# PHYSICAL ACTIVITY MONITORING AND AMBULATORY MOVEMENT ANALYIS USING INERTIAL MEASUREMENT UNITS

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This applied session will present the technology and methodology based on Inertial Measurement Units (IMUs) in the context of physical activity monitoring and ambulatory motion analysis. It will also expose projects that have used this technology to monitor or analyse sport activities. During this session, the perspectives but also the issues met when dealing with this technology will also be discussed.

**KEY WORDS:** inertial measurement unit, physical activity monitoring, motion analysis.

**INTRODUCTION:** As early as the 50's, inertial data -more precisely accelerations- began to be used to monitor human movement (Saunders, Inman, & Eberhart, 1953). However, some limits in the accelerometer price, size, weight, and autonomy restricted at this time the development of their exploitation. With advances in science, technology, and methodology, accelerometry got a boost in the 1970s with, for main application, physical activity monitoring (Morris, 1973). Body-segment accelerations could indeed be used for activity recognition but weren't sufficient to provide quantitative data on human-body motion.

It's only at the beginning of the 21th century that progresses in sensor miniaturization, energy consumption, and communication enabled the development of wearable inertial measurement units (IMUs). Wearable IMU also called micro-electromechanical system (MEM) or only microsensor includes by definition 3D-accelerometers, 3D-gyrometers and magnetometers. The development of these IMUs offered the possibility to also measure body-segment orientation, opening thus doors to another form of human motion capture.

Thanks to these recent developments, IMUs are then considered now as a mature technology to investigate human motion outside the laboratory (Lowe & Ólaighin, 2014). Many studies have for instance used this technology to analyse sport movements (Dellaserra, Gao, & Ransdell, 2014; Chambers, Gabbett, Cole, & Beard, 2015). Some studies even propose to use IMUs instead of optoelectronical motion systems to perform the well-codified gait analysis (Seel, Raisch, & Schauer, 2014).

However, despite the recent development and improvements brought to IMU motion capture, challenges remain to be solved (Bleser et al., 2015) and new uses and rules of practice might have to be defined.

The five speakers of this applied session are all expert in IMU motion capture. They will, during their talk, present the technology and methodology based on Inertial Measurement Units in the context of physical activity monitoring and ambulatory motion analysis. They will also present projects that have used this technology to monitor or analyse sport activities. Their experience in the domain will also be the opportunity to evoke perspectives but also issues met when dealing with this technology.

**SHORT SUMMARY:** The first presentation of this applied session, Pr Frédéric Marin will introduce the use of IMUs technology for physical activity monitoring and ambulatory motion analysis. This presentation will begin by presenting the history of this technology in the context of human motion analysis. After evoking, the actual state of this IMU technology, it will expose the challenges and the problems that this technology will face and could potentially create.

In the second presentation, Dr Camomilla from the University of Roma will provide a systematic review of the articles that used the IMU technology to analyse motor tasks or sport performance.

The third talk presented by Dr Mahmoud El-Gohary from the company APDM will expose the interest of IMU motion capture for clinical applications throughout a study that used IMUs to monitor pathological subjects. Gait analysis performed in laboratory is the gold-standard for gait assessment whatever the subject or the context. However, subject's behaviour might differ between laboratory and daily-life. It is thus often reported that patients with PD walk better when they are examined in an outpatient clinic or in a research laboratory than at home. Continuous monitoring of mobility during spontaneous daily activities may then provide clinicians and patients with objective measures of the quality of their mobility. A study that proposed a continuous monitoring of spontaneous gait with wearable inertial sensors during daily life will be presented here.

The talk by Dr Taetz from the Technical University of Kaiserslautern will focus on the methodology and modelling associated with IMUs. Physical activity monitoring or motion capture is indeed still a subject of research in terms of technology and methodology because of a number of limitations that still remains: measurement errors and sparsity, body models, calibration routines, soft tissue artefacts, which lead to limited precision and robustness compared to optical gold standard systems. This talk will then expose these different challenges and show how the research group wearHEALTH at the TU Kaiserslautern try to tackle these challenges by bringing together ideas and approaches from different. An overview of the approaches and applications of this research group will also be presented.

The last presentation made by Dr Mariani from the company Gait UP will present two recent collaborative projects for translating movement data into relevant information measuring objectively performance or disability. Using the signals from body-worn inertial units (Physilog®) combined with advanced data fusion algorithm, daily-life motor performance on one side and running performance on the other side were measured and analysed using new descriptive metrics referred as "Barcode" and "Signature". The development and validation of those two applications in the case of Stroke patients and Amateur athletes are described, and their potential use in clinical and sports routine will be discussed.

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