Machine Learning and Time Series Motion Classification: Is it possible to write real-world, single sensor algorithms to detect the activities of daily living used in patient reported outcome questionnaires?

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Introduction

Clinical improvements in function are often measured using survey-based PROs (e.g. ODI) with questions about walking, sitting, standing, traveling (driving) and sleeping (lying down). However, survey data is time consuming for both the patient and clinician. Multiple sensor and rules-based algorithms have shown positive predictive values greater than 85% for ability for walking, jogging, sitting, and lying down in a laboratory setting. The purpose of the current study is to determine positive predictive value of activity in a real-world setting of a single wearable sensor containing an extremely high -end inertial measurement unit (IMU).

Methods

Three healthy volunteers wore a single navigation-grade IMU (SBG Systems Ellipse2-N) for 60 minutes in a real-world (outside) environment and asked to sit, stand, lie supine, drive and walk in an unscripted manner. Data were continuously recorded at 200Hz using a combinatorial supervised ML approach. A multinomial logistic regression (MLR) was first used to classify posture with results fed to a second layer of support-vector-machines (SVM). A classifier finalized the results in 1 second

Results

573,600 5ms data points were analyzed. After the two layers (MLR followed by SVM), accuracy was found to be 99.65% across all activities. Positive predictive values were 99.24% for walking, 99.67% for sitting, 99.8% for driving and 100% for both lying and standing.

Conclusions

The use of a high-end IMU and ML algorithms in this study to classify a subset of ODI activities in a real-world setting achieved greater accuracy than multiple sensors and rules-based algorithms reported in prior studies. This type of technology offers the potential for measured function to replace or supplement patient reported function focused on established patient-centric activities routinely considered reflective of health status.

Learning Objectives

By the conclusion of this session, participants should be able to:

1) Consider the pros and cons of collecting objective activities of daily living using noninvasive sensors.

2) Discuss in small groups the strengths and weakness of this initial work and the potential for clinical studies.

References

Lugade, Vipul, et al. "Validity of using tri-axial accelerometers to measure human movement—Part I: Posture and movement detection." Medical engineering & physics 36.2 (2014): 169-176.