Meta-perception: Reflexes and bodies as part of the interface

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Abstract
Meta-perception is both an interaction design concept and the theme of a research group at the University of Tokyo. As a design concept, meta-perception is used to describe experience of novel phenomena made possible by devices that extend the human percepts. As a research group, our goal is to develop methods for capturing and manipulating information that is normally inaccessible to humans and machines. In this paper we describe various displays and devices that exemplify meta-perception. These include: several displays with which the human bodily interacts and wearable haptic devices that act as an extended skin. We reflect upon a design approach which borrows from elements of philosophy and media art to describe a different relationship between humans and technology.

Keywords
displays, haptics, augmented reality, input devices

ACM Classification Keywords
B.4.2 Input/Output Devices,
H5.m. Information interfaces and presentation

Meta-Perception as a Design Concept

In our laboratory we are interested in sensory systems both human and computer. Naturally, we are also interested in ways in which the two can become interconnected. Augmented reality is one style of interconnecting the two: superimposing computer-generated displays upon the real world in a manner such that users can relate the two. We are interested in extending this concept by building devices and displays that capitalize upon innate cognitive and motor skills.

Proprioception is subconscious sensation dealing with the positioning of body extremities relative to one another.

Reflex arcs are paths between sensory neurons and motor neurons that allow rapid responses to stimuli.

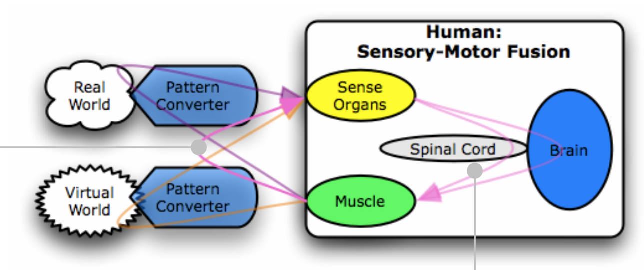

figure 1. Meta-perception displays and devices are tightly coupled with the human senses and convert virtual or real patterns in into understandable sensations.

Influences

Deeply inspired by the performance art of Stelarc on the theme of the relentless hybridization of human and machine we have begun to consider not only how machines transform humans but how human perception itself can be altered by machinery. Systems which perform sensory substitution [1] as well as techniques like galvanic vestibular stimulation [2] (which interact with human balance and gait) provided further influence upon us by demonstrating actual devices which act upon human percepts.

However, interaction systems which manipulate human perceptions and reflexes are potentially menacing. One might ask where values such as informed consent and user control might appear in designs motivated by the Meta-Perception concept. An important part of our design process is philosophical introspection and debate about the consequences and uses of such technologies. We are also curious about how robotic and computer systems might operate in a tight loop with the human moral enterprise.

Media art, applied ethics and physiology each provide elements that motivate our research into devices and displays to enable Meta-perception. From these generalities, it is difficult to grasp what is meant by the design concept. Thus we next turn our attention to a device whose specific goal is stimulation of reflex arcs.

Haptic Radar

Felines and insects are endowed with long whiskers which they use to make sense of the world around them and to avoid imminent danger. Indeed, some insects are able to use their whiskers in an extremely rapid manner to avoid collisions [3].

We have developed Haptic Radar to mimic these sorts of whiskers and to provide humans with an unusual capability. We found in pilot experiments that the majority of participants (86%) were able to move to avoid stimulus [4]. Of particular interest is that the participants were untrained and thus moving in an intuitive or reflexive manner to the haptic stimulus.

A headband is equipped with eight modules which contain infrared range sensors coupled with actuators. The actuators are vibro-tactile devices that stimulate the skin beneath the modules.

Participants were asked to avoid objects approaching from behind but were given no training. With the device on, 86% moved to avoid the stimulus. In a control condition with the device off, participants were unable to avoid the stimulus.

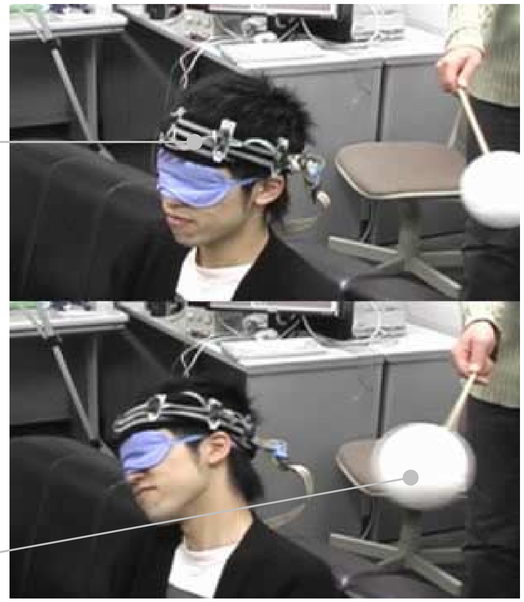

figure 2. The Haptic Radar device allowed wearers to move to avoid unseen stimulus approaching from behind.

The Haptic Radar project is a work in progress. We are actively working to miniaturize (current self-contained prototypes are 35 cm x 35 cm x 35 cm) and conduct wider studies of the device. We will also observe with interest the work of other researchers developing synesthesia devices making use of vibrators and optical technologies [5].

Parallax Augmented Desktop

The Parallax Augmented Desktop exploits a simple spatial metaphor to simulate a much larger desktop area on a two-dimensional displaying screen. The user's head is continuously tracked by a webcam on top of the screen, and the virtual cube is rotated and projected on the screen creating the illusion of a real cube right behind the screen. The user thus physically interacts with the display which responds in a manner consistent with visual processing of everyday 3D space.

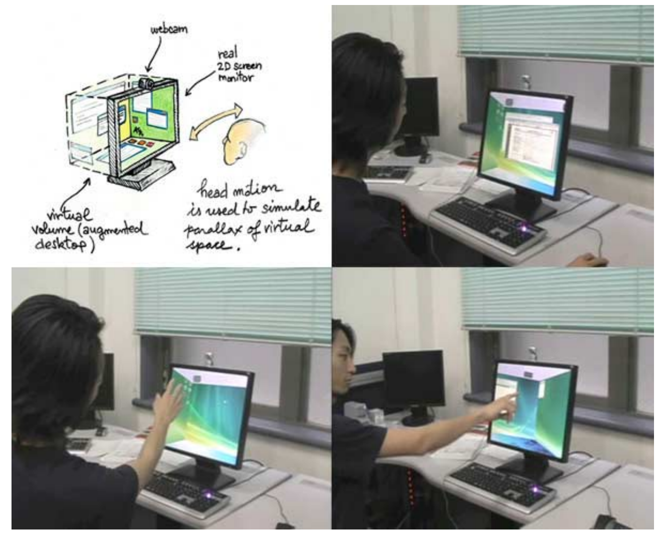

figure 3. Parallax Augmented Desktop reacts to user's head movements allowing interaction with a larger space.

Kitajima [6] and Ashdown [7] have previously used head trackers to control graphical user interface environments using techniques like placing the cursor on the display the user is currently viewing. The Parallax Augmented Desktop extends these works by relying on preexisting visual processing skills of humans to simulate a display with depth. This technique can greatly enhance 3D compositing desktops such as Compiz Fusion. Indeed, we have coupled the head tracking component with a live 3D workspace on Ubuntu Linux and are in the process of testing and improving this prototype.

Preliminary usability tests have been encouraging. The tests show that the speed of use of the Parallax Augmented Desktop is roughly the same as using a keyboard for an interaction task involving inputting data into dialog boxes situated past the edge of the visible screen. Our pilot experiment also indicated that the use of Parallax Augmented Desktop was faster than use of a mouse for the same task. However, these results are drawn from pilot studies with N=3 participants. We are planning more rigorous testing of the concept to validate these early observations.

LEDs provide a high speed camera with markers from which the orientation of the display is computed.

A slice of a virtual 3D object is rendered and projected onto a handheld sheet.

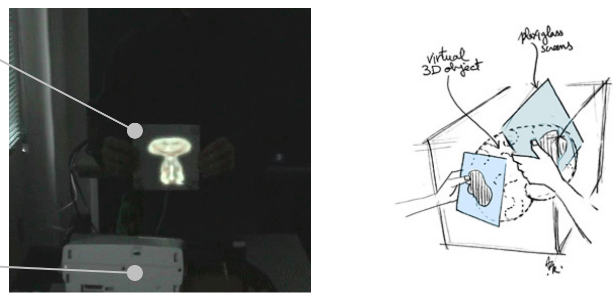

figure 4. the volume slicing display (above left) visualizing a slice of imagery from the visible human project.

Volume Slicing Display

Another technology with which users can bodily interact and which also integrates movement and proprioception is the Volume Slicing Display [8]. The system tracks the shape and the position of a passive screen (a piece of Plexiglas) on 3D space using a custom monocular high-speed vision system [9], then a set of projectors project the corresponding slice of a 3D virtual object on the surface in real time. This experimental interface will enable multiple users to feel as if 3D virtual objects co-exist in real space.

The traditional method for visualizing 3D objects often makes use of orthogonal perspectives and complex controls that occur in CAD and 3D modeling packages such as Blender. In contrast, the Volume Slicing Display makes use of our spatial intuitions; a virtual object floats in real space and the display's cuts through it can be easily repositioned by moving the position of the slicing screen as if it were intersection a real 3D object.

Khronos Projector

Similar to the Volume Slicing Display is another technology with which users can bodily interact entitled Khronos Projector [10]. The Khronos Projector is an interactive-art installation allowing people to explore pre-recorded movie content in an entirely new way. By touching the projection screen, the user is able to send parts of the image forward or backwards in time. By actually touching a deformable projection screen, shaking it or curling it, temporal waves and patches are created within the visible frame. An OpenGL program interactively reshapes a two-dimensional spatio-temporal surface which cuts a spatio-temporal volume of data extracted from video.

The Khronos Projector's deformable screen is unusual in that it is both touch-sensitive and elastic. The system's principle of operation is use of a high speed camera to detect the intensity of reflected infrared light from an array of LEDs. When users push on the screen light is reflected from the area they are pushing back towards a camera which is able to gauge where and how intensely users are touching.

Deformations caused by user touch are rendered as time punches from imagery in a video database.

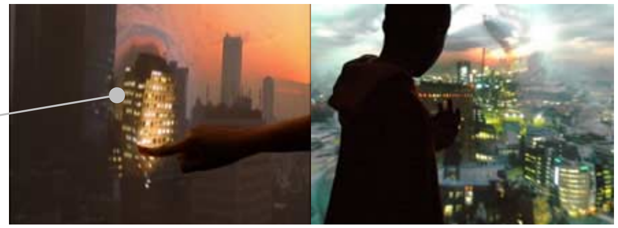

figure 4. The Khronos Projector is a touch screen which composts video to allow users to figuratively punch holes through time.

The combined effect of the touch screen and composited video is very much in the meta-perception style. Users often express pleasure and awe at the temporal punctures created by touching the screen. The displays lets users see a vantage which is atypical in everyday life: scenes animated over time-scales spanning many hours instead of the traditional instantaneous snapshot.

Smart Laser Scanner

Bodily interaction is also quite apparent with the Smart Laser Scanner device [11]. This is a system which rapidly scans the user's fingertips. The precise position of the finger in three-space is computed by the device. As in input, the system provides a great deal of flexibility, allowing users to perform gestures as well as manipulate virtual 3D objects. Moreover, the system does not employ markers but instead uses active illumination to track fingers.

The scanner is able to double as a simple display as well. The laser is able to trace out messages on the hands of users. Now, for instance the scanner can write the distance the user's hand is from the system. We are in the process of miniaturizing the device and also experimenting with handheld tracking devices with haptic feedback.

Future Work

Bodily interaction and communicating with the reflex arcs of users provide several unusual capabilities. One concept that we look forward to developing is the Earlid: a wearable device that allows voluntary control of the amount of audio energy entering the ear. It is conceptually similar to an eyelid but one that shuts out sound instead of light. We are currently experimenting with coupling noise canceling technology with electromyography sensors so that muscles near the ear can reflexively block out loud or deafening sounds [12].

Clearly, there is much to be done in this emerging domain. We hope that in viewing the breadth of technologies and concepts at play, other researchers and designers will be inspired to experiment with human perceptions.

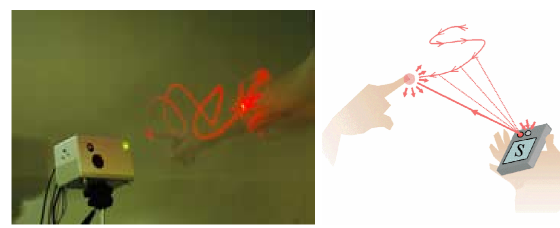

figure 5. The Smart Laser Scanner is able to track fingers and gestures in 3-space without using a camera.

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