Predictive Maintenance Using Fleet Data

Capstone Project Proposal for Sky Ledge

Project Overview

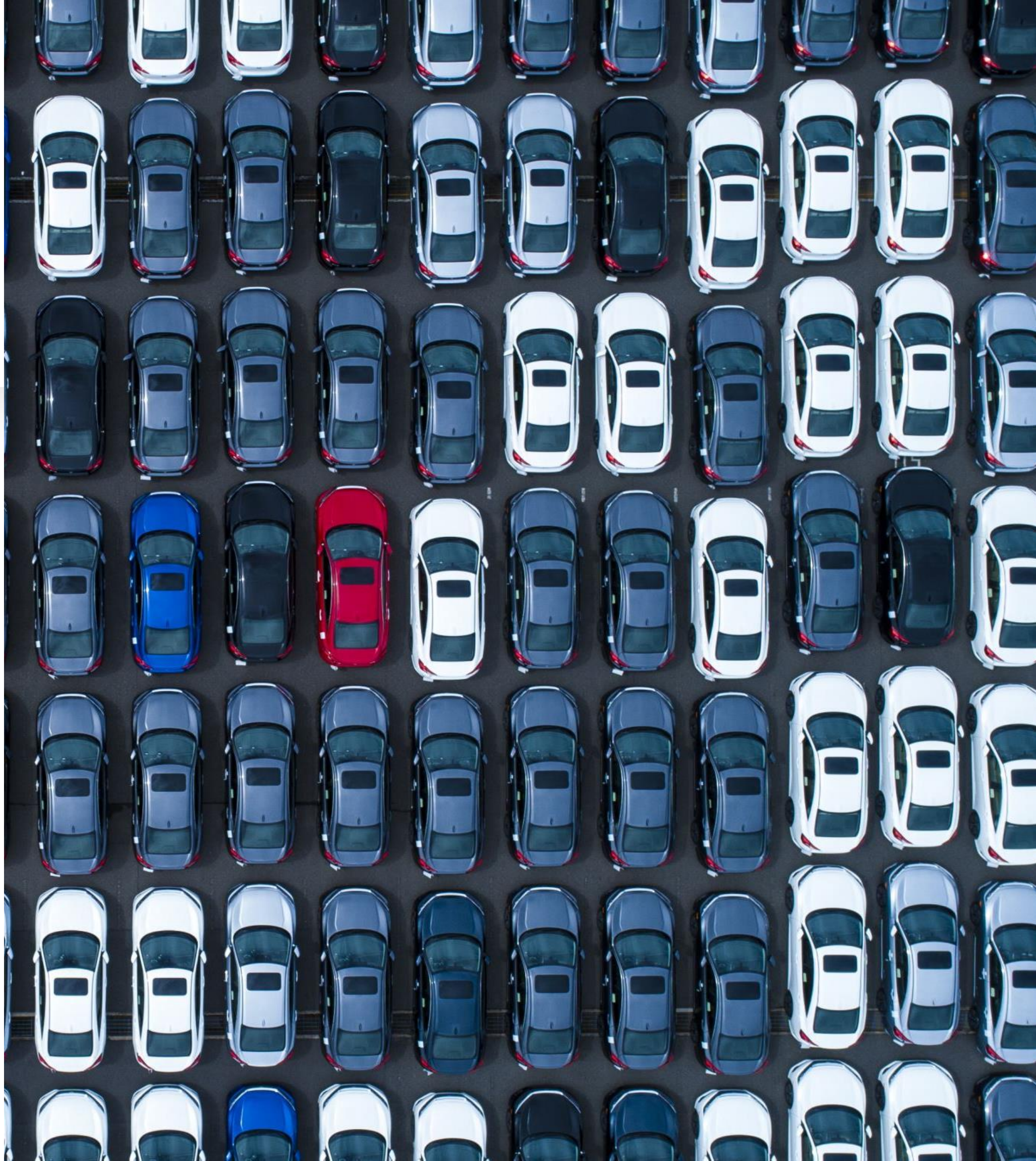
- Sky Ledge is an operational insights platform for asset monitoring
- Use of advanced telematics and data analytics
- Sky Ledge want to leverage predictive data analysis
- Through the use of historical and real time data to identify patterns

Problem Statement

In the automotive industry, the traditional approach to vehicle maintenance relies heavily on static, time-based or mileage-based schedules - for example, servicing a vehicle every 10,000 km or every 6 months. While simple, this method does not account for the actual condition of vehicle components or the intensity of usage, leading to two critical issues:

- **Over-Maintenance:** Performing routine maintenance when it may not be necessary, resulting in increased costs for parts and labor, as well as downtime.
- **Under-Maintenance:** Failing to detect early component degradation, which leads to **unexpected breakdowns, costly repairs, safety risks,** and reduced vehicle lifespan.

This project aims to solve the gap between static maintenance schedules and actual, data-driven vehicle health monitoring by developing a predictive maintenance system that leverages OBD-II data streams, machine learning, and real-time analytics to forecast maintenance needs before failures occur.



Project Plan

Project Plan:

Phase 1: Finalize data collection sources and decide on research methods.

Phase 2: Set up data pipelines to organize and process collected data.

Phase 3: Develop predictive models based on the gathered data.

Phase 4: Test and refine the models to improve accuracy and performance.

Phase 5: Design and build a prototype dashboard to present results to stakeholders for feedback.

Project Objectives

- Gather historical and real-time fleet data from vehicles
- Analyse data to determine key performance indicators (KPIs) linked to vehicle maintenace requirements
- Develop machine learning models to predict accelerated vehicle degradation and recommend proactive maintenance.
- Compare predictions with real-world data to ensure accuracy and reliability.
- Create a dashboard for fleet managers
- Overall goal to minimise downtime and maintenance costs

Technical Scope

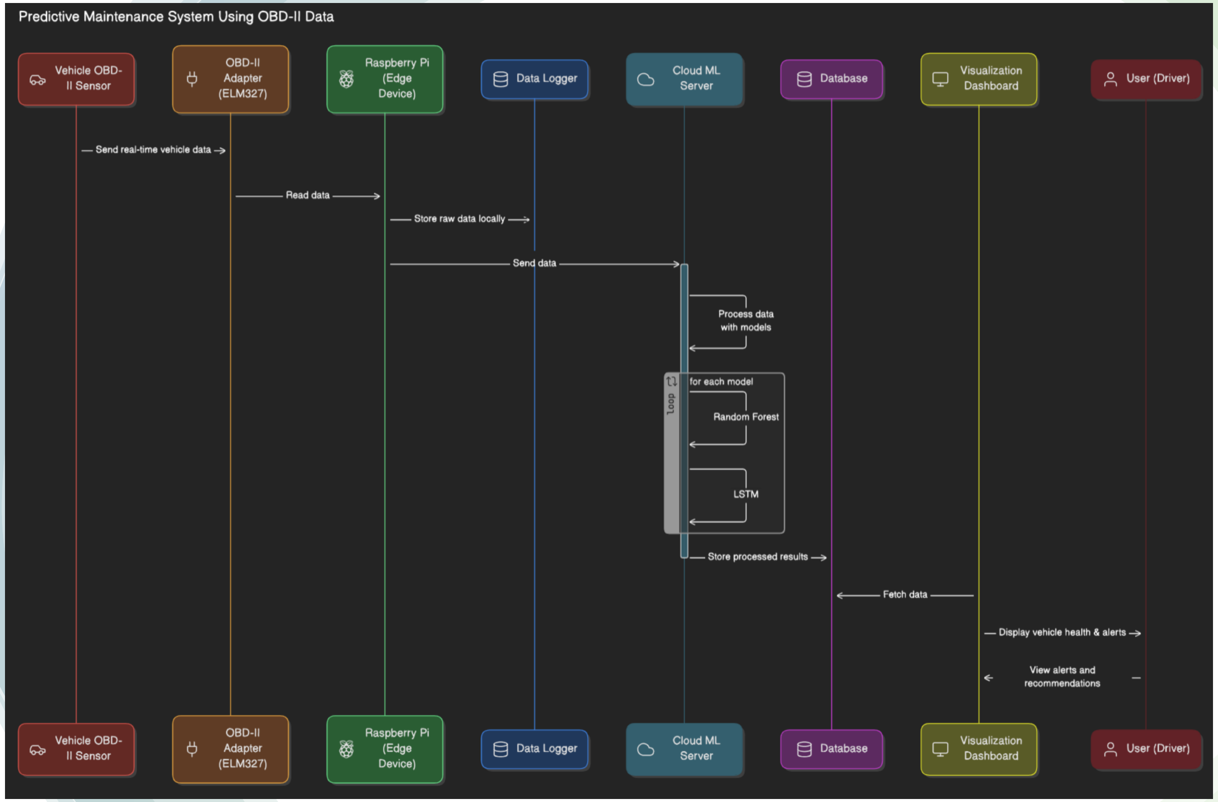
- **Hardware Layer:**
- **OBD-II Adapter (ELM327 Bluetooth/Wi-Fi):**
  - Connects to the car's OBD-II port
  - Reads real-time vehicle parameters
- **Raspberry Pi (or similar SBC):**
  - Runs Python scripts to pull data from the adapter
  - Acts as an edge computing device for initial data filtering and storage
  - Optional GPS module for location-based analysis

- **Data Collection and Storage:**
  - Data Points: Engine RPM, coolant temperature, engine load, speed, fuel trim, throttle position, DTC codes, battery voltage
  - Data Storage: Locally in SQLite or sent to a cloud database (PostgreSQL / MongoDB)
  - Data Logging Frequency: Configurable (e.g., every 5 seconds)

- **Machine Learning and Predictive Analytics:**
- **ML Techniques:**
  - **Random Forest / XGBoost:** Predict which component is likely to fail based on historical data patterns
  - **LSTM / GRU Models:** For time-series predictions of component degradation
  - **Autoencoder / Isolation Forest:** Anomaly detection when sensor values deviate from normal behavior
- **Output:** Maintenance risk scores, Remaining Useful Life (RUL) estimates, and predictive alerts
- **Dashboard & Visualization:**
- **Technology:** Streamlit, Flask, or Power BI
- **Features:**
  - Real-time health monitoring
  - Visualization of key sensor metrics
  - Alert generation for users
  - Maintenance prediction reports

System Architecture

1. Vehicle OBD-II sensor sending real-time data to the OBD-II adapter (ELM327).
2. Raspberry Pi (Edge Device) reads data, stores it locally, and forwards it to the Cloud ML Server.
3. In cloud, ML models (Random Forest and LSTM) process the data to detect issues and predict maintenance needs.
4. Results saved in the Database, fetched by the Dashboard, and presented to the User with health status and maintenance alerts.



Expected Outcomes

Operational Insights:

•Deep understanding of the factors affecting vehicle maintenance.

Predictive Model:

•A validated machine learning model that forecasts potential vehicle failures.

Dashboard:

•An intuitive, real-time dashboard providing maintenance alerts and vehicle health insights.

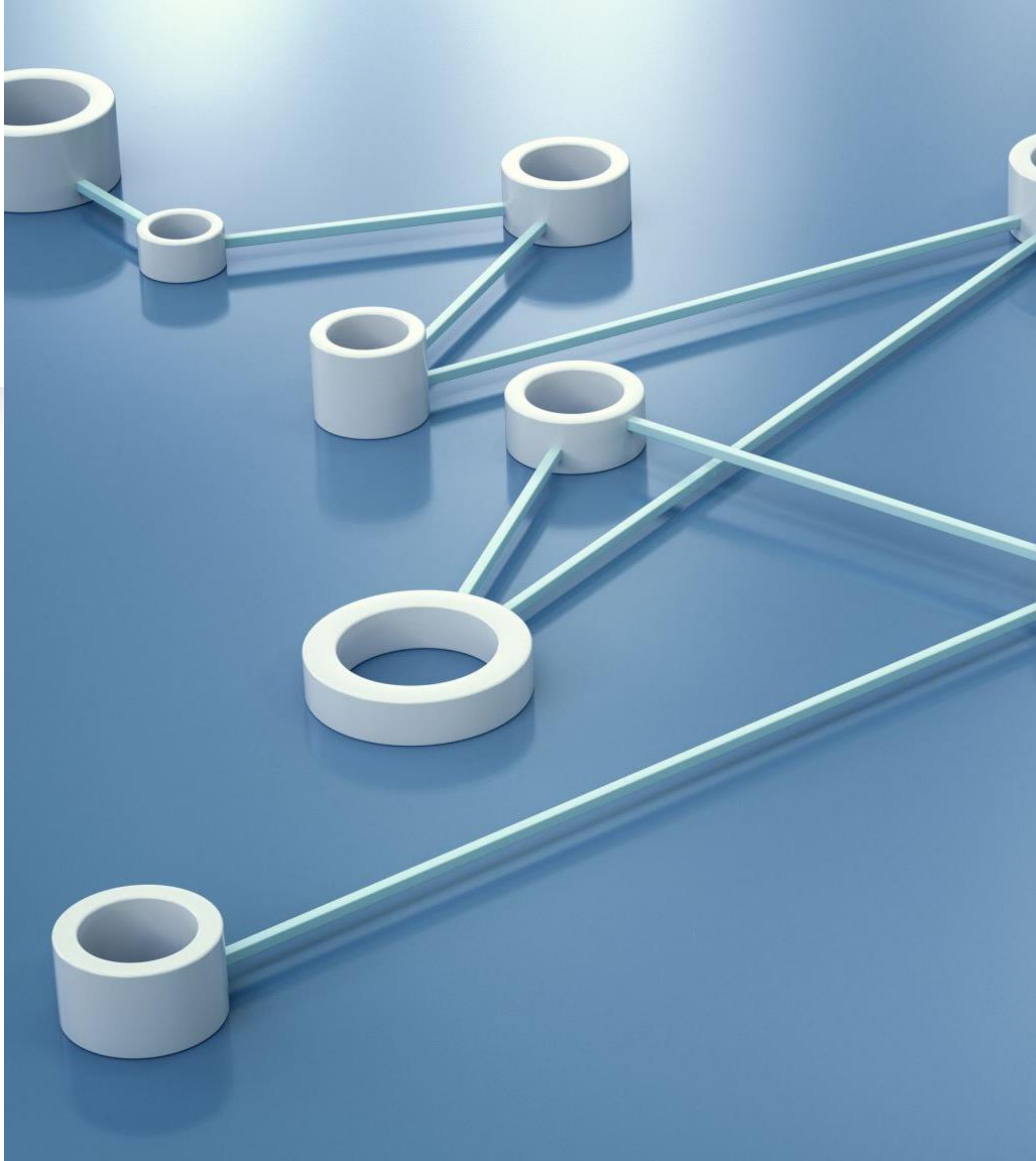
Business Impact:

•Reduced downtime and lower maintenance costs leading to improved fleet performance.

Communication & Collaboration Tools

To ensure smooth teamwork and project coordination, we will use the following tools:

- **Discord** – Primary platform for real-time chat, voice/video meetings, and quick updates.
- **GitHub** – Code repository for version control, issue tracking, and collaborative development.
- **Jira** – Agile project management to track tasks, sprints, and progress.
- **Google Drive/SharePoint** – Centralised documentation, meeting notes, and knowledge sharing.



Conclusion and Next Steps

- We propose to build a predictive maintenance system that leverages fleet data to proactively address vehicle failures.
- Initiate data collection and preliminary analysis.
- Begin Sprint 1
- Frequent client - developer meetings to ensure parity between parties