INTERNSHIP 2024-2025

Research team : GEPETTO

Project title: Development of a wearable system to compute a mechanical parameter of gait stability

Keywords : Biomechanics, human movement analysis

Supervision : Bruno Watier
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Length of internship: 5 to 6 months depending on availability

Master or engineer student

Gratuity : 660€/mois

Context:
The ultimate aim of this project is to develop an embedded system for human movement analysis and insole device that will enable three-dimensional measurement of mechanical actions during locomotion or physical activities. It is funded by the ANR project (BAC2WALK) involving several laboratories.

Project description:
The ability to maintain locomotion in all circumstances is an essential factor in preserving the autonomy of individuals whose locomotor system is impaired due to aging, disability, or illness. The measurement of dynamic balance during human movement can be done in laboratory settings. However, their accessibility remains limited in the global population. On a translational aspect, laboratory-based parameters should be able to be estimated through wearable systems.

Several literature reviews focused on laboratory-based parameters to evaluate dynamic stability (*1–6*). Recently, a new parameter has been introduced, as it enables a continuous tridimensional quantification of gait stability. It is computed as the distance between the position of the body center of mass (BCoM) and the minimal moment axis (MMA) (dBCoM-MMA) (*7*). This parameter takes into account the time rate of change of whole-body angular momentum (*7*).

This parameter has exclusively been computed in laboratory settings, using expensive data acquisition and protocols with a low ecological validity. Traditionally, 3D BCoM position is obtained through force plates of optical cameras. A more affordable, lightweight and discrete solution could be to use wearable sensors, such as inertial measurement units (IMU) (*8–10*). Several approaches have been developed to estimate 3D BCoM using IMUs (*e.g.*, single IMU, kinematic chain, inertial models). However, they still suffer from several drawbacks (*e.g.*, drift, body inertial parameters)

that limit their application to out of the laboratory measurements (*9*, *11*). On the other side, 3D ground reaction forces (GRF) and moments (GRM) are mainly obtained by force plates. These could be replaced by instrumented insoles to obtain a direct and reliable estimation (*12*). Some authors attached forces and moments sensors underneath the shoe (Figure 1) but, they are heavy, rigid, and uncomfortable (*13*). Recently, several insoles have been developed but, they only provide normal ground reaction forces (Figure 1).

In this context, the PhD of Ariane aims **developing a wearable system** combining **IMUs** and **instrumented insoles** to estimate **3D BCoM** and **3D GRF, GRM**.

The goal of this internship will be to **(1) develop algorithms to estimate 3D BCoM using IMUs**, **(2) build a protocol** to validate them against a gold standard.

Figure 1: Left: Instrumented outsole with forces and moments sensors. Middle: Instrumented insole. Right: Developed instrumented shoes.

Bibliography

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Course of the internship

This 5 to 6-month internship will be carried out at the LAAS-CNRS in Toulouse and will be supervised by Bruno Watier and all the partners in the ANR BAC2WALK.

Skills required

The candidate with a mechanical or sport science background (solid mechanics) will be able to implement experiments in human movement analysis. He will be fluent in English. Proven skills in Python programming and/or biomechanics will be an appreciated asset.

To apply:

Send your CV and covering letter to Bruno Watier: bruno.watier@laas.fr