Proceedings of the Indo-Korea Joint Workshop on Robotics held at IIT Delhi during March 22-23, 2017

Department of Science and Technology, Gov. of India

National Research Foundation of Korea

Indian Institute of Technology Delhi

October 02, 2017
Message from the Coordinators

The Indo-Kora Joint workshop on Robotics which was held at IIT Delhi during March 22-23, 2017 is the follow-up of the visit by the Hon. Minister of Science and Technology (Dr. Harsh Vardhan) to Korea in 2015. Six Korean and more than 10 Indian scientists from academia and industries participated in that. All of them shared their research experiences in their own countries. The summary of their presentations are reported in this proceedings.

Strengths of both the countries were discussed. It was emphasized that Korea is strong in hardware development, be it precision manufacturing or electronics, whereas India is good at modelling, control, and IT. It was felt that a collaboration between these two countries not only will allow them to develop more efficient and economic robotic systems but will also enhance closer interactions between the scientists of both countries through joint workshops and the student exchanges. Hence, a concept of the Joint Network Center (JNC) on Robotics was proposed at the end of the 2-day workshop. The proposed JNC is expected to be virtual, i.e., no physical center will be created. Instead, existing infrastructure and hardware set-ups of both the countries will be used.

The coordinators take this opportunity to thank the Department of Science and Technology to sponsor the workshop. The support of IIT Delhi’s administration is also acknowledged. The speakers also kindly accepted our invitation with a relatively short notice. Thanks to all of them. Last but not the least, the tireless efforts of our students and staff are not to be missed. It is hoped that all our effort culminate to a fruitful JNC in future!

October 02, 2017

Subir Kumar Saha
Sunil Jha
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Background Note

The purpose of this note is to identify areas and modes for establishment of the “India-Korea Virtual Network Centre on Robotics & Automation”. It also tries to identify the Indian agencies through which joint R&D initiatives in Robotics and Automation can be taken up between India and Republic of Korea. On the Indian side there are three prominent partners who may join for this initiatives:

1. **Academic Institutions like the IITs, IISc, NITs and a few other Engineering Institutions of repute,**

2. **The Govt. Research Labs comprising Dept of Atomic Energy (DAE), Defense Research & Development Organization (DRDO), Council of Scientific and Industrial Research (CSIR) and probably in a small way Indian Space Research Organization (ISRO), MoES, DST and DBT; and lastly**

3. **Industries like PARI Pune, Hi-tech Robotics Gurgaon, and a few others working in the area of Robotics and Automation.**

The strength of the above academic institutions is in design, analysis, algorithm development and simulations, whereas the Research Labs have experience of building equipments and devices for solving practical automation problems by garnering support from related industries. Thus, in the proposed scheme, one or more of these partners will come together to build Robotic and Automation solutions in selected areas.

Many of the useful Robotic applications arise mainly from the Government Departments projects like DAE, DRDO and ISRO. The role of Government Research Labs are important in defining problems, monitoring progress, evaluating solutions and applying them in their fields to build deployable product prototypes. Technologies of these prototypes can then be transferred to interested industries for manufacturing. The solutions can come from academia through projects initiated under the proposed scheme of Robotics and Automation.

Industry, on its front, can participate through orders for fabrications placed with them. They can at the end receive the technology at a small price and start manufacturing of the product. Moreover, their association with the technology development right from the beginning may also facilitate in identifying off-shoot technologies in consultation with the experts which may be of use in other fields.

Some of the areas mentioned below are possible areas for joint collaboration:

1. **Building an affordable and quality industrial robot including Automated Guided Vehicles (AGVs), Mobile Robots for industrial applications**

2. **Rehabilitation Robotics & Haptics devices**

3. **Autonomous Navigation of Unmanned Vehicles including Indoor Environments**

4. **Medical Robotics including Robotic Hand / Arm**

5. **Unmanned Aerial Vehicles**

6. **Humanoid robots for education and skill development**
Joint collaborations can play a crucial role in stimulating innovations and fostering knowledge transfers which would foster interconnections that link intellectual, financial, human, and creative capital as well as unleash underutilized capital. Such enterprises could take the shape of physical or virtual clusters, which bring together research, business, risk capital, and creativity to turn ideas into products, processes, and services. In the Open Innovation Model, by using an “open source” and collaborative approach, organizations could expect to develop affordable products for the world which otherwise would not be a cost effective option for many organizations.

India-Korea Joint Virtual Centre in Robotics & Automation will build an extensive collaborative research network enabling research challenges to be met in a most effective manner. The establishment of the Virtual Network Center will effectively lead to the creation of an academic powerhouse around outstanding scientists and facilities by adopting some of the best practices. The concept behind the need to establish such center in Robotics & Automation is to:

a) Establish world class center of research for joint collaborative work through identified research capabilities both in India and South Korea
b) Set up training programs and hands-on workshops to enable young researcher towards capacity building
c) Set-up facilities to attract young researchers for active involvement in research activities
d) Enable visiting scientists to contribute significantly to the program
e) Intensify the research in identified emerging areas
# Programme

Time & Place: March 22-23, 2017, Senate Hall, IIT Delhi, New Delhi, India

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<th>March 22</th>
<th>Arrival and Registration: In front of Senate Hall, IIT Delhi</th>
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<td><strong>Opening Ceremony</strong></td>
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<td>• Welcome Remarks by Prof. V. Ramagopal Rao, Director, IIT Delhi</td>
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<td>• Opening Remark by Mr. Wonho Choi, DG of International Cooperation Bureau, MSIP, Rep. of Korea</td>
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<td>• Congratulatory Message by H.E. Mr. Hyun Cho, Ambassador of the Republic of Korea, New Delhi</td>
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<td>• Inaugural Remarks by Prof. Ashutosh Sharma, Secretary, DST, Govt. of India</td>
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<td>• Introduction to the concept of Virtual Network Center (VNC) and Vote of Thanks by Prof. S.K. Saha</td>
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<td><strong>Photo Session</strong> (Next to IIT Delhi’s Main Security Office)</td>
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<td><strong>Keynote Addresses</strong> (Theme: Strengthening Plan for Robotics R&amp;D through Korea-India Partnership)</td>
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<td>• Prof. S. Chaudhary, CSIR-CEERI, Pilani</td>
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<td>Title: Robotics as Integral Component in Cyber Physical System</td>
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<td>• Prof. Seul Jung, Chungnam National University</td>
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<td>12:15–13:45</td>
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<td>14:00–15:20</td>
<td><strong>Presentation by researchers from Korea-India</strong></td>
<td>Moderator: Prof. S. Jung</td>
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<td>Korean-1: Prof. Jung-Min Yang, Kyungpook National University</td>
<td>20 min. for each (*15 min. presentation followed by 5 min. Q&amp;A)</td>
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<td>Title: Development and Control of Multi-Functional Hyper-Redundant Robots</td>
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<td>Indian-1: Prof. G.C. Nandi, IIT Allahabad</td>
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<td>Title: Solving Biped Locomotion Challenges using Computational Theoretic Approach</td>
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<td>Korean-2: Prof. Jae-Woo Lee, Konkuk University</td>
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<td>Title: Wing Morphing Technology for Autonomous Flying Robot</td>
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<td>Indian-2: Prof. P.M. Pathak, IIT Roorkee</td>
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<td>16:00–17:20</td>
<td>Korean-3: Prof. Suk Ho Park, Daegu Gyeongbuk Institute of Science &amp; Technology</td>
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<td>Title: : Biomedical Micro/Nano Robotics</td>
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<td>Indian-4: Dr. Soumen Sen, CSIR-CMERI, Durgapur</td>
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Aims at promoting research and development in robotics, particularly in the areas of design, development, and applications.

### March 23

#### 10:00–12:00

**Presentation from Korea-India**
- **Indian-5**: Mr. Parvez Alam, UCAL Chennai
  - Title: Design and Development of Autonomous Amphibious Unmanned Aerial Vehicle with Water Sampling and Assessment Device for Water Based Applications
- **Korean-5**: Prof. (Ms.) Varsha Khare, Seoul National University
  - Title: Nanorobotics—Combining Computational and Experimental Aspects in Design and Manufacturing
- **Indian-6**: Mr. Suresh Kedia, East Coast Magnets Private Limited, Kolkata
  - Title: Safe Magnetic Gripper for Robots
- **Indian-7**: Dr. Swagat Kumar, TCS, Greater Noida
  - Title: Service Robotics—Challenges and Opportunities
- **Indian-8**: Prof. K. Issac, IIST, Thiruvananthapuram
  - Title: Space Robotics—IIST Initiatives
- **Indian-9**: Mr. Alok Mukherjee, R&DE, Pune
  - Title: Robotics in Military Applications

#### 12:15–13:45

**Lunch (Faculty Guest House)**

#### 14:00–15:00

**Robotics at IIT Delhi (10 min each)**
- **Indian-10**: Prof. Sudipto Mukherjee
  - Title: Pointing with the Hand
- **Indian-11**: Prof. Prem Kalra/Dr. Subodh Kumar
  - Title: Immersive Environment for Robotic Tele-operation
- **Indian-12**: Prof. I.N. Kar
  - Title: Formation Control of Multiple Robots
- **Indian-13**: Dr. Sumantra Dutta Roy
  - Title: Bin Picking with Sensor Fusion
- **Indian-14**: Dr. Tapan Gandhi
  - Title: Understanding Cross-modal Sensory Mapping

#### 15:00–15:30

**Way Forward**: Prof. S.K. Saha, and Prof. Seul Jung

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### Free Discussion & Networking

**Theme**: Setting up of Indo-Korea Virtual Network Center on Robotics

**Moderator**: Mr. Rajiv Kumar

### Dinner (Faculty Guest House)
Abstracts
Robotics as Integral Component in Cyber Physical System

Santanu Chaudhary
CSIR-CEERI, Pilani

The use of robots in future is expected to increase tremendously. Some of the areas include industries, security, health care, agriculture, disaster management and households. Cyber physical system (CPS) intensively interact with physical processes where sensors sense the physical world, computational components process sensor data and activate actuators to influence the physical process in real time. The computational components for CPS need to be adaptive to deal with uncertainty of observations from sensor and outcome of actuator actions. Cyber physical space is potentially hosting innumerable spatio-temporal data streams due to increasing use of social networking platforms as real-time information dissemination system and world-wide deployment of sensors for continuous monitoring of physical phenomena. This can be used in various applications like sensing and responding to global calamities such as earthquake or giving useful information to farmers. Here we look at the role played by Robotics in CPS with examples from several application areas.

Development and Control of Multi-Functional Hyper-Redundant Robots

Jung-Min Yang
School of Electronics Engineering, Kyungpook National University

Hyper-redundant Robots
- Robots which have more than the minimum number of degrees-of-freedom are termed "kinematically redundant," or simply "redundant"
- Redundancy as a means to improve manipulator performance in complex and unstructured environments
- "Hyper-redundant" robots have a very large degree of kinematic redundancy, and are analogous in morphology and operation to snakes, elephant trunks, and tentacles.
- While "snake-like" robots have been investigated for nearly 25 years, they have remained a laboratory curiosity.

Soft Robots
- Non rigid robots with sensors, bodies, or actuators constructed with soft and deformable materials like silicone, plastic, fabric, rubber, or compliant mechanical parts like springs.
- Less space problem, free deformation, safe
- Not only dependent on mechanics and electronics, but physics, chemistry, and biology
- Conventional methodology on rigid robotics frequently fails, so new research field should be explored.

Research Proposals: Hyper-redundant robots + Soft robots
- Comparatively low cost
- Solve safety problems effectively
- Simple principles and easy implementation
- Applicable to various applications
Collaboration Proposals

Introduction to Robotics Research at CNU for Possible Joint R&D and Collaboration

S. Jung
CNU, Korea

In this talk, general research topics that have been conducted at ISEE, CNU were introduced.

- Robot manipulator: Design, implementation, control
  Control algorithms: DOB, intelligent control, force control
- Mobile robots: balancing mechanism
  Two wheel mobile robots, one-wheel mobile robot
  Control algorithms: intelligent control, time-delayed control
- Drones: Hybrid drones
  Control algorithms: intelligent control
- Capstone design Projects
  Undergraduate projects
Wing Morphing Technology for Autonomous Flying Robot

Jae-Woo Lee
Professor and Director
Konkuk Aerospace Design-Airworthiness Institute, KADA
Konkuk University, Seoul Korea
jwlee@konkuk.ac.kr

1. Scientific Impact and its Application in UAV
   - **Significant drag reduction** through continuous camber change
   - Multifunctional smart interface between wing and control surface, which reduces the flow discontinuity and also improves the load carrying capability of the wing airframe
   - **Improved L/D** in the operational envelope
   - Developed technique is scalable to any MAV/UAV and implementable with inflight power source and electronics.

2. Development of Modular Wing Design for Improved Aerodynamic Performance
   - In general, morphing aircraft technology tries to change the shape of aircraft wings in order to optimize aerodynamic performance. The shape of the wing must change during takeoff, cruising and landing. Current designs only consider one condition (normally cruising), so they use high lift devices, such as flaps and slats for take-off and landing.
   - We will be focusing on the research on solving the problems of structural mechanization and control law development that are hindering wing morphing. This work leads the application of variable geometry truss mechanisms (VGTM) to morphing technology. VGTM are truss-based structures comprised of linear actuators which can be manipulated to control movement.
   - VGTM technology can be used to fully integrate the variable capabilities of a morphing wing. VGTM modules can be integrated into existing structural components.
   - Each module being inserted into one of the longitudinal sections that comprise the wing. They work together with extant wing structures and enable the wing to morph in sections, allowing for greater control over shape changes
   - VGTM can cater for all morphing methodologies as wings can be automatically configured and reconfigured to meet specific flight requirements.

3. Design & Realization of Mechanism Dynamics

![Diagram of morphing mechanism]
4. **Key Research Focused**

- Wing morphing for all terrain multi mission mode UAV
- Load Monitoring for control system operations/limiting the maneuverability
- Sub-Systems innovations
- Dynamic scaling issues: Through which Actual flying Aircraft with morphing wing technology can be aimed

5. **Indian Counterpart**

CSIR-National Aerospace Laboratories, Bangalore, India
Dr. S Raja, Sr. Principal Scientist
P. Shanmugam Sr. Scientist, pshan@ccadd.cmmacs.ernet.in

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**Microrobots for a Capsule Endoscope**

Byungkyu Kim
School of Aerospace & Mechanical Engineering, Korea
Aerospace University, (Phone: 82-2-300-0100; e-mail: bkim@kau.ac.kr)

Various actuators have been studied to develop microrobots for a capsule endoscope. In particular, some locomotive mechanisms based on the SMA (Shape Memory Alloy) actuator, the PZT actuator, the Polymer actuator, and the micro motor have been actively studied to fabricate a microrobot for a capsule endoscope. Before we fabricate microrobots, smart material-based actuators such as SMA, PZT, Polymer, and a micro motor are evaluated from the viewpoint of power consumption, response time, and generative force. Based on the evaluation results, some microrobots are developed properly to diagnose the digestive organ. The earthworm-like robot based on the SMA and PZT actuators is fabricated and tested in the colon of a swine in order to demonstrate the performance of locomotion. However, the smart actuator-based micro robot does not supply enough driving force to locomote in the digestive organ. Therefore, a paddling-based locomotive mechanism is constructed and tested in order to diagnose diseases in the small intestine. Based on these research efforts, we expect to develop the next generation microrobot that can diagnose diseases in human digestive organs.
Biomedical Micro/Nano Robotics
Suk Ho Park
Multiscale Biomedical Robotics Lab, DGIST, Korea

Recently, various types of biomedical micro/nano robots have been developed for the use in bioengineering and healthcare applications. Generally, micro/nano robots can approach to complicated and small regions of human body and perform non-invasive or minimally invasive manipulations to targeted areas. In this talk, I will briefly introduce our frontier researches on biomedical micro/nano robotics, such as active locomotive capsule endoscope with functional modules of biopsy and drug delivery, magnetically steerable catheter/needle system, intravascular therapeutic microrobot, bacteria-based microrobot, hybrid microrobot, macrophage based microrobot, externally actuating nanorobot system, entertainment microrobot, hydrogel based microrobot for micro-manipulation, and stem cell delivery microrobot. Especially, I will describe not only the concepts of our biomedical micro/nano robots but also their brief fabrication procedures. Therefore, I expect that this talk can give us an insight on new concepts of micro/nano robots for biomedical applications.

Nanorobotics: Experimental and Theoretical Considerations
Versha Khare
Department of Mechanical & Aerospace Engineering, Institute of Advanced Machinery and Design, Seoul National University, South Korea

Abstract of collaborative Research

The project aims to pursue ‘bioinspired micro/nanorobotics’ to innovatively explore the development of functionalised magnetized nano heterostructures of nano- and quantum materials assembled as nanowires/nanorods in the field of medical robotic devices by applying a biomimetic design towards the future development and implementation of nano/microrobots that can be actuated through biological fluids to desired targets as efficient drug delivery and diagnostic tools. In this project, we aim to combine a multidisciplinary approach at the interface of biology, materials and engineering science by constructing a bio-inspired biocompatible magnetic robot with potential use in a number applications including drug delivery. The field of nano/micro robotics to aid the development of medical devices is only just emerging and we have already established capabilities in the fabrication of hybrid materials with precise control of heterostructures of carbon and biocompatible semiconductor structures of nanorods, nanoneedles, nanosheets, nanowires and nanoflakes morphologies.

Need for collaboration

An INDO-KOREA joint proposal in the field of micro/nano medical robotic devices are based on needs that combine joint efforts at the boundary of computational, functional materials and manufacturing activities. A multidisciplinary objective is essential in which computational expertise will aid the experimental drive for integrating functional materials in devices. Needs center on:

- Addressing theoretical and experimental problems in biomedical engineering of medical device
Solving Biped Locomotion Challenges using Computational Theoretic Approach

G C Nandi
Robotics and Artificial Intelligence Laboratory
Indian Institute of Information Technology, Allahabad
gcandi@iiita.ac.in

We envision in near future humanoid robots would share a common space in our household. Those robots should essentially be bipedal since the space they are going to share with us is made by us and for us. Hence like us, the humanoid robots should have the capability of negotiating with stairs, door sealing and other steps which is difficult to attain for a wheeled mobile robot. However, as we know the biped walking is extremely challenging in terms of maneuverability maintaining required stability/balance. Human learns to face these challenges during initial 8-9 months of birth. During this time in a healthy subject the locomotion articulation gradually reduces to a cycle, where the articulate sequence, which we call as “gait”, is repeated for a particular speed of walking. The architecture of a human’s lower limb is very complex, specifically the human foot is a strong and complex mechanical structure. There are 26 bones, 33 joints among which 20 are actively articulated. It also has sophisticated actuating devices such as more than a hundred muscles, tendons, and ligaments. In terms of architectural sophistication, the existing humanoid robots are nowhere nearer to the humans. Apart from this, there are constrains in the required actuator and joints. All these make existing humanoid robot’s locomotion articulation inefficient for the real world unstructured environment. Here we discuss some of our research for making biped humanoid robot’s locomotion human like. Two data driven model development techniques are highlighted- one is based on Central Pattern Generator (CPG) and the other one is based on Hybrid Automata (HA). Human walking uses a sub phase where stance heel rises above the ground and the stance foot rotates about the toe and this significantly reduces the energy consumed during walking. Both the techniques, CPG and HA can effectively accommodate this foot rotation. To the best of our knowledge no existing humanoid robot executes this foot rotation sub phase. More specifically, we show that incorporating this sub phase in a 3-D humanoid robot walking model, the torque cost function can be minimized significantly. We illustrate our observations through simulation results using both humanoid robots HOAP-2 (without foot rotation) and our own model designed using Opensim platform (with foot rotation).
Some illustrations:

**Fig. 1** Human gait with sub phases

**Fig. 2** A typical gait cycle for normal walking

**Fig. 3** CPG based design

**Fig. 4** HOAP-2 with flat foot
Fault Tolerant Control of a Quadruped Robot for Free Swinging Failure*

M M Gor¹, P M Pathak², A K Samantaray³, J-M Yang⁴and S W Kwak

Quadruped robots are designed to work in remote or hazardous environments which are unreachable or harmful for humans. In these situations, reliability and adaptability are the most critical issues for the quadruped robot. During the failure of any actuator, it can be locked joint or free swinging. In the case of free swinging failure, leg joint loses actuator torque and also the capability to support the robot body on the ground. Leg joint also loses resistance to external load and acts as a free rotating hanging link. This work presents strategies for free swinging failure fault tolerant control of a compliant legged quadruped robot. The strategy is motivated by the natural crawling by infants and adapted crawling by persons with specific disabilities.

* The work of M. M. Gor, P. M. Pathak, and A. K. Samantaray was funded by DST, India under Indo–Korea Joint Research in Science and Technology vide Grant No. INT/Korea/P–13. The work of J.–M. Yang and S. W. Kwak was supported by the National Research Foundation of Korea grant funded by the Korea government (MEST) (No. NRF–2011–0027705).

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S. W. Kwak is with Keimyung University, Daegu, South Korea, (e-mail: ksw@knu.ac.kr).

Variable Impedance Actuation: From Biomimetics to Emergence of Soft Robots

Soumen Sen
Principal Scientist
Robotics and Automation Division
CSIR – Central Mechanical Engineering Research Institute, Durgapur
Email: soumenSen@cmeri.res.in

New generation robots are no longer designed to be rigid in order to make them human friendly and safe for physical interactions in doing work hand-in-hand with operators and other machines. There happens to be a paradigm shift in design of such machines by making them flexible (and so 'soft') rather than 'rigid' in the actuation. Safety against accidental impact is ensured by design through introduction of compliance, while performance is achieved by varying them through control. Introduction of flexibility not only provides means for making intrinsically safe robots, but is also beneficial for enhanced energy efficiency, especially in periodic motions. The ubiquitous presence of compliance in actuation in the biological world justifies the new design approach and motivates the development of these artificial devices. This presentation discusses on the scientific basis of the need of compliant actuation and eventually arrives at the need of variability in mechanical impedance of the actuator.
transmissions in physical-human-robot-interaction (pHRI). This talk then presents a first principle, derived from biological muscle’s passive behaviour, in the ‘not-so-obvious’ design basis of the compliant actuator transmission and describes the development of an agonist-antagonistic actuator, resembling a musculoskeletal system. Issues in estimation of mechanical impedance parameters and its control are addressed by exploiting a derived property of stiffness-force proportionality. Eventually, prototype development of a Variable-Impedance-Actuator at CSIR-CMERI is described and its application in exoskeletons, rehabilitation, prosthetic and orthotic devices is discussed. Finally, the talk considers the usefulness of flexibility (in joint as well as body) in building energy-efficient biomimetic fish-fin like actuators for propulsion of underwater vehicles. Ongoing activities in CSIR-CMERI for development of biomimetic underwater actuators are delineated in the presentation.

As an introduction, the talk will brief on current robotics activities in CSIR-CMERI including its achievements in development of underwater vehicles (AUVs and ROVs), and robotic vehicle for mining and nuclear applications.

**Service Robotics: Challenges and Opportunities**

Swagat Kumar  
Tata Consultancy Services, New Delhi, India

According to IFR, the growth in robotics market will be driven by the service robots. These robots are capable of working in an unstructured cluttered environment. Several challenges need to be solved before the full potential of service robots could be realized. These challenges also offer opportunities to make a niche for ourselves. The speaker would take about some of these trends and how a service company like TCS is preparing itself for this new changing world.

**Safe Magnetic Gripper for Robots**

Suresh Kedia  
Shree Magnets Private Limited, Kolkata

Robots have always excited humans and they have imagined about developing a new world of autonomous agents. Technically, a robot is an electro-mechanical agent or device which by its action can cause a change in its operating environment. Robots can be human operated or can act in autonomous fashion. A robot can have the ability to sense its environment through sensors. The major problem/hurdle faced by robotic and automation industry is safe and secure clamping, lifting and movement of components of ferrous and its alloys. The magnetic force, since it is invisible the sensing of actual flux during operation is seldom done because of its complex nature.

Industrial robots are made up of six basic constituent elements, they are: the dynamic system, the computerized digital controller, the actuators, the feedback devices, the sensor and the end-of-arm tool. Dynamic system is needed for movement in the working area. The most important of which is the robotic arm. According to the designs of the robots, the main axis will move linearly or rotationally along what is called ‘the degree of freedom’. Usually, there are 3 types of drive systems, they are: electrical, hydraulic and pneumatic. The objective of this project is to develop a magnet with flux sensing technology for the robotic end-of-arm tools system.
The project partners intend to solve this problem by introducing our patented Flux Sensing Electro Permanent Magnetic system vide Patent Application No. 1003/KOL/2012 dated 31st August, 2012. We for simplicity will sense the flux on the neutral side of the magnet which are independent of power source as they are electro permanent magnet. The product would be a Robotic Arm Clamping Fixture having an EPM to handle / lift / transport / place ferrous and ferrous alloy items. The system / fixture will be electronically controlled and will give real-time assessment of clamping power and accuracy.

This will be first of its kind of magnetic clamp which can assess clamping power not only when it is switched on but also during the load condition. The research will introduce magnetic clamping fixture in a way which was neither successful nor investigated extensively. Our intended invention should solve the perennial problem faced by Robotic Automation industry for handling, lifting and transporting ferrous and its alloys. This includes Design and development of electro permanent magnetic lifter with real time flux sensing and digital indicators for safe operations.
Design and Development of Autonomous Amphibious Unmanned Aerial Vehicle with Water Sampling and Assessment device for Water Based Applications

Parvez Alam
UCAL, Chennai

Design and development of an “Autonomous Amphibious Unmanned Aerial Vehicle (AAUAV)” that can fly autonomously to the polluted water areas where human accessibility is formidable to test the water quality. The AAUAV system is an integrated Multi-copter with an amphibian base to facilitate easy landing and navigation on the water surface. This robust system will have both Hyper Spectral Imaging sensors and Water Quality Analyzing Sensors on-board to analyze the polluted content of the water in real time and it can be Geo-tagged. This system also offers the collection and storage of water samples from the polluted sites for the further comprehensive research at the laboratory. AAUAV system is a novel solution to the polluted environment by a complete integrated system. This will be an effective alternative for the conventional water sampling techniques.

Space Robotics - IIST Initiatives
Kurien Issac
IIST, Thiruvananthapuram

Indian Institute of Space Science and Technology (IIST) has several robotics initiatives for space applications. These include Virtual Reality for planetary exploration, virtual prototyping of space shuttle, virtual walk/fly through etc.

Robotics in Military Applications
Alok Mukherjee
DRDO, R&DE, Pune

Robotics has several applications in military. Unmanned systems based on ground, air and water are of tremendous use for surveillance, communications, operations and combat. Some of the robots developed by us are ‘DAKSH’ a Remotely Operated Vehicle (ROV) equipped with material handling capabilities and ‘NETRA’ an unmanned aerial vehicle with vision capabilities. These systems are continuously improved for better versions.
Pointing with the Hand
Sudipto Mukherjee
IIT Delhi

In situations involving inaccessible locations, a teleoperation of a manipulator is required. We have developed an exoskeleton to operate a KUKA manipulator. In order to achieve smooth motion of the KUKA, a velocity-based adaptive gain algorithm was implemented. This algorithm focuses on dynamically adjusting the gain based on the velocity of the exoskeleton. The motion of the exoskeleton is tracked for a certain small interval of time.

Immersive Environment for Robotic Tele-operation
Prem Kalra
IIT Delhi

In various modern day situations, controlling a robot from a remote location is essential due to hazardous environmental conditions (for human operators) near the robot. Thus arises the need for an intuitive user interface for tele-operation, which must be efficient as well as easy to use. In this presentation, we present an innovative user interface and overall framework for robotic tele-operation and demonstrate its application to simple bin-picking and hole-packing tasks. We have adopted technologies from Virtual Reality (VR) systems for environment mapping and used modern interface devices to provide haptic feedback.

The user interface of our framework renders a virtual replica of the remote site in which the virtual objects are animated based on the tracking information received from cameras and robot placed at the remote location. A haptic device was used by the human operator to control the remote robotic arm while simultaneously aided by the haptic feedback received from the robotic arm. A tele-operation system using our framework was developed in laboratory environment and the usability of our system was verified by a user survey.

Formation Control of Multiple Robots
I.N. Kar
IIT Delhi

There are numerous scenarios where a need arises to accurately map an unknown noisy scalar field present in the environment. Some common examples are nuclear/biological/chemical contamination, etc. Such applications require cooperative exploratory missions using autonomous mobile sensor networks. In this work, an efficient, generic, easy to design control strategy was developed for multiple mobile platforms to explore a noisy scalar field collectively. A geometric approach was taken in formation control, modelling the entire robot formation as a deformable body whose shape and orientation are described by a special set of Jacobi vectors.
Bin Picking with Sensor Fusion
Sumantra Dutta Roy
IIT Delhi

Here we use a manipulator to perform picking of some objects out of a bin using multiple sensors. Our approach avoids blindly fusing image and depth data. We push the depth information as much as possible to arrive at results we are certain. We use the premise built by our 3D segmentation to create a context for image search in restricted way, which ensures the errors do not creep in with reference to the images. Thus our algorithm outperforms most published algorithms in both speed and detection rate in respect to number of visible object.

Understanding Cross-modal Sensory Mapping
Tapan Gandhi
IIT Delhi

Humans are known to possess ability to integrate information across the senses. For example we can predict the visual appearance of an object based upon how it feels to touch. Understanding the mapping between various senses and how it is learned is helpful for various reasons. One such application is restoring visual abilities in children who had no visual stimulation during childhood. There have been some successful cases of this application which encourage such endeavours.

Another Presentation from IIT Delhi
J.P. Khatait
IIT Delhi

Prof. J.P. Khatait spoke about his research in the area of medical robotics, and how his expertise area can be exploited for future development.
As illustrated in Figure 1, the proposed Indo-Korea Virtual Network Center on Robotics (IKVNCR) should carry out the following activities:

1. Research in the area of Robotics which are of common interest to both the countries.
2. Travel to each other’s country to plan the common research goals, and conduct joint research through student exchange, etc.
3. Organize joint workshops/conferences to disseminate the outcomes of the joint research.

The structure of the team to achieve the above goals is suggested as follows:

a. One coordinator in the Coordinating Institute of the country.
b. Representative from 5-8 interested participating institutes from various parts of the country.

The functions could be carried out in the following way:

- DST will provide a fund to the coordinating institute to take care of few local staff to run the day-to-day activities, budget to conduct 2-3 workshops/conferences in a year in India, travel grant to make 1-2 visits to Korea by 2-3 researchers, and seed money to initiate 5-8 short-term (~ a year) low-volume (~Rs. 3.5 lakhs or US$5,000) research activities.
- The coordinator with the help of representatives will identify key areas of research which are of interest to both the countries.
- The coordinating institute will announce the call for research on the above key areas.
- Any institute can immediately initiate by taking the seed money from the coordinating institute.
- For any long-term high-value project, a separate proposal will be jointly (Indian and Korean) prepared with the help of the coordinating institutes to the funding agencies for financial support.

The above fund from the DST to coordinating institute could be initially for three years, which can be reviewed for its continuation.
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Photo Gallery