A Motion Capture System for Hand Movement Recognition

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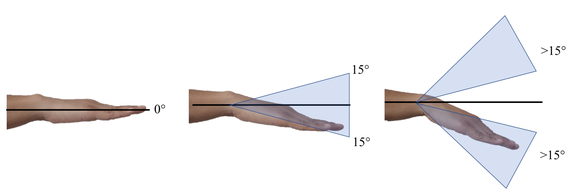
Introduction

Most manual-work at factories is highly repetitive and requires huge force and awkward postures to be executed, sometimes exceeding the workers' capacities, causing many work-related musculoskeletal disorders. As a result, it is important to study the hand movements executed at work to see how they can affect workers' health and productivity.
This study relies on the analysis of data collected by a hand-motion capture system conformed by inertial and force resistive sensors to determine its use in the classification of the hand and fingers movements.

Materials & Methods

1. **Motion capture system and data collection:** A data glove motion-capture system adapted from six inertial sensors with 9 degrees of freedom located on the proximal phalanges and the dorsal side of the hand, and six force resistive sensors, collocated on each fingertip and palm, were used to generate data regarding hand and fingers movements.
   Data collected included ten variables for each finger and hand: triaxial accel-eration (m/s^2), triaxial angular velocity (rad/s), triaxial magnetic field (μT), and the force exerted by each fingertip described by the voltage (V) measured by the master-slave system.
2. **Experimental design:** Two movements using the dominant hand were performed: wrist flexion-extension(Figure 1) and spheric hand grip.



(a) Movements within the small range -15° to 15° and movements in a wider range (<-15° and >15°)

(b) Flexion-extension movement was recorded when wrist is pronated, supinated and in a neutral position

Figure 1: Flexion-extension movement

The spheric hand grip was performed using the five fingers. A compressible ball was used to reproduce the movement
Data were segmented based on a sliding window with size=30 observations and step=10 observations. Accuracy of k- nearest neighbors (k-NN), support vector machine (SVM), decision trees, and Naïve-Bayes algorithms were obtained as a performance metric

Results

Data collected from small and wide wrist flexion-extension movement are presented in figure 2.

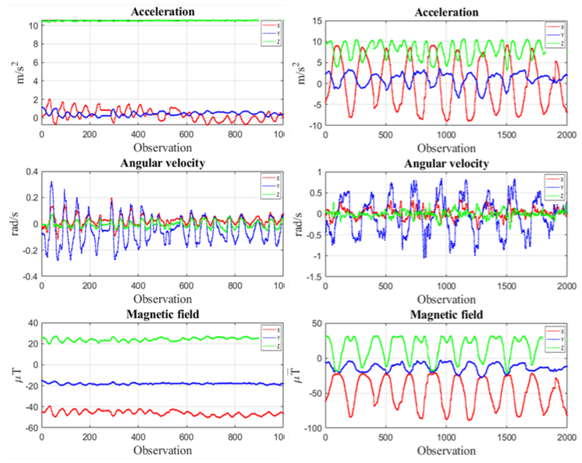


Figure 2: IMU data for the wrist small-wide flexion-extension movement

Data can be classified correctly in both datasets: wrist flexion-extension and the flexion-extension in combination to the wrist pronation-supination movements.

Classification method	Accuracy(%)	
	Small-wide FE	Pronation-Supination FE
Decision Tree	95.9	98.1
Naïve-Bayes	92.4	97.6
SVM	94.5	81.9
kNN	93.5	97.5

In the case of the spheric 3-finger handgrip movement, thumb, index, medium, ring and little finger lectures show an easy to identify patron in the data plot.

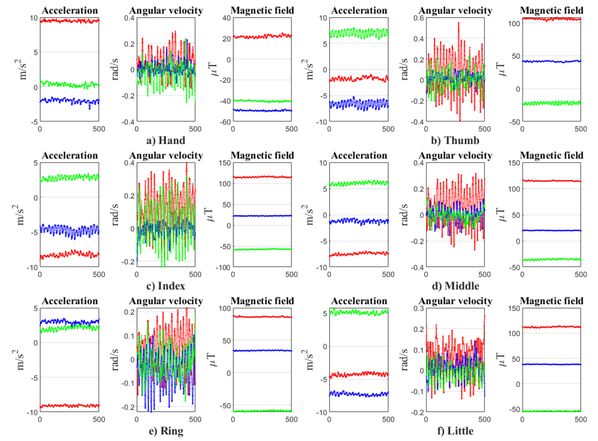


Figure 3: IMU data for the3-finger spherical grip

The voltage measures let to identify the time when the force resistive sensors placed at the thumb, index, and middle fingertips were used and when the hand palm, ring and little finger force sensors were not.

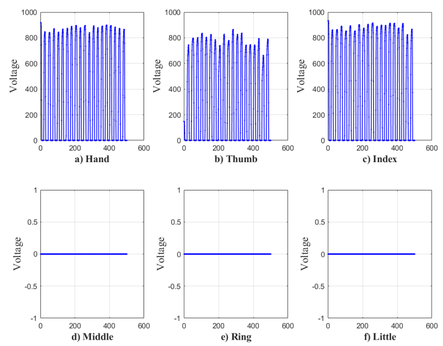


Figure 4: Voltage value for the FSR, spherical grip

References

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Conclusion

- The use of only six 9 degree of freedom inertial sensors and six resistive force sensors, can be used in identifying the basic movement of flexion-extension in a small and a big range of motion, as well when identifying a pronation and supination position when the flexion-extension movement is executed.
- Data patterns can also be found when performing a 3-finger spherical handgrip.
- This study can be extrapolated to the other two wrist movement such as lateral movements and to the common hand grasp types.