Robotics Projects at Pusan National University

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Abstract: Soft engineering, based on symbiotic coexistence of human, machines and environment, is a new engineering field to explore the proper technology and the proper way of engineering. To explore soft engineering intents easily, various robot projects at Pusan National University conducted are presented. Thought experiment, interactive e-leaning, rapid prototyping engineering, biomimciry, tangibility, and ubiquity are concepts to be explored. Thought experiments projects are organized and performed, which include robot assembly game, Turing test, and robotics in science fiction. "Junk robot project" and "ubiquitous Pusan National University (u-PNU) project" have been organized. Also, bug robot project, interactive robot project, and interactive emotional robot projects are introduced. Weekly science fiction films are shown and discussed.

Keywords: Soft engineering education, interactive e-learning, PNU engineering, thought experiments, rapid prototyping robotics, robotics in ubiquitous environment

1. INTRODUCTION

Soft engineering, based on symbiotic coexistence of human, machines and environment, is a new engineering field to explore the proper technology and the proper way of engineering. To explore soft engineering concept, various robot projects at Pusan National University conducted are presented [1-16].

"Junk robot 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 project. Technology and materials recycling, 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 coevolve in interactive ubiquitous computing environment.

Based on interactive technology paradigm, various projects have been organized and performed. These robot projects include junk robot, bug robot, interactive robot, and tangible emotional robot.

2. SOFT ENGINEERING EDUCATION

2.1 Intentions and design

It's about time for humans and computers to co-evolve. Possibility of technology recycling raises questions regarding engineering process as means to achieve 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 belongs to the 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 philosophers of technology. Computer culture magazine like Wired and science fiction movies like Minority Report and Matrix are leading texts on philosophy of technology [1, 2, 8, 17-20].

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 [21].

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 [16, 22-24].

2.2 Soft engineering projects

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 are important issues [25].

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. The PNU junkbot projects have been demonstrated during May of 2003, October of 2003, and June of 2004. These results will be constantly refined for the future use for the popularization of technology [4, 9].

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 "ubiBot" is a shown [16, 18, 25].

2.3 Robotics education

Course attendance is checked utilizing finger identification system. Each student is required to summarize and present one topic assigned. Presentation has been performed taking advantage of multimedia. Each presentation recorded can accompany the text as an audio book. Various related visual contents also serve as excellent accompany course materials [7, 8].

Ruth Aylett looks at what is really necessary to build a successful robot, which include the issues of robot intelligence as 1) intelligence, 2) mobility, 3) sensing, 4) integration: thinking, deciding, & learning, 5) bodies, 6) interaction: the function and desirability of emotions, and the ability to socialize and make friends, and 7) future: fear of robot domination. Aylett further delineates issues we should consider for bring intelligent machines to life. 1) The quest for **intelligence**: creation of a living being, fears about robots, views on intelligence, intelligence test, animal analogies. 2) **Moving** matters, wheels: feet, legs, hopping, swinging, climbing, slither, underwater, wing, robot orangutan Lucy. 3) **Sensing** the world: active or passive sensing, animal behavior, synthetic psychology, grasp of distance, vision, active vision, smells, obstacle avoidance, map, homing, uncontrollable art. 4) **Putting it all together**: reflexes, reactions, & thinking, artificial neural networks, neuro-silicon, learning strategies, watch & imitate, togetherness, swarms, flocks, & formations, work together in teams, planning; cognitive robotics, dancing queen. 5) Shame about the **body**…: robot's body and animal's body, muscles, skin and soft touch, batteries, energizing, size, robot zoo. 6) **Making friends**: emotional intelligence, expressive features of robots, sensing human emotions, how human?, toy robots, helping and guiding, therapeutic robots, creative applications, robot competitions. 7) So **will they take over the world?**: robot culture, reproduction, the state of the art, robot ecosystems, autonomy, self-design, humans rule, making your own robot [26].

Syllabus of the robotics course of year 2003 and 2004 is organized as [7]

Week 1: Introduction and history: assembly game;

Week 2: Robotics in science fiction: writings and movies;

Week 3: Issues for robotics: intelligence, information and controls, manipulation and mobility, embedded control and middleware, perception and cognition, communication and interaction, intelligence and information;

Week 4: Industrial robotics: kinematics, dynamics and control;

Week 5: Personal robotics: intelligence and interaction;

Week 6: Building physical robots: junk robot projects;

Week 7: Mind and artificial intelligence;

Week 8: Synthetic psychology and mental robots;

Week 9: Robot platforms: LEGO, Kepera, Evolution Robot, etc;

Week 10: Invited talk: multimedia arts and cyber ethics;

Week 11: Invited talk: Personal robotics in ubiquitous computing environment;

Week 12: Design, intention and evolutionary robotics;

Week 13: Robotics for the handicapped and the elderly;

Week 14: Research trends and advanced issues: humanoids, entertainment and toy robots, reconfigurable robots, swarm intelligence, nanobots, extreme robotics, web based telebotics, haptics, medical robotics, tangible space and interactive technology;

Week 15: Review and open discussions.

3. THOUGHT EXPERIMENT PROJECTS

Thought experiment is an excellent education methodology. Two role playing actions, robot assembly game and Turing test, and science fiction film showing is successfully performed.

3.1 Robot assembly game

In robot assembly game, course attendees are instructed to mimic robot bahaviors in various assembly situations. Two groups of two people are designated as robot(s), robot controller(s), or robot-controller team. Let them pick a coin on a table and relocate to other table for assembly operation. Students try to pick a coin with or without pencil, where pencil is a gripper and manipulation is the key problem. Make one or two to be blind. Problem gets worse, where sensing the world issue arises. How about making a robot person blind and let the controller person command motions? Control and autonomy problem comes up. During the operation, instructor could move coin to issue moving target problem. Students experience many issues lain robotics. They do understand various complicated robotics issues easily and they are really stimulated this experience and ready to start the course study [7].

3.2 Turing test

One other interesting experiment is ready for the students. This time, Turing test for intelligence and intelligence measure. The **Turing test** was proposed in 1950 by British mathematician Alan M. Turing. In the test, a judge would hold a three-way conversation with a computer and another human. If the judge cannot distinguish between the responses of the human and those of the computer, the machine would pass the test [8, 29].

Human and computer playing human are selected. Juries about four possibly representing different majors are also chosen. Students ask twenty questions to distinguish human and computer. Students ask to find out computer and computer human try to fool jury. It's an exciting game. We are amazed by the surprises we experience. Really [7].

3.3 Robotics in science fiction

Some notable comments on science fiction stories are presented. Donald Norman writes, “Science fiction can be a useful source of ideas and information, for it is, in essence, detailed scenario development. Isaac Asimov was one of the earliest thinkers to explore the implications of robots as autonomous, intelligent creatures, equal (or superior) in intelligence and abilities to their human masters [30]”

Mikell Groover writes, “Science fiction has no doubt contributed to the development of robotics, by plating ideas in the minds of young people who might embark on careers in robotics, and by creating awareness among the public about this technology [31].”

Asimov’s fiction even influenced the origins of robotic engineering. “Engelberger, who built the first industrial robot, called Unimate, in 1958, attributes his long-standing fascination with robots to his reading of [Asimov’s] ‘I, Robot’ when he was a teenager [32, 33].

These aspirations were lent vivid, tangible imagery in Minsky’s and others’ minds by books such as Isaac Asimov’s I, Robot. “I’ve always read science fiction for ideas,” Minksky says. “These writers think a lot about what an artificial mind would do, what it would need. They put things together in a plausible way.” [34]

In a Stanford lecutre on Cyborgs and Synthetic Human, issues discussed include 1) Body Machines; 2) Junior Cyborgs; 3) Birth without Women; 4) Labor without Men; 5) Dream Dates; 6) “We Have the Technology…”; 7) American Dreams (Spousal Equivalents); 8) Cyborg Sex; 9) “We Are the Robots”; 10) To Err is Human…; 11) Loving the Alien; 12) Electronic Simulacra & Armored Bodies; and 13) Armored Arnold. Science fiction films and writings are served as course materials according to these topics [7].

Isaac Asimov was one of the earliest thinkers and science fiction writers to explore the implications of robots as well deigned, fail-safe, autonomous, and intelligent machines that perform to three later four principles. These principles are called the Asimov’s Three/Four Laws of Robotics. These three laws dealt with the interaction of robots and people, but as history progressed into more complex situations, Asimov felt compelled to add an even more fundamental law dealing with the robots’ relationship to humanity itself. Asimov’s laws are an excellent tool for examining just how robots and humans should interact. The zeroth law could be labeled “humanity” and the first law could be labeled “safety.” The second law is about “obeying people,” in contrast to the first, which is about protecting them. The third law is about “self-preservation.” Asimov detected and investigated the laws’ weaknesses [35, 36].

Roger Clarke analyzes and classifies issues, which include 1) the ambiguity and cultural dependency of terms, 2) the role of judgment in decision making, 3) the sheer complexity, 4) the scope for dilemma and deadlock, 5) audit of robot compliance, 6) robot autonomy, 7) scope for adaptation, 8) perceptual and cognitive apparatus, 9) recognition of stakeholders interest, 10) closed-system versus open-system, 11) blind acceptance of technological and other imperatives, 12) human opposition to robots, 13) the structuredness of decision making, 14) risk management, and 15) enhancements to codes of ethics. According to issues raised by Clarke, discussions on around twenty problems from the first seven issues are held during fall semester of 2003 [7, 35, 36].

As machines become more capable, as they take over more and more human activities, working autonomously without direct supervision, they will get entangled in the legal system, which will try to determine fault when accidents arise. Before this happens, it would be useful to have some sort of ethical procedure in place. There are numerous practical, moral, legal, and ethical issues to think about. Yoh wrote an article such concern: .Reading philosophy in films (1): who’s to be blamed for HAL’s murder of the space crews?-A philosophical reconsideration on the nature of A.I. through the film “2001: a space odyssey”- [30, 37].

Complete list of films shown at the weekly Sci-Fi Film Screening during the first semester of 2004 are as follows [7].

1) 3/11: Abre Los Ojos (Open Your Eyes) by Alejandro Amenabar (1997, 117 minutes). SIGGRAPH 2003 Electronic Theater Program: Respire by Jerome Combe, 227 seconds.

2) 3/18: Minority Report by Steven Spielberg (2002, 145 minutes). SIGGRAPH2003 Animation Theater Program Part 1: Solder Man -Crash & Sues by Dave Novak, 233 seconds.

3) 3/25: Animatrix by Andy Jones, Peter Chung, et al. (2003, 89 minutes) with SIGGRAPH2003 Animation Theater Program Part 2: Ode to Summer by Ron Hui, 157 seconds.

4) 4/1: Blade Runner by Ridley Scott (1982, 117 minutes). SIGGRAPH2003 Electronic Theater Program: GDF “Dolce Vita” by Bruno Aveillan, 67 seconds.

5) 4/8: Metropolis by Fritz Lang (1926, 89 minutes). SIGGRAPH2003 Animation Theater Program Part 2: Gone With The Wind In Sixty Seconds by Scott Chantler, 63 seconds.

6) 4/29: Sleeper by Woody Allen (1973, 89 minutes). SIGGRAPH2003 Electronic Theater Program: After You by Christopher Cordingley, 144 seconds

7) 5/6: Gattaca by Andrew Niccol (1997, 106 minutes). SIGGRAPH2003 Electronic Theater Program: Molecular Visualization of DNA by Max Whitby, 185 seconds.

8) 5/14: The MATRIX (1999, 136 minutes) / The MATRIX 2(Reloaded) (2003, 138 minutes) / The MATRIX 3(Revolution) (2003, 128 minutes) by Larry Wachowski and Andy Wachowski. Documentaries on weekley Sci-Fi film screening.

9) 5/20: Modern Times by Charlie Chaplin (1936, 89 minutes). SIGGRAPH2003 Electronic Theater Program: Exigo by Jeni Udvardi, 220 seconds.

10) 5/27: Solaris by Andrei Tarkovsky (1972, 169 minutes) Documentary on Matrix trilogy screening.

4. EDUCATION ROBOT PROJECTS

Three robot projects at Pusan National University are introduced, which include junk robot project; bug robot interactive robot project; and rapid prototyping robot project.

4.1 Junk robot project “junkBot”

During the first semester of year 2003 at Pusan National University, we, Mechanical Engineering department at PNU, had a control engineering course to train sixty PNU junior students about engineering processes. Information on parts and fabrication procedures were provided in visual forms to the students. Except solar cells and some basic electronic parts, junk parts from computers and audios were 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 less than one (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, approximately four dollars. Junk robots operated on solar systems are artificial life forms. The PNU junkbot project as shown Fig. 1 is constantly being refined for the future use for the popularization of technology [25, 38].

Fig. 1 PNU junk robot project.

4.2 Bug robot project "bugBot"

Nature is amazing area to look for natural intelligence and intelligent beings. The most successful living organisms on Earth in terms of numbers are not humans but insects. There are about three-quarters of all classified species in the animal kingdom. They are capable of some surprisingly clever things. They have the ability to fly, navigate, and land; to identify targets, mates, and breeding areas; to survive as a species over millions of generations in a changing, unpredictable world [26, 39-43].

A biologically inspired hexapod walking robot "DongGuRi," as shown in Fig. 2, won the first prize at the 2003 PNU Bug robot competition. Also, it won the prize at the 2003 Samsung HumanTech paper contest [44, 45]. "DongGuRi" mimics the walking behaviors of a Copris ochus. This robot creeps and rolls a ball forward. To implement rolling mechanism, front paw is designed to acquire wider working range. "DongGuRi" also interacts with environments. It avoids obstacles and collision; creeps over slanted plane; and react to the sound and light.

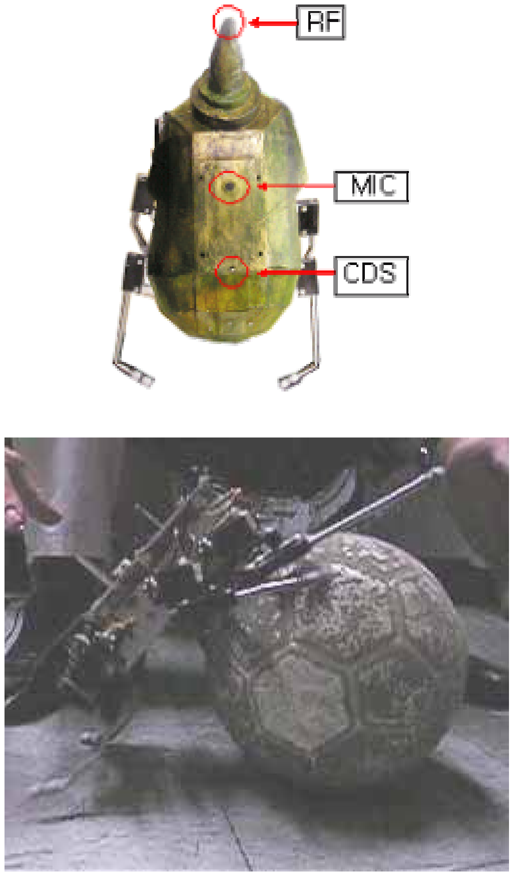

Fig. 2 A Corpris Ochus inspired hexapod walking robot.

4.3 Rapid prototyping robot project "RPbot"

We are often frustrated with the difficulties we are experiencing when we build physical robots. This complexity takes lots of excitements from robot lovers and dampens efficient research activities. Not any more. With robot platforms like LEGO Mindstorm, Khepera, Evolution Root, we can easily experiment ideas on physical robots. Recently various Braitenberg vehicles are experimented on these robots [25, 27, 46, 47].

5. RESEARCH ROBOT PROJECTS

Three cases are introduced, which include personal robotics in ubiquitous computing environment; interactive robot project; and tangible emotional robot project.

5.1 Robots in ubiquitous computing space: ubiBot

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 "ubiBot" is a shown [18, 48].

5.2 Interactive robot project: iBot

As interactive robotic cane "RoJi" evolves from interactive robot project. "RoJi" 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 [49-52].

Fig. 3 An interactive robotic cane "RoJi."

5.3 Tangible emotional robot project: itBot

Three cases are introduced, 1) a stuffed ox to interact with the audience by overall sensations: breathing, touching, and eye tracking [2, 11]; 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 [2, 5]; and 3) a sound sculpture "Schwarzwald (Black forest)," which constantly reshapes sound space by interacting with the motions of audience(s) [2, 5, 11, 14].

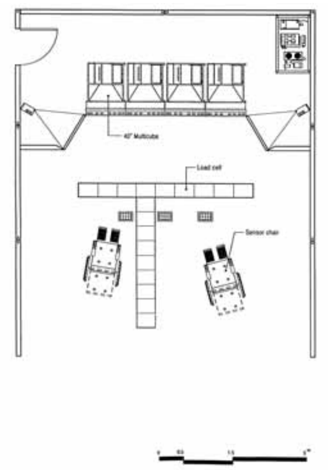

Fig. 4 A tangible space "A room with sensors."

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 [14].

6. SUMMARY

To explore soft engineering concept, various robot projects at Pusan National University conducted are presented. This is an interdisciplinary effort in investigating a new paradigm of technology. "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 have been explored to implement such engineering intents easily. Our goal is to develop robot systems capable of interacting with their environment and eventually with humans.

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