the Virtual Reality Driving Simulation Laboratory (VRDS Lab). The latter is a scale 1-1, fully immersive VR driving simulator developed for the assessment of in-vehicle prototype systems. The results

of the users' responses will be analysed and discussed in contrast to their initial appraisal of such systems before experiencing their functionality in the VR simulation.

2 Gamification and Servitization

2.1 Gamification for Servitization offers

The majority of computer games produced are for entertainment; however, their application can be beneficial for various sectors and disciplines in conveying information, simulation and/ or education.
Businesses in various sectors that do not commonly engage with expertise beyond their specialism may not see the potential of this innovative technology as a solution to their problems. Current studies that utilise gamification for training purposes or to present complex ideas have produced encouraging results [12-15].

2.2 Servitization in Manufacturing, Fintech and Construction

The delivery of the aforementioned automotive servitization offers bears similarities to other servitization strategies, particularly in the fintech domain. Previous work on the latter presented significant difficulties in the explanation of such offers to the potential customers [3]. This was a result of the offers' complexity and bespoke structure which overcomplicated the potential choices. Such offers were met with reduced interest as the customers couldn't identify quickly and clearly the benefits of the offers or the potential risks of not acquiring them.

To alleviate this issue it was deemed essential to simplify the information and explain them through an unconventional conduit namely a serious game. The gamification of such complex information and its presentation through a relaxing and enjoyable channel presented a significant uptake by the potential customers as they experienced the different scenarios and the benefits of the offers through a playable simulation [3-5]. In the fintech project, several financial products were developed to customise the insurance offers for various construction projects.

These offers were designed to reflect different potential weather or construction issues that could hinder or in some cases stop completely the development of a building. The project embedded a complex set of weather data patterns based on previous recorded and analysed information. The above was used to predict potential weather issues that might negatively affect the construction as presented in Figure1 &2.

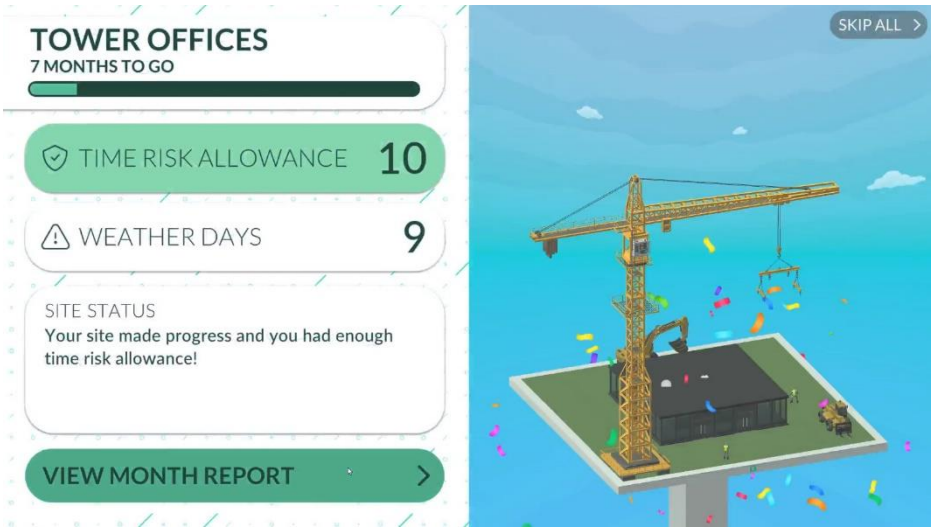

Fig. 1. Screenshot of the 3D application which presents a construction progress overview.

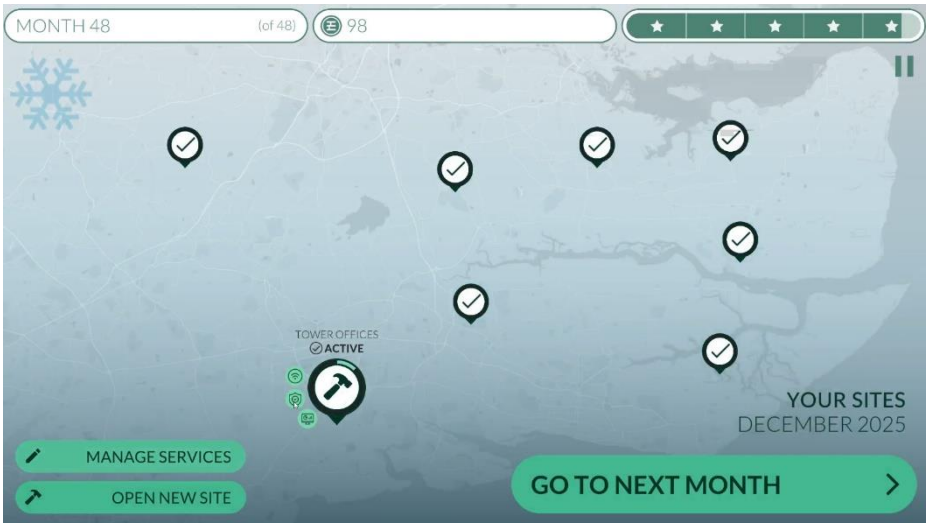

Fig. 2. Overview of the construction sites and weather predictions for each month.

3 Vehicular Consumer Electronics and Servitization

3.1 Current Consumer Electronics Trends

The servitization in the automotive industry currently appears through a two-fold approach. Firstly the automotive companies are experimenting with the monthly or yearly renting of vehicles through a subscription system. Through this avenue, the customer can use different vehicles of the same company or group of affiliated companies, for a period of time, by paying a monthly subscription that covers the use of the vehicle, services and other related expenses [6-8].

These offers vary per automotive company but this approach becomes gradually popular as enables the customer/user to experience different vehicles. The latter allows the customer to use vehicles for their different activities or requirements without committing to one particular type of car that might not be ideal for all situations. In addition, the companies are producing vehicles depending on the customer requirement trends and as such reducing waste both in materials and energy consumption.

The second type of servitization is focusing mainly on the consumer electronics embedded within the vehicles. Typically the hardware is preinstalled in these vehicles and the software can be activated remotely or through a quick visit to the authorized dealer depending on the customer's subscription. These subscriptions can enable various extra features related to infotainment, safety and automation of the vehicles and are becoming a major attraction point, particularly for the electric vehicles (EV). As electric motors have very specific capabilities and output the customization options of fossil fuel engines cannot be applied. As such EV manufacturers have redirected the customers' attention to consumer electronics that could offer additional interaction and user experience (UX) with the vehicle such as different User Interfaces (UI), live traffic visualization, karaoke, music and video streaming, internet browsing and different levels of autonomous capabilities [7,8].

3.2 Vehicular Servitization

Based on the aforementioned fintech and manufacturing projects this work aimed to transfer the development experience and users' feedback to the automotive sector and particularly to the vehicular consumer electronics that employ emerging technologies such as VR/AR, and Artificial Intelligence [16-18].

As these technologies are not commonly available in the mainstream segment of the automotive market, their benefits are unknown to the everyday user and typically appear as another expensive gadget in a long list of add-on equipment in the vehicle's optional specifications. In addition, such devices could facilitate additional software add-ons and updates which could fall within the servitization business model. Yet, these software servitization offers are not typically selected as the hardware equipment is not selected and installed in the original vehicle specifications.

In order to present both hardware and software offers to the potential customers, we considered the gamification of the above through a driving simulator that could clarify the use and derived benefits of the equipment.

3.3 AR HUD Case Study

To test the above hypothesis, this work utilised a prototype AR HUD interface which assists the driver to filter and prioritise the incoming infotainment data. The particular interface presents three types of data related to navigation, mobile phone text messages and phone calls as illustrated in Figure 3. The information is typically controlled and withheld by the software until is safe for the driver to read and interact with them. The interaction is enabled through a gesture-recognition interface that complements the visual User Interface (UI) [9]. This direct manipulation interaction method enables the user to operate the AR HUD without gazing away from the road [19-20]. The latter advantage is in contrast to current Head-Down Display (HDD) and small screen HUD systems [21].

Fig. 3. Simulation Screenshot of the AR HUD and gesture recognition for controlling infotainment sources.

The benefits of the prototype system were documented through previous evaluation studies designed to compare existing Head-Down Displays and HUDs [10,11,20]. However, the demand for such systems is limited due to the inadequate clarification from the current servitization systems in place.

In addition, the potential customers have no prior user experience (UX) of even similar systems and this further contributed to the limited adoption. To identify the intention of the potential customers to use such a system and accept the servitization cost involved this work utilised the gamification option following closely the game design principles used for the fintech and manufacturing projects mentioned above. Nevertheless, the propagation of such systems and devices to newer vehicles is expected as the EV sales and servitization models gradually expand as a market segment against fossil fuel engine vehicles.

4 Simulation

To evaluate the users' experience and acceptance of the prototype hardware, as well as the provision of different servitization, offers based on the software provision this work utilised a full-scale driving simulator based on a real-life vehicle (Mercedes A-Class 2003 model). The simulator immerses the user within a CAVE (Cave Automatic Virtual Environment) projection system. The immersion is further reinforced with the use of surround audio (5.1) and vibrotactile devices imitating road-surface irregularities [10].

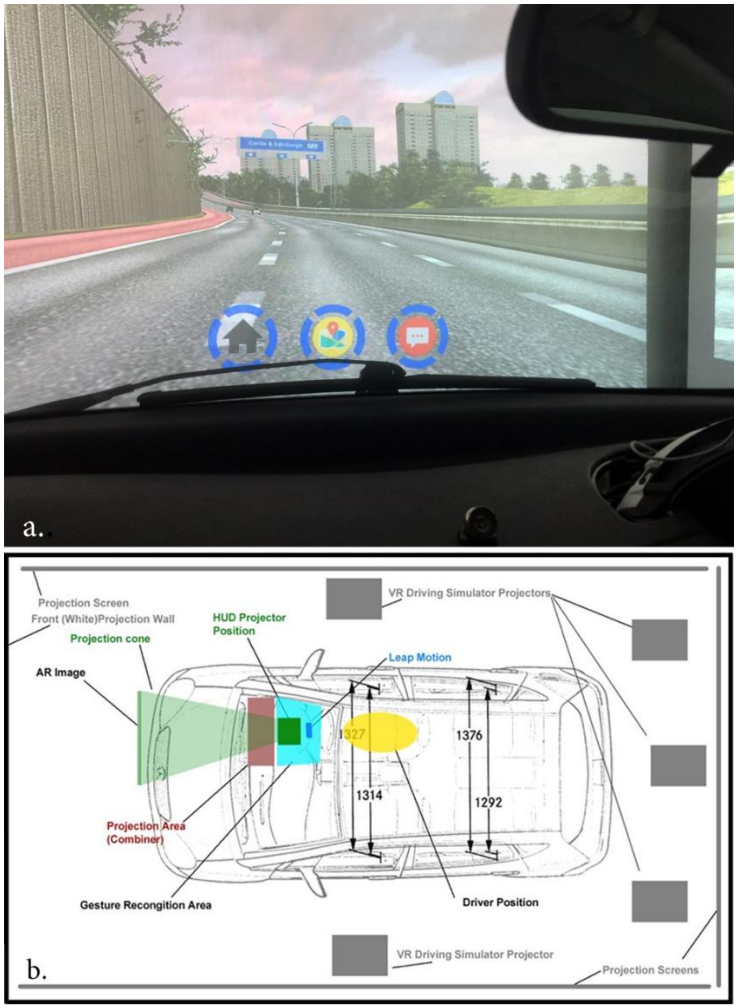

Fig. 4. (a) Driver's and gesture recognition version (b) Top view schematic of the Virtual Reality Driving Simulator laboratory (VRDS Lab)

5 Evaluation

5.1 Evaluation Method

For the evaluation of the system, this study employed 5-point Likert Scale Questions. The evaluation process involved a prequestionnaire of six questions which collected primarily the demographic information of the participants and previous knowledge of computing, computer games and driving habits.

In the second stage of the evaluation, the participants drove in a 28 miles Scottish motorway network between Glasgow, Edinburgh and Stirling. During the driving, a series of events (i.e. incoming text messages and navigation warnings) occurred aiming to distract the driver and increase the probability of rear collision with lead braking vehicles [10, 22, 23]. This scenario was repeated seamlessly with and without the HUD interface, following previous studies for HUD interfaces [10,11, 24].

After the simulation, the participants completed a post-questionnaire designed to acquire information related to their experience (UX), the simulation/serious game concept, and the embedded learning goals for the HUD system servitization offers as presented in Table 1. The questionnaire was based on similar studies that utilised Technology Acceptance Models to measure the user experience and identify the future purchasing tendencies for new products and services [25-29].

Table 1. 5 Point Likert Questionnaire

Q7	The VR Driving Simulator was easy to operate.
Q8	The gesture recognition system was easy to operate.
Q9	The VR Driving Simulator was immersive and enjoyable.
Q10	The AR HUD User Interface (UI), supported the driving experience.
Q11	The AR HUD User Interface (UI), enhanced the driver's safety.
Q12	The benefits of the AR HUD were clearly explained and experienced.
Q13	I can clearly see the benefits of the AR HUD hardware.
Q14	I can clearly see the benefits of the AR HUD software.
Q15	Please rate your preference comparing the proposed AR HUD to the HDD interface.
Q16	Would you purchase the AR HUD hardware for your vehicle?
Q17	Would you purchase additional software updates, subscriptions and service offers for this product?

5.2 Participants

The evaluation was performed by 15 participants, with ages spanning from 18 to 60 years old and with valid driving licences. The group was composed of 6 female and 9 male drivers.

6 Results and Discussion

The evaluation presented that the Q7 (The VR Driving Simulator was easy to operate) was mainly positive (10 users) with only two users finding the simulator difficult and very difficult to operate respectively. This could be attributed primarily to the custom reconstruction of the real vehicle's steering wheel and the modifications for the experimental HUD projection and gesture recognition hardware. As these are still not commercially ready, could hamper the users' ability to operate them effortlessly. The responses on the Q8 confirm the above hypothesis as three users found the gesture recognition system difficult to operate and two users were neutral. The results of Q9 were 100% positive (agree and strongly agree) on the statement "The VR Driving Simulator was immersive and enjoyable". This outcome highlights that the gamification method to present the functionality and benefits of additional software and servitization offers could entice the users through an enjoyable learning process.

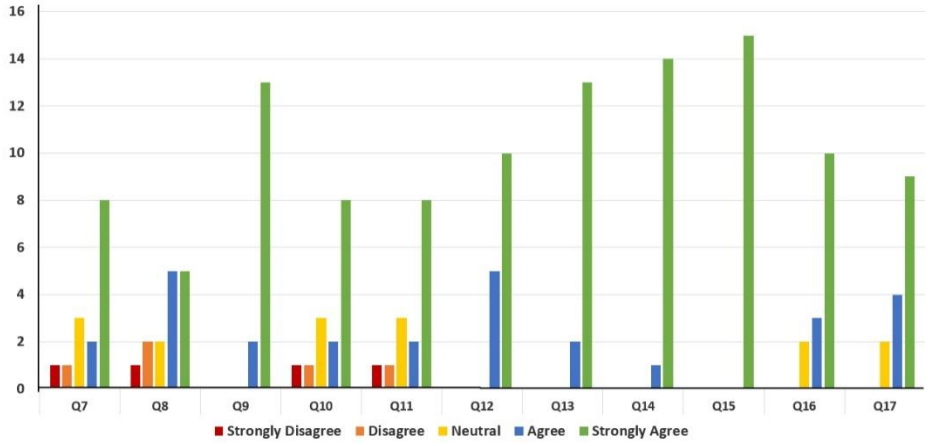

Fig. 5. Post Questionnaire results of 15 users.

The HUD scored equally well on Q10 and Q11 proving again the point that the users experienced the product through this gamification avenue and understood the benefits of acquiring the relevant services that could improve their driving performance and reduce unnecessary distractions. In turn, Q12, Q13 and Q14 received high scores reinforcing further the above assumption.

The users' preference for the AR/ HUD interface (Q15) was 100% in contrast to the typical HDD highlighting a paradigm shift toward the typical vehicle instrumentation. This could be a result of the younger generations of drivers that are accustomed to

advanced user interfaces that support smartphone/tablet interactions and gaming environments overall. Finally, the last two questions aimed to identify the intention to purchase the add-on equipment (Q16) and the software services (Q17) revealed that the users were keen to purchase (agree and strongly agree) both offers. Overall the results of the post-questionnaire illustrated an improved understanding of the software services and offers that could be provided with the use of an AR HUD system. This is in direct contrast to the pre-questionnaire where 100% of the users could not see the point of having a HUD device and the relevant software services. As such, before experiencing the system in the gamified version of the VR driving simulator, the users considered such devices and software applications as contemporary trends and gadgets with no particular value to the driving task. As shown by the post-simulation evaluation results their views on this matter changed significantly. This provides encouraging results for the future use of gamification for explaining complex services to potential customers.

7 Conclusions

The paper presented an overview of the servitization offers that currently advance in multiple domains such as manufacturing, finance and consumer electronics. In turn, the paper demonstrated the use of gamification through a VR driving simulator to convey and explain the benefits of emerging technologies and software upgrades in the vehicular environment. To demonstrate the above this work used an AR HUD interface case study. The aforementioned system was contrasted to the existing automotive technologies and evaluated by 15 users.

The evaluation results highlighted the benefits and drawbacks of using gamification and emerging technologies (i.e. VR/AR) to present consumer electronic products and services. As this was a preliminary study, future work should entail an evaluation process performed by larger groups of users. Additional servitization offers in the form of software upgrades and add-ons should also be investigated to better understand the consumers' behaviour and expectations.

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