BHASKAR VUNDURTHY

Email(p): pvundurt@nd.edu

Email(s): bvundurthy@outlook.com

Website: https://bvundurthy.github.io/

Postdoctoral Research Associate

University of Notre Dame

Phone: +1 (540) 449 7899

RESEARCH INTERESTS

My doctoral dissertation primarily uses tools from Computational Geometry to compute an optimal location for rendezvous of multiple robots in an environment cluttered with obstacles, while constraints are imposed on distances and times of travel. The research also employs tools from Game Theory to study the effect of an intelligent self-sufficient adversary in the rendezvous of multi-agent systems. An important part of the research involves the implementation of the designed algorithms on in-house fabricated bipedal and mobile robots. My current postdoctoral research computes optimal strategies for an intelligent player amidst n boundedly rational players in a repeated games framework.

Further, an ongoing collaborative endeavor focuses on designing incentive schemes for agents in a federated learning setup to encourage truthful elicitation of information. My time at The MathWorks Inc. led to the development of advanced examples involving robotic applications to (i) deploy deep learning algorithms on ARM devices like Raspberry Pi and (ii) create a scenario for a high fidelity vehicle model in a cluttered environment (with traffic) using an agent-based modeling approach. In summary, my research work involves elements of Computational Geometry, Game Theory, Robotics, Multi-agent systems, Deep Learning and Autonomous Driving.

EDUCATION

Ph.D. in Electrical Engineering specializing in Robotics   *August 2013 - July 2019*

Indian Institute of Technology Madras, Chennai, India.

Thesis: *Rendezvous of multiple agents amidst obstacles and constraints*

Advisor: Prof. K. Sridharan

Keywords: Rendezvous, Constraints, Obstacles, Hardware-efficient Algorithms, Experimentation

Summary: The thesis deals with rendezvous of multi-agent systems when constraints are imposed on the individual and total distance or time traveled by the agents. The thesis further explores the notion of competitive rendezvous where an agent deliberately prevents rendezvous of other agents. The major contributions of the thesis include:

1. Computing an optimal location with minimax distance constraint and minimum time constraint for k agents amidst n polygonal obstacles in $O(k^2 + kn \log n)$ time.
2. Computing an optimal location where two non-identical agents achieve rendezvous when faced with an intelligent obstacle (an adversary) that travels at a superior speed.
3. Implementation of all the algorithms on custom fabricated mobile robots equipped with only a microcontroller (no external memory) and no communication with a central controller.

Master of Technology in Control and Instrumentation   *August 2011 - July 2013*

Indian Institute of Technology Madras, Chennai, India.

Thesis: *Design and Development of bipedal robots and implementation of various gait algorithms*

Advisor: Prof. K. Sridharan

Keywords: Bipedal Robots, Kinematic Analysis, Gait Algorithms, Static and Dynamic Stability

Summary: This thesis oversaw the design and fabrication of two bipedal robots. The first robot is meant for fast walking and makes use of dynamic stability (the robot is stable in motion). The second robot is designed for stable walking and is thus much slower. Various gait algorithms to help the robots walk (forward and sideward), turn, climb, etc. have been implemented.

Bachelor of Engineering (Honours) in Electronics and Instrumentation   *Aug '06 - July '11*
The Birla Institute of Technology and Science (BITS) Pilani, Pilani, India.
<u>Project:</u> *AOTF Spectral Data Pre-processing with LPC2148 ARM7 based Microcontroller*

Master of Science (Honours) in Chemistry   *August 2006 - July 2011*
The Birla Institute of Technology and Science (BITS) Pilani, Pilani, India.
<u>Project:</u> *Molecular Modeling of Bio-Protein Molecules*

RESEARCH AND INDUSTRIAL EXPERIENCE

Postdoctoral Research Associate   *February 2021 - Ongoing*
Department of Electrical Engineering, University of Notre Dame, USA.

<u>Project:</u> *Optimal strategies in a Bounded Rationality Framework for Repeated Games*   *Ongoing*
<u>Keywords:</u> Metalearning in Games, Adversarial environment, Bounded Rationality, Fictitious Play
<u>Summary:</u> In repeated games, players with bounded rationality use a subset of the history of plays to determine their future actions. We explore one of such paradigms: Fictitious Play, and discuss how the presence of an intelligent player affects the expected payoff of all the players. We show that such an intelligent player can do better than the Nash Equilibrium payoff, wherever possible and in some cases, improve the overall payoff of all the players. We further discuss the conditions under which this assumption extends to a generalized n-player setting.

<u>Project:</u> *Mechanism Design for truthful elicitation from agents in Federated Learning*   *Ongoing*
<u>Keywords:</u> Federated Learning, Mechanism Design
<u>Summary:</u> We allow for the agents to misreport their local model update parameters during federated learning and use techniques from mechanism design to determine an optimal incentive scheme that ensures truthful elicitation of information from the agents.

Software Engineer - Advanced Visualization   *July 2019 - January 2021*
The MathWorks Inc., Bengaluru, India.

<u>Project:</u> *Deep Learning on Embedded Devices via Code Generation*   *Available since R2020a*
<u>Keywords:</u> Deep Learning, Embedded Targets, Code generation, Object identification and tracking
<u>Summary:</u> This project involved creating an example (see link 1 and link 2) employs a Raspberry Pi connected to a HD web camera on a pan tilt servo mount to perform two independent functions:

1. Determine the age of people in the camera frame in real time.
2. Detect and track a specific object such that the object remains in the center of the frame (horizontally and vertically).

<u>Project:</u> *Model and Simulate Vehicle Dynamics in a virtual 3D environment*   *Available since R2021a*
<u>Keywords:</u> Automated Driving, Vehicle Dynamics, Simulated Environment, Time optimal tracking
<u>Summary:</u> The project (see link) entails creating advanced examples to advocate Vehicle Dynamics and Autonomous Driving in simulated environments. The highlights from the project include:

1. Creation of a closed loop track with specific cone density using RoadRunner.
2. Integrating the track with Unreal engine and identifying waypoints using Simulink
3. Navigation of a high fidelity vehicle (14 DOF) along the waypoints in minimum time.

SCHOLASTIC ACHIEVEMENTS

1. Secured All India Rank (AIR) 7 in Graduate Aptitude Test in Engineering (GATE) 2011, Instrumentation Engineering

2. Selected for the research fellowship awarded by the Department of Science and Technology (DST), Government of India, for three years in a row.   *October 2016 - July 2019*
   <u>Project:</u> Rendezvous of Heterogeneous Robots satisfying distance constraints amidst obstacles.

PUBLICATIONS

Journal Papers (Peer Reviewed)

1. **B. Vundurthy** and K. Sridharan, "Protecting an Autonomous Delivery Agent Against a Vision-Guided Adversary: Algorithms and Experimental Results," in **IEEE Transactions on Industrial Informatics**, vol. 16, no. 9, pp. 5667-5679, Sept. 2020 (Journal Impact Factor: **9.112**).[PDF]

2. **B. Vundurthy** and K. Sridharan, "Multiagent Gathering With Collision Avoidance and a Minimax Distance Criterion—Efficient Algorithms and Hardware Realization," in **IEEE Transactions on Industrial Informatics**, vol. 15, no. 2, pp. 699-709, Feb. 2019 (Journal Impact Factor: **9.112**). [PDF]

3. S. K. Singh, P. V. Reddy and **B. Vundurthy**, "Study of a multiple active-target attacker defender differential game using a mode switching strategy," IEEE Transactions on Control Systems Technology, accepted for publication. [Preprint]

Conference Papers (Peer Reviewed)

4. **B. Vundurthy** and K. Sridharan, "Time Optimal Rendezvous for Multi-Agent Systems Amidst Obstacles - Theory and Experiments," IECON 2018 - 44th Annual Conference of the IEEE Industrial Electronics Society, Washington, DC, 2018, pp. 2645-2650.

5. **B. Vundurthy**, A. More, S. V. V. Raju and K. Sridharan, "Rendezvous of heterogeneous robots amidst obstacles with limited communication," 2016 Indian Control Conference (ICC), Hyderabad, 2016, pp. 347-353.

6. Onkar Kulkarni, **B. Vundurthy**, and K. Sridharan. 2019. "Rendezvous of Heterogeneous Robots in Minimum Time - Theory and Experiments". In Proceedings of the Advances in Robotics 2019 (AIR 2019). Association for Computing Machinery, New York, NY, USA, Article 38, 1–6.

Journal Papers (Submitted and Under Review)

7. **B. Vundurthy**, Onkar Kulkarni and K. Sridharan, "Rendezvous of a Humanoid with a Wheeled Robot Amidst Heterogeneous Objects Based on a Minimax Distance Criterion," under review in IEEE Transactions on Mechatronics.

8. S. Harinath and **B. Vundurthy**, "A survey of Deep Neural Networks for Mobile Robotics," under review in Robotics and Autonomous Systems.

9. Datla, U.S., **Vundurthy B.**, Hook, J.S., Moreland, J.G., and Jones, C.N., "A multi-sensing microfluidic platform to study the host response to *Pseudomonas aeruginosa* infections, from an innate immune standpoint," submitted to Lab on a Chip.

10. P. Nagachandrika, **B. Vundurthy**, Yashrajsinh Parmar, R. Sarathi and K. Sridharan, "SRASRH: Design, Kinematic Analysis and Grasping Studies for a Silicone Rubber-based Anthropomorphic Soft Robot Hand," to be resubmitted to Advanced Robotics.

11. **B. Vundurthy**, Aris Kanellopoulos, Vijay Gupta and Kyriakos Vamvoudakis, "Optimal strategies in a Bounded Rationality Framework for Repeated Games," to be submitted to IEEE Transactions on Automatic Control.

Theses

12. **B. Vundurthy**. Rendezvous of multiple agents amidst obstacles and constraints. PhD Thesis, Indian Insitute of Technology (IIT) Madras, 2019.

13. **B. Vundurthy**. Design and Development of Bipedal robots and implementation of various gait algorithms. Master's Thesis, Indian Insitute of Technology (IIT) Madras, 2013.

TEACHING EXPERIENCE

Invited lectures for The GATE Academy

1. Instrumentation Theory   *Summer 2012*
2. Control Systems   *Summer 2012*
3. Engineering Mathematics   *Summer 2013*
4. Digital Electronics   *Summer 2013*

Creating Course Content and Teaching at IIT Madras

5. Control and Dynamics Lab   *Fall 2014 and Fall 2016*
   This lab course involved creation of experiments using mobile robots and inverted pendulums to help students understand robot motion planning and control theory.

Teaching Assistant for graduate and undergraduate courses at IIT Madras

6. Synthesis of Control Systems   *Fall 2013 and Fall 2015*
7. Control Engineering   *Spring 2014 and Spring 2017*
8. Digital Signal Processing Architecture (Theory and Lab)   *Spring 2015*
9. Basic Electrical Engineering   *Spring 2016 and Spring 2018*
10. Digital Electronics (Theory and Lab)   *Fall 2017*

Awards and Honors

I have been awarded the **'Best Teaching Assistant (TA) award'** for the academic year 2016-17 by the Electrical Engineering Department at IIT Madras.

RESEARCH MENTORING AND LEADERSHIP

Masters level projects

1. 2013-2014   A. More and S. V. V. Raju, "Rendezvous in multi-agent systems without communication"
2. 2014-2015   M. Yellalingh and V. M. Sonawane , "Optimal union of mobile robots with limited sensing"
3. 2015-2016   V. G. Gupta and R. B. Takumi, "Sliding mode control of a Quadcopter"
4. 2016-2017   Vinayak S. P. and A. Devarakonda, "Design of an Autonomous Underwater Vehicle"
5. 2018-2019   O. V. Kulkarni, "Rendezvous of heterogeneous robots amidst distance constraints"

Ph.D. level projects

6. 2018-2019   S. K. Singh, "Implementation of pursuit evasion games amidst various constraints"
7. 2019-2020   N. C. Peddamallu, "Design of a Soft Robotic Hand and applications to grasping"

The MathWorks Inc.

8. 2019-2020   Group Leader for more than 30 Application Support Engineers in Technical Support Team

INVITED TALKS

1. "Career Paths in Instrumentation Engineering", a live Q&A session for aspiring grad students on YouTube; hosted by The GATE Academy, Bengaluru.   *Spring 2013*

2. "Latest Trends in Robotics" at The MathWorks Inc., Bengaluru, India.   *Winter 2019*

REFERENCES

Prof. K. Sridharan

Professor, Department of Electrical Engineering
Indian Institute of Technology (IIT), Madras, Chennai, India
Email: sridhara@ee.iitm.ac.in
Phone: +91 44 2257 4423

Kerry Grand

Development Manager - Simulink Automotive
The MathWorks Inc.
Email: kgrand@mathworks.com

Prof. Srinivasan K.

Professor, Department of Mechanical Engineering
Indian Institute of Technology (IIT), Madras, Chennai, India
Email: ksri@iitm.ac.in
Phone: +91 44 2257 4703

Dr. Krishna Chaitanya Kosaraju

Postdoctoral Research Fellow
University of Notre Dame, IN, USA
Email: kkrishnachaitanya89@gmail.com