REMOTE MONITORING FOR PARKINSON DISEASE

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1. Summary of the project:

This project focuses on the development of a telemedicine application designed for the remote monitoring of patients with Parkinson's disease, one of the most common chronic neurological disorders both in Spain and worldwide. Since Parkinson's involves progressive motor symptoms—such as tremors, rigidity, slowness of movement and falls—as well as non-motor issues like fatigue, anxiety, or autonomic dysfunctions, continuous supervision is essential for adapting treatments and improving the patient's quality of life.

The proposed solution is a Java-based application that allows patients to record their daily symptoms while also connecting to a portable device built using a Bitalino board. This device captures key physiological signals, including electromyography (EMG), electrodermal activity (EDA), electrocardiography (ECG), and accelerometer data (ACC) to evaluate mobility and detect falls. All collected data is sent to a hospital server, where it is stored and made available for review by healthcare professionals. This system reduces the need for frequent hospital visits and provides clinicians with continuous, objective information about the patient's condition.

The main goal of the project is to enhance clinical follow-up by enabling constant remote supervision, giving medical staff reliable and regularly updated data. The program aims to increase patient autonomy, support more personalized treatments, and ensure that healthcare professionals have access to precise information that facilitates timely and effective interventions.

The solution is structured around a three-application architecture formed by a Patient Application, a Doctor Application, and a central Server Application. These components communicate over a dedicated network connection, enabling a unified ecosystem where information can be exchanged remotely and securely. The server acts as the coordination point of the system, managing communication, organizing data storage, and ensuring that patient and doctor interactions are properly linked and maintained. By centralizing these interactions, the platform enables a stable environment for remote clinical oversight.

2. List of actions:

Patient Application, which allows patients to register, log in, log out, view their information, create detailed clinical reports, and review history of reports. These reports include textual observations, selected symptoms, and physiological signals captured through a BITalino device (EMG, EDA, HR, and ACC). The signals are stored in CSV files and automatically transmitted to the server.

Doctor Application, which enables physicians to register, log in, log out, manage their patients, review submitted reports, visualize symptoms and captured signals, and add medical observations or follow-up notes. Doctors can also access the list of patients assigned to them and navigate through their historical reports.

Server Application, which acts as the communication backbone. It handles all TCP socket connections, distinguishes between patient and doctor clients, processes registration and login requests, assigns doctors automatically, stores and retrieves clinical reports, manages user data, and maintains the integrity of the system through database access (via JDBC managers).

3. Decision taken:

During the development of the telemedicine system, several architectural and clinical decisions were made in order to create a robust and medically meaningful monitoring tool. The following decisions summarize the rationale behind the chosen communication protocol, data model, file structure and clinical parameters considered in the project.

3.1. Choice of TCP over UDP:

The communication between the Patient Application, the Doctor Application and the Server Application is based on TCP sockets instead of UDP. TCP ensures reliable, ordered and complete delivery of data, which is crucial when transferring clinical reports, login credentials or physiological signal files.

In a medical context, data loss or corruption is unacceptable, and UDP's lack of delivery guarantees makes it unsuitable. Although UDP can be faster, reliability and integrity were prioritized over performance, making TCP the correct choice for telemonitoring sensitive medical data.

3.2. Removal of inheritance between User, Patient and Doctor:

Originally, the system used an inheritance model where Patient and Doctor extended from the User class. However, this design generated inconsistencies when mapping to a relational database. Without a dedicated User table, foreign keys could not be implemented properly.

Furthermore, the model prevented one person from being both a patient and a doctor simultaneously, which is a realistic and entirely possible scenario.

After consulting with the professor, the inheritance hierarchy was replaced with a composition-based model: User is now its own table, and Patient, Doctor and Admin reference it through foreign keys (emails). This results in a cleaner design, better relational consistency and increased flexibility.

3.3. Storing all captured signals in a single CSV file:

When a patient creates a report, multiple physiological signals may be recorded. A decision was made to store all captured signals in a single CSV file instead of creating one file per signal. This improves usability in several ways:

- Doctors can review all recorded data in a unified file instead of opening several separate documents.
- Each report becomes self-contained, reducing fragmentation and simplifying storage and transmission.
- CSV files can be easily imported into Python, MATLAB or Excel for visualization, statistical analysis or machine learning, without requiring additional formatting.

This design enhances clarity for doctors and maintains excellent compatibility with data analysis tools.

3.4. Selection of physiological signals (EMG, EDA, ACC, ECG)

The BITalino device allows multiple types of biosignals, but four were selected specifically because they provide clinically relevant information for monitoring Parkinson’s disease:

- EMG (Electromyography): Parkinson’s patients present tremors, rigidity and bradykinesia. EMG helps quantify muscle activation patterns, tremor frequency and muscular rigidity.
- ACC (Accelerometer): Motor symptoms such as shuffling gait, postural instability and freezing episodes can be monitored through accelerometry. This makes ACC essential for evaluating mobility and balance issues.
- EDA (Electrodermal Activity): Parkinson’s patients often experience autonomic dysfunction, including stress fluctuations and changes in sympathetic activity. EDA provides insight into emotional states, anxiety, and autonomic disturbances.
- ECG (Electrocardiography): Cardiovascular autonomic dysfunction is common in Parkinson’s, sometimes causing dizziness, fainting or orthostatic hypotension. ECG allows monitoring heart rhythm and detecting irregularities that may affect patient safety.

These four signals together offer a complementary view of both motor and autonomic symptoms, making them an effective minimal set for telemonitoring Parkinson’s progression.

3.5. Selection of symptoms included in the system:

The symptoms included in the project were chosen based on clinical signs commonly associated with Parkinson’s disease. Each symptom in the Symptoms enumeration corresponds to well-documented motor or non-motor manifestations:

- Motor symptoms: tremor, slow movement, stiff muscles, difficulty with balance, shuffling walk, reduced facial expression, small handwriting.
- Speech and swallowing issues: soft voice and difficulty swallowing, both of which are typical in moderate stages of the disease.
- Autonomic dysfunction: constipation, dizziness or fainting, bladder problems.
- Sleep and psychiatric symptoms: sleep problems, depression and anxiety, which are extremely common non-motor symptoms that strongly affect quality of life.

By selecting symptoms that reflect both motor and non-motor aspects of Parkinson’s disease, the system provides the doctor with a broader view of the patient’s condition. The chosen symptoms align with widely recognized clinical scales, such as the UPDRS (Unified Parkinson's Disease Rating Scale).