Analysis of Week-long Inertial Sensor Data, Lessons Learned

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Abstract— We present a method used for analyzing week-long kinetic sensor data collected using foot mounted inertial sensors. We demonstrate data reduction techniques for observing meaningful information from large datasets of gait parameters. Our method allowed comparing participants regardless of their physical condition.

Keywords— inertial sensors, motion tracking, gait analysis

I. INTRODUCTION

The use of wearable inertial measurements units (IMUs) for real-life gait collection is becoming increasingly popular [1]. This is due to several factors such as portability, small size, long battery life, and relatively low cost. We present a method for analyzing week-long gait parameters collected on diabetic patients before and after wearing two orthotic interventions. The interventions are commonly used as a preventive measure and treatment for reducing foot complications associated with diabetic peripheral polyneuropathy (DPN). We used IMUs to collect foot kinematic information to later quantify the effects of these interventions on gait. The rationale behind data collection and processing of gait parameters in a natural setting is that it provides a huge amount of data that, if handled well, will generate tremendous and realistic results, unrepeatable in a clinical setting.

II. METHODS

We collected three weeks of foot-mounted IMU sensor data (GT9X, ActiGraph, Pensacola, FL) on seven participants (1F, 6M, age 68.14 ± 2.34 yrs) diagnosed with DPN (≥ 1 yr), and Type II diabetes mellitus (≥ 2 yrs). The University of Michigan IRB approved the study. On each week, participants wore normal shoes (NRS), extra-depth shoes (EDS) and these fitted with custom orthotic insoles (CIS). For the two orthotic interventions, we started the data collection after a week of breaking-in period. We used custom algorithms to integrate the IMU sensor data (gyroscopes and accelerometers) to obtain foot orientation, velocity and position using a method similar to [2]. Using the foot trajectories, we determined individual strides and timing information and computed several common gait parameters (e.g. stride speed, length) [3]. We assumed left and right foot symmetry and eliminated any foot displacements that were smaller than 0.2 m, which we considered not representative of regular walking. For every gait parameter of interest, we determined the peak values on the smoothed curves and designated them as the preferred corresponding gait parameter (Fig 1 left). For most subjects, the histograms resembled unimodal distributions indicating a single gait preference; however, in a few cases, we also observed bimodal distributions that could be interpreted as the patients walking in different environments (e.g. indoor vs outdoor). In these cases, we picked the higher value peak to be consistent with other shoes’ options. Using the selected peak values, we calculated gait parameter differences across the three types of shoes. Finally, we used one sample t-test (alpha=0.1) to determine statistical significance (Fig. 1 right).

III. DISCUSSION

Given the sizable amount of data, combined with the wide variety of unsupervised motions, processing the information was particularly challenging. We determined that simple statistical analysis of any given gait parameter provided little information. In order to process the large amount of data, we developed a methodology using histogram representations that helped making this task manageable. We found that the differences in gait parameters of each participant normalized the results, facilitating the comparison across all individuals. We must acknowledge the differences in daily life environments between patients and their activities patterns greatly influenced their performances across three types of shoes. A better or improved filtering method that accounts for specific gait conditions (e.g. walking along corridors) may draw more insight from the data [5]. These results must be further investigated under a longer period of testing and more importantly with a larger sample size.

REFERENCES


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