Context-Aware Design and Interaction in Computer Systems

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ABSTRACT

As human computer interface gets more immersive, it will need to explicitly draw upon cognitive science as a basis for understanding what people are capable of doing. User experience and situation should be integrated into the computer system design process. Situational awareness can be used to reduce the amount of explicit input a person has to give a computer. Contextual information of where and what the user task is, what the user knows and what the system is capable of can greatly simplify the user scenario. Such use of contextual models in computers can also reduce the teaching needed to accomplish tasks. An approach for contextual-computing framework for design is illustrated though examples.

Keywords: Context, User, System, Task, Design

INTRODUCTION

This paper describes creating contextually-aware systems using increasingly sophisticated task, user, and system models. A framework for analyzing them is introduced along with a discussion of design techniques and technology.

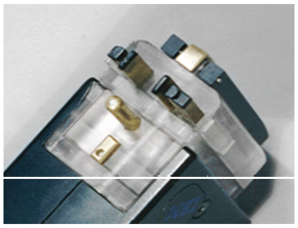
A task model refers to the acts that a person performs with a system and what s/he intends to accomplish. Consider an oven mitt: the task for the person is to remove food from the oven and protect the surface that the food is placed on. The task for the mitt is to protect the person and the surface from heat; the mitt expects to be hot and then to cool. A new augmented task model might include the mitt telling the person that food is too hot or that food is getting cold or to say "fire" when the mitt is about to burst into flames. Such a "talking trivet" has been constructed which uses a voice chip and speaker to communicate to the user.

A person's user model refers to the knowledge that a user has about what s/he is doing and about his/her ability to accomplish goals. User models have been variously defined. Grundy [1] used a list of characteristics about a library visitor identified in a "stereotype". Deep Blue [2] used a list of game starts and style of play to characterize a chess opponent. The user model, developed and stored in the computer consists of task-relevant background information about the user (i.e. the Digital Threshold described below knows who its users are, what access they should be given, and their preferences). Users' needs are often intangible, affected by habit, self-image and even issues of motivation (i.e. a person might be most efficient in the morning). Aspects of the user model that focus on what a person wants to accomplish have at least two elements, user congruency and user comfort. User congruency addresses a user's desire to be seen a certain way as they present themselves, through look, actions, and words. A person might use a Personal Digital Assistant (PDA) to show that they are technologically savvy. User comfort with certain thoughts, actions and words also affects actions. Some people will use and even become obsessed with a PDA in spite of what "other people think". Such people are comfortable with and accept it in their life. Some people might like the way a PDA works, enjoy or be neutral to other's opinions, but simply not see themselves as a person who carries such things. Their lack of comfort may come from one of a number of concerns; they may even feel that it violates their privacy or person.

The system model refers to the capabilities of the computer system: its structure and ability to accomplish an existing task. The multimedia bed, described below, has the ability to project an image on the ceiling and play sound, track a three-dimensional input device, and to record body posture through a sensor mattress pad. To this extent it has the ability to help people relax, keep them entertained and facilitate effective sleep.

Context-aware computing relies on the task, user, and systems models to meet the explicit congruency, and implicit comfort needs of users while explaining and simplifying life. The examples incorporate increasingly explicit and dynamic models, which are used to create their value and flexibility as interaction tools. The techniques and technologies used to develop contextually-aware systems include examples both with and without computation. Many contextually-aware scenarios can be spatial or mechanical without the need for electronic sensors. Keys, for example, are made to work for particular people in particular places. A physical example is a plug that works in any power outlet. Analog sensors and switches are the simplest kinds of electronic sensors. Even an automatic door that opens when a mat is stepped on is contextually-aware. The electronic oven mitt relies on simple sensors. Slightly more advanced context scenarios an be developed by coupling a switch with an internal clock. Such a system is useful for intermittent interaction with the object or sensor. An automated watering system measures moisture and uses a timer to decide when to water plants. Integration of numerous sensors in support of or driven by sophisticated task, user, and system models can support still more complex scenarios. Modern exercise machines use weight, height, heart rate, etc., to monitor and prescribe a training experience. The electronic wallet integrates many activities through carefully chosen sensors and scenarios.

Design Prototypes of Contextually-aware Systems



The Universal Plug [3] is a system that has state and uses mechanical logic to select task model. When the plug is pressed against a wall it automatically selects the correct voltage and power prongs to fit anywhere in the world. If there are holes in prong positions for an American plug, the American prongs become fixed in the out position and can be inserted into the wall, while the European and British prongs retract into the plug base. Likewise, if the outlet is British, the British prongs get inserted into the outlet, while the rest retract. This plug will work around the world without the user having to be aware of the differences of outlets. The task selection is made by the force of the user's hand, the interaction of the holes on the wall, and the decision-making logic internal to the plug. The task model of getting power from an outlet is integral to the functionality of this device. The system model is that physical pressure will select mechanical prongs and pawls. The user model is that they will reset the prongs and plug it into various outlets.

The Flexor is a design study that recognizes contextual

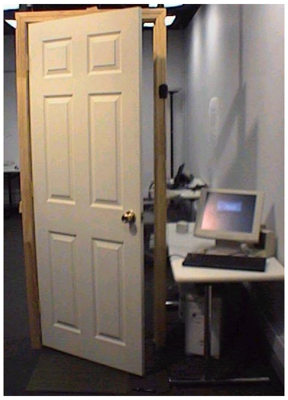
communication through arm motion. It consists of an analog force-sensing variable-resistor measuring elbow position, a PIC computer, lights and an enunciator as effectors. Socially, arm motions are significant. When a person moves his arm wildly we stand back; when s/he waves we wave back. While costumes have employed blinking lights and sound for some time, they have not focused on distinguishing user goals. In contrast to wearable games such as the electronic gloves that give feedback on a monitor [4], Flexor is an integrated display. Flexor uses an arm-bending sensor to evaluate motions made by an arm. It is an electronic sleeve that allows a person expressive capability based on a user model of the person's arm movements. When a person is moving his/her arm as though s/he is dancing, it flashes a varying sequence of lights. When the user is moving his/her arm as though s/he is exercising, Flexor counts how many repetitions have been completed. This device can also be used to encourage and motivate specific patterns of physical activity and therapy. Flexor is an example of context-aware computing in which a model of what a person is doing allows the computer to help that person without any explicit interaction from the user.

Typically people wear jewelry both for themselves and for the effect it has on others. As society moves into the digital age it is increasingly using digital technology on wearable items. Sometimes these implementations are intrusive or confusing in social situations, but more often they are not. The Flexor's role is clear: it is an explicit, dramatic, seductive, and audacious use of lights and sounds in a wearable computer that augments one's personal expressive manner and physical activity. The flashing lights and audio signals seductively incite interest in the device and make visitors eager to try the Flexor themselves. Its clarity of feedback behavior obviates the frustration of understanding difficult instructions. Users are able to quickly pick up on the concept of the sleeve and select between the scenarios included in the user model. The Flexor efficacy is surprisingly robust, even with only one sensor; ideas and scenarios are easily detected and implemented.

Computer-user interfaces have historically required users to explicitly type, send cards, or select actions through recognition. The Flexor is accomplishing context-awareness based on spatial positioning. Tiger Electronics' has developed a line of Fishing and Golf games which sense a user's cast and swing. These interesting toys have been doing well simply by recognizing a single action per scenario and providing feedback. The best of this genre is Vadim's Gerisimov's baseball bat. It depends on accelerometer data to provide a batting coach[5].

Whereas the bat is designed to teach a user to hone a task the Flexor distinguishes among many tasks. Flexor senses that a certain pattern of motion is being performed, it responds according to scenarios built into the user model. Each arm motion scenario is like the script in a story. A group of related motions, when performed in succession trigger the corresponding script. Such scripts have been used to distinguish and classify newspaper articles [15]. The flexor senses groups of motions and couples them with a category of action. This work demonstrates that single-sensor gesture recognition can be used to recognize actions through a user model. By careful placement, the style and communication goals of a user are simply distinguished and displayed.

The threshold of a door might be the most important demarcation in a social environment. It is the space a person walks by to find out if a colleague is in his/her office. Should they enter or should they have a scheduled meeting? If there are people in the room is it OK for them to enter? The Digital Threshold [6] makes greater use of schedule to mediate interactions between multiple users than Couch The Digital Threshold relies on two switches, one on the outside and one on the inside of the door. Coupling these switches to a voice recognition system and Microsoft Office the system counts the number of people in a room, notices whether a person has an appointment, identifies people, allows the occupant to respond, and updates and manages the office owner's calendar. The visitor or office occupant can modify the task: bringing someone in; rescheduling; or leaving a message. The Digital Threshold adapts its task model relative to people's positions, statements, and schedule to mediate meetings. This system adds two-way interaction with the office task model as well as the office occupant to make a collaborative system with dynamic modifiable task model.

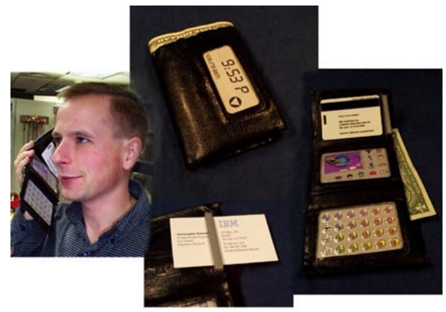


Multifunction systems – The Electronic Wallet

Integration is a technique for making something more contextually-aware by combining many functions that a person needs together into one design. The "multifunction army knife" approach to many designs can be a productive way of making a user believe that their particular situation has been taken into account. Making a tool that will do most everything, is a dangerous but sometimes effective design goal. The personal computer attempts to be the multifunction army knife of our time; it runs games, finds information, types letters, does accounting and checks paperwork. A designer's task is to overcome constraints to find solutions to make function and form work together.

People typically carry a wallet, usually keys, and sometimes a watch or pen when not at home. Contextual tools have always been part of human existence. Bodies of prehistoric humans have been found with pouches for carrying objects of value such as arrowheads, precious herbs, sacred carvings, etc. Wallets today are used to carry papers, money and codes (i.e. credit and debit cards). A wallet represents the credentials and wealth the owner needs to make available while they are in public. A wallet is a toolbox, sitting outside of the awareness of the user when not in use, but close at hand when needed.

The Electronic Wallet reduces the physical materials in a person's pocket while improving their ability to identify themselves, record financial transactions and present personal effects with style. It is an integration of documents that people take from their pocket: lists for buying things, pictures for sharing, receipts and business cards, etc. The design of the Electronic Wallet commenced with a use scenario consisting of the diverse contextual environments and capabilities it needs. The Electronic Wallet displays time in large numbers on the side of it. Now it vibrates gently in my pocket and I look at the external display to see that my friend is paging me. I open my wallet and it shows when I got a previous page from this number. I lift it to my ear to call him back. Later, it vibrates displaying a reminder to go meet a friend at a restaurant. I arrive at the restaurant and meet my friend. He has a new job. He hands me his new business card and I scan it into the wallet. Optical Character Recognition (OCR) software updates the wallet's address book. After we're seated, I open my wallet to the central display and take notes on ideas to talk about. We talk and I use the half-QWERTY keyboard to touch type with one hand [7] and enter notes for later. At the end of our meal, I hand the waiter the generic credit card, with my major credit card number encoded on the magnetic stripe. The wallet remembers my credit card numbers, so it is only necessary for me to physically carry one plastic card. If I forget to get the card back, within a few minutes the card's volatile memory loses the number. My wallet vibrates to remind me I have failed to retrieve the card. The waiter returns with a receipt, I scan it into my expense database.



First attempts to make integrated wallet devices were checkbooks with calculators in them. The calculator added bulk, cost, and the simple calculations were easily done in one's head. Consequently they were not widely adopted. Early PDAs aggregated technology rather than synergistic function. New designs should have more utility (e.g. smaller, more convenient, and more functional) than the devices they replace. The effect of social and stylistic issues is central to deploying contextually-aware systems successfully. The Electronic Wallet borrows the task model of a standard wallet. It is full of personal things that make up its user model. Its system model is that it can deliver and record important documents, communicate wirelessly and display information. The industrial design encourages users to think of the functions they would expect a typical leather wallet to have. Such metaphorical implementation of technology has been shown to increase learning and productivity [8].

CONCLUSION

Design is a process of collecting and organizing affordances to work in a context for people. Successful designs are accomplished by making things that perform tasks in situations. Memorable design must be extra useful, capable, aesthetic, or powerful. The context-aware design framework celebrates design that accounts for contextual information or setting. This paper has shown how context can be embodied in the form and material of design, in sensors and in computer models. Context-aware system designs anticipate where and how designed artifacts will be used. Watching and recording users' actions and needs can change experience and introduce new and beneficial affordances.

REFERENCES:

1 Rich, E.. Users are Individuals: Individualizing user models. *Int. Man-Machine Studies*, *18. 1983*: 199-214.

2 www.research.ibm.com/deepblue/meet/hteml/d.3.3.html

3 Universal Electric Power Plug . #5423690. June 13, 1995

4 Zimmerman, T., Lanier, J., Blanchard, C., Bryson, S., and Harvill, Y. A Hand Gesture Interface Device, Graphics Interface '87, May pp 189-192

5 Vadim Gerisimov's Article IBM System Journal, Vol?,Pg?, NY,NY, 2000.

6 Yan, H., Selker, T. Context-Aware Office Assistant *IUI2000, Int. Conf. On Intelligent Interfaces,* New Orleans, January 2000. ACM, January 2000.

7 Edgar Matias, I Scott Mackenzie, William Buxton Half –QWERTY: typing with one hand using your two handed skill. Companion Proceedings of CHI '94 Conference on Human factors and Computing Systems pp. 51-52. NY: ACM.

8 Douglas, S. A., And Moran,T.P. Learning text editor semanitics by analogy. Proceedings of the CHI'83 Conference on Human Factors in Computer Systems, Boston.