# Tangible Space and Interactive Technology

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**Abstract**: Recent advancement in information technology requires new interpretations for the space among human, machines and environment. Investigation of space between information and human could lead to the proper ways, in which human and machines meet. Various concepts regarding space have been explored in terms of "virtual reality in cyberspace" and "embodiment in tangible space." "Mom (embodiment)," space, virtuality, sensation/perception, and interactive technology are some of the key ideas to be explored. Human "Mom" is such a fundamental membrane through which human can interact with the environment physically and mentally. An embodied interaction paradigm, based on "Mom," is investigated. This leads to interactive technology paradigm. Sound space is an invisible but a tangible space in a sense that it travels in emotional tremors and stimulates new sensations and perceptions. Three cases are introduced to experiment such tangible space as a new and proper interactive paradigm. Also, a historical model of interaction is reviewed, which includes electrical, symbolic, textual, graphical, tangible, and social interaction.

**Keywords:** Tangible space, interactive technology, philosophy of cyberspace, Mom (embodiment)

## 1. INTRODUCTION

One of the major issues in recent technology is "humanizing technology" or "technology serving human." Human issues are revaluated as the basic and fundamental virtues in understanding and implementing proper technology and machines. Recent advances in information technology further require new interpretations for the space, which we are surrounded by and we are experiencing with [1, 2].

Investigation of space, which is composed of information, and human, who interacts with this space, could lead to the proper ways in which human and machines meet. Various concepts regarding space have been explored in terms of "virtual reality in cyberspace" and "embodiment in tangible space." "Mom (embodiment)," space, virtuality, sensation/perception, and interactive technology are some of the key ideas to be explored.

Human "Mom" is such a fundamental membrane through which human can interact with the environment physically and mentally. An embodied interaction paradigm, based on "Mom," is investigated.

Sound space is an invisible but a tangible space in a sense that it travels in emotional tremors and stimulates new sensations and perceptions. Three cases are introduced to experiment such tangible space as a new and proper interactive paradigm. Also, a historical model of interaction is reviewed, which includes electrical, symbolic, textual, graphical, tangible, and social interaction.

## 2. TANGIBLE SPACE

Characters of interactions among human, environment, and machines are heavily dependent on the nature of space among them. Implementation of more realizable interactive systems requires the understandings of physical space and/or artificially reorganized space lain between human and environment. Reality and embodiment are key concepts around which our thoughts will experiment.

### 2.1 Virtual reality in cyberspace [3]

In recent times, it is difficult to find terms that are more frequently used despite their impreciseness than "virtual reality (VR)" and "cyberspace." As words created by the development of computers and electronic technology, "cyberspace" is sensibly understood as the information space mediated by the vast communication network and high-performance computers, whereas "virtual reality" causes misunderstanding and hinders discourse because of its completely different meaning under different context.

This confusion with "virtual reality" seems to be stemming from the ontological weight of the predicate, "virtual," and the noun, "reality." It is especially problematic in the context of using languages with many root words derived from Chinese character such as Chinese, Japanese, and Korean. Because when written in Chinese character form, the word "virtual" takes on connotations of "fake," "fictitious," "imaginary," or "hallucinatory." Therefore, not only for the intellectual sake, but also to seek an appropriate way of using relevant technology, it is important to clarify the reality of virtual reality.

The "virtuality" in virtual reality is not a concept in comparison with the "reality", but with the "actuality" part. Virtuality, together with actuality, forms the two ways objects can exist. Virtual things have not yet gone through "actualization" in the space-time but still it subsists somewhere. Once it encounters the right chance in such a state, it is then actualized.

Often things of virtuality are treated as if these are equal to things of "possibility"; this only points to the abundance of possibilities in being actualized, and strictly speaking, it does not mean that the two are equal. Possible things only lack the trait of existence in space-time, but they retain all of the qualities of actuality. In contrast, virtual things do not retain the traits of actuality. The process of possible things gaining existence in the actual world and the process of virtual things gaining existence in the actual world are different. The possible thing is realized without undergoing any change itself, but the virtual thing goes through change according to the given criteria while being actualized.[1]

Virtual reality is a virtualized object, which is sense-able or imagine-able. In this process of virtualization, both the computer's information processing capability and the intentions of humans contribute together. Virtualization is a opposite process of actualization, the dynamic integration process.

Therefore, virtual reality and actual reality do not share the same qualities. It is a changing of form for the quantitative characteristics determined by the spatial and temporal rules of the actual world and the qualitative characteristics. Depending on the level and degree of virtualization, there are several ways to virtualize the actual reality. For example, writing and converting it to text is a type of virtualization. A writer's novel written down is his thoughts (memories) virtualized. The thoughts of the writer evolves into something different than what it was before, and becomes preserved in the form of written text. The readers then read this text in order to actualize the thoughts of the writer. However, the reader's intellectual background and the physical, psychological conditions during reading determine the degree of reader's actualization. The same applies to a wider sense of "text"--in pictures, shapes, and sounds [4]. Hypertext as virtual reality is yet another step of virtualization of many sorts of text existing in the real world.

Specially, computer and communication network based virtual reality exists as an objective entity that corresponds to the perceptive content of each user participating in cyberspace. And even when there is no user participation, it exists in cyberspace as digitized patterns. The reason the experience of virtual reality, unlike the experience of physical objects, is unable to remain fixed is because it is sensitive to the user's mental activities. The fact that virtual reality depends greatly on the physical and mental condition could be a basis for composing a unique realism for virtual reality, but it cannot be an argument against it.[2]

Based on above discussion, it could be suggested that the appropriate Chinese translation for "virtual reality" is not "假想現實" ([gasaŋhyunsil] in Korean and [kasougenjitsu] in Japanese) or "虛似現實 ([xunixianshi] in Chinese)" which has the connotation of "fake reality" or "hullucination," but "可象現實" which means "possible reality." This way of writing is more in line with the definition of VR, which is the entities, agents, or events within cyberspace. Especially, since this is similarly pronounced as the above one in Korean-[gasaŋhyunsil] and in Japanese-[kazougenjitsu], there would not be much linguistic confusion caused by the correction of the meaning of the term at least in Korea and Japan.

1) The relationship between possibility and actuality is purely logical. In contrast, virtuality and actuality have a relationship of potentiality and temporality. The concept of virtuality is similar to the potentiality of Aristotle's Potentiality-Actuality Theory. For example, when a seed becomes a tree, the tree already virtually exists within the seed. The virtuality in this case is the determination or property to become a tree, not the tree itself [4].

2) Heim called the realism of virtual reality a "virtual realism", and this possesses the duality of naïve realism and network idealism. Here, network idealism does not seem to refer to Berkelean Subjective Idealism, but to a certain kind of objective idealism [5].

### 2.2 Embodiment in tangible space

Natural philosophers have always been interested in the relationship between sensation, perception and the external world. Human detects surroundings: sees, hears, touches, tastes and smells by sensory organs of eyes, ears, flesh, tongue and nose. We might say that there are two expressions for sensation and perception in Asian countries. If the ability to know what is "out there," rather than just "what is happening to me," is the process of perception[6], the word "感知([gamjee] in Korean)" is close to the expression "sensation and perception," which means that human senses environment first and then knows (perceives) later. On the contrary, "感覺([gamgak] in Korean)" is close to "the ability to feel what is out there" or "instant sensation and perception," which means that human senses and knows (perceives) simultaneously or human feels instantly.

While vision and hearing seem to closer to the contemplative sensations or "感知([gamjee] in Korean)," touch, taste and smell seem to closer to the instinctive sensations or "感覺([gamgak] in Korean)." In many ways, touch stands apart from the other senses. It covers our entire body surface. While we say that we perceive visual objects, sounds, tastes and smells, we talk instead about feeling texture, heat and pain. Unlike the other senses, touch often carries an intense emotional charge and many studies have demonstrated the positive psychological effects of touch. Tangible cyberspace may be viewed as a touchable space with the sense of reality. This is similar to a space of sight and hearing with a sense of touch added or an "augmented virtual reality" [6, 7].

In addition to these five senses, human has a unique sense, called synesthesia, from Greek *syn* (together) + *aisthanesthai* (to perceive). Synesthesia is the technical name, meaning the simulation of one sense stimulates another [8]. Newborns ride on intermingling waves of sight, sound, touch, taste, and, especially, smell. In time, the newborn learns to sort and tame all its sensory impressions by the age of between six months and twenty-four months, some of which has names, many of which will remain nameless to the end of its days. Those who experience intense synesthesia naturally on a regular basis are rare-only about one in every five hundred thousand people-and neurologist Richard Cytowič traces the phenomenon to the limbic system, the primitive part of the brain. As he says, "synesthesia … may be a memory of how early mammals saw, hears, smelled, tasted and touched [6, 9].

Aristotle argued that the five senses were drawn together by a "common sense" located in the heart; and the anatomical drawings of Leonardo da Vinci reflect the 15th-century belief that the senses had a common mechanism. The physicist Isaac Newton wrote that, for him, each note of the musical scale corresponded to a particular color of the spectrum: when he saw a color, he sometimes heard the note. Some of the most famous synesthetes have been artists. Composers Aleksandr Scriabin and Nicolai Rimsky-Korsakov, C major was white; to Scriabin it was red. To Rimski-Korsakov, A major was rosy, to Scriabin it was green. Both associated E major with blue, A -flat major with purple, D major with yellow, etc [6, 8].

Either writers have been especially graced with synesthesia or they've been keener to describe it. Baudelaire took pride in his sensory Esperanto, and his sonnet on the correspondences between perfumes, colors, and sounds greatly influenced the synesthesia-loving Symbolist movement. Rimbaud, who assigned colors to each of the vowel sounds and once described A as a "black hairy corset of loud flies," claimed that the only way an artist can arrive at life's truths is by experiencing "every form of love, of suffering, of madness," to be prepared for by "a long immense planned disordering of all the senses." Great artists, like Vladimir Nabokov, Faulkner, Virginia Woolf, Hyusmans, Baudelaire, Joyce, Dylan Thomas and other notorious synesthetes, feel at home in the luminous spill of sensation, to which they add their own complex sensory Niagara [8].

Synestheisa closely resembles the concept of 法 ([bub] in Korean) in Budism [10]. Reconsidering the better way of implementing state-of-the-art technology, the first step toward humanizing technology might be based on technology to properly augment realities in the new form of space and spatial perception. Building tangible space using interactive technology could be one approach to enhancing human conditions.

## 3. INTERACTIVE TECHNOLOGY

After we explore the ideas about space lain between human and environment, next question might be how we can build an interactive system based on these observations on space. First, a historical model of interaction is presented and then our search for an interactive paradigm, interactive technology, is followed.

### 3.1 A historical model of interaction [11]

Matthew Cahlmers made the observation that computer science is based entirely on philosophy of the pre-1930s. Similarly, much of contemporary cognitive science is based on a rigorous Cartesian separation between mind and matter, cognition and action. These are philosophical positions of long standing, dating from the nineteenth century or earlier. However, they have been under continual assault since around the 1930s, when philosophers such as Martin Heidegger and Ludwig Wittgenstein began to articulate radically new positions on cognition, language, and meaning. This new approach abandoned the idea of disembodied rationality and replaced it with a model of situated agents, at large in the world, and acting and interacting within it. Practical action and everyday experience replaced abstract reasoning and objective meaning as the foundations of a philosophical psychology.

The development and application of computational technologies is an engineering discipline, and one that has been spectacularly successful over the past fifty or sixty years. It is philosophical in the way it represents the world, in the way it creates and manipulates models of reality, of people, and of action. Software depends inevitably on our ideas about representation and reality. Phil Agre comments, "Technology at present is covert philosophy; the point is to make it openly philosophical." While any software system introduces some kind of formalization of the world, Human-Computer Interaction (HCI) like Artificial Intelligence (AI) deals with formalizations of human cognition and activity. These are the issues that have lain at the heart of philosophical debate for centuries. Debates over philosophical foundations are deeply relevant, because they determine the limits of what can be done and the chances for success of our efforts to have people and computers work effectively together.

Paul Dourish focuses on one particular way in which these philosophical questions have lately arisen in the area of HCI. The context is the historical evolution of the idea of interaction and the technology of HCI.

There are many ways to conceptualize the history of interaction with computer systems. The technological view would recount the history of the input and output devices (that have characterized different stages of interface development), and would describe their computational demands. A political view would consider the movement of ideas from one laboratory to another, while an economic view would consider how user interface development has influenced, and been influenced by, the growth of the high-tech industry and PC economy. Grudin describes the history of interaction as the story of the "computer reaching out," in which interaction moves from being directly focused on the physical machine to incorporating more and more of the user's world and the social setting in which the user is embedded. Dourish presents the stages in the historical development of user interfaces in terms of the different sets of human skills they are designed to exploit, which are characterized as electrical, symbolic, textual, and graphical forms of interaction.

**Electrical**: When we talk of "computer," we inevitably mean digital devices. Originally, the word "computers" referred to human beings-people whose daily work was the figuring of calculations. Before digital computers came analog computers. Then follows the stored program computer. Even as we made the transition from hardware configuration to digitally stored programs, the dominant paradigm for interaction with the computer was electronic. **Symbolic**: The introduction of programming systems moved computer interaction from an electrical level to a symbolic one. We are all highly skilled at various forms of symbolic interaction; language and communication are largely symbolic in nature, whether these symbols take the forms of icons, traffic signs, flags, maps, or marks on paper. We are generally able to exploit a greater range of skills-visual, cognitive, and so on-as we move from electrical to symbolic forms of interaction. **Textual**: The best-developed form of symbolic interaction with which we are familiar is written language and textual interaction. Textual interaction can draw on our linguistic skills, not by letting us simply "talk" to computers, but rather by drawing on our abilities to create meaningful sentences by combining elements each of which contributes to the sense of the whole. The other significant feature of the textual interface paradigm is that it brought the idea of "interaction" to the fore. **Graphical**: Graphical interaction is characterized by its use of space; information is spread over a larger screen area, so that the locus of action and attention can move around the screen from place to place or can even be in multiple places simultaneously. The task of managing information becomes one of managing space. Moving from one-dimensional to two-dimensional interaction made it possible to exploit further areas of human ability as part of the interactive experience. These included peripheral attention, pattern recognition and spatial reasoning, information density, visual metaphors, and progress.

Graphical interaction remains the dominant paradigm for interaction with computers. In 1981 Xerox's Star was the first PC to ship with the features of a graphical user interface (GUI) –windows, menus, and a mouse-and the Macintosh, three years later, was the first to ship in volume ay an affordable price. Twenty years later, this trend is still true. However, recent research programs have begun to explore new paradigms for interaction and interactive system design.

Working on physical interaction has been a particular active topic in the last few years. **Tangible computing** encompasses a number of different activities. One general trend is to distribute computation across a variety of devices, which are spread throughout the physical environment and are sensitive to their location and their proximity to other devices. A second trend is to augment the everyday world with computational power, so that pieces of paper, cups, pens, ornaments, and toys can be made active entities that respond to their environment and people's activities. A third topic of investigation in tangible computing is how these sorts of approaches can be harnessed to create environments for computational activity in which we interact directly through physical artifacts rather than traditional graphical interfaces and interface devices such as mice.

The last decade or so has also seen increasing attempts to incorporate understandings of the social world into interactive systems. This **social computing** encompasses a range of different activities. It attempts to understand how the "dialogue" between users and computers can be seen as similar and dissimilar to the way in which we interact with each other.

### 3.2 Mom intelligence and interactions

Most Korean words describing very important things in life are in one syllable word or single breathing sound. It is necessary to transfer important things and events as quickly and precisely as possible. Things and events fundamental to the lives are more so. There are many one syllable words in Koran language centered around human Mom. Words are basically tremors (vibrations) of Mom. This is a process leaving from me alone and entering into the world of us. Mom exists through the process of exchanges and responses. Language is resulting from the combinations of the avoiding and confronting situations to maintain my Mom and other Mom in good conditions. Mom language is the origin of the spoken language. As Merleau-Ponty pointed out, Mom language represents actions and spoken language represents fine actions. Indication aims at tremor of Mom. Language is specific tremor of Mom and meaning of language is Mom's special tremor, Mom's special situations inducing such tremors and Mom's special functioning to maintain Mom in such situations [2, 12].

In Lovejoy's theory of intelligence, human oral cavity has been formed due to standing walk and the changes of dietary life. Repeated sound programming in oral cavity creates human intelligence [7].

In 1961, Dennis Papin invented the first pressure-cooker valve to regulate pressure, as shown in Fig. 1. Since the diaphragm of this device senses the pressure and moves according to the pressure difference, its sensing, control, and action parts are not clearly separated. It reacts easily and efficiently to the pressure changes as a whole piece. These characteristics of embodiment and relativity suggest important virtues of interactions.

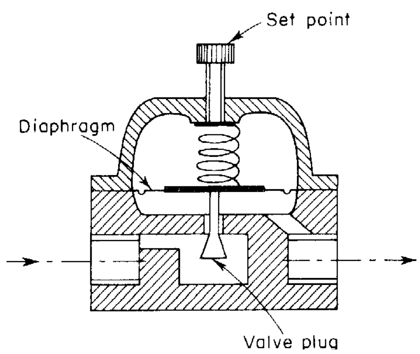


Fig. 1 Self-operated controller.

There is a logical sensation or sensual logic code to interpret nature in human cognition. Like insect's antenna, this is a logic system connected to all cognitive systems and a sensory system required to its survival. The fact that nature's small structure contains its bigger structure is self-similar thus very much connected to the geometric and intuitive world. This is the basic nature of fractal way of thinking [13].

Many present intelligent machines attempt to perceive surrounding environment with complicated sensors and sensor processing systems. However these attempts do not match with the perceptual and reactive capabilities of the insect's antenna.

Advancement in computer technology made real-time interaction possible by processing information from user inputs and sensor data. Problem lies in that, even if the size of data is increasing, approachable user's connection types are limited to the selectively classified ones. This rather shrinks user's intentions into few patterns.

If we follow these clumsy patterns, user's easiness and intentions are greatly damaged. These classifications seem to be only easily possible to the context of Westerners to whom body and mind is separable. Westerners' anatomical body, if necessary, can be always separable from the self. Also, in industrialized countries, characters of body have been being documented. On the contrary, Koreans' embodiment has very instinctive natures. In addition, Koreans treat embodiment and mind as same thing.

To Koreans, body is neither an inferior nor a separable concept to mind as you may see in the words, like "身體髮膚 ([sinchebalbu] in Korean)," "身言書判 ([sinunsopan] in Korean)," "身外無物 ([sinwemumul] in Korean)." Since body and mind to Koreans is connected, Koreans deny the notion that we interface only by classifying body's characters. Koreans in general believe that mind follows body. Koreans like to touch and confirm with hands. This has something to do with the fat that Koreans are familiar to short-distance sensations. Sound and light can travel far away. Multiplication and transportation is also possible. Storage, classification and documentation is possible. On the contrary, relatively short-distance sensations in spectrum of sensations, like touch, taste, and smell, disintegrate the relationship between subjectivity and objectivity. In the countries where subjectivity and objectivity is clearly separated, people tend to prefer long-distance sensations. Short-distance sensations are more persuasive to the people in countries, where subjectivity and objectivity is intermingled.

In this context, we need to have a different view to start a new interaction paradigm, interactive technology, from that of the West. Koreans already have more active environment in interactivity and preferable embodiment to interactivity.

## 4. TANGIBLE SOUND

Emotions in general can be interpreted as different forms or scales in spectrum, as shown in Fig. 2. Sound and light are emotional entities, which only differ in the location in an emotion spectrum scale [7, 14]. Sound space is an invisible but a tangible space in a sense that it travels in emotional tremors and stimulates new sensations and perceptions. We experiment such tangible space as a new and proper interactive paradigm.

Three cases are introduced, which include 1) an interactive robotic cane "RoJi," which aids blind or visually impaired travelers to navigate safely and quickly among obstacles and hazards faced by blind pedestrian with the help of restructured spatial perception, as shown in Fig. 3 [15, 16]; 2) a tangible space "A Room with Sensors," which makes you feel outdoor climate changes and indoor information flow on a sensor chair in the form of vibrations, as shown in Fig. 4 [17]; and 3) a sound sculpture "Schwarzwald (Black forest)," which constantly reshapes sound space by interacting with the motions of audience(s), as shown in Fig. 5 [18].

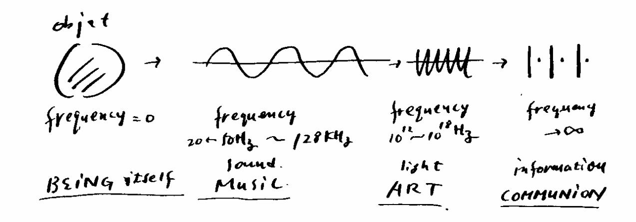


Fig. 2 Waviness in emotions.

The sound sculpture "Schawarzwald" is a technological artwork, which has been implemented and presented at the Sungkok Art Museum in Seoul, Korea, on March 5-30, 1999. It interacts with a spectator at upto sixteen pyroelectric sensor locations with sixteen corresponding sound samples of $2^{16}$ possible cases. Sound samples utilized include raindrops, noise in a fish market, quarreling, coughing, birdsongs, musical sounds, crying, barking, and glass-breaking, etc. Pyroelectric sensors were selected to isolate the spectator's movements to sense the distance between the roof and the spectator's various locations. The spectator walks freely around the "Schawarzwald" and interacts with it by watching it and listening to the corresponding sounds activated. This sculpture starts to become an artwork as the spectator interacts with it. It is ever-changing and continues to interact with the spectator [18].

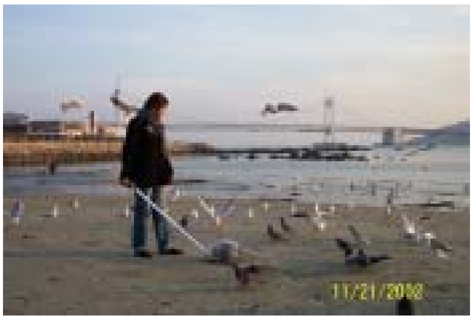


Fig. 3 A tangible interaction "RoJi."

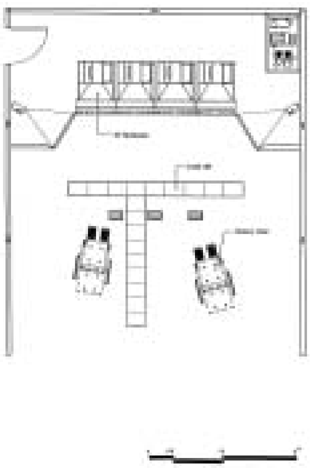

Fig. 4 A tangible space "A room with sensors."

Fig. 5 A sound sculpture "Schwarzwald (Black forest)."

## 5. SUMMARY

Working on physical interaction has been a particular active topic in the last few years. Tangible space focuses on such embodied interactions between human and environment. An embodied interaction paradigm, based on "Mom," is investigated. Understanding human "Mom" and space surrounding human "Mom" could be the first step toward exercising proper technology for human. Some observations in "virtuality" as possible reality, "gamgak" as instant sensation and perception or the ability to feel about what is out there, synesthesia could provide grounds for an alternative paradigm to build interactive systems more suitable and comfortable to human.

A historical model of interaction is reviewed and then our search for an interactive paradigm, interactive technology, is followed. Key ideas in interactive technology include synesthesia: unification of five senses-vision, hearing, smell, taste, and touch, examination of spatial perception, and emergence of a new perception; sensibility ergonomics for Koreans; mind based system; organic relationships among human and machines. Interactive technology initiative (ITI) is an interdisciplinary research group to search proper technology and way of implementing technology. Some experimental activities conducted by ITI are also presented.

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