Apurva Joshi *Ph.D. candidate*

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Education

Doctor of Philosophy in Engineering, *IITB-Monash Research Academy*
(Dual-badged Ph.D. degree awarded by Indian Institute of Technology (IIT) Bombay, India, and Monash University, Australia).
July 2014 - March 2019 (expected)
PHD ADVISORS: Prof. Debraj Chakraborty (IIT Bombay), Dr. Hoam Chung (Monash University)

Master of Technology in Robotics, *University of Petroleum and Energy Studies*.
2012 - 2014.
CPI: 3.54/4, RANK: 1
ADVISOR: Dr. Om Prakash.

Bachelor of Engineering in Electrical and Electronics Engineering, *Visvesvaraya Technological University*. 2006 - 2010.
GRADE: First Class with Distinction. MARKS: 75%

Work Experience

Research:

IITB Research Internship, Industrial Research and Consultancy Centre, Indian Institute of Technology Bombay (IITB), Mumbai, Dec 2013 - June 2014.

Summer Intern, Centre for Artificial Intelligence and Robotics, Defense Research and Development Organization, April - June 2013

Industry:

Engineer - Power Systems, Power Research and Development Consultants Pvt. Ltd., Bangalore, July 2010 to October 2011.

Academia:

Teaching Assistant, IIT Bombay for the courses EE749 - Decentralized control of Complex Systems (Autumn 2016), EE640 - Multivariable control (Autumn 2015), EE631 - Optimal Control (Spring 2016), EE340 - Control Systems Lab (Spring 2015, 2017).

Teaching Associate, Monash University for the course MEC4418 - Control Systems (S2 2018), TRC3000 - Mechatronics Design (S1 2017).

Projects

Academia

Cooperative outdoor flight: Theory, System development and Integration
SUMMARY: In this project we have developed and implemented a holistic system architecture capable of handling control and communication of a multi-agent system.

We have implemented a decentralized consensus algorithm which drives robots (quadrotors in our case) from any initial condition in space to an autonomously decided common point. This is commonly known as the rendezvous problem. Each agent only uses information from its neighbours to take decisions and trajectory planning is done completely on-board.

A novel synchronized, time-slotted and scalable communication protocol which avoids data packet collisions and ensures real-time connectivity between agents is proposed and implemented. This protocol can address changing communication graph topologies and temporary link breaks and additions.

Min-max time consensus tracking on a multi-quadrotor testbed
SUMMARY: In this project, an algorithm which solves the multi-agent consensus tracking problem for one leader and multiple followers is implemented on a testbed of four quadrotors in an indoor environment. The leader agent generates a reference trajectory autonomously for the pursuer agents to track. The feedback control law guarantees that the group of followers converge on to the trajectory of the evader in shortest possible time.

Microscopic model for lane-less (Indian) traffic
SUMMARY: In this project, a new model is introducted for traffic on broad roads, where the drivers do not follow lane discipline. Instead of the traditional car-following models, the driver reactions are assumed to be influenced by possibly a number of vehicles, obstacles and unmodelled entities in visibility cones to the front and to the sides of each vehicle. It is shown that in congested traffic situations, the vehicles converge to a layered formation with fixed inter-vehicle distances and in sparse and heterogeneous traffic, the velocity and inter vehicle separations can oscillate continuously, but are uniformly bounded.

These model-based predictions are verified experimentally. Detailed motion information of groups of cars is extracted through image processing techniques. The proposed model is initialised with the extracted data and the computed trajectories are compared with the actual ones.

Modelling and low-level control Quadrotor helicopters (M.TECH. THESIS)
SUMMARY: This project was aimed towards development of quadrotors that are capable of autonomous flight. Quadrotors were fabricated using commerical off-the-shelf components and 3D-printed parts. A MATLAB based simulator was developed to test performance of control algorithms. Low-level drivers were written to interface various sensors on-board the quadrotor with 8-bit and 32-bit microcontrollers. Firmware implementing control algorithms for autonomous flight were also written.

Industry

Modeling, Control and Stability Analysis of Large Scale Complex Networks
SUMMARY: Power System Network Modeling, Stability and Load Flow Analysis and Protection Study of the Qatar Electricity Distribution network (Kahramaa). Deployed on-site at Doha, Qatar for system review and training of client engineers for a period of two months. Provided novel algorithms for development of the simulation software, MiPower which lead to streamlining of the modeling process and 4x time savings for client. Led a team of 10 engineers involved in system modeling

Study of Transformer Loading
SUMMARY: Studied the effect of the introduction of a new electric arc furnace to the shop floor on the loading patterns of the power transformers and the harmonics in the system

Courses

Applied Linear Algebra, Multivariable Control Systems, Decentralized Control of Complex Systems, Optimal Control Systems, Control of Mobile Robots, Image Processing, Artificial Neural Networks and Machine Learning, Matrix Computations, Behavioral Theory of Systems, Model Order Reduction: Theory and Algorithms.

Publications

Journal Papers

1. Mulla, A.K., **Joshi, A.**, Chavan, R., Chakraborty, D. and Manjunath, D., 2018. A Microscopic Model for Lane-Less Traffic. *IEEE Transactions on Control of Network Systems*, DOI: 10.1109/TCNS.2018.2834313
2. **Joshi, A.**, Wala, A., Ludhiyani, M., Chakraborty, D., Manjunath, D., 2018. Outdoor cooperative flight using decentralized consensus algorithm and a guaranteed real-time communication protocol. *Control Engineering Practice*, (under review).

Conference Papers

1. **Joshi, A.**, Limbu, N., Ahuja, I., Mulla, A.K., Chung, H. and Chakraborty, D., 2016, June. Implementation of distributed consensus on an outdoor testbed. In *Control Conference (ECC), 2016 European (pp. 2146-2151). IEEE.*
2. **Joshi, A.**, Chakraborty, D., 2017, July. Experimental verification of a dynamic model for lane-less (Indian) traffic. In *IFAC World Congress, 2017.*

3. **Joshi, A.**, Wala, A., Ludhiyani, M., Singh, S., Gagrani, M., Hazra, S., Chakraborty, D., Manjunath, D., Chung, H. 2016, June. Implementation of distributed consensus with guaranteed real-time communication on an outdoor quadrotor testbed. In *Conference on Decision and Control (CDC), 2017. IEEE.*

Talks

1. 'Implementation of distributed consensus on an outdoor testbed'. Speaker at European Control Conference, Aalborg, Denmark, 2016
2. 'Experimental verification of a dynamic model for lane-less (Indian) traffic'. Speaker at IFAC World Congress, Toulouse, France, 2017.
3. 'Implementation of distributed consensus with guaranteed real-time communication on an outdoor quadrotor testbed'. Speaker at Conference on Decision and Control, Melbourne, Australia, 2017
4. 'Integration of Inertial Navigation Systems and Global Positioning Systems using Kalman Filters'. Seminar at the Dept. of Electrical Engineering, Indian Institute of Technology Bombay, Mumbai, India
5. 'Introduction to Quadrotor Helicopters: From Flight to Control'. Invited speaker at the Students' Reading Group, Dept. of Electrical Engineering, Indian Institute of Technology Bombay, Mumbai, India

Other Activities

Reviewer
JOURNAL: ACM Transactions on Spatial Algorithms and Systems (**TSAS**)

Demonstrator
VOLUNTEERING: Robogals, Monash
Robogals is an organization with a mission to inspire, engage and empower young women into engineering and related fields. I helped run outreach workshops in schools, libraries, community centers for kids aged 10 -18 by teaching them to program robots and talking to them about engineering

Mentor
Mentored several undergraduate students from across India over the past 4 years to take part in engineering competitions like the SAE Electric Kart Racing challenge, ASME Robot building challenge, and several other engineering projects taken up by enthusiastic students.

Awards

1. **Silver Medal**, First rank in Robotics Engineering at UPES, Dehradun, 2014
2. **Second Prize** Texcellence (National level Paper Presentation), Sigma v4.0, 2009
3. **Second Prize** National Level Technical Quiz, Sigma v4.0, 2009
4. **Best Student Award**, MVJ College of Engineering, 2008
5. **Academic Excellence Award** MVJ College of Engineering, 2007

Language Proficiency

Intermediate: C, C++, MATLAB, Robot Operating System (ROS), Arduino (Processing)
Basic: Python

References

1. *Debraj Chakraborty*, Associate Professor, Dept. of Electrical Engineering, IIT Bombay (dc@ee.iitb.ac.in)
2. *Hoam Chung*, Senior Lecturer at Dept. of Mechanical and Aerospace Engineering, Monash University, (hoam.chung@monash.edu)
3. *Madhu Belur*, Professor, Dept. of Electrical Engineering, IIT Bombay (belur@ee.iitb.ac.in)