

Abubakr Muhammad

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

Bio

- **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)572 2670 **Email:** abubakr@lums.edu.pk
URL: <http://cyphynets.lums.edu.pk>

Research Interests

- **Disciplines:** applied mathematics; systems engineering; applied physics
- **Focus Areas:** networked sensing & control; computational geometry & topology; quantum information sciences; robotics; feedback control systems; cyber-physical systems for third-world development;

Education

- **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

- **Assistant Professor of Electrical Engineering** *Dec 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

Industry Experience

- **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

Visiting Positions

- **Visiting Researcher** *July 2010*
Automatic Control Laboratory, ETH-Zurich, Switzerland
- **Visiting Scientist in Physics** *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

Publications

Books

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

Journal Articles

1. **Abubakr Muhammad**, “Can You Hear the Shape of a Network?” ACM Transactions on Sensor Networks (Submitted)
2. **Abubakr Muhammad** and Magnus Egerstedt, “Feasibility, Reachability and Optimal Control of Connectivity Graph Processes,” SIAM Journal on Control and Optimization. (Under revision)
3. Kamil Bradler, Niculus Dutil, Patrick Hayden and **Abubakr Muhammad**, “Conjugate Degradability and the Quantum Capacity of Cloning Channels,” Journal of Mathematical Physics, Vol. 51, Issue 7, 2010.
4. **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

1. **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.
2. **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.

3. **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.
4. **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.

Conference Papers

1. Hasan A. Nasir and **Abubakr Muhammad**, “Feedback Control of Open Channel Flows: A Cyber-Physical Systems Approaches towards Managing Irrigation Networks.” (Submitted)
2. Ishtiaq Maqsood, Hasan A. Nasir and **Abubakr Muhammad**, “PID Controller Optimization in the Presence of Network Delays.” (Submitted)
3. Mhequb Hayat and **Abubakr Muhammad**, “Spectral Analysis of Probabilistic Roadmaps.” (Submitted)
4. **Abubakr Muhammad**, Distributed Electrical Power Distribution Using Evolutionary Variational Inequalities, Mathematical Theory of Networks and Systems (MTNS), Budapest, Hungary, 2010.
5. 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.
6. **Abubakr Muhammad**, “Sensor Selection and Motion Planning in Robotic Sensor Networks Under Communication Constraints”, Control and Decision Conference (CDC), 2008.
7. **Abubakr Muhammad** and Ali Jadbabaie, “Decentralized Computation of Homology Groups in Networks by Gossip”, American Control Conference, 2007.
8. **Abubakr Muhammad** and Magnus Egerstedt, “Control Using Higher Order Laplacians in Network Topologies,” Mathematical Theory of Networks and Systems, Kyoto, Japan, 2006.
9. **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.
11. **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.
12. 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.
13. 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.
14. **Abubakr Muhammad** and Magnus Egerstedt, “Connectivity Graphs as Models of Local Interactions,” IEEE Conference on Decision and Control, Bahamas, December 2004.
15. **Abubakr Muhammad** and Magnus Egerstedt, “On The Structural Complexity Of Multi-Agent Robot Formations,” American Control Conference, Boston, Massachusetts, USA, July 2004.

16. **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.
17. 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.
18. 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.
19. **Abubakr Muhammad**, Biological Receptive Fields for Motion Detection, FAST-IEEE Student Conference on CS and IT, FISC' 98, Lahore, Pakistan, 1998.

Research Funding / Grants

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|----------------------------------------------------------------------------------|----------|
| ○ Research startup, 2008-11
LUMS Faculty Grant (PI) | \$30,000 |
| ○ Unmanned ground robotics, 2010-11
LUMS FIF Grant (PI) | \$10,000 |
| ○ Mine detection robotics, 2010-11
National Instruments, Arabia Division (PI) | \$30,000 |
| ○ 3D Terrain mapping for robotics, 2010-11
LUMS FIF Grant (co-PI) | \$10,000 |
| ○ Gunshot localization, 2010-11
Zephyr Textiles, Pakistan (PI) | \$10,000 |
| ○ Acoustic tracking of Indus river Dolphins
WWF Pakistan (PI) | \$10,000 |

Teaching Experience

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|--------------------------------------------------------------------------------|---------------------------|
| ○ Lecturer, CMPE-633, <i>Topics in Robotics and Control</i> | LUMS Fall 2010 |
| ○ co-Lecturer, MATH-522, <i>Advanced Graph Theory</i> | LUMS Spring 2010 |
| ○ Lecturer, CMPE-432: <i>Feedback Control Design</i> | LUMS Spring 2010 |
| ○ Lecturer, EE-210: <i>Signals and Systems</i> | LUMS, Spring 2010 |
| ○ Lead Instructor, EE-241: <i>Introductory Electronics Laboratory</i> | LUMS, Fall 2009-10 |
| ○ co-Lecturer, Bio-103: <i>Freshman Biology (Systems Biology Module)</i> | LUMS, Spring 2009-10 |
| ○ Lecturer, CS-683: <i>Information theory</i> | LUMS, Spring 2009 |
| ○ Lecturer, COMP-208: <i>Computers for Engineering</i> | McGill, Winter 2008 |
| ○ Reading gp. lead, <i>Computational topology in Science & Engineering</i> | McGill, Winter 2008 |
| ○ Teaching assistant, ECE-6553: <i>Optimal Control</i> | Georgia Tech, Spring 2005 |
| ○ Substitute lecturer, ECE-6550: <i>Linear Control Systems</i> | Georgia Tech, Fall 2005 |

Presentations/Invited Talks/Seminars (Selected)

- 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 Supervision Experience

- Mohiqab Hayat. MS (CMPE) thesis / RA
Spectral Analysis of Probabilistic Roadmaps LUMS, 2009-
- Hasan Arshad Nasir. MS/PhD (CMPE) thesis / RA
Cyber-Physical Control for Large-scale Irrigation Networks LUMS, 2009-
- Suleman Sami Qazi. Co-supervisor, MS (EE) thesis
Ground based Tracking and Estimation of Satellites UET, 2008-09
- Talha Manzoor. Full-time research assistant.
SLAM algorithms for Unmanned ground vehicles. LUMS, 2010-
- Shahzad Bhatti. Full-time research assistant.
Evolutionary Variational Inequalities for Power Grids LUMS, 2009
- Talat Nazir. Full-time research assistant.
Numerical Modeling and Control for Open Channel Irrigation Networks LUMS, 2009-10.
- Rabi Javed, Saad Qasim, Ali Ahmed. BSc. (CMPE) thesis
Dynamic Wireless Networking In Multi-Agent Robotics LUMS, 2009-10
- Zubair Ahmad, Syed Atif Adnan, Farhan Ateeq, Hassan Mohy-ud-Din, Ishtiaq Maqsood.
Lab Engineers LUMS, 2009-10
- Dana Mendelson. Undergraduate summer research.
Efficient Quantum Compilation McGill, 2008

Awards and Honors

- Award for Outstanding Service to EE program (2008-2010), LUMS
- Sigma Xi Best PhD dissertation award from Georgia Tech for the year 2006
- Graduate-track Coordinator for Georgia Tech Robotics Initiative Workshop 2003
- Best in Session Award, American Controls Conference, Boston, 2004
- Gold medalist, SSC examination, 1992 from Lahore Board
- Silver medalist, HSSC examination 1994 from Lahore Board
- National Talent Scholarship recipient, 1990, 1992, 1994, 1995-2000 on various levels

Professional Services

- 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.
- Reviewer for IEEE Transactions on Automatic Control, IEEE transactions on Robotics, IEEE transactions on Information theory.
- 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).
- Member Association of Computing Machinery (ACM).

Workshops/Summer Schools Attended

- Summer School on *Telerobotics*, July 2010, TU Munich, Germany.
- CIMPA Summer School on *Control of Partial Differential Equations*, May 2009, Marrakech, Morocco.
- *Workshop on Computational Geometry*, Jan 2008, Bellairs Institute, Barbados, West Indies.
- Workshop on *Application of Topology in Science and Engineering*, Sept. 2006, MSRI-Berkeley
- Summer School on *Control in Quantum Systems*, Aug, 2005, Caltech, Pasadena
- Workshop on *UAV Autonomy and Multi-Vehicle Coordinated Control*, Dec 13, 2004, Bahamas
- Workshop on *Semi-definite Programming Relaxations and Algebraic Optimization in Control*, June 29, 2004, Boston, MA

References

- Dr Magnus Egerstedt, Associate Professor, School of Electrical & Computer Engineering, Georgia Institute of Technology, Atlanta, GA (PhD Adviser) magnus@ece.gatech.edu
- Dr George Pappas, Professor, Department of Electrical & Systems Engineering, University of Pennsylvania, Philadelphia, PA pappasg@ee.upenn.edu
- Dr Ali Jadbabaie, Assistant Professor, Department of Electrical and Systems Engineering, University of Pennsylvania, Philadelphia, PA (Postdoc supervisor) jadbabai@seas.upenn.edu
- Dr Kostas Daniilidis, Associate Professor, Department of Computer and Information Science, University of Pennsylvania, Philadelphia, PA kostas@cis.upenn.edu
- Dr Robert Ghrist, Professor, Department of Mathematics, University of Illinois at Urbana-Champaign IL (Collaborator) ghrist@math.uiuc.edu
- Dr Patrick Hayden, Canada Research Chair in Physics of Information, McGill University, QC (Postdoc supervisor) patrick@cs.mcgill.ca
- Dr Vijay Kumar, Professor, Department of Mechanical Engineering, University of Pennsylvania, Philadelphia, PA kumar@me.upenn.edu
- Dr Gregory Dudek, Professor and Chair of Computer Science, McGill University, QC (Postdoc supervisor) dudek@cim.mcgill.ca
- Dr Asad Ali Abidi, Professor, Department of Electrical Engineering, University of California, Los-Angeles (Former Dean LUMS-SSE) abidi@ee.ucla.edu