Technology-Based Complex Motor Tasks Assessment: A 6-DOF Inertial-Based System Versus a Gold-Standard Optoelectronic-Based One

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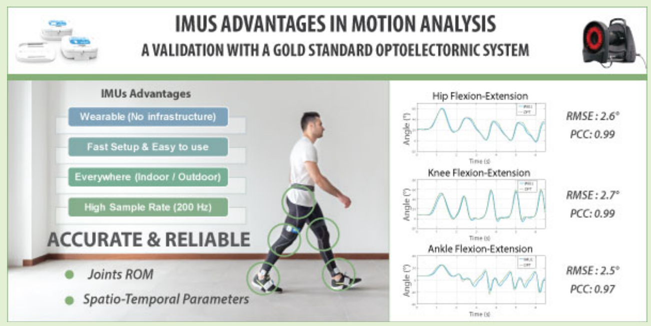
***Abstract*—Currently, the gold-standard method of assessing human motion is by means of optoelectronic analysis systems. However, such systems have some drawbacks (time-consuming procedure, specialized room, expensive,..) and therefore other analysis systems are gaining in importance. Here, we report a novel inertial-sensor based system (Movit System G1, by Captiks) with an innovative calibration, testing its strengths and weaknesses when compared to an optoelectronic gold standard one (Vicon, by Oxford Metrics). In particular, the validation was executed with different subjects performing different motor exercises: walking (Test 1) and joint movements (Test 2). Gathered data from measurements were anlayzed to evidence accuracy and reliability of the inertial-sensor based system, and the statistical agreement between the two measuring approaches. Results demonstrated a very good measurement accuracy of the inertial-based system for hip, knee and ankle's ROMs in the sagittal plane during walking (RMSE < 2.66°, PCC >0.97), and for joint movements in all planes (RMSE < 3.46°, PCC > 0.94). In addition, the two systems performed with a good agreement (the percentage errors of spatio-temporal parameters were lower than 5%, except for double support which was equal to 8.6%). The reliability was proved for the most gait parameters and joints.**

***Index Terms*—Inertial measurement unit, IMU, optoelectronic analysis, gait analysis, wearable system.**



I. Introduction

The assessment of human motion patterns during functional activities plays an important role in different fields, such as medicine [1], sport [2], [3] or ergonomics [4]. We can achieve such an assessment by means of eye-based evaluation of an expert examiner, by rating scale questionnaire results (e.g. the UPDRS scale for Parkinson's disease patients [5]), and/or by analytical evaluation of data gathered from measurements.

Unconveniently, some tremours during motion cannot be detected by a human eye expecially in discriminating multi-plane components, the judgment of an expert examiner can be biased by wrong beliefs, and the steps of the rating scales questionnaires can be too few to evidence some peculiar aspects of the subject motor (in)abilities [6]. In the necessity of a motor assessment as correct as possible, these inconveniences represent an important limitation.

Conveniently, key enabling technologies (KETs) have been developed to overcome aformentioned disadvantages, with the further advantage to allow objective data comparisons during a patient's treatment period so to evaluate the progress and the efficacy of the therapy [7], [8].

Motor assessment KETs include, among others, the so called "Outside-In" and "Inside-Out" systems, the first with signal generating sources attached to the body and the signal acquisition sensors somewhere else, vice versa for the latter [9]. Among "Outside-In", high-performance optoelectronic systems (OSs) represent the current gold-standard for motor assessment KETs, when sources are passive or active markers, strategically located on the subject's skin, while sensors are fixed cameras, around the subject. Among "Inside-Out", wearable-electronic based systems (WSs) represent an

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