Ambulatory Estimation of Foot Movement during Gait using Inertial Sensors

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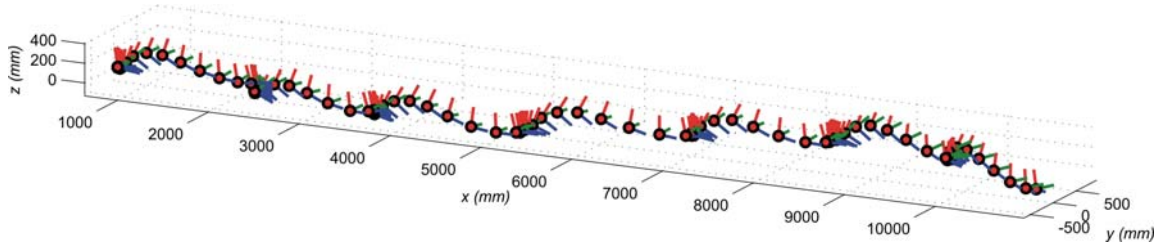
ABSTRACT

Human body movement analysis is commonly done in so-called 'gait laboratories'. In these laboratories, body movement is measured using optically based systems like Vicon, Optrotrak. The major drawback of these systems is the restriction to a laboratory environment. Therefore research is required to find ways for performing these measurements outside the gait laboratory.

The estimation of foot movement is important, since balance is controlled by foot placement during gait. This study investigates whether it is possible to estimate foot movement, specifically foot placement, during gait under ambulatory conditions. The measurement system consisted of an orthopaedic sandal with two six degrees-of-freedom force/moment sensors beneath the heel and the forefoot. It should be noted that the force sensors were merely used for gait phase detection. The position and orientation of heel and forefoot were estimated using the accelerometers and gyroscopes of two miniature inertial sensors, rigidly attached to the force sensors [1,3]. In addition, errors in the walking direction were compensated for by using knowledge about the average walking direction.

Heel position and orientation during gait assessed by the ambulatory measurement system



The proposed ambulatory measurement system was similar to the one used in a previous study [3]. In that study the position and orientation determination was restarted each step, while this study allows estimation of position and orientation during several steps including a change of direction. However, the accuracy should be investigated in more detail by an evaluation study. Moreover, the measurement system can be simplified by using a different gait phase detection system, for example by a gyroscope based detection system [2].

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REFERENCES

[1] H.J. Luinge and P.H. Veltink, "Measuring orientation of human body segments using miniature gyroscopes and accelerometers", *Med. Bio. Eng. Comp.*, Vol. **43**, pp. 273-282, (2005).

[2] I.P.I. Pappas, M.R. Popovic, M.R. Keller, V. Dietz and M. Morari, "A reliable gait phase detection system", *IEEE Trans. Neural Syst. Rehabil. Eng.*, Vol. **9**, pp. 113-125, (2001).

[3] H.M. Schepers, P.H. Veltink and H.F.J.M. Koopman, "Ambulatory assessment of ankle and foot dynamics", *IEEE Trans. Biomed. Eng.*, **Submitted**, (2006).