FRAMEWORK TABLE

Modules	Sensors Used	Use	Data Type	Data Collection Method
Smart Bench	NFC	Identification	Stored Database of users	**Type of Data:** All the collected data from 3 sensors. **Collection Method:** Use a microcontroller or a computer to collect, process, and log the data from the various sensors. **Format**: Tabular format or structured JSON/XML format for easy storage and retrieval.
	Surface Sensor Map (Pressure Sensor, Weight Sensor)	1. Measure the quantity of sit-to-stand exercises. 2. Where the user is landing and how heavily they are landing.	1. Numeric data indicating the count of sit-to-stand exercises. 2. Coordinates (X, Y) or zone labels indicating where the user is landing & Numeric data indicating the force or pressure exerted during landing.	
	Sensor mat placed at the foot	Collects data to assess how much effort the user is exerting with their foot to stand & evaluate their balance while standing	**Force Exertion -** Numeric data indicating the total force exerted. **Balance –** Centre of pressure (COP) or weight distribution changes in Time-series data format	
	Capacitive touch sensors on the bench's handles and the front	How much support when transitioning from a seated position	**Duration of Touch:** Numeric data indicating the duration of touch for each sensor. **Pressure or Force Exerted:** Numeric data indicating the force or pressure exerted. **Support Level:** Categorical labels representing the support level.	
	Sensor tiles	Measuring gait speed, step length, stride length, and foot pressures	**Gait Speed –** Collection Method: measure the time it takes for a user to traverse. Format: Numeric data representing gait speed (e.g., meters per second).	
			Step Length: Collection Method: Measure the distance covered by each foot from one step to the next. Format: Numeric data representing step length (e.g., centimetres).	

Smart Path			**Stride Length:** Collection Method: Calculate the sum of the step lengths for each leg during two consecutive steps. Format: Numeric data representing stride length (e.g., meters).	
			Foot Pressures: Type of Data: matrix of pressure values across the sensor tiles. Collection Method: Utilize pressure sensors to measure the pressure exerted by each foot, Format: Matrix of pressure values corresponding to different areas of the foot.	
	Surface sensor	Reliance on handrails during the walk and frequently used sides	**Handrail Activation Duration:** Type of Data: Time spent holding onto the handrails during walking. Collection Method: Use a timer. Format: Numeric data indicating the duration of handrail activation.	
			Frequently Used Sides: Collection Method: Track which side of the handrail is activated more often. Format: Categorical data ("Left," "Right") indicating the frequently used side.	
	3D LIDAR	To enhance the system's capabilities for gait monitoring and data collection	**High-Resolution Gait Monitoring:** Type of Data: 3D point cloud data capturing the detailed geometry of the user's body during movement. Collection Method: Use 3D LIDAR sensors to create a point cloud representation of the user's body. Format: A 3D point cloud with coordinates representing the shape and position of body parts.	**Type of Data:** All the collected data. **Collection Method:** Use a powerful computing system to process and log the 3D LIDAR data.
			Joint Movement Analysis: Type of Data: Angular and positional data of joints during walking. Collection Method: Analyze the 3D point cloud to track the movement of key joints, Format: Time-series data indicating the joint angles and positions during each step.	

			Gait Dynamics: Type of Data: Metrics related to gait dynamics, including step length, step width, and walking speed. Collection Method: Use the 3D LIDAR data to calculate various gait parameters. Format: Numeric data representing step length, step width, walking speed, etc.	**Format:** Structured format suitable for storing 3D point cloud data and associated metrics.
			Posture and Balance Assessment: Type of Data: Posture and balance data Collection Method: Analyze the 3D point cloud to assess the user's posture and balance, identifying any deviations or abnormalities. Format: Metrics indicating posture and balance status.	

Framework and Methodology:

Data Acquisition from Sensors:

SMART BENCH

The initial phase of the Smart Bench Gait Monitoring System involves gathering data from various sensors. NFC technology is used for user identification, ensuring unique retrieval from the user database.

The Surface Sensor Map, comprising Pressure Sensors and Weight Sensors, records sit-to-stand exercises count and landing process details, including coordinates and pressure during landing.

The Sensor Mat at the foot collects data on standing effort, balance, and foot force distribution, represented in numeric and time-series formats.

Capacitive touch sensors on the bench handles gauge user support during transitions, recording touch duration, pressure, and support levels.

SMART PATH

Sensor tiles on the Smart Path measure gait dynamics like speed, step length, stride length, and foot pressures. Handrail usage is also tracked, capturing activation duration and frequently used sides.

LiDAR

3D LIDAR technology enhances gait monitoring, capturing body geometry and enabling Joint Movement Analysis, Gait Dynamics assessment, and Posture and Balance Assessment.

Data Collection, Pre-Processing & Logging

Real-time data collection, noise reduction, calibration, and synchronization processes ensure data accuracy. Processed data is logged in tabular or structured formats for storage and retrieval.

Data Fusion

Data fusion techniques integrate sensor data for a comprehensive view of user mobility patterns, enhancing data quality.

Feature Extraction
Different sensors yield features like Center of Pressure (COP), gait parameters, touch duration, and joint movement angles, enabling detailed analysis.

ML/AI Algorithms
Machine Learning (ML) and Artificial Intelligence (AI) algorithms like Hidden Markov Models (HMM), Support Vector Machines (SVM), Random Forests, Neural Networks, Isolation Forests, Autoencoders, Reinforcement Learning, and K-Means Clustering are applied for gait analysis, health assessment, anomaly detection, user feedback, and multi-agent systems.

Analytics & Insights
Data visualization, user profiling, predictive analytics, and real-time monitoring techniques are employed to provide understandable insights, personalized feedback, predictive models, and continuous monitoring for improved gait patterns and health status evaluation.