GAIMS: a powerful gait analysis system satisfying the constraints of clinical routine

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Background

Walking impairment is frequent and appears early in the disease course of MS Patients (MSP). It is a good indicator of disease activity. However, its objective evaluation remains of limited interest for various reasons. For example, stopwatches can only be used to get a rough estimate of the walking speed, and electronic walkways capture only the contact points with the floor.

Goal

To develop a gait measure system (GAIMS) that does not require the patient to wear special clothes, tags or sensors, compatible with standardized tests. This system allows to capture feet trajectories both in the stance and in the swing phase, and to know when a foot moves over a spot in the *six spot step test*, or when the person crosses the start and stop lines in the *timed-25 foot walk test*. The work presented summarizes the major aspects of our validation strategy.

Method

By placing 4 range laser sensors in the corners of a 11m by 5m room, we scan a common horizontal plane 15cm above the floor, and consider each foot as a point in the plane. Subjects walking in preferred pace, as fast as possible, and tandem gait are analysed on a 25ft straight path, and on 20m, 100m, and 500m (several laps of a 20m 8-shaped path). We designed calibration, feet localization, tracking, and signal processing algorithms to extract reliable feet trajectories, and derive 26 meaningful Gait Descriptors (GDs): walking speed, mean inter-feet distance, swing phase duration, gait asymmetry, maximal deviation from the path painted on the floor to be followed, ...

Results

Forty-nine healthy volunteers (HV) and 73 MSP (median EDSS 4.0) were recorded. We achieve 4 results. (1) GDs allow to detect subtle (intra-subject) gait alterations. These were induced on 24 HV by a low dose of alcohol. With a machine learning technique (*ExtRaTrees*), the majority of the tests were correctly classified as pre or post alcohol intake for 22 of the 24 subjects (by *leave-one-person-out*). (2) GAIMS is more powerful than a stopwatch to detect gait abnormalities: with only speed related GDs, we cannot differentiate between the tests performed before or after alcohol intake. (3) It is possible to identify MSP based on their gait: we obtain an accuracy of 92% with the *ExtRaTrees* (by *cross-validation*). (4) Significant gait differences are found between HV and MSP, and between MSP with different EDSS levels. These results establish the effectiveness of GAIMS.