Designing to maintain human agency in context-aware systems

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ABSTRACT

This paper describes a series of design games, specifically aimed at exploring shifts in human agency, how they are managed, and the impact this will have on the design of future context-aware applications. The games focused on understanding information handling issues in dental practice with participants from the University of Queensland Dental School playing an active role in the activities. Participatory design activities reveal how technology solutions impact on dental practice. By finding methods of representing technological possibilities in ways which can be easily understood we enhance the contribution that dentists can make to the design process.

Categories and Subject Descriptors

H.5.2 [**Information Interfaces and Presentation**]: User Interfaces – *input devices and strategies, interaction styles, prototyping, user-centered design.*

General Terms

Design, Human Factors.

Keywords

Human agency, context-aware, design games.

1. INTRODUCTION

An important step towards designing effective context-aware systems is developing an understanding of how humans manage agency. Suchman describes agency as the "capacity for action" [7]. For a human (or an information system) to have agency they must have the ability to make decisions and act on them in a way which they perceive to be appropriate. When humans coordinate their actions with each other they are able to expertly negotiate and manage shifts in agency and responsibility. We are highly skilled at being able to read subtle social cues and react appropriately. Context-aware systems should support the same level of seamless interaction.

A technologically optimistic view is that these interfaces can achieve this by incorporating knowledge of the user's context into

the design of the application or by encoding the application with mechanisms for detecting context. However, through the process of predicting, then reacting to detected context information, the system makes decisions on the user's behalf, reducing the amount of control that they have over their situation. The responsibility for determining what actions are, or are not appropriate is shifted to the system which is not always effective.

So how do we design technology which allows humans to have agency when they need it? How do we strike the right balance between giving a user control of their situation and weighing them down with unnecessary controls? How much agency is enough?

1.1 Related Work

There are many different interpretations of what context is, and what it means for technology to be "context-aware", evident in current computer science (in particular, pervasive/ubiquitous computing) literature.

A common approach to designing with context is to work with a collection of information which is derived from sensors that have been distributed throughout a particular setting. This approach lends itself to a fairly impoverished view of what context is, reducing it to a property of a setting which is typically characterised by the location, identity, and preferences of people and objects. This neglects the many social aspects of context which have a strong influence on the way that work actually unfolds in a particular setting.

In putting forward that "context isn't something that *describes a setting*; it's something that people *do*", Dourish highlights the emergent nature of context [4]. Suchman further emphasizes the rich social aspects of context in the way she describes the "embodied competencies involved in intelligence and interaction as these are enacted by humans" [7].

These perspectives on context suggest that as designers we should not try to predict context but instead should make context information visible and provide simple ways for users to act on it [1]. In order to design with this view of context we need to start by understanding exactly what it is that people *do* and how they manage the context in which they work. Brown and Randell present a particularly interesting example of designing with context when they describe the issues related to the design of a context sensitive telephone [2]. In their example they observed the company office worker using information available to them in the form of a Caller ID system to determine the importance of an incoming call. The office worker was able to make a decision on whether or not to answer the call based on information which was

available at-a-glance. By being able to assess the situation with very minimal interruption to the task at hand they are able to concentrate their efforts on what they perceive as most important, whether that is answering the call or continuing with what they were doing. Rather than a system trying to predict their needs, they are instead provided with a resource which they can use to make their own decision. They manage their own context.

There are very few research efforts devoted to designing resources similar to the Caller ID presented in this example. In order to understand how we might design artifacts which can be easily appropriated and which merge seamlessly with existing work practices this paper describes an exploration of how people negotiate agency and how they manage and control change.

1.2 Outline
The remainder of this paper describes the process and results obtained from a series of design games and discussions held at both the UQ Dental School and a UQ design lab. *Section 2* introduces dental practice and the rich physical and social nature of the work context. *Section 3* describes the design discussions as well as the design game *What can an agent do for me?*, which was used to explore the concept of agency with participants from the dental school. *Section 4* discusses future directions and implications for the design of context-aware systems.

2. DENTAL PRACTICE
The dental surgery is a particularly interesting domain for exploring issues related to context-aware computing because of the rich nature of the context in which the work occurs. In many dental surgeries the dentist will operate on the patient while an assistant provides support during the procedure. The expert relationship that exists between the pair influences the social interaction and the way the work unfolds. The surgery contains a larger number of instruments ranging from precise and delicate probes, mirrors, automatic drills, and scaling instruments to larger and more robust suction instruments. In addition to the coordination of tasks managed by the dentist and assistant and the use of a variety of instruments there is an ongoing task of managing the patient record which is stored electronically on a desktop computer in most modern dental surgeries.

Traditional modes of interaction (keyboard/mouse interfaces) are problematic when operating under infection control conditions in a dental surgery. Working on the patient and updating the patient record at the same time is often necessary (when charting the mouth for example when there is too much information to be memorised and recorded later, or when performing a root canal treatment when it is crucial that precise measurements are obtained and accurately recorded) but becomes a difficult task because of the requirement that the dentist and assistant maintain clean operating conditions at all times when working on the patient. This means they can't touch a keyboard or mouse with gloved hands.

There is a lot of potential for improving the ways in which the dentist and assistant can interact with the patient record if the information system can be designed to take advantage of the context in which the work occurs. To gain a deeper understanding of the work context with a particular focus on the negotiation of agency, a series of design games and discussions

were organised and run at the University of Queensland Dental School and a UQ design lab.

3. WHAT CAN AN AGENT DO FOR ME?
There were two different activities in which we had the opportunity to engage participants in exploring issues related to context detection and the negotiation of agency – design discussions, and a design game. The first discussion was with a senior lecturer from the dental school and the second with the CEO from a software company which develops applications for dental surgeries. The design game was run at the UQ Dental School with two students. Each activity was preceded by an introduction to the concept of agency in the form of a prototype demonstration, a context-aware bracket table[1] – the Sensing Table.

3.1 Introducing the Concept of Agency
The concept behind the Sensing Table prototype is that there is a link between the instrument that the dentist is using at any given point in a procedure and the information that they need to be looking at in the patient record (for example, a chart, a graphical representation of the patient's mouth, or an x-ray).

A typical scenario might be that the dentist has just seated the patient in the dental chair at the start of the procedure. To begin with they need to perform an examination of the patient's mouth; the mirror instrument is always used to do this. The dentist would pick up the mirror off the bracket table and at the same time the information system would load the most recent chart of the patient's teeth. The dentist could then refer to the chart while performing the examination.

The prototype was demonstrated by selecting the mirror and sickle probe instruments off the Sensing Table causing a chart of the patient's teeth to load on a nearby computer screen. When the instruments were put back down on the table, the chart closed (Figure 1).
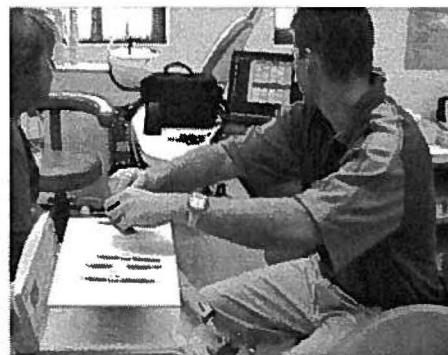

Figure 1. Demonstration of the Sensing Table.

During periodontal procedures in particular, but also when conducting examinations, doing a filling, and giving an anesthetic, these one-to-one mappings exist between the instruments and the information, and can be drawn upon to make the dentist's work easier.

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[1] The "bracket table" is a small moveable bench, generally positioned beside the dental chair (where the patient sits), which the dentist uses to lay out and arrange instruments that they plan to use during the procedure.

By trying to predict what a dentist wants based on context information that is detected (ie. a particular instrument has been picked up), the dentist's ability to control the situation is restricted as the responsibility for loading the chart/form/x-ray is shifted to the information system. Even though on many occasions this may save the dentist from some additional work (loading up the right form etc), there is likely to be a situation where the dentist would like to have more control over what information is displayed.

In this instance the prototype is used as a design artefact which provokes a discussion about the issues related to agency, rather than as a firm technical solution to the interaction problems faced in the dental surgery.

3.2 Design Discussions

The design discussions presented two interesting perspectives on how agency could be managed in the dental surgery. The first conversation was with a senior lecturer from the UQ Dental School.

Their view of the prototype was that although there were cases where it would be effective, when using instruments like the mirror which are required in nearly every procedure (and many times during a given procedure) it might not always be easy to make a one-to-one mapping. This raised questions like What screen should it bring up and when? and What if the screen is still needed once the instrument is put down?

They suggested that perhaps a more effective way for a dentist to manage the information system which would give them more control, could be to add new buttons (beside the existing ones for adjusting the dental chair, light, etc.) to the bracket table which correspond to the charts/x-rays that they typically use. This is interesting because the solution is in the form of a simple resource which fits with an interaction paradigm that dentists are already accustomed to. The information system could then be controlled and managed as it is needed.

The second conversation was with the CEO of a software company which develops applications for dental surgeries. They described how different screens in their application correspond to different "work contexts" between which the dentist often needs to switch when they are performing a procedure. What was interesting about this discussion was rather than seeing the multiple uses of some instruments as a hurdle for context-aware computing, it was seen as an opportunity to rethink the role of instruments in the dental surgery. Could an instrument be designed with its mapping to the information system in mind? The dentist could then select their charting mirror, or their x-ray mirror depending on the information that they needed. As in the first discussion, with this solution the dentist is provided with a way to control their situation – they maintain an appropriate level of agency.

3.3 Agency Game

Game-based activities are particularly useful as a design method because they provide a means of establishing a common design language [6] which both domain experts and researcher/designers can draw upon and use to ground their understandings.

The aim was to involve the two participants in an exercise which would allow everyone to develop a deeper understanding of how

humans negotiate agency. There were two main research questions which helped to focus the game:

1. How do we strike the right balance between giving a dentist control of their situation and weighing them down with unnecessary controls?

2. How much agency is enough?

The demonstration of the prototype was an important activity leading up to the game in the sense that it established the foundation for a design language which the game then helped to develop.

It was important for the purposes of the game that we operate in the context of a real dental surgery [3]. The clinical setting of the dental school provided an excellent workspace and backdrop for the game. Working in this context was beneficial because it helped us to develop a sense of the "movements and spatial relationships" that are permitted by the surgery layout [5].

To begin with, the participants were asked to complete some individual tasks. These involved, first of all thinking about an aspect of dentistry that they would like to have automated (controlled by a computer agent), then drawing a picture of this task or action on a piece of A3 paper which was provided. They were encouraged to use the sketch to show what they would have their agent do and to write a brief description beside it.

Following this, they used a Polaroid camera to take pictures of the objects from their workspace which were represented in the drawing. The photos were stuck onto the sheet of paper with the drawings. The sheet of paper became a poster-like representation which they used to describe their agents (Figure 2).
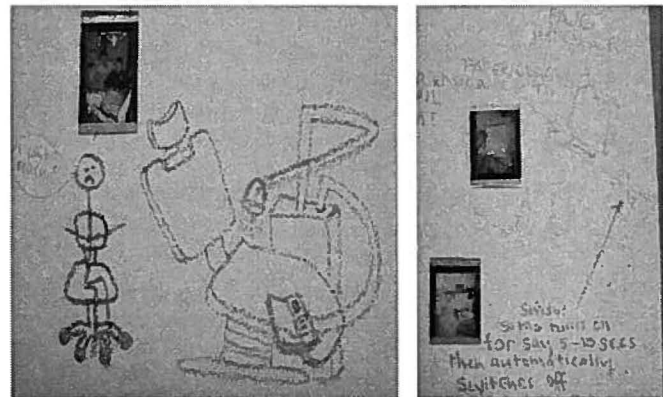

Figure 2. Posters created during the design game.

They took turns describing the sketches to each other, placing a particular emphasis on the role that the agent had in the sketch. As a pair, they had to then act out the role of the dentist and agent in their workspace. One person played the role of the dentist, and the other played the role of the agent which is helping him/her.

Throughout the game the students developed two agents. The first one was responsible for moving the bracket table and light towards the dentist when they needed it, and away from them when they didn't need it. On many occasions, the light and bracket table get in the way of people moving about in the surgery and it would be useful if they did not need to be physically adjusted on a regular basis. In the scenario that the students

sketched and then role-played it was the agent's responsibility to adjust the bracket table and light depending on whether the dental chair was reclining (they should be moved closer to the dentist) or sitting up (they should be moved away from the dentist).

The second agent was responsible for turning on the taps for the dentist when they needed to wash their hands. To maintain clean conditions the dentist often has to wash their hands without touching any part of the taps or sink with their hands. This requires awkward movements such as the dentist using their right elbow to turn the tap on, and then their left elbow to dispense some soap. The role of the agent here was to turn on the taps at the correct temperature without requiring an adjustment from the dentist, and for an appropriate amount of time. It was interesting to see how the agents were designed, had their role articulated, and then acted out throughout the game.

4. DISCUSSION

Designing effective context-aware applications is difficult. If they are ever to merge seamlessly with our existing work and social practices they must do so in way which ensures that human agency is preserved.

The design discussions were valuable because they presented two very different perspectives on how agency can be managed. They challenge us to consider the question, What is equivalent to the Caller ID in the dental surgery? Could it be a button which the dentist can press when they need to, an instrument which can be selected based on its capabilities both as an instrument and a mode of interaction, or perhaps a different resource that is available to the dentist?

The prototype was important because it represented our ideas of what context-aware technology might be like in a dental surgery in the future. It allowed us to experiment with technical ideas while at the same time having the exploration and discussion grounded in a real work context. It was useful not as a firm technical solution but rather as a design artefact which was capable of provoking a stimulating discussion about agency and context awareness. The prototype demonstration and discussion created a design language which the games then developed, helping us to critically examine and talk about agency.

What was interesting about the game was that the negotiation of agency occurred both in the process of role playing the sketched scenario and also in the process of drawing it. The poster was important because the visual thinking task encouraged the participants to think critically and to represent the important features of the agent through their sketch. The scenarios on the other hand, allowed them to develop a physical understanding of the role of the agent which made it easier to articulate.

When involving users in the design process there is a tension between designing in small steps which results in making incremental changes to the current context, and on the other hand, exploring how ubiquitous computing technology could have a more significant impact on the work practice. By introducing issues related to ubiquitous computing, the dentist is faced with a paradigm shift in the way that they view the use of technology in the surgery.

This tension was particularly evident in the two agent examples that emerged from the design game. The examples were simple and related to physical aspects of the setting which could be re-designed. This is precisely the reason why the use of a prototype like the Sensing Table is important. It introduces a technical possibility like context detection and presents it in a way which is easily related to dental practice. This allows a rich discussion and exploration of the technical issues around context detection and agency in a dental surgery setting. Future work will include introducing more specific technical prototypes (such as using RFID tags to track the movement of instruments around the surgery during a procedure) to participants with the aim of developing a deeper understanding of agency and how dentists might potentially manage their own context.

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