Huawei Wang (4th year PhD)

Contact Information

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Research Interests

Human Motion (Gait) Control: Wearable Robotics; Human Machine Interaction; Human Motion Analysis and Optimization; Robot Dynamics and Control.

Education & Awards

Washkewicz College of Engineering, **Cleveland State University**

Doctoral Program, Controller Identification in Human Motions, 2016 - present

- Supervisor: Dr. Antonie van den Borget
- Kerka Research Poster Award (*2nd Place*)
- Research Day Poster Award (*honorable mention*)

School of Energy and Power Engineering, **Beihang University**

Master Study, Control Theory and Engineering, 2012 - 2015

- Supervisor: Dr. Xi Wang
- China National Scholarship (*0.2%*)
- Outstanding Master Thesis
- GPA: 3.64/4.0 (6th/90 *students*)

College of Aeronautical Engineering, **Civil Aviation University of China**

Bachelor Study, Aircraft Propulsion Engineering, 2008 - 2012

- Outstanding Graduates
- GPA: 3.77 (1st/402 *students*)
- China National Scholarship (*0.2%*)
- Outstanding Undergraduate Student
- Outstanding Teaching Quality Control Assistant

Research Experience

Human Motion & Control Lab, **Cleveland State University**

- Cycling Exoskeleton
  An Indego exoskeleton was used as a force feedback device to provides corresponding resistance torques at hip & knee joints for users to do cycling. Dynamic parameters and friction of the Indego was identified. Robust impedance control turned the Indego into a mass-spring-damper system.
- Step Strategy Identification in Human Walking
  Foot placement controller were identified from nine participants' walking data at three walking speed (0.8, 1.2, 1.6 m/s). Results showed that capture theory is not a bad estimation of how humans choose their foot placements, but a little bit conservative. In addition, control gains vary with walking speed, instead of constant as previous understanding.
- Impedance Controller identification in Human Walking
  Phase dependent impedance controllers are identifying from nine participants' walking data at three walking speed (0.8, 1.2, 1.6 m/s). We are trying to show that a single perturbation (treadmill belt speed) is sufficient to identify parametric impedance controllers in all leg joints (hip, knee, and ankle). With this, we will be able to identify impedance parameters of hip and knee joints from regulate perturbed data.

- Perturbed Walking Experiment
  Collaborating with Farzad Ehtemam, 13 Gigabyte perturbed walking data was collected. Twenty-five young adults participated this study. Perturbations are in both AP and ML directions. Recorded information includes kinematics (motion capture marker data), ground reaction force (2x6 dofs), and muscle activations (11 EMG sensors).
- Controller Identification in Human Standing
  Standing balance experiment was conducted with random square wave perturbation. Multiple types controllers were identified from the experiment data. Results suggested that control system with cross joints feedback can better explain the experimental data. Nonlinear and time delay property inside control system helps improve the explanation also.
- Ball Bouncing Optimization
  The optimization speed of Ipopt and Snopt was examined through the ball bouncing trajectory optimization. Ball bouncing is the simplest system which has the similar strong nonlinear property as the landing in human walk. Results showed that Ipopt (ma-87) is slightly faster than Snopt.

Robotics and Automation Lab, **Tsinghua University**

- Push-Recovery Strategies for Biped Robot
  - Capture theory for biped robot push-recovery
  - Capture point calculating based on 3D linear inverted pendulum model (3D-LIPM)
  - Capture point calculating based on 3D inverted pendulum model (3D-IPM)
  - Capture point calculating based on 3D-LIPM considering collision with ground (three collision models were posed)
- M2V2 Humanoid Robot Simulation Platform
  - Finite-state machine (FSM) in humanoid robot
  - Apply new capture point calculating algorithm in M2V2 simulation system
- Human Motion Experiment and Analysis
  - Design human push recovery experiment
  - Analyze human push recovery strategies under different perturbation directions
  - Model-based analysis of knee's function in push recovery strategies

Aircraft Engine Control Lab, **Beihang University**

- Real-time Modeling of Gas Turbine system
  - Set up a nonlinear model for a turbofan engine feedback system
  - Extracted the linear state-space model of each component
  - built a real-time and accurate model based on the linearized component
- Modeling Hydraulic-mechanical Units in Turbofan Engine Control System
  - Constructed a hydraulic-mechanical unit model in AEMsim
  - Identified linearized actuator models in the frequency domain
- Difference Evolution Optimization
  - Extracted state-space models from nonlinear aero-engine model and mechanical-hydraulic actuator models
  - Optimized controller parameters using difference evolution method

Peer Reviewed Publications

[1] **Huawei Wang**, Antonie van den Borget. Identification of the Human Postural Control System through Stochastic Trajectory Optimization. *Journal of Neuroscience Method*. under review

[2] **Huawei Wang**, Antonie van den Borget. Identification of A Foot Placement Controller in Human Walking. *Journal of Biomechanics*. under review

[3] **Huawei Wang**, Antonie van den Borget. Identification of parametric standing posture control laws from randomly perturbed experimental data. *Journal of Biomechanical Engineering*. Drafted

[4] **Huawei Wang**, Xi Wang, Huating Yao and Bin Wang. Generic Design Methodology for Electro-Hydraulic Servo Actuator in Aero-engine Main Fuel Control System, In: *Proceedings of ASME Turbo Expo 2014*, June 16–20, Dsseldorf, Germany, GT2014-27337, 2014.

[5] **WANG Hua-wei**, WANG Xi, LI Zhi-peng, DANG Wei and LI Hong-sheng. Quantitative Analysis on Constant Pressure Valve Stability, *Journal of Propulsion Technology*, 2015.

[6] WANG Bin, WANG Xi, SHI Yu-lin and **Huawei Wang**. A real-time piece-wise linear dynamic model of aeroengine. *Journal of Propulsion Technology*, 2014.

Conference Proceedings & Posters

[7] **Huawei Wang**, Antonie van den Borget. Identify posture controller in standing balance using direct collocation. *Dyanmic Walking 2016, Ann Arbor, Michigan..*

[8] **Huawei Wang**, Antonie van den Borget. Ramp perturbation tests are too simple to identify realistic controller in human standing balancing. *2017 BMES Annual Meeting, Phoenix, Arizona.*

[9] **Huawei Wang**, Antonie van den Borget. Identification of stable human posture controllers through stochastic trajectory optimization. *ASME 2017: Dynamics and Control of Robotics, Cleveland, Ohio.*

[10] **Huawei Wang**, Antonie van den Borget. Identification of posture controllers in human standing balance task. *Dyanmic Walking 2018, Pensacola, Florida.*

[11] **Huawei Wang**, Antonie van den Borget. Identification of swing leg control laws from human walking data. *Midwest ASB 2019 Annual Meeting, Dayton, Ohio.*

Research & Skills

Operated Experimental Devices:
- Motion capture system (Motion Analysis)
- Instrumented dual-belt treadmill with 6-axis GRFs (Motek)
- EMG and IMU systems (Delsys Trigno)
- Portable metabolic analyzer (Cosmed K4b(2))

Engineering Skills:
- Multibody dynamic modeling
- Human body muscle-skeleton mathematical modeling
- Large scaling optimization – gradient and evolutionary based
- Feedback control system design – classical and modern control
- Robotics – forward and inverse kinematics/dynamics
- Human motion data analysis – motion capture marker/GRFs/EMGs/IMUs data

Coding &Skills

Coding Languages:
- Most Fluent: **Python**; **C**; **Cython**; **Matlab**; **Simulink**
- Less Fluent: Julia; R

Productivity Applications:
- **GitHub**; **LaTeX**; **Jupyter Notebook**

Languages:

- **Chinese** (native tone);
- **English** (fluent)