

Curriculum Vitae

Saurav Agarwal

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Research Interests

Artificial Intelligence: Motion planning of multiple robots with applications in autonomous vehicles and aerial agents while incorporating static and dynamic constraints.

Education

1. University of North Carolina at Charlotte, USA

Ph.D. student, Computer Science, GPA: 4.00/4.00

(Aug. 2016–present)

Research field: Motion planning of multiple agents

Courses: Algorithms and Data Structures, Intelligent Systems, Intelligent Robotics, Probabilistic Robotics, Machine Learning, Robot Motion Planning, Digital Image Processing, Computer Vision, Computer Graphics, Parallel Computing.

2. National Institute of Technology, Durgapur, India

B. Tech., Mechanical Engineering, CGPA: 8.40/10.00

(July 2009–May 2013)

Final year thesis: Development of fault tolerant gait patterns in legged robots and analysis on the basis of optimal feet force distribution

- Determination of optimal force distribution based on minimisation of energy, torques, and forces and maximisation of leg traction
- Novel algorithm to develop fault tolerant gaits and analysis on the basis of stability and feet forces

Journal and Conference Publications

1. Line Coverage with Multiple Robots as a Capacitated Arc Routing Problem (Under review)

S. Agarwal and S. Akella. *International Conference on Robotics and Automation, 2019*

- Approach for large scale line coverage problems with multiple robots formulated as Arc Routing Problem
- Consideration of practical factors such as battery capacity, wind speed
- Development of Integer Linear Programming model and heuristic algorithms

2. Simultaneous Optimization of Assignments and Goal Formations for Multiple Robots

S. Agarwal and S. Akella. *International Conference on Robotics and Automation, 2018*

- Simultaneously optimal assignments and goal formation for scale and translation
- Collision-free trajectories through minimization of sum of squared distances

3. Design of Six-bar Function Generators using Dual-order Structural Error and Analytical Mobility Criteria

S. Agarwal and S. Bandyopadhyay. *Mechanism and Machine Theory, Elsevier*, pp. 326–351, vol. 116, Oct. 2017.

Optimal synthesis of six-bar function generators

S. Agarwal, J. Badduri and S. Bandyopadhyay. *14th IFToMM World Congress, 2015*, OS2-031, Oct. 2015, Taipei, Taiwan.

- Determination of *full-mobility* (singularity and assembly) criteria based on architecture parameters
- Determination of mobility over a range of input parameters and segregating branches of the mechanism

- Novel formulation of *dual-error* and use of *genetic algorithm* to find optimal solutions
 - Application to various Stephenson-III and Watt-II function generator problems
4. **Identifying Singularity-free Spheres in the Position Workspace of Semi-regular Stewart Platform Manipulators**
A. Nag, V. Reddy, S. Agarwal and S. Bandyopadhyay. *Advances in Robot Kinematics* pp. 421–430, June 2016
 - Analytical computation of maximal spherical workspace which is free of singularities
 - Development of a novel approach for exact symbolic computation in a Computer Algebra System
 - Exact expressions enable faster and precise numerical computation of the final solutions
 5. **Analytical Determination of the Proximity of Two Right-circular Cylinders in Space**
S. Agarwal, R. A. Srivatsan and S. Bandyopadhyay. *Journal of Mechanisms and Robotics, ASME*, vol. 8, issue 4, March 2016
 - Novel analytic formulation for computing proximity, proxima points and direction of shortest distance using four geometric primitives and quaternions to describe cylinders and their relative orientation
 - Geometric interpretation of all the cases arising from the mathematical formulation. Identification of one/two dimensional solutions. Implementation in C++ for path planning of *pick-and-place* operation of a six degrees of freedom PUMA configuration robot
 - Add-in created in Autodesk Inventor to verify the algorithm and serve as a fast primary level automated collision detection application
 6. **Optimal Design of Parallel Manipulators using a novel Dynamic Performance Index and Singularity Free Workspace**
J. Kilaru, M. K. Karnam, S. Agarwal and S. Bandyopadhyay. *14th IFToMM World Congress, 2015*, OS13-129, Oct. 2015, Taipei, Taiwan.
 - Computation of singularity manifold and thereby Safe Working Zone (SWZ) and implementation in GPU using CUDA C
 - Formulation of the dynamic performance index based on *intrinsic* parameters of the manipulator using the mass matrix
 - Optimal design of parallel manipulators based on larger SWZ and better dynamic performance index under defined constraints using genetic algorithm
 7. **Improved Tracking Performance Using Dual and Double Dual Feedback Loops**
M. K. Karnam, R. Kalla, A. Nag, S. Agarwal and S. Bandyopadhyay. *2015 Indian Control Conference*, Jan. 2015, Chennai, India.
 - Improved trajectory tracking by using multiple control loops and redundant feedback sensing
 - Study of different control strategies (open loop, PD, PI+PD) and validation with experiments
 8. **Dynamics and Optimal Feet Force Distributions of a Realistic Four-legged Robot**
S. Agarwal, A. Mahapatra and S. S. Roy. *International Journal of Robotics and Automation (IJRA)*, pp. 223–234, vol. 1, no. 4, Dec. 2012.
 - Kinematic and dynamic analysis of Quadruped robot. Formulation for computing optimal distribution of feet forces based on minimisation of (a) feet forces (b) joint torques (c) joint power
 - Dynamic simulations performed based on Lagrange-Euler formulation and results from different optimal criteria compared

Professional Experience

Indian Institute of Technology Madras, Chennai, India

Project Associate, Department of Engineering Design

(June 2013–June 2016)

1. *Design and development of 3-DOF motion seat for payload of 150kg*
Simulator Development Division, Indian Army

- Design of a three degrees of freedom (roll, pitch, and heave) parallel manipulator to perform off-road driving simulation for the said payload
 - Computing the singularity free workspace of the robot and improving dynamic performance to reduce actuator size and cost. Study and implementation of kinematics, dynamics and various control strategies to enable real-time manipulation
 - Interfacing with the simulation software via TCP/IP protocol. Implementation of ADS/OPC communication with the hardware, and use of **OpenGL** and **C++** to develop the user interface
2. *Development of a 3-RRR parallel robot for industrial applications*
Systemantics India Pvt. Ltd., Bangalore, India
- Computing and optimising for large singularity free workspace
 - Designing robot to have good dynamic performance for sharp turns
3. *Stability analysis of Load Haul Dumper (LHD)*
Bharat Earth Movers Ltd., India
- Study of dynamics for toppling instability
 - Introduction to stability index to characterise toppling tendency
 - Computation of operation envelope and suggestions in design modification
4. *Investigation of expanding air bag concept to dry clothes in a vertical axis washing machine* Whirlpool GTEC, India
- Analysing the pressure developed due to centrifugal action on clothes
 - Proposed a feasible design for introducing expanding air bags to dry clothes in present system

Central Mechanical Engineering Research Institute, Durgapur, India

Research Intern under Scientist Abhijit Mahapatra

(May 2012–July 2012)

Kinematic and dynamic modeling of hexapod robot and its simulation for straight and rough path

- Development and design of a hexapod robot using CATIA (CAD software)
- Kinematics, dynamics and trajectory planning performed for smooth and rough terrain

Patent

Plunger system for measuring pressure on the wall of a rotating drum and methods thereof. S. Agarwal, S. Arul, E. Jero, M. K. Karnam, S. Bandyopadhyay, G. S. Kumar and P. Ramu. Filed for Indian Provisional Patent, Oct. 2014, file no. 5972/CHE/2014. Work carried out as part of Whirlpool GTEC project.

Skills

Programming

- C/C++, GPU parallelism (CUDA C), Matlab, Mathematica

Software and Tools

- CAD (CATIA, Autodesk Inventor and AutoCAD), Linux OS, \LaTeX
- Hardware integration: PLC programming, TwinCAT, TCP/IP protocol, ADS/OPC communication

Extra-curricular Activities

- *President, Society of Automotive Engineers (SAE)*, NIT Durgapur chapter, 2013
- *Training and placement representative*, National Institute of Technology, Durgapur, India, 2013
- *Student district operation board*, **American Society of Mechanical Engineers** India, 2011
- *Philately*: Awarded silver medal at ARIPEX philately exhibition, Arizona, USA, 2005