Proposal

Aim

1. To accurately predict the Hip-Knee-Ankle angle deviation (HKA) and Foot Progression Angle (FPA) values by using 3D marker trajectory data.
2. To determine the accuracy of deep learning models for knee adduction moment (KAM) prediction in people with knee osteoarthritis (OA), with only 3D marker trajectory data as input.
3. Following data obtained from Aim 1 and 2, to determine the performance of the deep learning models for HKA, FPA and KAM predictions in people with knee OA, by inputting 2D marker trajectory data.

Data

5,840 csv files, including 2,920 model outputs and 2,920 trajectory data. CSV files were generated from 3D motion capture system (VICON), which contains model outputs and trajectory data of each marker. All csv files start with L or R, which is the leg index for that specific file. In csv files with 'model', only columns that start with correct leg index are usable.

The model used was CGM2.4 with details listed in the following link: https://pycgm2.netlify.app/cgm/cgm2.4/

3D marker trajectory data was collected by 3D motion capture system, VICON Nexus system, with frequency 100 Hz. Markers are located at positions including: LFHD, LBHD, CLAV, C7, T10, RBAK, LASI, LPSI, LTHAP, LTHAD, LTHI, LKNE, LKNM, LTIB, LTIAP, LTIAD, LANK, LMED, LHEE, LTOE, LFMH, LSMH, LVMH, RFHD, RBHD, RASI, RPSI, RTHAP, RTHAD, RTHI, RKNE, RKNM, RTIB, RTIAP, RTIAD, RANK, RMED, RHEE, RTOE, RFMH, RSMH, RVMH. More information of marker can be found in the Vicon Nexus guide.

Trajectory data will contain three main parts, including trajectory of each marker, first derivative of trajectory of each marker and second derivative of trajectory of each marker. First and second derivative of trajectory data are also considered as velocity and acceleration.

Trajectory data was pre-processed to have only one stance phase, which starts from heel strike and ends at same leg toe off.

Method

Deep learning models, such as Long Short-Term Memory (LSTM) and transformer. A receiver operating characteristic curve (ROC) will be applied to indicate the performance of the model.

For HKA information, please see following study:

Palad, Y. Y., Leaver, A. M., McKay, M. J., Baldwin, J. N., Lunar, F. R. M., Caube, F. D. M., … Simic, M. (2018). Knee thrust prevalence and normative hip-knee-ankle angle deviation values among healthy individuals across the lifespan. Osteoarthritis and Cartilage, 26(10), 1326–1332. https://doi.org/10.1016/j.joca.2018.06.009

For KAM prediction, please see following study:

Boswell, M. A., Uhlrich, S. D., Kidziński, Ł., Thomas, K., Kolesar, J. A., Gold, G. E., … Delp, S. L. (2021). A neural network to predict the knee adduction moment in patients with osteoarthritis using anatomical landmarks obtainable from 2D video analysis. Osteoarthritis and Cartilage, 29(3), 346–356. https://doi.org/10.1016/j.joca.2020.12.017

Outcome

1. Maximum HKA
2. Maximum FPA
3. KAM graph