ROBOTICS: BASICS AND SELECTED ADVANCED CONCEPTS

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PRE-REQUISITES : UG level mathematics and programming knowledge.

INTENDED AUDIENCE : Primarily Masters and Ph D students in mechanical, electrical and computer science disciplines. UG students taking Robotics as an elective.

INDUSTRIES APPLICABLE TO : Ashok Leyland, Chennai, GE and GM, TAL and Tata Motors,Government organizations such as ISAC-ISRO (Bangalore), BARC (Mumbai) and CAIR-DRDO (Bangalore)

COURSE OUTLINE :

This course starts with an introduction to robotics, the key elements and constituents of a robot and science and technology in robots. It provides a unified treatment for the modelling and analysis of serial, parallel, and hybrid manipulators using the key concept of Denavit-Hartenberg parameters, solution of the direct and inverse kinematics of serial and parallel robots and the associated concepts of workspace and mobility are presented. The concept of velocity of the links of the robots and the Jacobian matrix is developed and the associated concepts of singularities in robots are discussed in depth. The equations of motion are derived using the Lagrangian formulation and their solutions using numerical methods are presented. To fully understand control of robots, basic concepts in linear control is introduced using the example of control of a single link of a robot and then the more advanced concept of model-based control is discussed. The course also introduces advanced topics in robotics such as modelling and analysis of wheeled mobile robots, deployable structures and cable driven and pneumatically actuated small/ micro robots. The course draws upon a great deal on experiments and hardware developed by research students at IISc and software simulations and hardware experiments are suggested for the course students to do on their own to complement the material taught in the course.

ABOUT INSTRUCTOR :

Ashitava Ghosal is currently a Professor in School of Engineering and Applied Science, Ahmedabad University. Until recently, he was the Prof. Satish Dhawan Chair Professor at IISc, Bangalore. He completed his PhD from Stanford University, California, MS from University of Florida, Gainesville, Florida and BTech from Indian Institute of Technology, Kanpur. His broad research area is in robotics and other computer controlled mechanical systems, dynamics and control and product design. He is the author of ``Robotics: Fundamental Concepts and Analysis'', Oxford University Press (2006) which is used as a textbook in many UG and PG programs in India and abroad. He has 5 patents, published 83 archival journal papers and more than 100 papers in national and international conferences. He has guided 17 PhDs and more than 70 Masters students at the Indian Institute of Science, Bangalore. He is currently associate editor of the international journal Mechanism and Machine Theory (Elsevier), and has been an associate editor of the international journals Mechanics Based Design of Structures and Machines (Taylor & Francis), Journal of Mechanisms and Robots (ASME) and Journal of Mechanical Design (ASME). He has been a member of the Executive Committee of IFToMM (International Federation for the Promotion of Mechanism and Machine Science) (2016-2023) and was elected as a fellow of the Indian National Academy of Engineering in 2010. More information is available at https://mecheng.iisc.ac.in/~asitava

COURSE PLAN :

Week 1: Introduction, Elements of a robot

Week 2: Mathematical preliminaries, D-H convention, Examples

Week 3: Direct and Inverse kinematics of serial robots, Workspace, Analytical and numerical solutions

Week 4: Parallel robots - direct and inverse kinematics, Mobility, Stewart-Gough platform

Week 5: Applications of parallel robots in sun tracking, vibration isolation

Week 6: Velocity analysis, Singularities in serial and parallel robots, Statics

Week 7: Redundancy and resolution of redundancy in robots

Week 8: Dynamic equations of motion, derivation & simulation using Matlab

Week 9: Motion planning, Introduction to linear control, simulations & experiments

Week 10: Nonlinear position and force control of robots, Simulations

Week 11: Wheeled mobile robots, modeling and simulations

Week 12: Over-constrained and deployable structures, Cable driven & pneumatically actuated flexible robots