Contents

President's Message

Dear partners,

Welcome to Korea Institute of Medical Microrobotics[**KIMIRo**] & Robot Research Initiative[**RRI**].

RRI was established as an affiliated organization of Chonnam National University in March 2008 with the target of advanced research and bringing up of professional resources on medical microrobotics. Based on diversified research spectrum, Medical Microrobot Center was established in 2016 with the purpose of R&D on medical microrobotics and support of related space/facility/equipments.

In the beginning of 2019, research foundation "Korea Institute of Medical Microrobotics[**KIMIRo**]" was founded.
The major functions of KIMIRo are as followings :
- Professional research on medical microrobotics
- Clinical GMP based prototyping for industry
- Cooperation among industry-academia-institute-hospital-government on medical microrobotics

We are pursuing 'Global Leader in Medical Microrobotics' and based on it simultaneously establishment of medical microrobot industry complex.

We wish to be your precious partner with your valuable comments in promising emerging field in 21C.

Thank you.

Jong-Oh Park,

President, Professor, Dr.-Ing.

History

2019. 01. 29	Opening of Korea Institute of Medical Microrobotics
2017. 05. 17	Announcement of Stem cell-based Microrobot world first
2017. 04. 11	Medical Microrobot Industry Forum at National Assembly
2017. 03. 24	Foundation of "The second Council of Medical Microrobot Industry"
2016. 10. 19	Opening Ceremony of 'Medical Microrobot Center'
2016. 07. 27	Announcement of Immune-cell based Microrobot world first
2015. 03. 31	Technology transfer of 'Active Capsule Endoscope' to Wooyoung Medical
2014. 04. 07	MOU on mutual cooperation with Daewoo Shipbuilding & Marine Engineering, Korea
2013. 12. 18	Announcement of In-vivo Test of Bacteriobot as the world first Biomedical Nanorobot
2013. 06. 07	Cooperation Agreement with Fraunhofer-Gesellschaft and Fraunhofer-IPA, Germany
2013. 06. 07	Opening of "Joint Robotics Lab of CNU RRI in collaboration with Fraunhofer IPA"
2012. 05. 09	MOU on mutual cooperation with MRSEC of Brandeis University, USA
2011. 06. 21	MOU on mutual cooperation with Fondazione Istituto Italiano di Tecnologia(IIT), Italy
2011. 03. 02	MOU on mutual cooperation with Center for Micro-Nano Mechatronics, Nagoya University(CMM), Japan
2010. 06. 03	Opening of 'Pioneer Research Center on Bacteriobot'
2010. 05. 13	Announcement of In-vivo Test of Intravascular Therapeutic Microrobot to the Public world first
2010. 01. 29	MOU on mutual cooperation with Fukuda Lab in Nagoya Univ. Japan
2008. 10. 21	MOU on mutual cooperation with Sitti Lab in Carnegie Mellon Univ. USA
2008. 10. 20	MOU on mutual cooperation with Biorobotics Institute in Scuola Superiore Sant`Anna, Italy
2008. 10. 15	RRI hosted "The 39th International Symposium on Robotics"
2008. 06. 04	RRI was selected as CNU-XRC by Chonnam National University
2008. 04. 23	Prof.Dr.-Ing. Jong-oh Park was nominated as the Founding Director of RRI

Vision

Quality

Microrobotics Research

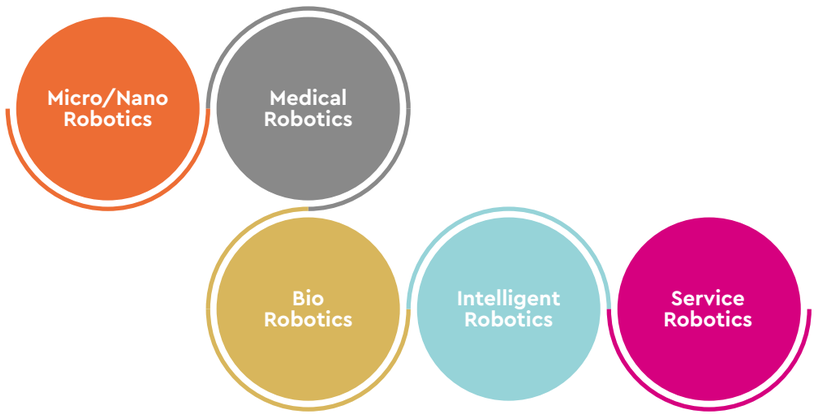
Domestic Top1 / Global Top 3

Scale

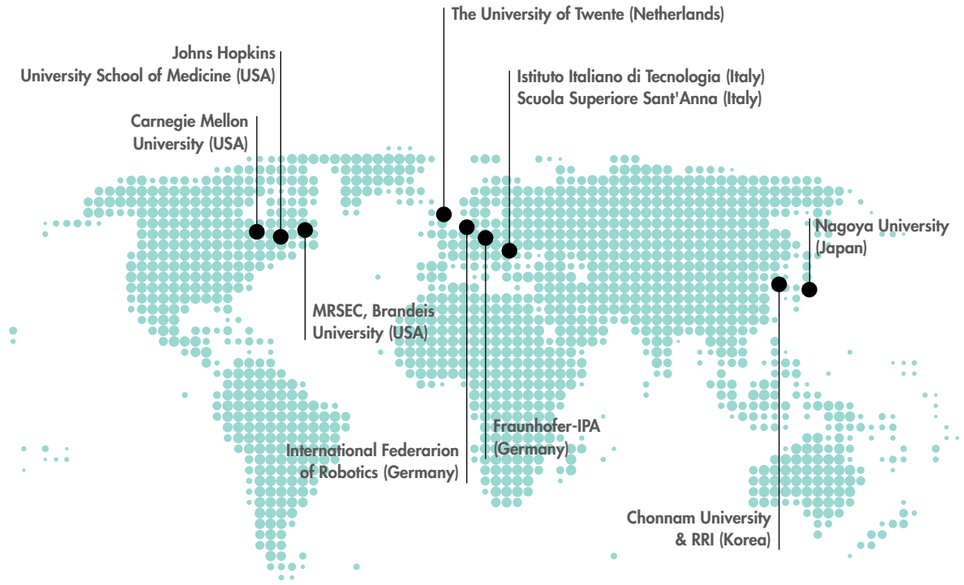
Robot Institute in University

Domestic Top 1

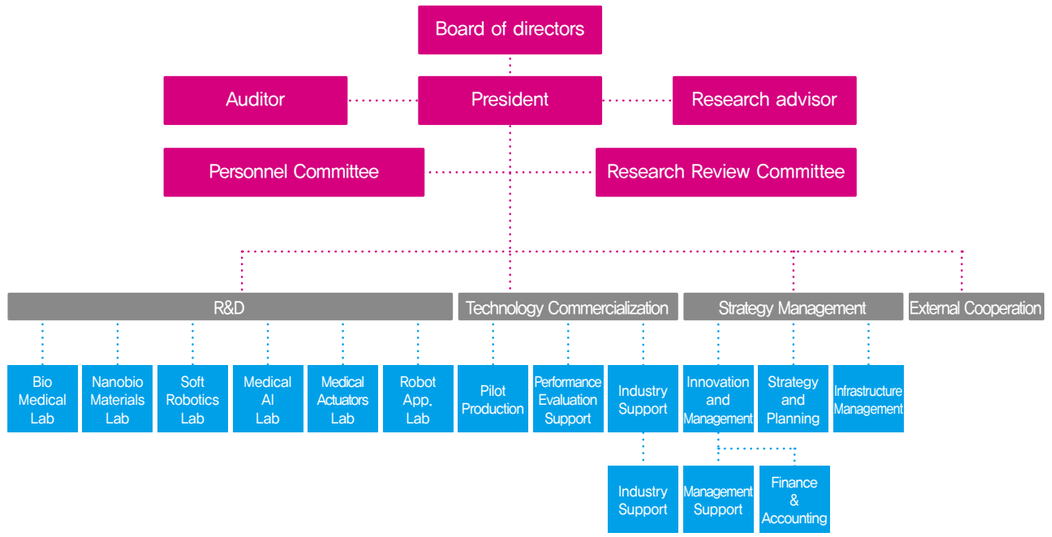
R&D Focus



Global Research Network



Organization



Funding Source

Title	Period	Budget(M$)	Sponsor	Achievements
Intelligent Microsystem Program (21C Frontier Program)	1999 – 2004	32	Ministry of Science	Colonoscope robot Capsule endoscope Micro PDA
Development of Intravascular Microrobot	2007 – 2014	13	Ministry of Industry	Microrobot in artery
Development of Image-guided Surgery Robot	2008 – 2013	2.5	Ministry of Industry	Brain surgery robot
Pioneer Research Center "Bacteriobot"	2009 – 2015	6.0	Ministry of Science	Bacteriobot
Nuclear Energy Research Infrastructure Program (KIRAMS)	2011 – 2016	0.4	Ministry of Science	Couch robot for heavy ion therapy
Industrial Strategic Tech. Development Program (HHI)	2012 – 2017	1.3	Ministry of Industry	Hybrid control for bone-fracture reduction robot
Leading Foreign Research Institutes Recruitment Program	2012 – 2018	6.0	Ministry of Science	Joint Robotics Lab of CNU in collaboration with Fraunhofer IPA Cable robotics
Establishment of Medical Microrobot Center	2013 – 2018	34	Ministry of Industry	Headquarter of medical microrobot industry
Next-generation Medical Device Development Program	2015 – 2018	1.8	Ministry of Science	Active capsule endoscope
Industrial Technology Innovation Program	2015 – 2020	4.5	Ministry of Industry	Locomotion and targeting of medical nanorobotics
Biomedical Technology Innovation Program	2016 – 2022	2.4	Ministry of Science	Stem-cell based microrobot for precise targeting
R&D Center for Practical Medical Microrobot Platform	2019 – 2022	22.9	Ministry of Health and welfare	

Medical Micro / Nano Robotics

From cm up to nm scale
from integrated system up to cell

... toward Miniaturization of Medical Robots

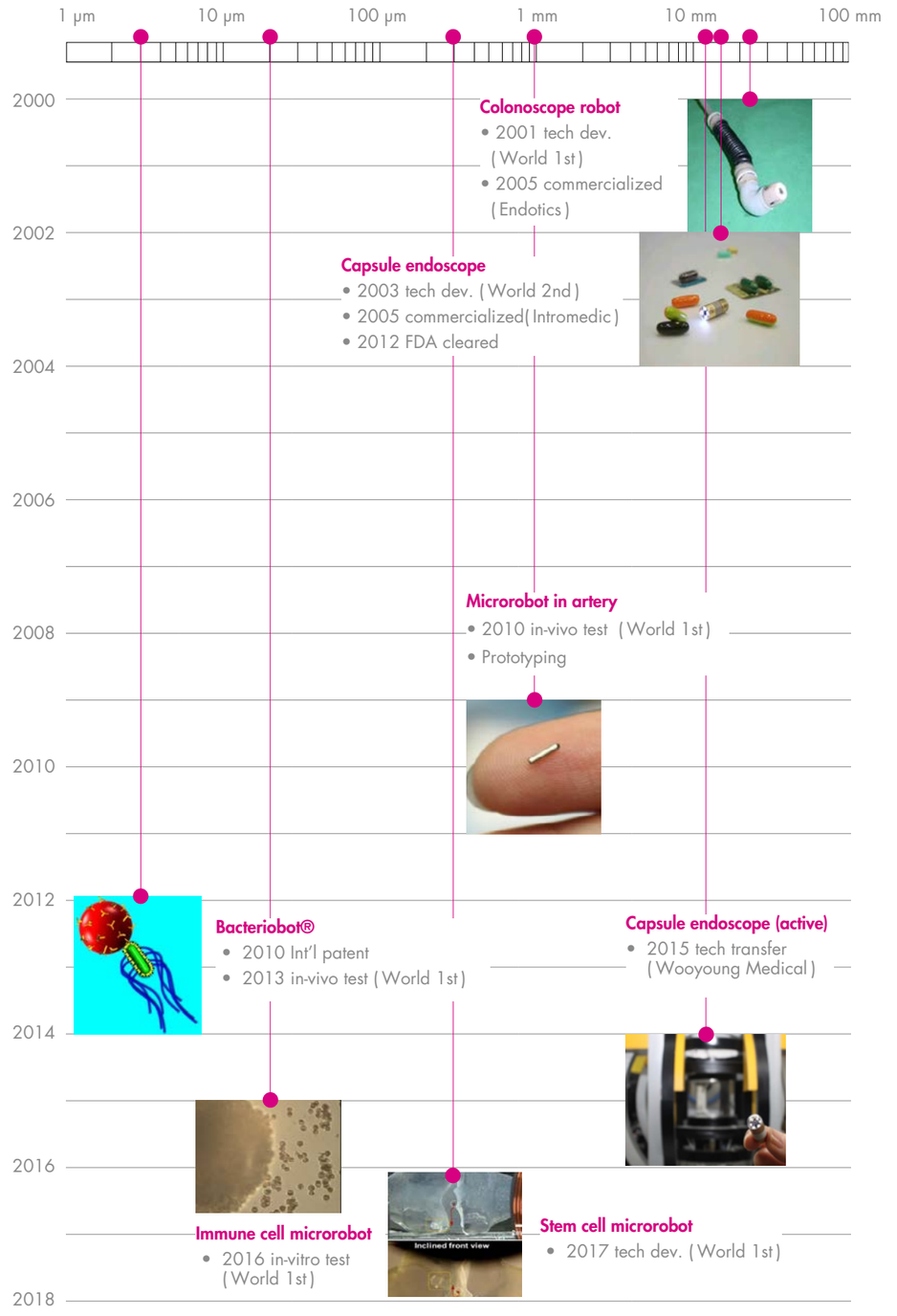
- 21C is the era of Genetics, Nanotechnology and Robotics
- Micro/Nano Robotics = Genetics + Nanotechnology + Robotics
- Human body is characterized as Nanobio Cluster
- Reference model in different robot size

Robot Size	Reference Model
m - scale	Human/Animal
cm - scale	Insect
less than 1mm	Bacteria
less than 1 μm	Virus

"Intelligent Microsystem Program" as one of the 21C Frontier R&D programs has been the momentum to develop the microrobots, for instance, colonoscope robot as well as capsule endoscope robot since the beginning of 2000, where RRI staff played the leading role in this challenging program at KIST. On the base of successful results and experiences, further researches have been initiated, such as Intravascular microrobot, active capsule endoscope and cell-based micro/nanorobot including bacteriobot, immune cell-based microrobot, and stem cell-based microrobot and so on.

KIMIRo / RRI Competence in Micro / Nano Robotics

Medical
Micro / Nano
Robotics



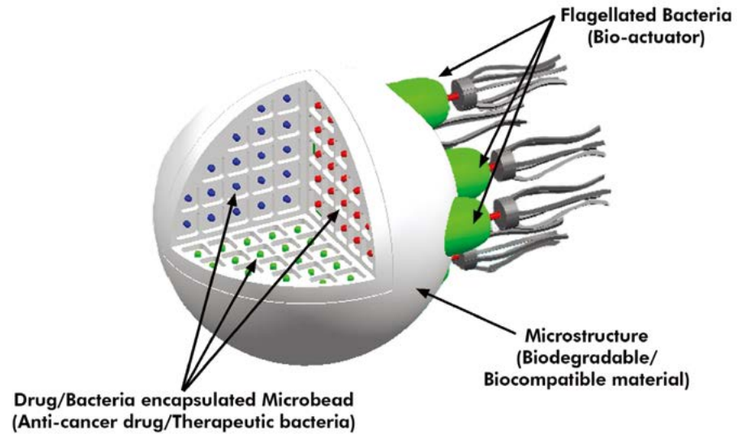
nm robot :
Bacteria-based Biomedical Nanorobot

[Int. Patent registered in 2013]

Technical Overview

Development of the intelligent theragnostic bacteria-based biomedical nanorobot technology for fusion of the fundamental technology and acquirement of the fundamental patent

Bacteriobot speed	100 μm/min
Bacteriobot size	3 μm
Target disease	Solid tumor (Colon cancer, Breast cancer)

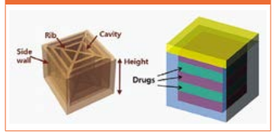


Bacteria	Microstructure	Bacteriobot
Active locomotion	μ chamber/channel	Active locomotion
Specific cell binding	Biodegradable materials	Specific cell binding
Fluorescence	Surface modification	Fluorescence
Gene modification		Gene modification
Self replication		Self replication
Extinction by macrophage	Long termed control not available	μ chamber/channel
Locomotion uncontrollable	Large volume transport impossible	Biodegradable materials
		Surface modification

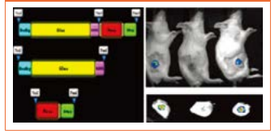
Medical
Micro / Nano
Robotics

Research Topics

Bacteria Enzyme Controlled Drug Delivery System



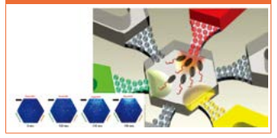
Strain for Bateriobot



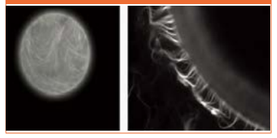
Tumor Targeting Bacteriobot

Tumor Specific Active Drug Delivery

Modelling/Analysis of Bateria Chemotaxis



Swimming Microrobot using Synthetic Flagella/Cilia



Achievement

- New microrobot paradigm
  - Bacteria act as microactuators/microsensors
- New fundamental methodology using biomedical microrobot
  - Diagnosis and therapy of solid tumors

Application Area

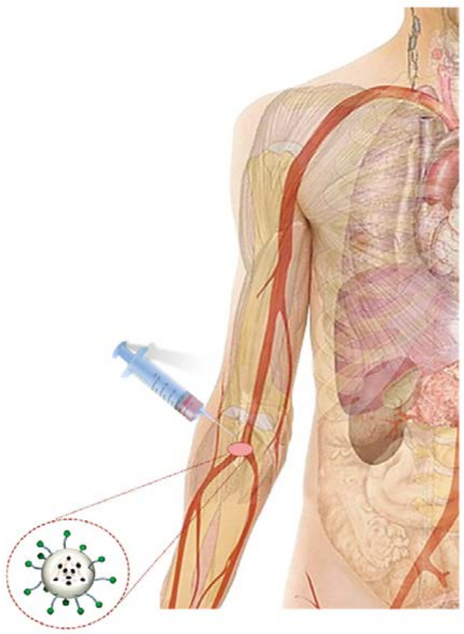
- New biological actuator of biomedical microrobot
- Active DDS (Overcome the toxicity and drug resistance)
- Affordable medical equipment (Diagnosis and therapy at the same time)

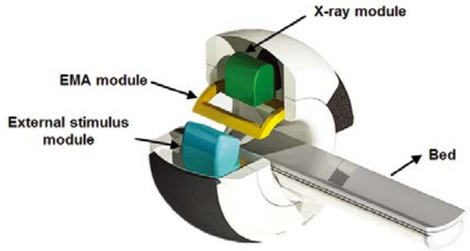
nm robot :
Nanorobot for Precise Targeting and Controlled Releasing of Drugs

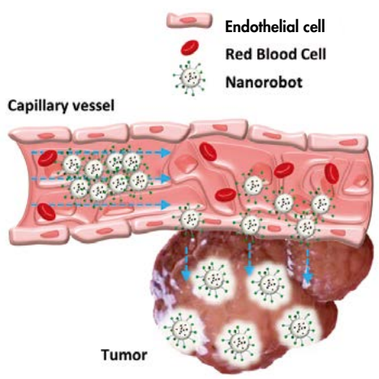
Technical Overview

Polymer-based nanorobots which are loaded with anticancer drugs actively transfer to solid tumors (liver cancers) and give high targeting performance, and drug release is triggered by remote stimulation around cancer cells.

Size	100 nm (single part)
Accuracy of migration	< ±1°
Performance of drug loading	> 86 %
Releasing amount of active drug	> 8 %/min
Disease	Solid tumor (Liver cancer)



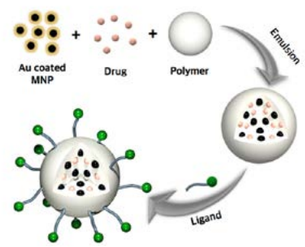




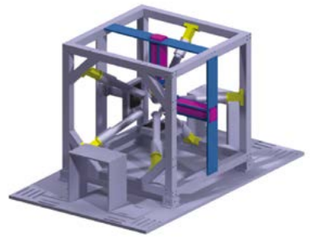
Medical
Micro/Nano
Robotics

Research Topics

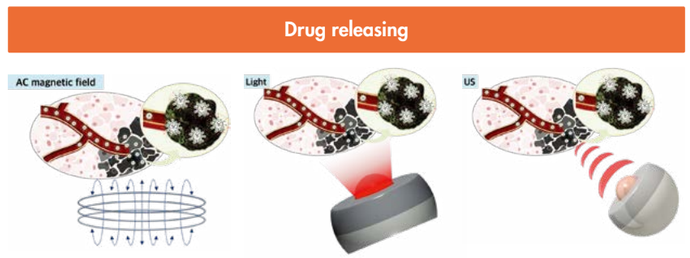
Nanorobot development



Actuator development



Drug releasing



Medical verification

Achievement

- The first national project in 'Nanorobotics' field
- The world's smallest medical remote controlled robot

Application Area

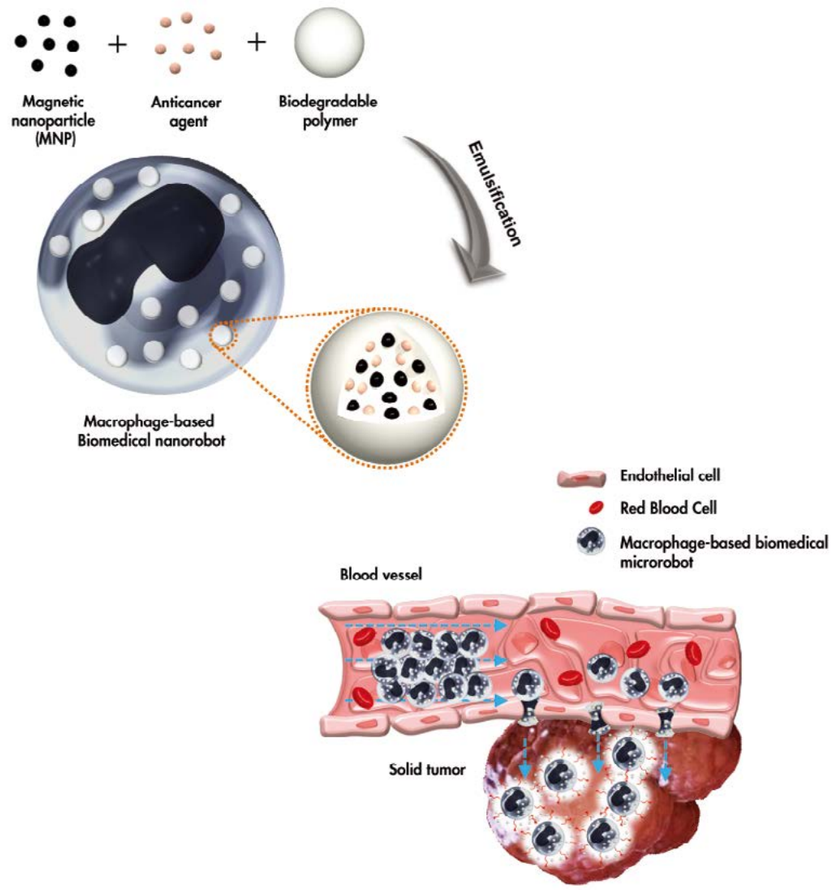
- Combined therapy: Photodynamic or high intensity focused ultrasound therapy with enhanced permeability and retention effect for chemical therapy
- Active DDS (Overcome toxicity and drug resistance)
- Nanomedicine – the medical application of nanotechnology

μm robot : Macrophage-based Biomedical Microrobot

Technical Overview

Development of active transportable and cancer theragnostic macrophage-based microrobot technology for advanced and synergetic immune therapy for incurable disease

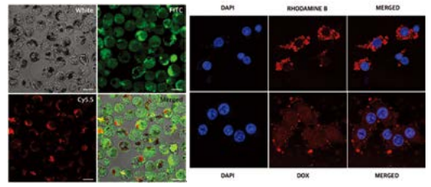
Microrobot speed	40 μm/sec
Microrobot size	10 ~ 20 μm
Target disease	Solid tumor (Colon cancer, Breast cancer)



Medical
Micro/Nano
Robotics

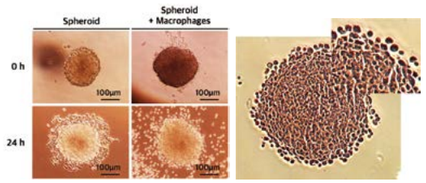
Research Topics

Bio Technology



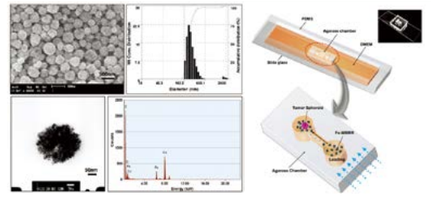
- Manipulation of immune cells
- Fabrication of cell-based robot
- Live cell imaging

Medical Technology



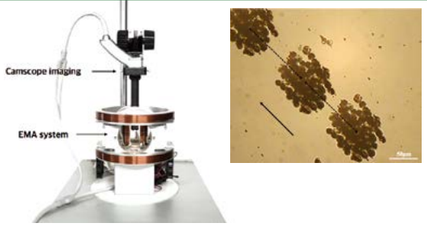
- Tumor mimic environment
- In-vitro tumor therapy
- In-vivo tumor therapy

Micro/nano Technology



- Biocompatible nanoparticles
- Nanostructure for Drug delivery
- Microfluidic Channel

Robot Technology



- Electromagnetic actuation system
- External cellular actuation
- Control of moving direction

Achievement

- The world's first immune cell-based medical microrobot
  - Hybrid actuating and Active therapy by immune cell
- Advanced therapeutical method for cancer
  - Chemotherapy & Immunotherapy

Application Area

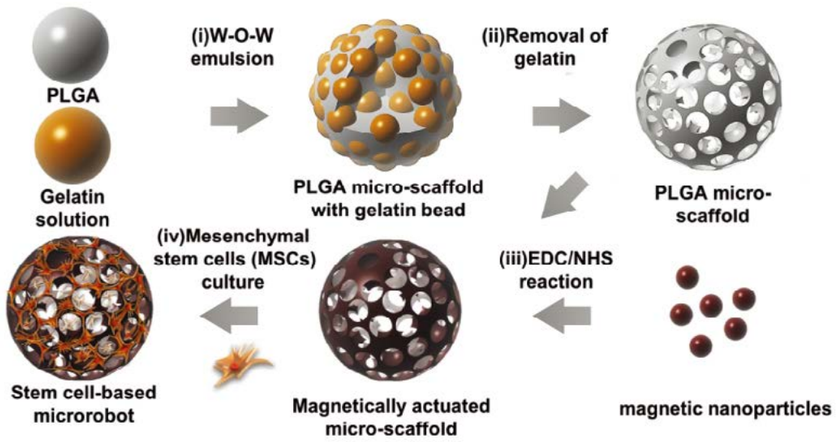
- Evolved cell-based biomedical microrobot
- New Express DDS (Quick & Precise drug delivery)
- Complex DDS (Immunity and synthetic drug)
- Trojan horse method for attacking incurable diseases

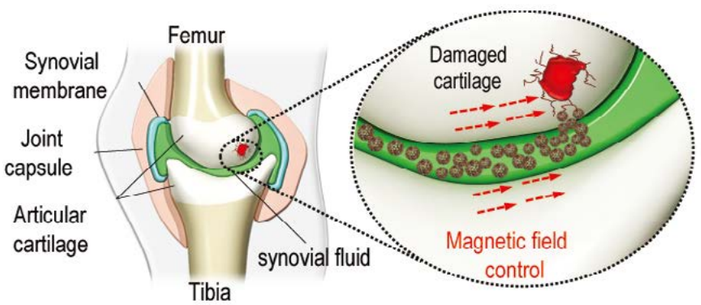
µm robot :
Stem Cell-based
Biomedical Microrobot

Technical Overview

Development of magnetic actuating stem cell-based microrobot technology for convergence of BT, NT, RT and mesenchymal stem cell (MSC) delivery for articular cartilage regeneration

Microrobot speed	40 µm/sec
Microrobot size	300 ~ 800 µm
Target disease	Osteoarthritis

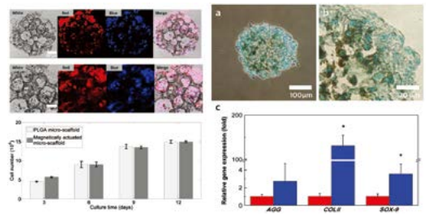




Medical
Micro/Nano
Robotics

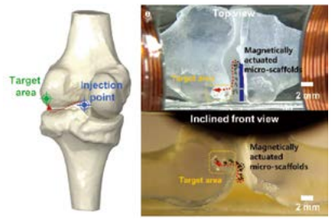
Research Topics

Bio Technology



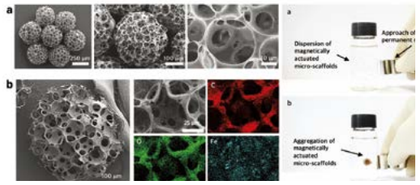
- Cultivation of stem cells
- Differentiation of stem cells
- Molecular biology of stem cells

Medical Technology



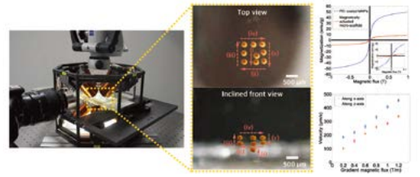
- Articular cartilage mimic environment
- In-vitro cartilage regeneration assay
- In-vivo cartilage regeneration assay

Micro/nano Technology



- Biodegradable polymer scaffolds
- Biocompatible magnetic particles
- Magnetically actuated scaffolds

Robot Technology



- Electromagnetic actuation system
- Magnetic actuation of scaffolds
- Control of moving direction

Achievement

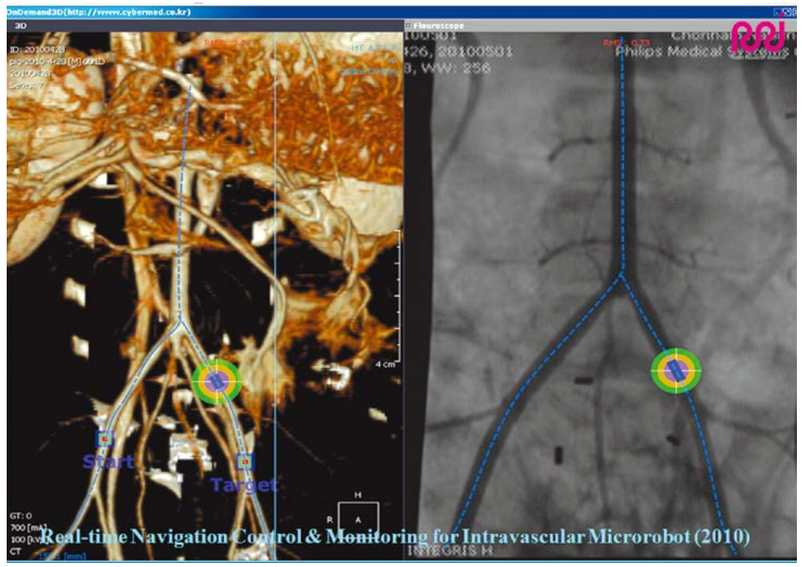
- Active and targeted stem cell delivery for cartilage regeneration
  - Quick and precise location controlling of stem cells
- Advanced therapeutical method for articular cartilage repair
  - Mass fresh stem cells and optimized differentiation

Application Area

- Stem cell-based biomedical microrobots for incurable diseases and joints
- New Express stem cell delivery (Quick & precise stem cell delivery)
- Complex cell delivery system (stem cells and drugs)

µm robot :
Intravascular Therapeutic Microrobot

[World 1st Success in In-vivo Test, 2010]

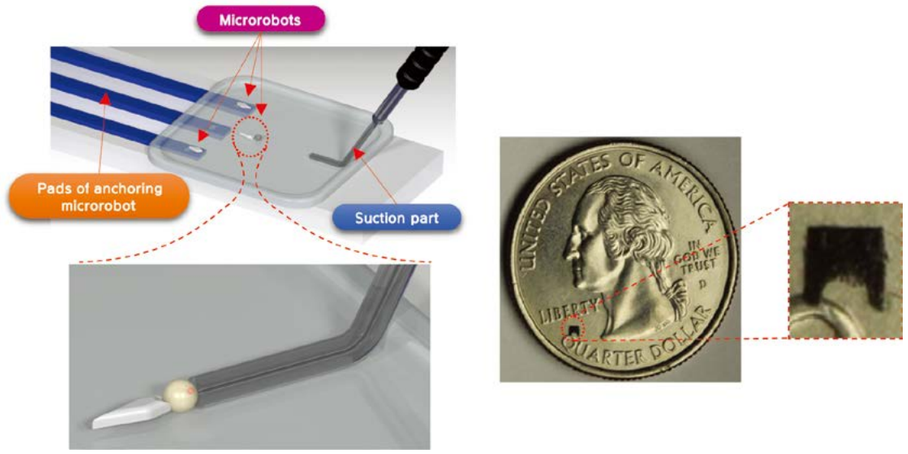


µm robot :
Microrobot
for Cell Manipulation

Technical Overview

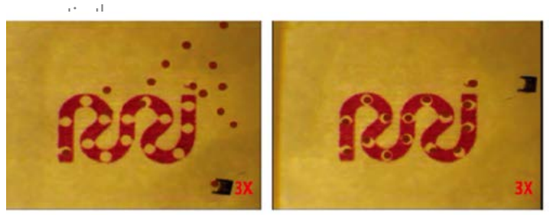
Cell manipulation using electromagnetic actuated microrobot such as cell sorting, dead cell removal, and cell assembly

Size	1000 µm width, 1000 µm length, 50 µm height
Fabrication method	Micro-molding technique
Material	Mixture using permanent magnet powder
Function	Cell or micro-particle assembly, sorting cell



Application Area

- Cell manipulation such as cell sorting, dead cell removal, and cell assembly
- In High skilled work, like ICSI (Intracytoplasmic Sperm Injection), pronucleus DNA injection,



Initial state Final state

mm robot :
Robotic Catheter System

Technical Overview

Robotic micro-catheter system for drug/stent delivery and treatment of coronary artery disease such as chronic total occlusion and thrombosis

Size	2.4Fr (0.8 mm) or less
DOF	4 DOF or over
Steering Accuracy	below 1.0°
Steering Method	Electromagnetic field

Active steerable micro-catheter

Control platform

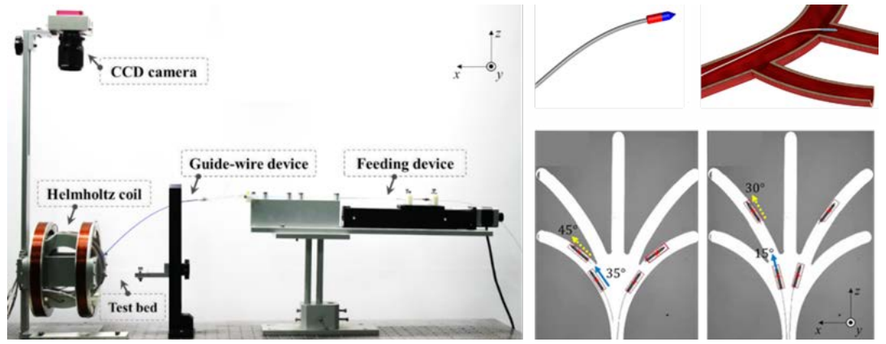
Electromagnetic actuation system

Imaging Platform

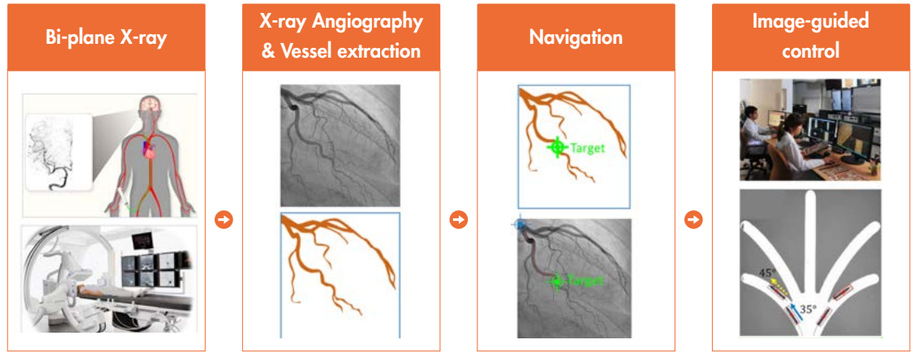
Medical
Micro/Nano
Robotics

Research Topics

- Steering mechanism and control of micro-catheter



- Imaging system & navigation S/W



- Medical treatment & clinical validation

Application Area

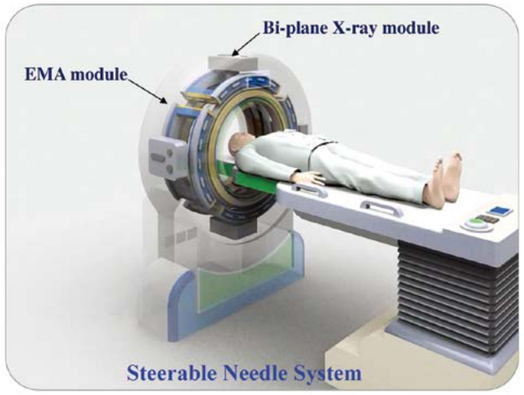
- Drug/stent delivery, Diagnosis and treatment for coronary artery disease
- Disease in spine, brain and liver

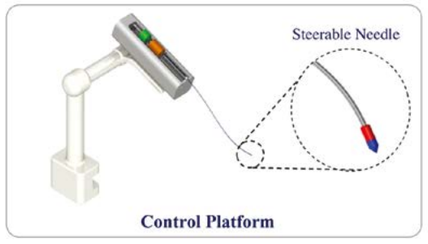
mm robot :
Steerable Needle System

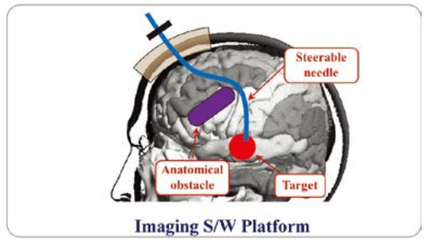
Technical Overview

Steerable needle system improves patient care for a variety of diagnostic and therapeutic medical procedures. Steerable needle tip can be precisely reached to a lesion while avoiding complex-shaped risk areas such as a nerve and a blood vessel.

Size	19 G (1mm) or less
DOF	4 DOF or over
Steering Accuracy	below 1.0°
Steering Method	Electromagnetic field

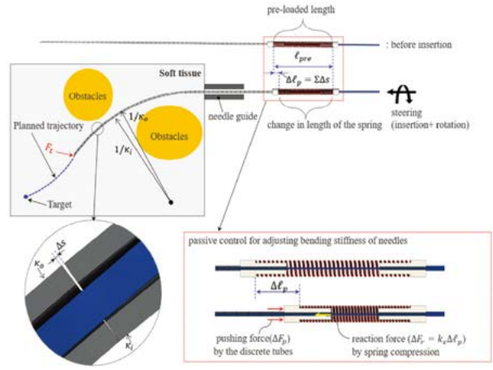


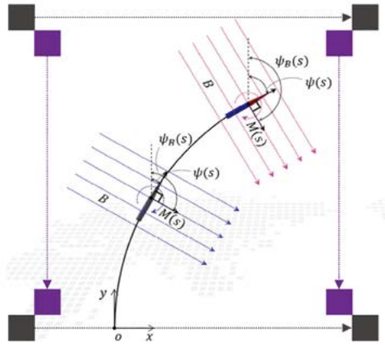




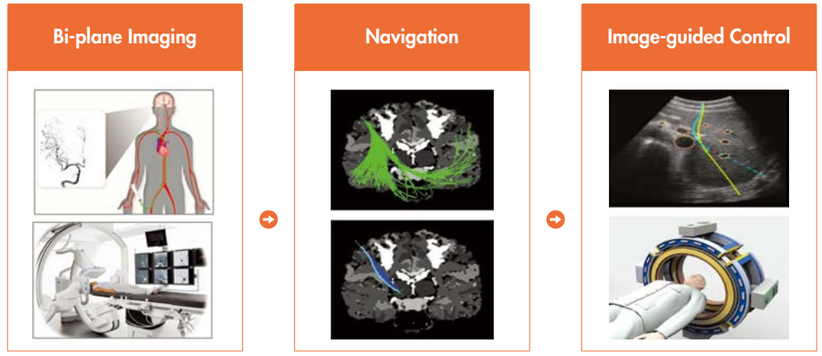
Research Topics

- Steerable needle mechanism and electromagnetic control





- Imaging system & navigation S/W



- Medical treatment & clinical validation

Application Area

- Deep brain stimulation, tissue biopsies, tumor ablation, and cancer treatments
- Disease in the brain, liver, lung, abdominal and pelvic cavity

mm robot :
Capsule Endoscope robot "MiRO"

World 2nd Success in Development & Commercialization, 2003 / 2005

IntroMedic
Capsule Endoscope

Medical
Micro/Nano
Robotics

cm robot :
Colonoscope Robot

World 1st Success in Cadaver Test & Commercialization, 2001 / 2005

Endotics

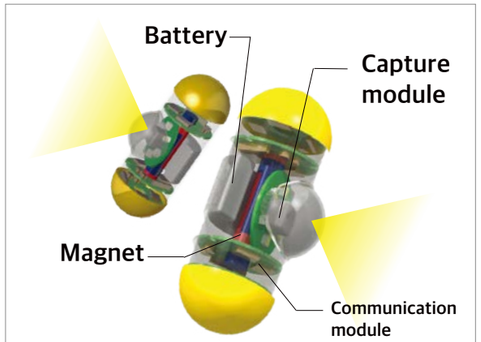
mm robot : ALICE

(Active Locomotive Intestinal Capsule Endoscope)

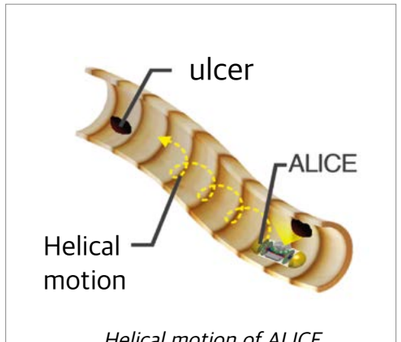
Technical Overview

Capsule endoscope (C.E.) movement through the digestive organ for diagnosis of diseases

Existing C.E.	Contents	Active C.E.
Passive locomotion by peristaltic motion	**Diagnosis**	Active locomotion by medical personnel
12 ~ 24 hours	**required time**	10 ~ 20 min
Small intestine	**Organs**	Whole digestive organs
Image capture	**Function**	Image Capture, Biopsy, Tattooing, Maneuvering



ALICE



Helical motion of ALICE

H/W Platform

Position display

Research Topics

Bio Technology

- Treatment of biopsy sample
- Bio-compatible material
- Bio-reagent for diagnosis

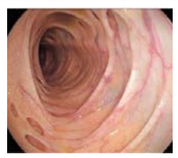
Medical Technology

- Diagnosis of digestive organ
- Micro medical device
- Development of medical device

Micro/Nano Technology

- Medical Micro/Nano Device
- Biopsy Tool, Drug Delivery Tool
- Micro/Nano Fabrication

Info & Com Tech.



- Image processing
- Data transferring and communication
- Analysis for maneuvering and diagnosis

Robot Technology

- Electromagnetic actuation System
- Localization and posture awareness
- Control of position and posture

Application Area

- Diagnosis and treatment for diseases of digestive organs
- Cancer, polyps, bleeding, ulcer

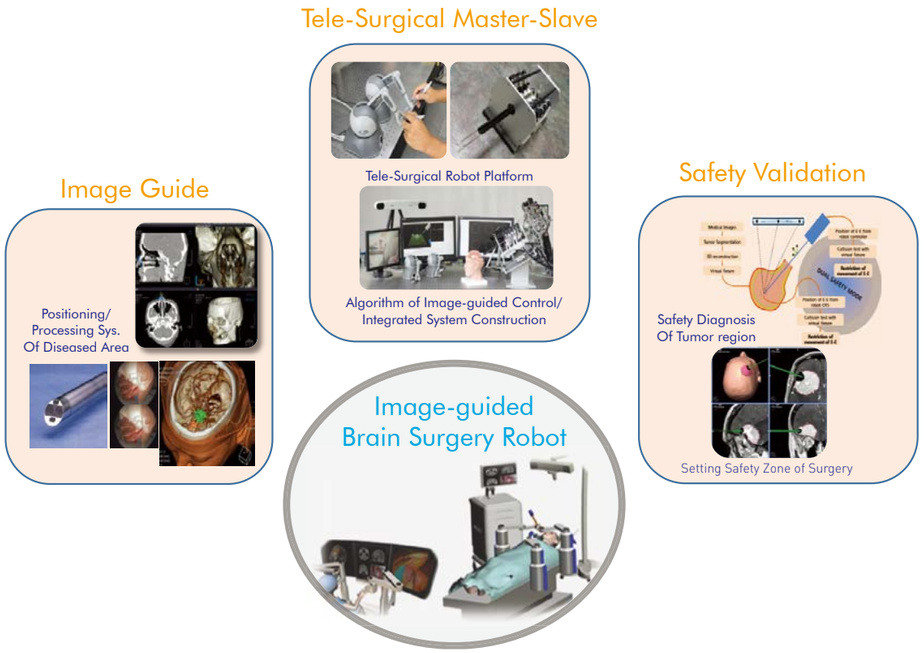
Medical Robotics

Highest value-added surgery robotics using AI, VR/AR, sensor and modeling

Image-guided Brain Surgery Robot

Technical Overview

- Multi-articulated manipulator for single-port brain surgery
- Master and slave system with force reflection control to overcome the limitation of operating range of instruments
- Image-guided surgery robot system using 3D reconstruction, vision and AR(Augmented Reality)



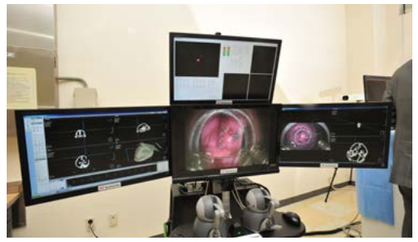
	1st	2nd	3rd
Manipulator (slave)			
Input device (master)			

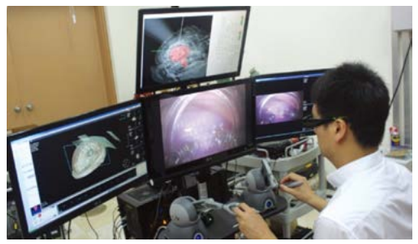
Research Topics

2EA End-effectors /
3D Stereo-endoscope

Single-port Robotic Manipulator System

Application Area





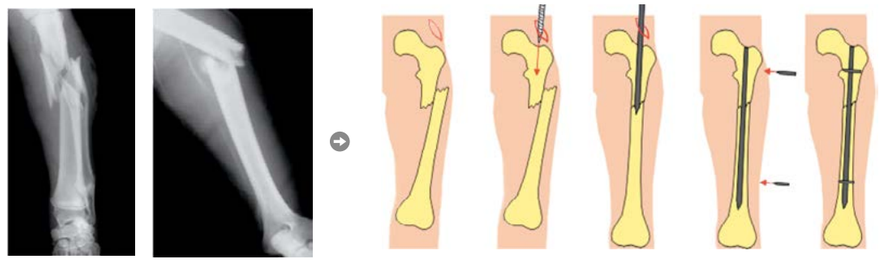
- The endoscopic endonasal approach to skull base surgery
  (General Surgery, Neurosurgery, Otolaryngology)
- Surgical procedures that require microsurgery and robotic surgery
- Elaborate surgery by image-guided surgery

Interactive & Remote Control for Bone-fracture Reduction Robot

(Principal Investigator : Hyundai Heavy Industry)

Technical Overview

Modern orthopedic surgical operation is actively attempting to employ invisible operations to minimize incision. The main difficulties in this surgery are radiation exposure and heavy load to align. This project suggests a robotic assistant and a navigation system. The robot-assisted surgical system will contribute to increasing the accuracy of surgery.



- **Next generation remote control (Hybrid control)**
- **Required technologies**
  - Tele-operation
  - Interactive / Remote mode control
  - Virtual Reality / Augmented Reality
  - Force Reflection
  - Haptics / Master part design
  - Navigation System Integration
  - 2D/3D Registration

Research Topics

Interaction between surgeon and robot is applicable in two modes: interactive control mode and remote control mode [robot(HHI), Jig(KPU Hospital)]

Interactive control

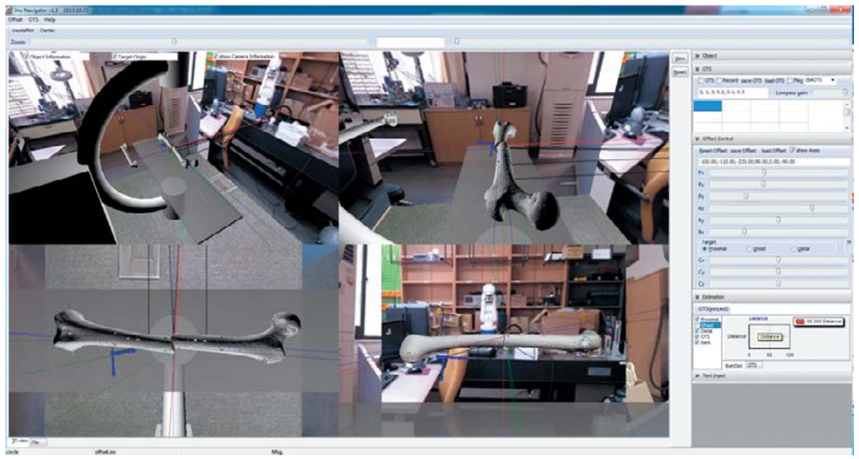
Interactive mode allows a surgeon to operate the robot motion directly without significant load

Remote control

Surgeons can control the robot motion through remote mode over the lead glass wall

Navigation system

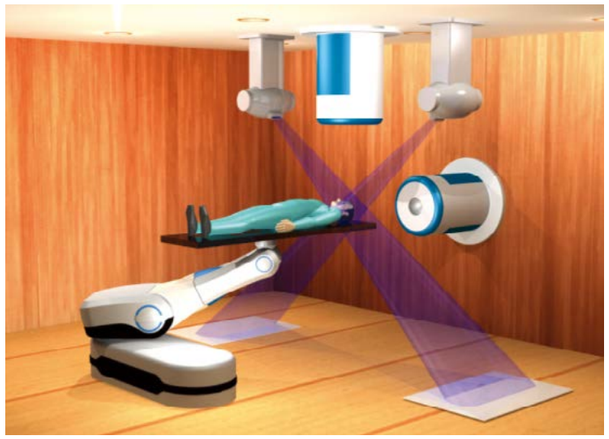
A navigation system can show status of bone and various information in real time without x-ray shootings



Robotic Bed System for Heavy Ion Therapy

Technical Overview

- Development of robotic patient positioning system to align lesion's position to a specific iso-center
- Achieving position accuracy less than 1 mm for brain / 3 mm for body



Robot Specification

Number of Axis		6	Maximum Payload		150 kg
Position Repeatability		±0.02 mm			
Motion Range	Axis 1	±180 °	Maximum Speed	Axis 1	40 °/s
	Axis 2	±165°		Axis 2	60 °/s
	Axis 3	-30~+20°		Axis 3	40 °/s
	Axis 4	±250 °		Axis 4	50 °/s
	Axis 5	-22 ~ +35 °		Axis 5	50 °/s
	Axis 6	±160 °		Axis 6	50 °/s

Research Topics

1st Prototype

2차 시제품

Treatment Specification					
Patient Loading Height		650 mm	Maximum Patient Weight		130 kg

Treatment Volume					
Linear Movement	Longitudinal	1,000 mm	Rotational Movement	Axial (Roll)	±15°
	Lateral	±240 mm		Sagittal (Pitch)	±15°
	Vertical	400 mm		Coronal (Yaw)	±90 °

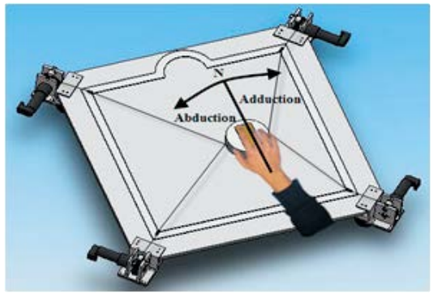
Application Area

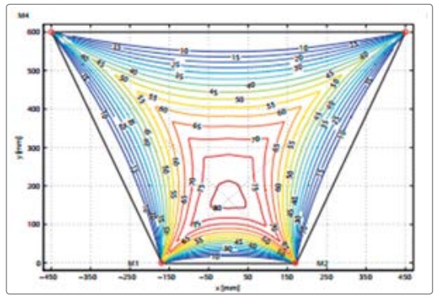
- Precise position control for respiratory motion and deformation of treatment couch due to patient weight
- Essential medical apparatus for a non-invasive surgery
- Useful solution for various surgery robots, therapeutic and diagnostic equipment
- The commercialized system was sold to Shanghai Institute of Applied Physics Chinese Academy of Science(SINAP)

Rehabilitation
Parallel Cable Robotics

Technical Overview

Development of fundamental researches for a rehabilitation parallel cable robotic system. The cable-driven philosophy makes the robot intrinsically safe, much lighter and less cumbersome.



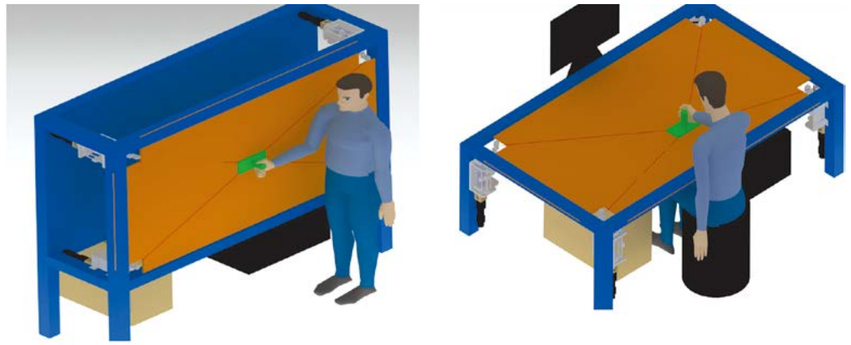


Research work includes design of winch system, forward/inverse kinematics, dynamics analysis, force distribution algorithm, Image Guided System and so forth.

Research Topics & Application Area

Cable robot therapy will be used in partial substitution of conventional upper-limb rehabilitation of acute stroke patients.

Cable Robot



Service Robotics

Professional service robotics
incl. cable robotics and beyond

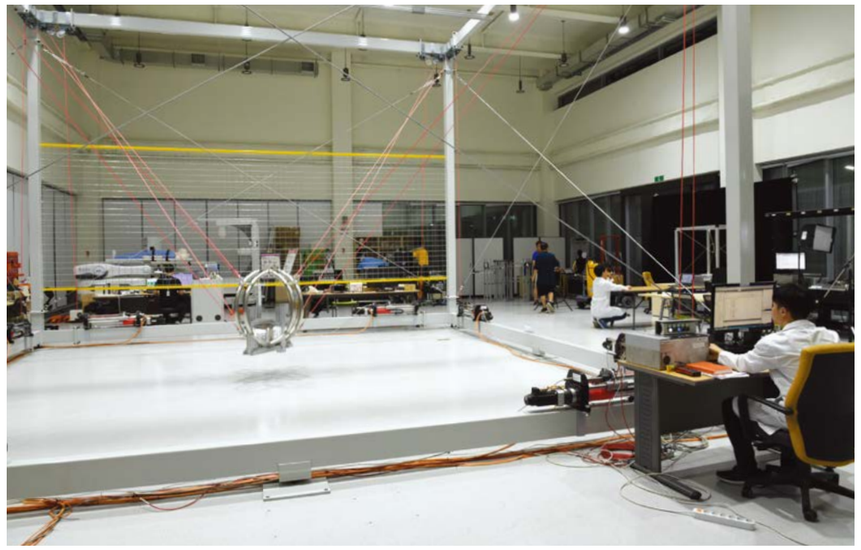
High Dynamic Parallel Cable Robot

High Payload Cable Robot

Technical Overview

- Development of high payload robot with large workspace
- Achieving high payload transfer and assembly handling heavy parts of over 200kg

Performance Objectives			
Size	7 × 7 × 5 m^3	Payload	200 kg
DOFs	> 3	Max. velocity	1 m/s



Research Topics & Application Area

- Cable length control considering high payload and cable dynamics
- Nonlinear cable modeling and robust tension control
- Large workspace operations for high payload transfer and assembly

Service
Robotics

High Speed Cable Robot

Technical Overview

- Development of industrial high-speed pick and place robot with large workspace
- Achieving pick and place cycle time of 0.4sec (handling speed of 150parts/min with 1kg payload)

Performance Objectives			
Size	2m × 2m × 2m	Max. velocity	10 m/s
DOFs	6	Max. acceleration	100 m/s^2
Cycle time	0.4 sec	Max. cycle velocity	3 m/s
Payload	1 kg	Max. cycle acceleration	50 m/s^2

Research Topics & Application Area

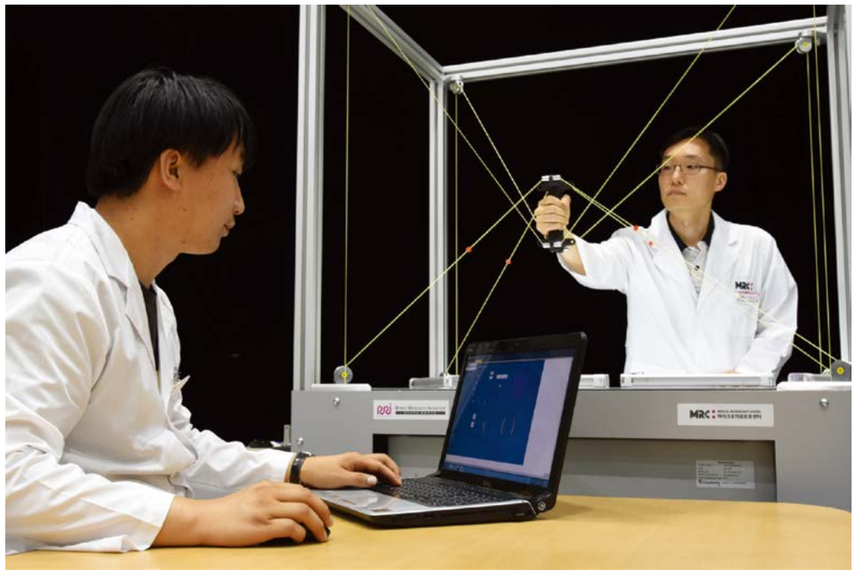
- Reduction of vibration by high inertial forces and cable dynamics
- Nonlinear cable modeling and collision with objects inside workspace
- Industrial large workspace operations for sorting and transferring small parts

Mini Cable Robot

Technical Overview

- Compact test bed capable of 6 DOFs motions
- Feasibility tests for diverse applications
- Demonstration of a parallel cable robot

Robot Specifications				
Size	Full	1.4m × 1m × 2m	Max. cable tension	50 N
	Workspace	1m × 0.9m × 0.7m	Max. cable velocity	2 m/s
DOFs		6	Number of cables	8
Controller		Built-in IPC	Cable diameter	2 mm



Application Area

- 6DOFs Haptic interface for manipulating a cable robot
- Rehabilitation device

Infra

World's best infrastructure & global collaboration

Korea Institute of Medical Microrobotics

Facilities

Main building (4103.8 m²)

- 4F Conference room & Administration
- 3F Industry complex
- 2F Auditorium, R&D Support Lab
- 1F Medical robotics Lab, Micro/nanorobot prototyping Lab, Exhibition hall

Annex (1869.6 m²)

- 2F Animal Research Lab, Biomedical Lab
- 1F Microrobot Fab

The front view of KIMIRo

Cleanroom

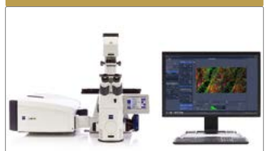
Auditorium

Exhibition hall

Research Equipments

- Equipment for prototyping
- Equipment for experiment, analysis, and performance evaluation
- Equipment for preclinical and clinical evaluation

Confocal Microscope



Field Emission Scanning Electron Microscope

3D Bioprinter

Immunohisto Chemistry System

Ultra-Precise 3D component manufacturing system

Aligner

Laser surface ablation system

Electrical discharge machining

Universal test machine

Vascular simulator

Portable 7 axis laser shape scanner

C-ARM flat panel X-Ray system

R&D Support for SMEs

Purpose

To provide excellent human resources and equipment of KIMIRo to enable SMEs to grow into global champions on the basis of technology power with R&D support

Overview

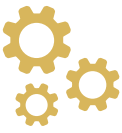
Product development phase	• Prototyping & production support • Resolution of technical difficulties
Advancement phase	• technology consult • test bed, certification support
Commercialization phase	• Commercialization and HR support • Boost corporate growth model

Detail

Prototyping & production support
Providing max 50M KW for medical device/robot SMEs to commercialize

Technical seminar & Education program
To strengthen technological capability and professionalism

Resolution of technical difficulties
Dispatch of competent workforce to resolve technical issues



Equipment service
One-stop service offering test, investigation and prototype fabrication

Network
Support SMEs to say competitive by building a diverse network of Medical microrobot industry association

Industry complex service
Providing core technology of MRC for technology entrepreneurs