AEI Project

Erik Li - Systems Software Engineering Intern

About the speaker

- Name: Erik Li
- Education: BS CS '25 (AI/ML and Theoretical CS), MS CS (Machine Learning) '26, Georgia Institute of Technology
- Role: Software Engineer Intern
- Internship period: 10 weeks
- Mentors: Aditi Mishra, Joe Clements
- Assignment Leader: Brad Von Tersch

Part 1 : TagMaster Interface

A streamlined user-centered internal testing tool

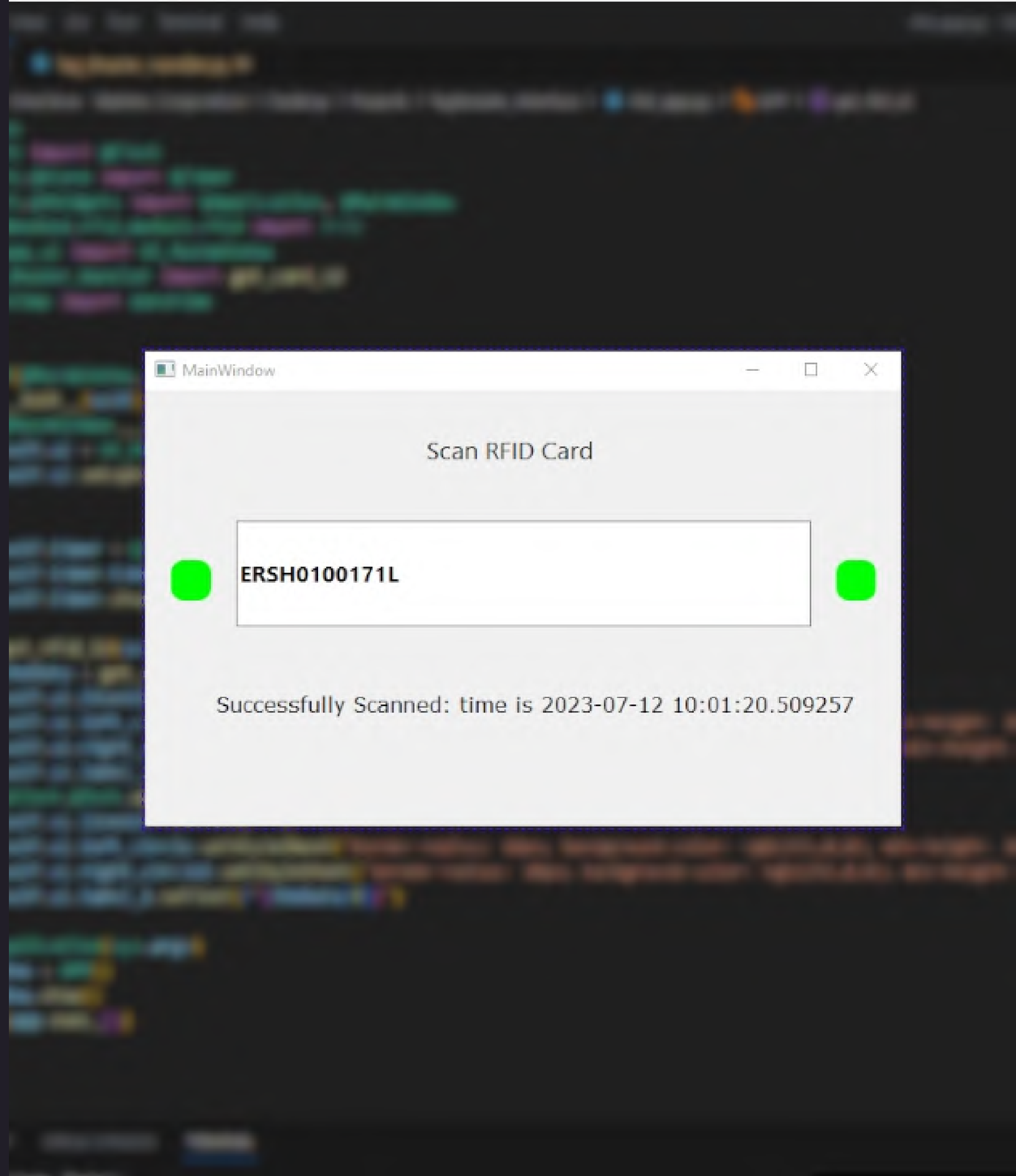
Problems

- Very few user-friendly internal testing tools
- Device management difficulty
- Need for program used by site/internal employees with little/no technical background
- Need for reading/manipulation of data values externally (hard to access through internal systems)

Conclusion: need for an easy-to-use tag reader interface with minimal setup supporting data retrieval/manipulation

Features

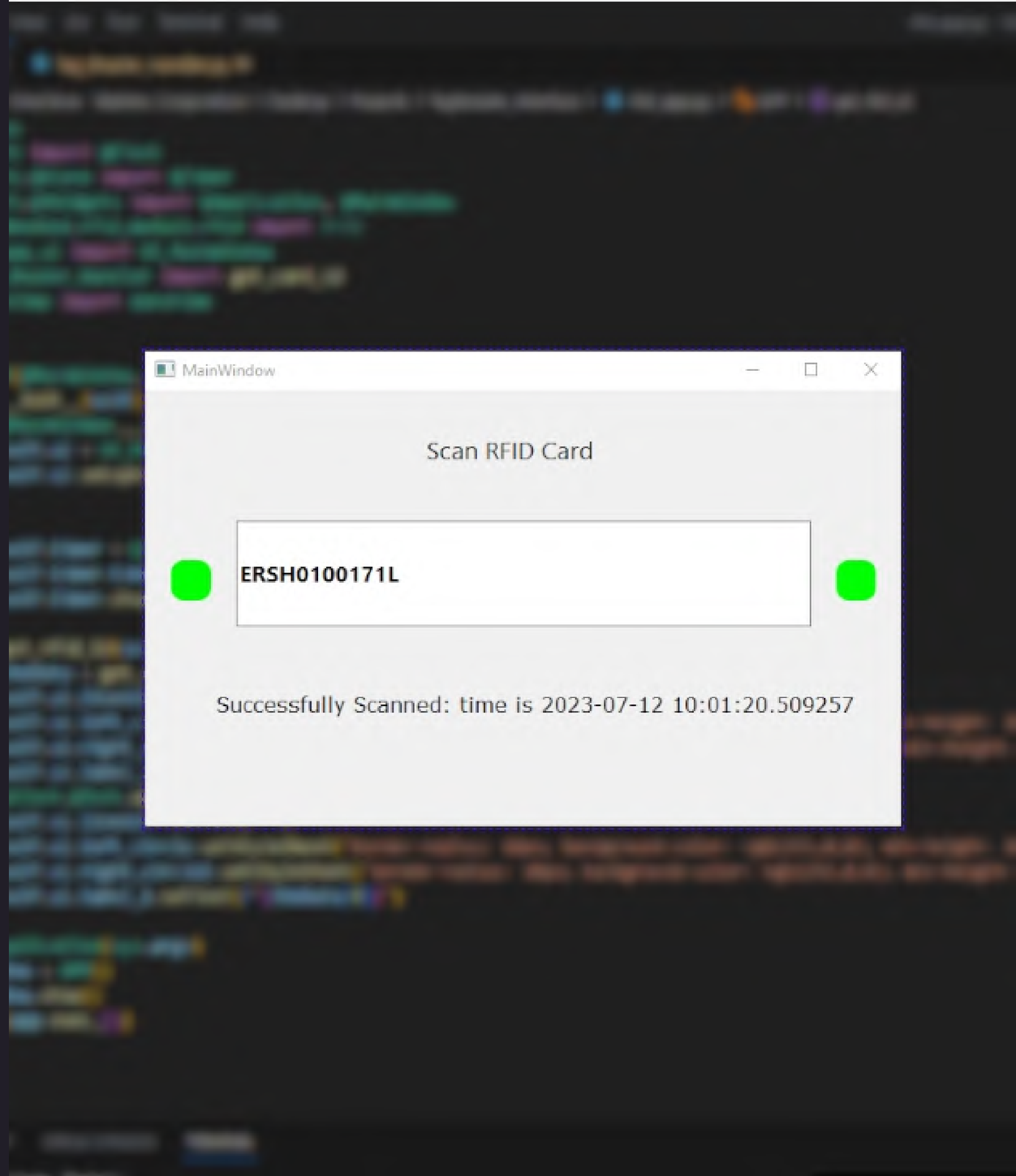
- High performance data TCP/IP retrieval
- Highly user-friendly, adaptable PyQt5-powered UI
- Live tag ID display
- Connection Status Feedback
- High precision time display
- In-program data manipulation
- Simple deployment and management



Feature Demo

Demo video link:

https://app.weet.co/play/0daed438/create-video-tutorials-with-weet



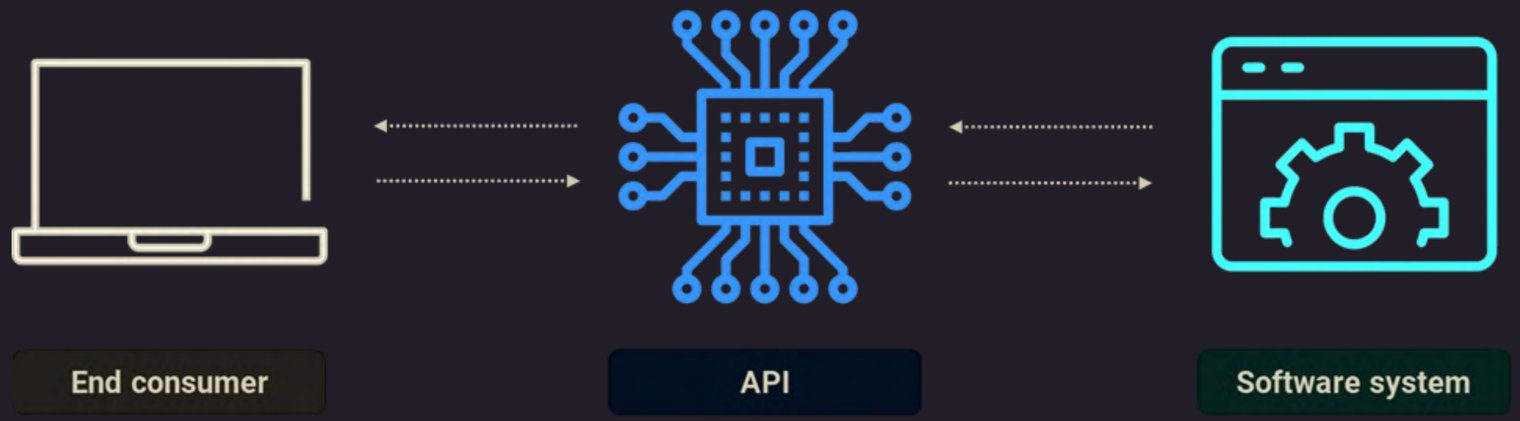
Part 2 : AEI Decoding System

A new design for optimal performance

Problems

- No centralized management system (separate files)
- Difficult to manage access/modification
- Difficult to track/view data
- Few supporting tools/environments
- O(n) worst case search time algorithm

Conclusion: need for a new, more efficient system



Efficiency Metric

420x

Efficiency increase for a data mapping file of 5000 entries.

Design Structure

AEI Decoding System

Processing Algorithms

Tag Processing

Raw tag ID from reader is processed for data retrieval.

Python Psycopg2 API

Data Retrieval

Low latency API retrieves corresponding data from ID.

PostgreSQL Database

Information Access

Car information is efficiently accessed and returned.

Decoding Database

Raw Tag	isLoco	strEquipNo	strEquipName	Orientation
9345324770	0	100100	EXAMP	Left
9345324780	1	100101	EXAMP	Right
9345324812	1	100102	EXAMP	Left
9345324912	1	100103	EXAMP	Left

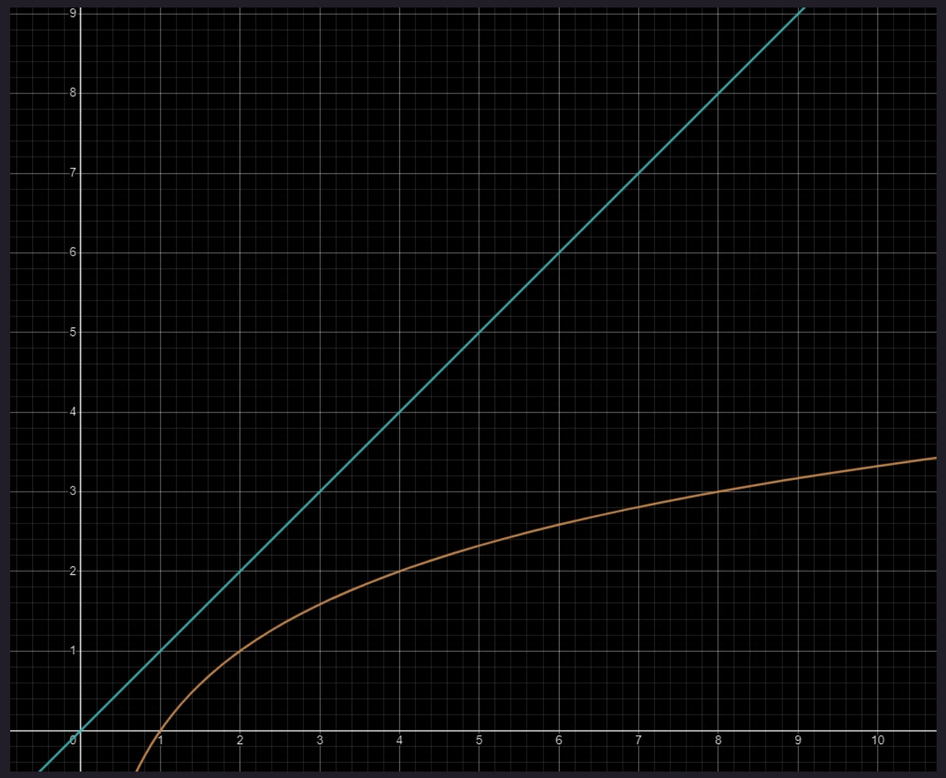
Sample Database Mapping Representation

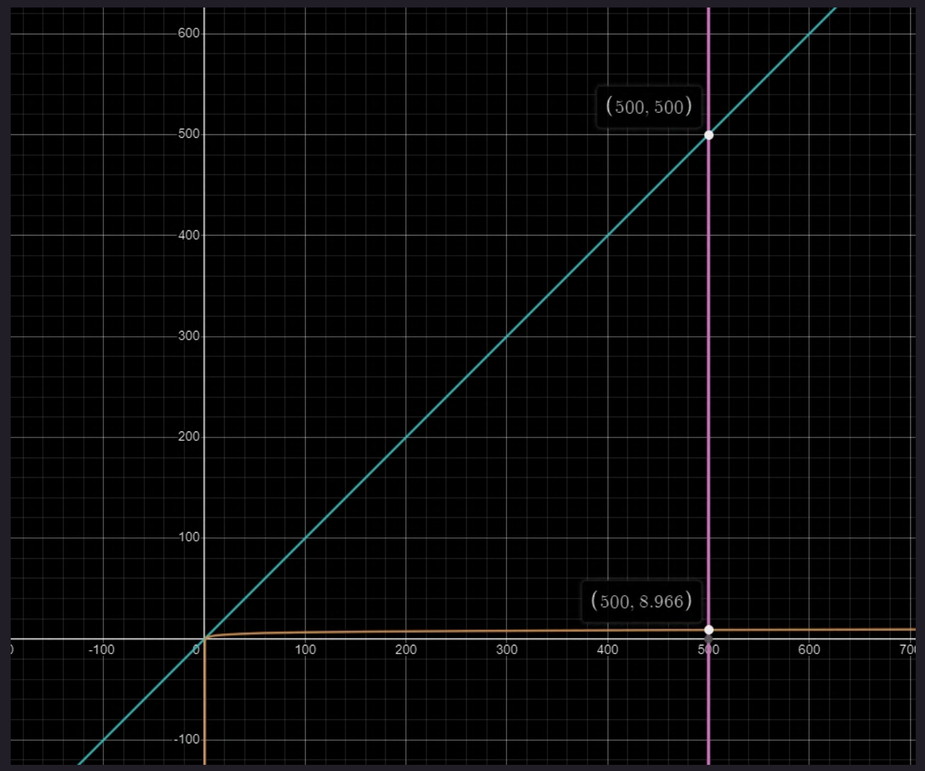
Hashmap Output

hashmap = {'info' : 'complete', 'retrieval' : 'O(1)'}

data['isLoco']	data['strEquipNo']	data['strEquipName']	data['orientation']
1	100101	'EXAMP'	'L'

Mathematical Efficiency Analysis

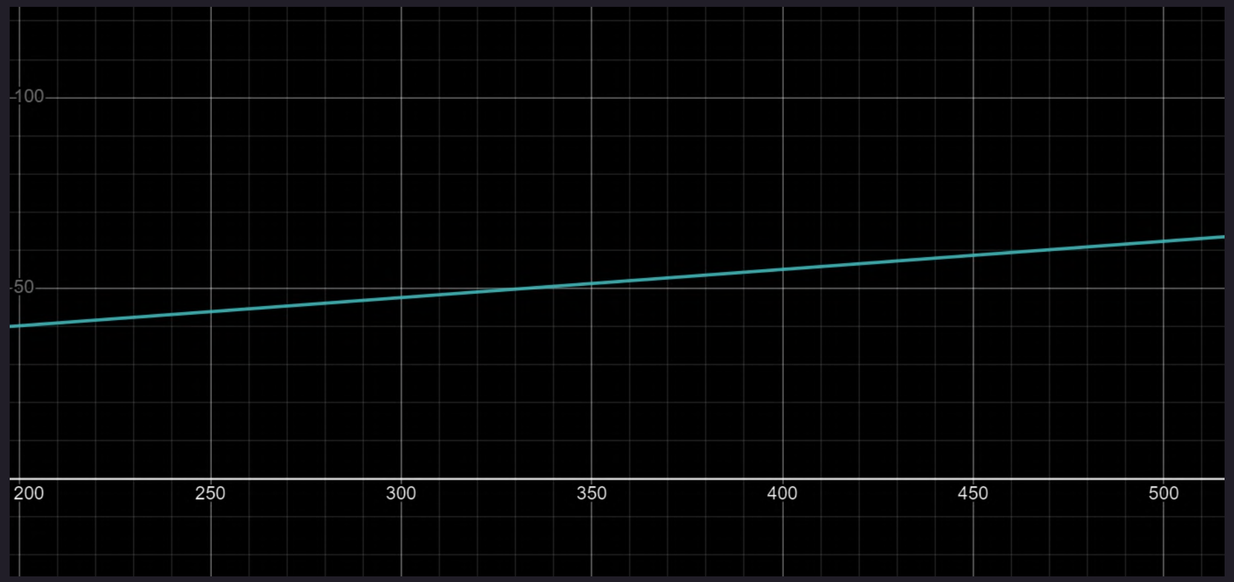




Graphical representations of function time complexities

Efficiency Prediction Function

$$\hat{y} = 0.07392x + 25.3469$$



Linear Regression function

Function predicting efficiency multiplier of new design given database entries

Efficiency Multiplier Function

Graphical representation of efficiency multiplier of new design with respect to number of entries in database

Efficiency Comparisons

5000ms

Time taken by current system

12ms

Time taken by the novel system

42,000%

Percentage of efficiency increase

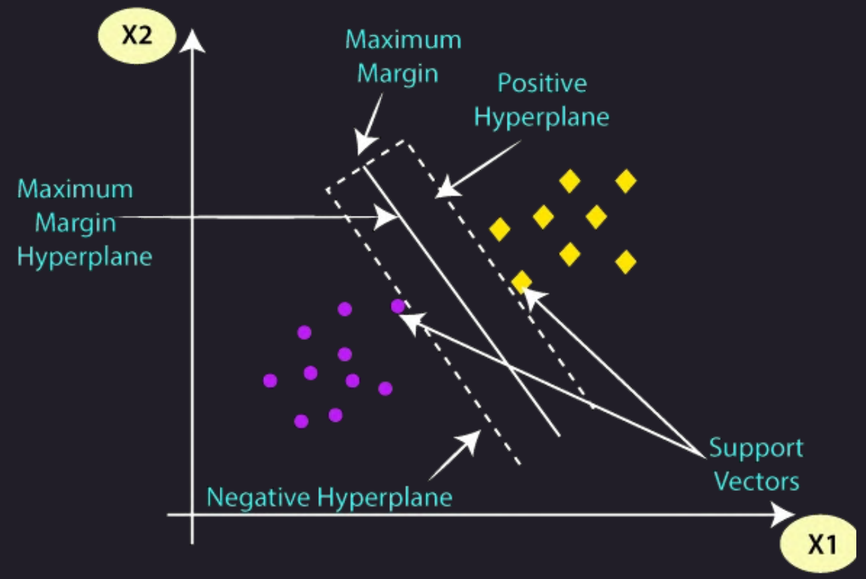
Runtime Efficiencies

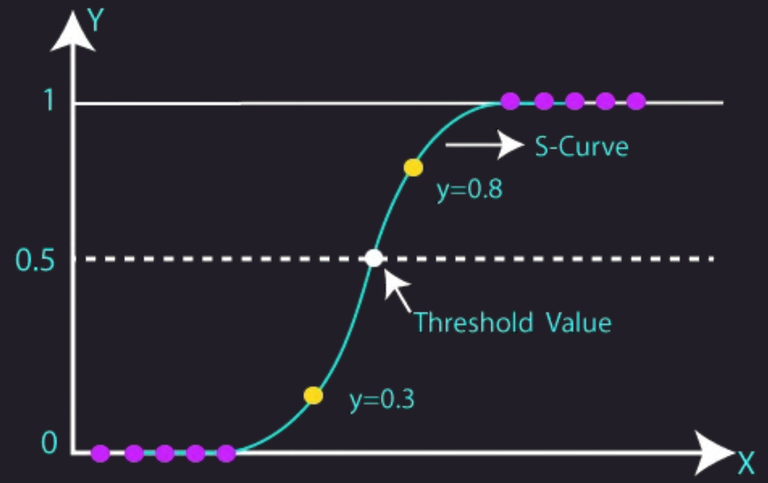
Part 3 : Tag Reader Interference Filter

Powerful new system mechanism built with Machine Learning

Predictive Machine Learning Models

- Process a dataset of RSSI values and interference/misreading status
- Train a machine learning model to identify presence of interference
  - Classification: whether a tag has been misread
    - XGBoost
    - Support Vector Machine
  - Regression: what is the probability that a tag has been misread
    - Logistic Regression
    - Ridge Regression





Logistic Regression for Classification

Single Input Sigmoid Predictor

$$P(Y=1|x) = \frac{1}{1+e^{-(w_0+w_1 x)}}$$

Multi Input Sigmoid Predictor

$$P(Y=1|x_i) = \sigma(x_i^T W) = \frac{1}{1+e^{-(w_0+w_1 x_{i,1}+w_2 x_{i,2}+\cdots+w_d x_{i,d})}}$$

Cross Entropy Loss Function

$$L_i = -y_i \ln(p_i) - (1-y_i) \ln(1-p_i)$$

Average Loss

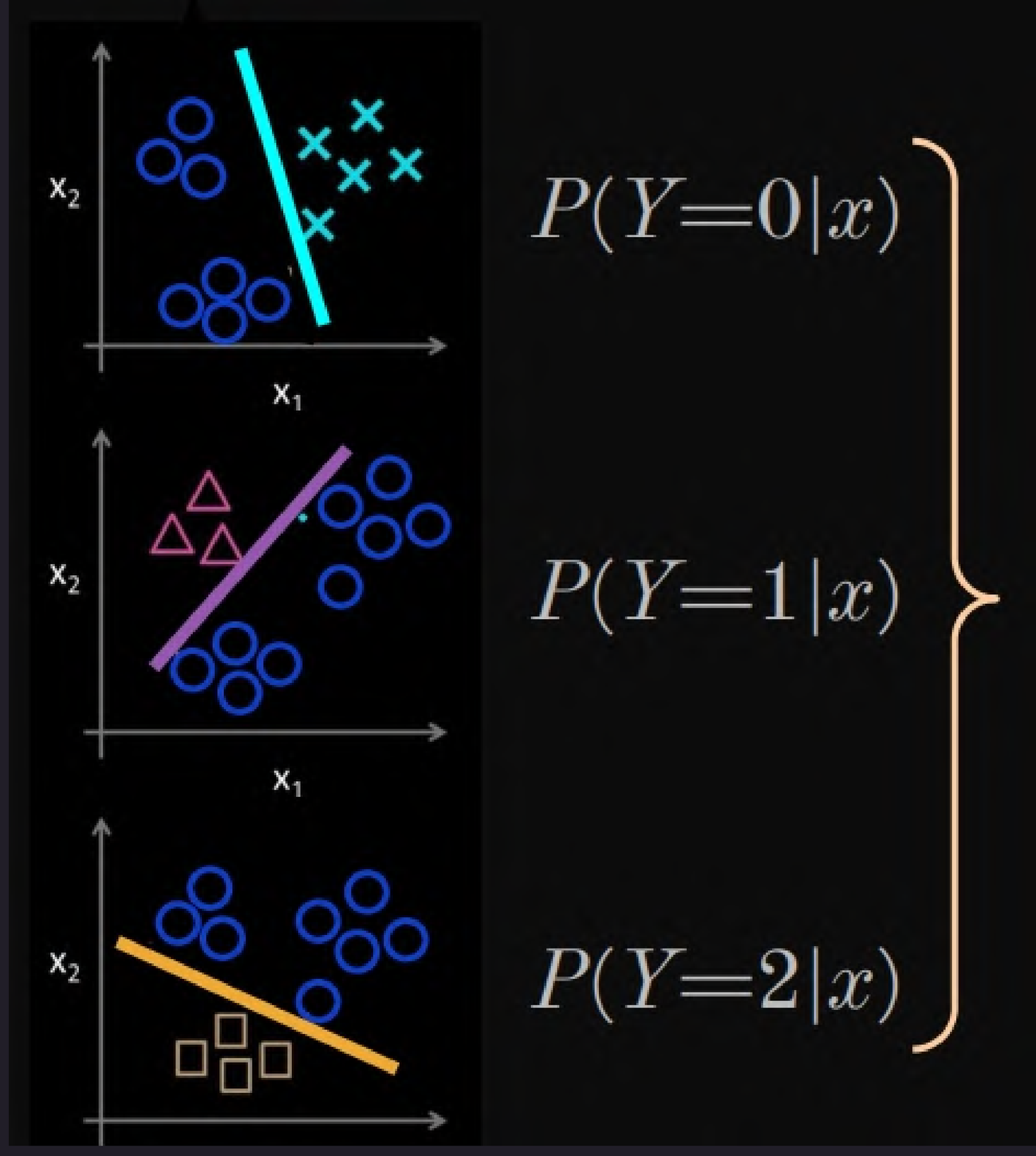
$$\frac{1}{n}\sum_{i=1}^{n} L_i$$

- Sigmoid Function: 1/(1+e^(-x))
- Adjust weight w_i values to fit points on the graph
- Evaluate fit using cross entropy loss function
  - y_i (0 or 1) are classification output prediction values
  - p_i [0, 1] are probability output prediction values
  - closer y_i and p_i the better
- Calculate average loss
- Solve for sigmoid function of least average loss

Logistic Regression for Multiclass Classification

One vs All method

Create individual logistical regressions for each class to calculate possibilities for a test sample belongs to each class (e.g, in our case we can create priority levels for interference management and classify)

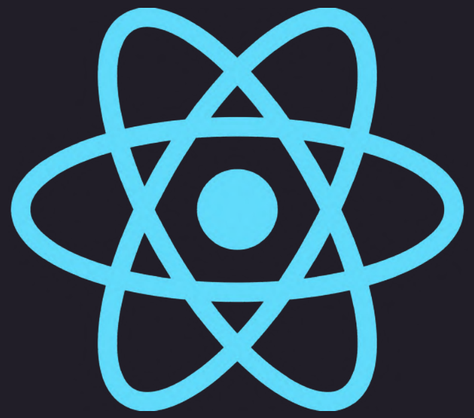


Tag Overseer

Moving Wabtec into the face of the future

Modern Full-Stack WebDev

React + Flask + Python + Postgres



React

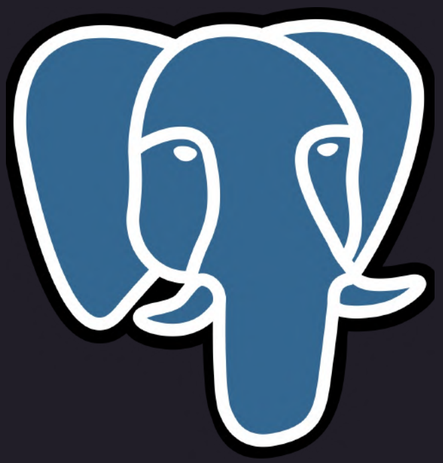
The foremost development library for building beautiful UIs in modern webdev.

Flask

Lightweight micro web application framework; fast and easy to deploy with

Python

One of the most popular programming languages in the world; high-level general purpose with dynamic semantics



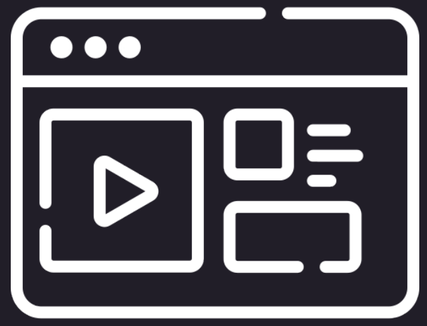
PostgreSQL

Powerful, open source object-relational database system with over 35 years of active development

React/Javascript

Flask/Python

PostgreSQL



Frontend

Backend

Flask

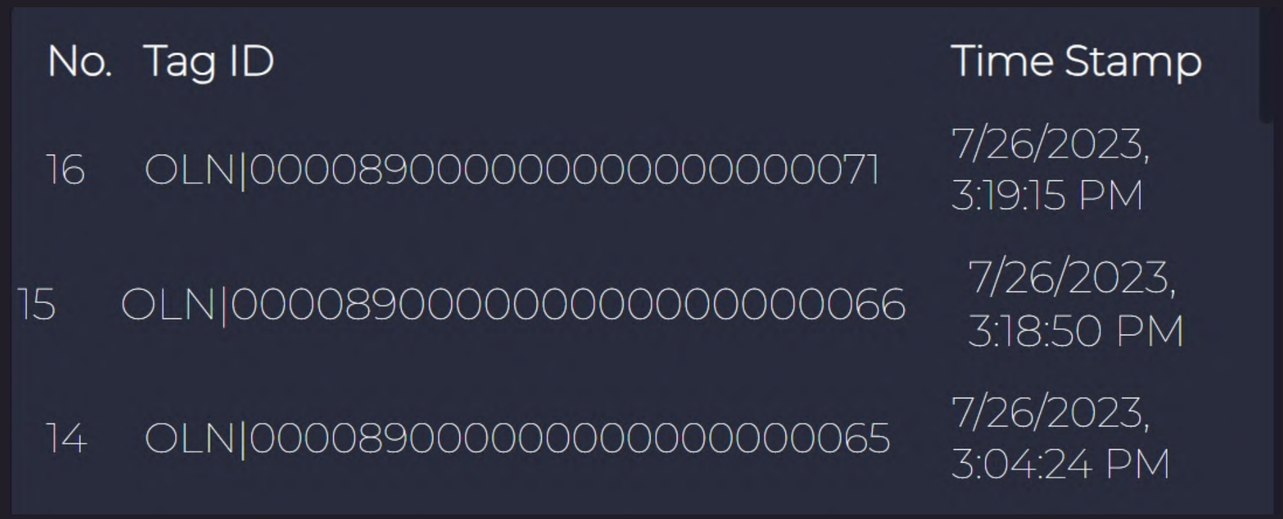
Tag Overseer ©

Scan a tag... Scan

No.	Tag ID	Time Stamp
15	OLN|00008900000000000000066	7/26/2023, 3:18:50 PM
14	OLN|00008900000000000000065	7/26/2023, 3:04:24 PM
13	"OLN|00008900000000000000003"	7/26/2023, 2:34:42 PM
12	OLN|00008900000000000000003	7/26/2023, 2:34:32 PM
11	2343242	7/26/2023, 2:34:19 PM
10	23432432	7/26/2023, 2:34:18 PM

Tag Overseer Dashboard

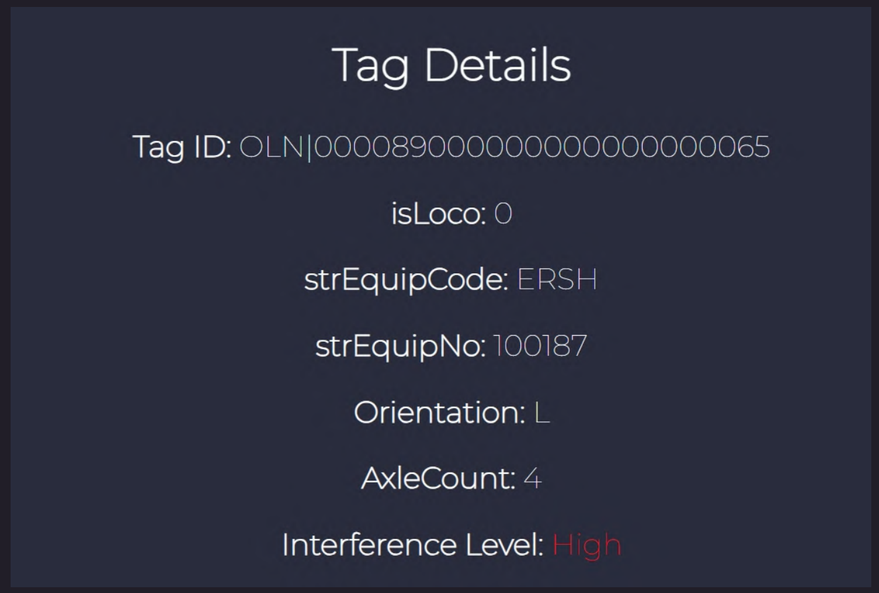
Dashboard Feature Sample



No.	Tag ID	Time Stamp
16	OLN|00008900000000000000071	7/26/2023, 3:19:15 PM
15	OLN|00008900000000000000066	7/26/2023, 3:18:50 PM
14	OLN|00008900000000000000065	7/26/2023, 3:04:24 PM

Live Scan Logs

Easy-to-navigate toggleable rows



Tag Details

Tag ID: OLN|00008900000000000000065

isLoco: 0

strEquipCode: ERSH

strEquipNo: 100187

Orientation: L

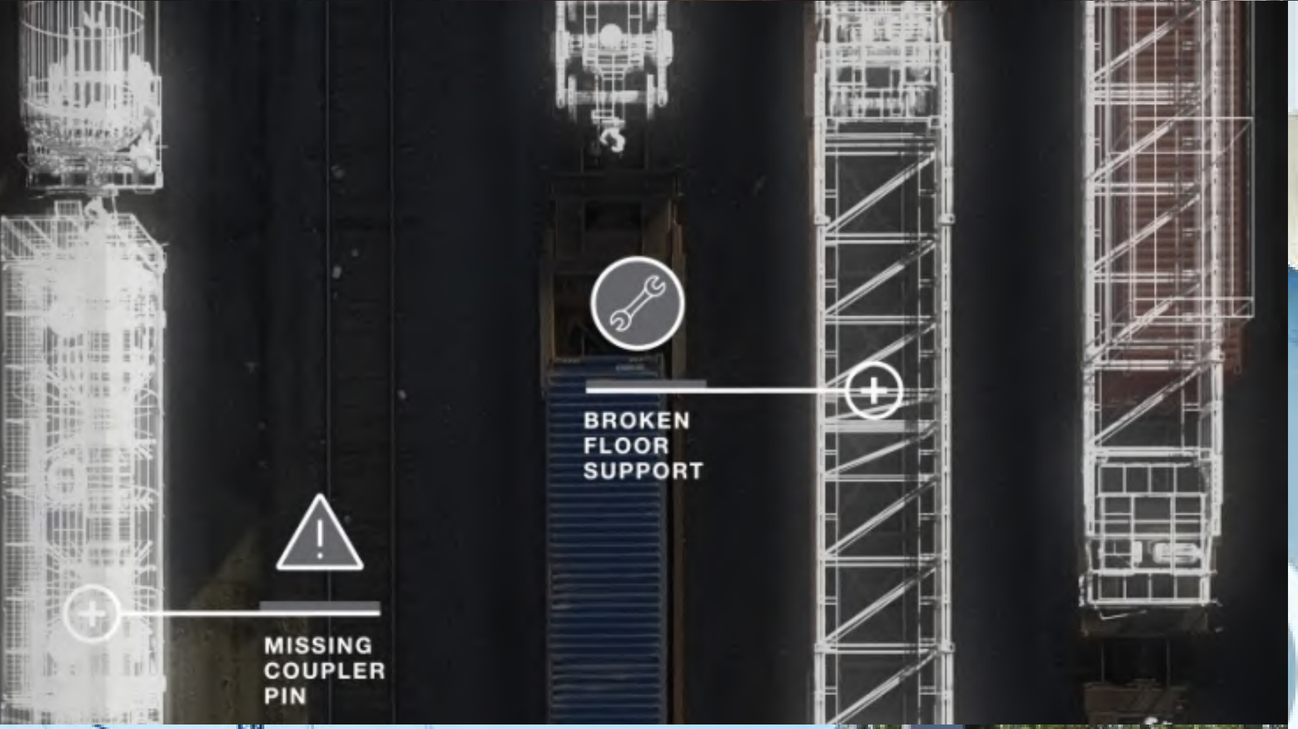
AxleCount: 4

Interference Level: High

Low Latency Data Retrieval

Detailed, clean display with rapid data fetching

Live Demo


BROKEN
FLOOR
SUPPORT
MISSING
COUPLER
PIN


Try Pitch


Wabtec
CORPORATION

Thank You for Listening

Systems Software Team

AEI Project

Presenter : Erik Li

BS CS '25, MS CS '26 - Georgia Institute of Technology

Mentors

Aditi Mishra

Joe Clements

Assignment Leader

Brad Von Tersch