

# SUBHRAJIT BHATTACHARYA

## Assistant Professor

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### PERSONAL INFORMATION

Year of Birth: 1983

Country of Citizenship: India

Marital Status: Married

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### EDUCATION

#### **M.S. and Ph.D., Mechanical Engineering and Applied Mechanics** (January 2012)

University of Pennsylvania, USA.

Ph.D. dissertation title: *Topological and Geometric Techniques in Graph Search-Based Robot Planning*.

Ph.D. supervisors: Prof. Vijay Kumar and Prof. Maxim Likhachev.

#### **B.Tech., Mechanical Engineering** (June 2006)

Indian Institute of Technology, Kharagpur, India.

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### ACADEMIC AND PROFESSIONAL EXPERIENCE

#### **Assistant Professor** (August 15, 2016 – present)

Department of Mechanical Engineering and Mechanics, Lehigh University, USA.

#### **Postdoctoral Researcher** (February 2012 – August 15, 2016)

Department of Mathematics, University of Pennsylvania, USA.

Supervisors: Prof. Vijay Kumar and Prof. Robert Ghrist.

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### RESEARCH INTERESTS

*Topological Motion Planning* (application of topological techniques to solving problems in robot motion planning, coverage, sensor networks and control theory).

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### SELECTED LIST OF AWARDS

1. **Best Paper Award** at the seventh Robotics: Science and Systems (RSS), University of Southern California, Los Angeles. (June 2011)
2. **MSC Simulation Software Award** at the 2008 ASME International Design Engineering Technical Conferences (IDETC), New York City, NY. (August 2008)
3. Departmental Fellowship award for Graduate studies at the Department of Mechanical Engineering and Applied Mechanics, University of Pennsylvania. (Summer, 2006)
4. **Best Paper Award (students')** at Second World Congress on Lateral Computing, 2005, Bangalore. (Dec, 2005)

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### PUBLICATIONS

#### **Journal Publications**

1. Sikang Liu, Michael Watterson, Kartik Mohta, Ke Sun, Subhrajit Bhattacharya, Camillo Jose Taylor and Vijay Kumar, “*Planning Dynamically Feasible Trajectories using Safe Flight Corridors in 3-D Complex Environments*”, IEEE Robotics and Automation Letters (RA-L), January, 2017. [*accepted. to appear.*]
2. Rattanachai Ramaithitima, Michael Whitzer, Subhrajit Bhattacharya and Vijay Kumar, “*Automated Creation of Topological Maps in Unknown Environments Using a Swarm of Resource-Constrained Robots*”, IEEE Robotics and Automation Letters (RA-L), 1(2):746–753, January, 2016. DOI: 10.1109/LRA.2016.2523600.
3. Subhrajit Bhattacharya, Robert Ghrist and Vijay Kumar, “*Persistent Homology for Path Planning in Uncertain Environments*”, IEEE Transactions on Robotics (T-RO), 31(3):578-590, April, 2015. DOI: 10.1109/TRO.2015.2412051.

4. Subhrajit Bhattacharya, Soonkyum Kim, Hordur Heidarsson, Gaurav Sukhatme and Vijay Kumar, “A Topological Approach to using cables to separate and manipulate sets of objects”, International Journal of Robotics Research (IJRR), 34(6):799–815, April, 2015. DOI: 10.1177/0278364914562236.
5. Subhrajit Bhattacharya and Mihail Pivtoraiko, “A Classification of Configuration Spaces of Planar Robot Arms for a Continuous Inverse Kinematics Problem”, Acta Applicandae Mathematicae, 139(1):133-166, October 2015, Springer Netherlands. DOI: 10.1007/s10440-014-9973-1.
6. Subhrajit Bhattacharya, Robert Ghrist and Vijay Kumar, “Multi-robot Coverage and Exploration on Riemannian Manifolds with Boundary”. International Journal of Robotics Research (IJRR), 33(1):113-137, October 2013, SAGE Publishers. DOI: 10.1177/0278364913507324.
7. Subhrajit Bhattacharya, David Lipsky, Robert Ghrist and Vijay Kumar, “Invariants for Homology Classes with Application to Optimal Search and Planning Problem in Robotics”, Annals of Mathematics and Artificial Intelligence (AMAI), 67(3-4):251-281, March 2013, Springer. DOI: 10.1007/s10472-013-9357-7.
8. Subhrajit Bhattacharya, Maxim Likhachev and Vijay Kumar, “Topological Constraints in Search-based Robot Path Planning”, Autonomous Robots, 33(3):273-290, October 2012, Springer Netherlands. DOI: 10.1007/s10514-012-9304-1.
9. Subhrajit Bhattacharya, Siddharth Talapatra, “Robot Motion Planning Using Neural Networks: A Modified Theory”, International Journal of Lateral Computing, Vol.2, No.1, December 2005, ISSN 0973-208X, 9-13.

#### **Selected Preprints and Articles Under Review**

1. Subhrajit Bhattacharya, “A Search Algorithm for Simplicial Complexes”, Electronic preprint, July 2016. arXiv:1607.07009 [cs.DM].
2. Subhrajit Bhattacharya, “A General Continuous Inverse Kinematics Algorithm for a Planar Robot Arm”, Electronic Pre-print, September, 2013-14. [Complete publication in Acta Applicandae Mathematicae, September 2014, Springer Netherlands.]
3. Subhrajit Bhattacharya and Mihail Pivtoraiko, “A Classification of Configuration Spaces of Planar Robot Arms with Application to a Continuous Inverse Kinematics Problem”, Electronic preprint, September 2013. arXiv:1309.7960 [math.DG].
4. Subhrajit Bhattacharya, David Lipsky, Robert Ghrist and Vijay Kumar, “Invariants for Homology Classes with Application to Optimal Search and Planning Problem in Robotics”, Electronic preprint, Aug 2012, arXiv:1208.0573 [math.AT].
5. Subhrajit Bhattacharya, Robert Ghrist and Vijay Kumar, “Relationship Between Gradient of Distance Functions and Tangents to Geodesics”, Electronic preprint, 2012. [Complete publication in International Journal of Robotics Research (IJRR), 33(1):113-137, October 2013, SAGE Publishers.]

#### **Peer-reviewed Conference Publications**

1. Sarah Costrell, Subhrajit Bhattacharya and Robert Ghrist, “Reconstruction of Euclidean Embeddings in Dense Networks”, In Proceedings of the IEEE Global Conference on Signal and Information Processing (GlobalSIP). Washington, D.C., USA, IEEE Signal Processing Society, 7-9 Dec, 2016.
2. Rattanachai Ramaithitima, Siddharth Srivastava, Subhrajit Bhattacharya, Alberto Speranzon and Vijay Kumar, “Hierarchical Strategy Synthesis for Pursuit-Evasion Problems”, In Proceedings of the European Conference on Artificial Intelligence (ECAI). August, 2016.
3. Michael Whitzer, James Keller, Subhrajit Bhattacharya, Vijay Kumar, Trevor Sands, Lee Ritholtz, Adrian Pope and Dean Dickmann, “In-Flight Formation Control for a Team of Fixed-Wing Aerial Vehicles”, In Proceedings of The 2016 International Conference on Unmanned Aircraft Systems (ICUAS), June 2016.

4. Dhanushka Kularatne, Subhrajit Bhattacharya and M. Ani Hsieh, “*Time and Energy Optimal Path Planning in General Flows*”, In Proceedings of the Robotics: Science and System (RSS), June 2016. [*Acceptance rate for 2016: 24%.*]
5. Rattanachai Ramaithitima, Michael Whitzer, Subhrajit Bhattacharya and Vijay Kumar, “*Automated Creation of Topological Maps in Unknown Environments Using a Swarm of Resource-Constrained Robots*”, In Proceedings of IEEE International Conference on Robotics and Automation (ICRA), May 2016. [*Acceptance rate for 2014: 34.7% (818 papers out of 2357 submissions)*]
6. Subhrajit Bhattacharya and Robert Ghrist, “*Path Homotopy Invariants and their Application to Optimal Trajectory Planning*”, In Proceedings of IMA Conference on Mathematics of Robotics (IMAMR), St Anne’s College, University of Oxford, September 9-11, 2015.
7. Rattanachai Ramaithitima, Mickey Whitzer, Subhrajit Bhattacharya and Vijay Kumar, “*Sensor Coverage of Unknown Environments by Robot Swarms Using Limited Local Sensing*”, In Proceedings of IEEE International Conference on Robotics and Automation (ICRA), May 2015. [*Acceptance rate for 2014: 41% (933 papers out of 2275 submissions)*]
8. Vijay Govindarajan, Subhrajit Bhattacharya and Vijay Kumar, “*Human-Robot Collaborative Topological Exploration for Search and Rescue Applications*”, In International Symposium on Distributed Autonomous Robotic Systems (DARS), November 2014. [*Nominated for Best Paper Award.*]
9. Chanyoung Jun, Subhrajit Bhattacharya and Robert Ghrist, “*Pursuit-Evasion Game for Normal Distributions*”, In Proceedings of IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS), September 2014. [*Acceptance rate for 2014: 47% (755 papers out of 1616 submissions)*]
10. Soonkyum Kim, Subhrajit Bhattacharya and Vijay Kumar, “*Path Planning for a Tethered Mobile Robot*”, In Proceedings of IEEE International Conference on Robotics and Automation (ICRA), May 2014. [*Acceptance rate for 2014: 48% (1001 papers out of 2085 submissions)*]
11. Soonkyum Kim, Subhrajit Bhattacharya, Robert Ghrist and Vijay Kumar, “*Topological Exploration of Unknown and Partially Known Environments*”, In Proceedings of the IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS). Tokyo, Japan, November 3-7, 2013. [*Acceptance rate for 2013: 43% (903 papers out of 2089 submissions)*]
12. Soonkyum Kim, Subhrajit Bhattacharya and Vijay Kumar, “*Dynamic Simulation of Autonomous Boats for Cooperative Skimming and Cleanup*”, In Proceedings of the ASME 2013 International Design Engineering Technical Conferences (IDETC), Portland, USA, August 4-7, 2013.
13. Soonkyum Kim, Subhrajit Bhattacharya, Hordur Heidarsson, Gaurav Sukhatme and Vijay Kumar, “*A Topological Approach to Using Cables to Separate and Manipulate Sets of Objects*”. In Proceedings of the Robotics: Science and System (RSS), Sydney, Australia, June 24-28, 2013. [*Acceptance rate for 2013: 30% (55 papers out of 183 submissions)*]
14. Soonkyum Kim, Koushil Sreenath, Subhrajit Bhattacharya and Vijay Kumar, “*Optimal Trajectory Generation Under Homology Class Constraints*”, In 51st IEEE Conference on Decision and Control. 10-13 Dec., 2012.
15. Soonkyum Kim, Koushil Sreenath, Subhrajit Bhattacharya and Vijay Kumar, “*Trajectory Planning for Systems with Homotopy Class Constraints*”. In 13th International Symposium on Advances in Robot Kinematics (ARK), Innsbruck, Austria, June 2012, Springer, Netherlands, pages 83-90.
16. Subhrajit Bhattacharya, Robert Ghrist and Vijay Kumar, “*Multi-Robot Coverage and Exploration in Non-Euclidean Metric Spaces*”, In Proceedings of The Tenth International Workshop on the Algorithmic Foundations of Robotics (WAFR). 13-15 June, 2012.
17. Subhrajit Bhattacharya, Maxim Likhachev and Vijay Kumar, “*Identification and Representation of Homotopy Classes of Trajectories for Search-based Path Planning in 3D*” (Original title: *Identifying Homotopy Classes of Trajectories for Robot Exploration and Path Planning*) [*Winner of Best Paper Award*], In Proceedings of Robotics: Science and Systems. 27-30 June, 2011. [*Acceptance rate for 2011: 25% (45 papers out of 183 submissions)*]

18. Subhrajit Bhattacharya, Hordur Heidarsson, Gaurav S. Sukhatme and Vijay Kumar, “*Cooperative Control of Autonomous Surface Vehicles for Oil Skimming and Cleanup*”, In Proceedings of IEEE International Conference on Robotics and Automation (ICRA). 9-13 May, 2011. [*Acceptance rate for 2011: 49% (982 papers out of 2004 submissions)*]
19. Subhrajit Bhattacharya, Nathan Michael and Vijay Kumar, “*Distributed Coverage and Exploration in Unknown Non-Convex Environments*”, In Proceedings of 10th International Symposium on Distributed Autonomous Robotics Systems. 1-3 Nov 2010, Springer.
20. Subhrajit Bhattacharya, Vijay Kumar and Maxim Likhachev, “*Search-based Path Planning with Homotopy Class Constraints*”, In Proceedings of The Third Annual Symposium on Combinatorial Search, [*non-archival*]. Atlanta, Georgia, 8-10 July, 2010.
21. Subhrajit Bhattacharya, Vijay Kumar and Maxim Likhachev, “*Search-based Path Planning with Homotopy Class Constraints*”. In Proceedings of The Twenty-Fourth AAAI Conference on Artificial Intelligence. Atlanta, Georgia, 11-15 July, 2010.
22. Subhrajit Bhattacharya, Vijay Kumar and Maxim Likhachev, “*Distributed Optimization with Pairwise Constraints and its Application to Multi-robot Path Planning*”. In Proceedings of Robotics: Science and Systems. Zaragoza, Spain, 27-30 June 2010, MIT Press. [*Acceptance rate for 2010: 25% (39 papers out of 154 submissions)*]
23. Subhrajit Bhattacharya, Maxim Likhachev and Vijay Kumar, “*Multi-agent Path Planning with Multiple Tasks and Distance Constraints*”. In Proceedings of IEEE International Conference on Robotics and Automation (ICRA). Anchorage, Alaska, 3-8 May 2010. [*Acceptance rate for 2010: 41% (847 papers out of 2062 submissions)*]
24. Paul Vernaza, Maxim Likhachev, Subhrajit Bhattacharya, Sachin Chitta, Aleksandr Kushleyev and Daniel D. Lee, “*Search-based planning for a legged robot over rough terrain*”. In Proceedings of IEEE International Conference on Robotics and Automation (ICRA), pages 2380-2387, 12-17 May 2009. [*Acceptance rate for 2009: 43% (699 papers out of 1624 submissions)*]
25. Subhrajit Bhattacharya, Sachin Chitta, Vijay Kumar and Daniel Lee, “*Optimization of a Planer Quadruped Dynamic Leap*” [*Winner of MSC Simulation Software Award*], In Proceedings of 2008 ASME International Design Engineering Technical Conferences (IDETC), New York City, NY, 3-6 August, 2008.
26. Subhrajit Bhattacharya, “*A Study on Effect of Stiffener Geometry on the Modal Frequencies of a Rotating Disk with Radial Stiffeners using FEM and Analytical Methods*”, Proceedings of Ninth International Conference on Recent Advances in Structural Dynamics, University of Southampton on July 2006.
27. Subhrajit Bhattacharya, “*A study on a generalized wave equation for disturbances propagating through a one-dimensional medium placed in a two-dimensional space*”, Proceedings of International Conference on Theoretical, Applied, Computational and Experimental Mechanics, p. 235-237, Indian Institute of Technology, Kharagpur, 2004.

## TEACHING EXPERIENCE

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### Instructor

1. Mech 102: Dynamics; Fall 2017, Lehigh University. *Instructor*. Description: *Undergraduate-level course on Dynamics. [Assigned.]*
2. Mech 425: Analytical Methods in Dynamics and Vibrations; Spring 2017, Lehigh University. *Instructor*. Description: *Graduate-level course on Dynamics and Vibration, covering topics that include Lagrangian & Hamiltonian mechanics and rigid-body dynamics.*
3. Mech 102: Dynamics; Fall 2016, Lehigh University. *Instructor*. Description: *Undergraduate-level course on Dynamics.*
4. Math 114: Calculus II; Spring 2016, University of Pennsylvania. *Instructor*. Description: *Undergraduate-level course on vector and multi-variable calculus.*

5. Math 170: Ideas in Mathematics; Fall 2015, University of Pennsylvania. *Instructor.* Description: *Undergraduate-level course on topics in mathematics including sets theory, logic, topology, graph theory, geometry, and their applications.*
6. Math 170: Ideas in Mathematics; Fall 2014, University of Pennsylvania. *Instructor.*
7. MEAM 899: Introduction to Topology and Differential Geometry for Application to Robotics; Fall 2014, University of Pennsylvania. *Instructor.* Description: *Graduate-level independent study for first and second year graduate students pursuing research in Robotics.*
8. Engineering Pre-freshman Program on Mathematics; Summer 2014, University of Pennsylvania. *Co-instructed* with Dr. Robert Ghrist and Dr. Vidit Nanda. Description: *Math 103 level undergraduate calculus course for incoming first year undergraduate students.*
9. MEAM 899: Independent study on Topics in Robotics; Fall 2012, University of Pennsylvania. *Co-instructed* with Dr. Koushil Sreenath and Steven Gray. Description: *Graduate-level independent study for first and second year graduate students pursuing research in Robotics. Was responsible for lectures on “Configuration Spaces and Topology”.*

### Teaching Assistant

1. “Calculus: Single Variable”; Summer 2014. Coursera massive open online course (MOOC) instructed by Prof. Robert Ghrist.
2. “Calculus: Single Variable”; Spring 2014. Coursera massive open online course (MOOC) instructed by Prof. Robert Ghrist.
3. MEAM 535: Advanced Dynamics; Fall 2010. Graduate level course instructed by Prof. Vijay Kumar and Prof. Michael A. Carchidi.
4. CSE 390: Robotics and Automation; Fall 2008. Graduate & undergraduate level course instructed by Prof. Jonathan Fiene and Prof. Jianbo Shi.
5. MEAM 211: Engineering Mechanics: Dynamics; Spring 2008. Undergraduate level course instructed by Prof. Michael A. Carchidi and Prof. Jonathan Fiene.
6. MEAM 535: Advanced Dynamics; Fall 2007. Graduate level course instructed by Prof. Vijay Kumar and Prof. Michael A. Carchidi.

### Students Supervised

1. Fall 2016 – present, Lehigh University: Currently supervising one Ph.D. student on research related to robot motion planning and coverage.
2. Fall 2016 – present, Lehigh University: Currently supervising one MS student on research related to multi-robot robot coverage control.
3. Spring 2017, Lehigh University: Supervised an undergraduate student on a research project on unmanned aerial vehicle.
4. Spring 2013 – Spring 2015, University of Pennsylvania: Co-supervised an undergraduate student with Prof. Vijay Kumar for a term project on graph search algorithms and a summer research project on human-robot collaborative coverage and exploration. The research project successfully culminated into a peer-reviewed conference paper.
5. Fall 2012, University of Pennsylvania: Advised a graduate student on an independent study credit on topology of and planning in configuration spaces of robot arms.

### INVITED LECTURES

1. “*Some Applications of Topological Motion Planning*” at the Topological Robotics seminar, Department of Mathematics, Lehigh University, April 2017.
2. “*Homotopy Invariants and Their Applications to Optimal Motion Planning*” at the Topological Robotics seminar, Department of Mathematics, Lehigh University, October 2016.

3. “*Topological Methods in Robot Motion Planning*” at the EECS Friday seminar, University of California, Berkeley, January 15, 2016.
4. “*Path Homotopy Invariants and their Application to Optimal Trajectory Planning*” at the Applied Topology Seminar, University of Pennsylvania, October 19, 2015.
5. “*Effective path planning for end effector of high-DOF planar robot arms through Reeb graph construction*” at the Mathematics Colloquium, Lehigh University, April 22, 2015.
6. “*Topological Techniques in Graph Search-based Motion Planning*” at the Geometry-Topology Seminar, University of Pennsylvania, Feb 12, 2015.
7. “*Topological Techniques in Graph Search-based Robot Planning*” at the IMA Annual Workshop on “Topological Systems: Communication, Sensing, and Actuation”, University of Minnesota, March 3-7, 2014.
8. “*Topological Techniques in Graph Search-based Planning*” as part of the Center for Foundations of Robotics’ seminar series at the Carnegie Mellon University, Pittsburgh, Nov 18, 2013.
9. “*Search-based Path Planning with Homotopy Class Constraints in 3D*” at the sub-area spotlights track on ‘Best-paper talks’ of the Twenty-Sixth Conference on Artificial Intelligence (AAAI-12), July 22-26, 2012. [*Because of inability to travel, the presentation was made by Prof. Maxim Likhachev.*]
10. A talk on the ‘Littledog’ Robot and ‘Learning Locomotion’ project for an undergraduate level class on robotics at the Swarthmore College, Pennsylvania, April 15, 2008. Invited by Prof. Ani M. Hsieh.

#### FUNDING

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- “*Topological Representations and Algorithms for Robot Swarms*”, subaward from University of Pennsylvania, \$60,000, (**PI**), 2016-17.
- “*Topological Representations and Algorithms for Robot Swarms*”, Office of Naval Research, \$613,126, (**co-PI** with Vijay Kumar), 2014-16.
- “*Human-robot peer-to-peer communication and coordination for tactical operations in urban environment*”, Army Research Laboratory, \$100,000 / year, (*senior/key person* in capacity of *co-PI* with Vijay Kumar), 2009-17.
- Past funding from ONR, ARL, AFOSR and DARPA. Experienced with writing research grant proposals, review reports and presenting at project review meetings. Two NSF grant proposals under preparation.

#### PROFESSIONAL SERVICES AND EXPERIENCES

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- *Interviewer*, Penn Alumni Interview Program, 2017.
- *Member*, Graduate Curriculum & Advisory Committee, Mechanical Engineering and Mechanics, Lehigh University, 2016-17.
- *Co-organizer*, Workshop on “Emerging Topological Techniques in Robotics”, IEEE International Conference on Robotics and Automation (ICRA), May 2016.
- *Program Committee*, “Distributed Autonomous Robotic Systems” (DARS) conference, 2016; *Program Committee*, “International Joint Conference on Artificial Intelligence” (IJCAI) conference, 2016; *Program Committee*, “Robotics: Science and Systems” (RSS) conference, 2014; *Program Committee*, “International Symposium on Combinatorial Search” (SoCS), 2015, 2016, 2017; *Program Committee*, “Intelligent Robotics and Multi-Agent Systems” (IRMAS) track of “ACM Symposium on Applied Computing” (SAC), 2016.
- *Prize Committee*, Department of Mathematics, University of Pennsylvania, 2014-15.
- Reviewer for *IEEE Transactions on Cybernetics* 2017; *Computational and Applied Mathematics (A Springer journal)* 2017; *IEEE Robotics and Automation Letters (RA-L)* 2016 & 2017; *International Journal of Mechanical Engineering (IJME)* 2016; *Robotica (Cambridge University Press)* 2016; *Automatica (An Elsevier journal)* 2015; *IEEE International Conference on Robotics and Automation (ICRA)* 2011–2017; *Mediterranean Conference on Control and Automation (MED)* 2017; *IEEE Conference on Decision and Control (CDC)* 2012 & 2013;

*IEEE International Conference on Automation Science and Engineering (CASE) 2011; IEEE International Conference on Intelligent Robots and Systems (IROS) 2011–2016; Tenth International Workshop on the Algorithmic Foundations of Robotics (WAFR) 2012; Distributed Autonomous Robotic Systems (DARS) 2012; ASME Journal of Dynamic Systems, Measurement and Control: 2013; Autonomous Robots (AURO), Springer: 2012, 2016, 2017; International Journal of Robotics Research (IJRR): 2011, 2012, 2015 & 2016; IEEE Transactions on Robotics (T-RO): 2012, 2014; ACM Transactions on Sensor Networks (TSN): 2012; Proceedings of the National Academy of Sciences, India, Section A: Physical Sciences: 2015; ASME Journal of Mechanical Design: 2015; IEEE Transactions on Automatic Control: 2015; A TOP Grant Module submitted to The Netherlands Organisation for Scientific Research (NWO) 2014.*

- Volunteer for the The Twenty-Fourth AAAI Conference on Artificial Intelligence, 2010.

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## COMPUTATIONAL SKILLS AND SOFTWARE DEVELOPMENT

### Programming and Software Skills

- *Programming Languages, Libraries and Softwares:* C, C++, MATLAB/Octave, Python, FORTRAN, Mathematica, OpenGL, Open CV, ROS (Robot Operating System), experienced Ubuntu Linux user.
- *Web development and Graphics:* Photoshop, Gimp, Blender, Javascript, HTML5, PHP, JSP, MySQL, Apache.

### Open-source Development and Community Projects

- i. Developer and maintainer of the YAGSBPL (Yet Another Graph-Search Based Planning Library) and DOSL (Discrete Optimal Search Library) C++ libraries. [Project page: <https://github.com/subh83/YAGSBPL>, <https://github.com/subh83/DOSL>]
- ii. A contributor to the PmWiki content management system. Developed several modules for this wiki project. [User page: <http://www.pmwiki.org/wiki/Profiles/Subhrajit>]
- iii. Contributed to Wikipedia. [User page: <http://en.wikipedia.org/wiki/User:Subh83>]

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## PERSONAL INTERESTS

1. **Volunteer for AID:** Association for India 's Development (AID) (<http://philly.aidindia.org/>) is a volunteer movement committed to promoting sustainable, equitable and just development by supporting grassroots organizations in India and initiating efforts in various interconnected spheres such as education, livelihoods, natural resources, health, women's empowerment and social justice. Have served as President (Apr 2008 - Nov 2009), Secretary (Summer 2007 - Apr 2008), Webmaster (Summer 2007 - Nov 2009) and Treasurer (Nov 2009 - June 2010) for the Philadelphia chapter of AID.
2. **Sports:** *Martial Arts:* Brown (6<sup>th</sup>) Kyu in Zen Shitoryu Karate approved by AIKF (All India Karate-Do Federation) ; *Swimming:* Was in National Sports Organisation, India (swimming) for two consecutive years.
3. **Music:** Trained in Indian classical music (especially in instrument *Sitar*). Play classical acoustic guitar, harmonica and piano.
4. **Arts:** *Fine arts:* Final year in diploma in Fine Arts (All India Fine Arts Association). *Dramatics:* Played major roles in several dramas organized by BTDS (Bengali Technology Dramatics Society) at IIT Kharagpur.

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## REFERENCES

- Dr. Vijay Kumar, Professor, Department of Mechanical Engineering and Applied Mechanics, University of Pennsylvania. e-mail: [kumar@seas.upenn.edu](mailto:kumar@seas.upenn.edu).
- Dr. Maxim Likhachev, Professor, School of Computer Science, Carnegie Mellon University. e-mail: [maxim@cs.cmu.edu](mailto:maxim@cs.cmu.edu).
- Dr. Robert Ghrist, Professor, Department of Mathematics and Department of Electrical and Systems Engineering, University of Pennsylvania. e-mail: [ghrist@math.upenn.edu](mailto:ghrist@math.upenn.edu).
- Dr. Gaurav S. Sukhatme, Professor, Department of Computer Science, University of Southern California. e-mail: [gaurav@usc.edu](mailto:gaurav@usc.edu).