**Marshee Smart Tracker: AI Model Development & Deployment Report**

**1. Data Collection & Preprocessing**

**Step Data Collection**

* The step data is collected from the **Marshee Smart Tracker**, which uses an **accelerometer** and **gyroscope** to detect motion patterns.
* Data is transmitted to the cloud/app via **Bluetooth or Wi-Fi**.

**Noise Handling & Data Cleaning**

* **Possible Noise Sources:**
  + Sensor drift
  + Sudden jerks (false steps)
  + Missing or duplicate values
* **Cleaning Techniques:**
  + **Moving average filtering** to smooth step count variations
  + **Interpolation** for handling missing values
  + **Outlier detection** using z-score analysis

**Normalization & Feature Engineering**

* **Normalization:** Min-Max scaling for uniform range.
* **Feature Engineering:**
  + **Step frequency**: Steps per minute
  + **Activity duration**: Total active time per session
  + **Rest period ratio**: Time spent inactive vs. active

**2. Model Development**

**Model Selection & Justification**

* **LSTM (Long Short-Term Memory):**
  + Suitable for sequential time-series data
  + Captures temporal dependencies in step patterns
* **Comparison with Other Models:**
  + **Decision Tree & Random Forest**: Good for static data but not effective for time-series trends
  + **CNN (Convolutional Neural Network)**: Works well for image-based data but less effective for sequential data

**Feature Selection & Training**

* Feature selection using **Principal Component Analysis (PCA)** to reduce dimensionality.
* Hyperparameter tuning using **GridSearchCV**.

**Performance Metrics**

* **Mean Squared Error (MSE)** – Measures prediction error.
* **Mean Absolute Error (MAE)** – Evaluates step count deviations.
* **R-Squared Score** – Determines how well the model explains variance.

**3. Integration with Firmware & App**

**Model Deployment on Marshee Smart Tracker**

* Model converted to **TensorFlow Lite (TFLite)** for embedded deployment.
* Runs on-device for real-time step classification.
* If hardware constraints exist, cloud-based inference via an API.

**Real-Time Inference Implementation**

* Steps processed in real-time using an **Edge AI framework**.
* If **cloud-based inference** is used:
  + Data sent to a **Flask/Django REST API**.
  + Model processes steps & returns predictions.

**App Integration**

* Step data & insights visualized in a **React Native app**.
* Key insights displayed:
  + Daily step goal progress
  + Activity trends & recommendations

**Optimization for Embedded Systems**

* **Quantization:** Converts model to 8-bit for efficiency.
* **Pruning:** Removes redundant neurons for faster inference.

**4. Deployment Strategy**

**Firmware Updates via OTA**

* New model versions pushed via **Over-the-Air (OTA) updates**.
* Model stored on flash memory of the device.

**Cloud-Based Inference Architecture**

* Model hosted on AWS/GCP.
* Step data sent via API → Processed on the cloud → Sent back to the device.

**Periodic Model Retraining**

* New data collected periodically.
* Retraining pipeline using **AutoML & MLOps tools**.
* Updated model automatically deployed.

**5. Additional Considerations**

**Challenges in Real-Time Processing & Solutions**

| **Challenge** | **Solution** |
| --- | --- |
| High latency in cloud inference | Optimize using Edge AI |
| Limited computational power on device | Use quantization & pruning |
| Data inconsistency | Implement robust preprocessing |

**Security & Privacy Considerations**

* **Data encryption** before transmission.
* **User consent** for step data collection.
* **Anonymization** of user data for compliance.

**Potential AI-Driven Features**

* **Anomaly Detection:** Detects irregular step patterns.
* **Fitness Recommendations:** Personalized insights based on trends.
* **Pet Activity Tracking:** If tracker used on pets, AI suggests activity levels.

**Conclusion**

This report provides a complete roadmap for developing, deploying, and optimizing an AI-powered step tracking model for the Marshee Smart Tracker. The combination of **LSTM-based inference**, **efficient firmware deployment**, and **cloud-based enhancements** ensures real-time, accurate step analysis.