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Calibration of low-cost MIMU sensors for knee joint movement measurement

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Background: Magneto inertial sensors (MIMU) are used for tracking human body movements. These sensors are widely used and not only in Biomechanics. There are several brands on the market: Xsens, APDM and Shimmer with costs between 430 € to 1600 €. To estimate any joint movement, two MIMUs are necessary, doubling the cost. We chose Mbientlab MIMUs which have accelerometer, gyroscope, magnetometer at an affordable price (87$ - 117$). By using cheaper sensors there is a risk that the data present greater variations, modifying the final result of the orientation and therefore requiring prior calibrations. **Aim:** Obtain the raw data from each of the triaxial sensors of the MIMU, analyze the data to calibrate it and to subsequently estimate its orientation in space as it rotates around an axis. **Material and Methods:** Two MetamotionR sensors (Mbientlab) are used. Raw accelerometer, gyroscope and magnetometer data were obtained and subsequently orientation estimation is performed using a Kalman filter [1]. Four tests were performed: (1) Static test with the sensors resting on the table; (2) Static test with the sensors at 90° with X-axis as rotation; (3) Dynamic test from 0° to 90° around X-axis at 0.7853 rad/s; (4) Dynamic test from 0° to 90° around X-axis at 1.5707 rad/s. The tests are performed on a firm surface with no ferromagnetic components around that would alter the data. The movements seek to simulate knee motion. **Results:** The accelerometer measurements vary between 0G to 1G gravity. The characteristic gyroscope drift was corrected. The magnetometer shows an unpredictable behavior, not coincident with the expected magnetic field in Montevideo of 23 uT: the magnetometer modulus was 16 uT up to 85 uT. Soft iron distortion is discarded but hard iron distortion may be caused by MIMU elements. To calibrate, the MIMU magnetometer data are fitted to a 3D ellipsoid obtained by an "infinity" movement. Starting with an acceptable modulus around 23 uT, as time progresses, any magnetic field modulus which differs more than ± 0.5uT is ignored. Such magnetometer clipping has the effect of omitting all environment errors and stick to the Uruguayan expected magnetic field. It turns out to be that for any given time and place, the center of gravity of the measurements must be translated to the expected magnetic field modulus and orientation, for example: deltaX: -4.71 uT , deltaY: -3.85 uT and deltaZ:-21.38 uT . With such prior calibration the MIMU is ready to give accurate results within 5% of the expected magnetic field modulus. **Conclusions:** When using cheaper MIMUs there is a risk of large variations in output values. We have seen that such magnetometer variations can significantly alter the orientation of each MIMU. Therefore, before using these MIMUs for motion tracking, it is important to perform sensor calibration in the environment where the motor gesture is going shall be performed. Only the magnetometer of the three sensors (accelerometer, gyroscope, and magnetometer) has a significant error, which must be compensated by a proper calibration.

Bibliographic references:

Guo S, Wu J, Wang Z, Qian J. Novel MARG-sensor orientation estimation algorithm using fast Kalman filter. *J Sensors.* 2017.