**Advanced AI Activities for Multi-Sensor Patient Data**

**Activity 1: Preprocessing & Handling Missing Data**

Objective: Ensure the dataset is clean, consistent, and ready for analysis.

Steps to Perform:

1. Check for Missing Values:

* Identify missing values in Heart Rate, ECG, SpO₂, Temperature, and Motion Activity.
* Determine the percentage of missing values per sensor.

1. Handle Missing Data:

* Use forward fill and backward fill methods to interpolate missing values.
* Drop records with excessive missing data if necessary.

1. Normalize Sensor Data:

* Scale each sensor’s readings using Min-Max Scaling to ensure all values are within a common range (0 to 1).
* This helps AI models learn more effectively.

1. Save the Cleaned Dataset:

* Store the cleaned dataset for feature extraction and AI training.

Outcome: A cleaned dataset with no missing values and normalized sensor readings, ready for AI analysis.

**Activity 2: Feature Engineering for Multi-Sensor Analysis**

Objective: Extract advanced features from raw sensor data to improve AI predictions.

Steps to Perform:

1. Rolling Mean & Standard Deviation:

* Compute moving averages over short time windows to detect trends and sudden changes in sensor values.
* This is crucial for identifying abnormalities in ECG, Heart Rate, and Temperature.

1. Entropy Calculation:

* Calculate signal entropy to measure randomness in sensor data.
* A higher entropy may indicate irregularities or unusual patterns in ECG or motion activity.

1. Power Spectral Density (PSD) Analysis:

* Use PSD to analyze frequency components of ECG and Heart Rate signals.
* This helps in detecting irregular rhythms (e.g., atrial fibrillation or stress-related anomalies).

1. Feature Storage:

* Save newly engineered features to use in AI training.

Outcome: Extracted advanced statistical and frequency-based features, improving AI’s ability to detect health anomalies.

**Activity 3: AI Model Training for Health Anomaly Detection**

Objective: Train AI models to detect and predict abnormal health events using multi-sensor data.

Steps to Perform:

1. Define Labels for Anomalies:

* Use 0 = Normal, 1 = Abnormal based on predefined medical thresholds:
  + Heart Rate > 100 bpm → Abnormal
  + ECG Voltage > 1.1 mV → Abnormal
  + SpO₂ < 92% → Abnormal
  + Body Temperature > 38°C → Abnormal
  + Motion Activity > 8 m/s² → Abnormal

1. Train-Test Data Split:

* Divide the dataset into training (80%) and testing (20%) sets.

1. Model Selection:

* Train two different AI models:
  + Random Forest (good for structured healthcare data).
  + XGBoost (stronger for time-series predictions).
* Evaluate models using:
  + Accuracy
  + Precision-Recall
  + Confusion Matrix

1. Hyperparameter Tuning:

* Optimize model parameters (e.g., tree depth, learning rate) to improve detection accuracy.

Outcome: A trained AI system capable of detecting real-time patient health anomalies.

**Activity 2: Real-Time Patient Monitoring Dashboard**

Objective: Develop an interactive dashboard to monitor sensor data and detect anomalies in real time.

Steps to Perform:

1. Dashboard Interface Design:

* Display real-time graphs for Heart Rate, ECG, SpO₂, Temperature, and Motion Activity.

1. Patient Selection & Personalization:

* Allow users to select a patient ID and view their historical and live sensor data.

1. Anomaly Detection Alerts:

* Highlight abnormal sensor readings with:
  + Red alerts for extreme health risks.
  + Yellow alerts for moderate deviations.
  + Green status for normal conditions.

1. Historical Trends & Predictions:

* Show trend analysis (e.g., heart rate over the last 24 hours).
* Provide predictive insights (e.g., risk of high blood pressure).

Outcome: A real-time AI-powered dashboard that tracks patient health & generates alerts.