Change Blind Information Display for Ubiquitous Environments

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ABSTRACT
Unless new strategies are considered for how applications will convey information so as to minimize visual distractions, occupants of future computing environments are likely to feel that they are being immersed in a space of continuously changing digital information. One solution is to create a reasoning module that accepts requests to display information from multiple applications and controls how the information is presented to minimize visual disruptions to users. Such a system might use information about what activity is occurring in the space to exploit a powerful phenomena of the human visual system: change blindness.

Keywords
Change blindness, ubiquitous and dynamic information

UBIQUITOUS ENVIRONMENTS
Ubiquitous and augmented computing environments integrate displays, computational sensors, and interfaces into real-world physical spaces such as offices and homes [2]. These environments will provide users with information at exactly the right time and place, pulling the human-computer interface off the desktop into the physical environment. Eventually low-cost, high contrast, reflective electronic ink displays embedded in many physical surfaces will be used to convey visual information.

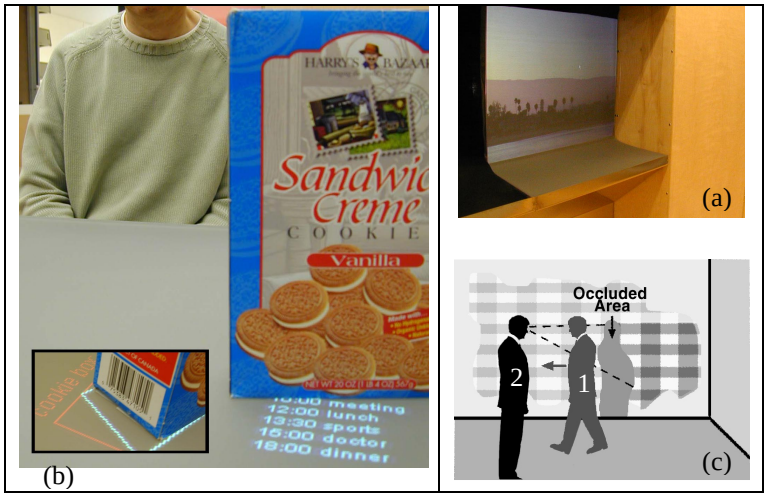
WORSE-CASE SCENARIO
The danger of constructing environments where information *can* be displayed everywhere is that information *will* be displayed everywhere. Today, devices that can display information within a space -- public information displays, websites, and television screens -- tend to be cluttered with information -- *changing* information. The motivation for this work arose from constructing a small "ubiquitous computing apartment" that has computer systems that track the positions of people and objects, receive input from occupants of the space, and display information on table, counter, and wall surfaces. The figure below shows an architect's rendering of the MIT lab forecasting how it might look if all the displays are used to their capacity, displaying ever-changing information.

SOURCES OF CHANGE
The clutter in the figure is exaggerated but raises a serious question: Can future computing environments present users with more information than environments today but in a way so that the user doesn't suffer from the feeling that information is continually changing?

Our visual systems have evolved to be keenly aware of sudden changes in the visual field. Nearly every time any visual stimuli changes, the eyes rapidly move, or saccade, to attend to the "motion transient" [1]. Future environments will have substantially *more* changing information than environments today for the following three reasons. Each person within an environment may want to have information displayed that (1) stays current, (2) remains available as the user moves about the space, and (3) changes based upon what the user is actually doing. The problem will be compounded because most environments will have multiple people in them -- each individual's information will clutter the visual space of other users. The human visual system will attempt to attend to all the resultant motion transients.

SOLUTION: EXPLOIT CHANGE BLINDNESS
One way to keep information current without attracting a user's focus of attention is to exploit "change blindness." Change blindness is a visual phenomenon that occurs when a person views two scenes immediately after one another (e.g. two images or image sequences). Assume some large (and often highly improbable or impossible) change occurs during the scene transition (e.g. an object disappears or a person instantaneously changes clothing). If a "visual distracter" is displayed either between the change or precisely at the time of change, people find the change difficult to detect -- even when they are told to

watch closely for differences [1].[1] Change blindness occurs because the model that the brain constructs of visual scenes is substantially less detailed than it appears to the person. Even after prolonged viewing of an image, the mental representation of the scene often does not include "obvious" details such as what objects are there, what their properties are, and where they are positioned. Although the brain can instantaneously detect changes (i.e. motion transients) between two visual stimuli flashed one after another, if the change is obscured either by removing the motion transient or by creating other motion transients, the brain must rely on its mental model of the scene. Once subjects are alerted to the changes they could not see, they are quite surprised they couldn't see the change before.



The following effects displayed at a scene transition mask motion transients and cause change blindness: (1) flashing a blank image, (2) changing views (e.g. a cut), (3) flashing small dots called "mud splashes" (these do *not* need to cover the change), (4) changing information slowly, (5) making changes during eye blinks or saccades, (6) and changing information when it is occluded by an object [1]. Change blindness makes change hard to see. Therefore, it can be exploited by user interfaces to minimize detectable change within a ubiquitous environment, particularly an environment that can detect where people and objects are and what the people are doing.

EXAMPLES

Three examples are shown here that illustrate how change blindness distracters can be employed to reduce the sensation of change in environments. Fig. 2(a) shows an implemented example that displays moving stock data using a slow-change distracter. Because the user's model of the information in the digital picture is weak, as long as the mountains change without creating motion transients, their shape can encode moving stock data. Fig. 2(b) shows a digital table that uses computer vision to track people and object positions and can therefore present changing information to only one of multiple people within a space using an occlusion change distracter (i.e. occlusion created by objects on the table given the positions of people). Not only does one user never see some information that is changing, private information can be conveyed to one without disrupting the second. Fig. 2(c) illustrates how information on a digital wall could be kept up to date by using the positions of multiple people within the environment. As person-1 moves between person-2 and the data on the wall, the visual disrupter event could be used to change the information without attracting person-2's attention. However, when person-2 eventually looks at this information, it will be up to date. Other change distracters can also be used.

A NEW MODEL FOR DISPLAY OF INFORMATION

Using change blindness in interface design will require a new software infrastructure, depicted in Figure 3. Change blindness requires that each process using output devices in the environment characterize and rank information that needs to be conveyed to the user. A change blindness module would accept information from user and activity recognition modules and control when and where information gets displayed in order to best minimize motion transients. Each application will need to specify the *contextual situations* in which the information is to be displayed.

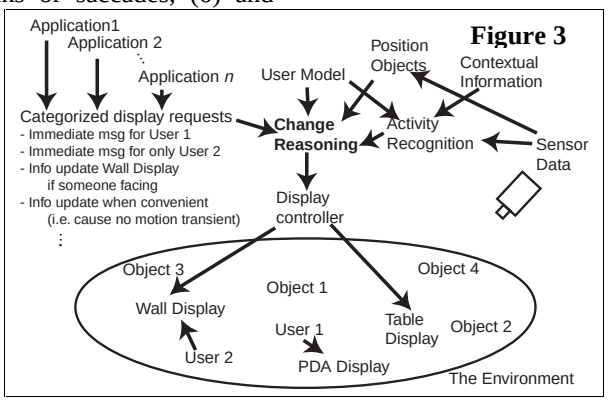


Figure 3

SUMMARY

At MIT we are exploring applications that exploit change blindness within a ubiquitous computing environment. Our goal is to create environments that present information exactly when and where it is most useful within a physical space without overwhelming users with a sense that information is continually changing. Using a change blindness reasoning mechanism may make this possible even when information on nearly every digital surface is being continuously updated.

REFERENCES

1. Simons, D.J. (ed.). Change Blindness and Visual Memory, *Visual Cognition* 7 (January-March 2000).
2. Weiser, M. The Computer for the 21st Century,*Scientific American* (September 1991), 94-104.

[1] Examples used in studies of the human visual system can be seen at http://www.wjh.harvard.edu/~viscog/change/