KOREA STATUS REPORT 2001

20^{th} Joint Coordinating Forum

INTERNATIONAL ADVANCED ROBOTICS PROGRAMME

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1. STATUS OVERVIEW

1.1. Introduction

This report summarizes the advanced robotics activities in Korea with a focus on research and development in government organization, academic institutes and industries. This is by no means a comprehensive list of all robotics activities in Korea but it highlights on some major national projects on advanced robotics and on some major achievements in academia and industries.

1.2. Current activity overview

Korea used to be recognized by its high installation of industrial robots and high robot density against industrial workers in manufacturing area. However as a result of economic crisis hit Korea in 1998, additional installation of manufacturing facilities sharply decrease which lead to the decrease of demand of industrial robots. Major robotic industries characterized by large size companies try either to restructure their organization or phase out marketing of industrial robot area to overcome the saturated industrial robot market in Korea.

One of the government effort to overcome the decreasing industrial robot market is to initiate national level R & D program on advanced robotics including service robot, robot in hazardous environment and micro robot. Through the government initiative R & D program, industry starts to gain interest in advanced robotics. Major industrial companies start to initiate in internal advanced research in the range from entertainment robots to house keeping robots. Small companies start to market hobby robots and utility robots.

There are a few outcomes of advanced robotics research from government sponsored research projects. Among them, rehabilitation wheel chair robot system in service robot program as well as active locomotion endoscopes micro-robot are noticeable.

This report will describe some outcomes of government initiated research projects and introduce national level planning activity on robot technology (RT).

2. Some outcomes of service robot research program

2.1 The purpose of the program

Service robot development research project is one of the "Critical Technology 21" program initiated by the Ministry of Science and Technology (MOST) started in 1999.The program is to promote selected technologies in 5 year project span. Service robot development project is to meet the marketing demands of advanced robotics in the world through the integration of information technology, robotics technology, communication technology and artificial intelligent technology. It is also to meet the needs of national welfare policy for the disabled and elderly people through providing them activity supporting system to aid their daily life using advanced robotic technology.

2.2 Scope of the program

The service robot development project consists of three sub-projects. It is formulated such that the products of the research and the core technology of the service robot are pursuit in matrix way. The first sub-project is for the development of locomotion and manipulation technology. It will be demonstrated by building helper service robot. The second sub-project is for the development of the man-robot interface technology which will be demonstrated through the development of wheel chair robot system for the disabled. The third sub-project is for the development of construction robots that can be automatically weld steel beams in high raise building. The core technology such as machine intelligence will be pursued by the first and the second sub-projects.

The building helper service robot aims to develop a multipurpose helping robot with high mobility and manipulability to guide guest, inspect leakage and fire, moving materials in the building, as well as cleaning office. For that omni-directional wheel, dexterous hands with intelligent navigation and task planning software.

The wheel chair robot aims to develop an intelligent wheel chair system with a soft robot arm that can perform different tasks to help disabled men including feeding, picking up things, pulling out books from the shelve, pounding belly to assist digestion of disabled men. The system also include eye-mouse system for the disabled person who wants to manipulate computer graphic menus using gazing point of eyes. Haptic suit is another input device for the disabled who could not manipulate joysticks to move wheel chair system. The disabled who could not use hand or arm can wear haptic suit to control wheel chair using motion of the shoulder to be translated into joystick signal through sensors in the suit.

2.3 Research phase of the project

The service robot development project started in 1998 and lasts 5 years. It goes through 3 developmental phase. The first phase of two years devoted to develop and test concepts of different service robot and technologies. First version of building helper robot and wheel chair robot was constructed at this phase. The second phase started in 2000 to develop technical functions of the service robot. It is 2 year developmental phase to develop final version of building helper robot and wheel chair robot system. The third, the final phase is one year developmental phase for pre-commercialization development. In that phase, optimization of the service robots in terms of cost and production method will be pursued. The results listed below are the outcomes of second developmental phase.

2.4 Recent research results

The building helper robot project produced simple and inexpensive omni-directional wheel mechanism which was demonstrated by tracing perfect circle without altering the direction of the robot body.

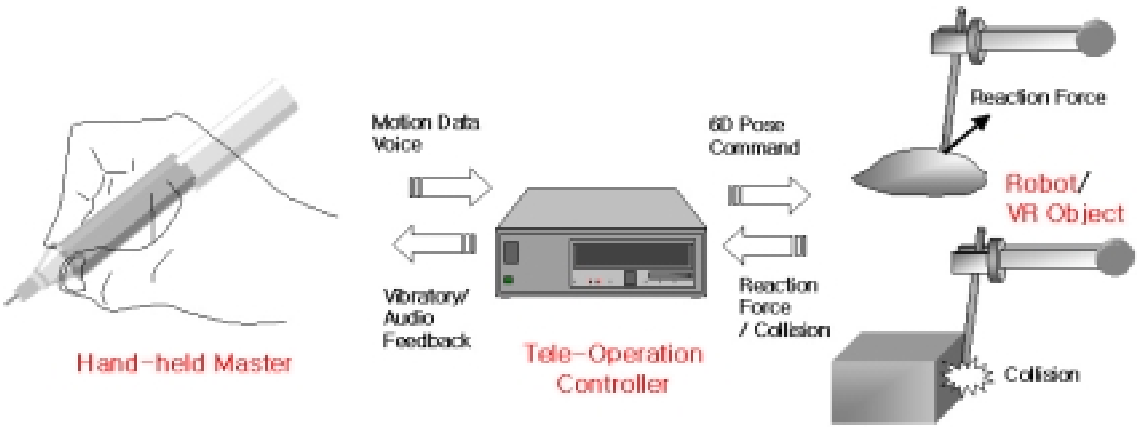
The wheel chair robot system project produced mobile base with soft arm, manipulation of soft arm using visual servoing, eye-mouse system, haptic suit and portable robot master devices.

The picture below shows a mobile base with a soft robot arm. It is a separate module to the wheel chair system which can be attached to the wheel chair to fix the position of the robot. The soft robot arm utilizes cable driven mechanism to reduce backlash. Monitoring of motor current provides means to prevent the arm from damaging person.

Eye-mouse system is a pointing device to the computer graphic menu for the disabled who could not manipulate other means of pointing devices. Eye gazing point of the patience is sensed and measured by LEDs and CCD camera either attached to the person or fixed to the monitor. Experiment shows that the disabled could be manipulate menu on the computer monitor screen with little practice.

Portable master device is an master device to the service robot. It has a pen like compact shape master that could be used in limited space. It has use in medical operation robot, rehabilitation robot, serving robot and many others. The master could achieve 6 degree of freedom control using 3 axes acceleration sensor and 3 axes gyroscopic sensor. Compactness of the master was achieved using MEMS technology.

The schematics of the master is shown below. Motion of the hand held master could be measured by the sensors and translated into 6 dimensional control commends through tele-operator controller. The control commands are send to the slave robot to perform required tasks. The reflecting forces and collision information could be translated into vibratory and audio signal and feed back to the operator to inform the operator the result of his command.



The first and second version of the portable robot master were constructed and tested. It shows the validity of the concept. However, shape optimization and signal processing need more improvement.

3. Some Outcomes of Duel-Use Technology Research Program

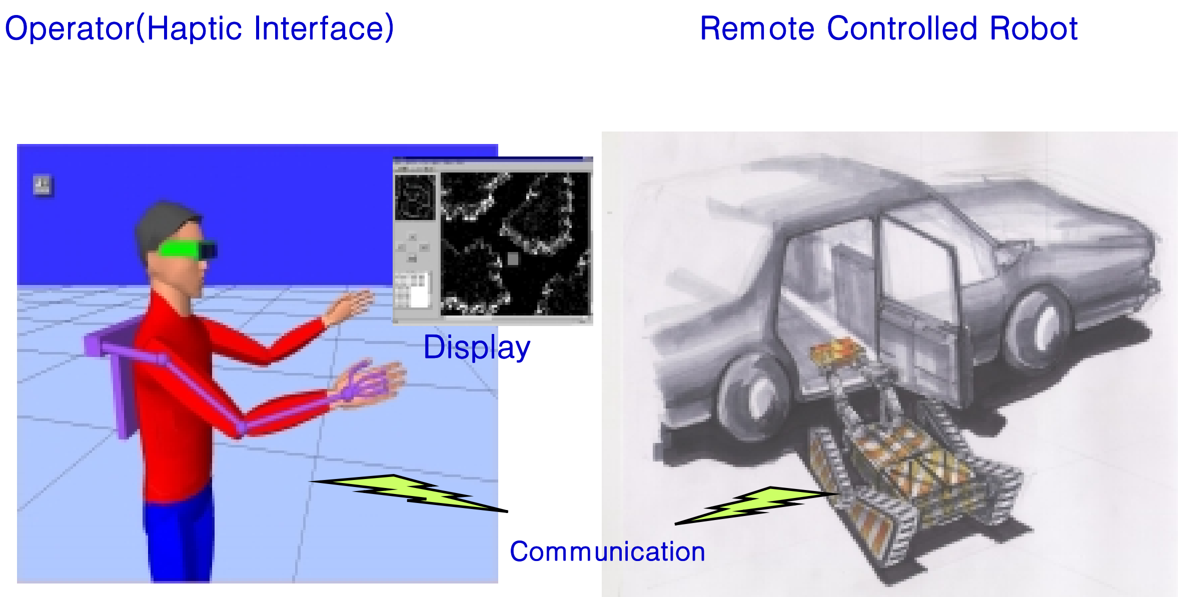
3.1 The purpose of the program

The objective of dual use technology is to develop the core technology that can not only improve the quality of industrial goods, but also enhance capability of military system. The program was initiated by joint efforts of Ministry of National Defense (MND) and Ministry of Science and Technology (MOST). Among the many projects in the program, project called "Tele-operated Robot the Removal of Dangerous Object" is the one related to robotics technology. The objective of the project is to develop a series of robotic system to remove dangerous objects such as bombs and mines in civilian as well as military environments. The operation on removing dangerous object are performed in teleoperation mode using compact and field wearable teleoperating equipment.

3.2 Scope of the program

The project aims to develop two types of robots, one for sensing and monitoring and one for removing dangerous objects. Both robots should be operable in indoor as well as outdoor. That requires function of climbing stairways and rough hilly terrain. The removal robot is equipped with two robotic arms with more than 6 degree of freedom and two fingered hands so that operator can manipulate the bomb removal procedure from the remote site with equal dexterity as he is in the bomb site. The payloads are targeted to 20 Kg for each robotic arm and 10 Kg robotic hand. The prototype of the removing robot has the size of 500 mm x 1000 mm x 700 mm and is powered by small gas engine or battery. Key technology of the project is the telepresence provide by the stereo vision with auto focus and compact wearable teleoperation master with force reflection function.

Conceptual view of the system is shown below. The bomb removal robot has two arms and two hands to manipulate the bomb with high dexterity. The robotic arms and hands are remotely controlled by the operator who wears exoskeleton type teleoperation master devices.



3.3. Research phase of the project

The teleoperated robot project has 5 year project span starting in 1999. It has two phase of the development cycle. First three years will be devoted to develop new concept and new approaches to the teleoperation and bomb removal methodology. It includes the development of first version of prototype with new concept of mobile base during the first project year, development of second version of prototype with manipulators and new navigation methodology during second and third project year. Second phase of the project starts in 2002 focused on the development of field operable prototype. For that the third and final version of the prototype will be constructed and tested.

The results listed below are the ones from second year research outputs.

3.4 Recent research results

Exoskeleton type wearable teleoperation master device is developed. One of the characteristics of the developed teleoperation master is its compactness and lightness. The device is designed so that the bulky and heavy joints are removed. Motion of the elbow and hand joints are delivered to the shoulder joints through light linkage mechanisms. Heavy motors to reproduce force reflected from the robot arms are replaced by the brakes to reduce the size, weight and unnecessary bouncing motion from feedback control instabilities.

Prototype of the wearable teleoperation master is shown above. Small brakes for force reflection are achieved utilizing hydraulic cylinder with close loop control valve.

The performance of the teleoperation master is tested using humanoid robotic arms developed previously as well as slave robot model in virtual space. It is shown that the slave robot in the virtual space behave predictably as the operator demonstrate teleoperation master in various fashion.

4. Some Outcomes of Intelligent Microsystems Research Program

4.1 The purpose of the program

The Intelligent Microsystems Program (IMP) is one of the "21st Century Frontier R & D Program" sponsored by Korea Ministry of Science and Technology (MOST). It aims to develop intelligent micro-systems integrated by emerging technologies such as nano technology, mechatronics, new materials, and optics. The intelligent micro-systems aim to spearhead high-valued industries such as micro-scaled medical appliances and micro-scaled information devices. Thus, it will help to build up national infrastructure and to join the ranks of the best 5 in the world in the relevant strategy technology by 2010.

4.2 Scope of the program

The program has two different scopes of research to pursuit. The first scope of work is to develop an endoscopic microcapsule for medical application and the second is to develop a wristwatch type micro personal digital assistant (PDA)

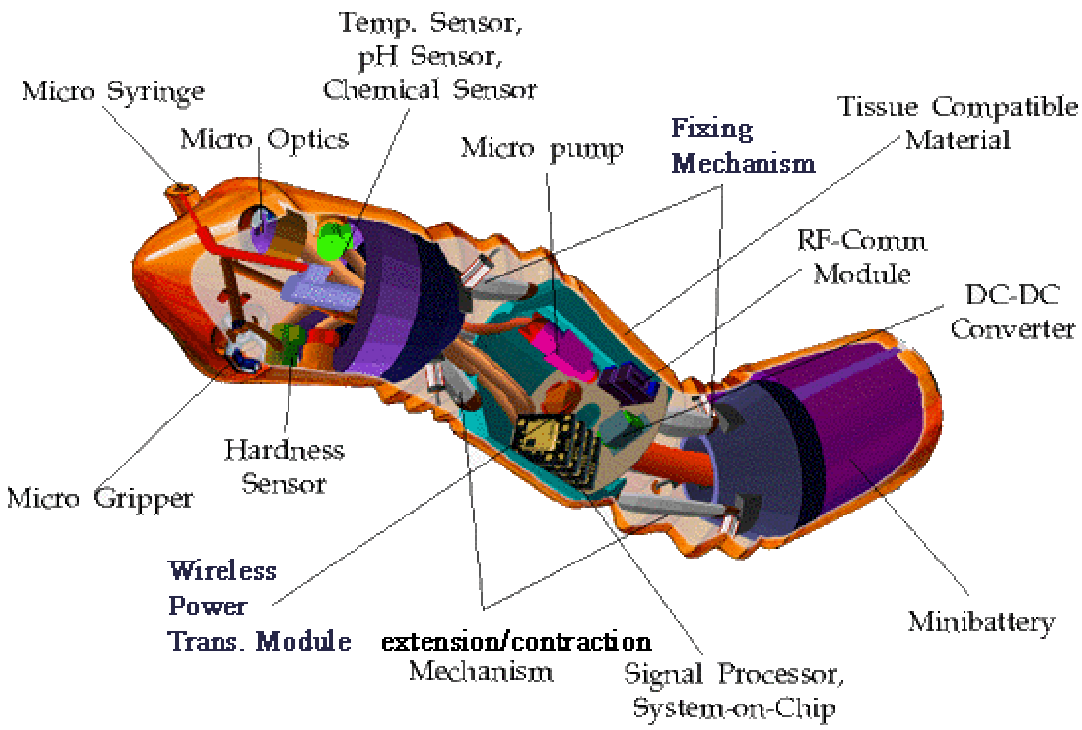
Final goal of endoscopes micro-robot is to develop a capsule-type endoscopes injected into human organs. It consists of many components for actuation, sensing, data acquisition / processing, communication and power source. The development of the endoscopes microcapsule will encourage micro-system industries as well as medical industries.

Main specifications of the endoscopes micro-robot is as follows

- Less than 10mm in diameter, less than 30mm in length
- Serial link type, modular removable type
- Human organs for inspection:
  stomach, the small and large intestine, the duodenum, womb, chest, the urinary bladder
- The medical diagnosis can be operated by in-body infrared/ ultrasonic images, temperature, bio-medical data such as pH, hardness and human internal chemical, and so on.
- Medical treatments sampling of body fluids, injection of medical drugs, cauterization, resection, removal of pneumothorax and so on.
- Movement of the microcapsule : forwarding, backwarding, pausing, fixing and rotating.

- Telemetry, tele-operation partially/autonomous control communication
- The mini battery has 2 Watts and 2 Wh (8mm in diameter and 8mm in length)

Conceptual cross-sectional view of the endoscopes micro-robot is shown below.



Operating procedures of the microcapsule is described below.

Doctors will select appropriate capsule type and assemble components needed for medical diagnosis and treatments Human organs: stomach,the esophagus, the small intestine, the large intestine, womb, the respiratory tract, the lungs

Functionality : symptom diagnosis, extraction of body samples, cauterization, drug injection, removal of pneumothorax

A patient takes a microcapsule in accordance with doctor's prescription

The microcapsule runs in the human organs

The microcapsule acquires and sends medical data, and receives commands from an operator

The microcapsule move forwards and backwards, it can pause for a medical treatment.

The microcapsule diagnose on the symptom and gives appropriate treatments, if needed.
The microcapsule runs in the human organs.
The microcapsule is eliminated from the patient's body by excretion.

Medical data are stored into a computer.

4.3. Research phase of the project

First phase of the project is 4 years from project year 1999 to year 2002. The target of the phase one aims to develop fundamental technologies associated with micro-robot and its components. It also aims to encourage commercialization of key components.

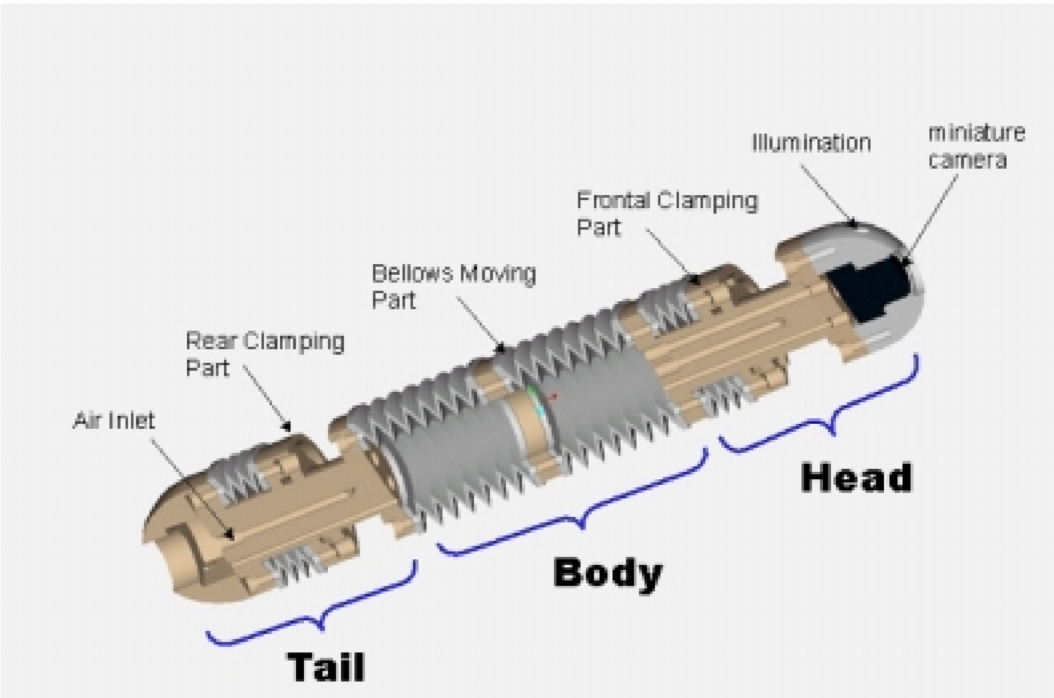
Second phase of the project is 3 years from project year 2003 to year 2005 whose target is to integrate fundamental technologies and developed components for endoscopic micro-capsule and micro-PDA

Third phase is 4 years from project year 2006 to year 2009 and aims to develop commercial version of micro-system and verify system reliability.

4.4 Recent research results

First prototype of the endoscopes micro-robot is produced in 2001. The size of the endoscopes micro-robot is 25mm in diameter and 50 mm in length. The prototype is developed by joint efforts of Intelligent Microsystems project team, Professor Dario's team of.S.S.Anna in Italy and Yonsei medical school. External view of the prototype is shown below.

In the first prototype of the endoscopes micro-robot, power supply and information transmission is through attached line. The difference between conventional endoscopes and the endoscopes micro-robot is its locomotion mode. The endoscopes micro-robot utilizes bellows mechanism for forward locomotion by contracting and expanding bellows in the main body part. Bellows are manipulated by pneumatic power as shown in the cross-sectional view of the prototype.
Attached lines will be removed in the final version of the endoscopes micro-robot so that the robot will be mobilized with self contained power and wireless communication.


Illumination
miniature camera
Frontal Clamping Part
Bellows Moving Part
Rear Clamping Part
Air Inlet
Head
Body
Tail

The performance of the endoscopes micro-robot was tested at the animal laboratory of medical school in Yonsei University with live pig as below. The endoscopes micro-robot is inserted from the rear into the large intestine of the pig internal. The purpose of the experiment is to test the active locomotion performance as well as the quality of the camera image of the internal organ. Results show that the prototype is well performed in locomotion and in sending clear images of internal organs. However the prototype needs a lot of improvement in reducing the size and smooth an safe locomotion mechanisms.

5. National Level Planning Effort for Robotic Technology (RT)

5.1. Background

Five critical technology area are identified as the technology area to be focused with national level efforts. Those are IT(Information Technology), BT(Bio-Technology), NT(Nano-Technology), ET(Energy Technology) and CT(Cultural Technology). Those technological area has been promoted by individual ministerial level without inter-ministerial cooperation. As the importance of those technology area increases, consensus has been made to coordinate the development strategy as well as financial resources to increase the efficiency of technological development. National level plans of those technological development have been made through the cooperation of the related ministries and field experts to be presented and formalized by the Presidential Council of Science and Technology (PCST) chaired by the president and consisted of Ministers and civilian experts. Ministry of Science and Technology (MOST) as well as robotics engineers reach a conclusion that Robot technology(RT) as one of the critical technology for economic development and human welfares should be included in the national level technology development plan with those 5 critical technology. MOST initiated an national level planning effort for robotics technology by organizing field experts in robotics area.

International Advisory Committee consisted of robotics experts in the world is formed to give assistance to the planning committee. The first international advisory committee meeting was held in May along with ICRA 2001 in Seoul.

5.2 Technology Roadmap

The RT planning and promotion committee is chaired by Dr. Sukhan Lee of Samsung Advanced Institute of Technology (SAIT). Some 40 experts take charge of the individual technology sections. Among the wide variety of products and wide spectrum of technology, the following area are identified to focus the efforts and increase the impact of national level robotics technology impacts.

■ Market pulling products

- Industrial Automation

- Automated Factory and customized manufacturing
- Automation of Industries under Unstructured Environments such as Agriculture, Construction

- Service to Human
  - Medical and Welfare Robotics
  - Entertainment and Personal Robotics
  - Robots in Hazardous Environments

- Intelligent System Integrated with Information Infrastructure
  - Intelligent Appliance, Home, Office and Building
  - Intelligent Machines, Vehicles and Transportation System

- Connection to Nano and Bio World
  - Micro and Nano Robotics
  - Bio Mimetics and Bio Automation

■ Technology Push

- Design
  - Mechanisms
  - Control

- Components
  - Sensing and Actuation
  - Interface and Electtronics

- Intelligence
  - Perception
  - Planning Decision-Making

- Human-Robot Interface
  - Programming
  - Man-Machine system

- System

- ♦ Real-time Processing
- ♦ System Integration

- Social and Economic Implications

Experts in individual products and technology sectors are asked to construct product-technology roadmaps. Those roadmaps are examined and evaluated by the committee to prioritize the importance of technology section and integrated with national technology promotion policy.

As the planning is scheduled to be formulated in first draft in the middle of October, public hearing is scheduled to be held at the same time. Revised version with the feedback from the hearing will be finalized at the RT planning and promotion committee and reported to the Presidential Council of Science and Technology scheduled in December.

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