Interactive Technology: Soft Engineering

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Abstract: Recent paradigm in technology shifts from object-based technology to environment-based technology. Issue here is interaction among human, machines, and environment. This requires new interpretations for the space among them. Holistic interactions based on "Mom (embodiment)" suggest a good starting point for this endeavor. The past, present, future of technology are presented in terms of technology's fundamental virtue: "humanizing technology" or "technology serving human." Interactive technology initiative (ITI) is an interdisciplinary research group to search for the proper technology and the proper way of implementing technology: "interactive technology" or "soft engineering." Some experimental activities conducted by ITI are presented in this organized session, "Interactive Technology." Metatechnology, soft engineering, "Mom (embodiment)," holistic interactions, tangible space, and ubiquitous computing are key concepts in interactive technology.

Keywords: Interactive technology, soft engineering, metatechnology, Mom (embodiment)

1. INTRODUCTION

Recent paradigm in technology shifts from object-based technology to environment-based technology. While object-based technology tries to solve various technological problems by producing final product and evolving to substitutes, environmental-based technology focuses on the interactive process between human and environment. Two monumental events in the history of technology, industrial revolution and information revolution, characterize the amplification of power and speed, which result in "de-space"-ing, i.e. alienating human. Recent interactive revolution tries to recover this alienation by questioning "space" around human and interaction with environment [1, 2].

The past, present, and future of technology are presented in terms of "humanizing technology" or "technology serving human." For the past of technology, some philosophical and historical views regarding evolution of technology and machines are presented. Mom and technology have been discussed and interactive technology based on Mom have been introduced to show the present of technology. For the future of technology, design and intentions seem to be important virtues for the proper technology and process of implementing technology. Soft engineering is proposed as a new way of doing technology.

Interactive technology initiative (ITI) is an interdisciplinary research group to search for the proper technology and the proper way of implementing technology: "interactive technology" or "soft engineering." Some experimental activities conducted by ITI are presented in this session, "Interactive Technology." Tangible space focuses on embodied interactions among human and environment, virtuality, and sensation/perception. Personal robotics, specifically for the elderly, is a major area in which to explore these ideas. Three cases related to implementing interactive technology are introduced, which include a human robot interactive system "An Interactive Robotic Cane "RoJi"," an interactive broadcasting technology in NHK "A Spoken Dialogue Interaction for TV Operation By Using A Robot Interface," and interactive robotics research at the Johns Hopkins University "Haptics for Human-machine Interaction at The Johns Hopkins University" [3-6].

2. PAST: EVOLUTION OF TECHNOLOGY

2.1 Evolution of technology [7, 8]

Until 18th century in Western intellectual society (circle), Natural Philosophy had been more widely used than Science. Philosophers in this age performed the roles of scientists who explored the nature. Scientists were also philosophers who sought overall intellectual knowledge. Looking back the 17th century genii like Kepler, Galilei, Descartes, Pascal, Newton, and Spinoza, we could easily guess the intellectual atmosphere when science was natural philosophy itself in a big picture. Until then, there was a strong tendency to understand nature as a whole. Science could not be separated into physics, chemistry, and/or biology. Understanding nature in this way portrays the window through which world is viewed in the name of philosophy. Philosophers until 18th century had more than amateurish understandings regarding science.

Starting 19th century, natural philosophy has been separated with the name of science and specialized as physics, chemistry and biology. Uprising German idealism in this period accelerated the process of separation. Unfortunately in this course it disrupted the sense of harmony and balance in intellectual system, which humanists have been trying to practice. Unlike Germany and Britain where idealism prevails, the separation of science and philosophy in France were not that severe due in part to their linguistic characteristics. Intellectual tradition of natural philosophy strongly had survived. We can still confirm this tradition in the case of 20th century French philosopher Gaston Bachelard.

Even though 18th century was not the period of Leonardo da Vinci, 19th century was the period that decisively separates science and arts. Especially, romanticism in this period differentiated the atmosphere of artists' studios from that of scientists' labs. One individual Leonardo da Vince had been forced to have dual personalities and take the position as either a scientist or an artist. The tradition of holistic homo sapiens was about to collapse completely.

The characteristics of this European culture have been misunderstood in the process of importing Korea's Western culture. Korea's encounter with Western culture was neither the 15th century's Renaissance nor the 17th century's gifted Natural Philosophy. It was limited to the 19th century when

human intellectual endeavor has been branched into many areas. In the eyes of people who do not follow their intellectual traditions, philosopher Bachelard, who sometimes studied mathematics and then immersed in science and philosophy, seemed to be a strange alchemist. Acts of poet Paul Valerie, who was preoccupied in mathematics by suspending his writing poems for a while, are hard to understand. 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 open-mindedness to accept this holistic system is virtue commonly required to good scientists and artists alike.

Geometry is an intuitive world. The attribute of geometry lies in grasping the whole via part. Intuitive world is another unique system in human, which overcomes logic and explanation. It is like an insect's antenna to decide its situation completely with limited information around it. 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.

Due to the 19th century romanticism, arts and science are separated. While there have been changes from Philosophy into Natural Philosophy, from Natural Philosophy into Science, from Science into Engineering, engineering has lost considerable thinking, which is lying or basic in natural philosophy. Our acceptance of Western science as serious reality was last half of 19th century. Science has been introduced not as thoughts or philosophy but as civilization or products. Also it has been distorted by 19th century romanticism. Thus our science has lost chance to make close companionship with humanities and arts. It has been considered as the fundamental (basic) concept of engineering or technology, Obviously that easily lack thinking and imagination.

2.2 Evolution of machines [9]

Then, is engineering a new field formed only after 19th century and 20th century. We might start to investigate the evolution of technology looking at development of arms. These include food-gathering tools in primitive age, weapons in modern war era, and processing devices in information age. These tools evolve by trying to achieve optimized performances. The representative technology include maximization of human power in primitive age tools; amplification of power via steam turbine, control technology and automatic looming and weaving technology in industrial revolution period; digital technology like abstraction and multiplication of patterns in information revolution period.

Or, we might view with alternative way. We look at the evolution of technology as harmonious and emotional musical instruments or toys. There was percussion in primitive age. Piano, which was invented in early 18th century, is a typical mechanical instrument, which follows the principles of Newtonian mechanics. Mechanical instruments convey (transform) performers' body movements in the form of gestures of the mouth, hands, and feet to the audience in the form of very subtle and gracious vibrating sound. 20th century witnessed electronic instrument. Human body movements are transformed into analog and/or digital signals. This makes possible various sound processing, which physical mechanical musical instrument could not generate. The evolution of musical instruments reflects the contemporary science and technology and the spirits of the time. Musical paradigm of ancient times was based on mathematical orders from Pythagorean school. Western musical ideas until 19th century were based on Newtonian deterministic rationalism. That of 20th century seems to be based on Einstein's theory of relativity, Heisenberg's theory of uncertainty, electronics technology and computers [10-13].

If we follow these observations, technology has been with humans all the time. With the theme "technology is serving humans." Why people have conception that technology is not easy to understand and warm to embrace?

3. PRESENT: INTERACTIVE TECHNOLOGY

3.1 Mom and technology

The traditional view on technology is that it is a very objective area and it has universal characteristics. Unlike Westerners emphasize subjectivities, Asians-Koreans value relationships. Current Western-dominated technology leads astray from the starting objective of technology, "serving human," and have been evolved to objects and substitutes while human has been excluded in that process. Prejudice against technology, not being friendly, has something to do with this Western view on technology [14-31].

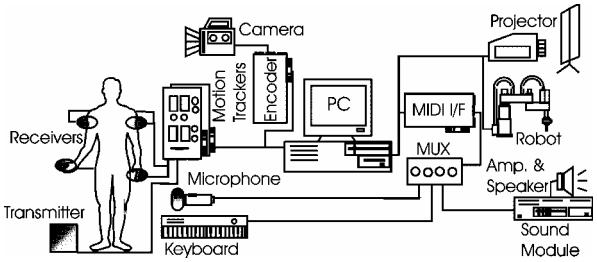
Originally, art and technology share the same coinage, "techne." If we view art as an extension of emotion and sensibility of human body, rudimentary engineering or technology is an extension of power and function of human body. Presumably the first technology might be a stone tool in Old Stone Age. In this case, a stone tool is an extension of human hand. Technology was totally disconnected from human body after modern era, especially after the invention of powerful steam engine. Invention and utilization of electricity further alienate human. After going through industrial revolution and information revolution, technology is defining his position toward an absolutely independent system where human body cannot confirm or participate in any way. As technology escaped away from human body strongly and quickly, it reached far beyond the boundary of human recognition. Now technology is a strange and an unfriendly area to the ordinary people [14-17].

Recent developments in and reflections on technology have tended to drive technology come closer to human body. Ironically, electricity that pushed human body away from technology is the binding force between technology and human body. Weak electronics, not power electronics, is the major force here. Weak electronics made possible personal electronics, which draws in technology even into the surface of and the inside of the human body [14-16].

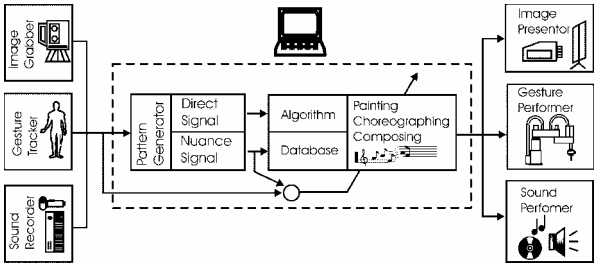
An interactive system based on human body has been implemented to explore these ideas. The conceptual diagram of the interactive system, called Emotional intelligence Interface and Performance System (EIPS), is shown in Fig. 1 [32].

3.2 Embodiment and interactive technology

If industrial revolution is based on amplification of power, information revolution is based on amplification of speed. Recent paradigm in technology shifts from isolated objects to environment related to human. In this context, interactive technology is a new of doing engineering by trying a new thought revolution regarding interaction among humans and machines. The development of information technology requires a new way of confronting environment surrounding us. The investigation of environment and people is the starting point to explore the new way of interaction among humans and machines [14].



(a) Emotional intelligence Interface and Performance System



(b) Physical and Mental Interfaces

Fig. 1 An interactive system: EIPS.

In countries with distinct subjects and objects, long-distance sensations like sound and light are more preferable. In countries with intermingled subjects and objects, short-distance sensations, like touch, taste, smell, are more pervasive. Koreans like to touch and confirm with hands. The fact that it was difficult to restrain the audiences not to touch artworks in Kwangju biennale is not totally considered as being lack of cultures of audiences. Accounting this, trying interactive technology in Korea should possess different starting point from that of the West. Koreans have Mom more favorable to interactions among humans, machines and technology. Furthermore, Mom and mind are unseparable things to Koreans. Mom is neither inferior to nor separable from mind. This may explain that Koreans have instinctive body suitable for confirming the proposition "engineering as serving humans" [3, 15].

4. FUTURE: SOFT ENGINEERING

4.1 Intentions and design

It's about time for humans and computers to co-evolve. Possibility of technology recycling raises questions regarding engineering process as achieving functions, performances and outcomes. More important questions should be addressed on intentions of engineering designs and qualifications of engineers as designers. The wide spread internet and wearables like cellular phones govern ordinary people's everyday life.

Technology nowadays no longer belong to limited expert group of engineers. Philosophy of technology that explores the proper technology and proper ways of doing engineering enters into the mainstream of philosophy. Philosopher Maurice Merleau-Ponty, media theorist Marshall Mcluhan, and ubiquitous computing inventor Mark Weiser are representative technology philosophers. Computer culture magazine like Wired and Sci-fi movies like Minority Report and Matrix are leading books on philosophy of technology [1, 33-40].

Most fundamental questions in philosophy of technology are "What is technology serving humans?" and "How can we design it?" What is technology for humans? How can we design machines that can recover human pride instead of alienation? What will be most inhumane human condition that technology can overcome? Humans are all handicapped in a sense that humans dream about unlimited extension of their limited bodies. The most desirable way to start engineering is to examine engineering in most vulnerable situations.

Engineering in nature seeks optimization. If the object of optimization is not only individual and working conditions but also reacting to environment, very complicated engineering problems could be expected to be solved in practical. Current active research in evolutionary engineering approach adopts the ways, which evolve to engineering solutions suitable to given intentions by mimicking evolutionary process of life [14, 41-44]. An interactive evolutionary system where system evolves with human evaluations is shown in Fig. 2 [45].

Technology evolves to amplification of power through industrial revolution, to amplification of speed through information revolution and to amplification of intention through interactive revolution [2, 14, 46-50].

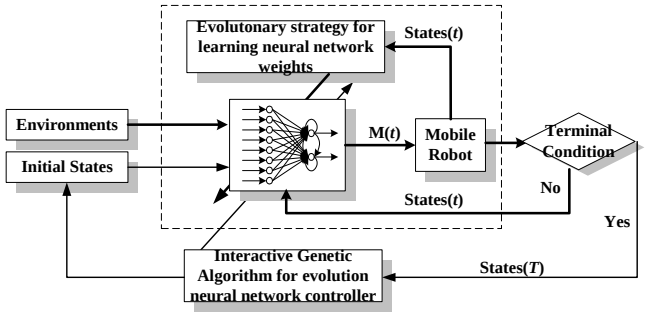


Fig. 2 An interactive evolutionary system.

4.2 Soft engineering

Soft engineering is an area, which seeks proper technology and proper ways of doing engineering. To investigate soft engineering concept, a robot fabrication project based on rapid prototyping method has been organized and performed. We try to revive survival systems from primitive age when engineering process and tools are closest to and complete to human body. Pusan National University (PNU) junk robot project is aiming to experience the engineering process to self-suffice materials and technology on the spot and implement engineering intention easily. Recycling of technology and materials, power autonomy by natural energy, utilization of environment friendly technology, and popularization of engineering by easy construction and implementation [44].

During the first semester of year 2003, there was a course to train the sixty PNU junior students about engineering process. Information on parts and fabrication procedures are provided in pictures to the students. Except solar cells and some basic electronic parts, junk parts from computers and audios are encouraged to be recycled. Students fabricated their own solar powered robots in either spinning top or racer following guide lines in pictures and model robots in moving images via course internet. After 1 hour in class session, they tested basic operations in a breadboard circuit with a fan and a small electrical motor. Once basic function is confirmed, prototype is further refined with soldering of electronic parts and designing mechanical structures. For evaluation purpose,

easiness and reproducibility in implementation is major checking points. Reports summarizing the fabrication process with final robots have to be submitted. Some restrictions imposed on cost and fabrication time are 1 hour and 5,000 won. Junk robots operated on solar systems are artificial life forms [44, 51, 52].

All process is basically based on the principle of self-sufficiency and no a priori experience in electronics and mechanism is required. This type of engineering based on locality was named as "JunPoDong-JangJonDong engineering" meaning Pusan version of "ChongGyeChon engineering." If we further solve the environment-dependent problems, large groups of junk robots may constitute an interesting artificial ecosystem outdoors. This project will be further experimented among many groups of people including students majored in arts and engineering, which is scheduled for the second semester of year 2003. The PNU junkbot project was demonstrated during May of 2003 as shown in Fig. 3. This result will be constantly refined for the future use for the popularization technology [44, 51, 52].

As another example for soft engineering, we explore an interactive ubiquitous computing environment which allows the coexistence of humans and robots. Interactive motion flows are constructed by implementing tags, pads and boards into the humans, robots, research labs., playground, shuttle bus, parking lots and libraries. For easy constructions, we adopt sensors capable of wireless networking and robot platforms easily constructible. Representative robot platforms are Lego robots and evolutionary robot from Evolution robotics, which allows recognition and reaction with laptop computers loaded. The basic conceptual drawing for the ubiquitous campus networking environment "u-PNU" is a shown in Fig. 4 [1, 44, 49].

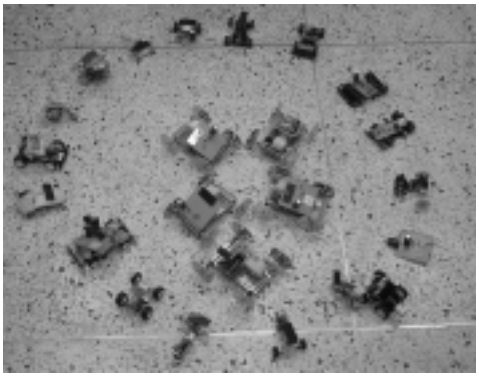


Fig. 3 A soft engineering project "PNU Junkbot."

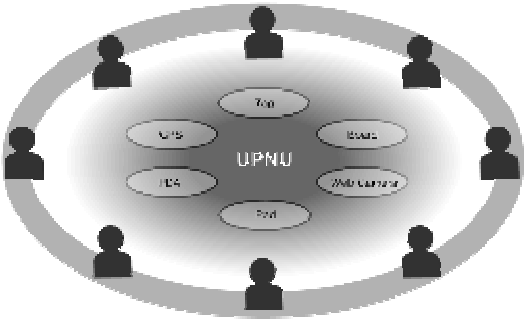


Fig. 4 A ubiquitous campus computing "u-PNU."

5. SUMMARY

This is an interdisciplinary effort in investigating a new paradigm of technology. Object-based technology is based on a reductionistic view, i.e., machines evolve to an intelligent but isolated object form by serially integrating precise subtechnology constituents. A new paradigm of technology, based on an interaction of human, machines and environment through Körperlichkeit (philosophy of "Mom"), is explored. Holism, embodiment, and relative interactions based on correspondence and interrelationships, are the key ideas of the proposed paradigm: "interactive technology."

Soft engineering is an interactive technology paradigm and engineering field, which seeks proper technology and proper ways of executing engineering activities. It is focused on symbiotic coexistence of human, machines and environment. To explore soft engineering concept, Junkbot project and ubiquitous Pusan National University (u-PNU) project have been organized. Focusing on fundamental notion of technology, i.e. "technology is for serving human," methodologies to implement such engineering intents easily have been explored. Junkbot project is a rapid prototyping based engineering. Recycling of technology and materials, power autonomy, green oriented engineering, and popularization of technology are major interests. "u-PNU" project aims to construct a campus based space, in which human and robots could coexist and co-evolve in interactive ubiquitous computing environment.

A historical model of interaction is surveyed. Four separate phases of development are characterized as electrical, symbolic, textual, and graphical forms of interaction. Also, new models for interactive system design are described. These models are tangible and social approaches to computing, and embodied interaction [3]. Philosophical and historical views regarding evolution of technology and machines are presented. Interdisciplinary attitude toward engineering is emphasized and history of machines as arms and toys are introduced.

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REFERENCES

[1] M. Weiser, "The computer for the 21st century," *Scientific American*, Vol. 23, No. 4, pp. 66-75, 1991.

[2] J. Yoon, "Tangible sound and interactive technology," *Proceedings of the Spring Annual Meeting of Korean Society for Precision Engineer*, 2003 (Korean).

[3] J. Yoon and M. Yoh, "Tangible space and interactive technology," *Proceedings of the 2003 International Conference on Control, Automation and Systems (ICCAS2003)*, Gyeonju, October 22-25, 2003.

[4] M. Yoh and J. Yoon, "Personal robotics for the elderly based on interactive technology," *Proceedings of the 2003 International Conference on Control, Automation and Systems (ICCAS2003)*, Gyeonju, October 22-25, 2003.

[5] I. Shim and J. Yoon, "A human robot interactive system "RoJi"," *Proceedings of the 2003 International Conference on Control, Automation and systems (ICCAS2003)*, pp. 2391-2396, Gyeonju, October 22-25, 2003.

[6] A. Okamura and S. Chang, "Haptics for human-machine interaction at the Johns Hopkins University," *Proceedings of the 2003 International Conference on Control, Automation and systems (ICCAS2003)*, pp. 2391-2396, Gyeonju, October 22-25, 2003.

[7] I. Hwang, *Exploration of Steels*, Gallery Shilla, 1995 (Korean).

[8] R. Audi, et al, ed., *The Cambridge Dictionary of Philosophy*, Second ed., Cambridge University Press, Cambridge, 1995/1999.

[9] J. Yoon, "Motion capture and mimic system for intelligent interaction," *Journal of Controls, Automation and System*, Vol. 5, pp. 585-592, 1999 (Korean).

[10] S. Holtzman, *Digital Mantras: The Languages of Abstract and Virtual Worlds*, The MIT Press, Cambridge, 1995.

[11] C. Roads, *The Computer Musical Tutorial*, The MIT Press, Cambridge, 1996.

[12] J. Yoon, "Aesthetic in Kuk Ak (國樂)," *Proceedings of the Spring Annual Meeting of Korean Society for Precision Engineer*, pp. 14-19, 1997 (Korean).

[13] J. Paradiso, "Electronic music: new ways to play," *IEEE Spectrum*, Vol. 34, No. 12, pp. 18-30, 1997.

[14] J. Yoon, "Interactive technology and evolutionary robotics," *Proceedings of the 15th ICASE*, CD- ROM, 2000 (Korean).

[15] I. Hwnag and J. Yoon, "Interactivity in technology and art," *Proceedings of the 15th ICASE*, CD-ROM, 2000 (Korean).

[16] J. Yoon, S. Chang, and I. Hwang, "Mom and interactive technology," *Proceedings of the 4th Asia-Pacific Conference on Control and Measurement*, pp. 321-326, Guilin, July 2000.

[17] L. Mumford, *Art and Technics*, Trans. By M. Kim, Columbia University Press/Minumsa Publishing Co., Seoul, 1952/1999.

[18] S. Park, et. al., *Mom*, Sanhe, Seoul, 2001 (Korean).

[19] H. Jung, *Body Politics*, Minumsa Publishing Co., Seoul, 1999.

[20] G. Lakoff and M. Johnson, *Philosophy in the Flesh: The Embodied Mind and Its Challenge to Western Thought*, Basic Books, New York, 1999.

[21] O. Dyens, *Metal and Flesh, The Evolution of Man: Technology Takes Over*, Trans. By E. Bibee and O. Dyens, 2001.

[22] A. Smith, *The Body*, Walker and Co., New York, 1968.

[23] D. Ihde, *Bodies in Technology*, University of Minnesota Press, Minneapolis, 2002.

[24] A. Danto, *The Body/Body Problem: Selected* Essays, University of California Press, Berkeley, 1999.

[25] R. Brooks, *Flesh and Machines: How Robots Will Change Us*, Pantheon Books, New York, 2002.

[26] B. Heinrich, *Why We Run: A Natural History*, HarperCollins Publishers, New York, 2001.

[27] F. Wilson, *The Hand: How Its Use Shapes the Brain, Language*, and Human Culture, Vintage Books, New York, 1998.

[28] M. Corballis, *From Hand to Mouth: The Origins of Language*, Princeton University Press, Princeton, 2002.

[29] D. Cervone and W. Mischel, eds., *Advances in Personality Science*, The Gilford Press, New York, 2002.

[30] H. Dreyfus, "The role of the body intelligent behavior," *What Computers Still Can't Do?: A Critique of Artificial Reason* (first published in 1972), The MIT Press, Cambridge, pp. 235-256, 1992.

[31] E. Tenner, *Our Own Devices: The Past and Future of Body Technology*, Alfred A. Knopf, New York, 2003.

[32] J. Yoon, "A digital aesthetic in music," *Proceedings of the 11th KACC*, pp. 130-133, 1996 (Korean).

[33] D. Stork, ed., *Hal's Legacy: 2001's Computers as Dream and Reality*, The MIT Press, Cambridge, 1997.

[34] K. Harber, ed., *Exploring the Matrix: Visions of the Cyberpresent*, St. Martin's Press, New York, 2003.

[35] M. McLuhan and Q. Fiore, *The Medium is the Massage: An Inventory of Effects*, Bantam, New York, 1967.

[36] P. Levinson, *Digital McLuhan: A Guide to the Information Millennium*, Routledge, London, 1999.

[37] N. Negroponte, *Being Digital*, Alfred A. Knopf, New York, 1995.

[38] F. Ferré, *Philosophy of Technology*, The University of Georgia, Athens, 1988/1995.

[39] P. Churchland, *Matter and Consciousness*, revised ed., The MIT Press, Cambridge, 1984/1999.

[40] P. Dourish, *Where the Action Is: The Foundations of Embodied Interaction*, The MIT Press, Cambridge, Seoul, 2001.

[41] S. Nolfi and D. Floreano, *Evolutionary Robotics: The Biology, Intelligence, and technology of Self-Organizing Machines*, The MIT Press, Cambridge, 2000.

[42] P. Bentley and D. Corne, ed., *Creative Evolutionary Systems*, Morgan Kauffman, San Francisco, 2002.

[43] P. Bentley, *Digital Biology: How Nature Is Transforming Our Technology and Our Lives*, Simon & Schuster, New York, 2001.

[44] J. Yoon, 2003, *Evolutionary Robotics based on Interactive Technology*, Phase 2 Report, KOSEF, 2003 (Korean).

[45] I. Shim and J. Yoon, "Evolutionary learning of mobile robot behaviors," Proceedings of KFIS 2002 Fall Conference, pp. 207-210, 2002 (Korean).

[46] C. Pierce, *Interactive Book: A Guide to Interactive Revolution*, Macmillan Technical Publishing, Indianapolis, 1997.

[47] A. Scholder and J. Crandall, eds., *Interaction: Artistic Practice in the Network*, Distributed Art Publishers, Inc., New York, 2001.

[48] M. Pesce, *The Playful World: Interactive Toys and the Future of Imagination, How Technology is Transforming Our Imagination*, Ballantine Books, New York, 2000.

[49] F. Johnson, A. Fox and T. Winograd, "The Interactive workspace project: Experiences with ubiquitous computing rooms," *IEEE Pervasive Computing*, Vol. 1, No. 2, pp. 67-74, April-June 2002.

[50] B. J. Fogg, *Persuasive Technology: Using Computers to Change What We Think and Do*, Morgan Kauffman, San Francisco, 2003.

[51] PNU Junkbot related contents, *http://iic.me.pusan.ac.kr*, Intelligence, Information & Controls Lab., Pusan National University, 2003.

[52] D. Hrynkiw and M. W. Tilden, *Junkbots, Bugbots & Bots on Wheels: Building Simple Robots with Beam Technology*, McGraw-Hill/Osborne, Berkeley, 2002.