

Paul Y. Oh

Mechanical Engineering Dept.
Columbia University
Room 220 Mudd Building
paul@cs.columbia.edu
New York, NY 10027
www.cs.columbia.edu/~paul

Office: (212) 939-7090
Home: (212) 662-6160

RESEARCH INTERESTS

robotics, dynamics, control systems, computer vision, mechatronics, data acquisition, manufacturing

EDUCATION

Columbia University(New York, NY)

Ph.D. in Mechanical Engineering, October 1999

Thesis: *Integration Of Joint-coupling For Visually Servoing a 5-DOF Hybrid Robot*

Advisor: Professors Peter K. Allen (Computer Science) & Richard Longman (Mechanical Engineering)

Columbia University(New York, NY)

M.Phil. in Mechanical Engineering, May 1995

Seoul National University(Seoul, Korea)

M.Sc. in Mechanical Design and Production Engineering, February 1992

Sub-minor in Control and Instrumentation Engineering

Thesis: *Improved Model Reference Adaptive Control of Electro-hydraulic Servo Systems Using the Euler Operator*

Advisor: Professor Kyo Il Lee

McGill University (Montreal, Canada)

B.Eng. (Honors) in Mechanical Engineering, May 1989

Thesis: *Decoupled Flight Control for Advanced Tactical Fighters*

Advisor: Professor Noriyuki Hori

RESEARCH EXPERIENCE

Columbia University,1993-1999

Joint work in Mechanical Engineering & Computer Sciences Departments

- Designed and prototyped a working visually controlled robotic gantry for an assembly workcell
- Investigated the use of coupling a robot's degrees-of-freedom to improve visual-servoing
- Integrated force and bending moment for multi-sensor fusion in a robotic gripper
- End-point vibration study and elimination for a robotic gantry using input shaping
- Modeled and prototyped the design of a left-ventricle-assist-device surgical testbed

Work exclusively in the Mechanical Engineering Department

- Designed a repetitive controller for a lathe to automate non-cylindrical part machining
- Consultant: Designed and prototyped a microprocessor controlled pump for dispensing pharmaceuticals

Seoul National University,1990-1993

Work in the Mechanical Design and Production Engineering Department

- Joint project with Canadian and Korean Ministry of Defense and Daewoo Heavy Industries Prototyped and designed an electrohydraulic servo controller for a ship-motion simulator Stewart Platform using a model reference adaptive strategy

- Korea Institute of Technology project with Hyundai Motor Company: Graphical user interface programming for an automated wheel-rim deburring robot

RESEARCH EXPERIENCE(continued)

Paul Y. Oh

McGill University, 1985-1989

Work in the Mechanical Engineering Department

- Designed a decoupled control system for highly maneuverable tactical fighters
- Finite element analysis of the human knee and prosthetic

FELLOWSHIPS AND AWARDS

- Columbia University, Computer Science, Graduate Research Assistantship, 1999-2000
- National Science Foundation Travel Scholarship, 1998 (for paper presentation)
- Columbia University, Mechanical Engineering , Graduate Teaching Assistantship, 1994-1998
- Canadian Ministry of Education Governor's Fellowship, 1989-1992
- Daewoo Heavy Industries (Korea) Research Fellowship, 1990-1992
- McGill University, McConnell Engineering Teaching Assistant Award, 1986-1989

PROFESSIONAL EXPERIENCE

Bell Atlantic Science and Technology, NY, NY USA, 1998-1999

C/C++ Software Developer: Programmed on Unix platform an automated telecommunications network planning system. Artificial intelligence based team project forecasts commercial and residential phone line needs in New York and New England areas and plans network connections. Implemented measurement algorithms for estimating potential savings costs to Bell Atlantic due to automation.

Central International Law Firm, Seoul Korea, 1992-1993

Engineering Consultant: Reviewed patent applications submitted by US and European companies filing intellectual property in Korea for the firm's mechanical and electronic devices department. Consulted for patent lawyers in engineering validity of claims and the correct Korean and English technical terminology.

Hyundai Motor Co., and Korean Institute of Science & Technology, Seoul, Korea, Summer 1992

Research Engineer: Designed and developed a control system for automatic car-wheel rim deburring work cell. Programmed industrial robot with path planning and force/torque feedback.

Daewoo Heavy Industries and Korean Agency of Defense Development, Seoul, Korea, 1990-1992

Research Engineer: Designed and developed a ship motion simulator control system with electromechanical hydraulic and pneumatic servo valves. Built electronic circuits and PC hardware interface cards. Programmed the graphical user interface.

CAE Electronics Ltd., Montreal, Canada, Summer 1989

Design & Software Engineer: Programmed and debugged software for both flight and nuclear power plant simulators.

Oerlikon Aerospace, Montreal, Canada, Summer 1988

Summer Intern: Wrote technical report on force/torque tolerancing and quality control. Cooperated with subcontractors in design of the laser-guided surface-to-air missile ground vehicle.

TEACHING EXPERIENCE

Columbia University - Graduate Level

Mechanical Engineering:

- Digital Data Acquisition: Lab Instructor and Manager, 1994-1999
Developed course with \$10,000 budget, designed all labs and authored manual, secured equipment grants, lab inventory purchases and built lab library
- Modeling, Control and Analysis of Manufacturing Systems: Teaching Assistant, Spring 1995
- Flexible Manufacturing Systems: Teaching Assistant, Spring 1995

Computer Science:

- Robotics: Teaching Assistant, Spring 1996

TEACHING EXPERIENCE(continued)

Paul Y. Oh

Columbia University - Undergraduate Level

- Mechanical Engineering Lab I: Lab Assistant, 1997-1998
Setup, supervised juniors and graded labs in stress analysis, fluid flow, thermodynamics
- Mechanical Engineering Lab III: Lab Assistant, 1997-1998
Setup, supervised seniors and graded labs in control systems, vibrations, stress analysis, fluid flow, thermodynamics

McGill University - Undergraduate Level

- Boundary Value Problems (Partial Differential Equations): Lecture recitation and grader, 1986-1989
- Ordinary Differential Equations: Teaching Assistant, 1986-1989
- Fluid Mechanics II (Supersonic): Departmental Tutor, 1988-1989
- Linear Algebra: Grader, 1986-1989

PROFESSIONAL SERVICES

Reviewer IEEE International Conference on Robotics and Automation (ICRA)
Reviewer IEEE International Conference on Intelligent Robotics and Systems (IROS)

SERVICES AND ACTIVITIES

- Graduate Student Representative Columbia University Mechanical Engineering, 1996-1999
- National Chairman of the Korean Canadian Youth Federation, 1986-1989
- Initiation Coordinator Sigma Chi Fraternity, McGill Gamma Lambda Chapter, 1989
- Student Member IEEE and ASME, 1993-1999

PUBLICATIONS

1. “*Coupling Effects for Visually Servoed Feedback*”, Paul Y. Oh, Peter K. Allen, IEEE International Conference on Robotics and Automation (ICRA) San Francisco, CA, submitted for publication, 2000
2. “*Performance of a Partitioned Visual Feedback System*”, Paul Y. Oh, Peter K. Allen, IEEE International Conference on Robotics and Automation (ICRA), Detroit, Michigan, pp. 275-281, 1999
3. “*Integration of Vision, Force and Tactile Sensing for Grasping*”, Peter K. Allen, Andrew Miller, Paul Y. Oh and B. Leibowitz, International Journal of Intelligent Machines, Vol. 4, No. 1, pp. 129-149, January 1999
4. “*Design of Partitioned Visual Feedback System*”, Paul Y. Oh, Peter K. Allen, IEEE International Conference on Robotics and Automation (ICRA), Leuven, Belgium, pp. 1360-1365, 1998
5. “*Using Tactile and Visual Sensing with a Robotic Hand*”, Peter K. Allen, Andrew Miller, Paul Y. Oh and B. Leibowitz, IEEE International Conference on Robotics and Automation (ICRA), Albuquerque, New Mexico, pp. 676-681, 1997

6. *"Improved Model Reference Adaptive Control of Electro-hydraulic Servo Systems Using The Euler Operator"*, Paul Y. Oh, IEEE International Conference on Robotics and Automation (ICRA), Albuquerque, New Mexico, pp. 1626-1631, 1997
7. *"Integration of Vision and Force Sensors for Grasping"*, Peter K. Allen, Andrew Miller, Paul Y. Oh and B. Leibowitz, IEEE/SICE/RSJ International Conference on Multi-sensor Fusion and Integration for Intelligent Systems, Washington, DC, pp. 349-356, 1996
8. "Visual Control for Robotic Hand-eye Coordination," Peter K. Allen, B. Yoshimi, A. T. Miller, P. Y. Oh, B. Leibowitz, Workshop on Robotics and Robot Vision,th International Symposium on Signal Processing and its Applications, ISSPA 96, Gold Coast, Australia, pp. 20-37, August 1996

REFERENCES

Paul Y. Oh

Peter K. Allen (Dissertation Advisor - Computer Science)

Professor, Dept. of Computer Science
Columbia University
1214 Amsterdam Avenue, M.C. 0401
New York, NY 10027
(212) 939-7093
allen@cs.columbia.edu

Richard K. Longman (Dissertation Advisor - Mechanical Engineering)

Professor, Dept. of Mechanical Engineering
Columbia University
500 W120th Street Room 220 Mudd Building
New York, NY 10027
(212) 854-2959
rw14@columbia.edu

Dr. George Klein (Digital Data Acquisition Course)

Adjunct Professor, Dept. of Mechanical Engineering
Executive Vice-President
Techno
2101 Jericho Turnpike
New Hyde Park, NY 11042
(516) 328-3300 ext. 400
georgeklein@hotmail.com

Michael Lai (Chairman)

Chairman and Professor, Dept. of Mechanical Engineering
Columbia University
500 W120th Street Room 220 Mudd Building
New York, NY 10027
(212) 854-4236
lai@cuorma.orl.columbia.edu

Research Statement

Paul Y. Oh

My current research interests involve the fusion of sensors, particularly vision, for robotically controlled tasks. Off-the-shelf CCD cameras, image processing hardware and software have converged technologically in recent years and are readily affordable. There are still many open problems and challenges in machine vision; recent research efforts have increasingly focused on image understanding and image processing for solutions. In my research at Columbia University, I approached visual servoing of robots slightly differently. My philosophy is that image data be integrated with other sensor data to perform vision-based tasks. People appear to fuse vision with other sensory information like kinematic (neck, head, torso position) and vestibulo (inner ear) data to effectively perform vision tasks. With this design philosophy, I built a robot that maneuvers a camera using both kinematic and image data to visually monitor a large assembly workcell. The net effect is that my design overcomes many of the limitations in conventional robot tracking systems. I also fused vision with tactile sensors and strain gages on a robot hand. Finger occlusion or limited camera field-of-view compels the use of additional sensors for hand-eye manipulation tasks. Fingertip deflections were visually monitored and tactile readings along the finger gave the locations of applied force. The finger was modeled kinematically using beam theory and using strain readings the finger curvature was determined for finer grasp configurations.

Machine vision is multi-disciplined and my approach presents opportunities to apply robotics research traditionally associated with mechanical engineering such as redundant manipulators, motion planning, control theory and kinematic synthesis to a machine vision context. My work demonstrates there is much to reap if such research is combined with disciplines in image analysis, signal processing and computer architecture. For example, I am interested in designing host mechanisms for sensor fusion. I would like to draw upon my multi-disciplined training in mechanical, electrical and computer engineering to develop a mechanical eye. Its design would host an embedded microprocessor and a suite of sensors like a CCD and accelerometer. The control system used in my thesis illustrates that by quickly actuating the camera, the mechanical eye acts like a lead-lag compensator. The end product would be a modularized eye that one could simply retrofit on existing robots so that they could easily perform vision-based tasks autonomously. Machine vision is also a multi-faceted. I would like to apply my cross training in control systems, data acquisition and flight dynamics to control and navigate an aerial robot for surveillance and 3-D terrain modeling. I am interested in using my skills in programming, digital hardware design and mechanism design to build teleoperated and animatronic robots.

"Tomorrow's Professors", a book published by the IEEE, describes the increased focus on partnerships between academia, government and industry. In 1989, I received a full fellowship to work with both the Canadian and Korean governments to help develop a ship motion simulator. Through my employment at Canada's CAE Electronics, a world leader in aircraft simulators, and my research in flight control at McGill, we developed a Stewart Platform for the Korean Ministry of Defense. The project's success was largely due to the collective wills and good communication I had with the universities, governments and industrial partners CAE and Korea's Daewoo Heavy Industries. Drawing from these partnership experiences, I hope to translate both my cross-disciplined technical background and management skills towards my future research endeavors.

Teaching Statement

Paul Y. Oh

In a recent feature issue on teaching control, the IEEE *Control Systems* magazine called attention for new pedagogical approaches. They cite that control courses should provide hands-on experiments that cement theoretical abstraction with real-world applications. This has been a common theme in both my undergraduate and graduate teaching experiences.

For the last five years, I managed the Digital Data Acquisition (DDA) Lab course at Columbia University. It is a one semester, graduate/senior undergraduate course on digital system design, computer architecture, sensors and signal processing. In 1994, I received a \$10,000 budget from the Mechanical Engineering department to completely renovate the DDA Lab. At that time, the Lab was in disarray and had antiquated equipment (Apple II computers). The department understood the value of the course; many of our graduate students relied on acquiring experimental data for their research, but few had any first hand experience designing experiments and interfacing sensors to a computer. I built six student lab stations consisting of PC's, data acquisition cards, scopes and circuit prototyping equipment. I wrote a new lab manual with hands-on circuit building and computer interfacing experiments to buttress classroom lectures. The experiments drew from my own Masters background in control systems and instrumentation engineering. It has received excellent student evaluations and has even attracted students outside our department. If given the opportunity to teach similar courses, I would like to add experiments introducing biomedical sensors, wireless technologies and remote data acquisition via the Internet.

In addition to managing DDA, I was a lab assistant for the undergraduate mechanical lab courses at Columbia that covered thermodynamics, solid mechanics, vibrations, and fluids. These courses are the first time junior and senior students get hands-on exposure to reinforce classroom theory. I have also assisted in the graduate manufacturing and robotics courses at Columbia for both the Mechanical Engineering and Computer Science departments. At McGill, I assisted, recited and graded engineering mathematics for 3 years and was a department tutor in supersonic fluid dynamics and computer programming.

The Internet also offers a unique opportunity to buttress design courses. Three years ago I started an internet-based company <http://www.boondog.com> that offers PC-cards and instructional kits that spun off from the DDA course. My clients include over 30 universities and small-to-large businesses. The kits teach computer interfacing, motor control and data acquisition. The Internet has precipitated my company into an effective consulting practice, which I believe can be translated into a design course. My clients present interesting real-world problems, which students can choose to address. The entrepreneurial aspects could attract students and reinforce professional qualities, teaching skills like product development, feasibility studies and engineering economy.

I feel that my combined experiences in theoretical and lab courses, multi-disciplined research and management give me unique pedagogical skills. I hope to implement these skills in my teaching endeavors and continuously motivate the up and coming generation of engineering students.