

# Abubakr Muhammad

Assistant Professor of Electrical Engineering  
Director CYPHYNETS (Laboratory for **Cyber-Physical Networks and Systems**)  
LUMS School of Science and Engineering, Pakistan

## Bio

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- **Date of Birth:** December 19, 1976   **Nationality:** Pakistan   **Marital Status:** Married
- **Current Address :** LUMS SSE, Sector U, DHA, Lahore Cantt 54792, Pakistan
- **Tel:** +92(42) 3560 8132   **Email:** abubakr@lums.edu.pk  
**URL:** <http://cyphynets.lums.edu.pk>

## Research Interests

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- **Disciplines:** applied mathematics; systems engineering
- **Focus Areas:** cyber physical systems; robotics; hydro-systems; physics of information

## Education

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- **PhD in Electrical Engineering, Georgia Institute of Technology, USA**      *2005*  
Dissertation topic: *Graphs, simplicial complexes and beyond: Topological tools for multiagent coordination*. Winner of Sigma-Xi Best PhD thesis award 2006
- **MS in Mathematics, Georgia Institute of Technology, USA**      *2005*  
Concentration in topology and geometry
- **MS in Electrical & Computer Engineering, Georgia Institute of Technology**      *2002*  
Concentration in signal processing, communications and control
- **BSc in Electrical Engineering, UET, Lahore, Pakistan**      *2000*  
Thesis title: *Synchronized chaos for secure communication*

## Academic appointments

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- **Assistant Professor of Electrical Engineering**      *Nov 2008–present*  
LUMS School of Science & Engineering, Pakistan
- **Acting Head of Electrical Engineering Department**      *April 2009–Feb 2010*  
LUMS School of Science & Engineering, Pakistan
- **Postdoctoral Research Fellow**      *Nov 2007–Nov 2008*  
Quantum Information Processing Group *and*  
Center for Intelligent Machines (CIM), McGill University, Canada
- **Postdoctoral Researcher**      *Jan 2006–June 2007*  
General Robotics, Sensing & Perception Lab (GRASP),  
University of Pennsylvania, Philadelphia, PA, USA
- **Research Assistant**      *Aug 2001–Dec 2005*  
Center for Research in Embedded Systems (CREST),  
Georgia Institute of Technology, Atlanta, GA, USA

## Visiting Positions

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- **Jr Associate Member** *2011-2016*  
International Center for Theoretical Physics, ICTP, Trieste, Italy
- **Visiting Researcher** *July 2012*  
Dept of Electrical Engineering, University of Melbourne, Australia
- **Visiting Researcher** *June 2012, June 2013*  
Robotics Research Lab, TU Kaiserslautern, Germany
- **Visiting Assistant Professor of Mechanical Engineering** *2011*  
Division of Physical Sciences & Engineering, KAUST, Saudi Arabia
- **Visiting Researcher** *July 2010*  
Automatic Control Laboratory, ETH-Zurich, Switzerland
- **Visiting Scientist** *July 2007–Oct 2007*  
School of Science & Engineering, LUMS, Lahore, Pakistan
- **Visiting Researcher** *Dec 2005–Jan 2006*  
School of Mathematical Sciences, GCU, Lahore, Pakistan
- **Visiting Researcher** *Dec 2004*  
Department of Mathematics, Stanford University
- **Visiting Researcher** *June 2004*  
Department of Mathematics, University of Illinois, Urbana-Champaign

## Industry Experience

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- **Research Scientist** *May 2002–July 2002*  
Advanced Engineering Research Organization (AERO), Pakistan
- **Design Engineer** *March 2000–July 2001*  
And Or Logic (pvt) Ltd, Islamabad, Pakistan

## Publications

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### Book

1. “Graphs, Simplicial Complexes and Beyond: Topological Tools for Multiagent Coordination,” VDM Verlag, Saarbrücken, Germany, 2008.

### Journal Articles

2. Kamil Bradler, Nicolus Dutil, Patrick Hayden and **Abubakr Muhammad**, “Conjugate Degradability and the Quantum Capacity of Cloning Channels,” *Journal of Mathematical Physics*, Vol. 51, Issue 7, 2010.
1. **Abubakr Muhammad** and Magnus Egerstedt, “Connectivity Graphs as Models of Local Interactions,” *Journal of Applied Mathematics and Computation*, Vol. 168, Issue 1, September 2005, Pages 243–269.

### Book Chapters

5. Zahoor Ahmad, Ehsan U. Asad, **Abubakr Muhammad**, Waqas Ahmad and Arif Anwar, “Development of a Low-Power Smart Water Meter for Discharges in Indus Basin Irrigation Network”, *Wireless Sensor Networks for Developing Countries*, Springer Communications in Computer and Information Science (CCIS), Volume 366, 2013.

4. **Abubakr Muhammad** and Ali Jadbabaie, "Dynamic coverage verification in Mobile Sensor Networks Via Switched Higher Order Laplacians," in Oliver Broch, (Editor), *Robotics: Science and Systems*, MIT Press, 2007.
3. **Abubakr Muhammad** and Ali Jadbabaie, "Asymptotic Stability of switched higher order Laplacians and dynamic coverage", in Alberto Bemporad, Antonio Bicchi and Giorgio Buttazzo (Editors), *Hybrid Systems: Computation and Control*, Springer Lecture Notes in Computer Science (LNCS), 2007.
2. **Abubakr Muhammad**, Meng Ji and Magnus Egerstedt, "Applications of Connectivity Graph Processes in Networked Sensing and Control," *Networked Embedded Sensing and Control*, Springer Lecture Notes in Control and Information Sciences (LNCIS), 2006.
1. **Abubakr Muhammad** and Magnus Egerstedt, "Decentralized Coordination With Local Interactions: Some New Directions," *Cooperative Control*, Springer Lecture Notes in Control and Information Sciences (LNCIS), Vol. 309, 2005.

#### Peer-Reviewed Conference Papers

32. Hamza Anwar, Syed Muhammad Abbas, **Abubakr Muhammad**, Karsten Berns, "Volumetric Estimation of Contained Soil using 3D Sensors", 3rd International Commercial Vehicle Technology Symposium (CVT), Kaiserslautern, Germany, 2014.
31. Talha Manzoor and **Abubakr Muhammad**, "Disparity as a Separate Measurement in Monocular SLAM", IEEE International Conference on Robotics and Biomimetics (Robio), Shenzhen, China, December 12 - 14, 2013.
30. Usama bin Sikandar and **Abubakr Muhammad**, "Modeling and Simulation of Surface-and-dive Behavior of a Bottlenose Dolphin," IEEE International Conference on Robotics and Biomimetics (Robio), Shenzhen, China, December 12 - 14, 2013.
29. Syed Muhammad Abbas, **Abubakr Muhammad**, Syed Atif Mehdi and Karsten Berns, "Improvements in Accuracy of Single Camera Terrain Classification", 16th International Conference on Advanced Robotics (ICAR), Montevideo, Uruguay, November 25-29th, 2013.
28. Zahoor Ahmad and **Abubakr Muhammad**, "Design, Calibration and Performance of a Low-Power Wireless Sensor Node for Open Channel Flows", 39th Annual Conference of the IEEE Industrial Electronics Society (IECON), Vienna, Austria, 2013.
27. Talal Ahmed, Momin Uppal, and **Abubakr Muhammad**, "Improving Efficiency and Reliability of Gunshot Detection Systems", 38th IEEE International Conference on Acoustics, Speech, and Signal Processing (ICASSP), Vancouver, Canada, May 26 - 31, 2013.
26. Zaeem Hussain and **Abubakr Muhammad**, "Sample size reduction in groundwater surveys via sparse data assimilation," IEEE International Conference on Networking, Sensing and Control (ICNSC), Paris-Evry University, France 2013.
25. Hasan Nasir and **Abubakr Muhammad**, "Locating Leaks & Dumps in Open Channels with Minimal Sensing," IEEE Conference on Control Applications (CCA), Dubrovnik, Croatia 2012.
24. **Abubakr Muhammad**, "Optimal Simplex Distribution in Homological Sensor Networks," *Mathematical Theory of Networks and Systems (MTNS)*, Melbourne, Australia, 2012.
23. Talha Manzoor, Adnan Munawar and **Abubakr Muhammad**, "Visual Servoing for Landmine Detecting Robot Marwa", 7th German Conference on Robotics (Robotik), Munich, Germany, 2012.
22. Syed M. Abbas and **Abubakr Muhammad**, "Outdoor RGB-D SLAM Performance in Slow Mine Detection", 7th German Conference on Robotics (Robotik), Munich, Germany, 2012.

21. Muhammad Umer Tariq, Hasan Arshad Nasir, **Abubakr Muhammad** and Marilyn Wolf, "Model-Driven Performance Analysis of Large Scale Irrigation Networks." ACM/IEEE International Conference on Cyber Physical Systems (ICCPS), Beijing, China, 2012.
20. Hasan Nasir and **Abubakr Muhammad**, "Feedback Control of Very-Large Scale Irrigation Networks: A CPS Approach in a Developing-World Setting." 18th World Congress of International Federation of Automatic Control (IFAC), Milano, Italy, 2011.
19. Mhequb Hayat and **Abubakr Muhammad**, Spectral Properties of Expansive Configuration Spaces: An Empirical Study. IEEE International Conference on Robotics and Automation (ICRA 2011), Shanghai, China. May 9-13, 2011.
18. Ishtiaq Maqsood, Hasan Nasir and **Abubakr Muhammad**, PID Controller Tuning for Network Delayed Motion Control. International Conference on Communications, Computing and Control Applications (CCCA11), Hammamet, Tunisia, March 3-5, 2011.
17. Mhequb Hayat and **Abubakr Muhammad**, "Spectral Metrics for Expansive Configuration Spaces", The Ninth International Workshop on the Algorithmic Foundations of Robotics (WAFR), Singapore, 13-15 Dec 2010.
16. **Abubakr Muhammad**, Distributed Electrical Power Distribution Using Evolutionary Variational Inequalities, Mathematical Theory of Networks and Systems (MTNS), Budapest, Hungary, 2010.
15. Hassan Mohy-ud-Din and **Abubakr Muhammad**, "Detecting Narrow Passages in Configuration Spaces Via Spectra of Probabilistic Roadmaps", ACM Symposium on Applied Computing, Sierre, Switzerland, 2010.
14. **Abubakr Muhammad**, "Sensor Selection and Motion Planning in Robotic Sensor Networks Under Communication Constraints", Control and Decision Conference (CDC), 2008.
13. **Abubakr Muhammad** and Ali Jadbabaie, "Decentralized Computation of Homology Groups in Networks by Gossip", American Control Conference, 2007.
12. **Abubakr Muhammad** and Magnus Egerstedt, "Control Using Higher Order Laplacians in Network Topologies," Mathematical Theory of Networks and Systems, Kyoto, Japan, 2006.
11. **Abubakr Muhammad** and Magnus Egerstedt, "Network Configuration Control Via Connectivity Graph Processes," American Control Conference, Minneapolis, 2006.
10. Meng Ji, **Abubakr Muhammad** and Magnus Egerstedt, "Leader-Based Multi-Agent Coordination: Controllability and Optimal Control," American Control Conference, Minneapolis, 2006.
9. **Abubakr Muhammad** and Magnus Egerstedt., "Positivstellensatz Certificates For Feasibility Of Connectivity Graphs In Multi-Agent Formations," 16th IFAC World Congress, Prague, July 4-8, 2005.
8. Vin de Silva, Robert Ghrist and **Abubakr Muhammad**, "Blind Swarms for Coverage in 2-D," Robotics: Science and Systems, Massachusetts Institute of Technology, Cambridge, MA, June 8-11, 2005.
7. Robert Ghrist and **Abubakr Muhammad**, "Coverage And Hole-Detection In Sensor Networks Via Homology," The Fourth International Conference on Information Processing in Sensor Networks (IPSN'05), UCLA, Los Angeles, CA, April 25-27, 2005.
6. **Abubakr Muhammad** and Magnus Egerstedt, "Connectivity Graphs as Models of Local Interactions," IEEE Conference on Decision and Control, Bahamas, December 2004.

5. **Abubakr Muhammad** and Magnus Egerstedt, "On The Structural Complexity Of Multi-Agent Robot Formations," American Control Conference, Boston, Massachusetts, USA, July 2004.
4. **Abubakr Muhammad** and Magnus Egerstedt, "Topology And Complexity Of Formations," in Proceedings of 2nd International Workshop on the Mathematics and Algorithms of Social Insects, Atlanta, Georgia, USA, December 15-17, 2003.
3. Henrik Axelsson, **Abubakr Muhammad**, and Magnus Egerstedt, "Autonomous Formation Switching For Multiple, Mobile Robots," in Proceedings of IFAC Conference on Analysis and Design of Hybrid Systems, Sant-Malo, Brittany, France, June 2003.
2. Magnus Egerstedt, **Abubakr Muhammad**, and X. Hu, "Formation Control Under Limited Sensory Range Constraints," in Proceeding of 10th Mediterranean Conference on Control and Automation, Lisbon, Portugal, July 2002.
1. **Abubakr Muhammad**, Biological Receptive Fields for Motion Detection, FAST-IEEE Student Conference on CS and IT, FISC' 98, Lahore, Pakistan, 1998.

### Presentations/Invited Talks/Seminars (Selected)

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|---|------------|
| ○ Conference on Water for Food Security: Challenges for Pakistan, Islamabad   | Dec 2013   |
| ○ Institute of Robotics & Mechatronics, German Aerospace Center (DLR), Munich | July 2013  |
| ○ IEEE Int. Conference on Networked Sensing & Control (ICNSC), Paris          | April 2013 |
| ○ IEEE Multi-conference on Systems and Control (MSC), Dubrovnik, Croatia      | Oct 2012   |
| ○ Mathematical Theory of Networks and Systems (MTNS), Melbourne, Australia    | July 2012  |
| ○ Department of Electrical Engineering, University of Melbourne, Australia    | July 2012  |
| ○ Hydrometry & control for distributory canals, PMIU, Punjab Irrigation Dept  | Feb 2012   |
| ○ CIMPA Workshop on Uncertainty Quantification, KAUST, KSA                    | Jan 2012   |
| ○ IEEE International Conference on Robotics & Automation (ICRA), Shanghai     | May 2011   |
| ○ SimIndus: Modeling the Indus Basin, Planning Commission, Islamabad          | April 2011 |
| ○ National Symposium on Quantum Information (NSQIP), Islamabad                | April 2011 |
| ○ Mathematical Theory of Networks and Systems (MTNS), Budapest, Hungary       | July 2010  |
| ○ ACM SAC 2010, Sierre, Switzerland   | March 2010 |
| ○ International Scientific Spring (ISS), NCP, Islamabad                       | March 2010 |
| ○ Department of Computer Science, Stanford University                         | Aug 2008   |
| ○ 7th McGill-INRIA Workshop on Computational geometry, Barbados               | Jan 2008   |
| ○ Decision and Control Seminar, CSL, UIUC                                     | Nov 2006   |
| ○ Mathematical Theory of Networks and Systems (MTNS), Kyoto, Japan            | July 2006  |
| ○ Systems and Controls Seminar, Georgia Tech                                  | April 2006 |
| ○ Networked Enabled Sensing and Control (NESC), Notre Dame                    | Sept 2005  |
| ○ GRASP Lab Seminar, University of Pennsylvania, Philadelphia, PA             | Sept 2005  |

- Department of Mathematics, Georgia Institute of Technology, Atlanta, GA July 2005
- Information Processing in Sensor Networks (IPSN), Los Angeles, CA Apr 2005
- Stanford University Topology Seminar, Palo Alto, CA Dec 2004
- 43rd Control and Decision Conference, Bahamas Dec 2004
- American Mathematical Society (AMS) Sectional Meeting, Evanston, IL Oct 2004
- American Control Conference, Boston, MA July 2004
- 2nd Workshop on Mathematics and Algorithms of Social Insects, Atlanta, GA Dec 2003

**Research Funding Won [Total. \$752,000 / 5 years]**

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| 15. Robotic Profiling for Clearing Watercourses (RoPWat), 2014-16<br>DAAD Grant with University of Kaiserslautern, Germany (PI)  | \$110,000 |
| 14. Options for effective water governance in Pakistans IBIS (WatGov), 2013-14<br>International Water Management Institute (IWMI), Pakistan Office (PI)  | \$25,000  |
| 13. IIASA-Pakistan collaboration, 2012-13<br>Planning Commission, Government of Pakistan (co-PI)   | \$130,000 |
| 12. Self Assembly of Hexagonal Structures, 2013-14<br>Higher Education Commission (HEC), Pakistan (co-PI)  | \$17,000  |
| 11. Energy Autarkic and Autonomous Wireless Sensor System for Real Time Monitoring of Large Scale Waterways, 2013-15<br>DAAD Grant with University of Applied Sciences, Offenburg, Germany (co-PI) | \$110,000 |
| 10. Revitalizing Irrigation in Pakistan, 2012-2014<br>International Water Management Institute (IWMI), Pakistan Office (PI)  | \$110,000 |
| 9. Hydrodynamic Data Assimilation for Contamination Monitoring, 2012-2014<br>Environment Protection Agency (EPA), Govt of Punjab (PI)  | \$25,000  |
| 8. Autonomous Land Vehicles for Agriculture and Demining, 2011-13<br>DAAD Grant with TU Kaiserslautern, Germany (PI)   | \$110,000 |
| 7. Testbed for Smart Water Grids, 2012<br>LUMS FIF grant (PI)  | \$6,500   |
| 6. Workshop Organization on Cyber Physical Systems, 2011.<br>IEEE Control Systems Society (CSS) Outreach Fund (PI)   | \$10,000  |
| 5. Acoustic tracking of Indus river Dolphins, 2010-12<br>World Wildlife Fund (WWF), Pakistan (PI)  | \$10,000  |
| 4. Mine detection robotics, 2010-11<br>National Instruments, Arabia Division (PI)  | \$38,500  |
| 3. 3D Terrain mapping for robotics, 2010-11<br>LUMS FIF Grant (co-PI)  | \$10,000  |
| 2. Unmanned ground robotics, 2010-11<br>LUMS FIF Grant (PI)  | \$10,000  |
| 1. Research startup, 2008-11<br>LUMS Faculty Grant (PI)  | \$30,000  |

## Teaching Experience

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- EE-562 / CMPE-633a, *Robot Motion Planning* [28#] LUMS Fall 2010, Spring 2014
- EE-561, *Digital Control Systems* [48#] LUMS Fall 2013
- EE-662, *Parameter & State Estimation* [8#] LUMS Spring 2013
- CS-xxx, *Mobile Robotics (3-week Module on SLAM)* [20#] TUKL Summer 2012,-13
- CMPE-633c, *Geometric Mechanics & Control* [12#] LUMS Spring 2012
- CMPE-633b, *Robot Dynamics & Control* [20#] LUMS Fall 2011
- ME-410, *Probabilistic Robotics* [10#] KAUST Summer 2011
- MATH-522, *Adv. Graph Theory (4-week Module on Graph Spectra)* [10] LUMS Spring 2010,-14
- EE-361: *Feedback Control Systems* [110#, 2 Sections] LUMS Spring 2010,-11,-12, -13, -14
- EE-361L: *Feedback Control Systems Lab* [110#, 4 Sections] LUMS Spring 2011,-12, -13, -14
- EE-210: *Signals and Systems* [110#, 2 Sections] LUMS, Spring 2010,11
- EE-241: *Introductory Electronics Laboratory* [120#, 4 Sections] LUMS, Fall 2009,-10
- Bio-103: *Freshman Biology (2-week Module on Systems Biology)* [160] LUMS, Spring 2009,-10
- CS-683: *Information theory* [8#] LUMS, Spring 2009
- COMP-208: *Computers for Engineering* [45#] McGill, Winter 2008
- Reading Gp. *Computational topology* (Lead) McGill, Winter 2008
- ECE-6553: *Optimal Control* (Teaching Assistant) Georgia Tech, Spring 2005
- ECE-6550: *Linear Control Systems* (Teaching Assistant) Georgia Tech, Fall 2005

## Graduate Research Supervision Experience

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- Talha Manzoor. PhD (EE) thesis  
*Optimal Control of Resource Networks.* LUMS, 2013-present
- Syed Muhammad Abbas. PhD (EE) thesis  
*3D Perception & Navigation in Mobile Robots.* LUMS, 2013-present
- Mudassir Khan. PhD (EE) thesis  
*Stochastic Control for Outdoor Exploration.* LUMS, 2012-present
- Zaeem Hussein. MS (CS) thesis  
*Sparse Data Assimilation for Groundwater models* LUMS, 2011-12
- Maryam Javed. MS (EE) thesis  
*Data Assimilation of Contamination Surveys in Hydrodynamic Models* LUMS, 2012-13
- Faiz Alam. MS (CMPE) thesis  
*WiFi Signal Strength Based Robot Localization and Mapping.* LUMS, 2011-13
- Bilal Talat. MS (EE) thesis  
*Visual Servoing of a Landmine-Detecting mobile Manipulator* LUMS, 2012-13
- Talha Manzoor. MS (CMPE) thesis  
*Vision based SLAM algorithms for Unmanned ground vehicles.* LUMS, 2011-13

- Syed Muhammad Abbas. MS (CS) thesis  
*Performance Metrics for Low-cost Field Robots.* LUMS, 2011-13
- Hasan Arshad Nasir. MS (CMPE) thesis  
*Cyber-Physical Control for Large-scale Irrigation Networks* LUMS, 2009-11
- Mhequb Hayat MS (CMPE) thesis  
*Spectral Analysis of Probabilistic Roadmaps* LUMS, 2009-11

## **Awards and Honors**

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- Lead winning team, National Instruments Mine Detection Robot Design contest (2011).
- Selected as Jr Associate Member for ICTP, Trieste Italy (2011-2016)
- Award for Outstanding Service to EE program (2008-2010 at LUMS)
- Sigma Xi Best PhD thesis award (all science & engineering disciplines at Georgia Tech, 2006)
- Gold medalist, SSC examination (1/150,000 candidates in Lahore Board, 1992)
- Silver medalist, HSSC examination (2/74,000 candidates in Lahore Board, 1994)
- National Talent Scholarship recipient, 1990, 1992, 1994, 1995-2000

## **Professional Services**

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- Conference Secretary & Principal organizer, Four day International Workshops on Intelligent Water Grids (IWG), LUMS, 2013.
- co-Chair organizing committee, Five Workshops on Field & Assistive Robotics (WFAR), Lahore/Dagstuhl, Fa2011, Su2012, Fa2012, Su2013, Fa2013.
- Convener, Graduate Program Committee, Dept of Electrical Engineering, LUMS (2013-present)
- Convener, University Research Council, LUMS, 2013.
- Vice President Academics, IEEE Control Systems Society Pakistan chapter (2011-present).
- Secretary NMO, IIASA-Pakistan Collaboration (2012-present).
- Member program committee : First International Conference on Robot Communication and Coordination (Robocomm 2007), Athens, Greece.
- Member program committee : Second International Conference on Robot Communication and Coordination (Robocomm 2009), Odense, Denmark.
- Member, organizing committee, Eighth Canadian Summer School on Quantum Information, Montreal, 2008.
- Graduate-track Coordinator for Georgia Tech Robotics Initiative Workshop 2003
- Reviewer for IEEE Transactions on Automatic Control, IEEE transactions on Robotics, IEEE transactions on Information theory, Automatica.
- Reviewer for various conferences and workshops (CDC, ACC, CAA, RSS, ICRA, SODA).
- Member IEEE since 1995.
- Member American Mathematical Society (AMS).
- Member Society for Industrial and Applied Mathematics (SIAM).



## References

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- Dr Magnus Egerstedt, Associate Professor, School of Electrical & Computer Engineering, Georgia Institute of Technology, Atlanta, GA (PhD Adviser) [magnus@ece.gatech.edu](mailto:magnus@ece.gatech.edu)
- Dr Ali Jadbabaie, Assistant Professor, Department of Electrical and Systems Engineering, University of Pennsylvania, Philadelphia, PA (Postdoc supervisor) [jadbabai@seas.upenn.edu](mailto:jadbabai@seas.upenn.edu)
- Dr Asad Ali Abidi, Professor, Department of Electrical Engineering, University of California, Los-Angeles (Former Dean LUMS-SSE) [abidi@ee.ucla.edu](mailto:abidi@ee.ucla.edu)
- Dr Shahid Masud, Associate Professor & Chair, Department of Electrical Engineering, LUMS, Pakistan [smasud@lums.edu.pk](mailto:smasud@lums.edu.pk)