A Hybrid Framework for Intelligent Crisis Management in Parkinson's Disease

Youness Amadiaz, Edgar Alfonso-Lizarazo, Ahmed Nait Sidi Moh

Université Jean Monnet Saint-Etienne, LASPI, UR, F-42023, Saint-Etienne, France
{Youness.amadiaz, Edgar.alfonso.lizarazo, Ahmed.nait}@univ-st-etienne.fr

Keywords : *Parkinson's disease, emergency dispatch, machine learning, explainable AI, optimization, P2X communications.*

1 Introduction

Parkinson's disease (PD) is a chronic neurodegenerative disorder with progressive motor symptoms (tremor, rigidity, gait freezing, falls) and disabling non-motor features such as depression, anxiety, sleep problems. Patients may suddenly deteriorate (severe OFF episodes, unexpected falls...) and require rapid medical intervention, often outside hospital settings [1]. This creates a strong need for timely detection of crises and efficient dispatch of appropriate emergency resources. Existing research on EMS in PD makes little use of longitudinal clinical information and digital biomarkers, rely on triage decisions based on incomplete data, and do not fully exploit modern connectivity (Internet of medical things, wearables, V2X) [2]. In this work, we propose an Intelligent Dispatch framework that connects smartphone-based monitoring, machine learning (ML), eXplainable AI (XAI) and optimization within the context of a crisis related to Parkinson's disease. The framework aims to detect clinically relevant deterioration in real time, classify patients into urgency levels, provide interpretable explanations of risk, and use these predictions to guide ambulance and hospital selection, ultimately reducing time-to-intervention and improving coordination of emergency care for people with PD.

2 Overview of the proposed framework

The proposed framework is organized into three cooperative layers: (1) a mobility and P2X (patient-to-everything) communication layer that acquires sensor data and executes routing based on OMNeT++ network simulation tool to model the communication network, and simulator SUMO traffic simulation tool to create the traffic simulation environment. (2) a predictive and explainable intelligence layer that categorizes patients by severity level, and (3) an optimization layer that makes dispatch decisions and coordinates optimally emergency interventions to the patient's location. Together, they form an end-to-end loop from patient sensing to ambulance assignment and route execution. Figure 1 illustrates the framework we propose for intelligent decision-making .

Data of the first layer data can be used to interface with vehicle on-board units (OBUs) in order to signal urgent events and collect GPS coordinates and other relevant measurements. Simple rule-based checks applied to these incoming data streams enables this layer to raise a preliminary URGENT alert for a patient and to send a structured message to the upper layers via roadside units (RSUs). Second, the predictive layer refines this alert by combining longitudinal clinical and demographic variables (age, sex, MDS-UPDRS III, Hoehn & Yahr stage, mood, sleep, autonomic and cognitive scores), which are fed into a GRU-based (Gated Recurrent Unit) model that outputs the crisis risk. This risk is converted into an emergency class (low/medium/high) and an interpretable XAI score, which is attached to the emergency

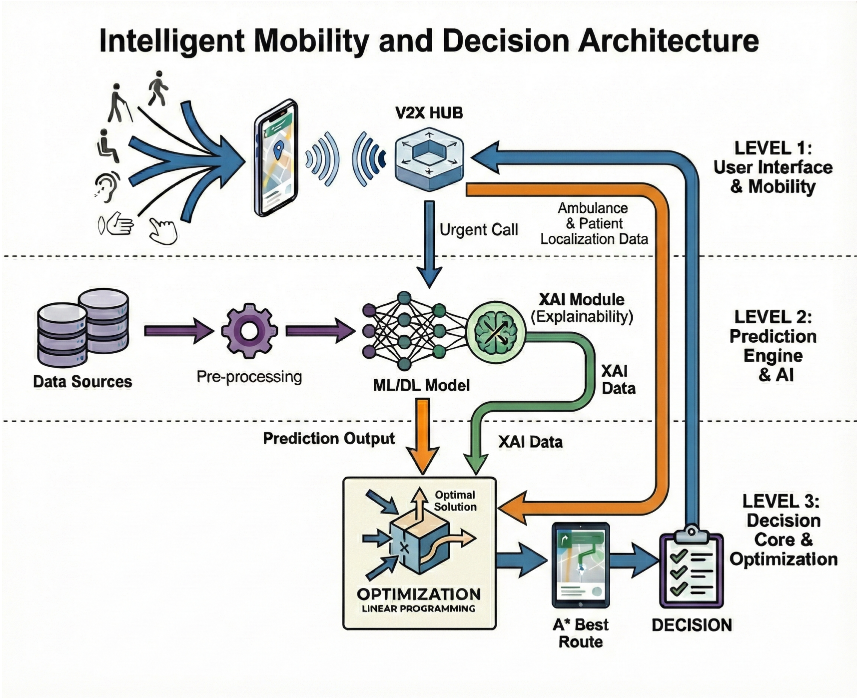

FIG. 1: General framework of the proposed decision-support system.

message. Third, the optimization and dispatch layer receives the set of active urgent cases with their severity, XAI scores and other information (patient location, ambulances locations and their availability, clinically appropriate hospitals). An Ambulance Dispatching and Relocation Problem (ADRP) could be developed in this layer to decide which ambulance should serve which patient and to which hospital, minimizing response and transport times. Metaheuristics could be used to obtain optimized solutions in quasi-real time. The final dispatch decision is sent back to the mobility/P2X layer, where the selected ambulance runs an A* algorithm search to follow the fastest safe route to the patient and then to the assigned hospital.

3 Conclusions and perspectives

This work proposes an integrated framework to support emergency care for people with PD. By linking smartphone-based monitoring, predictive models and optimization approach, the system aims to detect crises earlier and prioritize the most urgent patients and guide ambulances to appropriate hospitals in an optimized way. In this case, it shows how digital health data and operation research can work together to improve safety and continuity of care. In the futur work, we will further develop this framework, models and algorithms. These tools could be tested with EMS partners and larger clinical cohorts in order to validate its impact on response times and patient outcomes.

References

[1] Y. Amadiaz, E. Alfonso-Lizarazo, and A. Nait Sidi Moh, "A systematic review of healthcare cyber-physical systems with associated innovative technologies for Alzheimer's and Parkinson's Diseases," *Array*, 100575, 2025. https://doi.org/10.1016/j.array.2025.100575.

[2] Y. Amadiaz, A. Nait Sidi Moh, and S. Kharraja, "Decision Support for Patient Transport Efficiency Based on V2X Communications in Healthcare Systems," in *Proc. 2024 IEEE Symposium on Computers and Communications (ISCC)*, Paris, France, 2024, pp. 1–6, doi: 10.1109/ISCC61673.2024.10733640.