**Biography of Timothy Chang**

Timothy Chang is Professor and Associate Chairman for Graduate Studies at the Department of Electrical & Computer Engineering, NJIT. He received his B.Eng (honours) degree from McGill University, M.A.Sc. and Ph.D. degrees from University of Toronto. Prior to joining NJIT in 1991, he was a Senior Research Specialist and Program Manager at Kearfott Guidance and Navigation Corp., NJ, in charge of the Doppler mirror ring laser gyroscope program. From 1992-1994, he served as a consultant to Condor Pacific (NJ), responsible for the hardware/software design and development of the sidewinder inertial navigation signal processing system. From 1999-2001, he was a consultant to Intelligent Health Inc. where he was responsible for designing computer-controlled fitness equipment and software animation of the human-machine interface. Dr. Chang has been the Chairman of the North Jersey IEEE Control Systems Chapter since 1994. He also served as an elected member of the Montville Township Board of Education from 2000-2003. His areas of interest include: ultra-high precision systems, genetic systems, robotics/motion control, embedded real time systems, decentralized control systems, and web-based experiments. Dr. Chang holds 6 patents with 2 patents pending. He has published over 70 referred journal and conference papers. He is the author of "Servo Control Design", in Encyclopedia of Life Support Systems, published by United Nations Educational, Scientific, and Cultural Organization (UNESCO).

Dr. Chang was a recipient of several awards including:

- Robert W. Van Houten Award for Teaching Excellence, NJIT, 2008
- Thomas Alva Edison Patent Award, NJ Research Council, 2007
- NJIT Excellence in Teaching Award in the category, Outstanding Professional Development, 2007
- ECE Chair Recognition Award for Outstanding Contributions in the Undergraduate Program, NJIT, 2004
- Master Teacher, NJIT, 2003,
- NJIT Excellence in Teaching Award in the category, Excellence in Team, Interdepartmental, Multidisciplinary, or Non-Traditional Teaching, 2002,
- Saul K. Fenster Innovation in Engineering Education Award, New Jersey Institute of Technology, 2002,
- NCE Excellence in Teaching Award, New Jersey Institute of Technology, 2000
- Provost Challenge to Innovative Teaching, New Jersey Institute of Technology, 1999
- Excellence in Teaching Award, New Jersey Institute of Technology, 1997
- Best Teaching Assistant Award, University of Toronto, 1986
- Ontario Open Graduate Fellowship, 1986.
- University Scholar, McGill University, 1976-1980.

Ultra-high precision systems concern with the mechanical positioning platform design, operation, and control so that precision placement in the nanometer range can be achieved. Applications of ultra-high precision systems include semiconductor manufacturing, nanotechnology, optoelectronics, and biomedical systems. Over the past 5 years, Dr. Chang has been working on piezoelectric positioners, magnetic transmissions, as well as high precision robotics. Shown in Figure 1 is a low cost multiple degree-of-freedom (DOF) lead titanate, lead zirconate piezoelectric positioner which has a resolution of 2 nanometer, response time of 1.5 microns/millisecond, and minimum range of 15 microns by 15 microns. The development of this nanoactuator was part of a $10.3 million NIST Advanced Technology Project on Precision Optoelectronics Manufacturing where Dr. Chang was the co-leader of the platform team. Dr. Chang has been granted a US patent on this device.

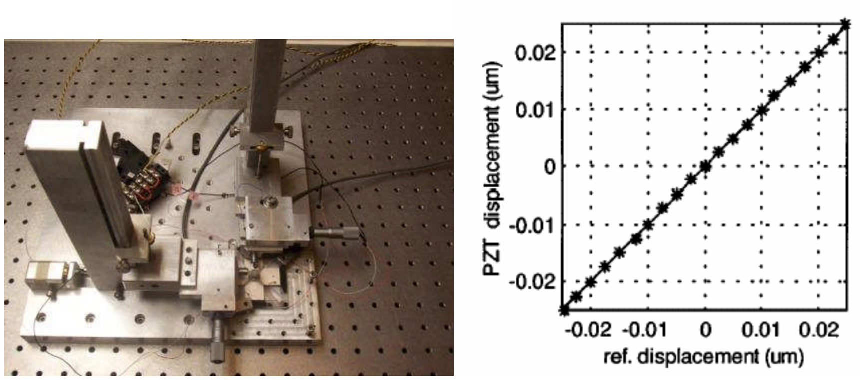



Figure 1: Prototype of a 2DOF nanoactuator, repeatability is better than 2nanometers.

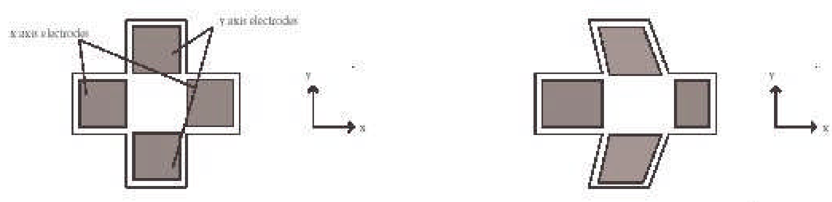



Figure 2: Motion of the nanoactuator in the x-direction

He is currently working, in collaboration with the Public Health Research Institute, University of Dentistry and Medicine of New Jersey, on a new generation of liquid dispensing/aspiring system (SmartPin, patent pending) for spotting DNA microarrays and molecular beacons (Figures 3a &b). This work is supported by a National Science Foundation Grant. Some of the microarray facilities are shown in Figure 3c with the Cartesian microarrayer and GeneTAC UC4 scanner donated by GenomicSolutions, the EcoSnow process chamber donated by Kearfott Corp, and the XY-3000 robots donated by Lucent Technologies. Other applications such as cell manipulation, single mode fiber alignment, nanomaterials manipulation are also being considered.

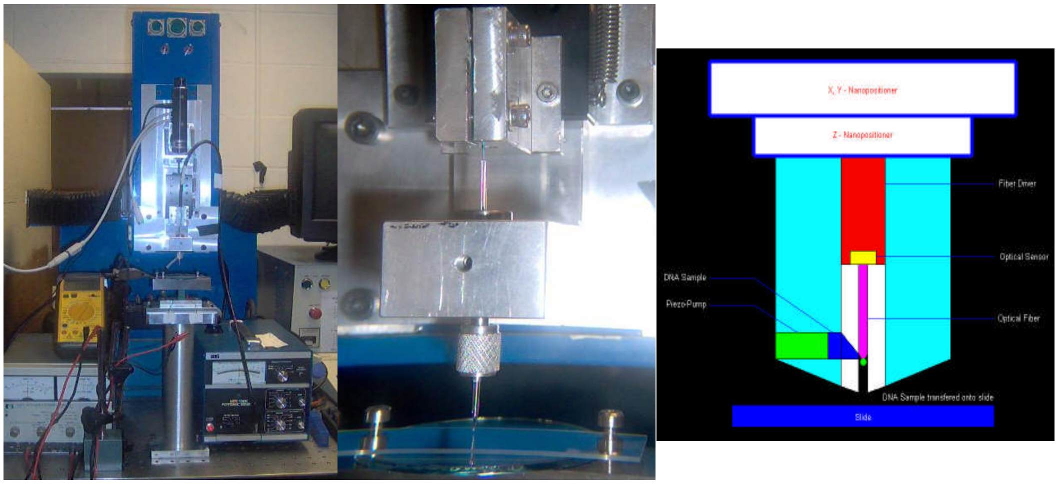



Figure 3a: SmartPin for DNA microarray

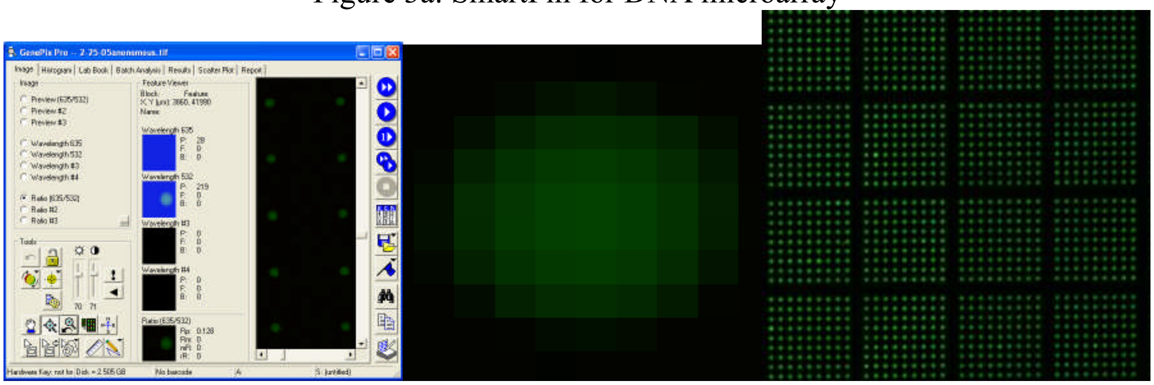
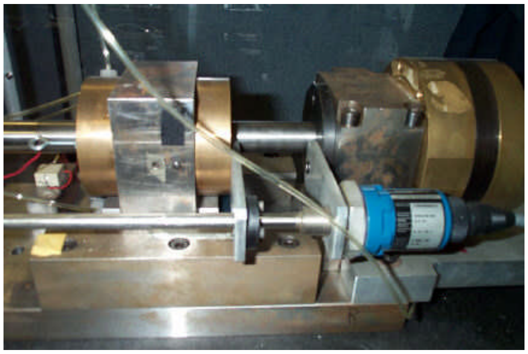


Figure 3b: DNA microarray produced by the SmartPin with spot size of 80microns.

Figure 3c: Realtime Lab Microarray facilities, left to light: Smartpin on XY-300 robot, Cartesian Microarrayer, GeneTAC UC4 scanner, EcoSnow process station.

Magnetic transmission is another example of ultra-high precision system. The operation is based on leadscrew/nut coupling to transfer angular motion into linear one. But unlike mechanical leadscrews, the threads of the nut and the leadscrew are aligned magnetically and do not come in contact due to the presence of an aerostatic bearing. Thus, ``hard'' nonlinearities are substantially reduced, resulting in high precision and high resolution. A prototype of a magnetic transmission system is shown in Figure 4.



In this prototype, the nut (on the left) moves horizontally with a range of 10cm and resolution of 10 nanometers. The transversal motion is supported by a thrust bearing (on the right). In conjunction with Adept technology, Inc. of San Jose, a number of low cost, long travel magnetic leadscrews have also been developed for their linear modules. Dr. Chang was granted a US patent for the magnetic transmission system.

Figure 4: Prototype magnetic transmission system

Figure 5: NEAT robotic workcell

A system-integrated high precision workcell is shown in Figure 5. A $250K New England Affiliated Technology (NEAT) ultra-high precision robot was donated to Dr. Chang by Lucent Technologies along with a HP laser interferometer. This robot is capable of 4 DOF with linear resolution to 0.1 microns. Dr. Chang and his students are currently developing control algorithms for this platform to improve speed of response and minimizing the effects of environmental factors. A novel matched model reference/feedforward control has been devised to minimize the effects of parasitic nonlinearities in the robot. A Graphical User Interface (GUI) based on LabVIEW is also being developed to facilitate open architecture software design. Besides graduate students, a number of under graduates also participate in the research effort, either as senior design projects or McNair Research Scholars. His undergraduate student teams won first place in the Senior Project Competition for three consecutive years.

Dr Chang's other research efforts in the robotic area include: modeling, vibration control, trajectory generation, robot vision, and state estimation. His lab is equipment with a large number of CCD cameras (stand-alone and board-level) and imaging processing hardware. Shown in Figure 6 is one of the two Seiko robots in the lab. Each of these robots provides 4 DOF of motion for coordinated, medium accuracy tasks such as inspection, assembly, and testing. A telephone life-time reliability test project was carried for Lucent Technologies to detect the dynamic characteristics of push button phones. His effort in vibration control is best exemplified by the linear module vibration control project in collaboration with Adept Technology, Inc. In this project, an Adept linear robot, shown in Figure 7, was being considered for improve transient in the x-y (horizontal) direction and vibration suppression in the z (vertical) direction. An optimal command shaper was devised for feedforward trajectory synthesis, resulting in a ten-fold improvement of cycle-time of the robot. For the z-direction, a digital servocompensator was designed to provide robust harmonic vibration suppression. In the experiment, up to seven vibration modes were eliminated. A 3D vision system is currently integrated with an Adept Cobra 600 robot for real time target acquisition and control (Figure 8).


Figure 6: Seiko Robot

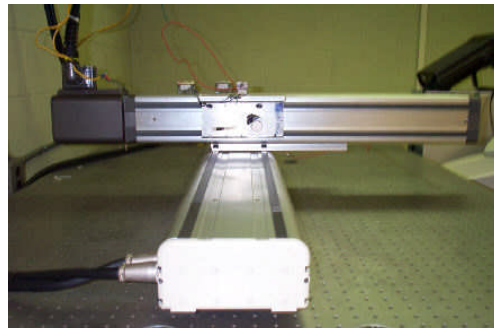


Figure 7: Adept Linear Modules


Figure 8: Adept Cobra 600 Robot

The third area of Dr. Chang's research is embedded real-time systems, specifically with fixed/floating digital signal processors (DSPs). He introduced two new graduate level courses ECE664 Real-time Control Systems and ECE789 Advanced Rea-time Contorl Systems to address the theoretical, experimental, and numerical issues of DSP based sampled data systems. His lab has 10 TMS320C25 DSP boards, 8 TMS320C3x boards, and a pair of Transtech DP12-2c each equipped with two TMS320C6701 ultra-fast floating DSPs. Dr. Chang, along with his graduate students, have developed various Application Programming Interfaces (APIs) and GUIs for the DSP system to be embedded in various application environments such as Matlab, LabVIEW, visual C++, etc. On going project include the Personalized Weapon Technology Program (Smart Gun), funded by the National Institute for Justice, US State Department and the US Army, where the handgun is electronically enabled to recognize authorized users and record all firing activities. An embedded DSP (Figure 9) along with piezoelectric sensors

(Figure 10) have been designed to provide high bandwidth, low power, low form factor data processing and decision generation. This work was recently featured in the New York Times.

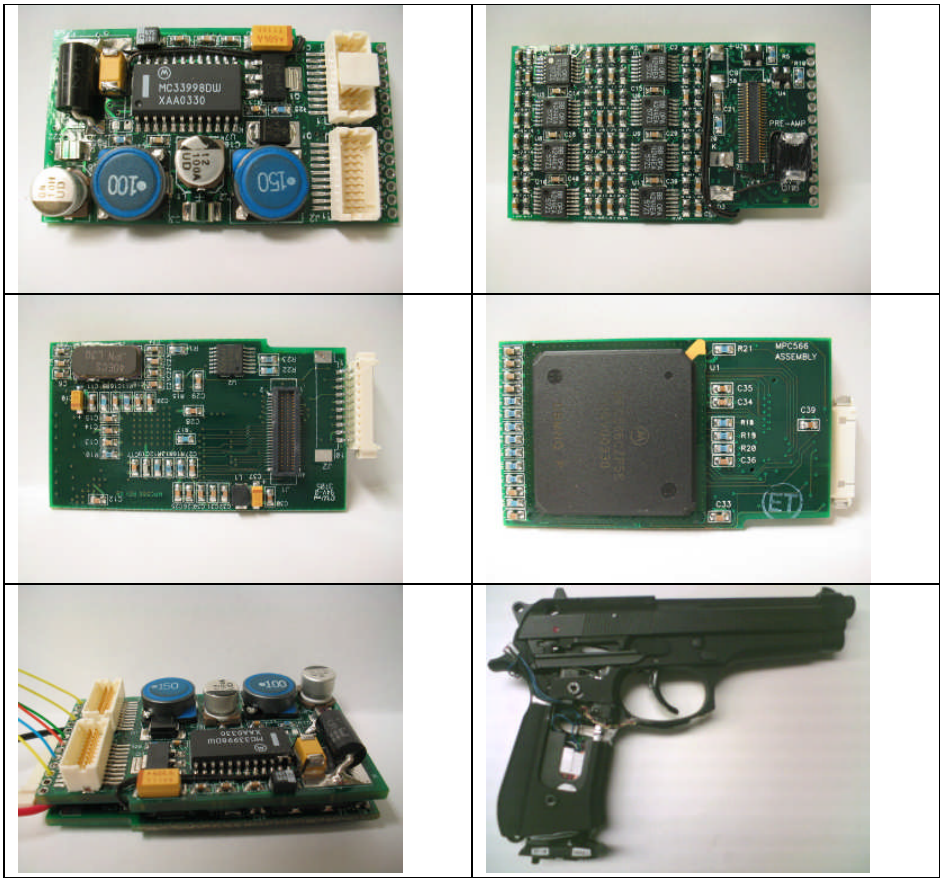



Figure 9: Handgun with dynamic grip recognition and embedded DSP

Figure 10: Piezoelectric disk and film sensors

Dr. Chang has also been investigating decentralized control systems and applications. Properties such as fault-tolerant, interaction, robustness, and optimal control have been considered. Application to traffic control systems was supported by a DOT/NJTIP grant to determine how to improve fault tolerant characteristics of an urban traffic network. Other applications of decentralized control include large power networks and data routing on the Internet. The ubiquitous Internet provides an excellent opportunity for multi-user multi-modal experimental systems where the plant (hardware) is to be regulated by remote users asynchronously. Traditional approach requires extensive software development such as with Java/C++. With the LabVIEW virtual instrumentation system (software along with data acquisition hardware), Dr. Chang and his students designed and implemented a plug-in for web-browsers to provide web experiment capabilities. The nanoactuator was commanded in real-time, via the Internet. The web-browser installed with plug-in is shown in Figure 11 while the server block diagram is shown in Figure 12. The plug-in produces a number of advantages: no LabVIEW G-programming knowledge is necessary (in fact, the client-server operation is transparent to the user), multiple users can logged on to conduct the experiments, and high system safety and security. Dr. Chang is currently applying this technology to engineering education where the undergraduate students access delicate experiments remotely on a 24/7 basis, thereby maximizing resource utilization while minimizing the maintenance costs. This effort is supported by the New Jersey Department of Education Information-Technology Opportunities for the Workforce, Education, and Research (NJ I-TOWER) grant. Dr Chang was also the recipient of an NSF Combined Research and Curriculum Development grant for optical Sciences and Engineering.

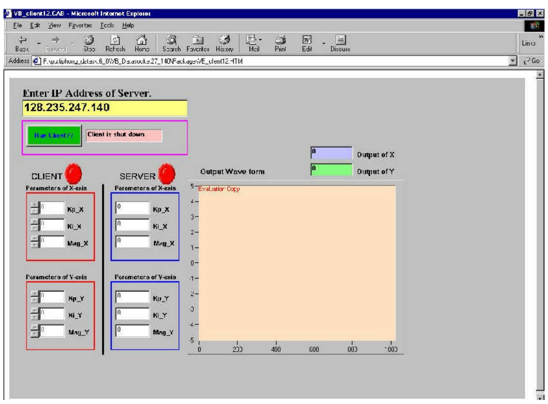



Figure 11: Web browser with plug-in

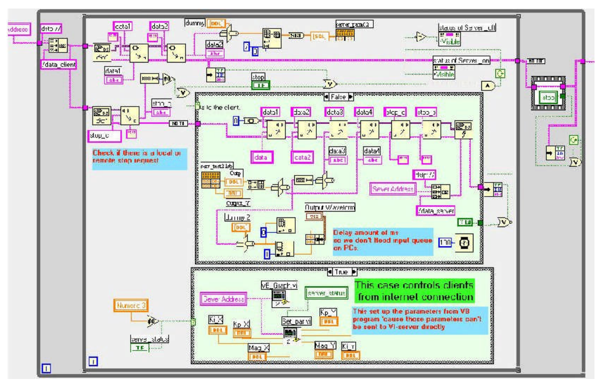



Figure 12: Block diagram of the server

**US Patents:**

- Timothy Chang and Biao Cheng, “Film based position and pressure sensor”. US Patent Number 7278327B2, DOI: Oct 9, 2007.
- Timothy Chang and Peter Tolias, “Delivery of metered amount of liquid materials”. US Patent Number: 7097810B2, DOI: Aug 29, 2006. European, Japan, and Australia patent pending.
- Timothy Chang “Multiple Degree-of-freedom Piezoelectric Actuator,” US Patent number 06359370, DOI: March 19, 2002.
- Michael Shimanovich, R. Caudill, T.N. Chang and Z. Ji, “Low Friction High Precision Actuator," US Patent No. 5990587, DOI: November 23, 1999.
- Timothy Chang “High Precision Piezoelectric positioning device," U.S. Patent number: 5686777, DOI: November 11, 1997.

- Timothy Chang, B. Ljung, and B. Friedland, "System for Substantially Eliminating Lock-in in a Ring Laser Gyroscope," U.S. Patent Number: 5,359,413.
- 2 US patents pending.

**Selected Recent Journal Publications:**

Timothy N. Chang and Nirwan Ansari, "Passband Control of Lightly Damped Systems with Mode Separation," IEEE Transactions on Industrial Electronics, Vol. 55, Issue 5, pp. 2169-2176, May, 2008 .

Ding Yuan and Timothy N. Chang, "Model Reference Input Shaper Design with Applications to a High-Speed Robotic Workcell with Variable Loads," IEEE Transactions on Industrial Electronics, Volume 55, Issue 2, pp. 842 – 851, Feb. 2008.

Timothy N. Chang, D. Yuan, and H. Hanek, "Feedforward Control of a High Precision Robot with Velocity Deadzone," IEEE Transactions on Control Systems Technology, Vol. 16, No. 1 pp.894-102, Jan, 2008.

Biao Cheng, Timothy Chang, "Enhancing Ultrasonic Imaging with Low Transient Pulse Shaping," IEEE Transactions on Ultrasonics, Ferroelectrics, and Frequency Control, Vol. 54, No. 3, pp. 627-635, March , 2007.

Timothy N. Chang, B. Cheng, and P. Sriwilaijaroen, "Motion Control Firmware for High Speed Robotic Systems," IEEE Transactions on Industrial Electronics, Vol. 25, No. 5, pp. 1713-1722, October, 2006.

Timothy N. Chang and Z. Chen, **"**Reliable Decentralized Servomechanism Problem for Large Scale Systems," ASME Transactions on Dynamic Systems, Measurement and Control, Vol. 128, pp. 441-448, June, 2006.

Timothy N. Chang, P. Jaroonsiriphan, M. Bernhardt, and P. Ludden, "Web-Based Command Shaping of Cobra 600 Robot with a Swinging Load," IEEE Transactions on Industrial Informatics, Vol. 2 ,No. 1, pp. 59-69, Feb, 2006.

Timothy N. Chang, S. Parthasarathy, T. Wang, , K. Gandhi and P. Soteropolous, "Automated Liquid Dispensing Pin for DNA Microarray Applications," IEEE Transactions on Automation Science and Engineering, Vol.3, No. 2, pp. 187-191, Feb, 2006.

Timothy N. Chang and D. Chang, "A Hands-on Graduate Real-time Control Course: Development and Experience," International Journal of Engineering Education, Vol. 21, No. 6, pp. 1083-1092, Dec, 2005.

Zhengfang Chen and T.N. Chang, "Analysis and Design of Reliable Control Systems for Urban Traffic Networks," International Journal of System Sciences, Vol. 36, No. 11, pp. 679-688, September, 2005.

Timothy N. Chang, B. Dani, Z. Ji, R. Caudill, "Contactless Magnetic Transmission System: Vibration control and resonance compensation," IEEE/ASME Transactions on Mechatronics, Vol. 9, No. 2, pp. 458-461, June 2004.

Timothy N. Chang, R. Kwadzogah and R. Caudill, "Vibration Control of Linear Robots Using Piezoelectric Actuator," IEEE/ASME Transactions on Mechatronics Volume: 8, No. 4, pp. 439-445, Dec, 2003.

Timothy Chang, E. Hou, and K. Godbole, "Optimal Input Shaper Design for High Speed Robotic Workcells," Journal of Vibration and Control, Vol. 9, No. 12, pp. 1359-1376, Dec, 2003.

Timothy Chang, P. Jaroonsiriphan, and X. Sun, "Integrating Nanotechnology Into Undergraduate Experience, A Web-Based Approach", International Journal of Engineering Education, Vol. 18, No.5, pp. 557-565, Aug, 2002.

Timothy Chang and E.J. Davison, "Decentralized control of descriptor systems," IEEE Transaction on Automatic Control, Vol. 46, No. 10, pp. 1589-1595, Oct. 2001.

Timothy Chang and X. Sun "Analysis and Control of Monolithic Piezoelectric Nano-actuator," IEEE Transaction on Control Systems Technology, Special Issue on Smart Materials, Vol. 9, No. 1, pp. 69-75, Jan, 2001.

Zhiming Ji, T.N. Chang, and R. Caudill "Contactless Magnetic Leadscrew: Modeling and Load Determination," IEEE Transactions on Magnetics, Vol. 36, No. 5, pp. 3824-3832, Sept., 2000.

**Book Chapters**

Timothy Chang and MingJun Zhang, "DNA and Protein Microarray Fabrication Automation", in Life Science Automation: Fundamentals and Applications, Chapter 10, Artech House, Boston-London, March 2007.

Timothy Chang, "Servo Control Design," Encyclopedia of Life Support Systems, United Nations Educational, Scientific, and Cultural Organization (UNESCO), Section 6.43.13.19 (Also published in: Arabic, Chinese, French, German, Italian, Japanese, Russian, Portuguese, and Spanish), 2004.

Timothy Chang and Z. Chen, "Decentralized Reliable Control," in Topics in Control and Its Applications, Springer-Verlag, pp 33-65, 1999.