

RESEARCH INTERESTS

Bipedal Robot Walking Control, Trajectory Optimization, Optimal Control (Quadratic Program-based Control, Model Predictive Control, Time-Varying LQR Control), Wearable Robotics and Biomechanical Analysis of Human Walking.

EDUCATION

- **Texas A&M University** College Station, TX
Ph.D. in Mechanical Engineering (Robotics and Rehabilitation); GPA: 3.76 Aug. 2013 – May 2019
 - **Advisor:** Dr. Pilwon Hur (Human Rehabilitation Group)
 - **Dissertation:** Bipedal Walking Analysis, Control, and Applications towards Human-Like Behavior
- **National Taiwan University** Taipei, Taiwan
M.S. in Mechanical Engineering (Robotics) Sep. 2008 – Aug. 2010
 - **Advisor:** Dr. Han-Pang Huang (Robotics Laboratory)
 - **Thesis:** Mechatronic Design of a Biped Robot and Gait Coordination Control
- **National Tsing Hua University** Hsinchu, Taiwan
B.S. in Power Mechanical Engineering (System and Control) Aug. 2004 – June 2008

WORK EXPERIENCE

- **IHMC, Robotics Lab** Pensacola, FL
(Institute for Human and Machine Cognition), Software Intern May 2018 - Aug. 2018
 - **Simulations of SLIP-based Running Robots:** Built simulations for simple fast running robots (based on spring-loaded inverted pendulum (SLIP) model) using Simulation Construction Set (Java).
 - **Stability Analysis of SLIP-based Models for FastRunners:** Used direct shooting method to search stable limit cycles of SLIP-based running robots across different parameters and running speeds (MATLAB).
- **MathWorks** Natick, MA
Robotics Development Intern for Robotics System Toolbox (RST) May 2017 - Dec. 2017
 - **Workspace Analysis:**
Developed the prototype of workspace analysis functionalities for manipulators including kinematic and dynamic manipulability (joint limit and joint redundancy are considered), and the associated visualization with manipulability ellipsoid and manipulability map.
 - **Safe Trajectory Tracking:**
Implemented impedance control with trajectory scaling on Sawyer robot (from Rethink Robotics) in the simulation and experiment (via ROS and Itera SDK) using MATLAB/Simulink and RST. Contributed the Simulink version as one feature example in RST for MATLAB 2018a.
 - **Benchmark of Inverse Kinematic (IK) Solvers :**
Conducted IK solver benchmark for performance comparison between IK solvers (with various industrial manipulators) from ROS packages and IK solvers exported from RST and wrote a whitepaper for this benchmark.
 - **Software Testing:**
Assisted to write unittests for algorithms about 3-D occupancy grid map in RST.

RESEARCH EXPERIENCE

- **Texas A&M University** College Station, TX
Research Assistant in Human Rehabilitation Group Jan. 2015 - May 2019
 - **Trajectory Optimization for Walking Motion Generation:**
Developing methods using trajectory optimization with direct collocation for bipedal walking with foot-rolling motion, and for robust compass gait with LQR control. YouTube link 1, YouTube link 2
 - **Biomechanical Analysis of Human Walking with Slip Using Instantaneous Capture Point (ICP):**
Analysis of stepping location using ICP for humans walking with slip under different slip severities.

- **Bipedal Walking Experiments:**

Conducting bipedal walking experiments on the bipedal robot AMBER 3 for Zero-Moment point (ZMP)-based walking and walking with foot-rolling motion.

- **Texas A&M University**

College Station, TX

Graduate Assistant in AMBER Lab

July 2014 - June 2015

- **Quadratic Program (QP)-based Control:**

Developed an optimal controller unifying Center of Mass (COM) planning (using model predictive control) and nonlinear walking control with Control Lyapunov Function (CLF) into a single framework.

- **National Taiwan University**

Taipei, Taiwan

Research Assistant

Feb. 2012 - May 2013

- **IK Solver for Singular Configuration:**

Designed a real-time IK solver combined Jacobian method with Cyclic Coordinate Descent (CCD) which is capable of solving motions with stretching limbs.

- **Human-like Walking Motion Generation:**

Using the developed IK solver, generated the walking motion with human walking features (knee stretching and foot rolling motion) and tested in the experiment.

- **Computed Torque Control of Bipedal Walking Experiment via EtherCAT:**

Upgraded the electrical system of Nino's bipedal mechatronics, and implemented computed torque control with sliding mode control for walking upstairs and downstairs.

- **National Taiwan University**

Taipei, Taiwan

Graduate Student

Sep. 2008 - Aug. 2010

- **Bipedal Mechanism Design for a Humanoid Robot – Nino:**

Designed and performed stress analysis of a 12-DOF bipedal mechanism with a 2-DOF trunk mechanism for a human-sized humanoid robot – Nino.

- **Development of Distributed Electrical System for Nino:**

Developed the firmware and the control boards with micro-controllers for Nino's distributed electrical system via CAN bus and USB.

- **Gait Coordination Control:**

Used filtered ground reaction force and trajectory generation for end-effector and COM, designed a controller to improve the adaptiveness of bipedal walking under unknown stepping height.

UNDERGRADUATE PROJECTS

- **2-DOF Biomimetic Robotic Fish:**

Designed and developed a robotic fish with flexible, waterproof skin made from silicone rubber. The robotic fish can perform 2D motion under remote control via Bluetooth.

- **Automatic Page-flipping Machine:**

Designed and developed the mechatronic system with a micro-controller and two servo motors. The machine can perform page flipping for common books (no customization required).

SELECTED PUBLICATIONS

1. Kenneth Chao and Pilwon Hur, "A Direct Method of Trajectory Optimization for Compass Bipedal Locomotion under Terrain Uncertainty," *Dynamic Walking*, Pensacola, FL, USA, 2018.
2. Kenneth Chao and Pilwon Hur, "A Step Towards Generating Human-like Walking Gait via Trajectory Optimization through Contact for a Bipedal Robot with One-sided Springs on Toes," *IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)*, Vancouver, BC, Canada, 2017.
3. Kenneth Chao, Matthew Powell, Aaron Ames and Pilwon Hur, "Unification of Locomotion Pattern Generation and Control Lyapunov Function-Based Quadratic Programs," *American Control Conference*, Boston, MA, USA, 2016.
4. Kenneth Chao and Pilwon Hur, "Toward General Capture Point-Based Analysis on Standing, Walk and Slip: the Connection between Robotic Motions to Human Behaviors," *Dynamic Walking*, Holly, MI, USA, 2016.
5. Kenneth Chao, Jiu-Lou Yan, Meng-Ku Chi, and Han-Pang Huang, "Natural Walking Pattern Generation for Humanoid Robots with Toe and Heel Mechanism," *The 43rd International Symposium on Robotics (ISR)*, Taipei, Taiwan, 2012.
6. Pin-Yong Ling, Kenneth Chao, Han-Pang Huang, and Jiu-Lou Yan, "Footprint Searching and Trajectory Design of a Humanoid Robot," *IEEE International Conference on Robotics and Biomimetics (ROBIO)*, 2012.

QUALIFICATIONS

- **Robot simulation (7 years):** Simulating bipedal robots using ode solvers and physical engine-based simulators.
- **Embedded system software development and hardware implementation (3 years):** Bipedal walking experiments with integration of motion control and sensor data acquisition.
- **Optimal control (4 years):** Research experience about model predictive control, quadratic program-based control and trajectory optimization.

SKILLS

- **Programming and Software Package:**
(Proficient): MATLAB & Simulink, C/C++, Mathematica, \LaTeX
(Experienced): LabVIEW, ROS, Git, IPOPT, MSC ADAMS, JAVA
- **Mechanism Design and Stress Analysis:**
Autodesk Inventor, CATIA, SOLIDWORKS/Cosmos Analysis
- **Programming with Micro-controller and PCB Design :**
Intel 8051, Hitachi H8, Microchip PIC 18/30/32, OrCAD

HONORS AND AWARDS

- **Texas A&M University Graduate Student Travel Award, 2017:**
Award granted for attending IROS 2017.
- **Studying Abroad Scholarship, 2015–2016:**
Taiwan government scholarship for outstanding students to pursue graduate study abroad.
- **Charles Crawford '19 Fellowship, 2013:** Fellowship from mechanical engineering department at Texas A&M granted with admission.

TEACHING IN CLASS

- **Lecture TA (National Taiwan University):**
Digital Electronic Circuit (Fall 2009)
- **Grader and Lecture TA (Texas A&M University):**
Dynamic System and Control (Fall 2013 & Spring 2014), Advanced System Dynamics and Control (Fall 2013), Engineering Laboratory (Fall 2014), Material in Design (Fall 2014), Mechanical Vibration (Spring 2015).
- **Lab TA (Texas A&M University):**
Heat Transfer Lab (Spring 2018).

LEADERSHIP AND EXTRACURRICULAR ACTIVITIES

- **National Tsing Hua University** Hsinchu, Taiwan
String Orchestra Club 2004 - 2008
 - Provided individual violin courses as a volunteer teacher.
 - One of the concertmasters (violin).
 - Attended the annual end of term concerts and an orchestra contest.
 - As a violin solo performed “Vivaldi : Violin Concerto in D major from L'estro armonico No. 9 Op. 3” in the annual end of term concert.
- **National Tsing Hua University** Hsinchu, Taiwan
Chinese Music Club 2004 - 2008
 - Provided group erhu (a two-stringed bowed musical instrument) courses as a volunteer teacher.
 - As a erhu solo in chamber music contests and concerts.
 - One of the concertmasters (erhu).
- **Lanzhou University** Gansu, China
Travel on the Silk Road: The Interchange Activities for Cross-Strait Students 2006
 - Representative of NTHU as a member in Chinese music club and performed Chinese music in the farewell concert.