CULTURAL COGNITION AND SMART SPACE DESIGN CULTURE

ALFREDO ANDIA
Florida International University

BRANKO KOLAREVIC
University of Calgary

CHANGING HUMAN PERCEPTION

In the 1950s and 1960s Morton Heilig patented and developed several immersive cinematographic inventions that ranged from theaters, a personal immersive environment, and a stereoscopic television head mounting display apparatus. His arcade type prototype called "Sensorama" allowed users to see 3D stereoscopic movie pictures mixed with aromas, wind, stereo sound, and vibration on the seat, trying to immerse the user into a new type of realism of 3D cinematographic experience.

Parallel, in the early 1960s, Ivan Sutherland, a young Ph.D. student at MIT, developed "Sketchpad," the first CAD software and the first computer to have a graphical user interface. "Sketchpad" was revolutionary. A user could draw with a stylus in 2D and 3D in a CRT screen and edit the drawing with a combination of push buttons and stylus movements on the screen. The windows only displayed objects in wireframe. However, the interactive 3D wireframe window was fascinating. For the first time in history humans were able to interact at will in a parallel type of 2D and 3D world.

While Heilig multisensory stereo cinematographic 3D experience in the "Sensorama" machine was relatively high-fidelity, its interactivity was restricted to a predefined path. Sutherland "Sketchpad" was pointing to a new found capacity in which humans and computers could interact in a parallel 3D space. Later, in that decade, Sutherland outlined a number of ways human could immerse in a computer generated world. In his paper the "Ultimate Display" (Sutherland 1965) and his built prototype for a head-mounted 3D display (Sutherland 1968) were the basis for the field that later would be called "Virtual Reality" and "Augmented Reality."

Both Sutherland and Heilig 1960s prototypes were a first step to much larger question: How we can move human perception beyond the material construction of the world? At the essence of this question there is a grandiose vision: transforming human space - in a universal manner. In other words, the aim was to dramatically alter human perception without necessarily transforming analog space. This paper will be dedicated to explain the radical transformation in thinking this question brings. We will argue that the material age is quickly being altered by this question - dragging with it the relevance of traditional architectural space and design thinking.

Accelerating Computer Power and Miniaturization

Sutherland initial projects were not high-fidelity experiences, due largely to the limitation in processing power which didn't allow for high image resolution and it did not interact with any of the other human senses. "Sketchpad" was run in Lincoln TX-2 computer build with transistors that contained just 64K of 36-bit words (approximately 272k bytes). However, computing has doubled its power approximately every 18 months following the pattern of accelerated growth observed by Gordon Moore's in his now renowned article from 1965 (Moore 1965). A similar pattern of explosive improvements is also occurring in most other technological factors that surround computing. Today, computing is no longer solely inside PC machines but it also embedded in many types of objects and systems. Just in 2001 the US embedded more than 4 billion non-computer microprocessors in non PC items. It has been predicted that at the current grow of computation we will have a micropetacomputer with human computing capabilities that will cost around $2000 by 2025 for and $1 by 2035 (Nordhaus 2001) – a level of computing power that will be transformational. By 2035, cheap intelligent processors are likely to populate most human activities.

The steady increase in computer power and decrease in "price per bit" has been accompanied by a dramatic reduction in "atoms per bit." Physicist Richard Feynman had envisioned the miniaturization of computers in the late 1950s. In a now celebrated speech to the annual meeting of the American Physical Society in Pasadena in December, 1959, he envisioned a time in which we could build computers by maneuvering things atom by atom. He added "It's not an attempt to violate any laws, but it is something that has not been done because we are too big" (Feynman 1960). He pointed out that if this is attained all of the books in the world at the time, 24 million volumes, could be contained in a cube of material of one two hundredth of an inch wide. This is assuming we could write 50 to 100 atoms per bit. Typical data storage in the late nineties was still using millions of atoms per bit far away from Feynman's vision. However, memory engineers have been improving storage much faster than microprocessors, and with this new technology we could achieve Feynman's dream by 2050. There are three major eras about how digital technologies are altering perception as computer power and miniaturization grows explosively.

VIRTUAL AND AUGMENTED REALITY: 1960-TO-2020

Two emerging interface design visions began to emerge after Sutherland's pioneering work in the 1960s: Virtual Reality (VR) and Augmented Reality (AR). While the VR technology paradigm attempts to create a parallel digital world in which humans could be submerged; AR calls for digital technology to be embedded or mixed into the analog world. Pure VR technology always hit a mayor problem in achieving high-fidelity in all the senses. The human body and the real world are left out of computing in VR environments. Instead, AR is a mediated reality in which the user enhances the perception of the analog world.

AR's goals began to emerge in concepts such as "ubiquitous computing" or "calm technology" coined by Mark Weiser or "third paradigm" computing by Alan Kay. These ideas were reactionary against pure VR and the desktop metaphor (mouse and screen) that had dominated most of the human-computer interaction since the popularization of the PC in the 1970s. Xerox PARC from the 1980s to the mid-1990s developed pioneering research on technologies such as pads, tabs, tags, live-boards, and human tracking systems that allowed humans to be permanently connected to computer systems.

Image 1. augmented reality game displayed at Siggraph in the early 2000s. The environment included a head mounted display that mixed video with the computer rendered dolphins that user throw at each other hands. Every time a user receives a dolphin a sensor is triggered in the palm of the hand.

By the early 1990s a large number human-computer interaction labs around the world had a growing number of working mixed-reality and digitally-interactive prototypes. These ranged from the typical mixed reality goggles, interactive interfaces that read human gestures, to haptic devices. These prototypes began to be displayed in major conferences and became extremely popular in conferences such as such as Siggraph.

By the beginning of the 21st century, the idea of merging the digital and the analog began to mature as mobile technologies such as smart phones, GPS, sensors, phones networks, PDAs and a new array of microchips in cars, toys and computer games had definitely moved the phenomena of computing away from the PC-box. As Weiser stated, in the early 1990s, mainframe computing permitted one computer for many people, and the PC revolution allowed one person per computer, in this new era there where going to be many computers per person.

The merging of the analog and the digital realms signifies not only a clash between two types of human environments and technologies but a collision of detached design cultures, traditions, and understanding of human factors.

Interactive Art around 2000

The relationship between art and interactive digital media goes back to the late '50s. Several ambitious curatorial efforts between art and technology were presented more than 40 years ago. Among them: "The Machine as Seen at the End of the Mechanical Age," MOMA, 1968; "Cybernetic Serendipity," ICA, 1968; "Software, Information Technology: its Meaning for Art," 1970; "Information," MOMA, 1970; and "Art and Technology," LACMA, 1970. In the 1990s the art community began to consolidate its use of interactive technology and quickly matured in organizations such as the Karlsruhe Media Museum in Germany, Ars Electronica in Austria, and the Banff Center for the Arts in Canada.

By the year 2000 Interactive Arts had gone main stream. Shows like "Bitsreams" at the Whitney Museum in 2001; "010101: Art in Technological Times" at the SFMOMA, 2001; and an interactive display at the "un-private house" exhibit at the MoMA in the USA began to consolidate the field. The same occurred in many museums such as the Tate, the V&A, Science Museum in London in Europe. Interactive pieces helped museums gain momentum as they expanded into the new multimedia world brought by the sudden growth of the internet at the time. Museum attendance began to soar during that decade and interactive pieces were closely aligned with the new editorial policies of large museum to expand its activities to wider audiences.

Interactive Architecture around 2000

A significant number of emerging Architects also developed well recognized interactive projects around 2000. Among them there was the ADA project by ETH presented at the Swiss Expo.02 in 2002. The whole project was designed to interact via touch, sound, and visually with the user. The whole project was embedded in a neural network system from ETH that was connected with the floors, walls, and sounds of a large pavilion and made the users walk, dance, stay, and leave. For the same expo Diller & Scofidio designed the inbuilt “raincoat” interactive space that was going to be placed inside the now famous blur project – a cloud over a lake. Kas Oosterhuis developed several kinetic projects with the hyperbody group at Delft University and the pioneering interactive Water Pavilions with NOX in 1997. NOX developed the D-Tower in the Netherlands in 2004. An organic sculptural piece with whom the residents of a small town connected via the internet daily to display their mood.

There were also several wall and exterior surface projects such as the a kinetic wall Hyposurface developed by Decoi; the interactive BIX façade for the Kunsthaus Museum in Graz by Peter Cook, Colin Fournier, and Realities United in 2003; many screen buildings around Times Square in New York such as the NASDAQ Marketsite Tower opened in 1999; and the more sophisticated Real and Virtual 3D-Trading Floor environment build by Asymptote for the NYSE also in 1999.

Most of these interactive architectural projects found refuge in venues and clients that needed to portray a “dot com” image which was hip around the year 2000. The event-nature of interactive architecture, as interactive art projects, transcended the typical everyday experience. They were able to introduce the technology to a wider audience in a period in which AR is still not fully developed. Moreover, even today they tend to encourage sociability by producing effects of wonder on the users - at least in the first encounters with the digitally enhanced environments.

However, it can be argued that most of these early architecturally interactive projects fulfill a branding goal. But it is still difficult to see private or corporate clients moving into this realm for more radical or critical needs. Still the question remains: how architects and architecture can use this technology to reshape not only a partially fabricated emotional understanding of what is public today but also the way we fundamentally function in space?

A few endeavors such as the Smart Cities project led by Bill Mitchell at MIT in the early 2000s which rethought the whole ecology of the car, from the engine to parking, was among the few exceptions (Mitchell at. al. 2009).

AR in Smartphones: Personal AR

By the late 2000s smartphones and tablets have began to reshape how people interact with computing. AR applications have been quickly migrating to these new platforms. On October 2010, Dutch artist Veenhof and Skwarek developed an application for an uninvited art exhibit at the MoMA. The regular visitors could not see it, but those who had unloaded the application on their iPhone or Android system were able to see the 3D pieces send from all over world and displayed in their smartphones mixed with the walls of the MoMA Museum. This example of uninvited or unsolicited AR event-space illustrates an emerging social potential of AR in private platforms such as smartphones. Developers of AR applications no longer need the sponsorship or the permission of the owners of analog space to mount a public interactive space experience.

VIRTUAL RETINA DISPLAY AND BRAIN-COMPUTER INTERFACES: 2010-2030

Two major new metaphors in human computer interaction are emerging in this decade: Virtual Retina Displays and Brain-Computer Interfaces. Both are geared to further blend computing with human every day actions and spaces.

Virtual Retina Display (VRD)

Up until now the most prevalent human-computer interaction have been related to device metaphors such as the PC, Caves, VR goggles, and lately Smartphones, but as Mark Weiser pointed out the most profound technologies are those that disappear. The PC box, the computer screen, and the mouse are disappearing. In the past decade there have been significant advancements in VRD. VRDs are able to project an image directly into the retina. So the viewer can see the projected image in space merged with analog reality. Microvision has a commercialized a product since 2001 and Google from the US and Brother Industries from Japan have shown prototypes which have been promised to be released in the next year. Most of these emerging prototypes use glass looking devices, but with time they could be reduced to contact lenses or retinal prosthetic implants powered by light similar to the ones that are being designed for people suffering from retinal degenerations.

Image 2. Picture of a Virtual Retina Display prototype developed in the early 2000. Today this devices have been reduced to the size of wearable glasses.

Brain-Computer Interface (BCI)

Whatever happens to humans in human-body engineering it happens to laboratory rats first. In the late 1990s a team headed by Prof. John Chapin from SUNY implanted multi-electrode microchips in the brains of laboratory rats to investigate the sensory and motor system in their brain in the late 1990s. These investigations demonstrated that the lab animal can control a robot arm by recording the neural signals send from the motor cortex of the rat. In May of 2012 a team led by Prof. John Donoghue, a neuroscientist at Brown University, reported in the Journal Nature that a paralyzed patient with an implanted brain chip had successfully been able to use a robotic arm to grab and drink a cup of coffee by just thinking about her action. Similar results have been obtained in many research centers in Italy, Germany, and Austria, allowing people to control chess games, computer programs, and prosthetics arms by just thinking.

Ultra-personal AR experiences

Virtual retina display and direct brain-computer interfaces are part of a variety of disappearing human-computer interfaces that will mature in the next decade and further blur what is real and digital. Our AR experiences will become more personal and they can be deployed anywhere and at anytime, and as the technology becomes more high-fidelity it will further challenge what is a public or private spatial experience. The metaphors produced in this second period will be also temporary as the field of computing and neurobiology continue to merge in the next period.

THE ULTIMATE DISPLAY HAS NO DISPLAY: BEYOND 2029, 2045…

Neuroprosthetics

Many of these brain-computer interfaces that are becoming popularized in this decade are neuroprosthetic projects dedicated to restore body parts, hearing, and sight for the handicap. Neuroprosthetics is initially masking its potential with the paralyzed but it is quickly finding its purpose in the sick by repairing naturally decaying body parts. But ultimately, neuroprosthetics is opening a bigger door: the hybridization of digital technologies with the body and lastly unveiling how the human brain operates. Ivan Sutherland in his seminal article "The Ultimate Display" from 1965 foresees the merging of the computer and the body: "The computer can easily sense the positions of almost any of our body muscles. So far only the muscles of the hands and arms have been used for computer control. There is no reason why these should be the only ones." The contemporary advancements in brain-controlled neuroprosthetic interfaces are rapidly merging the fields of computer science, neuroscience, genetics, and nanotechnology.

2029: Technological Singularity

A significant number of famed computer pioneers and mathematicians that have observed the exponential growth of computing, such as John Von Neuman, Irvin J. Good, Vernon Vinge, and Ray Kurzweil, agree that we will be confronted with a sudden intelligence explosion. Kurzweil has calculated that at the current growth of computer power we would be able to reverse engineer the human brain by 2029. After which it will emerge super-intelligence via a series of rapid technological advancements. He argues that the process will occur very quickly after 2029. Kurzweil sees this as a "technological singularity," as an "event horizon" which will became difficult for contemporary humans to understand as there will be an intelligence explosion.

2029: the new age of the brain

The brain is the ultimate organ of perception. It is at the center of the nervous system and it is the most complex organ in humans and all vertebrate animals. However, the brain is completely isolated from the exterior world, there is no light, no sound, not a single external stimulus that can interact directly with it. Brain perception, what Sutherland thought computers were capable to transform via the ultimate display, is a complex sensory system that is made of specific receptor cells in the eye, ear, mouth, or in the skin. The axons of the sensory receptors travel through a complex path to the cerebral cortex where they are interpreted and mixed with the signals of other sensory systems, where we finally perceive.

2045: Uploading Consciousness

In theory, after we are able to reverse engineer the human brain it will become theoretically possible that a computer machine might eventually feed the brain directly with digitally controlled neurons or foglet nano-robots that artificially signal visual, sound, taste, smell, and touch information to the brain. By 2045 we might be able to isolate the brain from decaying body parts. And eventually if we are able upload our consciousness into a machine that can host our mind - achieving immortality. In that environment we will be able to challenge not only our biological body, but also our biological intelligence. Currently our biological intelligence grows very slowly. Potentially human intelligence in an artificial environment could be re-engineered to expand at an explosive pace unimaginable today and challenging all of our contemporary images about digital technologies, space, and life.

CONCLUSION

This paper has attempted to provide a context for understanding the impacts of digital technologies in human space. In the Architectural field we often forget the explosive growth of computer technology and we get trapped in discussions of temporary metaphors of computing such as CAD, BIM, fabrication, scripting, and parametric. Cultural Cognition refers to a subject that evaluates how the public understand certain adoptions of technology. However, still remains to be seen if cultural cognition has any power in the discourse since often the little procedures that makes the impossible possible takes over the conversation.

We argue that Ivan Sutherland "Sketchpad" software in 1962 and his subsequent work on the "Ultimate Display" in the late 1960s set a unique program for human-computer interaction. The vision was geared to transform matter by changing human perception, thus the relationship between consciousness and the material world our body perceives. In a first era virtual and augmented realities devices helped remove computers out of the desktop metaphor and moved the digital phenomena into interactions in space. In a second era the disappearance of those devices into virtual retina displays and mind-controlled computing is moving the phenomena of computing into a hybridization of our nervous system, the brain, and digital technologies. A third type of a digital era will emerge as computer power will allow us to reverse engineer the human brain around 2029 which will explosively increase computing intelligence - putting into question the relationship of digital technology, biology, and the dichotomy between the body and consciousness. We are close to achieve a level of control that definitely seems like fantasy or science fiction.

Ivan Sutherland finished his 1968 paper "The Ultimate Display" by stating:

> "The ultimate display would, of course, be a room within which the computer can control the existence of matter. A chair displayed in such a room would be good enough to sit in. Handcuffs displayed in such a room would be confining, and a bullet displayed in such a room would be fatal. With appropriate programming such a display could literally be the Wonderland into which Alice walked."

Of course, a bullet will not kill human consciousness uploaded in an immortal machine, nor handcuffs will be confining, and the room will be the universe. Humans hybridized in an ever expanding immortal machine can began to populate the universe in another form. The fusion of human intelligence and computer intelligence it is bound to became the ultimate portal of inhabitation.

REFERENCES

Feynman, R.P. 1960a. "There's Plenty of Room at the Bottom." *Engineering and Science* 23.5 (1960): 22-36.

Nordhaus, William D. "The Progress of Computing." *Cowles Foundation Discussion Paper No. 1324, Yale University* (2001).

Mitchell, William J., Chris Borroni-Bird, and Lawrence D. Burns. *Reinventing the Automobile: Personal Urban Mobility for the 21st Century.* Cambridge, MA: Massachusetts Institute of Technology, 2010.

Moore, Gordon E. "Cramming more components onto integrated circuits." *Electronics Magazine* 38.8 (1965): 114-117.

Sutherland, Ivan E. "The Ultimate Display," *Proceedings of IFIPS Congress.* New York, NY: IFIPS, 1965.

Sutherland, Ivan E. "A Head-Mounted Three Dimensional Display," *Proceedings of the Fall Joint Computer Conference.* Montvale, NJ: AFIPS Press, 1968.

Weiser, Mark. "The computer for the 21st century." *Scientific American* 265.3 (1991):94-104.