mLearn 2012 – 16-18 October 2012, Helsinki, Finland

Workshop Proceedings

Mobile Augmented Reality for Education

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Using augmented reality for mobile learning: opportunities and challenges

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INTRODUCTION

Augmented reality (AR) is becoming increasingly widespread, primarily through personal mobile devices using apps such as Layar or Wikitude, although also as part of larger, public displays such as video mapping demonstrated by the Macula[1] or as part of a advertising campaign, such as that used by the UK firm Marks and Spencer to sell lingerie for Valentine's Day (The Drum, 2012). However, the application of AR for mobile learning – and indeed education in general – is still in its infancy.

AR has traditionally emphasised the use of visual/graphical displays but it could be argued that this definition is too narrow and instead should encompass the fusion of any digital information within a real world physicality, i.e. being able to augment one's immediate surroundings with electronic data or information, in a variety of media formats that include not only visual/graphic media but also text, audio and video. This is much more in keeping with how AR is defined in the 2011 Horizon report: "the addition of a computer-assisted contextual layer of information over the real world, creating a reality that is enhanced or augmented" (Johnson et al., 2011). However, this in itself is not sufficient – we must also consider the context or intentionality of the digital information – it is not merely the placement of media, but more how it is used – its role – in relation to the immediate physical environment.

AUGMENTED REALITY AND SITUATED LEARNING

Vygotsky (1978) stated that human consciousness is associated with the use of tools and artefacts, which mediate contact with the world; this work was extended by Lave and Wenger (1991) and also Bowker and Star (2000) to develop the

[1] Such as 'old town' [http://vimeo.com/15749093], created to celebrate the 600 year anniversary of the astronomical tower clock situated at Old Town Square in centre of Prague

concept of situated learning. Whilst the application of augmented reality seems embedded within these theories, little research has been published that examines these theoretical aspects, and in fact, if they are sufficient in themselves, or if we need to also examine theories of embodiment and embodied cognition (Núñez et al., 1999; Radford, 2005) in order to fully comprehend human interaction with AR. It is also likely that the affordances, or properties, of the physical environment affect the way in which people engage with AR and it is possible that we need to start looking at ecologies of resources (Luckin, 2008)

CASE STUDIES

Several research projects have looked at AR for education, although many of these are around mobile gaming, which in itself can bring another dimension to the work. The case studies mentioned below do not use games as a focus and instead are embedded within formal and informal location-based learning:

Augmenting the Visitor Experience

This research looked at how visitors to the Lake District national park in the UK could potentially use a range of different methods to gain information about their surroundings (Priestnall et al., 2009; Priestnall et al., 2010). The methods were tested by geography undergraduate students on a field trip and ranged from low-tech printed acetate sheets, to the use of mScape (mediaScape, see Stenton et al., 2007) and partial virtual reality, created through the use of a head-mounted display connected to a laptop, carried in a rucksack.

Audio guides

The 'Hidden Histories' project was a comparison between two audio tours, one that was 'person-led' and one that was 'technology-led' (FitzGerald, 2012). Both tours were around Nottingham city centre in the UK and focused upon the events of the 1831 Reform Riot, using a number of points of interest along the route to convey different historical perspectives (sources/people). The technology-led tour used a smartphone with geolocated audio, that was triggered by the user's GPS position (i.e. their geographical location). A number of interesting findings have emerged from this study, especially when comparing the two walks, and also in terms of how authenticity is key to an effective and immersive experience.

CHALLENGES

A number of challenges exist within the use of AR for mobile learning; these are listed briefly below:

- innovation vs sustainability
- overcoming the novelty factor

- notspots rather than hotspots (see (Gaved et al., 2010); also hardware issues such as screen glare
- changing practice vs maintaining current practice
- moving from informal to formal learning – assessment, goals, accreditation?
- appropriateness of media vs physicality (or conversely, disjointedness as a good thing?)

AR has thus far concentrated on graphical or audio interfaces; it would also be fascinating to see how the use of other sensors e.g. haptic/force-feedback, could be used for effective AR experiences, such as that exemplified in the 'Haptic lotus' project (van der Linden et al., 2012). It is hoped that these challenges will be discussed at length in the workshop.

ACKNOWLEDGMENTS

The authors acknowledge the support of participants and other colleagues involved in the case studies mentioned above.

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Developing Spatial Literacy using Context Engineering within Augmented Spaces

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Successful patterns for interaction within augmented spaces are those that create contexts and concepts that successfully combine the strengths, features and possibilities of both the physical and the virtual aspects of these contexts. In order to create these 'augmented contexts' new tools for navigation that combine the use of analogue and digital literacy skill sets are required. These contexts should by definition enhance spatial cognition and improve pattern recognition.

Keywords: Augmented and Mixed Reality, Interaction Design Patterns, Spatial Cognition, Pattern Recognition and Contextual Design Research.

The central challenge for educational designers is to create contexts that promote effective learning. With the generation and increasing adoption of mobile augmented reality (MAR) and mixed reality techniques we now have the potential to explode the form and complexity of these learning contexts. The core question of this research is can we develop augmented contexts that are more effective because they take advantage of the affordances of these mixed reality methods and techniques. The majority of mobile learning research and mobile app development creates experiences which tie all the requirements of the user's attention down to and onto a four inch screen. This includes the majority of MAR applications. To avoid this, new interfaces must be created that take advantage of the physical and digital affordances of each learning situation.

The main utopian power of MAR is that we are capable of creating a new immersive reality completely beyond our known limits, and that it can be embedded not in a blog, a device or a computer, but in the world (Baraona, 2012). A good example of this new immersive reality is being developed in Japan by Professor Michitaka Hirose - "diet goggles" (http://www.youtube.com/watch?v=spk-2EuZ3hk). The goggles are designed to trick dieters into eating less by digitally enlarging food whilst they are actually eating it. This is an example of context engineering and highlights the extent to which MAR can subvert our perception of the physical world. The context becomes available for the learner to 'get to everything, add to everything, keep track of everything, and tie everything together (Waltham, 1989).

The inception app uses MAR (http://inceptiontheapp.com) with sound by synchronizing an augmented layer of music and ambient noise with the world around you. The app manages to augment context by forcing the user to get into a real world context that is producing a certain sound. Unless that sound is present then the content is not released by the 'listening' app. The app actually acts as a trigger or catalyst for real world activity. This allows the inception 'environment' to become a world where a lot of other stories can take place. This is in stark contrast to the usual predefined and prescribed content of traditional non context dependent apps (which also, invariably do not tap into existing analogue skill sets).

Another interesting project 'Flipping Between Analog and Digital: Lenticular Augmented Reality' by Helen Papagiannis involves using a tactile object that could store and display multiple moving AR images, combining both analog and digital modes of memory. Each technology, AR and lenticular, presents an architecture which serves as a memory container with the final image only coming into full-view upon activation by the user. Both analog and digital methods must work together and coexist to disclose lenticular AR. (Papagiannis, 2012).

A final example which highlights the pedagogical affect MAR has on the relationship between theory and practice is that of astrology. Traditionally a student of astrology would do their research and field work in two different places (one via print media or other forms of media and one via physical activity) now with a standard astronomy MAR app the student can simply point their mobile device towards the sky and instantly begin to collapse the space between their research and field work. They effectively begin to learn through seeing. The question is what is lost and gained in this new form of navigation and interaction?

Well designed augmented spaces should provide the ability to re-program associations for creative juxtapositions. One method of achieving this in terms of a navigational methodology is to give users access to the macroscopic (overview) and the microscopic (point of view) of the content simultaneously. This is designed to enable users to look across data sets and treat every object as a file (which can be mined) to rapidly reframe their understanding.

In order to achieve the aim of designing and supporting learning across physical and virtual space we need to combine the affordances of the physical with the affordances of the digital. This gives us an opportunity to reinvest value back into the full thick description of physical site specific space and at the same time ensure we are using embodied experience (and not just vision as is common in most AR) to interact with these spaces. In Kevin Slavins Mobile Monday presentation (2010) he discusses the importance of peripheral vision in learning situations by illustrating how reality is not actually communicated via a single focus. Reality is the whole world around us and not just what is in front of us. As a result MAR can often make things seem less real. Reality is only augmented when it feels different and not just when it looks different.

In other references to the 'augmentation of context' Cheok (2012) points out in a recent keynote that we are moving from an 'Information Communication' to 'Experience Communication' era. This research is not centred on the technology but the navigational shift that results when the world itself becomes the interface. The majority of design coming out of the MAR paradigm tends to replace imagination with computer animation but imagination should itself augment the values of reality (Bachelard, 1964). Miller (1957) sums it up with the phrase 'One's destination should never be a place but a new way of seeing things'.

Additional questions:

- How does the pedagogical MAR affect the relationship between theory and practice?
- How will interacting in these environments affect the relationship between spatial cognition and visualisation?
- Can we use this new space created by mobile augmented reality (MAR) to increase the capacity to process, analyze and transform ideas?
- Do the web of relationships made possible between the physical, digital and conceptual aspects of augmented space increase the potential for knowledge formation via pattern recognition?
- To what extent can we measure the improvements gained through the affordances of mixed reality environments including new visualisation and interaction methodologies?

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ARLearn: Learning activities and interaction in augmented reality

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Introduction

ARLearn (ARLearn, 2012) is a tool suite for educators and learners supporting different phases and activities during a field trip. Learners can use the ARLearn app to explore and annotate the real world, while teacher can monitor their progress in real time.

The ARLearn platform is intended for teachers that organize a field trip, but can support other serious game scenarios as well. For instance, professionals could use the app when inspecting a site a make notes that are synchronized with their current location. With a web based authoring tool, teachers can add assignments or information to a map.

Originally a tool for audio augmented reality, this software has grown over the past few years from a standalone smartphone app to a fully-fledged mixed reality application platform taking into account field-trips, serious gaming, augmented *virtuality* and a notification system (Ternier, 2012). This open source mixed reality (Milgram, 1994) application supports serious games both in the real environment as in the virtual envirment. The remainder of this article focuses on the real environment and illustrates this with Android client that was built for this purpose. Augmented *virtuality* is supported through StreetLearn, a Google StreetView mashup.

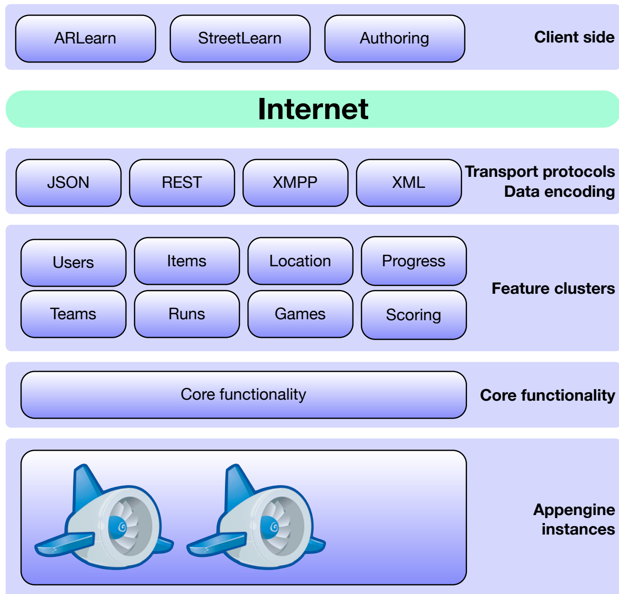

Figure 1: ARLearn architecture

The ARLearn tool suite features a client/server architecture. On the client side, the ARLearn authoring environment enables the creation and management of games (reusable instructional design) and runs (game instantiations with real time communication). With the ARLearn android client, a run can be played with mobile users. On the server side the architecture builds on the Google App Engine (GAE) stack to offer a scalable web service for content and notification management as well as game state persistence.

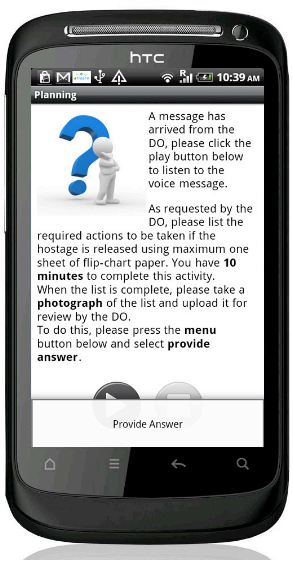

Figure 2: ARLearn app

At the top of the ARLearn architecture, the transport protocol enables communication between the clients and the backend infrastructure. Through a REST based protocol, these clients can pull data from the server. However, as new events might affect other users, a pull-based architecture is not sufficient. To support this kind of server-initiated communication, ARLearn implements a notification framework that builds on the Google channel API. This API is an implementation of the COMET web application model and allows a web server to push messages to a browser client over an http connection. The channel API works for this purpose with long-held HTTP request, for which the web server returns a response as soon as a message is available for the client

The next layer in the architecture covers the different ARLearn features. Some of the most important clusters include:

- A *game* is a blueprint for a simulation or a field-trip. Within a game media items, progress rules, scoring rules and dependencies between items are bundled. A game defines a configuration and captures whether scoring is enabled, whether a map view is enabled, etc.
- A *run* is a materialization of a game. A game can be played multiple times through the creation of new runs. A run defines teams, users and assigns roles to the users.
- A *user* is identified by a Google account. Users interact with media items and can obtain an individual score. A user can take a role, which implies that a user will receive content specific to the role and role-independent content. Users work together in a *team*. When scoring is enabled, users can compete with other teams and work together to increase the team score.

Games and runs are created with the ARLearn authoring environment. Here, an author can define various kinds of media objects.

- *Multiple choice* questions enable organising a poll and gather feedback from the user.
- *Narrator object* contains a piece of information that can be bound to a location and/or a timestamp.
- *Video Objects* and *Audio Objects* are special kinds of narrator objects and provide the user with a video or audio stream. These objects are important in creating a more realistic context.
- *Narratorial objects* feature an "open question" attribute. Using this attribute, one can turn the object into an open question, to which users can answer through recording audio or pictures.

The ARLearn architecture offers a high degree of flexibility and can be extended with other objects. For example, objects that need to be picked up and brought to a set location.

The ARLearn dependency framework enables media objects to appear or disappear when certain conditions are met. All media items can implement a dependsOn and a disappearOn attribute. When the dependsOn condition is satisfied, the item will appear. Similarly, disappearOn specifies when an item is to go away. ARLearn implements three kinds of dependencies that can be nested.

- An action-based dependency becomes true when an action has been performed by a user. For example, read a Video Object with identifier 100. Other actions are "startGame", "complete listening to an audio sample", "provide answer".
- A time-based dependency binds a timespan to another dependency and becomes true after the specified amount of time has been complete since the offset dependency was completed
- A Boolean dependency expresses an "AND" or "OR" condition between 2 or more dependencies.

Furthermore, dependencies implement a scope attribute, which can take “user”, “team” or “all”. If a dependency has the scope “team”, the dependency will become true for all users in a team, once one team member has performed the corresponding action.

ARLearn is currently piloted in various projects including

- The simulation of a hostage-taking scenario in collaboration with the United nations Refugee Agency (UNHCR).
- Teaching a second language to children aged 4-6 in the Elena project. In this project a field trip will be organized in shop. Children have to use a foreign language to execute shopping related tasks.
- Organising various trips in a public library. Here visitors will engage in tours (e.g. sadness) that will bring to books related to this subject. By scanning QR codes, users will be able to interact and influence/branch the story.

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