Interactive and Augmented Information Spaces to Support Learning and Dynamic Decision-Making

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Abstract

The rise of mainstream virtual learning environments has facilitated the operation of information spaces to support display, simulation, and interactive modelling. As well as disseminating information and knowledge, they can also be used to accumulate learning as each user is also a potential contributor. This paper examines the use of information environments to support mobile learning and dynamic decision making and the extent to which physical or social space can support the application. Such applications are not limited to the traditional data analysis and modelling functions but can be extended to include storytelling, theatre, and other aspects of the arts and the entertainment industry.

1. Introduction and Background

A joint EU/NSF initiative on human computer interaction and virtual environments emphasised the importance of the interrelationship between the user, the information space, and the data being analysed [1]. If the data is real-time and transitory, there are additional challenges in arriving at an optimum solution within a narrow time window. The increasing globalisation of databases and decentralisation of compute-intensive processes raises challenges in building and operating effective applications. However, it also increases the potential of smart applications that are effective, as it increases their utility and can transform traditional ways of working and interacting.

There is an increasing recognition of the importance of meeting the requirements of the human in interacting with information spaces. Interaction needs to more centred around human needs and capabilities. The human environment needs to be considered in virtual environments and other contextual information processing activities. This can improve information assimilation, reduce learning time, speed performance, reduce error rates, facilitate retention, and increase user effectiveness. In one sense this is all about good design across many aspects of real and virtual spaces to ensure continuity and consistency of the user experience. This is not easy to accomplish because of the multiple channels being used and the complexity of behavioural and cognitive aspects.

A virtual environment may be defined as a computer generated information space which supports interaction with a user. A networked virtual environment is a space in which a number of users can interact in real-time even though they may be in different physical locations. Singhal and Zyda [2] defined a networked virtual environment as a space which is characterised by the following five aspects -
1. A shared sense of space (illusion of being located in the same place)
2. A shared sense of presence (avatars of participants)
3. A shared sense of time (real-time interaction possible)
4. A way to communicate (various interaction methods)
5. A way to share (dynamic environment that can be interacted with)

These aspects are not discrete and separate but in fact may overlap in different ways in different circumstances and contexts. This increases the difficulty of successful augmentation which works well in all contexts and applications.

Relevant aspects to effective communication with virtual environments are [3,4] -
high level content descriptions and their access, such as metadata
- reducing cognitive load and providing more scope for creativity
- cross-disciplinary interaction and how to make it work
- handling interaction in specific social contexts and with cultural differences
- dealing with universality and the problems of the differently-abled
- interaction styles and their implications
- consistency of cognition models across information appliances
- paradigms for emerging new kinds of interaction; beyond WIMP interfaces: multimodal and perceptual user interfaces
- challenges for virtual environment technology and interfaces
- usability issues and measuring the effectiveness of symbiosis
- design and evaluation of online communities for intranet and internet
- scaling online communities to support millions of people
- universal access, social and ethical issues

This paper takes a mobile interactive game as a case study for exploring these issues.

2. A Mobile Interactive Game Example

The potential of mobile gaming, as a collection of both augmented and ‘real-world’ information spaces which can encourage learning, is beginning to be fairly well documented, at least on an anecdotal scale [5]. The potentials are recognised in certain parts of the academic community to the extent of entire conferences being dedicated to the themes around ‘mobile learning’, for example the annual M-Learn conference in the UK [6]. This is against an educational backdrop in which mobile devices are often legitimately seen by teachers as ‘objects of distraction’ from traditional learning, and potentially as something disrupting or even malevolent if inappropriately used within a classroom context.

We argue that the potential for using these ‘objects of distraction’ as either augmented spaces in traditional educational contexts or as enablers of learning outside the classroom is significant. We propose that this is a question of the development of appropriate applications, content and contexts for mobile-enhanced education. Such a task will require multi-disciplinary inputs and will include much needed application of established educational theory in addition to technological innovation. The potential is perceived as significant enough by governments for several research projects to receive significant amounts of public funding in the EU and elsewhere.

One such project that the authors are involved in is the AMICITIAS project (Ambient Intelligence as a Compelling Instructional Tool for Interlinguistic and Intercultural Skills) [7]. The educational goal of this project is to improve linguistic, gestural and cultural knowledge within multicultural locations. The AMICITIAS (‘Ami’ for short) team consists of international researchers, academics, teachers and programmers, building a language and culture educational game, to be played using mobile devices in six European locations - Barcelona, Toledo, Sicily, Sardinia, Galway and Bradford.

![Figure 1 The AMICITIAS R & D Environment](image-url)
language learning into the process of playing and discovering, using the mobile game as a component of this broader process.

The Ami game is built around the concept of “tracks” or paths that a visitor is likely to follow in a given location. We have specific users in mind – someone who, at least to an extent, is linguistically and culturally foreign to the place they are visiting and who has the aim of exploring. Ami is aimed at young adults, but the concept is relevant to a much broader demographic.

These tracks could be seen as a tourist route or a suggested itinerary around a given location – rather like one might find in a traditional guidebook, but they are actually much more than this because they are dynamic and changeable depending on the user’s behaviour. Each track presents specific objectives in a particular location within the area in the form of text, image, audio and animation.

What makes this more than a glorified print guide combined with an audio tape, apart from the vaguely interesting fact that this media is stored on a mobile phone, is that user progress can be evaluated through a combination of input and output to and from the mobile device. This digital media production and consumption is related to the actual space in which the user finds themself in real time. Progress and media collected by the user are also stored on their mobile device for later interactions online or in other learning spaces.

3. Interaction with the Game

The above is perhaps best explained through the use of a fictional player, who we will call Maria. Maria is a visitor to the UK from Spain as part of a school exchange programme. She is 17 and has downloaded the “Mystery in Bradford” Ami game to play when she has a couple of days to herself at the weekend. Maria’s mother tongue is Spanish, but she is fairly competent in English, having spent several years studying it at school. The game offers her not just a static glossary but something that can actively improve her location-based language skills.

Each of the six games we are constructing addresses two languages. There is a ‘main language’ – in the case of the Mystery in Bradford game, this will be English, and there is also a secondary language involved which will be touched on only at a very introductory level. In the case of Bradford this is Hindi but in the case of Toledo, for example, it is Arabic. The choice of languages is based on the EU’s target minority languages, hence targeting a certain educational objective, but the concept could easily be re-worked for other fields of education, entertainment and professional practice.

So, upon arriving in Bradford to play the game, Maria will launch the application from her phone and be greeted with a brief multimedia introduction and orientation, from which she can get a sense of where she is, physically. She then will select a ‘track’, that is the area of Bradford which she wants to explore/play first. This is all done through a narrative device of the character ‘Ami’ – a cute little sprite-based tour-guide who relates information and sets challenges.

Next, Maria selects, for example, Saltaire – a model village and World Heritage site, just out of the centre of Bradford. She is given instructions about how to get to Saltaire by train.

![Figure 2 Selection of area to visit](image)

She is given audio information about how to ask for directions there – a game technique that should encourage her to have more actual linguistic contact. GPS and other location-based technologies are also invoked to help orientate the user but in a gaming context, too much information could potentially reduce the need for ‘real-life’ interactions, which are one of the objectives of the game.

Once on the train to Saltaire, Maria can return to her phone and pass the short ride time with another multi-media introduction which unfolds some of the mysteries which she will have to solve, as game...
objectives, when she arrives. Once standing on the real train platform in Saltaire, she is ‘approached’, within the phone game version of the platform, by a fictional version of the historically based Sir Titus Salt, the mastermind behind the construction of Saltaire. It turns out he has lost his llamas. Llama wool was used in his mills in the mid-late 1800s to make a particularly sought-after textile. Maria is enlisted to help Salt find the missing llamas. The following extract from the game script illustrates this:

**Figure 3 Historical Map of Saltaire**

**Ami:** Welcome to Saltaire [Maria], you made it here! We're going to have a lot of fun in Saltaire, oh yes. Uh-oh, who is this imposing man with the big beard, walking towards us?

**Titus Salt Appears as a full-screen animation**

**Titus:** Huff, huff. What are you doing here? You don’t look like one of my work-people. What are these strange clothes you are wearing? And that's a very strange pet you have with you. Is it a dog or a monkey? Well well, never mind about that. What’s your name anyway?

**Player Input:** [Maria]

**Titus:** Well [Maria], I am the great Titus Salt and I founded this village in 1853. But for all my greatness, and the greatness of my beard, I am still in a bit of trouble and could do with some help. It's my Llamas – they’ve escaped and they are causing havoc all over my lovely village. Will you help me find them? I will give you a very special prize!

**Player Input:** [Yes]

**Titus:** I have to get back to town now, to get some more wool for my textile mill. If I'm late there will be trouble. Hmmm – my beard is itchy – why does my beard always get so itchy when I’m stressed? So [Maria] when you’ve found a llama – you can direct me to it on the map you will have in that strange beeping device in your hand. Your monkey dog will help you.

Oh. You do know what a llama is and why they are important round here don’t you?

**[EITHER]**

**Player Input:** [Yes]

**Titus:** Good - now get going!

**[OR]**

**Player Input:** [No]

**Titus:** No? You are really not from Bradford are you? Or perhaps you have travelled through time? Well you had better ask someone, or find out by having a look around the village. It's not hard to find out if you try. Now get going!

**Salt walks off screen.**

**Ami pops up.**

**Ami:** A dog or a monkey!? He may be ‘great’ but he is a very rude. Oh well, it looks like your quest has begun! You better get looking for those llamas. Why don’t we start at The Mill across the road? Hopefully we can find some help over there.

**Directions to The Mill accompanied by photo sequence.**

**Ami:** I'll give you directions - you can skip these by pressing "Next" if you want. Starting from Platform One. Turn left off the platform and walk up the path…

From this illustrative extract we can see the main ‘framing device’ for learning is a narrative – but this narrative ‘takes in’ the actual location in which the user
is standing, in addition to that which is taking place within the mobile device, and in this sense is different from a traditional hand-held game.

Upon entering Salt's Mill across the road, Maria will have to answer various questions about the art-works displayed in it, and the history of the building. She will also find a model of a llama inside one of the museum cases – and she will be able to ‘report’ its location back to Titus Salt, as one of the game objectives. Through this process she will have to absorb information from the museum area, and she will have to talk to people within the building also, to find out the answer to certain questions and also to navigate herself around the game objectives. The amount of knowledge she has picked up is assessed through questions during the track and she receives a bronze, silver or gold llama if she successfully completes the building objectives. She is then directed onwards and meets other characters within other locations in the town.

The ‘ambient’ linguistic learning which will be taking place through this process of playing is supplemented with more explicitly based language mini-games which can be played in more of an arcade or puzzle style on the device itself, whilst the user is taking a break for a cup of tea or a sit-down on a bench in a museum. Of course sound-controls need to be implemented in this scenario, and the use of headphones encouraged in certain areas.

There is a whole area of social etiquette around the use of mobile devices in public spaces to be considered. James Katz [8] discusses a collision between mobile and static forms of communication, in relation to the irritations which can be caused by other people's usage of technology in a pre-existing space. New forms of social etiquette in public space are being negotiated by technology users on a daily basis, and this is not a process which is free from conflict. This is no more the case than when dealing with young people in educational contexts.

4. The Implications of One Location to Many

Clearly in this example, the specificity of a location is important to the functioning of the application, and the authors have found that in some senses a reduction in status of the importance of the technology/device and graphical aspects and an elevation in status of the learning context or location is completely necessary for a successful learning experience. The introduction of a mobile device is significant, and possibly fundamental to the process as an aid, but not as a replacement for the location. The map does not replace the territory rather, what is important in our example is the ability of the framing narrative and visual design to provide coherence to the experience and to give a sense of progress or purpose. Graphics and media can clearly help this process but should act as pointers, enhancers or reference markers for the 'real-world' experience.

In this example users are educated about a variety of interesting facts associated with the culture and history of cities, including interacting with fictionalised versions of key people linked with developments of industry and the community over the years. A multi-sensory time-line can help to put the area into historical context as an entity in its own right. This kind of understanding of where a city came from can help to generate a sense of a place’s worth, and potentially help to give individuals an increased sense of a personal relationship to this history by recreating aspects of it in real-time and in situ.

Game playing is also a group activity. These kinds, hence these kind of activities can help solidify existing social networks but also generate and contribute to the generation of new ones, across many spaces.

The interaction of the media and digital footprints generated by playing the mobile-based game in a specific location can be brought into a new learning space, in the indoors comfort of the desktop scenario at home or in school, at any time after play.

5. Implementation Challenges and Cross Platform Compatibility

When looking to deploy an application over a number of devices, the Java platform is a common and sensible choice for many server or desktop applications because of its basis in a "virtual machine" which can allow the same code to run in several contexts.

When designing a media-rich application for limited capacity devices like mobiles, full Java is not generally available, so we made the decision to use code that runs under the J2ME (Java 2 Micro Edition) Mobile Information Device Profile (MIDP 2.0). This was for a number of reasons:

- Compatibility and extendibility across an extremely wide range of mobile devices
- Extremely large existing install-base
- No cost for SDK
• Large community of existing developers and thus pre-written classes / packages
• Object oriented approach which should be able to produce re-usable code

Whilst these advantages seem to make J2ME the obvious choice from the outset, we came across a major limitation: Any programme package (JAR file) with a size greater than 2Mb will simply not run on most mobile devices we tested (except for high-end smart phones such as the N95), due to memory cache restrictions. As the use of several hours of audio and some video was intended to be integrated into the project, these restrictions in particular began to quickly reduce our previously large install-base, and we realised that a simple solution must be found for the majority of devices that were now incapable of running even a fraction of the media that we needed them to serve through the application.

The fact that J2ME doesn't naturally handle large amounts of media well meant the project became pioneering in ways we had not expected. It was difficult to explain to non-technical partners what the limitations of J2ME were. An average user of an Apple iPod or a music phone would be quite right in asserting that it is possible to contain several hours of audio and possibly a couple of hours of well compressed videos or more on their mobile device, and that they should be able to do that from a learning game if they wished. In reality, accessing this data from a game-play point of view and in an application that will work effectively on more than one device is a major challenge. It would have been possible to design using C# for Symbian to work only on certain devices, .NET for Microsoft devices, or in the Apple iPhone's specific development environment, but this would defeat the purpose of making a product that was truly cross-platform in the way Internet applications are.

The workaround for the file size restrictions is to contain the numerous media files within what we describe as a dynamically referenced media box. Here the individual media files are stored, accessed and updated, along with the save files which include information about player status within a game track and player generated media - e.g. photos of certain location objectives. The main difficulty with this solution is how to get the 'media box' on to each device, in the right place, and how to tell the JAR file where it is. This is solved by writing a separate installer for the desktop which installs the media box on the phone, then installs the JAR file with a reference to where the media box has just been installed.

6. Conclusions

There are a number of cross-over benefits of integrating a real and virtual or augmented environment into a broader narrative. Interaction with the real-world environment can be dictated or suggested through the mobile application. Information that would not be directly available whilst situated within the environment can be mediated through the virtual environment representation of the real-world place. Of course the environment itself can reveal information that the mobile application cannot, and this simultaneous cross-over of information from both information spaces heightens the user's experience and makes it more memorable. It literally makes them the location of information cross over. This multi-sensory experience can be used to provide a more effective infrastructure for learning and teaching mechanisms.

There are actually some advantages gained by separating the media files from the .JAR, making the .JAR quicker to build and run. Also it is much easier to add, remove and edit individual media files, without the need to rebuild and re-install the JAR each time. This gives much more flexibility to the developers and artists involved in asset production, perhaps in a similar fashion to the separation of design from content that Cascading Style Sheets (CSS) brought to the Web.

In future work, new and emerging projects are likely to take greater advantage of the networked aspects of mobile device to produce interactive play between players in real time. The use of mobiles to educate young people about the effects of anti-social behaviour is likely to be an area of expansion for this field, as is their use for learning in general [9].

References


