Spatial and context awareness for mobile learning in a museum

Peter Lonsdale[1], Will Byrne[1], Russell Beale[2]
Mike Sharples[1], Chris Baber[1]
p.lonsdale@bham.ac.uk

[1]School of Engineering and [2]School of Computer Science
University of Birmingham
Birmingham B15 2TT

Abstract

The MOBIlearn project aims to develop a re-usable architecture for delivering mobile learning experiences. A key component of this architecture is a context-awareness subsystem that is intended to tailor the content and options made available to a learner, depending on their current situation, preferences, and learning history. The context awareness subsystem has been developed alongside a hierarchical model of context, and has been subjected to formative evaluation. A major input to the context awareness system comes from an ultrasound tracking system that has been developed at the University of Birmingham. This tracking system is being deployed along with the context awareness system to support learners in a visit to an art museum. The system is intended to offer not only content but also recommendations of collaborative activities based on physical and contextual proximity We describe our system and outline our plans for evaluation in the museum setting.

Keywords: context awareness, mobile learning

1. Context awareness for m-learning

Context aware computing (for a recent review, see Chen and Kotz, 2000) has a lot to offer to mobile learning. By taking account of the learner's surroundings, we can create engaging learning experiences, providing content and options that are tailored to the current context.

One of the aims of the MOBIlearn project (http://www.mobilearn.org) is to create an architecture for mobile learning that includes context aware recommendations of content, options, and services. Work so far has produced a hierarchical model of context (Lonsdale et al., 2003) and we have performed some preliminary formative studies of the system (Beale and Lonsdale, to appear).

Within the MOBIlearn project we have developed several learning scenarios designed to allow to the deployment and testing of the system, including the context awareness subsystem. Here we present our plans for deploying and evaluating our context awareness architecture for students in an art museum. This research is work in progress, currently being developed and planned for deployment in a local museum in September 2004. A major component of the system is a user tracking system that uses ultrasound to determine absolute and relative positions. We outline a number of research questions relating to the use of this system to provide input to the context awareness system.

1.1. Museum scenario

In our art museum scenario, two students visit the museum with a number of goals. Our aim is to support them in carrying out the following activities:

- Planning the visit according to personal interest and requirements.

- Reaching the area of interest as quickly as possible.
- Knowing exactly where a co-learners, guides, etc., are located the museum.
- Viewing a catalogue of works by a particular artist.
- Receiving detailed information about the work.
- Receiving information about the artist.
- Receiving information on other artists belonging to the same period of history.
- Using an audio guide on the mobile device.
- Downloading and saving information relating to the work of art.
- Adding comments/notes next of each work.
- Communicating with other learners and sharing opinions.

2. Implementation

The context awareness system is implemented as a web service in Java, running under a Tomcat server. We have defined appropriate XML schemas for sending and receiving contextual information, and for providing recommendations to the context delivery subsystems. This work has been driven and informed by our original context model, web services architecture standards, and pragmatic concerns for the MOBIlearn architecture as a whole.

A major input to the context awareness system is an ultrasound-based tracking system that allows us to track devices in real-time to a high degree of accuracy.

2.1. Location tracking

We are currently using an ultrasound location system, which offers a very high degree of accuracy. The system uses several small ultrasound transmitters deployed at intervals around the gallery space, and measures the 'time-of-flight' of the signals received by a transceiver attached to an iPAQ PDA. The transceiver communicates with the device by the serial port, and a client on the device can then calculate and deliver either its XYZ position or simply which sensor it is closest to, depending on the application.

2.2. Context Model

Formatted: Bullets and Numbering

There is growing recognition of the need for flexible, scalable, re-usable models of context that can be deployed for a range of applications. In MOBIlearn, we have been working to produce a re-usable model of context for mobile learning applications (see Beale and Lonsdale, 2004, Lonsdale et al., 2003). There have also been calls for a reconceptualisation of context to better represent the socio-cultural aspects of activity, moving away from the pre-dominantly technology centred approaches to context (Lueg, 2002a, Lueg, 2002b, Dourish, 2004).

For MOBIlearn, the purpose of context awareness is to enable learning on mobile devices, and so our approach to describing context and applying this description to producing a usable software architecture is based on this focus. Figure 1 shows the basic hierarchy for our description of context.

Instead of a rigid definition, our intention is to provide a hierarchical description of context as a *dynamic process with historical dependencies*. By this we mean that context is a set of changing relationships that may be shaped by the history of those relationships. For example, a learner visiting a museum for the second time could have his or her content recommendations influenced by their activities on a previous visit. More details of our context model can be found in Beale and Lonsdale (2004)

Contextual information is made available to other components of the MOBIlearn system by means of XML (eXtensible Mark-up Language) documents in an agreed format. At any given time, the current context state is represented as a nested set of context features, all described in XML form. An XML schema for this XML object is an agreed format that allows all components of the MOBIlearn architecture to access this information as and when it is required. Storage of a set of timestamped XML context objects provides the historical context trace that can be inspected and used by subsequent sessions.

2.3. Approach

Much of the current work on context awareness is technologically driven – that is, systems are developed to take into account of the capabilities of the available technology, but there is currently a debate about the exact nature of 'context' for context aware computing (for example, see Dourish, 2004). Our aim, in MOBIlearn, is to produce a learner-centred approach to context awareness by including contextual elements that are usable and useful for the a given learning scenario. These elements also need to be available from either the environment, a learner model/profile, or directly from the learner themselves. We aim to involve the user in the process of determining and using contextual information by consulting them for information and by making their current derived context both inspectable and modifiable.

2.4. Elements of Context

Formatted: Bullets and Numbering

What is becoming clear is that there are difficulties in implementing context-awareness. Firstly, how do we get hold of contextual information; and secondly, what do we do with it once we have it?

Within the MOBIlearn project, we are centring our designs around specific learning scenarios. At present we are working on deploying the system in an art museum setting.

For this scenario, the context awareness system is being set up to take account of several contextual elements from both the environment and the learner themselves. These contextual elements will be used to derive a usable *context substate* (see Lonsdale et al., 2003). Elements to be used in the context awareness subsystem include:

- current learning topic: this will be either explicitly indicated by the learner, or obtained from their profile
- time spent on each artefact: our location tracking system not only tracks learner's locations, it also times how long they spend in any one position. Standing in front of an artefact for a longer period is used to infer a higher level of interest, and content recommendations are updated accordingly
- artefacts or content annotated (through MOBIlearn system on handheld device): the MOBIlearn system supports the annotation of content and also artefacts themselves (a form of virtual graffiti) – this information will be tracked by the context awareness system to provide relevant recommendations (for example, recommending items that have been annotated by friends)
- content items shared with others (through MOBIlearn system on handheld device): the MOBIlearn system supports the sharing of content with other learners – this activity will be tracked and used as a source of contextual information

These elements of context will interact to give us a useful way of determining what is appropriate to show the user. For example, the time spent looking at each painting will be used to derive a measure of 'interest'. A low level of interest will mean that only the title and artist of the current artefact will be shown. However, if the subject of the current artefact matches the user's current learning goal, then the system will assume a higher level of interest and show more detailed information. The user will also be able to over-ride the system. For example if their goals change during the session and this is not reflected by their current profile then they will be able to specify their interests, or revert to default content delivery that is not customised in any way.

2.5. Integration

The context awareness system takes the location data as one of its inputs and uses this information in two ways. Firstly, content is filtered depending on which artefact the user is currently closest to. The dwell time at this position is then used to further filter the content. The user's level of interest is inferred from the time they spend at any one location. These two factors combine to give us recommendations of content.

3. Aims of Research

Several methods and systems for location sensing will be explored and assessed through user trials, with regard to three main criteria:

- The ability to deliver accurate and reliable location information to the context awareness system
- The impact on the user's experience as they move through the gallery
- The need for the user's device to have other capabilities beyond wireless network access.

In addition we will explore other issues arising from the use of location-aware systems, in particular:

- How to distinguish interest from simple proximity
- How to incorporate a 'location history' into context
- How to infer a change of position in the contextual sense from changes in physical location reported by a location service
- How location-driven changes to content or services can best be presented to a mobile user.

Our aim is to provide not only context-dependent content to learners' mobile devices but also to encourage and support collaboration between different learners. These collaborations should be dependent on context, so that learners in the same or similar contexts are offered the chance to interact.

We have identified a number of specific research questions for this work:

Does the use of context aware mobile devices affect the attention that learners give to artefacts in the museum?

With the mobile device itself being an artefact that requires attention, it is important to determine what proportion of their time users spend looking at each. In relation to this, content displayed on the device will be directly relevant to the current painting or other object of interest, and so it will be important to explore co-referencing between these two sources of information.

What options do users find most useful?

Our model of context aware delivery of content and options will be shaped by users actual behaviour in the museum, and their expectations of the system.

Do users prefer technology mediated delivery over traditional presentation?

We hope to provide a support for learners that they will find useful and appropriate.

How can we identify and support users' goals?

Providing context aware learning means supporting users in their goals. To do this we must first identify these goals. We can either do this automatically or by seeking input from the users. However, we need to be sure that users' exposition of their own goals is consistent with their behaviour.

Do people want/like to have control – push vs pull models of content delivery

For the most part, the delivery model for our museum trials will be push – content will be delivered to the user's device when it is deemed appropriate. However, we should not deliver new content if the user is not yet ready to receive it, and it should be possible for the user to specify content that they would like to see that might not be related to their current context.

What is the correlation between how the system and the user determine changes of context?

The system defines a change in context as whenever a feature of the context state changes. For example, moving from one location to another constitutes a context change. However, the user might have a different conception of context, and for them a change might only occur when they complete a goal and set a new one. A dissonance could arise between the user's perception of the current context and the system's own record.

Being able to accurately represent the context state along with any context changes and their impact on recommendations will be crucial to making the system usable.

Can we direct and change people's paths?

Visitors to a museum will tend to follow certain routes through the spaces. We want to explore whether it is possible to recognise specific route-following behaviours and direct users to follow another path, according to a pedagogic plan or other constraint. For example, we might want to change users' paths if they are not visiting the correct locations for their study plan, or if the museum is busy we might want to optimise people's movement through crowded spaces.

4. Next steps

Formatted: Bullets and Numbering

Several specific challenges for implementing this kind of context aware experience are apparent:

- How can the context-aware system be supportive in a non-intrusive way?
- How can we make suggestions about content or activities without causing distraction?
- How can we effectively combine various sources of contextual information to provide recommendations appropriate to the goals of i) the learners; ii) the experience designers, iii) the system designers; and iv) the teachers/docents?

The context awareness system, along with the other major components of the MOBIlearn system, will be deployed in a local museum in September 2004. There are also ongoing trials of various context sensing mechanisms at the University of Birmingham.

References

Beale, R and Lonsdale, P (2004) Mobile Context Aware Systems: the intelligence to support tasks and effectively utilise resources. In *Proceedings of MobileHCI 2004 (to appear)*.

Beale, R and Lonsdale, P (to appear) Mobile Context Aware Systems: the intelligence to support tasks and effectively utilise resources. In *Proceedings of MobileHCI 2004*.

Chen, G and Kotz, D (2000) *A survey of context-aware mobile computing research*. Technical Report TR2000-381, Dartmouth College, Hanover, NH.

Dourish, P (2004) What we talk about when we talk about context. *Personal and Ubiquitous Computing,* 8(1), 19-30.

Lonsdale, P, Baber, C, Sharples, M and Arvanitis, T (2003) A context awareness architecture for facilitating mobile learning. In *Proceedings of MLEARN 2003*, London: LSDA, 36-37.

Lueg, C (2002a) Looking under the rug: on context-aware artifacts and socially adept technologies. Workshop on *"The Philosophy and Design of Socially Adept Technologies"*, ACM SIGCHI Conference on Human Factors in Computing Systems, 20-25 April, Minneapolis, Minnesota, USA.

Lueg, C (2002b) Operationalizing context in context-aware artifacts: benefits and pitfalls. *Informing Science: Human Technology Interface,* 5(2).