Drift-Free 3D Orientation and Displacement Estimation for Quasi-Cyclical Movements Using One Inertial Measurement Unit: Application to Running

Authors: Marit A. Zandbergen*, Jasper Reenalda, Robbert P. van Middelaar, Romano I. Ferla, Jaap H. Buurke and Peter H. Veltink

University of Twente, Faculty of Electrical Engineering, Mathematics and Computer Science (EEMCS), Biomedical Signals and Systems group (BSS)
Roessingh Research and Development, Rehabilitation Technology group

*Corresponding author: Marit A. Zandbergen (m.a.zandbergen@utwente.nl)

General introduction

This dataset contains data collected as part of Marit Zandbergen's PhD Thesis project. This dataset is made public as supplementary data for the manuscript titled: "Drift-Free 3D Orienation and Displacement Estimation for Quasi-Cyclical Movements Using One Inertial Measurement Unit: Application to Running".

The data in this dataset were collected in the gait lab of Roessing Research and Development (Enschede, The Netherlands) between 2018 and 2019.

Purpose of data collection

The purpose of these experiments was to develop and validate a new orientation and displacement algorithm for quasi-cyclical movements based on a single inertial measurement unit.

Measurement systems

Inertial measurement unit (IMU)
- Sensor located on the left (subject 1) or right (subject 2, 3 and 4) proximal lower leg (see picture)
- Sensor coordinate system (see picture):
    - X-axis pointing out of the front of the sensor
    - Y-axis pointing out of the side of the sensor
    - Z-axis pointing out of the top of the sensor
- Measured with a sampling frequency of 240 Hz
- Measured with Xsens MVN Link sensors (Xsens, Enschede, The Netherlands)

Optical motion capture system
- Positional data of 4 optical markers which together form the optical cluster marker set (see picture)
- Optical cluster marker set located on the left (subject 1) or right (subject 2, 3 and 4) proximal lower leg
- Data expressed in a global coordinate system:
    - X-axis pointing forwards into running direction
    - Y-axis pointing to the left
    - Z-axis pointing up
- Measured with a sampling frequency of 100 Hz
- Measured with 8 Vicon Vantage cameras (Vicon, Oxford, UK)

Measurement protocol

Subject first performed a serie of calibration movements:

- 5 Squat movements
- 5 Heel raises
- 5 Bending over movements (hip flexion)
- 5 Flexion-Extension movements with the right leg
- 5 Flexion-Extension movements with the left leg

Subject then stepped on the treadmill. The treadmill speed was increased to 13 km/h. Subejct ran for 2 minutes at 13 km/h before the measurement was ended.

Data structure

Two structs ("imu" and "optical") for each subject are included in the dataset. Both structs contain general information about the measurement (measurement system, description, sampling frequency (fs) and the included leg (left or right))

Struct titled "imu"
- Contains 3D acceleration (including gravity) of the sensor measured in the sensor coordinate system for the calibration movements ("cal_acc") and for the running measurement ("run_acc").
- Contains 3D angular velocity of the sensor measured in the sensor coordinate system for the calibration movements ("cal_gyr") and for the running measurement ("run_gyr").
- Matrices have an Nx3 format.

Struct titled "optical"
- Contains 3D position of one of the four optical markers (m1, m2, m3 or m4) expressed in a global coordinate system for the calibration movements ("cal_pos_m1", "cal_pos_m2", "cal_pos_m3", "cal_pos_m4").
- Contains 3D position of one of the four optical markers (m1, m2, m3 or m4) expressed in a global coordinate system for the running measurements ("run_pos_m1", "run_pos_m2", "run_pos_m3", "run_pos_m4").
- Matrices have an Nx3 format.