Functional Document

1. Introduction

Gait analysis plays a crucial role in evaluating post-knee replacement recovery by assessing movement patterns, balance, and joint function. This project explores a video-based gait analysis system using deep learning model LSTM. By leveraging artificial intelligence, the system aims to provide accurate gait assessment, assisting medical professionals in rehabilitation monitoring and treatment planning.

2. Goal

The goal of this sprint is to develop an efficient gait analysis system using video-based input to evaluate post-knee replacement recovery. By employing LSTM model, the system will improve the accuracy of gait pattern recognition, automate movement tracking, and provide insights into rehabilitation progress. This project aims to support clinicians in making informed decisions for better patient outcomes.

3. Demography (Users, Location)

Users:

- **Medical Professionals:** Physiotherapists, orthopedic surgeons, and rehabilitation specialists using gait analysis for post-surgery assessment.
- **Healthcare Institutions:** Hospitals, clinics, and rehabilitation centers employing AI-driven gait analysis.
- **Medical AI Researchers:** Academics and developers enhancing AI applications in biomechanics and movement science.

Location:

- Applicable globally in medical facilities equipped with video-based motion tracking systems.
- Beneficial in rehabilitation centers where AI-assisted movement analysis can enhance patient care.
- Useful in regions with limited access to advanced gait labs, providing cost-effective alternatives.

4. Business Processes

1. Data Acquisition and Preprocessing

- Collect video-based gait data (MOV files) from post-knee replacement patients.
- Preprocess data: frame extraction, noise reduction, normalization, and augmentation for model optimization.

2. Model Development and Training

- Implement HSV color segmentation for spatial feature extraction and LSTM for temporal gait analysis.
- Train the hybrid model using labeled datasets for improved movement tracking and anomaly detection.
- Validate model performance against clinical gait assessment benchmarks.

3. Integration and Deployment

- Deploy the trained model as a standalone application or integrate it into a cloud-based AI platform.
- Enable batch video processing for gait assessment.
- Implement API connections for integration with hospital management systems and rehabilitation tools.

4. User Interaction and Analysis Support

- Medical professionals upload or stream patient gait videos for automated analysis.
- The system extracts gait parameters (stride length, cadence, joint angles) and provides a recovery assessment.
- Visual reports and anomaly detection assist in tracking rehabilitation progress and therapy adjustments.

5. Continuous Improvement and Maintenance

- Gather feedback from medical users to enhance model accuracy.
- Update the model with new patient data to improve adaptability across different cases.
- Ensure compliance with medical data security standards and ethical considerations.

5. Features

1. AI-Driven Gait Analysis

Utilizes a hybrid MobileNetV2-LSTM model to analyze gait patterns from video data with high precision.

2. Automated Movement Tracking

Eliminates the need for manual gait assessment, reducing clinician workload.

3. Real-Time and Batch Processing

Supports both real-time gait analysis for in-clinic assessments and batch processing for research.

4. Noise Reduction & Image Enhancement

Applies preprocessing techniques to minimize motion blur and improve feature extraction.

5. Scalable & Deployable

Compatible with cloud-based systems, standalone diagnostic tools, and hospital infrastructure.

6. User-Friendly Visualization

Provides intuitive graphs, heatmaps, and recovery trend insights for easy interpretation by medical professionals.

7. Continuous Learning & Improvement

Improves accuracy over time with updated training data and user feedback.

6. Authorization Matrix

Role	Access Level	Permission Scope
Admin	Full Access	Manage users, configure models, monitor system performance.
Medical Professional	High Access	Upload videos, analyze gait patterns, track patient recovery.
Researcher	Medium Access	Access datasets contribute to model improvement.
Patient	Restricted Access	View personal gait analysis reports.
External Partner	Limited/Role-Specific	View reports or collaborate on research projects.

7. Assumptions

- **Labeled Data:** High-quality gait videos with annotated movement data are available.
- **Video Quality:** Input video has sufficient resolution and frame rate for accurate pose estimation.
- **Model Suitability:** MobileNetV2-LSTM is effective for gait pattern recognition.
- **Computational Resources:** Sufficient hardware (GPU/CPU) for model training and real-time inference.
- **User Expertise:** Medical professionals can interpret system-generated gait analysis results.
- **Data Security:** System complies with HIPAA, GDPR, and other data protection regulations.
- **Model Generalization:** Capable of handling diverse patient cases and variations in gait patterns.
- **Real-Time Usability:** Optimized to deliver fast and reliable gait assessment when needed.