ANG Jr, Marcelo H

Associate Professor
Control & Mechatronics

Contact

6516 2555 **mpeangh@nus.edu.sg**

Website

Google Scholar

Location

E3A-04-09

His work experience include heading the Tech. Training Div of Intel Phils, research positions at the East West Center in Hawaii and at the Mass Inst of Tech, and Asst Prof of EE at the Univ of Roch, NY. Marcelo joined NUS in 1989. His research span robotics, automation, computer control, and artificial intelligence and he is actively involved in the Singapore Robotic Games as its founding chairman.

Qualification

Ph. D. EE, MSc EE Univ of Rochester; MSc ME, University of Hawaii; BSc ME and Indl Mgt Eng, De La Salle Univ

Research Interests

Robotics, Mechatronics, Intelligent Systems
Link: http://guppy.mpe.nus.edu.sg/~mpeangh/research.htm

Selected Publications

R.O. Atienza, and M.H. Ang Jr., “A Flexible Control Architecture for Mobile Robots: An Application for a Walking Robot,” Journal of Intelligent and Robotic Systems, 30: 29-48, 2001.

D. Oetomo, M H Ang Jr., and S Y Lim, “Singularity Handling on Puma in Operational Space Formulation,” Experimental Robotics VII, LNCIS (Lecture Notes in Control and Information Sciences) 271, March 2001.

NUS Mechanical Engineering

9 Engineering Drive 1
Block EA #07-08
Singapore 117575

+65 65162210

Key Words: *robotics, robot design, neural networks, fuzzy reasoning, task planning, robot compliance, flexible robots, hybrid force and position control, walking robots, mobile robots, autonoumous navigation.*

Research Interests

Currently Funded Research Projects

1. Man-Machine User Interface

For a robot to perform its task, it is imperative to have a *complete* and *unambiguous* description of the workcell environment as well as of the robot itself. In addition, the robot must be capable of geometric reasoning in order for it to be able to accomplish its tasks. External sensors are required to account for any uncertainties and/or inaccuracies in the workcell environment. The robot must be able to update its knowledge of not only its environment but of itself. We refer to a roboti c system as intelligent if it possesses the two important capabilities of geometric reasoning and environment adaptation.

The first phase of the project involves the integration of a geometric (solid) modeling system into the robot controller architecture as a necessary first step towards intelligent robotic system design. The study involves: (i) the design and synthesis of an friendly user-interface for robot offline programming (ii) robotic task planning; (iii) task-level languages and task-based control;and (iv) robot simulator design for program verification and analysis.

- Possible research projects include the following:
- Motion Planning of Robots in a Known Environment
- Local Planning for Sensor-Based Mobile Robotic Systems
- Walk-Through Robot Programming System
- Force and Position Control of Telerobotic Systems
- Task Planning for Constrained Motion Tasks
- Specification of Manipulator End-Point Compliance According to the Task
- These projects can have scope for M.Eng or Ph.D. work.

2. Control of Dynamic Behavior of Robot Manipulators

Active control can make a robot manipulator behave with a different dynamics in response to external forces exterted on the end-effector. The apparent mass, damping, and stiffness of the robot as seen from its end-effector can be achieved using advanced control strategies.

Impedance Control has been achieved using the basic formulation of Hogan. Current work addresses improvement of the performance for

- force control
- motion control
- hybrid force/position control
- impact and contact task control
- walkthrough programming

3. Passive Compliance and Flexible Robots

Current robot manipulators possess inherently stiff and massive structures, and are primarily designed to be positioning (and orienting) devices. This design philosophy has severely limited robotic applications. The payload to mass ratio of current manipulators are indeed very low and the justification of robot usage against automatic machine tools (i.e., hard automation) is unclear. Furthermore, many manipulation tasks require compliance, the ability to accomplish force as well as position control. For example, constrained motion movement and many tasks associated with touch or feel in fine assembly require compliance. The rigid structure of current manipulators have made compliance impossible and have made robotics use difficult in automation tasks. Only a few of the compliance related tasks have been automated, and usually by means of compliance devices as end-effectors rather than in the structure of the manipulator itself.

In order for a manipulator to be useful, improvements are required in two areas: (1) manipulators must be smaller and lighter in weight for what they do, and (2) manipulator must be able to do force as well as position control. This research addresses the aforementioned two areas. Future generation manipulators would consist of not only rigid but also compliant limbs capable both of force and position control. Positioning accuracy will no longer be the only primary concern and lighter manipulators can be built. Such manipulators would have high payload to mass ratios since the flexible limbs would be much lighter. Manipulator tasks would constitute not only position commands but also the associated compliance required for the task.

The research objective is to design a robotic manipulator with programmable passive compliance structure that possesses the following characteristics: (i) capable of force and position control, (ii) consisting of compliant (flexible) limbs, (iii) high payload to mass ratio, (iv) end-point compliance can be actively controlled.

The other research objective is the specification of the desired dynamic behavior, e.g. compliance, needed for a specific task. This is related to task planning. The apparent mass is desired to be small when impact is expected. Desired compliance can be specified by appropriately choosing appropriate stiffness values to describe the desired motion/force interrelationships, and to be consistent with force and motion control directions.

The methodology would include both theoretical work and experimental work. Actual devices would be built together with the required computer-interface hardware. Powerful computers would be required to control these future generation robots. Promising new technologies would be explored for application to the control of these robots. These technologies include neural networks, fuzzy reasoning, and artificial intelligence techniques.

Possible research projects include the following:

- Vibration Control of Robots with Flexible Limbs
- Pose Compensation of Robots with Flexible Limbs
- Visual-Based Feedback Control of Robot Manipulators
- Control of the Dynamic Behavior of Robotic Manipulators
- Force and Position Control for Constrained Motion Tasks
- These projects can have scope for M.Eng or Ph.D. work.

4. Mobile Robotics

Robots are finding increasing applications in the manufacturing and service industry. Their usefulness, however, has been limited by their non-mobility. Some mobile robots, such as the automated guided vehicles, are very constrained in their movements and lack the intelligence to move freely, planning their paths intelligently taking into consideration the environment they are in, and avoiding obstacles in their paths.

Once imbued with the capabilities to roam freely, robots will be capable of performing a much greater variety of tasks not now possible. With greater intelligence incorporated, they will also be able to perform more intricate tasks and negotiate obstacles without endangering people around them or causing damage to themselves or the things in their paths.

Research work can be classified into hardware and software. Hardware work includes the design of mobile robots capable of operation in uneven terrain with full dexterity. Issues to be addressed include design and analysis of different gaits for walking, energy efficiency and dexterity, sensors, and arms and end-effectors. In the software aspects, research issues addressed will include autonomous navigation, path planning and motion control, task execution software, visual and location information capture and processing.

There are many potential applications to intelligent autonomous mobile robots. Among these are the intelligent autonomous motor car, intelligent patrol and surveillance robot, intelligent material transporters for factories or the hospitals, intelligent submerged or surface vehicles, and various types of service robots.

Current research projects include the design of a quadrupedal walking robot, and the research and development of a patrol and surveillance robot.

5. Intelligent Control

Neural networks offer several potential advantages over conventional computer architectures. Calculations can be carried out in parallel yielding speed advantages, and programming can be done by training using examples rather than defining explici t instructions. Neural networks are modeled to emulate the human brain while a robotic manipulator tries to duplicate the dexterity of the human body. It is therefore natural to explore neural network applications in robotics.

Neural networks may address current limitations of robotic systems. The inherently parallel architecture make neural networks ideal for real-time implementations requiring fast speed, such as inside robot control servo loops. Their training capabilities can be exploited for the development of adaptive and self-learning systems, such as in adaptive robot control wherein the neural network continuously learns the robot dynamic model.

Research interests in neural networks include the theoretical and experimental studies of neural network architectures with the objective of gaining insight into the their "trainability" and structural functionalities.This research also, explores the pos sibilities of using neural networks in robotics, the ultimate objective is to use them to control future generation robots whose structures are made deliberately and variably compliant.

The theoretical framework provided by fuzzy sets and fuzzy logic allows analysis and synthesis of intelligent systems capable of fuzzy reasoning. Indeed, a characteristic of intelligence is the ability to reason and make decisions using fuzzy or inexact information. Providing a machine with intelligence therefore means incorporating fuzzy reasoning.

Research in fuzzy reasoning aims at the study of several paradigms for fuzzy logic control of robotic manipulators. In addition, we are exploring the possibilities of using fuzzy reasoning in robotic task planning. One objective to to create a knowledge base capable of fuzzy reasoning. Such a knowledge base, for example, can be used to help specify the end-effector compliance required for different families of robotic tasks.

It is our belief that intelligent systems will be hybrid systems incorporating neurocomputing as well as fuzzy reasoning to conventional computing techniques. Each of these has distinct roles to play in a structured intelligent system.

Possible research projects include the following:

- Neural Network Based Learning - Algorithms and Architectures
- Neural Networks for Robot Motion Control
- Neural Networks for Control of Dynamic Behavior of Robotic Manipulators
- Learning Based on Hybrid (Neuro-Fuzzy-Genetic) Systems

These projects can have scope for M.Eng or Ph.D. work.

Currently Funded Projects (PI: Marcelo H. Ang Jr.)

1**. "**Integration of Solid Modeling Systems and Robot Controller Architectures Towards Intelligent Robotic Systems", funded by the *National University of Singpapore*, Project Number RP890659, $267,150 (MOE), 1990-1995.

2. "Management of Manufacturing Technologies: Trends in Technological Development - Identification, Infusion and Education," funded by the *National University of Singapore*, Project Number RP910708, $33,000 (NUS), 1993-1995.

3. "Research and Development of a Ship-Welding Robot," funded by the *National Science and Technology Board*,

Singapore, Project Number GR6253, $1,651,200 (NSTB), $60,000 (FELS), 1994-1997.

Back to Home Page of Marcelo