universität innsbruck
Institut für Sportwissenschaft

MACHINE LEARNING & DATA ANALYTICS

Topic: Validation of an IMU-based motion analysis framework for the assessment of change-of-direction movements

Scientific background

Knee injuries such as ruptures of the anterior cruciate ligament (ACL) are common during sports that require fast change-of-direction (COD) movements such as sidestepping and pivoting during soccer, basketball, handball, and related sports (1). Consequently, there is a plethora of studies to investigate COD movement strategies and the associated biomechanical loads to differentiate between riskier and safer COD movement strategies and identify targets for preventative training (2). The large majority of those studies, however, analyzed COD movements in controlled laboratory environments, in which participants are sidestepping into pre-planned movement directions without external stimuli or interaction with other players. This leads to the concern that the knowledge generated from such laboratory studies may not translate to COD movements on the playing field, which are heavily influenced by the coupling of the players' perception of their environment and the resulting action (3). Therefore, the successful assessment and training of COD movement strategies to reduce the risk for ACL injuries requires assessment frameworks that are ecological validity, i.e. a framework that closely resembles the real-world playing environment of the athletes. Such a framework critically depends on motion analysis systems that are wearable, minimally obstructive for the player but can still provide accurate and reliable information regarding joint movement and loading during COD movements.

Thesis goal

The goal of this master thesis will be to develop and validate a motion analysis framework based on inertial measurement units (IMUs) for the assessment of COD movements. The development will build on previous work of the Machine Learning and Data Analytics Group, specifically the Biomechanical motion analysis and creation (BioMAC) (4,5) who used optimal control simulations to estimate joint movement and loading of the lower extremities from IMU data during walking and running. This master thesis will be part of a larger collaboration between the Department of Sports Science at the University of Innsbruck, Austria and the Department for Artificial Intelligence in Biomedical Engineering at the University of Erlangen-Nuremberg, Germany.

Specific research objectives

1) To conduct a literature and patent review of relevant work resulting in a comprehensive list of existing IMU-based motion analysis frameworks for highly-dynamic and whole-body motor tasks.
2) To adapt and further develop an existing analysis framework (4) for tracking IMU (accelerometer and gyroscope) data with a 3D musculoskeletal model in an optimal control simulation for the assessment of COD movements.
3) To determine the validity of the IMU-based estimates of ankle, knee, hip, and trunk movement and loading during COD movements in comparison to the gold-standard of optical 3D motion capture combined with measurements of ground reaction forces. The data will be collected at the University of Innsbruck and shared with the BioMAC group.
4) *Optional:* To test the application of the developed analysis framework to movement data recorded during a field-based assessment of COD movement strategies.

5) *Optional:* To test whether the validity of the IMU-based estimates of joint movement and loading can be improved by including machine learning algorithms into the analysis framework (e.g. prediction of joint movement/loading from IMU data using a convolutional neural network (5).

The thesis must contain a detailed description of all developed and used algorithms as well as a profound result evaluation and discussion with respect to the technical developments and in the sports science and injury prevention context. An extended search with respect to literature, existing patents and related work in the corresponding areas has to be performed. The optional research objectives may be included in the thesis depending on the progress in objectives 1-3. The implemented code has to be documented and provided.

Students from various research backgrounds and qualifications are encouraged to apply for this thesis topic. A strong background in programming (preferable MATLAB) and interest in the sports science application are preferred.

This master thesis project will be advertised both at the University of Erlangen-Nuremberg and the University of Innsbruck. If of interest to the master student, there is the possibility for a 1-month exchange (Innsbruck ←→ Erlangen) during this master thesis project. There is, however, no financial support for this exchange.

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Student: Student Name
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References

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