Centre for Artificial Intelligence and Robotics – DRDO

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Weekly Report

Week 10 (3rd October 21 to 8th October 21)

Objective

Finding more suitable use of OpenSim for the control and simulation of Exoskeleton [1]. Literature survey of torque prediction [2], control interface [3] and anatomical analysis of Human motion [4].

Literature Survey

- Chanjuan Su and et al, [2] worked on an algorithm to predict ankle joint torque using time delay artificial neural network (TDNN) model with help of signals from sEMG and angular velocity. To verify their work, they conduct an experiment using TDNN model, which was trained by 80% data and 20% data for the testing from 8 subjects. Data was collected from using Delsys Trigno Wireless System. Data from sEMG and position sensor was sampled at 2000 Hz and 418 Hz respectively, EMG data was filtered by a 10-500 Hz bandpass filter and RMS value was calculate for a small range at regular interval. TDNN contains 10 hidden layers and 1 output layer and backpropagation learning algorithm, which takes joint angular velocity and RMS value of the sEMG signal as input and produces joint torque as an output. Two criteria were chosen to compare performance of the model, Cross-correlation coefficient, mean normalized root mean square deviation (NRMSE) and was compared with some existing model for similar task but with ANN and Support Vector Regression (SVR) models. In the end it was analysed that TDNN predicted better then ANN and SVR model.
- In [3] a myoelectric control interface to an exoskeleton for the elbow and wrist was evaluated on the 10 fit and 4 people with Cervical level Spinal Cord Injuries (SCI). They designed a classifier algorithm to detect single and multi DoF movement intention from EMG signals. It was designed for Elbow flexion/extension, supination/pronation, wrist flexion/extension and wrist radial/ulnar deviation. The following classifier was trained using Linear Discriminant Analysis (LDA) and Recursive Feature Elimination with Cross Validation (RFECV). Data was collected using Delsys Bagnoli EMG system, which was filtered using analog bandpass filter of 20 Hz – 450 Hz then data was sampled at 1 kHz and again filtered using a digital bandpass filter of same bandwidth and same range. It was found, after test, that, on average, classification performed with accuracy between 100 % to 89.5 % for abled people and between 95.0 % to 61.3 % for people with SCI depending on level of injury.
- In 1983 Plagenhoff and et al, in his research [4] tired to determine different anatomical data for analysing human motion. His main focus was on the trunk of the human body. His most work was based on Dempster's work in 1955. He performed experiments with 135 athletes to find Center of Mass, body segment lengths and weight percentage with special focus on trunk. He created a lead model of human trunk and dissected a cadaver to perform experiments, like water submersion, to detect all those value for 3 segments of the trunk, Thorax, Abdomen and Pelvis. All the data is given in [4] in tabular form with an error of 10% to 15% from an actual living body.

Work

Meeting with DEBEL, understanding different aspect of OpenSim software and its usage, such as need of Ground Reaction Forces (GRF) needed for simulating a Musculoskeletal model with the help PRTC data. Along with the help of OpenSim documentation [1] learning OpenSim.

Future Work

More extensive and detailed research towards usage of OpenSim. Literature survey towards mechanical properties of human joints and muscles (Musculoskeletal model) such as damping coefficient, stiffness and other related properties.

Reference

[1] Jennifer Hicks and et al, “OpenSim Documentation”, *Biomedical Computation at Stanford University*, 2018.

[2] C. Su, S. Chen, H. Jiang and Y. Chen, "Ankle Joint Torque Prediction Based on Surface Electromyographic and Angular Velocity Signals," in *IEEE Access*, vol. 8, pp. 217681-217687, 2020.

[3] C. G. McDonald, J. L. Sullivan, T. A. Dennis and M. K. O’Malley, "A Myoelectric Control Interface for Upper-Limb Robotic Rehabilitation Following Spinal Cord Injury," in *IEEE Transactions on Neural Systems and Rehabilitation Engineering*, vol. 28, no. 4, pp. 978-987, April 2020.

[4] Stanley Plagenhoef, F. Gaynor Evans & Thomas Abdelnour, “Anatomical Data for Analyzing Human Motion”, *Research Quarterly for Exercise and Sport, University of Massachusetts*, 54:2, 169-178, 1983.