Ph.D. COURSE IN INDUSTRIAL ENGINEERING – XXXIV CYCLE

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Abstract of the thesis

In this work, robust mechanical setup and highly effective algorithms have been proposed to optimize the performance of the inertial measurement unit (IMU) in orientation tracking. This work aims to develop new techniques to minimize the noise as well as the weakness of Euler angles measurement in the industry. The imperfect structure and limit of low-cost accelerometer, gyroscope, and magnetometer with external interferences significantly decrease the precision of roll, pitch, and yaw. A new algorithm, No Motion No Integration (NMNI), was developed to eliminate the gyroscope drift, which opened a new way to calculate the yaw/heading value without magnetometer and Global Positioning System (GPS). Moreover, the NMNI method successfully improved the inclination outputs from sensor fusion Madgwick and Mahony. To deal with external vibration, another technique Orientation Axes Crossover Processing (OACP), has been applied on vibration optimization for Microelectromechanical systems (MEMS) accelerometer without sensor fusion. The proposed filter works on a principle based on the characteristics of vibration impact on whether the X-axis or Y-axis to optimally minimize the noise. In addition, the support from Machine Learning (ML) and Deep Learning (DL) have been exploited to advance the outcome of inclination and heading. The results were validated carefully with a mechanical test bench, based on a Pan-Tilt Unit-C46 (PTU-C46) with accurate positioning as reference angles for static and dynamic experiments. In the company activity, a robust orientation system for inclinometer with full redundancy was described. The designed structure provides high efficiency for inclinometer performance with tolerance of $\pm 0.2^{\circ}$, and stability is always guaranteed thanks to safety function, which is strongly recommended for the application of heavy industry 4.0.

The below figure illustrates the orientation angles generally: