INERTIAL MEASUREMENT UNIT IN BIOMECHANICS AND SPORT BIOMECHANICS: PAST, PRESENT, FUTURE

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The current technologies and methodologies used for physical activity monitoring and ambulatory motion analysis are based on the Inertial Measurement Unit (IMU). Perspectives and issues met with when performing physical activity monitoring and ambulatory motion analyses with this type of device are presented here.

KEY WORDS: Inertial Measurement Unit, presentation, survey.

INTRODUCTION: Inertial parameters, such as accelerations or angular velocity, are well established in kinematics and dynamics as a good means of analyzing and quantifying states of rigid body kinematical chains. Because of the common hypothesis of the segmental decomposition of the human body (as held since the early days of biomechanics and specifically, sport biomechanics), these parameters demonstrated relevance to analyzing pathological subjects, rehabilitation programs, and sport performance. However, in concurrence with the use of optoelectronic devices to perform motion capture, the inertial measurement unit (IMU) was restricted to all except elite research groups due to its high cost and the sophisticated post processing necessary to produce comprehensive results. Recent technological and methodological advances in micro-electromechanical systems (MEMS) have drastically reduced the cost, the size, and the portability of IMUs. Thanks to these developments, many technologies and applications have become affordable, and relatively easy to set-up. IMUs now offer researchers an amazing new field of investigation for biomechanical and sport biomechanical study, full of promise, but also, with some remaining limitations.

Past: Age of development: The beginning of IMU development was dedicated to the improvement of the technology, especially in sensing, energy consumption, and communication. With time and sensor miniaturization, IMU fused more and more of its sensors, including its triaxial accelerometers, gyroscopes, magnetic field detectors, and pressure temperature sensors.
The second major development was the improvement of post-processing. IMUs were mainly used to obtain orientations and translations from its measurements of angular velocity and linear acceleration. Noise and drift of the inertial data were then an important source of measurement errors that had to be corrected. Sophisticated filters, calibration techniques, and modeling were then tested and implemented to increase accuracy and reliability.

Present: Age of applications: The present time brings a total democratization and massive use of the IMU in the study of biomechanics, especially and sport and clinical biomechanics. Integrated and turnkey systems based on IMU technology are nowadays commercialized. IMU motion capture systems now enable the monitoring of sport activities such as gait, running, biking, and skiing. The use of IMUs has also branched out into clinical applications dedicated to the monitoring of pathological subjects, musculo-skeletal pathology prevention,

rehabilitation— for example, the healing of anterior cruciate ligament deficiency— and also for material design of prostheses and braces.
Every field of research in connection with motion capture and motion analysis are impacted by this substantial development of IMU application. Moreover, new fields of research are opening in pervasive tracking and ecologic motion capture. MoCap (motion capture) in studio in time will be replaced by ecological PeCap (performance capture).

Future: Age of intended use: Despite the benefits of new perspectives to physical activity monitoring and ecological sport movement analysis, these new perspectives will, in turn, bring new challenges to the field. Firstly, there is a risk that IMU technology will become a catch-all technology. IMUs could become ubiquitous, implemented by experienced and unexperienced parties, and used for an increasing number of applications with more or less accuracy as it is increasingly favored by the development of related technologies. Furthermore, IMUs, after future progress in MEMS, energy supply, communication, data storage, and data mining (i.e. big data), will be able to measure, quantify, compare, and then monitor, classify, and archive a great deal of kinematic and dynamic performance over the time. This could become an ethical issue as the possibility for more or less well intentioned companies to exploit these data increases, as is the case now for personal data stored on the internet.

CONCLUSION: The use of inertial measurement units in biomechanics and sport biomechanics was, is, and will be not only promising, but also a breakthrough in motion and, more specifically, sport performance analysis.

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