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# A multimodal sensor fusion platform for objective assessment of motor states in Parkinson's disease

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**Abstract**— This study proposes a platform to objectively assess motor states in Parkinson's disease (PD) using sensor technology and machine learning. The platform uses sensor information gathered during standardized motor tasks and fuses them in a data-driven manner to produce an index representing motor states of the patients. After investigating clinimetric properties of the platform it was found that the platform had good validity and responsiveness to treatment, which are essential for developing systems to individualize treatments.

## I. INTRODUCTION

PD is characterized by considerable inter- and intra-individual variability in clinical manifestation of symptoms. Each patient has an individual symptom profile that varies from day to day or even hour to hour, significantly affecting their health-related quality of life [1]. Currently, evaluation of motor symptoms is done according to the Movement Disorder Society – Unified PD Rating Scale (MDS-UPDRS). Its application is not practical since it is expensive and time-consuming. To address these shortcomings in PD care, analysis of bio-signals gathered via sensors may help in objective assessment of motor symptoms and possibly pave the path to individualized treatment [2, 3]. In this study, the aim is to investigate clinimetric properties of a multimodal sensor fusion platform to objectively assess motor states in PD.

## II. METHODS

The data contained recordings of standardized motor tasks such as alternating movements of hands (AMH), leg agility (LA) and gait from 19 (5 females) PD patients and 22 (6 females) healthy controls. The data were captured by 3D motion sensors (accelerometer and gyroscope) attached to the ankles and wrists of the subjects. Additionally, the data consisted of clinical ratings by 3 movement disorder specialists who observed the video recordings of the patients and rated six items of UPDRS-III (motor section), Treatment Response Scale (TRS), and dyskinesia. Sensor data were divided into 4 parts including AMH, LA, upper limb movements during gait, and lower limb movements during gait. Spatiotemporal features from the sensor data were

extracted and used in machine learning to produce a multimodal sensor-based index on TRS scale.

## III. RESULTS

A correlation coefficient of 0.95 between the sensor-based index and mean ratings of TRS was achieved after selecting relevant features with stepwise regression and numerical prediction with linear regression. The analysis for determining the responsiveness of the index to levodopa changes indicated that it had good responsiveness to levodopa (Fig. 1). Healthy controls were accurately classified compared to PD patients with an accuracy of 97%, using Support Vector Machines.

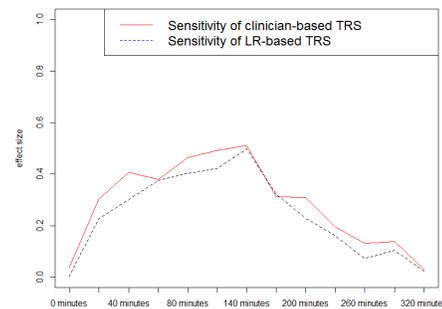


Figure 1. Responsiveness to levodopa of the clinical TRS and sensor-based index over time. The y-axis shows the effect size representing the ability to detect any change between baseline, the time point when the levodopa was administered (0 minutes) and follow-up tests. The x-axis represents the time (in minutes) from dose administration.

## IV. CONCLUSIONS

The study presented a multimodal analysis of PD motor symptoms using machine learning that fused information from standardized motor tasks. The findings suggest that the platform had good validity, responsiveness to levodopa and had a high accuracy to classify patients and healthy controls.

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