Abstract

Optimization of Medicine Dosing in Parkinson's Disease, Based on Signals from Sensor Measurements

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Parkinson's disease (PD) presents significant challenges in management, requiring precision, and a deep understanding of each patient's experience with the disease. This thesis explores the application of machine learning (ML) and optimization techniques to enhance the treatment of PD, focusing on creating personalized medication schedules. The primary aim is to develop a method that suggests optimal doses and intake times for medication, specifically levodopa, the main medication used in PD treatment, to maintain patients in an optimal state throughout the day.

The research presented in the thesis is divided into several key areas:

- symptom severity evaluation,
- medicine response modelling,
- optimization of medication schedules,
- implementation of the patient monitoring system.

Symptom severity evaluation involved developing machine and deep learning models to predict the severity of PD motor symptoms using data collected from mobile devices and wearable sensors. Experiments focused on determining how different exercises could be used to predict the severity of individual symptoms and the overall state of the patient were the main part of the chapter. The best results were obtained from inertial sensor signals such as accelerometers and gyroscopes. The study highlights the effectiveness of both machine and deep learning models, with the latter showing slightly better performance but requiring significantly more data.

Medicine response modeling included building predictive models to understand individual patient responses to medication. These models were based on neural networks particularly on Long

short-term memory cells and demonstrated success in predicting patient states after medication intakes. The study validated these models on both synthetic and real patients, showing that integration of patient demographic and clinical data allows for personalized medication response predictions.

Optimization of medication schedules employed optimization algorithms and reinforcement learning to create personalized levodopa intake schedules. These methods provided flexibility in dose sizes and intervals, leading to more personalized treatment plans. Comparison of optimization results using both pharmacokinetic/pharmacodynamic and ML models showed close alignment, confirming the applicability of the proposed methods.

The last part of the thesis presents a system implemented to support real-time data collection and patient monitoring. This system includes a mobile application for patients and a web platform for clinicians. The mobile application allows patients to easily record their symptoms, medication intake, and other relevant data in real-time. This data is then synchronized with the web application, where clinicians can monitor patient progress, and make decisions about treatment adjustments. The integration of these tools improves real-time data collection and continuous patient monitoring, ensuring that any changes in the patient's condition can be promptly addressed. By providing a simple interface for both patients and clinicians, this system supports continuous patient care and enables the development and implementation of personalized treatment strategies that are tailored to the individual needs of each patient.

The findings of this thesis demonstrate the potential for significant improvements in symptom management and patient quality of life through personalized treatment approaches. Recommendations for future research include conducting larger clinical trials, exploring additional patient-specific factors, and updating optimization tasks to further enhance model accuracy and applicability.

In conclusion, this dissertation presents a comprehensive approach to personalized PD treatment, integrating ML models and optimization algorithms to offer a promising direction for future PD treatment strategies.