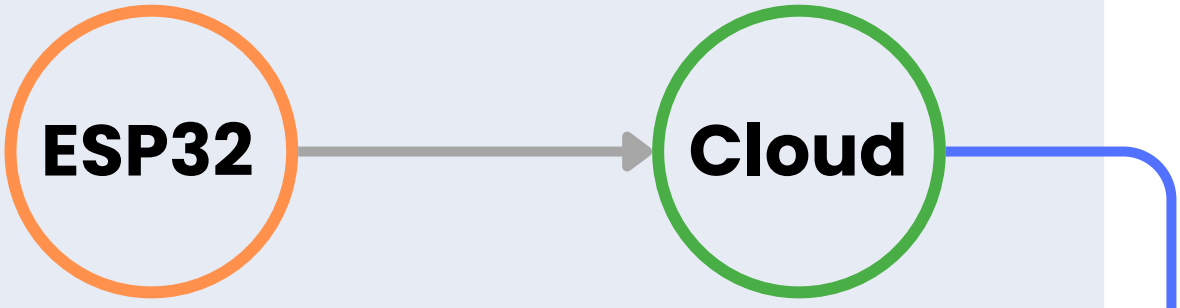
SYSTEM ARCHITECTURE SIH_24_ACOUSTIC

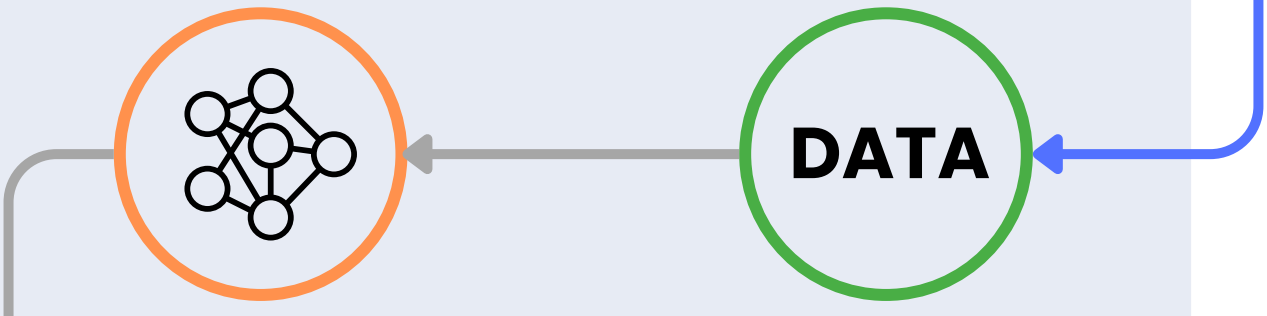
Data Ingestion Layer



Microcontroller: Continuously collects WAV files and metadata.

Upload to Cloud : Data is uploaded every 10s to a secure, centralized cloud (AWS,GCP CLOUD)

Data Processing Layer



PREPROCESSING

- **Convert WAV to 16kHz Mono:** Standardize the audio format across the system.
- **Slice WAV into 3s Chunks**: Segment audio data into 3-second chunks to reduce processing time and GPU load

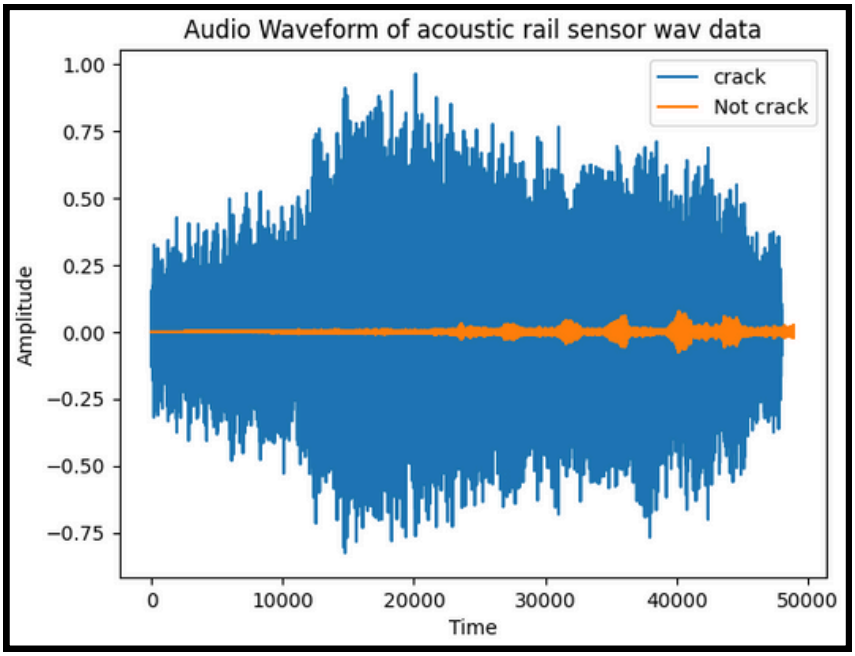
SPECTROGRAM CONVERSION

Each chunk is converted into **spectrograms using Tensorflow I/O**.

CLASSIFICATION VIA CNN MODEL:

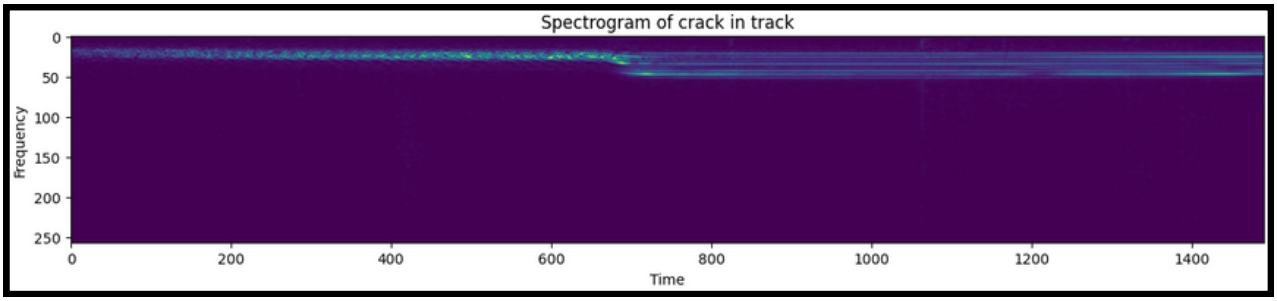
The pre-trained **TensorFlow CNN model**, which uses **Conv2D** layers and is trained on crack and no-crack spectrograms, classifies each input chunk by assigning a probability score. If the score is greater than or less than 0.5, it determines whether a crack is present or not.

SOME GENERATED RESOURCES

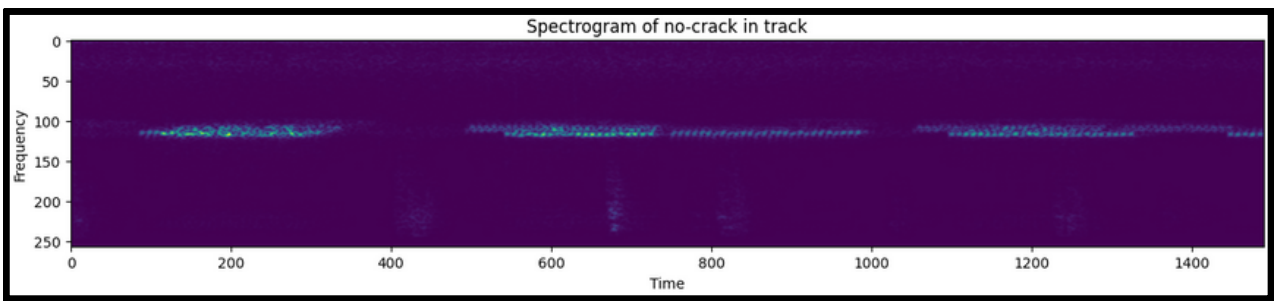


WAVE FORM OF WAV DATA

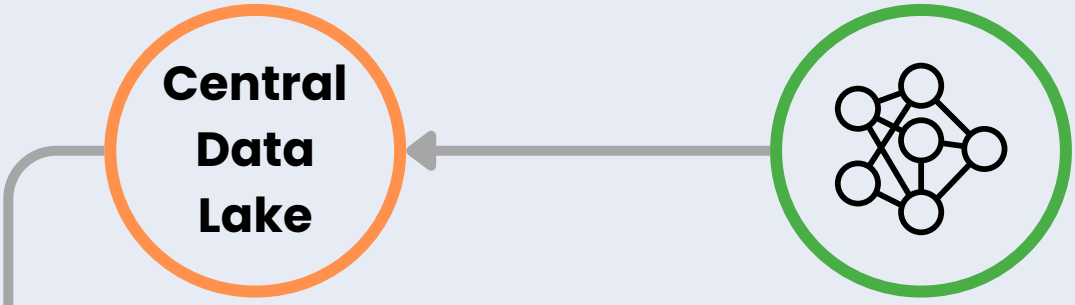
SPECTOGRAM OF CRACKED RAIL



SPECTOGRAM OF NON-CRACKED RAIL



Centralized Database Layer



The Data Lake will handle diverse and large-scale raw data (like the WAV files and other sensor data)

SQL/NOSQL DATABASE

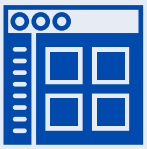
It will manage structured data, making it suitable for real-time queries, analytics, and reporting

Analytics and AI Processing Layer

Batch Data Processing: Process historical data using AI and ML pipelines (AWS SageMaker, GCP AI Platform).

Real-Time AI Inference: Perform real-time crack detection on incoming data using autoscaling cloud services (AWS Lambda, GCP Functions).

This Layer adds depth to your system's intelligence, enabling it to handle complex, large-scale operations efficiently while providing insights beyond basic defect classification.



Centralized Dashboard System

Django/Flask Web App

Centralized Dashboard: Government officials monitor real-time updates on track conditions, visualizations, and alerts.

Real-Time Alerts: Alerts for detected cracks are pushed to responsible parties via SMS, email, or push notifications.

Reports & Analytics: Generate periodic reports and visual analytics on track conditions, historical defect data, and predictive maintenance.

Government Compliance and Scalability Layer

Compliance & Security

Encryption: End-to-end encryption of data in transit and at rest

Access Control: Role-based access and audit logs for data access and system usage

Data Governance: Comply with government standards (ISO 27001, GDPR)

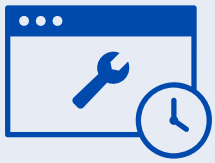
Scalability & Resilience

Auto-Scaling: Use cloud services (e.g., Kubernetes, AWS ECS) for dynamic scaling based on load.

Disaster Recovery: Multi-region failover and redundancy ensure continuous operation.

Data Backup: Automated backups for long-term storage and recovery.

Load Balancers: Distribute data processing load across multiple servers.



Maintenance and Monitoring Layer

Monitoring Tools

CloudWatch/Prometheus: Monitor system health, resource utilization, and detect anomalies in the workflow.

Auto-healing: Automatically detect and recover from failures (e.g., server crashes, data inconsistencies).