

# Validation of inertial sensor fusion algorithms in the context of hemiparetic gait assessment

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Electrical stimulation (ES) assisted correction of foot drop in hemiparetic subjects would benefit from an efficient adaptation of the stimulation pattern regarding foot and/or shank orientations. In order to satisfy practical rehabilitation constraints and to design a feasible solution we propose a body area network (BAN) of embedded inertial measurement units (IMU). This preliminary study presents gait assessment results from experiments realized on seven hemiparetic patients (5 male, 2 female, age: 26 to 65 years, height: 1.63m to 1.85m). The subjects were instructed to walk along a 5 meters GAITRite<sup>®</sup> electronic walkway (CIR Systems, Inc., Havertown, PA, USA) with two FOX HikoB<sup>®</sup> (HikoB Villeurbanne, France) inertial measurement units respectively strapped to the foot and the shank of each leg, as illustrated in Figure 1. A motion capture system (VICON<sup>®</sup> Bonita, USA) combined with an industrial object tracking software (VICON<sup>®</sup> Tracker) has been used to provide the reference measurements for each IMU and to compare reconstruction results.



Fig 1. Experimental setup (two IMUs and motion capture markers)

This work essentially aims at competing 3 existing literature attitude and heading reference system (AHRS) algorithms results to the gold standard ones from the motion capture device. We compare the performances and reliability of Martin-Salaün [1], Mahony [2] and Madgwick [3] approaches for the estimation of the tilt angle of the foot as well as ankle angle in the sagittal plan (Figure 2) in order to select an AHRS algorithm adapted to our constraints. We also extract from available signals stride lengths of the valid and the affected side based on an adaptation of [4,5]. The GAITRite<sup>®</sup> walkway enabled us to compare results. Influence of calibration procedure and acquisition parameters is also discussed. In the future real-time version, the algorithms will be implemented in order to closed-loop control Electrical Stimulation of dorsiflexion during swing phase [6,7].

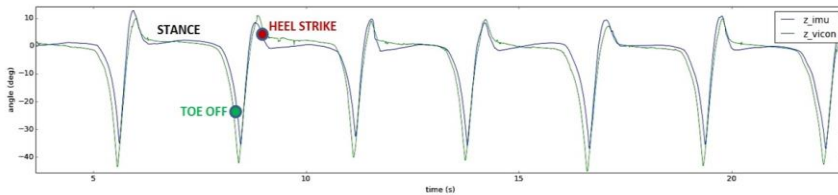


Fig 2. Sagittal orientation of the valid foot using Martin Salaun filter compared to motion capture results. The pitch angle is negative clockwise. A null orientation means that the foot is flat relative to the ground (stance phase).

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