Category: Paper

Mobile Exploration of Medieval St Andrews

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Abstract: Saint Andrews is a town with a rich history. It was the religious centre of Scotland for close to a millennium. The Cathedral was strongly associated with the wars of Independence and Robert the Bruce. The castle was the scene of pivotal revolt leading to the reformation and hosted the first Scottish protestant congregation. St Salvators chapel was the religious centre of Scotland's first University. This paper presents work which explores using mobile technologies to support investigation, learning and appreciation of the past. It builds on tradition and world class scholarship into the history of this important town and makes them available to school students, researchers and tourists using mobile technologies. From text based quests, through mobile apps to location aware stereoscopic 3D experiences the gamut of available commodity hardware is used to enable the past to be explored in new ways.

Introduction: Exploration of the past is often seen as a dry subject to be conducted with dusty tombs in dark libraries. Yet the widespread use of mobile and increasingly immersive technologies mean that new generations are more literate in the manipulation of digital data than ever before. These technologies and literacies can be put to use both to provide new insights into the past and to communicate established scholarship in ways that are accessible and engaging to new audiences.

The work described in this paper extends a Virtual Time Travel Platform (VTTP) [McCaffery et al., 2013] to support exploration of the past on mobile devices. The VTTP supports both the creation and deployment of 3D digital reconstructions of historical scenes. It is based on Open Virtual World Technology and has been engineered [Oliver et al., 2010] [Oliver2012] [Oliver & Miller, 2013] [McCaffery et al., 2014] to support real time interaction in large scale high fidelity environments using open source software and commodity hardware.

The reconstructions are based upon archaeological [Dawson et al., 2013] and historical evidence [Fawcett, 2011, Fawcett et al., 2003, Fawcett & Rutherford, 2011]. They model not just the physical scenes but tangible and intangible culture, both the fixtures and fittings of everyday life and the people together with their work, songs and stories. They enable engaging learning environments to be created which make sue of digital literacies developed playing games [Getchell et al., 2010].

This platform has formed the basis of installations in Museums, for example a reconstruction of the Scottish highland Caen township in the Timespan museum and arts centre. It has been used to enable school students at Madras college to explore reconstructions of the local St Andrews cathedral, has been used in higher education degrees in the arts [Getchell et al., 2009], social science [Ajinomoh et al., 2014] and the sciences [McCaffery et al,. 2014] and is accessible over the Internet [Dow et al., 2014]. In [Davies et al., 2013] a virtual time window system is described where mobile devices present a window into the past.

This paper presents and compares three modes of interacting with the past, it also describes the technologies which support the interactions. The Oculus Rift enables digital models to be appreciated in stereoscopic 3D. Here we present a system which enables physical exploration of a digital model, whilst occupying a parallel physical space. We describe the reconstruction of St Salvators chapel and its exploration using the Mirrorshades system. The QuestIt system guides a visitor through medieval St Andrews using texts sent and received by a mobile phone. This is complemented by a location aware app, which contains text, audio, graphics and video relevant to historic locations. This also provides access to the reconstructions.
We believe that the three modes of interaction are complementary to each other. Stereoscopic headsets provide a high quality immersive experience, text quests provide engagement and the app provide onsite access to multi-media context. Taken together they have the potential to revolutionise the way we interact with the past.

Figure 1: Contemporary View of Late Medieval St Andrews

Overview of Medieval St Andrews mobile learning app: This project brings together computer science, history and archaeology academics and students to create a Mediaeval St Andrews app. The Medieval St Andrews app will enable learners to concurrently explore the physicality of St Andrews and access location specific research. The app acts as a guide providing a narrative linking together specific locations on the physical trail. This encourages self-paced student centred learning. For each point of interest on the trail text, images, audio and video, combine with the physicality of the location to provide an engaging learning experience that motivates further reflection. Links to online digital resources, which index relevant scholarly research guide further investigation. In this way new research learning linkages are created. Smart phones and tablets are becoming ubiquitous and have the functionality to add a new dimension to learning. They typically contain GPS, a high resolution screen and connect to the Internet. The Medieval St Andrews App, enables the synthesis of scene and discourse in the learning process. Until now the cost of app authoring has been too high for this technology to be integrated into infrastructure of learning in higher education. This project demonstrates the

educational value of integrating location into the learning process and has developed a framework for educational app creation.
St Andrews is a town central to Scottish and world history (Figure 1). Robert the Bruce attended the consecration of St Andrews Cathedral (Figure 4), whilst the diocese funded him through the wars of independence. St Salvators dates from the foundation of Scotland's first University (Figure 9, 10, 11, 12). St Andrews was a driving force for the reformation with the Castle being home to Scotland's first protestant congregation. Evidence of this rich history is interwoven with the fabric of the town.

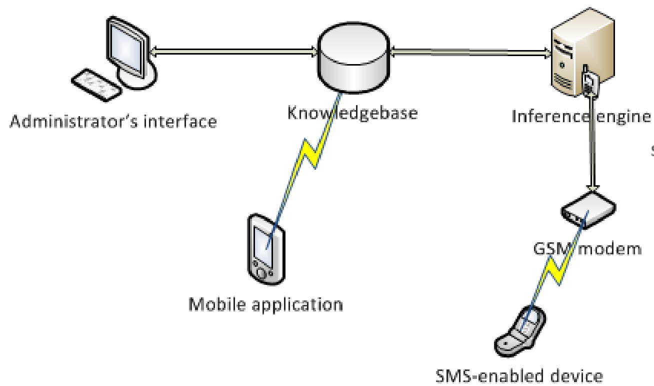

Figure 2 QuestIt System Design

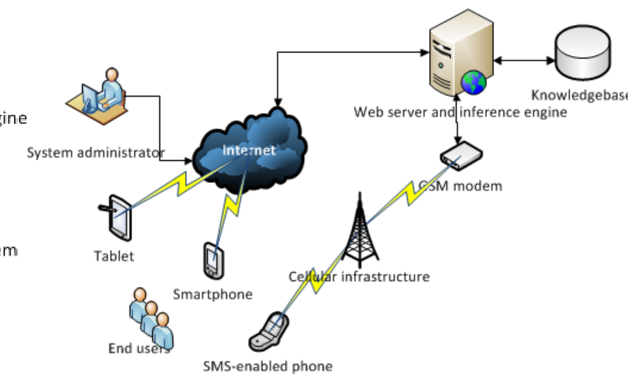

Figure 3 Conceptual Architecture

There is a rich potential for further location aware learning apps. Within St Andrews: History of the University, Witches Tour, the Books of St Andrews, Churches of St Andrews and History of Golf are examples. This approach is also valuable across disciplines with relevance in history, art history, classics and divinity, location aware apps will also enhance virtual fieldwork in geography, geo-science and ecology. The design and creation of apps currently attracts a premium. Single apps may cost between tens and hundreds of thousands of pounds to commission. We propose a generic format, abstracted from existing apps, which will support multiple disciplines and applications.
A welcome page with embedded photograph and image map provides a visually striking introduction. At the heart of each app is a zoomable interactive map. A user's location and clickable points of interest are represented. Each point of interest may have text, images, audio, video and a 3D model associated with it. These stimulate interest and act as gateways pointing to further learning and research materials.
We have designed a web user interface which enables app content to be easily created and updated. A simple form enables upload of the front page image and definition of menus. The live map area is defined in OS coordinates, if required a custom map may be uploaded. Points of interest are defined by entering OS co-ordinates. Each point of interest is then associated with text, images, audio and video as appropriate. This interface enables students to create apps enabling co curriculum development of communication skills and engagement with professional publication issues. Once the content for the app is defined open source tools allow automatic compilation for IOS, android and other platforms.
This project draws upon scholarship and student input in the schools of History, Art History and Classics. It marries the teaching and research agendas of staff in the Institute of Mediaeval Studies (SAIMS) and in the Institute of Scottish Historical Research (ISHR) which supports the

umbrella project and teaching portfolio of Mediaeval St Andrews. It will make accessible reconstructions of St Andrews Cathedral (https://vimeo.com/77928887), St Andrews Castle and St Salvators chapel.

Figure 4: Reconstruction of St Andrews Cathedral 1318

Texting: This section discusses the considerations and activities that went into the design phase of the system. There are two main user groups for the system: System Administrators: These are computer-literate staff of cultural heritage organisations. They will interact with the system through a web interface that provides functionality to populate the knowledgebase with heritage information as well as additional features to modify this information and monitor end user transactions. End Users: These are tourists, passers-by and members of the general public that are interested in learning about the cultural heritage of a given locality. They interact with the system by sending and receiving SMS messages on their mobile devices, and by using the mobile application developed.

The system is made up of the following five components. The knowledgebase: A structured repository that holds all the information used by the system. The SMS inference engine: A set of rules for making deductions based on the contents of the knowledgebase. The GSM modem: A modem that facilitates the receipt and sending of SMS messages from and to users respectively. The administrator's interface: A web interface that provides administrative functionalities such as creating trails, modifying trails and viewing records of SMS transactions. The mobile application: An application that users can download onto their mobile devices (smartphones, tablets, PDAs) to take their learning experience further.

The architecture of the system is shown in Figure 2 and Figure 3. System administrators and end users access the administrators interface and the mobile application respectively over the Internet. However, the SMS functionality of the system is accessed over the cellular (GSM) infrastructure and works independent of Internet access. The GSM modem is connected to an inference engine (which can be configured, started and stopped by the system administrator) connected to the knowledgebase.

An inference engine was developed in Java to facilitate connectivity between the GSM modem that sends and receives SMS messages from users and the server that the modem is connected to. The GSM modem used is the Wavecom Q2303A Module USB GSM Modem. An open-source Java API (SMSLib) was employed in the development of the inference engine to facilitate the AT command-driven communication between the server and GSM modem. This API was then leveraged by writing Java methods and classes to enable the server establish communication with the connected modem, instruct the modem to read incoming messages in real-time as they are being sent by users, generate appropriate responses based on the contents of the received messages, and automatically send those responses to users.

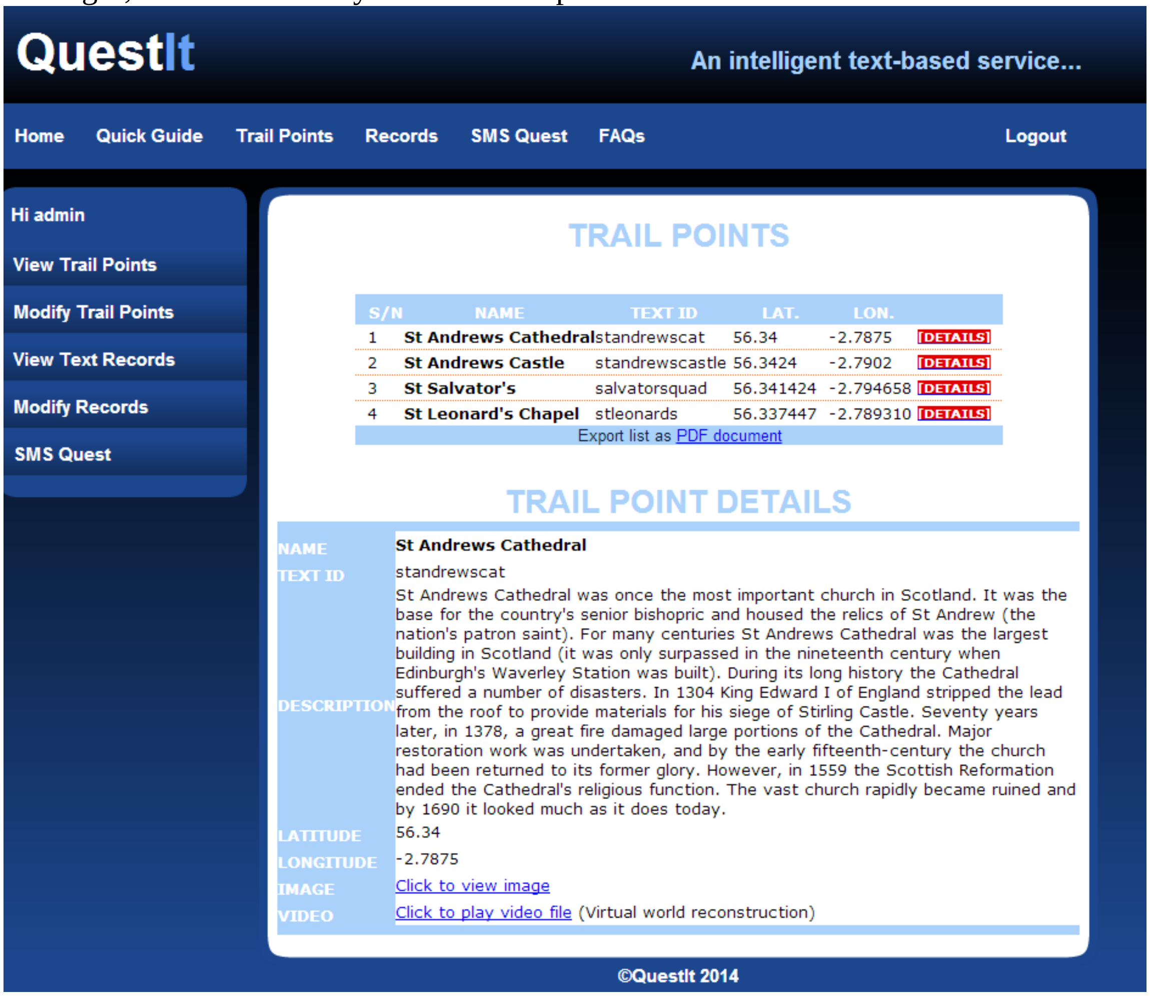

Figure 5 QuestIt Administrators Interface

The following steps take place when a user sends an SMS message to the mobile number controlled by the GSM modem:

User sends SMS message containing text string.

- Modem receives SMS message asynchronously and generates a notification to the inference engine.
- Inference engine connects to the knowledgebase and searches for the text string in stringid column of the trailpoints table. If a match is found, inference engine retrieves the content of the description column of the trailpoints table and stores it in a temporary variable. If no match is found, inference engine generates an “unrecognised string” message and stores it in temporary variable.
- The inference engine instructs the modem to send the contents of the temporary variable as an SMS to the user.

- Modem sends the appropriate response to the user.

The inference engine stores the transaction details in the records table and updates the users table of the knowledgebase.

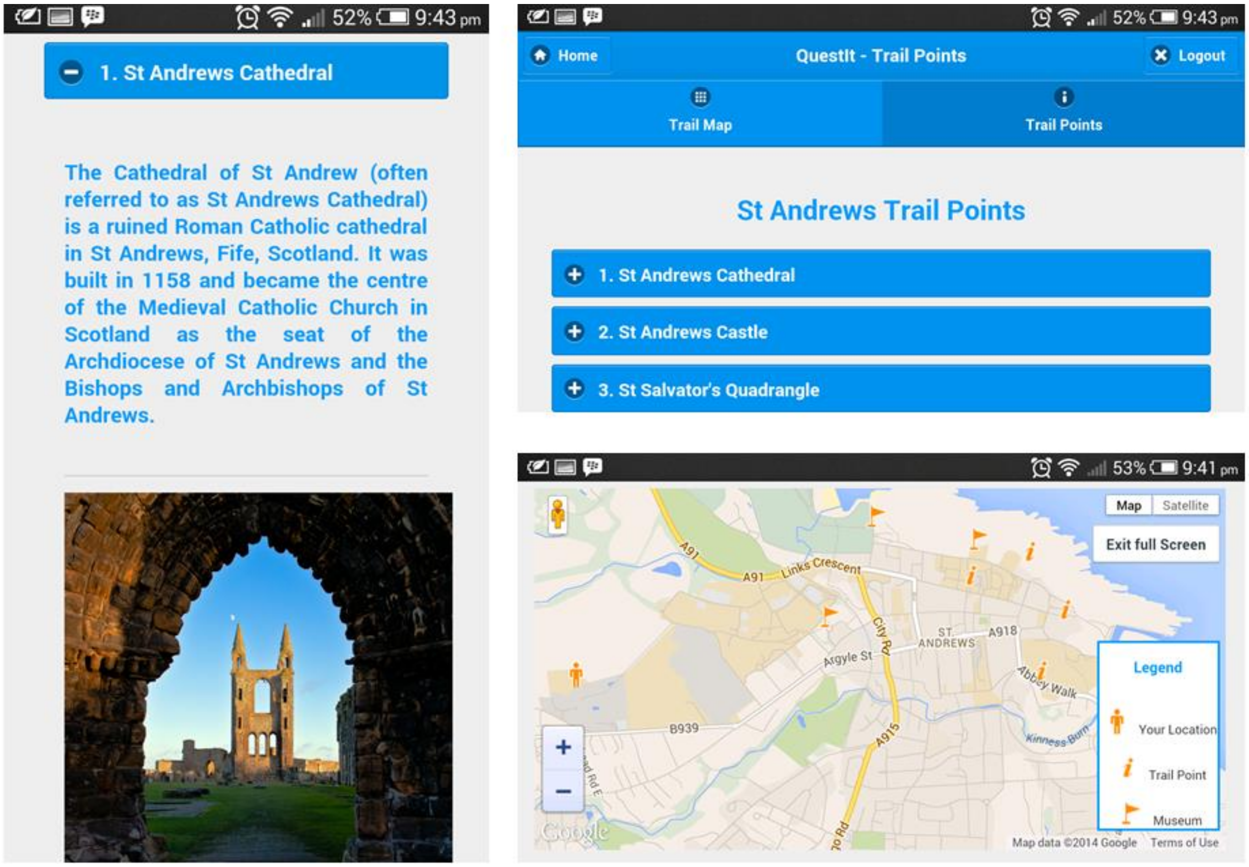

Figure 6: Screen shots from the App

Administrators Web Interface: To ensure accessibility and ease of use, the administrators interface was designed using web technologies and hosted on a server accessible over the Internet. This interface took the form of a dynamic website designed using PHP (for the server-side scripting) and HTML, Javascript and CSS for the client-side. The interface contains functionalities to create trails by adding (as well as deleting and modifying) a series of connected trail points and keeping track of end user usage by viewing records of SMS transactions. When adding a trail point, an administrator specifies the name (e.g. St Andrews Cathedral), a unique string identifier (e.g. "standrewscat"), a description of the trail point (history, important features, current state and so on), the latitude and longitude coordinates (e.g. 56.34, -2.7875), any additional text (e.g. riddles, quests or quotes associated with the trail point) and may choose to upload additional resources like images (pictures of the trail point), audio files (songs or stories associated with the trail point) and video files (ancient footage or virtual worlds reconstruction of the trail point). Once the submit button is clicked, the information specified is validated and then stored in the trail points and resources tables in the knowledgebase, and will appear as a trail point in the administrators web interface. The interface also features a brief introduction and guide on how to use the system and a page devoted to Frequently Asked Questions (FAQs).

Mobile App: A mobile application has been developed to take users' experience further by leveraging the features and capabilities of smartphones to deliver interactive and engaging contents to users (Figure 6). To ensure accessibility across multiple mobile platforms (Android, IOS, Windows Mobile, Blackberry, Symbian and so on), PhoneGap was leveraged to build a mobile application using Javascript, HTML5 and CSS3 and then compile the codes for these platforms.

Figure 7: App Front

Figure 8 Using Mirrorshades X Reality System

The mobile application connects to the MySQL knowledgebase and reads the contents of the trailpoints and resources tables. This communication is facilitated in Javascript by generating JSON (JavaScript Object Notation) and AJAX (Asynchronous JavaScript and XML) requests to PHP scripts (hosted on an online server) which make SQL queries to the knowledgebase, retrieve data and send the data (encoded as JSON objects) to the client device. The contents of these tables (which represent connected trail point entities and informative resources associated with these entities) are then visually represented in the mobile application in form of a heritage map view and a trail points view. The map view features a series of clickable icons that represent three categories of entities – heritage trail points (e.g. St Andrews Cathedral), heritage organisations (e.g. Museum of the University of St Andrwes) and the user's location (represented by the coordinates of the user's mobile device) – all on a live map sourced from googlemaps API . The map view allows users to view the locations of trail points and heritage organisations respective to their locations, and interact with a heritage map of the given locality by panning, zooming and clicking on icons to gather more information. The location of each trail point icon on the map corresponds to the latitude/longitude coordinates specified by the system administrators when creating the trail point using the web interface, and when a trail point icon is clicked, users are directed to the trail points view which displays information and resources about all trail points while highlighting the particular trail point clicked on. The information displayed for each trail point correspond to the contents specified by the system administrator when creating the trail point (using the web interface) and includes a description, one or more images, audio, video, riddles, quotes, puzzles, latitude/longitude coordinates as well as a button that displays the location of the trail point on the map view when clicked. Both the map view and trail points view have buttons that users click to change their view (e.g. navigate from the map view to the trail points), as well as buttons to toggle full screen mode, navigate to the welcome screen point and log out of the system. The following steps outline the flow of information between the administrators interface, mobile application and system resources:

- System administrator creates trail points, specifying the name, description, coordinates and multimedia resources using web interface.
- Trail points are stored in the knowledgebase.
- User with a smartphone or tablet launches the mobile application and mobile application makes JSON request to PHP script on a web server.
- PHP script queries trailpoints and resources tables of knowledgebase using SQL statements, encodes the retrieved information as JSON objects and transmits the objects.
- Mobile device receives JSON objects, formats them using JavaScript and visualises them on an interactive map view and trail points view.

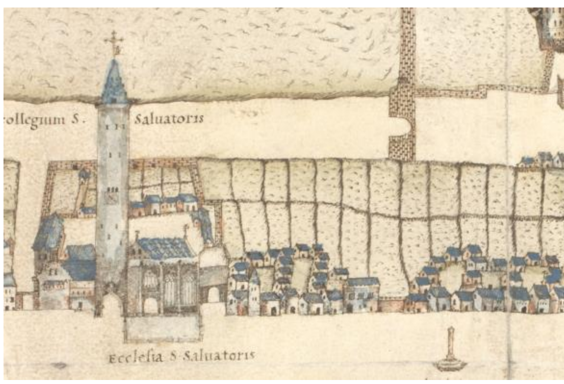

Figure 9: St Salvators Geddy View

Figure 10: St Salvators Reconstruction

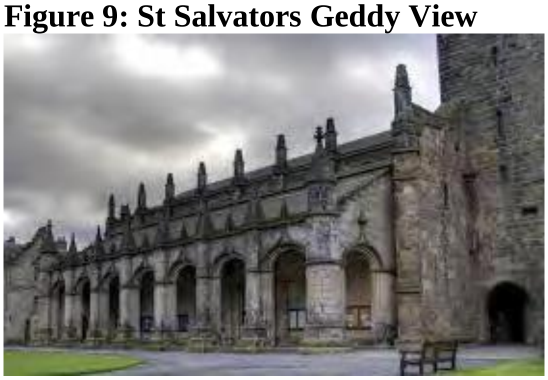

Figure 11: St Salvators Today

Figure 12: St Salvators Stereoscopic Altar

Into the third dimension with Mirror Shades: We have created 3D reconstructions of a number of medieval buildings in St Andrews. These reconstructions have been used in schools and public exhibitions to provide a new perspective on the past. Users are able to explore these reconstructions through the proxy of an avatar controlled by a key board and mouse or games controller. The models contain interactive content and non-player characters representing personalities from the past such as Robert the Bruce and Cardinal Beaton. These models have also been used to enrich mobile exploration of St Andrews. Images and videos of the reconstruction provide content for the text trails which may be accessed through Web references. The app also has 3D content linked into it. Images of the reconstruction enable comparison with the present day sites as well as with images from the past such as the Geddy map. Videos such as (https://vimeo.com/77928887) enable guided tours of the reconstructions to be followed whilst on site. These provide a valuable but cut down experience of 3D reconstruction but have the benefit of being available on site.

The Mirrorshades cross reality system is based upon the Oculus Rift, Web Cams and an indoor positioning system. This enables users to walk around the current day site of St Salvators Chapel and simultaneously to see the reconstruction of the chapel in stereoscopic 3D. This gives an immersive experience far superior to viewing via a traditional monitor. A challenge for this sort of cross reality system is how to overcome the ``vacancy problem'' where the user is cognitively present in one reality but absent from the other. We overcome this problem in part by automating navigation. As the user moves around the real space their viewpoint in the virtual space is changed automatically. The user is also able to easily switch between realities at any time. The video cameras provide a view into the real whilst the simulation provides a view into the past. In this way the user is freed to explore the past and to compare it to the current site.

This video shows the mirror shades system in use during an evaluation session where it is used for mobile exploration of St Salvators Chapel.

Mirrorshades has been used to enable comparison of St Salvators chapel as it is today and as it was in the 15th Century. System performance measurements showed that framerates of between 40 and 40 fps were achieved, that latency from cameras was around 180ms and that user position was tracked to within a few meters whilst moving and to within a meter whilst stationary.

An X-Box controller enabled users to switch between realities, by pushing a button or puling a trigger. There was a preference for alternating between real and virtual rather than viewing both simultaneously. The virtual was viewed more while stationary and the real was moving. The combination of easy switching and intuitive navigation effectively addressed the vacancy problem enabling easy comparison between the two realities. The strength of the immersive experience provided by stereoscopic vision, compensated for the low specs, in terms of framerate, resolution and accuracy of movement tracking provided by the system. All users found the experience to be extremely positive, enjoyable and informative.

Conclusion: This paper has outlined three approaches to mobile exploration of Medieval St Andrews. In each case users are able to explore the past and to compare reconstructions and historic images with present days site. The text approach has the advantage of simplicity, intimacy and low tech requirements. Digital literacies exist across the population with respect to texting. Also texts are often seen as high value communication items. The system enables the creation of Quests, where the user progresses from site to site.

The predominance of smart phones equipped with multimedia capabilities, broadband and geo-location systems under pines the creation of the St Andrews Medieval app. A visitor or student is able to locate points of interest that are close to them, receive directions on how to reach the point of interest and access a wealth of material about the site. This will include audio commentary, images and text. A valuable aspect of the app architecture is the inclusion of a web interface which enables the content to be created by filling in forms and uploading files. Consequently given appropriate content it is possible to create a trail app in a short period of time without specialist skills. The third mode of exploration Mirrorshades, enables a fully immersive experience to be achieved on site. The system addresses the vacancy problem and facilitates rich comparison of the present day with the past.

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