Multisegmental Motor Output Analysis in Critically Ill Patients

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ABSTRACT

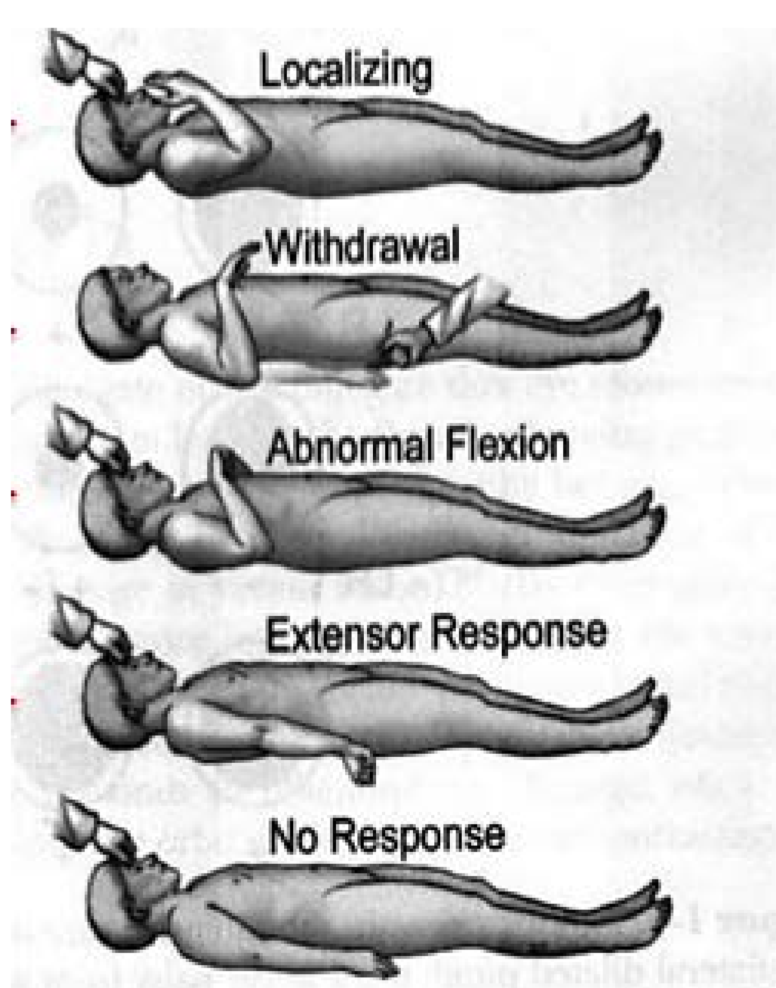
Evaluation of neurological function in the Intensive Care Unit (ICU) is generally achieved by screening for level consciousness using assessments that are subject to error from intra-observer bias and lack of precision. We present a system of wireless wearable sensors capable of non-invasively detecting patient motor output and precisely classifying this movement according to metrics currently used for neurological assessment.

INTRODUCTION

The Glasgow Coma Scale (GCS) is a scoring system for determining the conscious level and severity of neurological impairment after a traumatic brain injury. The GCS is composed of three sub-categories that assess patient ocular, verbal, and motor responses to stimuli and is performed by clinicians on a scheduled basis. However, there is no accurate, unbiased method to quantitatively assess and characterize motor function in critically ill patients.

Our research aims to eliminate this bias and provide a rich data set for predictive analysis by replacing the subjective visual assessment with an acceleratory assessment using calibrated accelerometers placed on the patient.

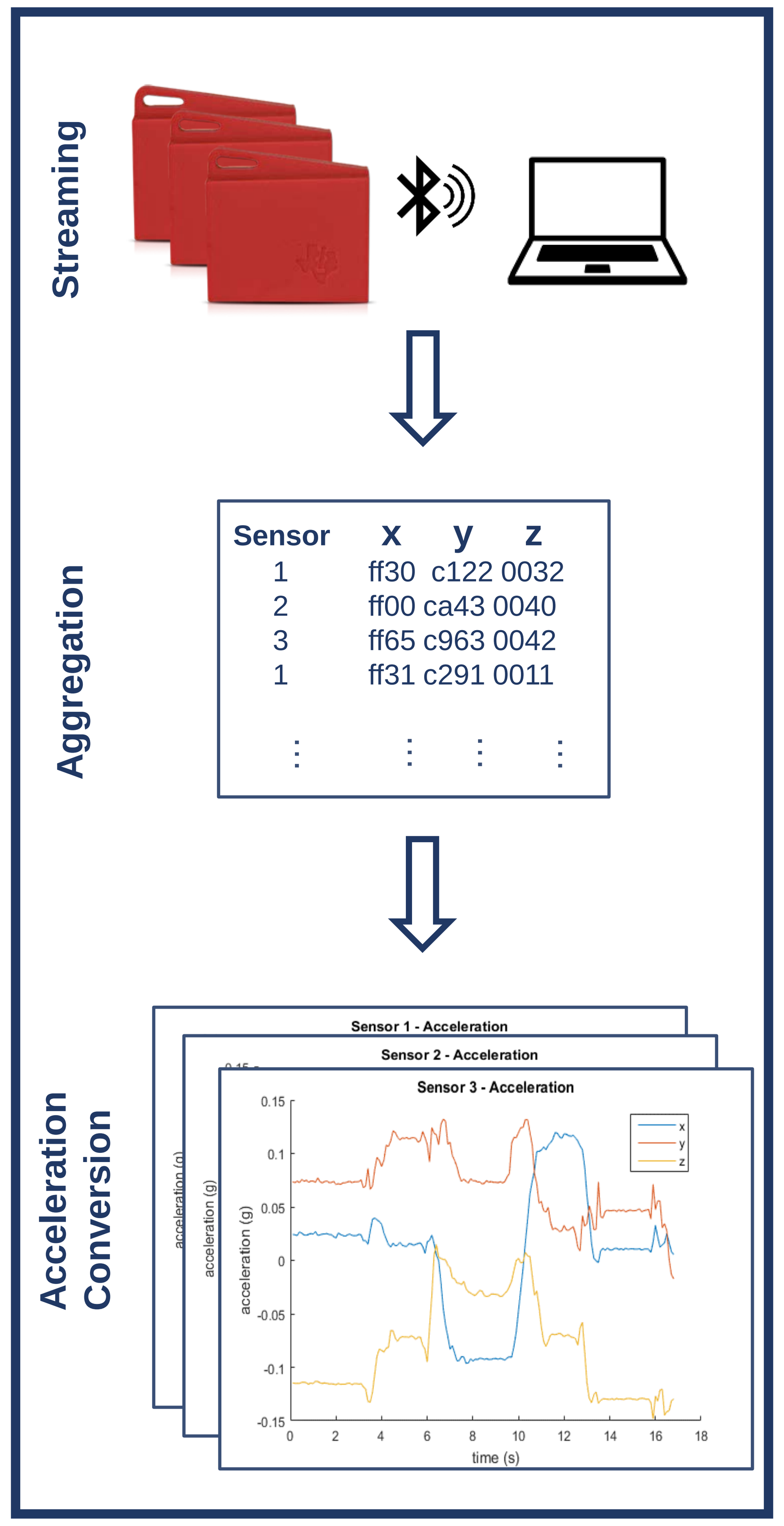
Glasgow Coma Scale: Motor Subcategory



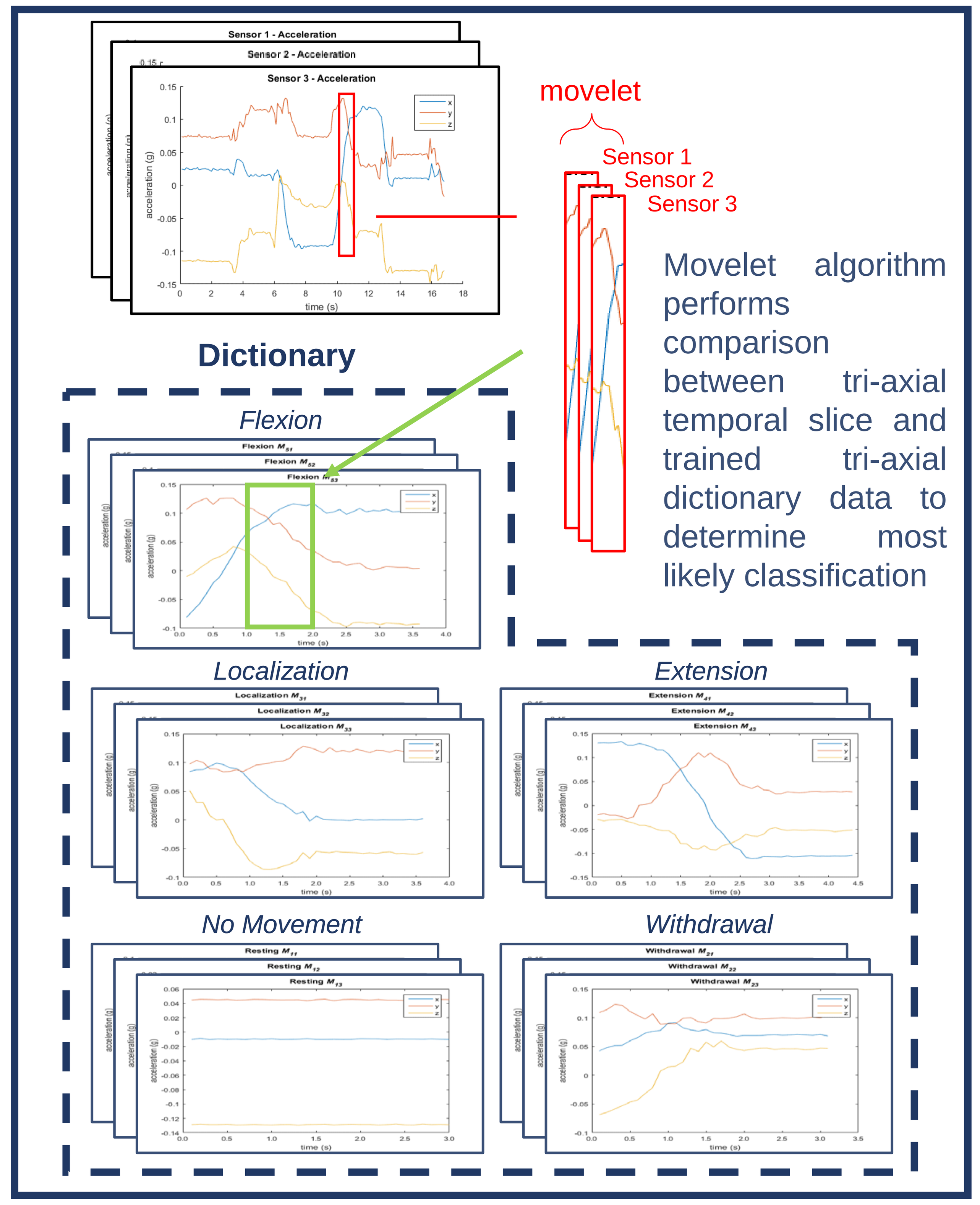
APPROACH

To classify movement, a dictionary was trained consisting of five chapters corresponding to five scales of the mGCS - no movement, extension, flexion, withdrawal, and localization (figure). Movement data is collected from a wearable network of wireless tri-axial accelerometers (TI SensorTags) and classified using movelets, a temporal slice of accelerometer data. Unclassified action is segmented into movelets which are then each classified by computing proximity between the unclassified movelet and all dictionary contained movelets. The chapter with which there is a minimum distance from the unclassified movement assigns the unclassified movelet its label.

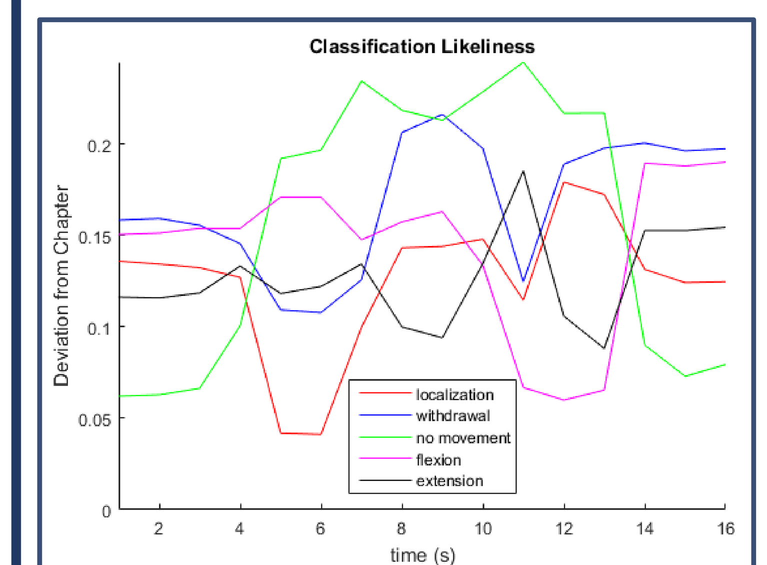
Data Collection



Analysis



Classification



An entire action is composed of many movelets. Each unclassified movelet is classified by computing the Euclidean distance between all movelets contained in the dictionary with itself and determining in which chapter the smallest distance occurs. The proper activity label is determined to be the same action as the dictionary chapter containing a movelet with which the unclassified movelet differs the least.

CONCLUSIONS

Our sensor-based motor output analysis allows hypotheses to be tested regarding the relationship between specific types and patterns of movement and current or future states of neurological function. As opposed to the current standard requiring clinicians to be present for assessment, these readings can be made over extended periods of time providing a more detailed description of motor output to determine patient progress. This analysis of a patient's motor output offers insight into both a patient's motor responsiveness and neurological status at a level that is indeterminable by human perception alone.

REFERENCES

[1] He B, Bai J, Zipunnikov VV, et al. Predicting Human Movement with Multiple Accelerometers Using Movelets. *Medicine and science in sports and exercise*. 2014;46(9):1859-1866.
[2] Bai J, Goldsmith J, Caffo B, Glass TA, Crainiceanu CM. Movelets: A dictionary of movement. *Electronic journal of statistics*. 2012;6:559-578.

RESULTS

Shown below is our approach combined with recorded verification of activity type and our system's classification in green. With little computational complexity and only seconds of training data our system was able to demonstrate high classification accuracy for static positions as well as the transitional movements in between. The next stage of our work will determine the accuracy of our system across multiple participants in both a controlled and clinical environment.