MSc. Part-II

INTERNAL EXAM DOCUMENTATION

SUBJECT : Ubiquitous Computing

TOPIC: Hidden UI Via Wearable

& Implanted Devices.

Roll Nos: 7 & 14

Hidden UI Via Wearable and Implanted Devices

1. *Posthuman Technology Model*

In the *Posthuman* model (Hayles, 1999), technology can be used to extend a person’s normal conscious experience and sense of presence, across space and time. There are three types of post human technology: accompanied, wearable and implants. Accompanied technology is technology external to the body which accompanies it but is not directly attached to it, e.g., personalised mobile devices, smart cards, smart keys, etc. (Chapter 4). Wearable technology is technology external to and directly attached to humans, e.g., hearing aids and wireless earpieces attached to mobile phones to support hands free use of phones. Implants are technology internal to the body. The obvious applications for implants are medical, to use various prosthetics and bio implants to overcome paralysis in limbs and muscles and to help regulate and treat irregular biological phenomena such as heart activity.

2. Virtual Reality and Augmented Reality

Most computers currently present visual information in two dimensions, although simple three dimensional or 3D effects can be created by using shadows, object occlusion and perspective. These are an important element of games consoles which heightens user satisfaction in the main group of users. More realistic 3D effects can be created by mimicking the stereoscopic vision of eyes where each eye sees a slightly different perspective of the same scene. For example, a 3D headset or goggles that contains two miniature screens, each one showing the same scene from a slightly different perspective. Alternative techniques to simulate 3D are to either use polarised light or to blank out each eye synchronised to the computer frame rate so that each eye sees alternate images. As the head moves, sensors detect the change in angle to view the scene and the changing scene perspective is calculated and presented.

Virtual reality seeks to immerse a physical user in a virtual 3D world whereas augmented reality seeks to make interaction in the physical world more virtual by digitally enabling relevant objects in the real world. Both virtual reality and augmented reality seek to enable humans to interact using a more natural interaction than humans use in the real world such as using voice and gestures, rather than using the keyboard mouse interface of the PC. Virtual reality (VR) uses a computer simulation of a subset of the world and immerses the user in it using head mounted displays, goggles, gloves, boots and suits (Section 5.4.1). In augmented reality systems, electronic images are projected over the real world so that images of the real and virtual world are combined. To this extent, virtual reality can be considered as a sub set of augmented reality in which there is no real world but just an artificial reality. One of the first examples of augmented reality was the head mounted display by Sutherland (1968). Similar systems are in use today in types of military aircraft.

3. Wearable Computer Interaction

The essence of wearable computing is to embed computers into anything that we normally use to cover or accessorise our bodies. This includes clothes, jewellery, watches, eye wear, teeth wear, ear wear, headwear, footwear, and any other device that we can comfortably attach to our bodies and allow to behave as hidden computers. In a broader sense, devices can also be embedded in the environment that accompany us, in our transport vehicles are extensions of wearable computing. Wearable computers are especially useful when computer access is needed while a user’s hands, voice, eyes or attention are actively engaged within a physical environment.

One of the first examples of wearable computers was a concealed card sized analog computer designed to predict the movement of roulette wheels (Thorp, 1998). An observer used micro switches hidden in shoes to indicate the speed of a roulette wheel. The computer would indicate an octant to bet on by sending musical tones via a radio to a miniature speaker hidden in a collaborator’s ear canal. The system was successfully tested in Las Vegas in the early 1980s, but hardware issues with the speaker wires prevented them from using it beyond their test runs. About the same time Steve Mann also developed experiences with MTOS ICT devices rather than ASOS devices called WearComp and WearCam (Section 2.2.4.5) which are still ongoing. Mann (1997) specified three criteria to define wearable computing.

- *Eudaemonic criterion* (in the user’s personal space): the ICT device appears to be part of the user as considered by the user and observers of the user.

- *Existential criterion* (iHCI Control by user): ICT devices are controllable by the user. This control need not require conscious thought or effort, but the locus of control must be such that it is within the user’s domain.

- *Ephemeral criterion* (responsiveness): interactional and operational delays are non existent or very small.

  - Operational constancy: It is always active while worn.

  - Interactional constancy: One or more output channels are accessible (e.g. visible) to the user at all times, not just during explicit HCI.

Wearable computers, because they can accompany users everywhere, represent a clear form of UbiCom. A more complete conceptual framework for wearable computing, called Humanistic Intelligence (H.I.) considers the informatic signal flow paths between the individual and the computer (Mann, 1998).

3.1 Head(s)-Up Display (HUD)

Head(s) Up Display or HUD, is any type of display that presents data without blocking the user’s view (Sutherland, 1968). This technique was pioneered for military aviation and is now being used in commercial aviation and cars. There are two types of HUD. In a fixed HUD, the user looks through a display element attached to the airframe or vehicle chassis, the system projects the image with semi transparency onto a clear optical element and the user views the world through it (augmented reality). In a head mounted display, the system precisely monitors a user’s direction of gaze and determines the appropriate image to be presented. The user wears a helmet or other headgear which is securely fixed to the user’s head so that the display element does not move with respect to the user’s eye.

3.2 Eyetap

EyeTap is a device that is worn in front of the eye that acts as a camera to record the scene available to the eye, and acts as a display to superimpose a computer generated imagery on the original scene available to the eye (Mann and Fung, 2002). An EyeTap is similar to a HUD but differs in that the scene available to the eye is also available to the computer that projects the HUD. This enables the EyeTap to modify the computer generated scene in response to the natural scene. The EyeTap uses a beam splitter to send the same scene (with reduced intensity) to both the eye and a camera. The camera then digitises the reflected image of the scene and sends it to a computer. The computer processes the image and then sends it to a projector. The projector sends the image to the other side of the beam splitter so that this computer generated image is reflected into the eye to be super imposed on the original scene. One use, for instance, would be a Sports EyeTap that enables the wearer to follow a particular player in a field and have the EyeTap display statistics relevant to that player as a floating box above the player.

3.3 Virtual Retinal Display (VRD)

Virtual Retinal Display (VRD), also known as a retinal scan display (RSD), draws a raster display (like a television) directly onto the retina of the eye (Johnston and Willey, 1995). The user sees what appears to be a conventional display floating in space in front of them. This is in contrast to past systems that have been made by projecting a defocused image directly in front of the user's eye on a small 'screen', normally in the form of large sunglasses. The user focused their eyes on the back ground, where the screen appeared to be floating. The disadvantages of these systems were: the limited area covered by the 'screen'; the heavy weight of the small televisions used to project the display, and the fact that the image would appear focused only if the user was focusing at a particular 'dept'. Limited brightness made them useful only in indoor settings.

3.4 Clothes as Computers

Unlike HUD, EyeTap and VRD that focus on single sensors, clothes as computers use a network of sensors that can be worn and the data from them fused to allow other types of non visual context awareness. Van Laerhoven *et al*. (2002) have reported their experiences with a body distributed sensor system that integrated tens of accelerometers spread over the body into a garment with the majority on the legs and the rest divided over the arms and upper body. The accelerometers for the legs were integrated into a harness to enable testing and capturing of data from multiple users of different figure heights, while the others were attached on regular clothing using Velcro. The experiments indicated that it is feasible to distinguish certain activities of a wearer whose clothing has an embedded distributed sensor network. These activities could also include gestures made by the user, and basic events related to garments, such as putting on a coat or taking off a coat. These can be recognised with a reasonably high precision.

Current sensors require rigid physical substrates to prevent de lamination, and the mechanical incorporation of bulky switches. This drastically limits the physical form, size and tactile properties of objects using these sensors (Orth *et al*., 1998). This has led to the creation of fabric based computers and a product the Musical Jacket that is being marketed by Levi in Europe. The Musical Jacket incorporates an embroidered fabric keypad out of a sewn metallic conducting fabric BUS and non conducting cotton and nylon tulle (the insulating layers), a battery pack, a pair of commercial speakers and a miniature MIDI synthesiser. When the fabric keypad is touched, it communicates through the fabric BUS to the MIDI synthesiser, which generates notes. The synthesiser sends audio to the speakers over the fabric BUS as well. Power from the batteries is also distributed over the fabric BUS.

4. *Computer Implants and Brain Computer Interfaces*

The opposite of wearing computers outside the body is to have them more directly interfaced with the body. Many people routinely use implants, for example, pace makers are used to regulate the electrical activity of the heart, artificial limbs can increase mobility and contact lenses inserted into the eye can improve the contrast to track balls in sports even for people with good sight.

Of specific interest is developing devices that can adapt to signals in the human nervous system. By connecting electronic circuitry directly to the human nervous system, physiological signals that represent our thoughts, our emotions, and our feelings can be directly input to computers allowing humans to operate machines by thought power (Warwick, 1999). This represents the ultimate natural interface, thought control instead of motor control of devices. Brain Computer Interfaces (BCI)[17] or Brain Machine Interfaces (BMI), in contrast to Human Machine Interfaces or Human Computer Interfaces which support indirect interfaces from the human brain via human actuators i.e., haptic interfaces and machine sensors, are direct func tional interfaces between brains and machines such as computers and robotic limbs. There are several design choices here: the human device interface could be situated to have a direct versus indirect connection to the nervous system and the device could be situated at the brain or situated elsewhere in the body. Lebedev and Nicolelis (2006) classify BMIs as whether or not they utilise invasive versus non invasive neural signals.[18] Invasive techniques where electrodes are implanted cranially can record from single or multiple sites and within these sites can sample signals from small groups of neurons or larger groups of hundreds of neurons. First, invasive, non brain BMI, then non invasive brain BMI are discussed and then invasive brain BMI is considered.

Warwick *et al*. (2003) reported that in 2002 an array of 100 electrodes was surgically implanted into the median nerve fibres of his left arm. A number of experiments were carried out that showed he was able to control an electric wheelchair and an intelligent artificial hand and that he was able to create artificial sensation by stimulating individual electrodes within it.

Non invasive BMI was first reported by Vidal (1973) whose early work laid much of the groundwork to collect and computer process high quality EEG signals. Features are extracted from the signals and a translation process converts these features into symbols or commands to control electrical devices. Non invasive brain BMI is more mature and has less safety issues than invasive brain BMI and is considered more suitable for use in daily activities. A typical wearable computer system for non invasive brain BCI consists of an EEG recording cap, and a Body Area Network (Section 11.6.4) to communicate the EEG signals to a mobile device which also acts as a gateway between the BAN and the Internet.

Navarro (2004) discusses the use of BCI to accurately predict brain activity triggers in a highly changing environment as commonly is the case in performing daily life activities. For example, there are differences between the real world environment and the experimental environments when identifying and matching brain pattern(s) to trigger specific things. BCI experiments in Virtual Reality (VR) environments have also been done in order to recreate more precisely the situations when triggering a BCI. Such experiments are able to minimise the uncertainty of the brain inputs originated from the 'outside' environment, by being able to recreate an identical wider multi sensorial experience for the user. This potentially engages the user's perceptions in a broader manner giving similar mental states and brain activity patterns when an identifiable event which triggers the BCI occurs.

Invasive BMI was first demonstrated in experiments by Chapin *et al*. (1999). He showed that rats could use their motor cortex to control the movement of a robot arm to dispense drinking water. Research has been initiated to discover if this approach could help restore the motor abilities in physically disabled humans, via the use of artificial limbs or by bypassing neural network failures in humans by functionally stimulating paralysed muscles.

Lebedev and Nicolelis (2006) envision the neuroprosthetic developments for invasive systems which might emerge in the next ten to twenty years. Invasive brain BMI will use a fully implantable recording system that wirelessly transmits multiple streams of electrical signals, derived from thousands of neurons. BMIs will become capable of decoding spatial and temporal characteristics of movements and intermittent periods of immobility. BMIs will be able to utilise a combination of high order motor commands to control an artificial actuator with multiple degrees of freedom or directly stimulate multiple peripheral nerves and muscles through implantable stimulators. Much research is needed before any of these types of BMI, non invasive and invasive, can be used more routinely as a UbiCom system in order to improve the convenience of the accuracy of use, the robustness and sustained use of systems, and allay safety concerns about implants for the host, concerning the psychological and physiological effects of using BMI systems.

6. Sense-of-Presence and Telepresence

1. The Posthuman model is related to a discussion of alternative realities which seek to extend the experience of the here and now conscious sense of presence of human beings situated in the physical world, to experiences of being somewhere else, possibly in another time. A feeling of presence in the experience provides feedback to a person about the status of his or her activity. The subject perceives any variation in the feeling of presence and tunes his or her activity accordingly. People can experience alternative realities depending on the type of environment people are situated in and on their perception of the environment. Reality can be technology mediated, chemically mediated and psychologically mediated. A discussion of the experience of presence in mediated environments is given by IJsselsteijn and Riva (2003).

2. Non interactive AV media such as films, theatre and music, and interactive AV media such as electronic games and even the sense of smell and touch, possibly relating to previous experiences, can transport the viewer into another realm or state of perception, transporting the sense of presence from a human's immediate physical locality to another remote presence or experience. Hyperreality, for example, characterises the inability of consciousness to distinguish between reality and non reality such as fantasy, particularly when someone becomes immersed in the experience. A sense of immersion can often be achieved when playing either real or electronic games in which someone is enclosed and embraced by the AV medium and transported to another realm or state of perception. In this kind of immersion, a person is affected by the environment at multiple levels perceptual, sensory, psychological and emotional.

3. *Telepresence* allows a person in one place to feel as if they are present in a remote place, to give the appearance that they are present and have an effect, at a location other than their true location. *Telecontrol* refers to the ability of a person in one place to control objects remotely. These can be linked to sensing body movements locally which can then be used to control such objects remotely coupled to telepresence. For example, it allows humans to manipulate dangerous substances in a remote environment, from a safe environment, as if they were present. Wilson and Shafer (2003) describe the development of a wand like device which the user points at the device to be controlled, and then makes simple gestures or speech to control the device. The intelligent environment system interprets the user's manipulation of the wand to determine an appropriate action in context. For example, the user may turn on a light in the room by pointing the wand at the light and pressing the button. Alternatively, the user may point the wand at the light and say 'Turn on'. Kim and Kim (2006) have also developed a gesture recognition method to open and close curtains and to turn on and off lights in a smart home environment sensed using three CCD cameras, which are attached at angles of 0, 45, and 45 degrees. variations in components and objects that they are manipulating.

4. There are two solutions here, either to use adaptive AI techniques or to allow human operators to be in the loop to either use remote control or send remote commands to a local manipulator.