Towards a multidisciplinary user-centric design framework for context-aware applications

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1 Introduction

In recent years, there has been an escalation of application areas of mobile context-aware computing, all of which offer great potential to support and enhance the activities of people in their daily lives. Our work has been motivated by a particularly challenging activity: supporting visually impaired people to navigate through new surroundings - an often vexatious task with traditional mobility aids. Accessing information and novel services *anytime* and *anywhere* could be realised through technologies distributed in a ubiquitous manner. The capabilities of context-aware technology are well presented by Pascoe [1], who separated between contextual sensing, adaptation, resource discovery and environment augmentation. Wireless user communities, for instance, could allow visually impaired users to share experiences, problems encountered along a route and solutions to negotiate hazards by electronically augmenting the route. Additionally, a mobile device could, say, automatically download timetables at bus stops and inform a visually impaired person when their next bus home will arrive.

The rate of technological investigation of context-aware services has not been matched by a suitable analysis of human issues; a key factor which will decide whether these technologies are to seamlessly benefit the user. Current navigational systems, for instance, do not provide information which would be of use to visually impaired people. The neglect of human issues is also evident in existing context-aware design frameworks which are predominantly software orientated [e.g. 2]. A multidisciplinary approach strongly suggests itself, combined with an extensive analysis of which factors make up a user's *context.* Cognitive mapping, for instance, provides an insight into the relationship between context and its influence on human behaviour. Understanding the processes by which people acquire, store and retrieve information about the environment will improve the design of context-aware systems that predict which information to give a user, based on his/her current activity and situation.

After our user studies illustrating the diversity of peoples preferences for contextual information, our aim is to create a model of a user's context that facilitates the production of user-centred design frameworks for context-aware applications. We will illustrate this in relation to context-aware applications for visually impaired people.

2 Previous studies undertaken

Our first two studies involved categorising verbal and written route descriptions from sighted and visually impaired people, in order to ascertain how people use clues in the environment to navigate and orientate [3, 4]. The results revealed that both sighted and visually impaired participants varied within and between groups. Visually impaired people, for instance, used considerably more contextual information generally and used information, not used by sighted participants, within categories relating to *sensory*, *motion*, and *social contact*.

Our third study* involved asking different groups of visually impaired and sighted participants to walk to pre-determined landmarks whilst being given proportioned verbal instructions derived from either sighted participants descriptions from the first study or visually impaired participants descriptions from the second study. An objective and subjective assessment revealed that visually impaired participants were quicker using proportioned visually impaired peoples descriptions, which was also reflective in a lower workload rating. On the other hand, the opposite result occurred for sighted participants. These results demonstrate that context-aware applications must adapt its information in order to match unique preferences of the user. In order for this to be achieved, a suitable model of a user's context is essential as addressed in the next section.

3 Proposed multidisciplinary model of context

A preliminary multidisciplinary model of context has been constructed, as illustrated in Figure 1. It is the outcome of a comprehensive review of literature* and captures the relationship between different interpretations by researchers within psychology, computer science, and linguistics.

The horizontal centre line, in Figure 1, separates the 'user's world' from the 'application's world'. The oval shaped circle in the centre represents what is 'focal' to the (i) *user* with respect to carrying out a primary activity/ action (e.g. interact with IPAQ, make a social interaction, etc.) in an attempt to achieve a particular high-level goal (e.g. navigate to train station), and (ii) *application* with respect to providing information and services via the User Interface (UI). In contrast, the hierarchy of circular layers, or sub-divisions of context, which surround the user and application, represent anything 'contextual' or peripheral to a focal action or service (this could either support/

* Described in full papers currently under review.

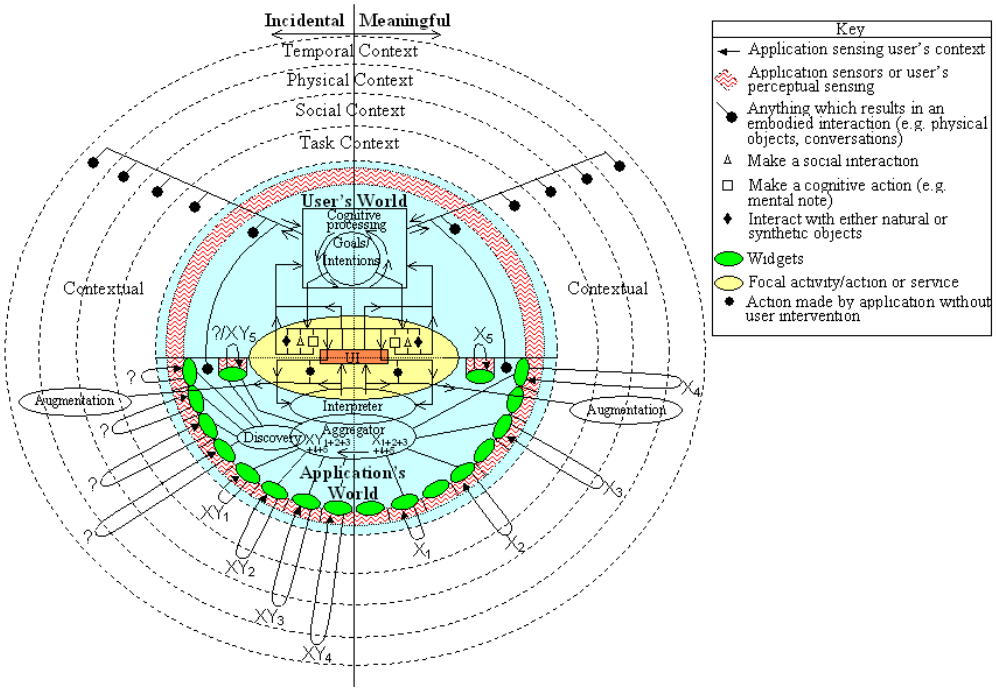

Figure one: Our proposed multidisciplinary model of context.

influence the focal activity or have no impact at all). The outermost layer of the user and application's world represents the user's perceptual sensing (i.e. using the five senses) and the applications sensing technologies (e.g. GPS receiver).

As depicted, the vertical centre line separates between 'meaningful' and 'incidental' context. Meaningful context implies that the user is both undertaking meaningful *focal* actions/activities (e.g. scan environmental landmarks to navigate) and using meaningful *contextual* resources (e.g. IPAQ giving verbal instructions), in which to achieve their goal (e.g. to catch a train). The application, on the other hand, is aware of (or thinks its aware of) the user's goal, and subsequently senses meaningful information in the *contextual* environment (e.g. status of train), which is used to provide a focal service/information to the user (e.g. informing the user train is delayed). Incidental context from a user's perspective is anything external (i.e. in the environment) or internal (i.e. within the user's mind) which occurs *contextually (e.g.* passing excavation work), normally as a result of human-environment interaction, and is unrelated to the primary goal. This may either remain incidentally contextual, or become incidentally focal (e.g. navigate *around* excavation work), meaningfully contextual (e.g. decide to walk another route on subsequent days) or meaningfully focal (e.g. if you fall down the hole!). Incidental context, from an application's perspective, is sensing environmental information to either make inferences about unknown intentions of the user or *discovering* new context-aware information/services (which the user may be unaware of).

The looped process illustrates how an application aggregates and interprets information which is used to provide focal services, whereas the user constantly processes information and forms goals for action.

4 Conclusions & future work

Despite our multidisciplinary model being in its early stages, it provides a valuable insight into the processes by which people access information in a ubiquitous environment, given the context they are in. It raises important questions regarding how information should be tailored to suit different types of users, contexts and situations.

The next stage will involve utilising our model to create a user-centric design framework for designing context-aware applications, which would complement more software orientated frameworks, such as Dey *et al*'s component-based framework involving widgets, aggregators, interpreters, context services, and discoverers [2]. Our framework and model will be used to design our next user study (drawing on cognitive mapping principles), which focuses on how people with different forms of visual impairment might prefer different varieties and proportions of contextual information when in different contexts (e.g. walking vs. travelling on a bus).

5 References

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4. Bradley, N.A. and Dunlop, M.D., 2002, "Investigating context-aware clues to assist navigation for visually impaired people", Workshop on Building Bridges: Interdisciplinary Context-Sensitive Computing, University of Glasgow, Scotland, p.5-10.