

COMMUNICATIONS ENGINEERING

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INTERNSHIP REPORT

Analysis of Anticipatory Postural Adjustments of Parkinson's Patients using Inertial Sensors

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Preface

This report presents my practical work within the Project “Analysis of Anticipatory Postural Adjustments of Parkinson’s Patients using Inertial Sensors” at the Research Centre for Information and Communications Technologies of the University of Granada (CITIC-UGR). The Muenster University of Applied Sciences required an intership of at least 10 weeks prior to the final bachelor’s thesis.

This is a conjoint project of the University of Granada and the Department of Neurology of the Klinikum Grosshadern of Munich, which is part of the Ludwig-Maximilians University.

The goal of the project is to carry out the so called Anticipatory Postural Analysis, which are the movements by a human subject between the moment he initiates gait and the first step. The medical community is interested in this procedure as it can be used for the diagnosis of neurodegenerative diseases such as Parkinson’s.

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Abbreviations

APAs Anticipatory Postural Adjustments

COM Centre of Mass

COP Centre of Pressure

HY Hoehn and Yahr scale

MIMU Magnetic Inertial Measurement Unit

PD Parkinson's disease

UPDRS Unified Parkinsons Disease Rating Scale

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Introduction

1.1 General

1.1.1 Parkinson's Disease

According to Patients Medical [1],

“Parkinson’s disease is a progressive, neurodegenerative disease that occurs when the neurons within the brain responsible for producing the chemical dopamine become impaired or die. Dopamine is essential for the smooth control and co-ordination of the movement of voluntary muscle groups. Once approximately 80% of the brain’s dopamine producing cells no longer function, the symptoms of Parkinson’s disease begin to appear. . . . Parkinson’s disease may be termed as a progressive movement disorder that is distinguished by marked slow movements, tremors, and unstable posture.”

Especially in advanced stages of the Parkinson’s disease (PD) many patients exhibit an episodic, brief inability to step that delays gait initiation or interrupts ongoing gait. This phenomenon is called freezing of gait and is often associated with an alternating shaking of the knees, termed as knee trembling. However, these clinical signs of balance or gait problems are not evident in early stages of the disease [2][3].

1.1.2 Anticipatory Postural Adjustments

To induce gait Anticipatory postural adjustments (APAs) are made. The Encyclopedia of Neuroscience [4, p.133] defines APAs as ”A predictive motor response that acts to counter, in

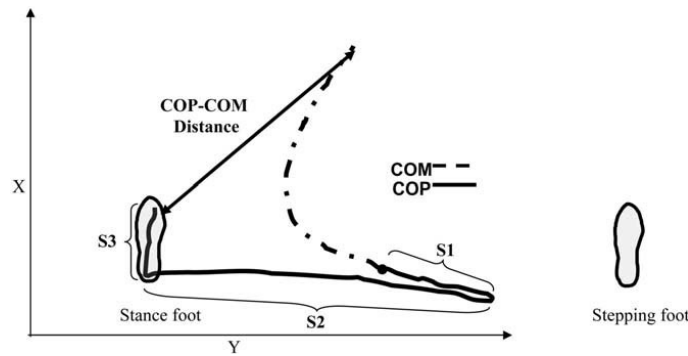


Figure 1.1: Anticipatory Postural Adjustments during forward-oriented gait initiation when stepping with the right foot. The arrow represents the distance between the COP-COM [5]

a preemptive manner, the postural destabilization associated with a forthcoming movement.” The centre of body mass (COM) is accelerated forward and laterally over the stance foot to make sure that the body does not fall laterally toward the stepping foot during the swing phase [4]. Figure 1.1 shows the whole process divided in three periods. Period S1 indicates the uncoupling of the centre of pressure (COP) and COM as the COP moves posteriorly and toward the intended stepping limb. Then, in the S2 period, the COP displaces mediolaterally toward the stance foot. Finally, during the S3 period the COP moves anteriorly under the stance foot [5].

1.2 Motivation

Advanced PD can increasingly diminish quality of life, due to the fact that patients are dependent on help from others to accomplish daily tasks. Early diagnosis of PD could optimise early treatment. Currently new drugs are being developed and are expected to decelerate or stop the course of the disease in early stages [6]. Moreover an objective PD classification could evaluate longterm treatment success while testing these drugs.

1.3 Goals

The goal of the project is to carry out the so called Anticipatory Postural Analysis, which are the movements by a human subject between the moment he initiates gait and the first step. The medical community is interested in this procedure as it can be used for the diagnosis of neurodegenerative diseases such as Parkinson’s. We aimed to build a classifier which is fed with data from both force plate and magnetic inertial measurement unit (MIMU) to distinguish between Parkinson patients and healthy subjects.

1.4 State of the art

There are several methods and devices to assess Parkinson's disease and to analyse Anticipatory Postural Adjustments. The state of the art at the beginning of the project is presented below.

1.4.1 Rating scales

One commonly used rating scale is the Unified Parkinsons Disease Rating Scale (UPDRS) which is a short test performed by a physician [7]. The patient is rated on 31 different items (see table ??) with a score of 0 (normal) to 4 (severely affected). Another method is the widely utilised and accepted Hoehn and Yahr scale (HY). Parkinsonian motor impairment is categorised in 5 stages: Unilateral (Stage 1) to bilateral disease (Stage 2) without balance difficulties, to the presence of postural instability (Stage 3), loss of physical independence (Stage 4), up to being wheelchair- or bed-bound (Stage 5) [8]. Klerk et al. [7] mentioned the disadvantages such as subjectivity, short observation periods and unfamiliarity of the environment that both rating methods bring along.

Mentation, mood and behavior	Activities of daily living	Motor examination
Intellectual impairment Thought disorder Depression Motivation/initiative	Speech Salivation Swallowing Handwriting Use of eating utensils Dressing Hygiene Turning in bed Falling Freezing when walking Walking Tremor Sensory Complaints	Speech Facial expression Tremor at rest Action or postural tremor of hands Rigidity Finger taps Hand movements Rapid alternating movements of hands Food agility Arising from chair Posture Gait Posture stability Body bradikinesia and hypokinesia

Table 1.1: UPDRS items adapted from [?]]

1.4.2 Instrumentation

In addition to the named subjective rating scales there are different devices used to quantify gait and posture and assess them objectively. All of them come with certain pros and cons. The following devices have been used:

- Electromyographs: Electromyography is a technique for evaluating the electrical activity of skeletal muscles. Successive action potentials generated by muscle cells are measured by means of needle electrodes inserted into the muscle and displayed on a cathode-ray oscilloscope. Thus medical abnormalities can be detected. The instrument used to capture the visual recording, termed electromyogram, is called electromyograph. [?].
- Force plates: Force plates quantify the ground reaction force (GRF), which is the force exerted to the human body by the ground. The GRF is a 3-dimensional vector with three orthogonal components. One component along the direction of gravity F_z one parallel to the ground in the sagittal plane and one parallel to the ground in the frontal plane voltage proportional to the force
- Inertial sensors:
- Camera based:

1.4.3 Calibration

Different calibration methods are used...

1.4.4 Classification

Different classification methods/techniques are used...

Signal processing

Bibliography

- [1] Patients Medical. Definition of parkinson's disease. <http://www.patientsmedical.com/healthaz/parkinsons.aspx>, 2014. [Accessed 22 November, 2014].
- [2] M. Mancini, C. Zampieri, P. Carlson-Kuhta, L. Chiari, and F. B. Horak. Anticipatory postural adjustments prior to step initiation are hypometric in untreated parkinson's disease: an accelerometer-based approach. *European Journal of Neurology: The Official Journal of the European Federation of Neurological Societies*, 16(9):1028–1034, September 2009. ISSN 1468-1331. doi: 10.1111/j.1468-1331.2009.02641.x.
- [3] Jesse V. Jacobs, John G. Nutt, Patricia Carlson-Kuhta, Marilee Stephens, and Fay B. Horak. Knee trembling during freezing of gait represents multiple anticipatory postural adjustments. *Experimental Neurology*, 215(2):334–341, February 2009. ISSN 1090-2430. doi: 10.1016/j.expneurol.2008.10.019.
- [4] Marjorie Woollacott. Anticipatory postural adjustments. In Marc D. Binder, Nobutaka Hirokawa, and Uwe Windhorst, editors, *Encyclopedia of Neuroscience*, page 133. Springer Berlin Heidelberg, January 2009. ISBN 978-3-540-23735-8, 978-3-540-29678-2. URL http://link.springer.com/referenceworkentry/10.1007/978-3-540-29678-2_279.
- [5] Chris J. Hass, Dwight E. Waddell, Richard P. Fleming, Jorge L. Juncos, and Robert J. Gregor. Gait initiation and dynamic balance control in parkinson's disease. *Archives of Physical Medicine and Rehabilitation*, 86(11):2172–2176, November 2005. ISSN 0003-9993. doi: 10.1016/j.apmr.2005.05.013.
- [6] Kai Prof. Dr.med. Btzel. Motivation for early diagnosis of PD, November 2014.
- [7] D. G. M. de Klerk, J. P. P. van Vugt, J. a. G. Geelen, and T. Heida. A long-term monitor including activity classification for motor assessment in parkinsons disease patients. In Jos Vander Sloten, Pascal Verdonck, Marc Nyssen, and Jens Haueisen, editors, *4th European Conference of the International Federation for Medical and Biological Engineering*, number 22 in IFMBE Proceedings, pages 1706–1709. Springer

Berlin Heidelberg, January 2009. ISBN 978-3-540-89207-6, 978-3-540-89208-3. URL http://link.springer.com/chapter/10.1007/978-3-540-89208-3_406.

- [8] Christopher G. Goetz, Werner Poewe, Olivier Rascol, Cristina Sampaio, Glenn T. Stebbins, Carl Counsell, Nir Giladi, Robert G. Holloway, Charity G. Moore, Gregor K. Wenning, Melvin D. Yahr, and Lisa Seidl. Movement disorder society task force report on the hoehn and yahr staging scale: Status and recommendations the movement disorder society task force on rating scales for parkinson's disease. *Movement Disorders*, 19(9):1020–1028, September 2004. ISSN 1531-8257. doi: 10.1002/mds.20213. URL <http://onlinelibrary.wiley.com/doi/10.1002/mds.20213/abstract>.