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Digital R&D Fund for the Arts

Live at Lica: Collection access via augmented reality

Research & Development Report

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Executive Summary

Background

There is significant scope to improve access to museums collections, with almost half of the UK population not visiting a museum in 2012-2013. Augmented Reality provides new opportunities to create access to and deeper engagement with collections. The museums sector has been exploring its potential to some degree, but survey data suggests many more will do so in the next few years.

To date, AR and mobile applications developed by the sector – such as the Let's Explore and Museum of London Streetview apps - have been limited in scope. Academic Research projects in this area have not often been taken beyond initial user engagement studies and released publicly.

AR sits in a distinct part of the virtuality continuum, which ranges from the completely real to the completely virtual. When deciding to deploy AR, there are a number of factors to consider right at the outset, including whether it will be available on a mobile device or wearable tech (eg headset), whether it is sensor or vision based and how the data will be stored and accessed.

The Project

This project took place between April 2013 and May 2014. It involved the creation of an Android mobile application which enables users to view 2D images from the Peter Scott Gallery as though exhibited in a physical space, accessed from any locaton with internet connectivity.

The research question was concerned with whether mobile augmented reality (MAR) could increase meaningful engagement with museums and art gallery collections.

The project team adopted a methodology closely aligned with 'Research through Design'. They produced 5 digital versions of the prototype and these were developed with iterative participatory design.

More than 80 users participated including gallery volunteers and staff, children from local schools and young people from local colleges.

The project team had to respond to several changes in personnel and technical challenges. This resulted in reallocated roles, increased development time, reduced content and reduced promotional activity.

The budget was £96,840 but this did not include significant additional unbilled time given by the project team.

As a result of the project, a free app was launched in the UK in May 2014 and in the USA in July 2014. It has been downloaded to date 45 times and remains accessible to the public. The software used is open source.

A key goal for the arts partner going forward is to find resource to extend the content available. The content management system which is fully functional has been designed to enable this to happen 'in house'.

The project has generated insights concerning ethical use of data, backwards compatibility of devices, publication and copyright issues and the quality of digitised collection images.

Background

Digital technology appears to offer solutions to two material challenges in the museums sector in England – the need to increase and improve access to collections balanced with the need to preserve and protect them.

Whilst provision for access to collections is increasing,[1] almost half of England's population did not visit a museum in 2012-13.[2] Reaching users and finding new forms of engagement is an ongoing challenge for arts institutions, with a constant conflict between resources and access ambitions.

In addition to providing access to their collections, public museums and galleries have a duty of care to the objects they hold. England's museums and galleries maintain millions of objects and artworks, but only a small proportion is on public display. Despite high standards, thanks to programmes such as the Arts Council England Monitored Accreditation Scheme, increasing access to collections whilst preserving them for future generations is an ongoing challenge. Digital technology seems to present the best solution outside the gallery for creating a meaningful experience with the country's collections for the widest group of people.

Digital technologies such as Augmented Reality (AR), and evolving digitisation techniques, are creating new opportunities for public access and engagement with collections. However, users have limited practical experience of AR and, when they do; these are of a particular type such as Layar (www.layar.com) or Wikitude (www.wikitude.com).

The museum sector has started to investigate the potential of AR. Although only 10% of museums taking part in the Museums Association's 2013 Mobile Survey offered augmented reality to visitors, this could more than double in the future. When asked what mobile offer museums planned to provide in the next 12 months, 32% answered augmented reality.[3]

Whilst museums are exploring augmented reality and novel mobile applications they are often limited in scope, for example:

[1] Museums Association, Collections Briefing. http://www.museumsassociation.org/download?id=143114
[2] DCMS, Taking Part Survey (2013).
[3] http://www.museumsassociation.org/museum-practice/mobile-in-museums-2013/15102013-augmented-reality

- The Let's Explore application has some similarities to the one developed in this research but provides a very different user experience. The application uses a similar technique of image detection to detect a particular artwork but this is used simply to trigger additional content within the application in a similar way to systems using QR codes. The application is thus designed to provide additional content as part within the gallery and used directly alongside the artwork. It does not allow the user to view virtual artworks situated in a real physical environment.

- The Museum of London Streetview application is a location-based application that provides users with old photographs of street scenes around London triggered when they enter a specific location. Although the photographs are presented over the normal camera view it is not augmented reality, it's a flat image displayed at a location. This type of system can only be used outdoors and has to work around other limitations In 2011 the British Museum did a small trial of mobile augmented reality called Passport to the Past. Whilst the users enjoyed the experience they suffered from many of the technical issues highlighted in the forthcoming section and the application was never developed further or to a level so it could be released to the public.

Whilst augmented reality has been used in academic research projects to view or create artworks, and even provide alternate infrared or ultra-violet views of a painting, none of these projects have been taken beyond initial user engagement studies. Whereas this project, called Taking the Artwork Home, creates the first mobile augmented reality artwork application made freely available to the general public through an app store and designed so that it can operate outside the gallery setting.

Augmented Reality – an overview

This section of the report provides an overview of what AR constitutes. The generally limited understanding of what AR is made the inclusion of a definition seem important for this report. The overview includes a summary of the principle choices that need to be made when considering how to apply the technology, including specific questions related to:

- Whether to create AR for handheld or wearable devices
- Whether to use a sensor-based or vision-based method for estimating the 'pose' of the camera (its position and orientation)

- What kind of markers to use (a marker is something that is recognised by the software to trigger the AR experience)
- Whether to store data on the device or in the Cloud.

The Virtuality Continuum

Augmented reality is best understood by considering its place on the virtuality continuum proposed by Paul Milgram [Milgram and Kishino 1994]. The virtuality continuum is shown in the figure below and can be regarded as a continuous scale, ranging from the completely real (real environment) and the completely virtual (virtual environment). The space between, generally referred to as 'mixed reality' or sometimes 'hybrid reality' represents the blending of the real and virtual worlds to produce new environments and visualisations, where physical and digital objects co-exist and interact in real time. For example a user could walk around a virtual object in a galley; with the combined view of the virtual and real displayed on their device updating such that they feel the object is actually present.

There are two distinct points within this mixed reality space known as augmented reality and augmented virtuality which can be defined as:

- *Augmented Reality* –a live view of the real-world environment upon which virtual objects are augmented. These objects can take variety of forms such as 2D images or 3D objects that are spatially combined with the real world view and the result is interactive in real time.

- *Augmented Virtuality* – refers to the merging of real world elements within virtual worlds. These physical elements, such as objects or people, are dynamically integrated into, and can interact with the virtual world in real-time.

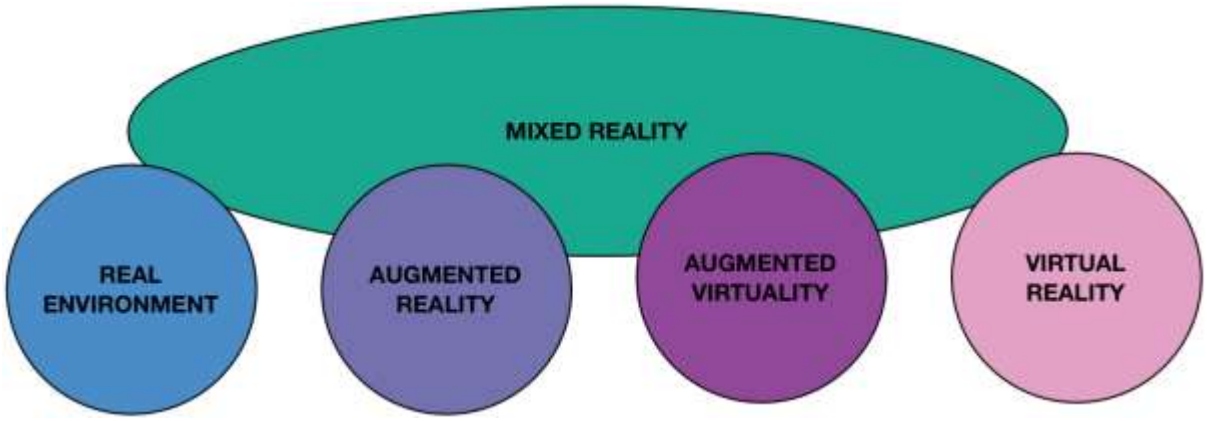

Image 1: Virtuality Continuum

Types of Augmented Reality

The augmented reality research community has traditionally divided Mobile Augmented Reality (MAR) into either handheld or wearable devices, although given the ubiquity of mobile technologies this is arguably changing to a division between mobile and wearable. Wearable AR has not been considered practical because up to now, it has required Head Mounted Displays (HMD) as the viewing platform. At present, phones and tablets are the most common viewing platforms.

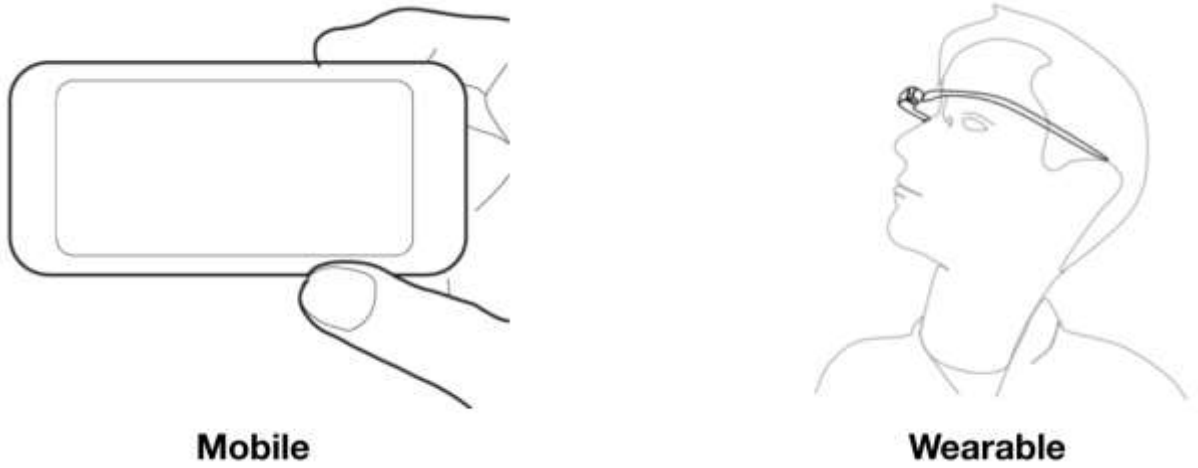

Image 2: Mobile and Wearable AR

Combining the virtual objects and the real-world view

Within MAR there can be significant differences in the implementation, and consequently the operation, of these services depending on the method they use to estimate the position and orientation of the camera (generally referred to as pose) in relation to the real world scene being viewed.

The methods for estimating pose can be divided into sensor and vision-based approaches:

- *Sensor-based approaches* – take advantage of increasing numbers of sensors such as Global Positioning System (GPS), accelerometers, magnetometers (digital compass), and recently gyroscopes on mobile phones. Combining the readings obtained from such sensors allows the camera pose to be estimated in relation to 3D space. Although such systems are relatively easy to implement, the main issue is that the use of GPS limits the applicability of this approach to cultural sites outdoors. This is because GPS accuracy can be highly variable due to the spatial scattering of devices and satellites that will ultimately impact on the sensitivity of any applications developed.

- *Vision-based approaches* – these use two-dimensional (2D) fiducial markers to activate the application and its content – the AR marker or preset examples shown in the figure below illustrate this type of approach. Although accurate, AR or preset markers present a visually disruptive option for the carefully considered spaces of museums and galleries. The MAR field is changing however and many of the new mobile application program interfaces (APIs) that can be used to develop AR applications now effectively allow any image to become a marker, for example, a photograph taken by a smartphone. This offers a more attractive option for galleries and museums, as the marker will not impact on the visual appearance of a curated exhibition space.

- The marker method selected for Taking the Artwork Home was a user defined approach. Users are encouraged to make use of their device to create markers from content within the room around them - for example pictures on the walls - that are then 'replaced' with virtual content by using the app. This also means the Taking the Artwork Home application can provide access to collection objects held in storage in the public display spaces of the institution without the need for disruptive physical markers in the space.

- *Future approaches* – Potentially technology enabling natural feature tracking and scene reconstruction would mean users would simply point their device at the environment, effectively creating a 3D virtual map of the world allowing digital content to augment almost anything. However, there is some way to go in adapting these techniques so that

they can be easily implemented on mobile phones, for example, even though these maps are generated in real time they are currently limited to static environments.

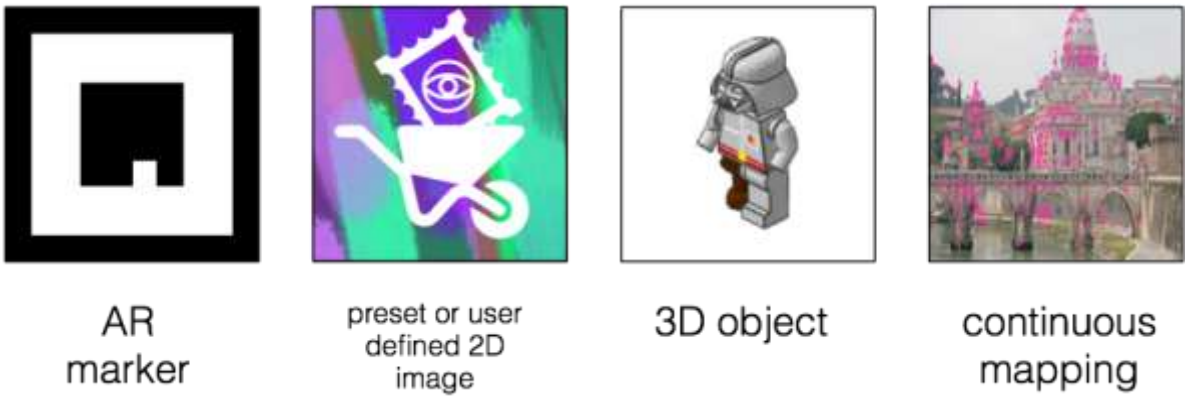

Image 3: Vision Based AR Techniques

Performing AR tasks – device or cloud?

As with other intensive tasks running on phones and tablets, whether to perform the entire task on the device or pass the task to a server on the network or a Cloud based service is an important choice. In terms of MAR both the detection of markers and the storage of the images could reside either on the device or in the cloud. Performing the entire task on the device would increase the size of the application considerably and potentially limit the number of devices on which the application could run due to computational power.

Doing everything in the cloud requires the device to have a strong network connection at all times and a break in connection or network lag may make the app feel less responsive. This decision ultimately affects the user experience that can be created but there are many factors to weigh up.

Summary of key choices for AR

The following figure illustrates the series of choices as they might flow for a museum or gallery considering using AR:

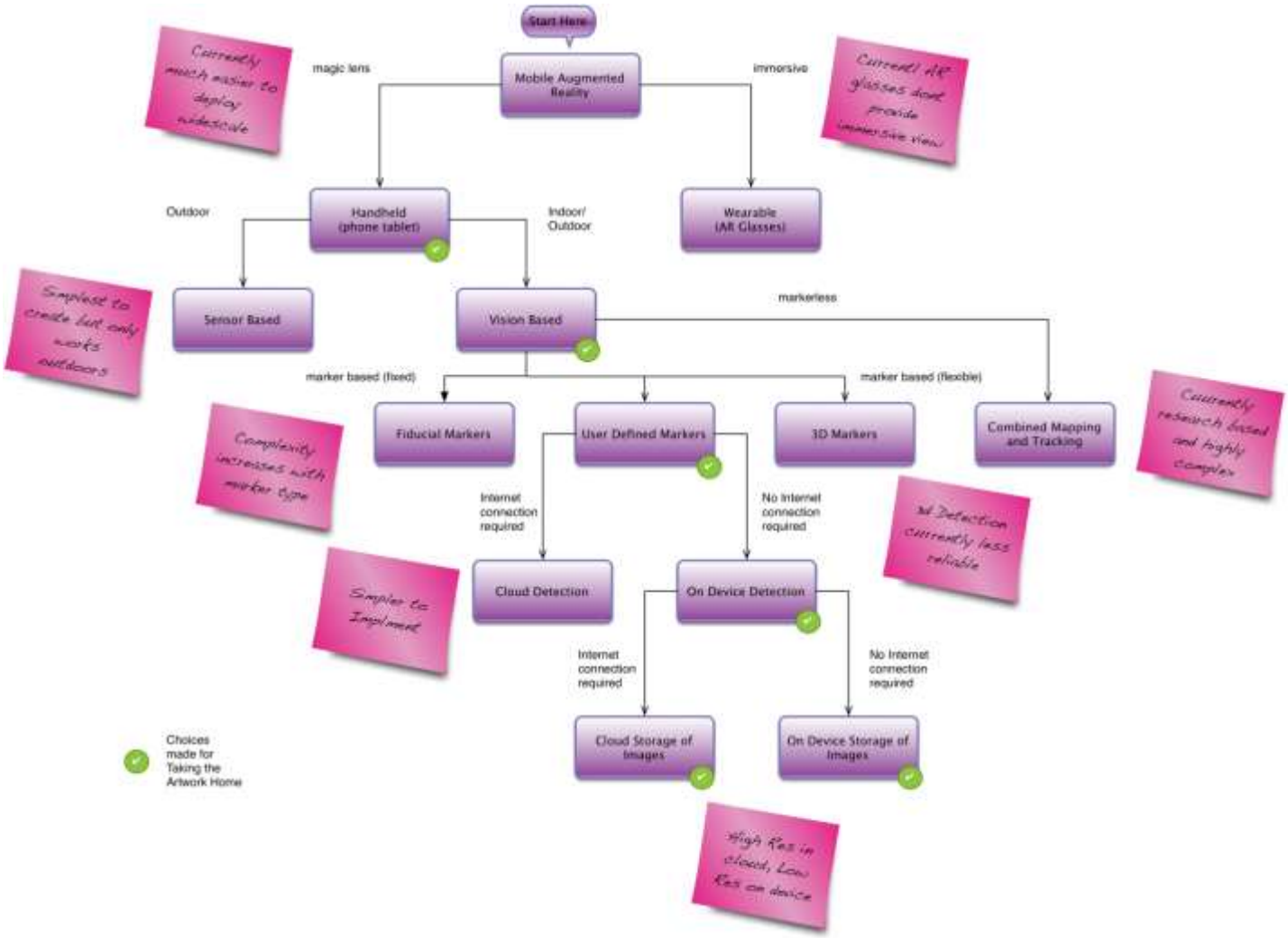

Image 5: MAR Decision Tree

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The project involved the creation of an Android app which enables users to view 2D images from the Live at Lica collection as though exhibited in a physical space.

The Project

The project was called 'Taking the Artwork Home' and it took place between April 2013 and March 2014. It involved the creation of an Android app which enables users to view 2D images from the Live at Lica collection (including items in storage) as though exhibited in a physical space. Viewing the images could take place at home, in the gallery or in any other location with an internet connection. The app was to be taken to 'proof of concept' stage.

In its most simple form, the project asked the question:

> Can MAR increase meaningful engagement with museum and art gallery collections?

This was borne of a sense that building awareness and understanding public art collections, as well as providing the opportunity to curate, share and comment on online 'exhibitions', had the potential to increase the knowledge, empowerment and pride of the communities served by the institutions holding the collections. A further benefit could be the potential to support learning and education by growing teachers' confidence in accessing collections as classroom learning and discussion tools.

The project partners

The partners involved in the project were Live at LICA, Imagination and m-ventions:

- Live at LICA's purpose is to cultivate excellence in and engagement across the performing and visual arts. Live at LICA supports talent through practice-based initiatives and provides audiences and its local communities with opportunities to participate in and engage with the contemporary and inspiring - making their own contributions to cultural experimentation.

  Based at Lancaster University and linked to its knowledge rich environment, Live at LICA's presentation and preservation of the contemporary arts and opportunities for artists, arts professionals and arts research are valued in regional, national and increasingly international contexts.

- A key element of Live at LICA is the Peter Scott Gallery, an accredited museum and art gallery which houses an international art collection including the most significant collection of Pilkington's Tile & Pottery Company material in Britain.

- Imagination is an open and exploratory design-led research centre at Lancaster University. They conduct applied and theoretical research into people, products, places and their interactions. They work with a variety of organisations to provide fresh perspectives on real-world issues and facilitate innovation.

- m-ventions are a specialised software research and development unit who have expertise in developing cutting edge games and experiences on mobile and tablets often using technology that has not yet reached full maturity.

All the partners saw distinct opportunities in carrying out this research project:

- Live at LICA saw the chance to create a new and dynamic digital experience for their audience, to meet its own audience development aims around its museum and gallery work, and to develop, on behalf of the sector, a freely available digital tool normally out of reach for small museums and art galleries.

- For the researchers of Imagination it was an opportunity to evaluate an agile participatory design process that explored the direct impact of technological decisions on the experience of users. Their goal was to create a product that uses the most advance technology available while also being useable for a range of audiences. As the team had not worked directly with an arts organisation as part of a research project, they were keen to explore such relationships and what tensions this might reveal in terms of our more typical research process.

- For m-ventions this was a very different way of working with a client, which would allow the company to explore different technological options throughout the process and get feedback both from user groups and the arts organisation. The aim was to learn new insights on to improve the development process. The unique opportunity to one of the

developers effectively embedded with the research team was also exciting.

The team had worked together informally prior to the project. With the majority of the team working for, or linked to, Lancaster University, the partnership represented a solid and harmonious team that would limit the risk of disagreement, particularly over a short timeframe.

Overall research proposition

This project sought to demonstrate the possibilities of audiences and sector professionals engaging with museum collections through MAR. This was to be demonstrated through the development of an application through to a proof-of-concept stage.

The project was designed to build on existing work aimed at encouraging public engagement with the gallery's collection, specifically the digitisation and cataloguing of the collection using the Modes museum database software. This was particularly important as it would be a natural extension of work designed to provide better access to aspects of the collection that often sit in storage; a challenge that faces many institutions with collections.

The Taking the Artwork Home team were particularly interested in using AR based technology to recreate what a user might experience in a gallery; that is, to recreate the experience of viewing an artwork as if situated in physical space and provide a more dynamic experience than existing digital viewing platforms. The project wanted to consider the differences between viewing work digitally and in the gallery space – with the intention of increasing qualitative engagement with both types of experience.

Furthermore, the data generated by users engaging with the collection was expected to provide valuable insights around what aspects of the collection people found interesting, how they curated and combined particular artworks would hopefully reveal even more. Ultimately this data could suggest new themes for exhibitions, events, projects and schemes of work that might attract a wider and more diverse audience – as well as telling the gallery more about the community it serves.

In summary, Taking the Artwork Home set out to explore:

- The impact of MAR on user engagement and user experience with the collection
- How user generated content reveals community interests
- The emerging curatorial and collections strategies as a result of this user-generated content
- The lessons learned for the wider arts sector, particularly regarding access, rights management and Intellectual Property (IP).

Project Methodology

The research approach adopted by the project is closely aligned to Sir Christopher Frayling's definition of 'research through design' [Frayling 1993, Frankel and Racine 2010]. This approach was chosen to avoid an artificial project schedule and maintain flexibility around the development to the application. The project used pre-determined milestones as agreed with the project funders to act as way-markers to ensure the project developed at the required pace. However, between milestones a flexible approach to the project was maintained to suit the unpredictable nature of research & development work, this was done in the following three ways:

- Research into the possible implementations of MAR were evaluated with different user groups as part of the design process - research papers suggest approaches based on this method are both desirable and productive for future practice [Gaver 2012] rather than the artefact itself.

- The end product was viewed as a prototype artefact in which all the thinking that went into producing it is embedded.

- The end product was not viewed as a finished ready-to-market app, but more an artefact in perpetual beta with implications for designers to take further.

The partners took into account the limited user experience of AR in the design of the project methodology. They decided not to utilise a co-design approach, through which the partners would act as facilitators for the users who would design the application, but chose an iterative participatory design approach to design the system instead, involving five digital versions of the application. The following figure illustrates the development process over the project duration:

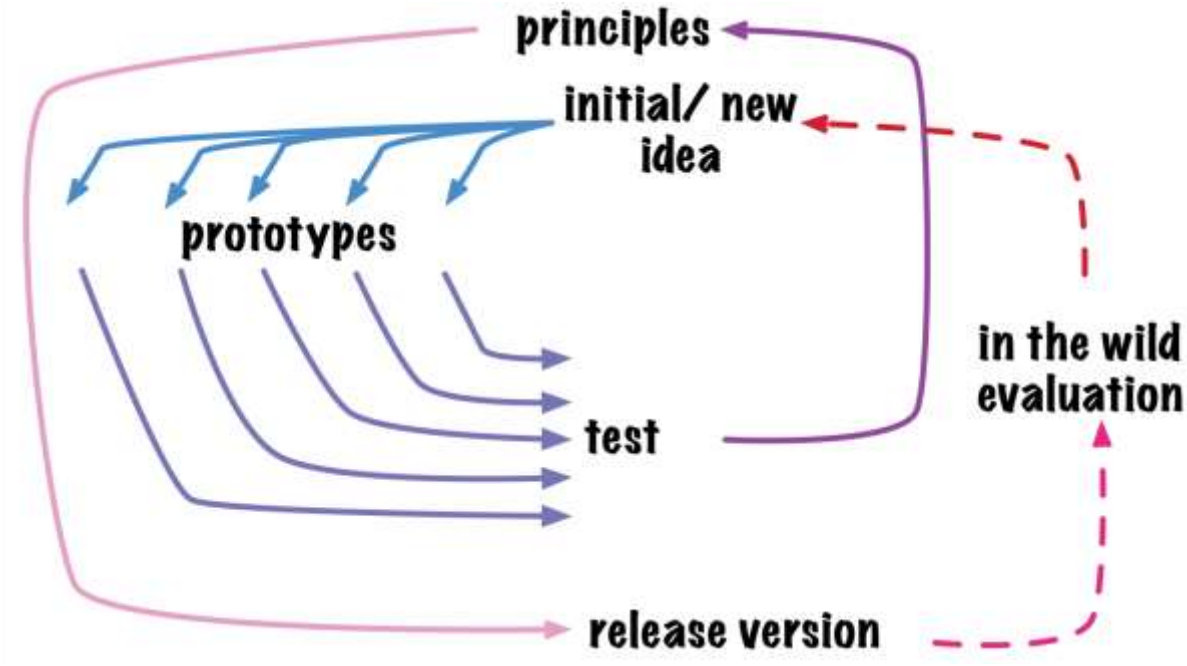

Image 6: Taking the Artwork Home
Research and Development Process

Images 7 and 8: images of user evaluation sessions of prototypes

User Evaluation Sessions of Prototypes

The project team deliberately adopted qualitative rather quantitative approaches to consider the overall user experience of the application rather than simply the usability or utility of AR in itself.

As part of the development process, there was direct engagement with 80+ users as part of five participatory design workshops. The groups included:

- gallery volunteers and patrons of the gallery
- children from local schools (Quernmore Primary School, Clitheroe Royal Grammar School) varying in age from 6-18
- a local college (Beaumont College) that provides courses for learners between 18 and 25 with a broad range of physical and learning disabilities.

In addition, an informal group of five testers were recruited who were able to able to install intermediate builds of the application remotely on their own devices to ascertain any obvious usability issues.

Each of the participatory design workshops lasted approximately one hour and followed the same format. The application was provided running on a range of phones and tablets to participants who were asked to speak aloud any questions that arose during use e.g. 'which button should I press?' At the end of every session there were group discussions to capture what they liked/disliked about the application and potential new features they thought could improve the application.

The project team were especially interested in:

- Were instructions/ prompts/ cues necessary?
- Were there any glitches with the interface?
- How easy was the app to use?
- Were there any other glitches/ bugs?
- What were the potential insights for future development of the app?
- How did the Mobile Augmented Reality experience compare with visiting a gallery in "real life"?
- How did the users describe this experience?

Workshops addressed different and specific aspects of the application in turn. The first was prototype (V 0.1) was used primarily to introduce users to the concept of AR so they could better discuss how they might use an AR app. Later prototypes were used to ascertain the advantages of storing images on the device over cloud storage and its effect on the user experience.

The prototype evolution was:

- Version 0.1 Introductory AR application - May 2013
- Version 0.2 On-Device Marker Tracking and Storage - August 2013
- Version 0.3 Cloud based Marker Tracking and Storage - October 2013
- Version 0.4 App navigation and exhibition creation - Jan 2014
- Version 0.5 user generated marker creation - March 2014

Resources

The roles and responsibilities were distributed as shown in the diagram below.

Image 9: Roles and responsibilities of staff

This division of responsibilities differed from our original project proposal because one of the key team members left post before the project fully started.

Changes to the project team

Changes of personnel during the course of the project had not been anticipated, largely because the partners were a pre-formed group all working for, or with direct links to Lancaster University. Whilst this created an excellent working relationship that was cemented prior to the commencement of the project, it perhaps created a sense of false security around the stability of the project team. In fact there were a significant number of changes to absorb; for example, even when departing staff were replaced, incoming staff weren't in a position to contribute to the project fully. The following changes in the team had the most significant impact:

- The former Director of Live at LICA, who was a key part of the original team and bid left before the project fully started. This resulted in the gallery's Curator (Richard Smith) stepping in to fill this role and then maintaining involvement even after a new Live at LICA Director was appointed. This Live at LICA staff change also had an impact on the project through an increased Live at LICA workload for the Curator.

- The Live at LICA Gallery Assistant who had supported the preparation of the collection also left at a key moment during the project, further increasing the workload for the Curator and squeezing capacity around gallery work.

- A member of the research team (Emma Murphy) left post towards the end of the project as it entered the final reporting stages. Although there was a continued to contribution in agreement with her new

> employer, the change in institution resulted in an impact on research and reporting – communication became more of a challenge and there was much greater effect on the remaining researcher's time (Paul Coulton).

Whilst the project still produced the required work and met agreed milestones, the changes invariably impacted on the output of the project. This was compounded by the need to adapt to external influences that are explained later in the report. Whilst the team was able to avoid delays and undertook the research and development aspect of the project, there was no scope for growing aspects of the work that would have provided additional feedback; for example, increasing the content of the application beyond the test material or brokering new partners for distributing the application. This type of work would most likely point to further areas of development; however, it is an area of work that has continued beyond the funded project period.

The planned time contribution of staff was exceeded, particularly by the staff that remained after others moved on to new posts elsewhere. The proposed working days ranged from 0.5 to 1 day per week. The project remained reasonably faithful to the proposed budget in billing terms. However had the whole team been submitting invoices for actual worked hours, this would have been different. M-ventions did not allocate time but instead agreed delivery of a staged application; this lead to the most accurate way of managing workload.

At the mid-point of the project it was recognised that due to unforeseen challenges, the app would benefit from more development time within the funded project period – a decision was taken to reduce the small percentage of resources originally directed at promotional work and invest in further development. If we were to undertake the project again, a more detailed review and breakdown of tasks, particularly following staff changes would be adopted to rely less on the enthusiasm of the team.

The partners and individuals in the team led in their areas of knowledge. As the project progressed a greater emphasis was placed on research and development, based on the expertise within the team it was agreed that the app development and research would be led by the research partner with the technology partner, whilst the arts partner led on collections management. All partners were involved in testing and analysis of findings.

The budget

The total budget for the project was £96,840 - which covered all aspects of the project. The budget was followed closely in areas where fixed procedures existed, such as the researcher costs managed through the Lancaster University Research Office. However, in terms of individual team members' investment of days and hours in the project the contribution went way beyond the time and effort anticipated. The project managed to maintain essential flexibility non fixed costs such as consumables to allow resources to be directed where they were needed most – which ultimately was development. It was ambitious to expect to realise a product involving third parties and meet all the needs of the Digital R&D scheme within a year using the available budget.

As key members of the team left, the project management and delivery of the project became more devolved. Regular team meetings ensured that the remaining members were aware of project milestones and any issues; at this stage the Lancaster University link and close proximity of the partners became vital.

The following table shows the proposed budget against actual budget:

Item	Proposed budget	Actual budget
Arts – collection preparation, copyright, workshop organization, user evaluations	£25,200	£25,200
Researchers- project planning, research questions, methodology, user testing, application design, user evaluation, results synthesis	£28,100	£28,100
Application Development – prototypes, user evaluations, final release	£18,000	£33,145
Application asset design	£2000	£2000
Test Devices, Sim Cards (for workshop evaluations) & Software Licenses	£10,000	£4000
Publicity and Dissemination	£5000	£1000
Travel	£4000	£2000
Contingency 5%	£4540	£1395
Total	£96,840	£96,840

Table 1: Budget

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Visually, the app has the appearance of traditional gallery space, which should be easily understood by those less familiar with museums and galleries as well as users who are knowledgeable about the field.

Results

The application

The main output of the project is the application that allows users to access high resolution reproductions of the Peter Scott Gallery collection, including objects held in storage at the gallery, and view them as though in the space they occupy. The application has been designed to be used across a range of Android devices. The aesthetics and navigation of the application were designed to provide a good user experience. Visually, the app has the appearance of traditional gallery space, which should be easily understood by those less familiar with museums and galleries as well as users who are knowledgeable about the field.

The application has a number of basic functions, shown in the images below:

- creating an exhibition (a)
- viewing an exhibition (b)
- help (c)
- settings (d)

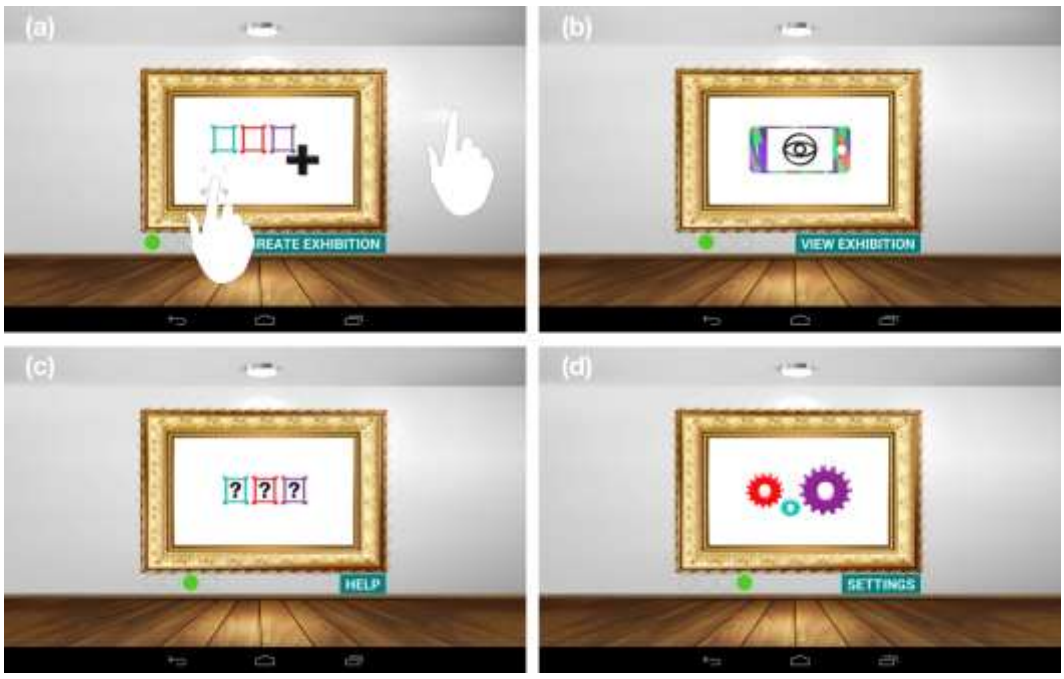

Image 10: Basic functions of the app

Creating an exhibition

The user selects three objects from the available works by tapping on thumbnail images. The user then names the exhibition and provides a description. At this point the user can also define how they wish the artwork to be displayed in proportional terms (i.e. display at the original dimensions of the artwork or a custom display size.)

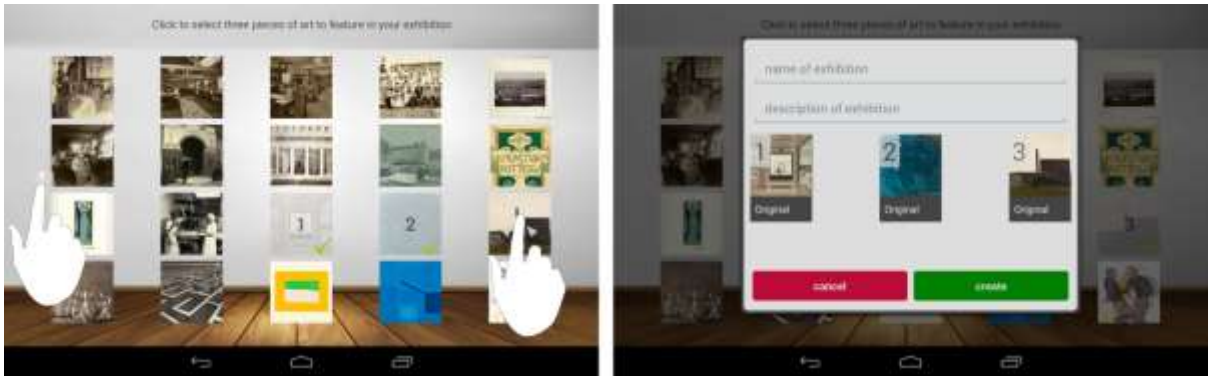

Image 11: Example of creating an exhibition

Users can select from either their own exhibitions or others created by the community, this is achieved by simply pressing the view button to enter AR mode to view the images. To view exhibitions the user must establish three 'markers'.

Markers are visual triggers for the app to indicate where collection objects will appear in a space. The user can define their markers by using the camera built in to their device; the user is able to access this function in the settings menu. This will allow the user to 'replace' objects in the space they occupy with collection objects, for example pictures hanging on their walls. In addition, three AR markers were created for the project and are available for download. They need printing and placing in the space where the user is viewing the work, whilst not the preferred way of using the app, especially in terms of environmental sustainability, it is a useful way of users understanding how the markers work and to view objects through the app in spaces without any discernible markers e.g. a room without furniture or decoration.

Included in the right hand corner of each image are details about the artwork the user is viewing. Crediting work is very important to artists and the museum sector, but this was not a key concern of the individuals in the

app test groups. Crediting and copyright became key issues when handling reproductions of artwork during the project and is one reason why the user has to agree to the terms and conditions before they can start using the application – this is considered in more detail in the insights section of this report.

The workshops produced the following key findings to influence prototype development:

- Locally stored content was faster to load and thus users felt it was more responsive and therefore there was some debate as to whether high resolution images should be stored on device. In the end, a system was put in place whereby low-resolution images were used to allow faster exhibition creation and viewing of artwork details - the high-resolution images are loaded dynamically when an exhibition is viewed. If no network connection is available the application uses the low-resolution images.

- One of the most straight forward features of the application is the exhibition creation function, although a number of users expressed a desire to have more than three choices of artwork for their personal exhibition. In the end the partners decided to restrict this to three because the associated feature of user generated markers proved more difficult for participants to pick up quickly; they often required instruction, or at least explanation of what a marker was. This was attributed to users' experience of MAR, rather than their ability to undertake the necessary steps to create and use markers. However, these explanations were used to inform the HELP instructions for this feature which was tested in the final alpha prototype.

- One of the most important features for users was a bespoke animation when the application is scanning the area in front of the device camera. The scanner animation, similar to those utilized for Quick Response (QR) code detection was created, as user studies showed that this helped users understand what action they were supposed to perform in order to be able to view the image.

- The developer had experience of HELP options added hastily at the last minute, to the detriment of the user experience. To avoid this situation, in the final stages of developing the application before release on the

app store, the HELP information provided in the application was evaluated in some specific user testing sessions. This testing resulted in the learning that users of phones and tablets generally preferred symbolic rather than text heavy instructions.

Part of the prototyping evaluation phase included an evaluation of the experience provided by the two main AR Software Development Kits (SDK) currently available to developers, one was from Metaio (//www.metaio.com) and the other from Vuforia (//www.vuforia.com).

When discussing the possibilities of AR with the user groups, all expressed real excitement for the prospect of interacting with 3D representations of objects within the gallery collection. There were some particularly imaginative uses from the younger children, although these were generally well beyond the scope and capabilities of the project.

The results of the final workshops informed the minor tweaks to the first beta version released on the app store in May 2014. The initial release was deliberately limited to the UK only and without publicity so that it would be possible to check that it installed and operated correctly on a range of devices before being offered to a broader audience.

Once 'in the wild' the app has constant evaluation and feedback via Analytics from Google Play and user comments. During the development of the five versions of the app for the project, the informal testers downloaded the app to provide more structured feedback to generate improvements.

Application Content Management Tool

The project originally aimed to utilise the Modes content management system (CMS) to support the application after completion of the development phase. Modes was selected as the most widely used collections management system for small and medium museums and galleries and the organisation has a cooperative approach to its work. Modes has been active for over 25 years and all Modes users who pay an annual subscription fee automatically become full members of the Modes Users Association (MUA) - an active community of more than 630 members (including Peter Scott Gallery) that play a part in developing the Modes collections management systems. By creating an app that could 'speak' to Modes, the app could be a tool easily adopted by many institutions using their existing data. Modes was attractive because its users play a part in defining the future of the software,

it seemed the possibility of developing a 'plug-in' app would have a benefit for both the project and Modes.

Although initial conversations with Modes were very positive, they did not take up engagement with the project because of their own workload. The main driver for engaging with them was to better understand the needs of the Modes system, but there had been no assumption about their time input or commitment required to adopt the product at the end of the project. In future, the project partners would be careful about assumptions about the availability of third parties to engage with the project.

It became clear that waiting for Modes to have window of time to engage with the project would extend the project timeline significantly. The project partners decided instead to create their own database system to store and catalogue the artworks used by the application. Whilst this was not ideal, considerable effort was made to ensure that the Extensible Markup Language (XML) schema created was compatible with the one used by Modes so that in the future this integration would be a relatively simple exercise. This has also allowed content to be updated by the gallery, therefore not relying on the technology provider to update the app. This avoids ongoing costs that would be prohibitive to most small institutions.

The figure below shows the prototype CMS which was developed in conjunction with the gallery staff. Although fully functioning at the end of the funded period of this project, it is expected that a relationship between the gallery and the developer will remain so future enhancements can be made if necessary.

Image 12: Application Content Management System

Downloads

The release of the final beta version has resulted in 45 installs which have been highly rated. The project team received only minor feedback about the position of the view icon on the exhibition screen. Although these numbers seem modest they are fairly typical of app stores when no publicity has been initiated [Coulton and Bamford 2011] and that the app requires a later version of the Android operating system; because the app isn't backwards compatible, it limits the number of devices on which it can be installed.

In addition to the UK release, the app became available to download in the USA on 24th of July 2014 and the aspiration would be to open it up to the rest of the world. Google analytics and user feedback through Google Play will enable future longitudinal evaluation that will focus on the data resulting from the app 'in the wild' and how it is viewed by users from around the world.

Can MAR increase meaningful engagement with museum and art gallery collections?

In relation to the research question, the project has so far found a positive impact on user engagement gallery collections, however, because it is a new technology for many users it is not [illegible] with museums and

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It is something many of our students have never seen before and was a great hit, keeping them engaged from the outset for an extended period of time – user feedback

yet intuitive – the effort needed to engage with the technology in these cases can detract from the experience.

The feedback from the 80+ users who took part in the project and people who have engaged with the app at various sector events has been extremely positive with the majority delighted by the different experience AR provides to viewing a flat image on a screen.

> "It is something many of our students have never seen before and was a great hit, keeping them engaged from the outset for an extended period of time."

> "I held a phone and made different pictures come alive"

However, what is also clear is that AR has still some way to go from being 'domesticated' for general use and applications should add complexity slowly so that users can build up a greater understanding of the affordances such an experience presents in use.

It has been more difficult to ascertain how user-generated content reveals community interests and what the emerging curatorial and collections strategies can be as a result of this user-generated content. This has largely been dictated by the project when it necessitated a shift in focus to development; increased downloads and making the application more visible to a wider audience would only be part of the solution however. Further time would need to be invested in this work which could include, for example, generating more content for the app and encouraging specific demographics to use it. The application has enough content for users to enjoy trying the application for the first time, but insufficient content to support continued engagement. A future aim is therefore to increase the content for the application.

However, the app has the functionality to provide data through Google Analytics, so the app is well placed to provide data that can be assessed to further understand users and the role of the app in the future - as shown in the following figure:

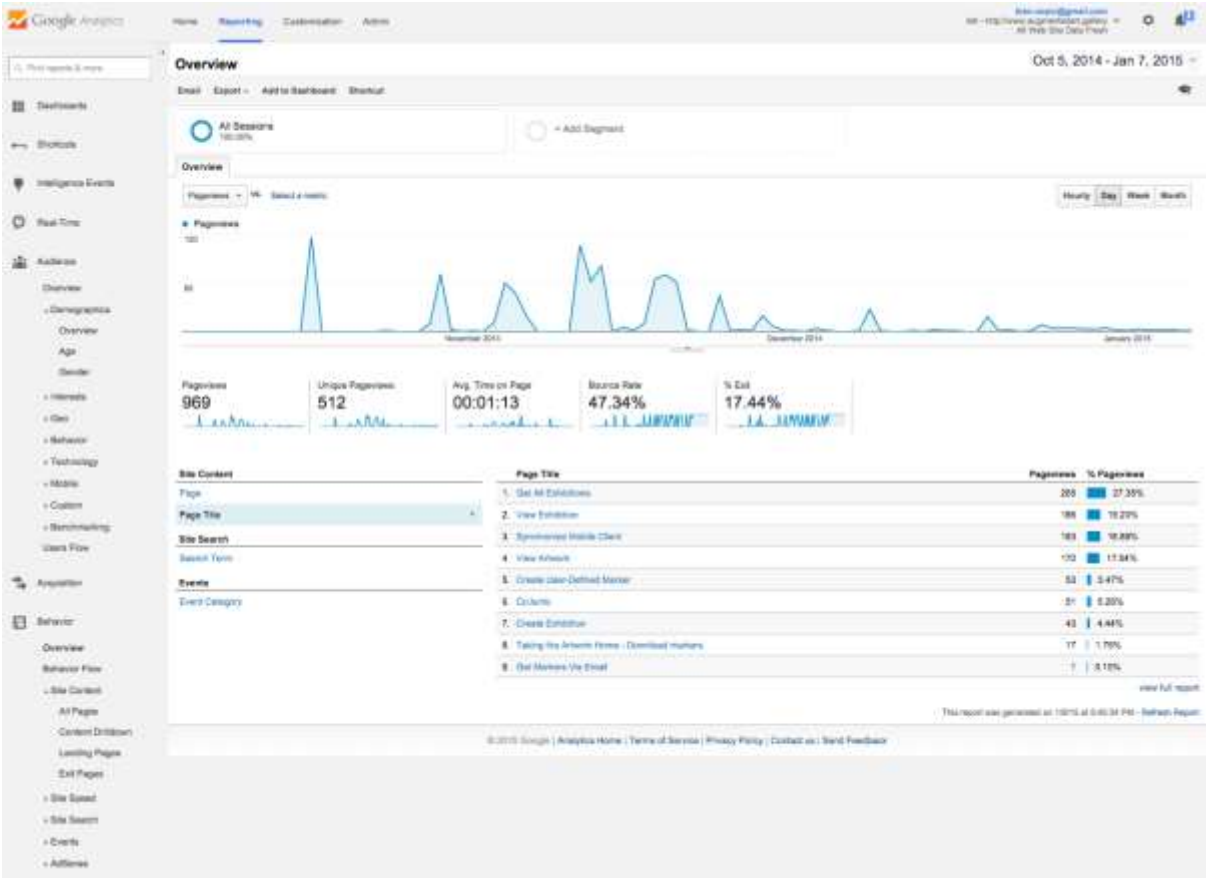

Image 13: User activity on individual app functions linked to google analytics

Museums and galleries continue to turn to digital technology as it seems to offer the best solution for extending their audience reach and improving accessibility to their knowledge and collections. AR presents one of the most dynamic and realistic ways of engaging with those objects through mobile devices; this combined with the wow-factor and exotic nature of the technology for new users will no doubt continue the exploration of the technology by arts institutions. However, at this point in time it is a safe assumption for museums and galleries that developing new apps requires resources, certainly to develop applications similar to Taking the Artwork Home. That said, based on our user group responses, it is a worthwhile area to undertake work in; for audiences that increasingly engage with the world through screens, AR seems to offer a dynamic and more meaningful experience with artworks and objects. It can provide access to collections that remain relatively unseen or unknown and provides the institutions that care for those objects with greater audience reach. By placing collections in the digital realm they can connect with the wider world to find new interpretation and meaning.

Insights

Ethics

During the course of this project the partners have been confronted with a number of ethical questions relating to participatory research practice. Difficulties arose particularly with informed data protection relating to activities conducted in the wild, where the researchers are unlikely to have had direct contact with the users of the application.

From a cultural organisation perspective, it appeared that the more information available from users the better; whilst from a university ethics perspective, information should only be collected that is directly relevant to the project for which informed consent from the users has been obtained. The result of this would be that less personal information would be obtained through the application than through the participatory design process.

Through discussion with the university ethics committee, a set of terms and conditions were developed that appear when the application is opened, effectively providing the information that would normally appear on a physical form given to users. The users also have to check boxes to say they have read and accepted this information before they are able to use the application.

Open Source

The partners had agreed from the outset that the intention was to make as many of the outputs open source as possible. For the academic partner, this required a discussion with the Universities Commercialisation Officer. Agreement was required that while the project was innovative from a research perspective, it was unlikely that any outputs created would be patentable due to the use of commercial devices.

Cross Device Compatibility

Despite concerted effort over recent years to consolidate the market for creating mobile applications, it still remains fragmented. When developing very technical applications, such as Taking the Artwork Home, choices have to be made as to what devices will be supported.

Factors to take into account

- Market share: Apple and its IOS operating system are perhaps the most well-known, according to the International Data Corporation report of smartphone sales in 2013 Apple had a worldwide market share of 13.2%, however Android achieved a 79.3% market share with the remaining portion going to the likes of Windows Phone and Blackberry.

- Backwards compatibility: All these operating systems have evolved over a number of years and many systems and features are not backwards compatible. The smartphones that users currently possess will be spread across this evolution. Choices have to be made as to which versions of the operating system will be supported and all of these will need to be tested before release.

- Look and feel varying on devices: Beyond the operating system there are also features that vary from device to device such as screen size, processor speed, memory etc. As there is no common agreed standard, the look and feel of the application may be different on every device. The overall effect is that even for a fairly modest coverage of devices the application needs to be tested across 10-15 different models to ensure correct operation. Whilst it is relatively simple for developers to create sensor-based AR applications on either Apple iOS or Android, the two main vision-based SDK's are only supported on Android.

Publication and Copyright

Museums and galleries digitising their collections and making public digital content are bound by publication and copyright laws that were established in a very different era. Any AR application intending to use images of artwork must take these conditions into account if the application is to be used in the public domain.

The laws relating to Copyright and Publication Right directly affect a gallery's ability to include artworks from their collection in an AR application. Specific permission had to be obtained for all the works featured in this application that were still subject to copyright law. This included approaching one of the well-known rights management organisations, the Design and Artists Copyright Society (DACS). DACS were very helpful and worked with us to find a solution for the project and their members, nevertheless, it was

interesting to discover there wasn't an existing protocol for using reproductions in an AR application. In terms of publication right, the situation becomes more complex in cases where copyright expires during the time period that the artworks are being used by an application. For example, if an artwork is used for an AR application, then publication rights would reside with the gallery if they published the application. If the gallery publishes the application on an app store but uses the account of the developer who created the application, then publication rights would transfer to the developer. To avoid losing the publication rights of their artworks, galleries and museums should start with the assumption that they will need to publish applications using their own app store developer accounts.

Insight: Image Resolution

It quickly became apparent during the discussions with the gallery that whilst there were digital images for many of the artworks in the collection, the resolution was quite varied, as the primary use for the majority of the images had been for in-house reference only. Peter Scott Gallery is digitising its collection as an ongoing process, many other museums and galleries will be in a similar situation – the time and effort required to digitise a collection to a high standard should not be underestimated.

One of the clear results of the user testing was that the users particularly enjoyed the ability to explore the fine details of the images such as brush strokes within the paint. This was very evident with the students with physical and learning disabilities studying at Beaumont College. One of college assistants remarked that the students on the whole, engaged more with the gallery objects using the MAR than when they physically visited galleries – because they could "get more involved" with the pieces – zooming in and out, rotating etc. They further commented that when moving through a gallery space, they may just acknowledge "that's a painting" passively, whereas the college assistants felt that the students on the whole were far more engaged by using the app. This surprised the project partners, who expected users to interact more with gallery content when physically in the space – with the unique object directly in front of them. As an example of this level of detail, the following shows a photograph from the Chambers Bequest held at the Peter Scott Gallery; the image was used in the prototype to evaluate resolution. During these

evaluations a number of people mentioned that they see the fingerprint present on one of the boys' faces, which is also highlighted in the Figure below; an aspect which is not readily apparent when viewing the image in its entirety.

To accommodate the desire for high-resolution images the gallery had to arrange for artworks to be re-digitised for the application. This new way of handling images has been adopted as a standard practice within gallery's collection management and will allow the wider collection to be used within the application.

Image 14: Advantage of High Resolution in AR

Summary

Whilst AR is an interesting technology, it is also highly complex and cultural organisations need to understand some of the technological constraints and the understanding of their audience if they are to use it effectively.

Research of this type presents interesting issues for academics in terms of adapting their normal ethics practices and for cultural organisations to

appreciate there may be constraints on what and how data is collected during the research phase.

Intellectual Property is undoubtedly an issue for organisations working together - open and frank discussions are recommended prior to commencing the project as the issue can easily impede proceedings once it has started.

Application compatibility is a huge challenge in mobile development because of the range of operating systems, screen sizes, processor speeds etc. Careful consideration needs to be given into what devices will be supported for the desired target audience. For example even a fairly modest coverage of Android devices will require application testing across 10-15 different models to ensure correct operation.

Copyright and Publication Right should be considered very carefully prior to considering MAR, or any other public facing digital tool for collections, as obtaining permissions can be a lengthy, time-consuming and expensive. Having too little content may affect the user experience and the data received by the organisation publishing the app.

It should be default practice for galleries and museums to publish applications using their own app store developer accounts otherwise they risk losing the publication right for their artworks in some circumstances.

For the best experience when viewing artworks via AR, the resolution of the images should be as high as possible. This has a direct impact on how images should be stored on the device, since without protection, copying the images from the device may be possible.

To maximise the understanding of an 'in the wild' research and development project such as this, some means of performing a longitudinal study is required; the necessary resources should be identified at the start of the project.

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In the short term, the Peter Scott Gallery is preparing and negotiating additional artworks to enrich the content of the app

Future

In the short term, the Peter Scott Gallery is preparing and negotiating additional artworks to enrich the content of the app. Due to the design of the app CMS developed following gallery staff feedback during the project, new content can be added directly without the need to update the application on the app store through the developer. The project team are also considering adding support for the major social media platforms within the app to help raise awareness of the app and provide further feedback channels for users.

A number of options beyond this project are being explored directly as a result of this scheme:

- The current version of the app is considered as in perpetual beta; this is common and is due to the rate of technology development that results in developers enhancing apps throughout their life, or the app will quickly cease to be relevant.
- There is a great deal of scope for AR work in museums and galleries, it has the possibility to change the way visitors and users experience culture through screens; it also has the potential to support the collections care and administration.
- It is not currently feasible for an average UK museum or gallery to undertake major AR development without a dedicated budget; however, Taking the Artwork Home has been designed open source to allow museums and galleries to access and utilise the technology at minimal or no cost.
- The project partners are exploring possible research funding to develop the app to scan 3D objects in mobile augmented reality.

Further Resources

Application

The application is free to download for Android phones and tablets on Google Play

https://play.google.com/store/apps/details?id=co.uk.imagination.nesta&hl=en_GB

As the software is still being refined, this project has not yet been placed on GitHub but the intention is to release both the application software and support database in the future.

Taking the Artwork home web pages

http://imagination.lancs.ac.uk/activities/Taking_Artwork_Home

Twitter handle: @AugmentedArt

Augmented Reality Software Development Kits

Qualcomm® Vuforian™

https://developer.vuforia.com

metaio

http://www.metaio.com

Create Hub

We were fortunate enough to be approached by Samuel Fry of Create Hub (an online arts and technology magazine) to do an interview q and a about

the project. This went live on and can be found at: http://create-hub.com/interview/emmamurphy.html and went live on 1st December 2013.

Demo at the AHRC Creative Economy Showcase 2014

https://www.youtube.com/watch?v=s-qQ74kLzO8

Youtube

Total views of prototype videos – 381

Demonstration

The project was demonstrated as part of the Digital Design Weekend at the V&A on 20th and 21st of September 2014 to over 500 people.

Associated Project

Peter Scott Gallery (Lancaster)

Documentation and licensing initiative

This project received funding to support the development of a model to use image licensing for income generation. The project has raised some interesting issues around image handling and work on copyright and considered Taking the Artwork Home as a possible route for image licencing. Details of this project appeared in Museum Development North West Annual Report 2013-2014.

Academic Papers

Coulton, Paul; Murphy, Emma; Smith, Richard and Čopič Pucihar, Klen. "Designing Mobile Augmented Reality Art Applications: Addressing the Views of the Galleries and the Artists", accepted for Mindrek Conference 2014, Tampere, Finland.

This paper is aimed at a more technically orientated audience and provides a full description of how the application was created under the influence of the project methodology.

Coulton, Paul; Murphy, Emma; Smith, Richard, Čopič Pucihar, Klen and Lochrie, Mark. "User Curated Augmented Reality Art Exhibitions", accepted for Demonstration at NordiCHI 2014.

This paper and demonstration primarily highlights the novel Taking the Artwork Home Research and Development Process.

Coulton, Paul and Murphy, Emma. "Gimmicks, Geeks and Gut: Challenges and Preconceptions from Collaborative Research in Art, Design and Technology. A Case Study Using Mobile Augmented Reality", to appear Digital Research in the Humanities and Arts Conference, Greenwich, UK.

This paper presents a reflection on the process primarily for an Arts and Humanities audience and particularly the needs for fully engaging in the development process

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Image 15: Paul Coulton demonstrating Taking the Artwork Home at the AHRC Creative Economy Showcase

Citation: Coulton, P., Murphy, E., Pucihar, Č., Smith, R., (2015) 'Live at Lica: Collection access via augmented reality research and development report' London: Nesta.

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