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Short Paper

Can Augmented Reality enhance to a greater visitor satisfaction of historical landmarks?

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Abstract

Augmented reality (AR) is gradually becoming more common for marketing of tourist locations to enhance the visitor experience. But do visitors of historical events value the use of this technology and if so, are they willing to pay extra for the experience? As a case study, Calshot castle, part of British Heritage and situated in the New Forest was selected to research if visitors of an event at a historical location identified the use of Augmented Reality as an improvement to their visitor experience and were willing to pay extra for the experience. As the basis for the research an AR prototype was developed that allowed a 3D representation to be projected on top of the screen of a mobile device and as such delivering computer-generated perceptual information in a constructive way on a selected topic both visually and textually. The overlaid sensory information made use of a QR code. Analysis of the results revealed differences in perception between different age groups.

CCS Concepts

• ***Software and its engineering*** → *Interactive games;* • ***Human-centered computing*** → *Virtual reality;*

1. Introduction

As people realised the great potential of Augmented Reality (AR), the use of AR increased within the area of mobile gaming, [HR17], medical training [BGS16] and manufacturing [PERT18]). AR can also play a significant role in higher visitor satisfaction rates which is linked to the motivation of cultural tourists to revisit tourist attractions [TB16] [Ric18]. An increasing range of AR and Virtual Reality (VR) are used by destination marketing organizations to attract visitors for tourist destinations by allowing visitors to explore the destinations before they visit and to engage them during their visit. How the new technologies affect destination visit intentions needs to be explored with further research [MBvN*18]. Historical landmarks, such as Calshot Castle [HER18] which is used as a case study for this research, are regarded as a part of Britain's tourism sector primarily because they attract tourists, sometimes in large numbers. Therefore it is important to examine how the use of technology can be used to influence the decision to visit and to encourage repeat visits.

2. Using Augmented Reality for Tourist Attractions

The rise of cultural tourism as an international phenomenon since the end of WWII is now well established [Ric18]. Cultural Tourism contains several niches such as heritage tourism which showed a total of 516 million international trips in 2017. The increasing application of technology in cultural tourism and the resulting overlaps between real world and virtual experiences will no doubt be an important area of investigation. The question for this paper is how the increasing use of VR and AR on-site at cultural heritage sites can enable visitors to explore the unfamiliar environment in a new and thrilling way [TB16]. Drivers of value are storytelling and engagement/interaction and the rapid increase in mobile applications is evident and is growing rapidly [CDJ18]. Tourism-based AR has been used practically to help visitors find their way around a theme park [WHC17]. Despite AR appearing to be extremely promising, there have been found to be certain flaws with the concept in terms of limitations and usability [RA17]. One question is why would you choose AR over VR? Bekele et al. [BPF*18] found that AR is the preferable at exhibitions compared to the use of VR in virtual museums. One major advantage of AR being implemented into tourist destinations is the accessibility of the technology [SSB*17]. A user's readiness to accept new technology is an important matter in usage of state-of-the-art technology such as AR [CHJ16].

3. Developing the prototype

The main aim of the research was to test if AR offers an added value to the visitor experience. To have a less biased result the development of the protoype was more emphasized on the use of the technology (AR) and less on the quality aspects of graphics and features, which could be a research on his own. This made a Rapid Application Development (RAD) software which could offer decent usability features the preferable choice. The following development methods were assessed in terms of how well suited they are to create a product for testing purposes as described above: Unity + WebVR - One of the leading game engines on the mar-

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ket, Unity [UNI18] is very suitable for the development of virtual 3D space, usually in the form of game 'level's'. It is highly adept at handling 3D objects as well as having a well-developed architecture for player movement and interaction, although not designed specifically for AR, WebVR [Web18]. This option was tested, and it was found that while it was possible to get a unity project onto HTML5, it was not possible to access the rear camera while using WebVR through Unity. Unity + Vuforia Unity paired with Vuforia [VUF18] is the most common way of developing AR within a game engine, allowing the use of objects within a 3D scene to create their own AR applications. Vuforia acts as a 'plugin' for unity, packaged with the game engine by default. Vuforia has different settings to enable AR, as well as game objects that can be put into the scene and customized. The key object is the ARcamera which points to the user's camera feed (sized appropriately to fill the user's screen). The plugin has a device tracking feature so that the phone's gyroscope is used to know where the objects should be shown in relation to the position of the phone. Unreal + ARkit - The Unreal Engine 4 [GAM18] is widely used, and with Unreal engine 4 it is possible to develop a smaller sized mobile game which could be used in this project. ARkit [App18] is supported within the engine as a plugin allowing development of AR applications for IOS systems ï£¡ it is tailored to Apple exclusive developers. Unity + Kudan - Kudan is an professional AR SDK providing a Unity plugin and is considered Vuforia's biggest rival [KUD18]. It can use marker-based AR as well as utilize Simultaneous Localization and Mapping (SLAM) in marker-less AR. The use of SLAM technology allows accurate reading of where to place AR objects and features. AR.js - JavaScript [SCH] AR.js is a development method that relies on the use of three.js, a JavaScript library which deals with 3D objects. AR.js is not linked to a game engine. The combination of Unity and Vuforia most met the requirements of an RAD and was selected to develop the prototype.

4. Methodology

The experiment was conducted in order to gauge how a range of different visitors respond to Augmented Reality (AR) and to assess whether it can be an enabler to enhance their visit. A prototype mobile based AR application was used to demonstrate the type of experience that could be provided as part of a historical landmark visitor attraction. The app was tested at Calshot Castle - a castle located on the south coast of England. The prototype was developed to highlight key features of this castle in order to assess how the user engaged with specific aspects of this historical landmark using AR. The specification for this project meant that it included marker-based AR (AR triggered by the recognition of a 2D marker), marker-less AR, and some form of interactivity, as well as providing as a source of information which can be used and called upon within the prototype for the historical landmark. The test took place during the Easter break to allow to have a wide age range of visitors. Eventually 50 visitors participated in the test. English Heritage provided support by making the appropriate space available and assisting in the physical set-up. The visitors directly tested the provided prototype avoiding in that way the shortcoming that AR app are usually tested within experimental settings. This is a shortcoming in most research and it is recommended to use the app in authentic environment [RBGSS17]. As feedback the visitors filled out a survey to show what they thought of the prototype app, the technology itself, and their opinion on whether it added value to their visit The AR demonstration included a small variety of examples of how AR may be developed to support the visitor experience for a historical landmark. It sought to capture a range of AR features, ensuring that test users were able to evaluate the actual AR techniques when giving their responses. The application was heavily influenced by the castle itself, as this is what gave the historical context to the software application (and is the basis for the subject matter of the app). Overall, the specific subject matter of this prototype meant that research had to be done to find the best features to use within the application in order to enhance the visitor experience, and to effectively assess whether the visitors thought the AR features add value. In short, three distinct areas / features of the prototype were incorporated in order to demonstrate and assess relevant aspects of AR, whilst incorporating subject material that is specific to Calshot Castle (see figure 1).

Figure 1: *Cannon Feature displaying information when tapped.*

5. Method of Evaluation and Results

Based on the assessment of possible development methods, Unity, paired with Vuforia, was used to develop the prototype AR app. Both marker-based and marker-less AR features were incorporated, as well as user interaction and information resources. This choice of development method meant the app was developed in a quite short time despite the wanted usability and functionality. Data was recorded to assess the general view and attitude towards AR. Likert-type questions were used, with responses being read as:

1-2 ratings being treated as an unfavorable attitude.
3 being indifferent.
4-5 being treated as a favorable attitude.

The survey was structured to provide data for analysis by feature, and to be further broken down by age group to determine which feature they favoured. The rationale for the significant questions in the survey are shown below: Question 1 - Question one was used to ascertain how old the user was. This is useful for cross tabulation of the results (see later). As seen in the pie chart, almost half of the responses were in the 51-65-year-old category (45.8 Question 2 - The second question in the survey was regarding whether the app would bring added value to their visit. As can be seen from the Likert Scale Chart, all the scores for all age group is in between 4 and 5, showing that most people believed the app would bring value to their visit. This may indicate the validity of development

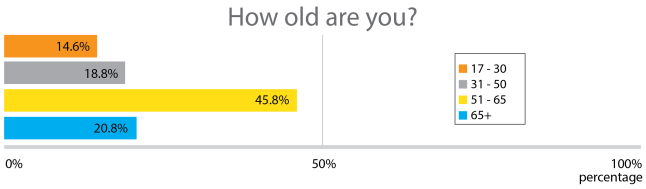

Figure 2: *Question 1: How old are you?*

of this type of application. 51-65-year old found the most value in the demonstration, however there is not enough difference for this to be something to be considered (see figure 3 and 4). Question

With added features, this app could bring a lot of added value to my visit

Answer Choice	1	2	3	4	5	Response Total
	0	2	2	15	29	48

Figure 3: *With added features, this app could bring a lot of added value to my visit.*

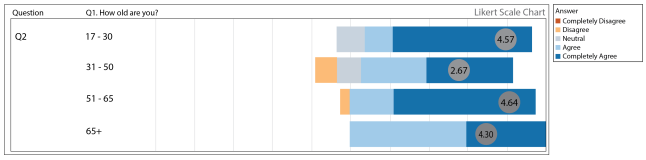

Figure 4: *T-test, no significant differences between the age groups were found - which indicates a high degree of agreement across the age groups.*

3 - Question three was used to assess if people would be willing to pay to use an app of this nature. The results indicate that most people are not willing to pay for such technology during their visit to a historical landmark. This could highlight the restricted potential to monetize AR within this environment. As can be seen from the Likert Scale Chart, there appears to be a factor that the older someone is, the more willing they are to pay for this kind of application. This will be discussed further within the 'trends' section. Specifically, the only age group that is above a score of 3 (Neutral) are 65+, which would indicate that this age group is the only one that would be willing to pay (see figure 5 and 6). Question 4 - Question four was structured differently compared to the other questions. The participant is asked to rate features within an AR app in terms of importance. This can indicate what users' value within an application of AR and so may highlight what aspects of development should be focussed on. What this experiment found, is that within the historical landmark environment, users valued ease of use the most, and valued having access to the app after their visit the least. While having access after their visit will be looked at further within the trends section, participants valued all features within an AR app. It is worth noting that access to the app after visit has a score above 3 which would indicate it is still valued, even if rated below the other features (see figure 7 and 8). Question 5 - The final question is regarding whether the participant would recommend

I would be willing to pay a small additional fee for use of an app like this to learn more about a range of features in a historical landmark such as this

Answer Choice	1	2	3	4	5	Response Total
	7	17	9	10	5	48

Figure 5: *Would you be willing to pay to use an app of this nature?*

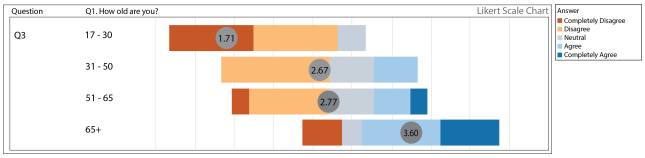

Figure 6: *T-test, dividing the participants by age into two groups - 16 aged 17 to 50, and 32 over 50. A significant difference was found for the will pay (p = 0.04), 17 - 50 Mean 2.25 - which is in the neutral section 51+ Mean 3.03 - which is in the agree section.*

this app to a friend. This question could highlight the growth potential for an AR app in terms of users within this environment, as well as how quickly the use of this technology could catch on. It also provides an overall assessment as to whether the participant values AR as a whole - and compliments question two which may show whether investment in AR is worth it (see figure 9 and 10).

6. Conclusion

Most participants were 51-65 years old, this could highlight the age of many visitors to historical landmarks of this type. Knowing this can help decide who AR software within this environment should be tailored for. We can see that users rated question 2 and 5 highly, indicating that, overall, users find this technology useful, and that it adds value to their visit. This means that investment in AR might be a good decision for historical landmarks. Specifically, we can see this because for questions two and five, all responses for all age groups were rated between 4-5. This is well above the neutral 3 rating and should be taken as a favourable attitude towards AR amongst users. It could be seen that most people were not willing to pay for an AR app like the one they tried out in this experiment. What stood out, however, is that while 31-65-year olds were slightly unfavourable towards the idea of paying, 17-30-year olds were very against it (with an average score of just 1.71), while the 65+ age group were slightly favourable towards paying a small fee. This could reflect the age group's disposable income. Overall, this could point to a potential market for historical landmark AR, charged directly, amongst older people. However, an AR app developed to support a similar environment which attracts a younger age group, may have to be monetized in a different way than direct

Which of the following features do you think are most important for an augmented reality app? (Rate from 1-5, with 5 being the most important)

Answer Choice		1	2	3	4	5	Response Total
1	Ease of use	0	0	3	10	35	48
2	Historical accuracy	0	0	7	12	28	47
3	Visuals	0	1	4	12	31	48
4	Low price / Free	1	2	6	18	21	48
5	Access to the app after visit	2	12	6	15	13	48

Figure 7: *Which features are the most important for an AR app?*

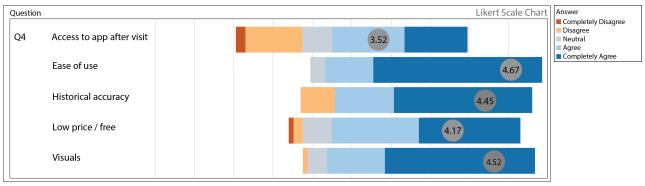

Figure 8: *T-test, all age groups valued ease of use the most.*

How likely are you to recommend the use of an app like this to a friend?

Answer Choice	1	2	3	4	5	Response Total
	0	1	2	21	24	48

Figure 9: *How likely are you to recommend the use of an app like this to a friend.*

payment. This indicates that monetization of the technology may have to be specific to the historical landmark's/attraction's demographic. The 17-30-year old looked slightly unfavourable towards the value of this feature, other age groups had a favourable attitude towards it (see figure 11). The only age group that had an average score between 4-5 however were the 65+ group. This could be due to the time available to this predominantly retired age group, but more research would be needed to confirm this.

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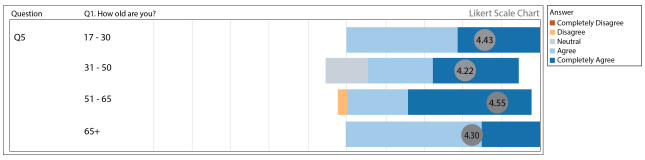

Figure 10: *The Likert Scale Chart and overall response to question 5 is (not unexpectedly) as like question 2. The observation here is that while users find value in AR they would also recommend it to friends.*

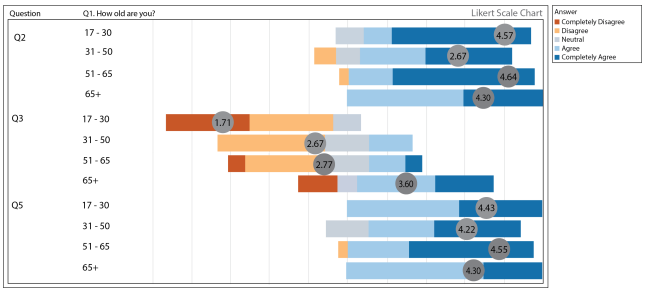

Figure 11: *The t-test shows that having access to the app after a visit was a positive feature but, there was again a difference in the responses from the different age groups.*

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