Inertial Measurement Unit calibration methods for the wrist joint: Which one should I use?

Alessandro Bonfiglio123, Elisabetta Farella3, Raoul M. Bongers4
1. Eulera, Rovereto, IT; 2. University of Trento, Trento, IT; 3. Fondazione Bruno Kessler, Trento, IT; 4. University Medical Centre Groningen, Groningen, Netherlands

Materials and Methods

13 healthy subjects with no sign of upper body injury or pain were recruited. Subject were instrumented with IMU and optical markers as shown in Figure 1. After performing static [7] and functional calibration [5,6] subjects performed 5 wrist flexion/extension and 5 wrist radial/ulnar deviation movements (Figure 2). Joint angles computed for each calibration protocol were compared with the optical reference system (Optotrak) as shown in Figure 3.

Results

Figure 3 and 4 wrist flexion/extension and radial/ulnar deviation movements for one subject. The plots show the optical reference in black and the data processed with the four different calibration procedures in colours. Table 1 shows RMSE, offset and correlation values calculated across the five subjects.

Discussion

NP and OA often show larger errors than MA and FC in most of the indices analysed. We hypothesize this is because the forearm and hand reference frame are built by involving the trunk heading during the N-pose calibration, which is generally poorly correlated to the anatomical axis definition of forearm and hand. On the other hand, FC and OA generate the best predictions in terms of correlation, RMSE and offset.

Conclusions and Future work

All models perform rather similarly in estimating the main wrist joint angle, but their performance differs on the secondary rotation axis. Therefore, we advise a functional calibration approach for the best estimation of the overall wrist joint motion. However, for the highest accuracy possible on the main movement axis, we recommend the manual alignment (MA) method.

References


This project has received funding from the European Union’s Horizon 2020 research and innovation programme under the Marie Skłodowska-Curie grant agreement No 956003