Suhun Jung

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EDUCATION

Integrated Ph.D course. in Mechanical Engineering, Korea University, Seoul, Korea — Mar 2013 – Aug 2021
- Research Lab: Human-Machine Systems Lab (Prof. Shinsuk Park)
- Major concentration: Rehabilitation, Functional Electrical Stimulation (FES), Powered Ankle-Foot Orthosis (PAFO), Machine Learning

B.S. in Mechanical Engineering, Korea University, Seoul, Korea — Mar 2009 – Feb 2013

WORK EXPERIENCES

Korea Institute of Science and Technology (KIST) — Aug 2021 – Present
Postdoctoral researcher in Center for Healthcare Robotics, Seoul, Republic of Korea

Human-Machine Systems Lab. — Mar 2013 – Jul 2021
Research Assistant in Korea University, Seoul, Republic of Korea

ACADEMIC/TEACHING EXPERIENCE

Teaching Assistant, Korea University, Seoul, Korea, 2013 to 2016
Performed Teaching Assistant for lectures as shown below:
- *Robotics*
- *Dynamics*
- *Mechatronics*
- *Computer-aided design (CAD)*

RESEARCH EXPERIENCES

User-personalized Motion Control and Monitoring System of Gait Rehabilitation Using Functional Electrical Stimulation and Exoskeleton Robot — Sep 2021 – Present
Supported by the *National Research Foundation of Korea (NRF)*
- Conducted research about hybrid gait assistive system of FES and powered knee-ankle foot orthosis (KAFO) for gait rehabilitation of stroke patients. Machine learning based algorithm was suggested to deliver FES amplitude of soleus and tibialis anterior adaptive to walking speed and intension of users. Developed a hybrid system of FES and exoskeleton robot for gait rehabilitation in treadmill condition.
- ***Hybrid control system of FES and Exoskeleton Robot.*** Developed hybrid gait support system for motion of knee, ankle joint via electrical motor and artificial muscle contraction. The system is affected by volitional muscle contraction of users and walking speed.
- ***DNN-based control of FES.*** Composed deep neural network (DNN) based estimation model to determine elaborate FES amplitude of soleus and tibialis anterior.
- ***Assessment of rehabilitation progress via web server and DNN model.*** Assessing rehabilitation progress and gait motion based on long-term data acquired from hybrid control system.

High-risk disaster medical and industrial emergency response technologies — Aug 2021 – Present
Supported by the *Korea Institute of Science and Technology (KIST)*
- Developed a testing booth and a robotic system for COVID-19 testing. Machine Learning based sub-systems were suggested to increase the testing performance of robot.

• ***Robotic arm for preparing and testing.*** Developed an algorithm for robotic arm performing key role in grasping, delivering swab and testing progress.

• ***DNN based Estimation model for deformation of swab.*** Suggested an DNN model estimating deformation rate of swab based on interaction force of it. Augmented reality based interface helped to visualize the shape of swab inside of nasal cavity.

Center for SoFT Meta-Human Nov 2016 – Jul 2021

Supported by the *National Research Foundation of Korea (NRF)*

• Conducted research about wearable robots and their control algorithm. Applied functional electrical stimulation (FES) to enhance the effectiveness of rehabilitation. Designed a Machine learning-based algorithm to modulate FES amplitude of soleus and tibialis anterior adaptively controlled by walking speed. Developed a hybrid system of FES and exoskeleton robot for gait rehabilitation in treadmill condition.

• ***DNN-based FES control system.*** Composed convolution neural network (CNN) based estimation algorithm to determine elaborate FES amplitude of soleus and tibialis anterior. Demonstrated the supportive and fatigue-reducing effect of the developed algorithm.

• ***Powered Ankle foot orthosis (PAFO).*** Designed 1-DOF powered ankle-foot orthosis (PAFO) supporting about 40% of ankle torque during gait motion. Simulated the gait condition wearing this PAFO using OpenSIM program and acquired reference gait data of ankle joint.

• ***Variable impedance control of ankle joint.*** Applied the reference impedance of ankle joint ensuring safe and cost-effective control.

• ***Hybrid control system of FES and Exoskeleton Robot.*** Developed hybrid control system for simultaneous support of ankle via motor and artificial muscle contraction. Presented novel algorithm self-modulating contribution of FES and PAFO according to the volitional force of users.

Hybrid System of Electrical and Vibrotactile System for Standing Balance Feedback Sep 2019 – Jul 2021

Supported by the *Sports Promotion Fund of Seoul Olympic Sports Promotion Foundation*

• Suggested the hybrid system of an electrical and vibrotactile system for balancing control of a human. Developed the feedback controller informing direction and distance from the center of pressure (CoP) via four-channel vibration motor and functional electrical stimulation (FES). Built prototype of the product ensuing user-friendly and easy to wear hardware.

• ***Simultaneous feedback of electrical and vibrotactile.*** Synchronized activation timing of electrical stimulation and vibration motor. Design an algorithm alarming direction and amplitude to restore the standing balance of humans.

• ***Recognition of balance status using insole sensors.*** Formulated balance state based on wireless insole sensors. Calibrated force-sensitive resistor (FSR) to obtain the precise center of pressure (CoP).

• ***Balance feedback program for mobile applications.*** Presented a program of balanced feedback of FES and vibration for mobile applications. Streamlined the stimulation program for mobile usage to prevent slowdown problems due to large computations.

• ***Prototype of integrated controller.*** Built prototype of an integrated controller using a 3D printer, guaranteeing lightweight and small size. Designed circuit of the system and printed PCB prototype. Combined stimulator, motor, circuit, and battery altogether and designed its mechanical structure increasing wearability.

Development of DQN model for Human-like Driving of Vehicle Jan 2020 – Jul 2021

Human-Machine Systems Lab

• Trained the deep Q-learning (DQN) model for the human-like driving of a vehicle. Studied lane change and obstacle avoidance of vehicle. Built simulation environment based on Pygame and designed the reward for DQN model.

• ***Environment for driving simulation.*** Designed a simple 2D road environment for DQN training and applied vehicle dynamics.

• ***Deep Q-learning model.*** Constructed multilayered perceptron model and its training algorithm.

Development of an Integral Interface for a Rehabilitation Robot that simultaneously stimulates the Muscular and Nervous System Jun 2017 – May 2019

Supported by the *National Research Foundation of Korea (NRF)*

• Developed an integral interface for robotic rehabilitation system using bio-signal based

Human-Machine Interface (HMI), Muscle-to-Muscle Interface (MMI), and navigation for precise FUS targeting.

• ***Muscle-to-Muscle Interface (MMI) and Neuro-Feedback system.*** Conceptualized the muscle-to-muscle interface delivering movement and bio-signal of healthy side to paretic side for hemiplegic patients. Presented FES artifacts filter and feedback system detecting patient's volitional contraction.

• ***Combined system of FES and FUS.*** Built Integrated control system of Functional electrical stimulation (FES) and Focused ultrasound (FUS) as a preliminary study.

• ***Wireless footswitch and stimulation system.*** Developed wireless and lightweight foot switch delivering ground contact information via wireless communication for both treadmill and outdoor walking.

Simulation and Design of Air Dam Skirt Preventing Damage May 2015 – Oct 2015
Supported by the *HYUNDAI NGV*

• Conducted dynamic simulation of Air Dam Skirt of the vehicle and design a novel structure preventing damage from collision with unknown objects.

Development of Human-Human Interface for Personalized Rehabilitation Training Jan 2015 – Dec 2017
Supported by the *Korea Institute of Science and Technology (KIST)*

• Designed an adaptive algorithm that enables treadmill gait for various walking speeds. The components of the system as follows:

• ***Heel-Toe switch.*** Designed the shoes acquiring ground contact information of heel and toe.

• ***FES control algorithm.*** Developed the control algorithm of the FES adaptive to gait speed.

Development of Bio-signal based Human-Human Interface for Rehabilitation Mar 2014 – Dec 2014
Supported by the *Korea Institute of Science and Technology (KIST)*

• Performed a preliminary study for treadmill gait using functional electrical stimulation (FES) based on foot-switch. Analyzed treadmill gait motion using insole sensor system, IMU sensor, and goniometer.

Analysis and Control of Precession of Low-Speed Flight Object Apr 2013 – Apr 2014
Supported by the *Hanwha R&D Center*

• Analyzed precession of low-speed object launched from launcher intended to generate spinning motion during flight. Suggested a modified structure of launcher which can reduce the effect of the precession.

PUBLICATIONS & PATENTS

PUBLICATIONS

• **DNN-Based FES Control for Gait Rehabilitation of Hemiplegic Patients** 2021
Applied Sciences, First author

• **Development of a Novel Robotic Rehabilitation System With Muscle-to-Muscle Interface** 2020
Frontiers in Neurorobotics, Co-author

• **Development of Gait Rehabilitation System Capable of Assisting Pelvic Movement of Normal Walking.** 2018
Acta Medica Okayama, Co-author

• **Design and analysis of ballistic ground scanning system based on dynamics simulation** 2016
International Journal of Precision Engineering and Manufacturing, First author

PATENTS

• **EXERCISE ASSISTANT SYSTEM USING WEARABLE STIMULATION MEMBER** 2020
Application (10-2020-0006630).

• **Assistance and Training System using Balance Feedback** 2020
Application (10-2020-0147923).

• **Functional Electrical Stimulation and Vibration Control System Based on User Fatigue** 2020
Application (10-2020-0137668).

• **WALKING ASSISTANCE SYSTEM** 2020

Granted (10-2352537).

- **UPPER LIMB ASSISTANCE SYSTEM FOR ASSISTING THROW MOTION** 2020

• *Granted (10-2348364).*

- **ACTUATOR USING MUSCLE FIBER** 2017

Granted (10-1985237).

- **BENDING STIFFNESS CONTROL DEVICE FOR JOINT DEVICE** 2017

Granted (10-1867763).

- **REHABILITATION ROBOT USING EMG AND FES AND CONTROL METHOD THEREOF** 2017

Granted (1018010420000).

- **REMOTE NAVIGATION SYSTEM OF MOBILE ROBOT USING AUGMENTED REALITY TECHNOLOGY** 2014

Granted (10-1478908), Transferred.

- **Variable Converting Device Capable of Ground Driving and Air Flight** 2013

Application (10-2011-0131781), Lapsed.

RELATED SKILLS

ARDUINO
Conducted several individual and granted research projects using different types of Arduino board such as Arduino UNO, MEGA, Due, Mini, IOT Nano, and 33 IOT. Designed and controlled various systems including exoskeleton robot, FES stimulator, foot switch, force plate, and robot hand. Educated undergraduate students as a teaching assistant.

SOLIDWORKS
Designed mechanical apparatus and robotic components. Taught undergraduate students modeling mechanical parts.

ADAMS
Analyzed a flight object and simulated it in various dynamic conditions. Instructed undergraduate students in the lecture as a teaching assistant.

OpenSIM
Simulated gait motion of human subject wearing exoskeleton robot.

MATLAB & SIMULINK
Mostly used at signal processing and analysis of bio-signal. Also used SIMULINK and SIMULINK Real-time in previous projects of robot control.

Python
Constructed machine learning-based algorithm determining amplitudes of functional electrical stimulation(FES) via footswitch and electromyogram(EMG), also acquired using Python. Conducted research about reinforcement learning using Tensorflow and Keras.

LabVIEW & FPGA modules
Obtained meaningful data about motions for human such as ground contact information, EMG and interaction force. FPGA modules enabled real-time control of robotic system using these data.

MAKER DEVICE EXPERIENCE
Learned how to use the 3D printer and PCB design program. Able to design and make products at the prototype level.