TEQIP Workshop on Introduction to Robotics
September 04-08, 2017

TEQIP Short Course on
Introduction to Robotics
04-08 Sep. 2017

Course Coordinators

Dr. Bhaskar Dasgupta
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Centre for Mechanical Sciences
IIT Kanpur

Dr. Anjali V. Kulkarni
Assistant Research Engineer
Centre for Mechanical Sciences
IIT Kanpur

Dr. Abhishek Dutta
Professor, IIT Delhi
Head, Centre for Mechanical Sciences
IIT Kanpur

Venue: PBCEC Building
IIT Kanpur
TEQIP Short Course on Introduction to Robotics
04 - 08 September, 2017

More pictures at: Link
Robotics technologies have wide spread applications and are diffusing fast into every walk of life. It is also a key component of the 'Digital India' as well as the 'Make in India' initiatives. The applications of robotics ranges from space exploration to house hold robots. This workshop comprised of the essential theory required for teaching and research in robotics, with hands on experiments through numerous laboratory sessions. Several experts from academia, research laboratories and industry delivered the lectures and shared their research experience during the workshop. This workshop aimed at motivating the students and teachers alike to take up the challenges in this interdisciplinary field.

TOPICS DISCUSSED

- Fundamental of Robotics
- Spatial Representation
- Robotics Kinematics
- Actuators and Sensors
- Design and Control of Field and Service Robots
- Jacobian, Singularity, and Workspace
- Manipulator Dynamics
- Robotics in BARC
- Motion Planning
- Basic Control
- Designing Reconfigurable Unmanned Aerial Vehicles
- Robot Learning by Imitation
- Autonomous Control of Variable Pitch Quadrotor Helicopters
- Smart Materials for Sensing and Actuation
- Towards Micro Nano Robotics: Manufacturing and Motion Control research
- **Laboratory Experiments:**
  
  a) VAL-II PUMA robot programming  
  b) Stepper Motor Control (Manual, Arduino and LabVIEW)  
  c) Servo Motor Control (Micro-controller Programming and Interface)  
  d) Micro-controller Interfacing with Sensors  

**WORKSHOP ORGANIZERS**

1. **Dr. Anjali V. Kulkarni**  
   Principal Research Engineer  
   Center for Mechatronics  
   IIT Kanpur  
   [http://home.iitk.ac.in/~anjalik/](http://home.iitk.ac.in/~anjalik/)

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   Professor  
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   IIT Kanpur  
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1. Dr. T. Asokan
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   Department of Engineering Design
   IIT Madras
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   IIT Kharagpur
   http://www.facweb.iitkgp.ernet.in/~cskumar/

3. Dr. T.A. Dwarakanath
   Professor
   Bhabha Atomic Research Centre Trombay
   Mumbai

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   http://home.iitk.ac.in/~dasgupta/

6. Dr. Saumya Ranjan Sahoo
   Assistant Professor
   Department of Electrical Engineering
   IIT Kanpur
   http://home.iitk.ac.in/~srsahoo/index.php
7. **Dr. Abhishek**  
   Assistant Professor  
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8. **Dr. K S Venkatesh**  
   Professor  
   Department of Electrical Engineering  
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9. **Dr. Bishakh Bhattacharya**  
   Professor  
   Department of Mechanical Engineering  
   IIT Kanpur  
   [http://home.iitk.ac.in/~bishakh/index.html](http://home.iitk.ac.in/~bishakh/index.html)

10. **Dr. Mangal Kothari**  
    Assistant Professor  
    Department of Aerospace Engineering  
    IIT Kanpur  
    [https://www.iitk.ac.in/aero/mangal/](https://www.iitk.ac.in/aero/mangal/)

11. **Samrat Dutta**  
    PhD. Student  
    Department of Electrical Engineering  
    [http://iitk.ac.in/new/samrat-dutta](http://iitk.ac.in/new/samrat-dutta)
# Participating Institutes

<table>
<thead>
<tr>
<th>Institute</th>
<th>Number of Participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Government Engineering College,</td>
<td>2</td>
</tr>
<tr>
<td>2. IIT Roorkee</td>
<td>1</td>
</tr>
<tr>
<td>3. Aligarh Muslim University, Aligarh</td>
<td>3</td>
</tr>
<tr>
<td>4. MMMUT Gorakhpur</td>
<td>3</td>
</tr>
<tr>
<td>5. Veermata Jijabia Technological</td>
<td>1</td>
</tr>
<tr>
<td>6. Jadavpur University</td>
<td>1</td>
</tr>
<tr>
<td>7. Dr. Babasaheb Ambedkar Technological University, Lonere</td>
<td>4</td>
</tr>
<tr>
<td>8. Coimbatore Institute of Technology, Coimbatore, TamilNadu</td>
<td>2</td>
</tr>
<tr>
<td>9. REC Kannauj</td>
<td>3</td>
</tr>
<tr>
<td>10. Kamla Nehru Institute of Technology,</td>
<td>4</td>
</tr>
<tr>
<td>11. Shri Gobind Singhji institutes of engineering</td>
<td>2</td>
</tr>
</tbody>
</table>

**Total**: 26

## Statewise Participation

- **UP**: 50%
- **Maharashtra**: 27%
- **Tamil Nadu**: 8%
- **West Bengal**: 4%
- **Uttarakhand**: 4%
- **Rajasthan**: 7%
- **Uttar Pradesh**: 50%
# WORKSHOP SCHEDULE

## Day -1

<table>
<thead>
<tr>
<th>Date/Day</th>
<th>Slot</th>
<th>Topic</th>
<th>Speaker</th>
<th>Institute</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monday, 4 September</td>
<td>9:00 – 10:30</td>
<td>Inauguration and Fundamental of Robotics</td>
<td>Dr. A. Dutta</td>
<td>PBCEC</td>
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<tr>
<td></td>
<td>10:30 – 11:00</td>
<td>High Tea</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>11:00 – 12:30</td>
<td>Spatial Representation</td>
<td>Dr. A. Dutta</td>
<td>PBCEC</td>
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<tr>
<td></td>
<td>12:30 – 13:30</td>
<td>Lunch Break</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>13:30 – 15:00</td>
<td>Robotics Kinematics</td>
<td>Dr. B. Dasgupta</td>
<td>PBCEC</td>
</tr>
<tr>
<td></td>
<td>15:00 – 15:30</td>
<td>Tea Break</td>
<td></td>
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<tr>
<td></td>
<td>15:30 – 17:30</td>
<td>Actuators and Sensors + VAL - II</td>
<td>Dr. A. Dutta</td>
<td>PBCEC</td>
</tr>
</tbody>
</table>

## Day -2

<table>
<thead>
<tr>
<th>Date/Day</th>
<th>Slot</th>
<th>Topic</th>
<th>Speaker</th>
<th>Institute</th>
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</thead>
<tbody>
<tr>
<td>Tuesday, 5 September</td>
<td>9:00 – 10:30</td>
<td>Design and Control of Field and Service Robots</td>
<td>Dr. T. Asokan</td>
<td>PBCEC</td>
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<tr>
<td></td>
<td>10:30 – 11:00</td>
<td>Tea Break</td>
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<tr>
<td></td>
<td>11:00 – 12:30</td>
<td>Jacobian, Singularity and Workspace</td>
<td>Dr. B. Dasgupta</td>
<td>PBCEC</td>
</tr>
<tr>
<td></td>
<td>12:30 – 13:30</td>
<td>Lunch Break</td>
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<tr>
<td></td>
<td>13:30 – 15:00</td>
<td>Manipulator Dynamics</td>
<td>Dr. B. Dasgupta</td>
<td>PBCEC</td>
</tr>
<tr>
<td></td>
<td>15:00 – 15:30</td>
<td>Tea Break</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>15:30 – 17:30</td>
<td>Vision and LAB SESSION –I</td>
<td>Dr. K. S. Venkatesh</td>
<td>PBCEC</td>
</tr>
</tbody>
</table>
### Day -3

<table>
<thead>
<tr>
<th>Date/Day</th>
<th>Slot</th>
<th>Topic</th>
</tr>
</thead>
</table>
| Wednesday, 6 Sept  | 9:00 – 10:30 | Robotics in BARC<br>
*Dr. T. A Dwarkanath*<br>
*PBCEC* |
|                   | 10:30 – 11:00| Tea Break                                                             |
|                   | 11:00 – 12:30| Motion Planning<br>
*Dr. B. Dasgupta*<br>
*PBCEC* |
|                   | 12:30 – 13:30| Lunch Break                                                          |
|                   | 13:30 – 15:00| Basic Control<br>
*Dr. S.R Sahoo*<br>
*PBCEC* |
|                   | 15:00 – 15:30| Tea Break                                                             |
|                   | 15:30 – 17:30| LAB SESSION - II (Experiments and Lab visits)<br>
*Dr. A. V. Kulkarni and Dr. A. Dutta*<br>
*Computer Centre & Mechatronics Lab* |
|                   | 19:00        | Workshop Dinner                                                     |

### Day -4

<table>
<thead>
<tr>
<th>Date/Day</th>
<th>Slot</th>
<th>Topic</th>
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</table>
| Thursday, 7 Sept   | 9:00 – 10:30 | Designing Reconfigurable Unmanned Aerial Vehicles (UAV)<br>
*Dr. Abhishek*<br>
*PBCEC* |
|                   | 10:30 – 11:00| Tea Break                                                             |
|                   | 11:00 – 12:30| UAV LAB SESSION - III<br>
*Dr. Abhishek*<br>
*IIT Kanpur Airstrip* |
|                   | 12:30 – 13:30| Lunch Break                                                          |
|                   | 13:30 – 15:00| Robot Learning by Imitation<br>
*Samrat Dutta*<br>
*PBCEC* |
|                   | 15:00 – 15:30| Tea Break                                                             |
|                   | 15:30 – 17:30| LAB SESSION - IV (Experiments and Lab visits)<br>
*Dr. A. V. Kulkarni and Dr. A. Dutta*<br>
*Computer Centre & Mechatronics Lab* |
<table>
<thead>
<tr>
<th>Date/Day</th>
<th>Slot</th>
<th>Topic</th>
</tr>
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<tbody>
<tr>
<td>Friday, 8 Sept</td>
<td>9:00 – 10:30</td>
<td>Autonomous Control of Variable Pitch Quadrotor Helicopters</td>
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<td><em>Dr. Mangal Kothari</em></td>
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<td><em>PBCEC</em></td>
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<tr>
<td></td>
<td>10:30 – 11:00</td>
<td>Tea Break</td>
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<tr>
<td></td>
<td>11:00 – 12:30</td>
<td>Smart Materials for Sensing and Actuation</td>
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<tr>
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<td><em>Dr. Bishakh Bhattacharya</em></td>
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<td><em>PBCEC</em></td>
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<tr>
<td></td>
<td>12:30 – 13:30</td>
<td>Lunch Break</td>
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<tr>
<td></td>
<td>13:30 – 15:00</td>
<td>Towards Micro Nano Robotics: Manufacturing and Motion Control research</td>
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<td><em>Dr. C.S Kumar</em></td>
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<td><em>PBCEC</em></td>
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<tr>
<td></td>
<td>15:00 – 15:30</td>
<td>Tea Break</td>
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<tr>
<td></td>
<td>15:30 – 17:30</td>
<td>Valedictory Function</td>
</tr>
</tbody>
</table>
SUMMARY of FACULTY FEEDBACK

**Workshop**

1. **Clarity of communication about workshop**

   ![Pie chart showing 100% Excellent rating for communication clarity](chart1.png)

2. **Organization of the sessions**

   ![Pie chart showing 60% Excellent, 40% Good rating for organizational sessions](chart2.png)
3. Quality of Lectures

4. Effectiveness of discussions
5. **Effectiveness of learning experience**

![Pie chart showing effectiveness of learning experience with percentages: 20% excellent, 80% good, 0% ordinary.]

6. **Workshop duration**

![Pie chart showing workshop duration with percentages: 100% appropriate, 0% short, 0% long.]

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**5. Effectiveness of learning experience**

- **Excellent**: 20%
- **Good**: 80%
- **Ordinary**: 0%

**6. Workshop duration**

- **Appropriate**: 100%
- **Short**: 0%
- **Long**: 0%
7. **Would you like to have more such sessions?**

- **Definitely 100%**
- **Maybe 0%**
- **No 0%**

8. **Would you like e-lectures by experts on special topics?**

- **Definitely 100%**
- **Maybe 0%**
- **No 0%**
9. **Suggest Specific topic that you would like additional expert lectures on**
   - Microcontrollers PIC, ATMEL, Embedded systems, AVR Robot programming.
   - Control – from very basic to advanced (for mechanical engg. background)
   - Embedded system, micro controllers.
   - Parallel kinematics, 3D printing.
   - Control: various control strategies/ controller
   - Design: concepts, methods and applications.

10. **Additional Suggestions**
   - Since I am from a CSE background, it would be better if topics related to microcontroller and Embedded System were included.
   - Excellent Program, more time allocate to real time hands on experiments.

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**Teaching**

1. **Do you have additional support for teaching (tutors, graders, teaching, assistants, etc)?**

   ![Pie chart](image-url)
2. Do you give class projects for UG classes?

3. Do you give class projects for PG classes?
4. Do you have sufficient resources for laboratory courses?

5. Is the library/journal/e-connection support adequate?
6. Would you like to have common (TEQIP) repository of course material?

7. Would you like to visit IITK to participate in and develop course material (existing or new)?
8. Would you like to participate in creation of the repository material (course file/lab Manuals/question bank etc.)?

9. How can IITK effectively help you prepare for teaching?
10. **Which Subject do you teach?**
   - Control Systems
   - Robotics metrology
   - Graphics & multimedia, information coding techniques, mobile Computing
   - Operating system, cryptography, C- Programming
   - Robotics Engineering, Machine Design Advanced AD

11. **What is average student to teacher ratio in your institute?**
   - 40:01
   - 15:01

12. **How TEQIP can improve your teaching?**
   - Arrange Workshop & industrial training.
   - STCs, Seminars workshop.
   - Short term course
   - Workshops
Research

1. **Would you like to visit an IIT for a short visit/internship/post-doctoral stint, if offered (via TEQIP)?**

   - Definitely: 100%
   - Maybe: 0%
   - No: 0%

2. **Would you like to share/use research infrastructure at IITK, if made available?**

   - Definitely: 100%
   - Maybe: 0%
   - No: 0%
3. Would you like to conduct collaborative research with IITK faculty?

- Definitely: 80%
- Maybe: 20%
- No: 0%

4. Would you like lectures by experts (Indian and International) on niche research areas/topics?

- Definitely: 100%
- Maybe: 0%
- No: 0%
5. Do you want special-topic conferences?

6. How can TEQIP help improve your research?
   - By organizing special topics based sessions.
   - Lab development.
   - Funds for model and development of robots.
   - Research oriented condition of STCs, seminars, workshops.
   - By attending conference short term course.
   - By resources, e-resources & physical infrastructure.
SUMMARY of STUDENT FEEDBACK

Workshop

1. Clarity of communication about workshop

2. Organization of the sessions
3. **Quality of Lectures**

- Excellent: 83%
- Good: 17%
- Ordinary: 0%

4. **Effectiveness of discussions**

- Excellent: 78%
- Good: 22%
- Ordinary: 0%
5. **Effectiveness of learning experience**

- Excellent: 72%
- Good: 28%
- Ordinary: 0%

6. **Workshop duration**

- Appropriate: 100%
- Short: 0%
- Long: 0%
7. **Would you like to have more such sessions?**

8. **Would you like e-lectures by experts on special topics?**

9. **Suggest specific topic that you would like additional expert lectures on**
   - Nano material applications in solar engineering.
- Non-conventional machining with practice sessions and lectures related to Nanotechnology advances in present and future.
- Fracture mechanics, Atomistic modelling of non-materials, Nanotechnology.
- Advanced Machining Mechanics.
- Further research topics on Robotics.
- Automation.
- May be more on rotor dynamics & mechanism.
- Jacobian Singularity and workshop and control.
- Sensor & Actuator.
- Power System.
- Control System.
- Industry based Robotics.
- Advanced Robots.
- Separate project discussion session.
- Power plant and manufacturing.
- Computational methods (CFD).
- Fracture Mechanics.
- Optimization Techniques.
- Basics of control/strategies for robotics.
- Basics hands on artificial intelligence.
- 3D printer
- Additive manufacturing.
- Thermal Engg related topic

10. **Additional Suggestions**
- Nano-composites - mechanics, polymers, smart materials.
- Generally, all the lecture should covers the basics of course, so that B.Tech pursuing students also understand topic clearly.
- Tell us more about programming & Balancing.
- Please keep more emphases on practical session. (Lab)
- Improve quality of lab session.
- Organize more event just like this.
- Give the experience for production.
- The arrangement of lecture and accommodation was excellent and the staff is very much helpful, so everything is good no more suggestion
- Design and manufacturing.
- Prosthetic & orthotics.
- EMG, ECG, EEG
- Provide study material
- I was happy with the workshop. It would be more beneficial if we got the work in labs for some duration.
1. Do you get enough class projects?

- Yes: 87%
- No: 13%

2. Is the learning adequate?

- Yes: 83%
- No: 17%
3. Do you have sufficient resources for laboratory?

- Yes: 56%
- No: 44%

4. Is the library/journal support/e-connection adequate?

- Sufficient: 87%
- Inadequate: 13%
5. Would you like to have a common (TEQIP) repository of course material?

- Definitely: 94%
- Maybe: 6%
- No: 0%

6. Would you like to visit IITK to attend specialized courses?

- Definitely: 100%
- Maybe: 0%
- No: 0%
7. Would you like MOOCs/e-resources based courses?

8. What is your area of specialization?
   - Production Engineering.
   - Design Engineering.
   - Nanotechnology.
   - Production.
   - Mechanical Engineering.
   - Thermal Engineering.
   - Robotics in Electronics Engineering.
   - Thermal Engineering.
   - Control system.
   - Mechanical Engineering.
   - Robotics.
   - Power plant, Manufacturing.
   - Nano-materials and solar related materials.
   - Manufacturing & Material Science.
   - Machining with WEDM.
   - Robotics, automation, physics based problem solving.
   - Additive manufacturing.
   - Design and manufacturing.
   - Biomedical engineering.
9. **How can TEQIP help improve your learning?**

- Research work becomes easy after learning.
- By focusing on practical experience more.
- Tell us more about the practical.
- Lab session is great weakness please improve lab session.
- By organizing more workshop and internship courses.
- TEQIP to help to give path to come this institute and give knowledge for different field.
- TEQIP increases our knowledge and interest toward robotic and creates awareness regarding our future too.
- Providing much better resources.
- By focusing on practical.
- By providing an interact platform.
- Plan more workshop practical experimentation.
- Yes, it can provide possible support like financial support.
- Due to TEQIP, I realized that there is some kind of support from MHRD to give our contribution to advances India in the field of technology.
- By providing material of related topic.
- Increasing the facilities of laboratories.
- Give a chance to discuss the research going on and given better direction for course.

---

**Research**

1. **Would you like to visit an IIT for a short visit/internship/post-doctoral stint, if offered (via TEQIP)?**

   - Definitely: 100%
   - Maybe: 0%
   - No: 0%
2. Would you like to share/use research infrastructure at IITK, if made available?

- Definitely: 100%
- Maybe: 0%
- No: 0%

3. Would you like to conduct collaborative research with IITK faculty?

- Definitely: 94%
- Maybe: 6%
- No: 0%
4. Would you like lectures by experts (Indian and International) on niche research areas/topics?

5. Do you want special-topic conferences?
6. **How can TEQIP help improve your research?**

- It definitely helps to enhance the research work with high precision.
- By providing an interest platform.
- Lab session is great
- More details can be taught about the research topics.
- TEQIP coordinates the research which we are doing currently and provide ways to improve our research.
- Give us a task related to topic that completed by us in the workshop.
- Provide project based internship for B.Tech Students (last 6 months).
- By giving proper information & organizing seminars.
- From giving opportunity to students under TEQIP program.
- It can give brief idea to how to boost research by making proper selection of topic of interest.
- It can help in collaboration and sharing of resources for effective R&D.
- Providing professor to help in area of specialization.
- By giving permission to do my work in mechanics lab
- Give us task related to topic completed by us in the workshop
- More details can be taught about the research topics.
Feedback

1. Was the theory taught in the workshop complemented by experiments?
   - Yes: 18, No: 02
   - Yes but we did not do any of the experiment, we just saw as demonstrated.
   - No, overall workshop is good & experiments are knowledgeable.
   - Yes, but want more experimentation.
   - Yes, the theory taught in workshop complemented by experiments.
   - Yes, absolutely, especially when I saw the PUMA robot for the first time and also being taught about the same.
   - Some of the theory lectures were complemented by experiments. But some were not which was due to lack of duration or unavailability.
   - Yes, there are some point which are taught otherwise the overall workshop is very good.
   - To some extent.

2. Did the experiments cover the basics of the course?
   - Yes: 17, No:01
   - More or less. The labs were good & interesting
   - Yes, that is more basic and useful for us.
   - Yes, I get overview/ basic of the topics.
   - It covered, but too fast & less time for lab sessions.
   - Yes, but the experiments should be more.
   - No, I want another experiments.
   - Yes, the experiments cover the basics of the course
   - Almost all experiments, but I would have loved if SPARA have been in working position, when I went to the lab.
   - Experiments did the basics of course, but all were only observatory. Not much was given to perform on personal level.
   - Definitely, but still some more days are needed for more and deep understanding of the respective topic.

3. Did you understand the experiments conducted in the laboratory in order to related to robotics?
   - Yes: 21
   - Definitely but it will be more beneficial if experiment conduct in laboratory by participants.
   - Little bit
   - Yes, related to all my research work.
   - Yes, I did. Conducted experiments were understandable but not performed any actually.
• Yes, there are some complex and competed experiments are conducted by the experts which are hardened to understand within such small time span.
• It was useful and I can related it too.

4. Suggestions to improve the laboratory components of the course?
• I think there should be some provision so that the attendance can work of sessions. It makes a difference. Theory is often easily found but the labs are more important and essential.
• Provide more experiment components.
• Increase time of lab.
• Duration for laboratory experiment could be increased, for better understanding of the subject.
• Course will conduct with more experiment & more details about internal parts also.
• Course will conduct with more experiments, which are depend on basic concepts course objective.
• Lab components are outstanding.
• For the 5 days enough the laboratory course.
• Laboratory are quiet good but it needs little bit of more advancement.
• Keep special session for indivisual part such as:
  o Val – 2 programming
  o Interfacing motors & control
  o Pick & place system & industrial robo design
• The practical should be performed by us.
• Laboratory duration should be extended.
• Since you guys have been covering the excellent work for our country, I would just say keep it doing.
• Interfacing of circuits is important and need to be taught in detail. Moreover we could have done a small mini project in workshop days so everyone should have got practical experience.
• More programming sessions.
• Conducting more hands on experiments.
• Basics of electrical & electronics part should be covered. Hands on design & development of any on robot will be helpful to understand the theory part learnt during sessions.
• Add programming skills, related to robotics.
• More embedded C programming to teach basics of ATMEL programming to know about firebird V robot.
OUTCOME

The main objective of this course was to give the participants a broad overview of the field of Robotics through numerous lectures and laboratory sessions. The participants were exposed to following topics:

- Types of robot manipulators
- Manipulator kinematics
- Dynamics and their control
- Singularity and workspace analysis
- Motion planning
- Configuration spaces of mobile vehicles and manipulators
- Geometric modeling and sensor based map building
- Path planning and obstacle avoidance
Report on workshop on ‘Introduction to Robotics’

A TEQIP and QIP joint workshop on ‘Introduction to Robotics’ was held during 4-8 September, 2017 at IIT Kanpur. The main objective of this course is to give the participants a broad overview of the field of Robotics through numerous lectures and laboratory sessions. The lectures covered the essential theory introducing almost all the aspects of the topics related to Robotics. The theory covered was substantiated by numerous demonstrations and hands on experiments through lab sessions. Three plenary/keynote lectures were delivered by the experts on the state-of-the-art research on tailor made robot developments in various fields in the country.

The workshop schedule is carefully designed to keep the pace and flow with the major topics in the field of Robotics. This is achieved through the numerous lectures based on the theme of the day and supporting lab sessions pertaining to the theory covered on that day. Based on the feedback of previous TEQIP sponsored workshops, an introductory lecture on VAL programming was added together with Computer Center and other labs visits.

The various topics covered are: History of robots, types of robot manipulators, manipulator kinematics, dynamics and their control, singularity and workspace analysis, motion planning, configuration spaces of mobile vehicles and manipulators, geometric modeling and sensor based map building, path planning, obstacle avoidance, designing reconfigurable unmanned aerial vehicles, autonomous control of variable pitch quad-rotor helicopters and robot learning by imitation.

On the first day, soon after the brief inauguration of the workshop, Dr. Dutta presented the history and evolution of robotics field. In the second lecture he continued with the explanation of degrees of freedom (dof), types of joints, workspace and spatial representation of manipulators. The third lecture by Dr. Dasgupta started with the rotation and translation transformations, representation of rigid body motion, and development of the basis of D-H parameters useful in frame transformations needed in direct and inverse kinematics. The day was concluded with Dr. Dutta’s lecture on various types of actuators and sensors used for internal and external sensing for close loop control of robots with VAL-II programming language of PUMA 560 industrial robot.

Second day session began with the keynote lecture by Dr. T. Asokan, Professor, IIT Madras, on ‘Design and Control of Field and Service Robots’. It was a motivating talk taking through the research details of the design and development of a trainer Surgical robot, it’s novel ‘Remote Centre of Motion’ design with the technical details of Slave arm, Surgical tool, Master arm and its Controller. Then he continued presenting the ‘Design of a novel
Quadrotor’ using patented vertical offset overlapping propellers (VOOP) concept, its mathematical modeling and measurements and controller design. He concluded his talk highlighting the experimental studies. Through second and third lecture, Dr. Dasgupta continued building the basic concepts of Jacobian, singularity, workspace and Newton-Euler and Euler-Lagrange formulation equations and trajectory planning notions of manipulator dynamics. The last lecture of the day was focused on the Vision topic. Dr. K. S. Venkatesh presented the introduction to vision and imaging theory, high speed shape estimation and gesture recognition using kinnect vision system followed by hands-on imaging programming using MATLAB. During this session, he and his students interactively conducted a tutorial on 3d sensor capture and recognition through reading the image, color segmentation, processing the image morphologically, use of Hough transformation, and silhouette based image reconstruction, etc.

The third day’s proceedings started with the second plenary lecture on ‘Robotics in BARC’ by Dr. T. Dwarkanath, Professor, Bhabha Atomic Research Centre Trombay, Mumbai. He presented the technical details of the variety of robots developed by BARC for specific uses at various stages in nuclear fuel cycle (NFC). BARC being the highest user of robotics in India, he explained the research and development of three piece Master-slave manipulator for hot cell operations, 6- axes joint-less hexapod as Force-Torque sensor, cooperative robots, single drive multi degree of freedom PSS based parallel mechanism, high precision beam alignment system for high vacuum synchrotron, and neuro surgical suite with surgical CMM, stereotactic frame, neuro navigation system, neuro visualization and the manipulator for surgery. The second lecture by Dr. Dasgupta covered the topics related to motion planning. Starting with problem statement to generate a path specifying a continuous sequence of positions and orientations of the robot, he went on building the mathematical formulation and the deterministic and probabilistic methods to solve the problem. He explained roadmap methods, cell decomposition methods, potential field methods as the deterministic methods, and probabilistic methods of planning a path for the manipulator with collision avoidance. At the end of the lecture he compared the techniques and presented the extension of the basic path planning problem. Post lunch lecture was an interactive session on the theory and problem solving of concepts in Basic control theory by Dr. Sahu. For the Laboratory session, the participants were divided in two groups. One group of students visited centre for Mechatronics for experiments on stepper motor control with and without Arduino, stepper motor interface using advanced motion control card with LabVIEW platform, motion parameter settings using measurement and automation utility (MAX) of LabVIEW and motion programming, interfacing of Force-sensing resistor (FSR) using data acquisition card (myDAQ) and its programming, study of quadrature encoder and DC servo motor control using Adruino interrupts, ultrasonic and IR sensor & PWM control and VAL-II language programming of PUMA robot. The other group participants were taken to visit the Computer Centre and Intelligent Systems Lab and Solar Energy Research Enclave. In the late evening workshop dinner was arranged to have informal discussions.

First lecture on fourth day by Dr. Abhishek was about ‘Reconfigurable Unmanned Aerial Vehicle –Design and Control’. The lecture elaborated on the step by step design procedure (propeller selection, motor selection, span of tilting wing segment, airfoil selection, wing sizing and integration of prototype) of a novel quadrotor convertiplane VTOL UAV with high
efficiency for efficient forward flight. The concept of ‘Navigation for Autonomous Aerial Vehicles by IIT Kanpur’ (NAAVIK), the first multi-platform auto-pilot developed in India, was also mentioned. In the consecutive session, participants visited the Flight laboratory situated at the airstrip. With a brief presentation on the structural design and development of a mini helicopter, its test bed for performance measurements and control, field demonstration of the flying autonomous helicopter was given. The next lecture was on an advanced topic about ‘Robot Learning by Imitation’ by Mr. Samrat Dutta elaborating on the mathematics evolved in different approaches used for learning. At the end of the day, laboratory sessions were as per the third day with flipped groups.

The schedule of fifth day started with a lecture on ‘Autonomous Control of Variable Pitch Quadrotor Helicopters’ by Dr. Mangal Kothari. Through this lecture, participants got the details of how the control has been designed for the quadrotor helicopter, whose flight was witnessed the previous day on the airstrip of flight laboratory during Lab session III. Dr. Kothari explained the theory and necessary mathematical background for achieving the control in normal course of flight and in reversal mode i.e. with negative thrust. Localization, sensor parameters, and rotor dynamics, etc. have been covered while discussing the control of quadrotor helicopter. The second lecture delivered by Dr. B. Bhattacharya was on ‘Smart Materials for Sensing and Actuation’. The topics covered are: Application of Smart Materials, Smart systems using Smart Materials, Smart Actuators, Direct and Reverse Effects, Shape Memory Effect, Self-Healing with applications such as: Vibration and Chatter Control, Shape Control, Micro-Positioning Devices, Distributed Sensing, Energy Harvesting for Wireless Sensor Networks. He concluded the lecture with future scope and advancement of Smart Polymers. Post lunch the third plenary lecture was delivered by Dr. C.S. Kumar, Professor, IIT Kharagpur on ‘Towards Micro Nano Robotics: Manufacturing and Motion Control research @ IIT Kharagpur’. While elaborating on the research activities of Robotics and Mechatronics across scales, he presented the design details of Underwater Robot, 22 dof Humanoid Robot, Robotic Hands in Medical Applications and Advanced Manufacturing for micro and nano systems (micromanipulator for use in microscopy).

The workshop was concluded with a valedictory function conducted by Dr. A. Dutta, where participants were requested to share their experience about the workshop. Certificates were presented to participants by our guest lecturer Prof. C. S. Kumar.

Thanks are due to the TEQIP and QIP IIT Kanpur cells and their teams. With their active support, the workshop turned out to be a successful academic event and nice learning experience.