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Review of Doctoral Thesis by Otakar Šprdlík

„Detection and Estimation of Human Movement Using Inertial Sensors:
Applications in Neurology”

During the last ten years we can see really fast increase of applications where body space sensors were implemented for human motion assessment. Accelerometer sensors or inertial measurement units (IMU's) play a dominant role in these applications. From this point of view, new knowledge about calibration of accelerometer sensors is actual and mostly required. Extended information related to precise tremor measurement of body segments is also perspective for clinical use. Generally, the doctoral thesis deals not only with innovative approach to the calibration of accelerometer sensors using new developed method, but mainly presents methods of hand tremor measurement by inertial sensor placed on the hand and its analysis.

In the first chapter, a short survey with author's contribution to the thesis and his publications related to the topic are presented. Also outlines of all chapters are given. The following second and third chapters consist of an excellent introduction to measurement using IMU's and subsequent estimation, and in which fields and how these inertial sensors should be used for human motion assessment and analysis. This survey documents a clear understanding problem to be solved, supported by good knowledge from appropriate references. The aim of doctoral thesis was to develop new method and also improve existing one, which is used for hand tremor measurement by inertial sensor. Furthermore, calibration of the accelerometer sensor was also involved in the development.

The results are aimed to improve measurement of body segment by inertial sensor and cover two main directions. At first, the new method for better calibration of accelerometer sensors during static or quasi-static condition is introduced and analysed. It is important that calibration is analysed from in-use data and also different methods of calibration are presented and compared.

At second, the results related to quantification of hand tremor measured by inertial sensor and separated to gravitational and linear acceleration of the hand are presented in the thesis. These results were already published in relevant journal and therefore were positively reviewed. I appreciate that emphasis was done on detailed processing of measured data from inertial sensors including calibration. Nevertheless, I would like to ask why tremor measurement in different positions of hand, for example hand in vertical position was not made? I consider as a very good contribution the finding about


decomposition of gravitational and linear acceleration during hand tremor. It could be advisable if author may interpret the results from tremor data in relation to any motor disease or to the control loop which is responsible for hand position control.

The thesis is very thorough. It explains in immense detail the documentation and calibration of accelerometers for tremor analysis in nearly static conditions. Furthermore it elaborates on sensor fusion between gyroscope and magnetometer to retrieve accurate results from IMU data in severe tremor analysis. The work also proposes methods to further improve the IMU measurements. The only thing I would really add (which I could not find in the work) is a comparative study to healthy human conditions in order to quantitatively identify the severity of the tremor being measured.

The theory is sound but its application must be further justified: if we are going to use this in a clinical setting it is unclear what the obtained results contribute to the treatment of the motor disease. Within the text I couldn't find a clear description of how the measurements can be used to benefit patients suffering from motor disease other than being implemented as an assessment tool?

Otherwise the work is very thorough and worthy of the PhD study. Results are important not only as a new knowledge in the field, but also from the point of view their involvement in clinical praxis. In the study are presented original results, which extended knowledge about calibration of accelerometer sensors used in assessment of body segment movement. The results are innovative in relation to the hand tremor and perspective for better and more precise hand tremor measurements in patients by inertial sensors placed on the body. Aims of doctoral thesis were fulfilled.

Taking into account presented results and positive review I recommend the doctoral thesis by Otakar Šprdlík to habilitation for PhD.



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