Project Vision Document

Project Title: Smartwatch-Based Locomotive Therapy System for Post-Stroke Rehabilitation
Team Name: Smartwatch Therapy Rehabilitation for Intelligent Data-Driven Exercise (STRIDE)

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Industry Partnership Info
Sponsor: Cadense (Goleta, CA)
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Cadense is an innovative company specializing in novel tools for gait therapy and rehabilitation. Their mission is to empower stroke survivors and individuals with motor impairments by providing accessible, adaptive, and user-friendly technologies that enhance recovery outcomes and improve quality of life.

Project Overview

This project aims to design and implement a smartwatch-based therapy system that supports stroke survivors in their post-stroke rehabilitation journeys. By leveraging off-the-shelf smartwatch hardware (e.g., TicWatch E3 with WearOS), the system will deliver multimodal cues (auditory, visual, and tactile) to guide users during walking exercises. The project focuses on integrating real-time sensor data (accelerometer, gyroscope, GPS) with adaptive algorithms to personalize therapy sessions based on each user's gait performance.

Problem Statement

Stroke survivors often face long-term mobility impairments, with gait abnormalities being one of the most common challenges. Traditional rehabilitation methods require extensive in-clinic supervision, which can be resource intensive, costly, and inconvenient for patients.

Key problems include:

1. Limited Access: Many patients cannot attend frequent in person therapy sessions due to financial, geographic, or mobility constraints
2. Low Adherence: Lack of real-time feedback during home therapy reduces understanding and clarity

3. One Size Fits All: Current tools don't adapt to individual patient needs, possibly leading to suboptimal outcomes in certain cases

By combining wearable sensing, adaptive feedback, and mobile integration, this project seeks to address these challenges and redefine the standard of remote gait rehabilitation.

Project Goals

- Develop a Smartwatch-Based Therapy System: Deliver multimodal cues (auditory, tactile, visual) to help patients improve walking cadence, balance, and coordination
- Enable Adaptive Rehabilitation: Implement real-time algorithms that adjust cue frequency and type based on user performance
- Support Independent Therapy: Provide patients with an easy-to-use, secure system that encourages adherence to daily walking routines
- Remote Monitoring: Enable optional smartphone integration for data visualization and remote clinician review

Technical Approach

Level 1 (Base Outcome):

- Feedforward metronome cueing to improve step cadence
- Step detection using smartwatch IMU data
- Session logging: time walked, step counts, cadence, distance traveled
- Clean, user-friendly UI on smartwatch

Level 2 (Enhanced Outcome):

- Adaptive feedback algorithms that adjust metronome frequency in real time
- Signal processing via filters for accurate gait data
- Closed feedback loops to encourage cadence correction

Level 3 (Stretch Goal):

- Smartphone integration with cloud-based storage (Firebase or REST API)
- Visualization dashboard for session history and performance trends
- Remote monitoring capabilities for clinicians and caregivers

Expected Benefits

- Improved Rehabilitation Outcomes: Personalized, adaptive feedback accelerates patient progress compared to static therapy tools
- Accessibility & Convenience: At-home therapy allows for rehabilitation within the comfort of being in one's home
- Higher Patient Engagement: Multimodal cues and progress tracking promote adherence and motivation

- Scalability: System can be expanded to support other motor rehabilitation scenarios beyond stroke therapy

Technologies

- Hardware: TicWatch E3 (WearOS), Android smartphone (for Level 3)
- Software: Kotlin/Java (WearOS app), Flutter/React Native (mobile app)
- Data Processing: TensorFlow Lite, Core ML, IMU filtering algorithms
- Database & Cloud: SQLite (on-watch), Firebase/REST API (cloud sync)
- Communication: Bluetooth Low Energy (BLE)

Process Model

- Agile Methodology: Iterative development with sprint-based deliverables
- Design Phase: User-centered design of UI/UX for stroke survivors
- Development Phase: Smartwatch software development, algorithm prototyping, and backend integration
- Testing Phase: Accessibility and performance validation with test users, iterative refinement based on feedback
- Deployment: Prototype release with potential smartphone integration (stretch)

Conclusion

This project envisions a transformative rehabilitation platform for stroke survivors by integrating wearable sensing, adaptive feedback, and mobile technologies into a smartwatch-based therapy system. By reducing dependence on in-clinic therapy, providing personalized rehabilitation, and empowering patients with real-time feedback, the system has the potential to significantly enhance recovery outcomes and quality of life.

Required Technologies

- Android studio
- Minimal Wear OS

Our Own suggestions:

1. AI-Driven Personalization Layer:
    a. **Personalized Calibration:**
    Use a brief calibration walk to model each user's "baseline gait" and adjust cues dynamically.
    b. **Machine Learning Prediction:**
    Use a simple regression or ML model (e.g., TensorFlow Lite) to predict fatigue or asymmetry and proactively modify feedback.
    c. **Anomaly Detection:**
    Detect irregular steps or dragging to alert users or caregivers.
2. Strong User Experience and Accessibility

a. **Easy to use for stroke survivors:**
    i. Large buttons, minimal text, clear icons, color schemes for visual impairments, voice controls
b. **Gamify the Process:**
    i. Badges, streaks, virtual coaches, etc.