Title: Development of Centroid Based Metrics to Provide Personalized Monitoring and Assessment of Gait

A methodology is presented to characterize a subject’s ability to ambulate using various metrics generated from the movement of the subject’s centroid as detected using an inexpensive depth camera system. Metrics have been developed focusing on three major categories of motion. The first, and most basic, class measures characteristics of movement in the direction of motion, laterally, and vertically. The second class focuses on measuring the entropy that exists in the subject’s walk. The third class uses periodicity in the subject’s motion to deduce temporal gait parameters including stride length, and step times on the left and right side. As each patient is unique with different histories, disease progression, and overall state, metrics and the associated analysis approaches integrate a personalized approach to selecting and using metrics.

These stride time, stride length, and average speed metrics were then validated against both the Vicon® system and an established reference algorithm. From these metrics, a set of methodologies were developed to study short and long-term effects of therapies, significant changes in metrics due to clinical events, as well as the ability to predict potential clinical events by identifying outliers in long term trends.

These metrics and my analysis approach were then tested using a group of subjects undergoing therapy using strategic weighted vests. The ability of the metrics to show changes in the subject’s ambulation when the vest is either put on, or taken off was examined. Results show sufficient sensitivity to detect changes when the vest is donned and doffed. Interestingly, results also show that the effects of the vest are not seen immediately, but over 2-4 hours following donning. Results also demonstrate the ability, using the window size, to focus on the time required for the effects of each metric to change. Lastly, results show distinct results for each individual subject.

Additional studies were also done using subjects not undergoing the vest therapy to identify trends and outliers as portents of clinical events. Results show the ability to identify potential clinical events by identifying outliers in long term trends. Again, results are improved if the metrics used in the analysis are chosen specific to each subject.

The metrics are also compared against existing Fall Risk Assessments to validate their potential usefulness in monitoring subjects for changing risk of falls. While results show strong correlation to some FRA’s, not every subject has the same relationships between metrics and FRA’s suggesting a unique “fingerprint” of metrics associated with a subject’s condition.

Lastly, the performance of these metrics was evaluated against a reference algorithm using in home data as well as against in home data into which a simulated obstruction was placed. In both cases, greater than 90% of the walks could produce a valid set of metrics and the simulated obstruction resulted in no significant changes in the examined metrics.

The metrics and methodologies presented here show a significant improvement in performance, a wider diversity of measurements, as well as the ability to measure both short term and long-term trends than currently existing approaches.