MICHIGAN STATE UNIVERSITY

Beta Presentation

ML/AI Pipeline For Condition-Based Maintenance

The Capstone Experience

Team Magna AI4CBM

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Daniel Chen
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Lizabeth Hanks
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Michigan State University

Fall 2025

From Students…
…to Professionals

Project Overview

- Unplanned downtime is costly
- Spot anomalies before becoming a problem
- Developed a ML pipeline to ingest machine diagnostic data
- Intuitive dashboard for monitoring all Magna machinery through live sensor readings and model output

Team Member's Technical Tasks

Technical Tasks Assigned

- Team Member Daniel Chen
  - Dataset Selection
  - Training Preprocessing
  - Model Architecture
  - Model Training
- Team Member Ethan Springer
  - MQTT Bridge Node
  - Admin Control Node/Handling
  - Model Deployment Node(in part)
  - Simulation/Testing Node
  - ROS2 Pipeline Adjustments throughout Development
- Team Member Athul Syam
  - Developed final Taskboard Page
  - Created initial Log Pages
  - Developed Notification signup/sending system
- Team Member Hector Dominguez Rojas
  - Developed final Dashboard Page
  - Developed final Log page
  - Developed feature selection and upper/lower bound on UI
  - Created initial Taskboard
- Team Member Liz Hanks
  - Postprocessing node (Formatting raw and model output data to store in db)
  - AWS server set up
  - Initial postgresql setup
  - Backend implementation
    - Mqtt subscriber node (Handling mqtt connections from frontend)
    - Backend node (Endpoints that query postgresql tables)
- Team Member Michael Gryn
  - Data preprocessing in pipeline
  - UI Backend endpoint support
  - Configuration file for pipeline instances

Technical Tasks Completed

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  - Dataset Selection
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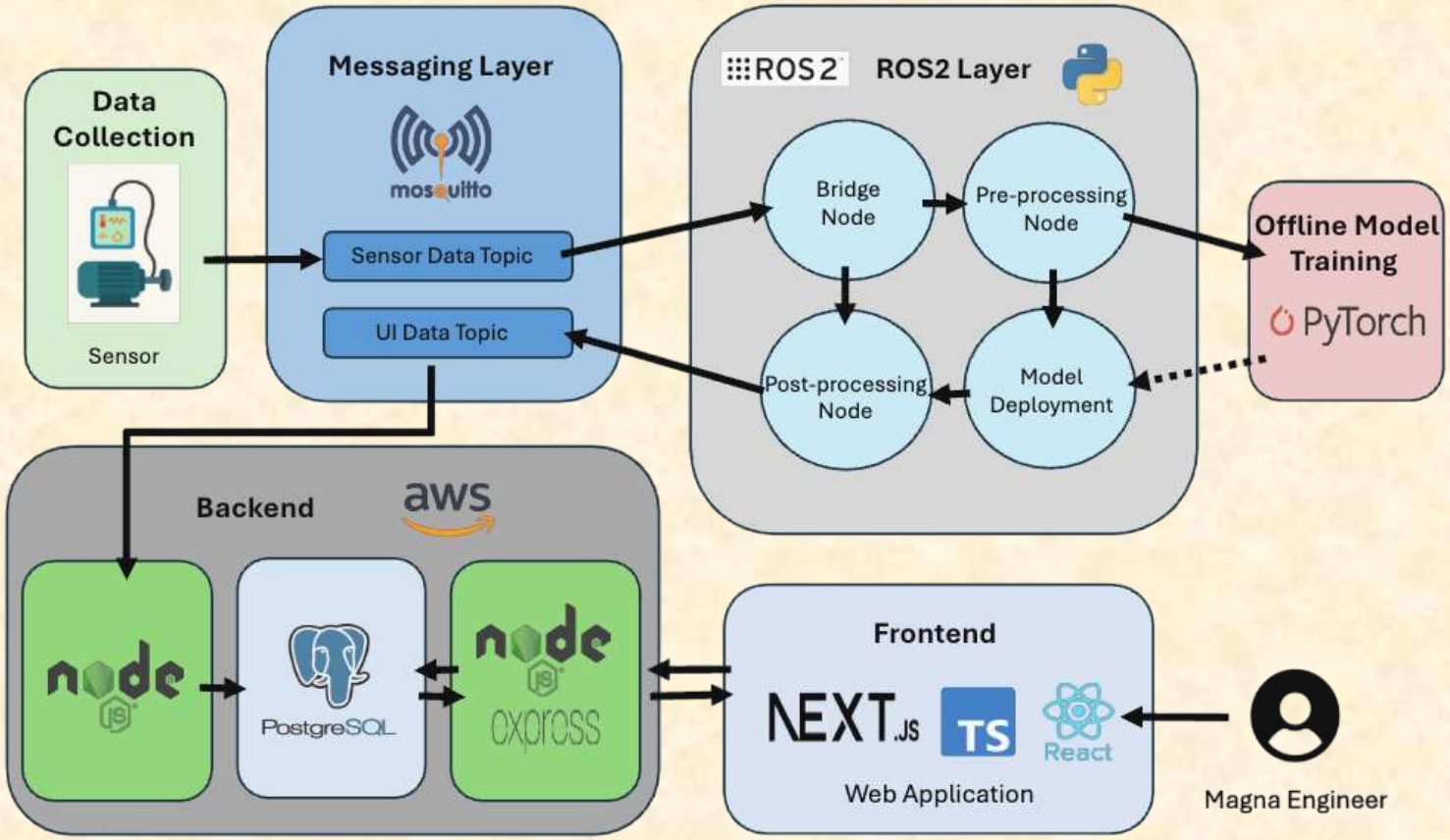
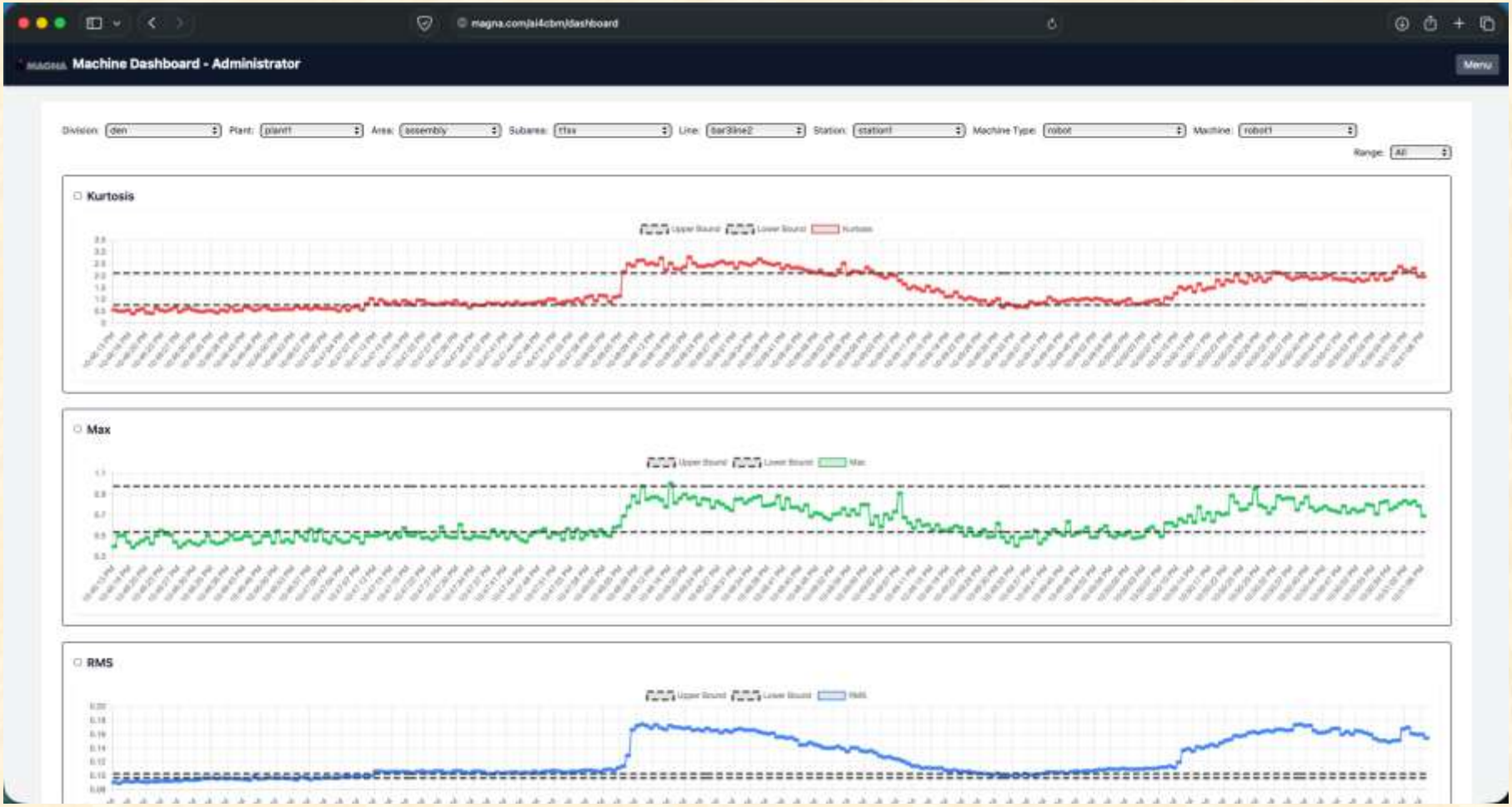
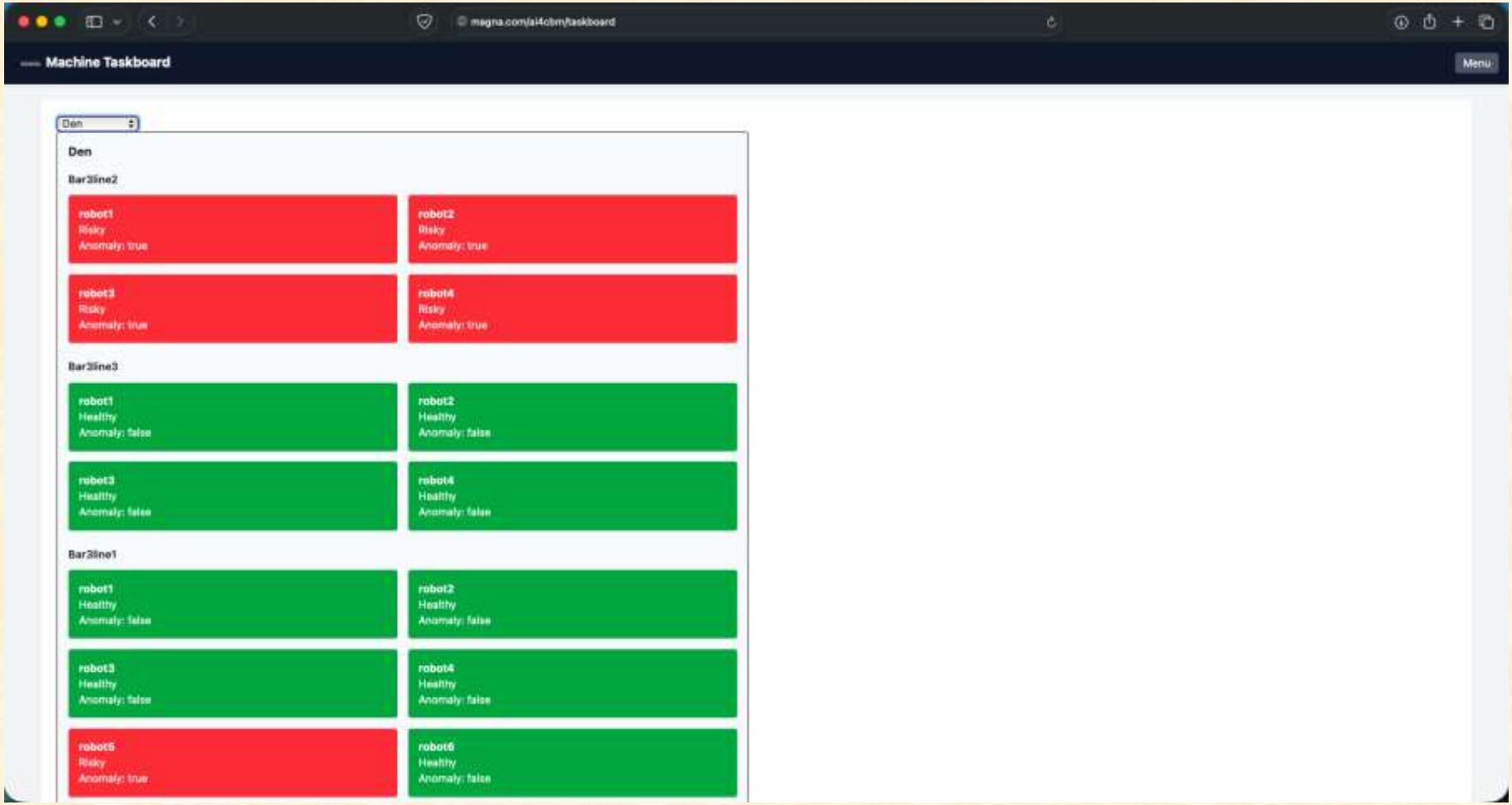
System Architecture



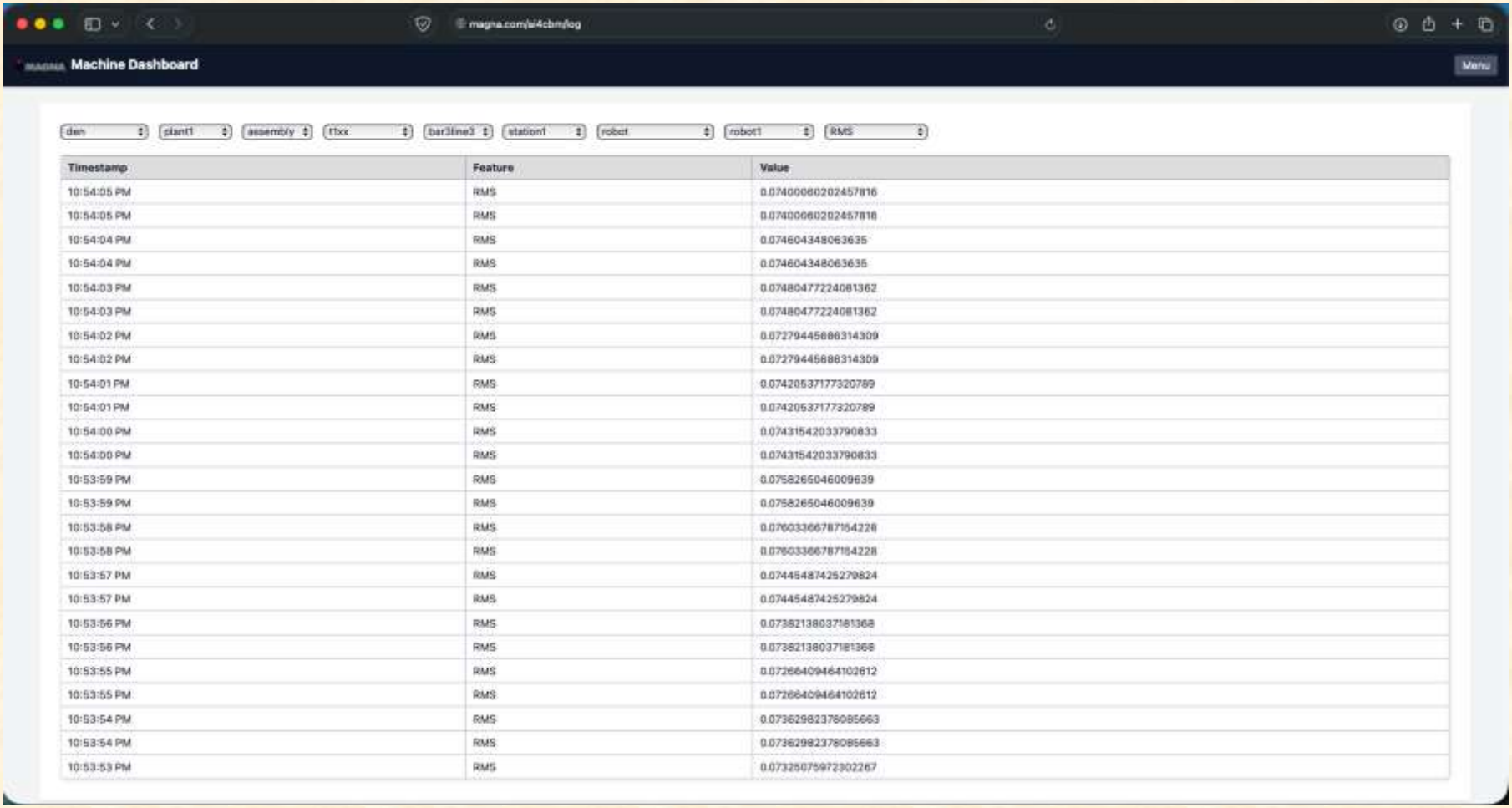
Dashboard


magna.com/ai4cbm/dashboard
Machine Dashboard - Administrator
Menu
Division: den
Plant: plant1
Area: assembly
Subarea: trax
Line: bar3line2
Station: station1
Machine Type: robot
Machine: robot1
Range: All
Kurtosis
Upper Bound
Lower Bound
Kurtosis
Max
Upper Bound
Lower Bound
Max
RMS
Upper Bound
Lower Bound
RMS

Taskboard

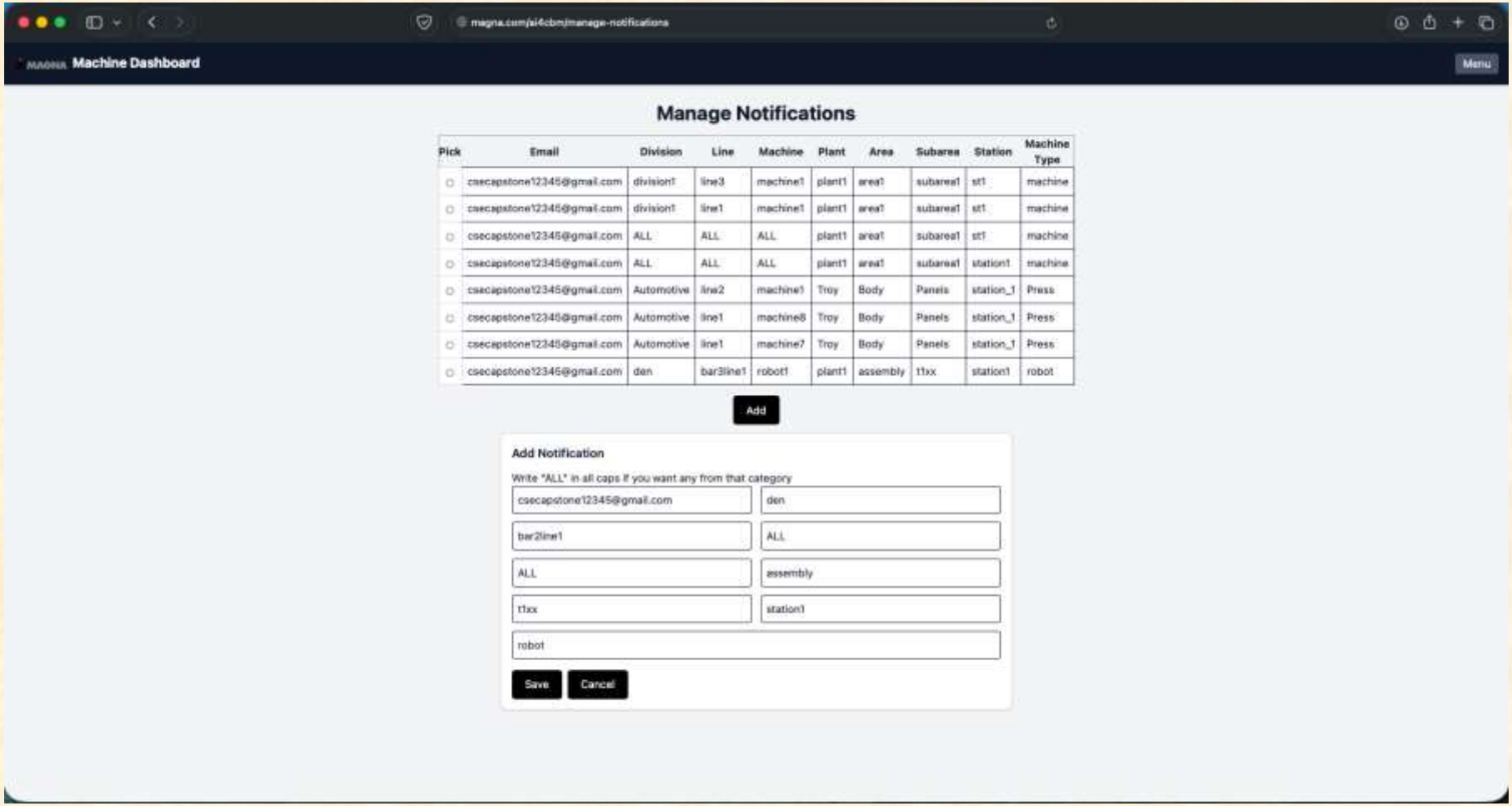

magna.com/ai4cbm/taskboard
Machine Taskboard
Menu
Den
Den
Bar3line2
robot1
Risky
Anomaly: true
robot2
Risky
Anomaly: true
robot3
Risky
Anomaly: true
robot4
Risky
Anomaly: true
Bar3line3
robot1
Healthy
Anomaly: false
robot2
Healthy
Anomaly: false
robot3
Healthy
Anomaly: false
robot4
Healthy
Anomaly: false
Bar3line1
robot1
Healthy
Anomaly: false
robot2
Healthy
Anomaly: false
robot3
Healthy
Anomaly: false
robot4
Healthy
Anomaly: false
robot5
Risky
Anomaly: true
robot6
Healthy
Anomaly: false

Log



Timestamp	Feature	Value
10:54:05 PM	RMS	0.0740060202457816
10:54:05 PM	RMS	0.0740060202457816
10:54:04 PM	RMS	0.074604348063635
10:54:04 PM	RMS	0.074604348063635
10:54:03 PM	RMS	0.07480477224081362
10:54:03 PM	RMS	0.07480477224081362
10:54:02 PM	RMS	0.07279445886314309
10:54:02 PM	RMS	0.07279445886314309
10:54:01 PM	RMS	0.07420537177320789
10:54:01 PM	RMS	0.07420537177320789
10:54:00 PM	RMS	0.07431542033790833
10:54:00 PM	RMS	0.07431542033790833
10:53:59 PM	RMS	0.0758265046009639
10:53:59 PM	RMS	0.0758265046009639
10:53:58 PM	RMS	0.07603366787154228
10:53:58 PM	RMS	0.07603366787154228
10:53:57 PM	RMS	0.07445487425279824
10:53:57 PM	RMS	0.07445487425279824
10:53:56 PM	RMS	0.0738213803718136
10:53:56 PM	RMS	0.0738213803718136
10:53:55 PM	RMS	0.07266409464102612
10:53:55 PM	RMS	0.07266409464102612
10:53:54 PM	RMS	0.07362982378085663
10:53:54 PM	RMS	0.07362982378085663
10:53:53 PM	RMS	0.07325075972302267

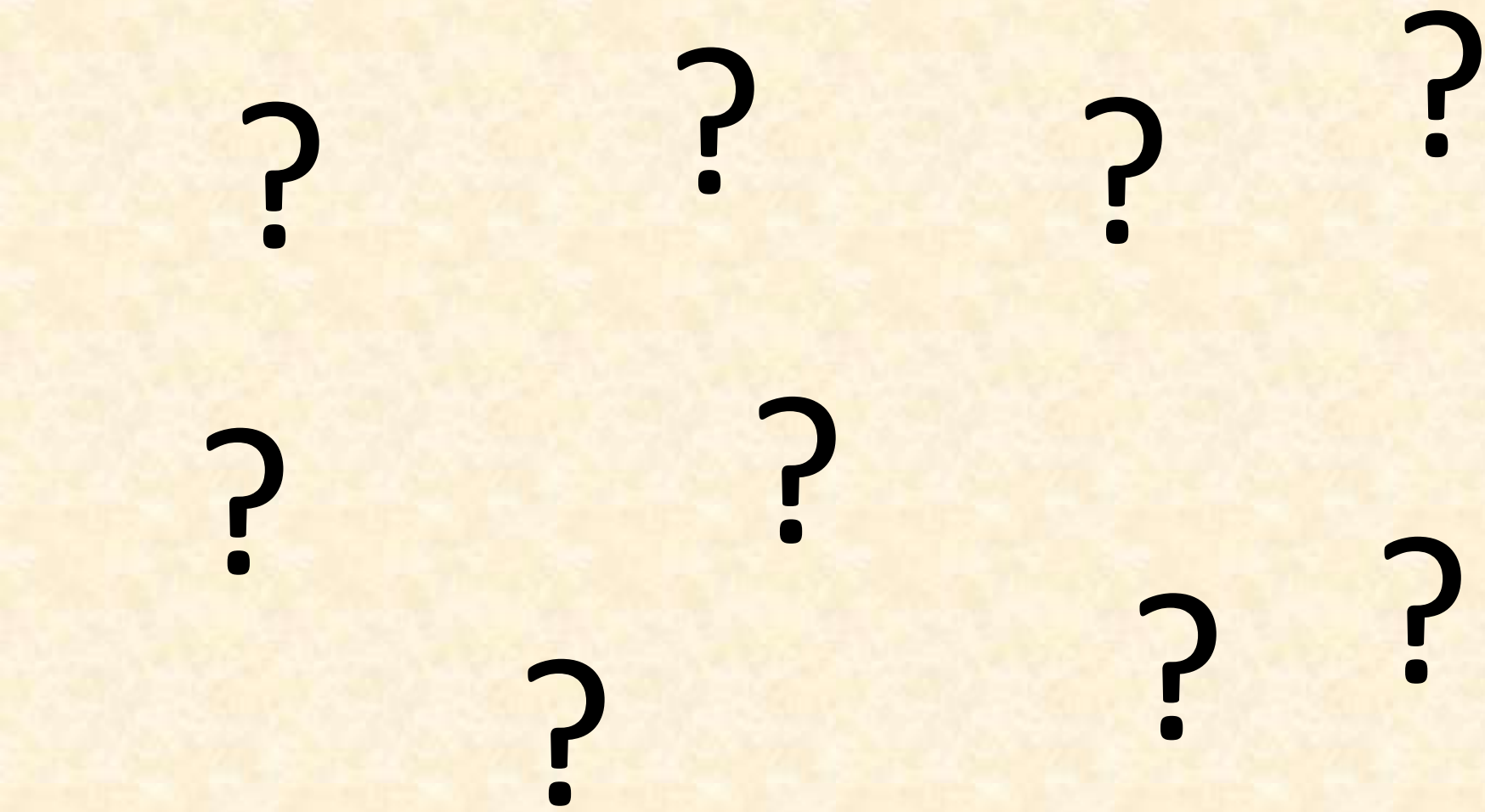
Manage Notifications



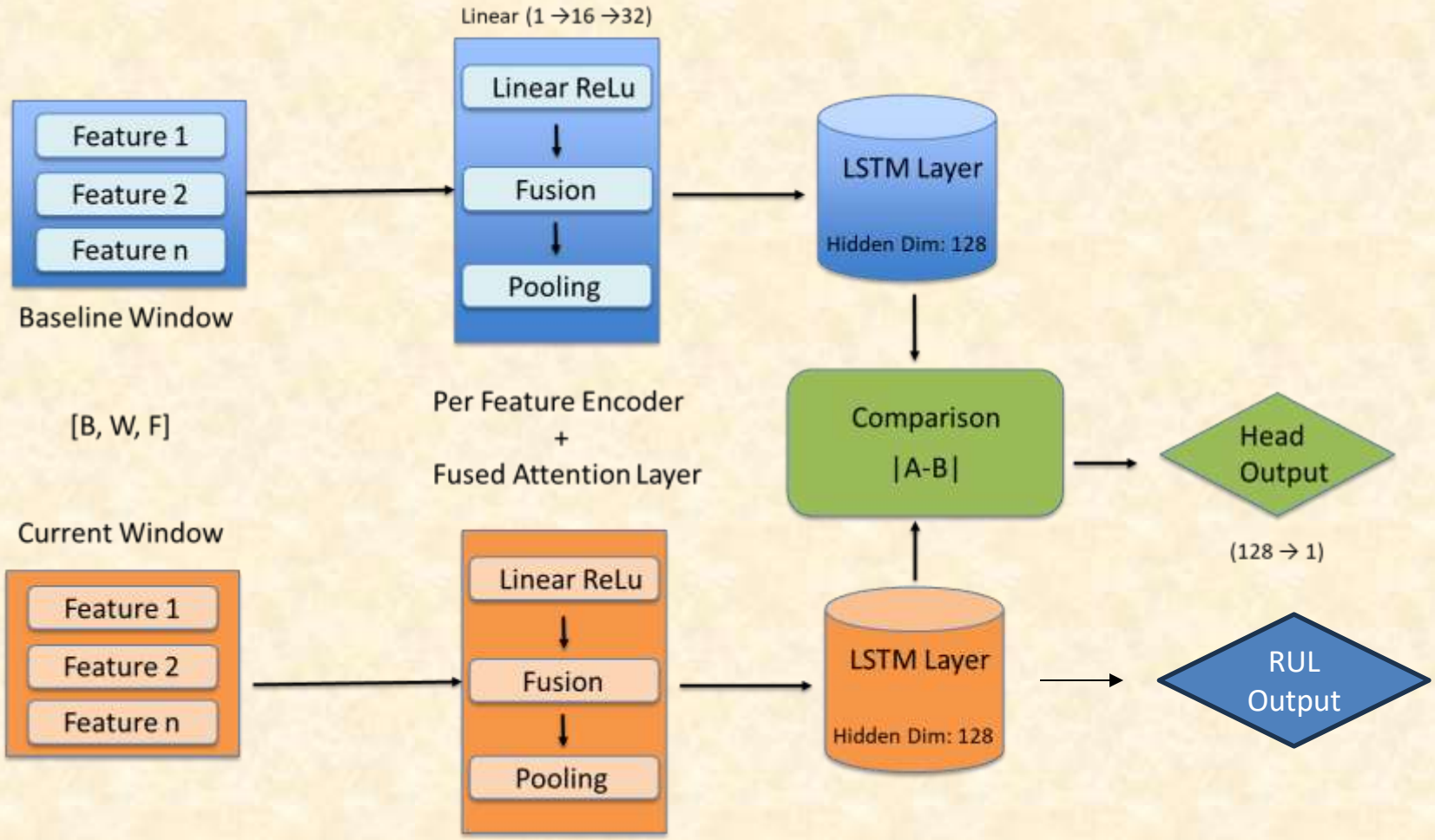
What’s left to do?

- Other Tasks
  - Migrate drop downs to a pop-up menu
  - Backend operation performance improvements

Questions?



Model Architecture



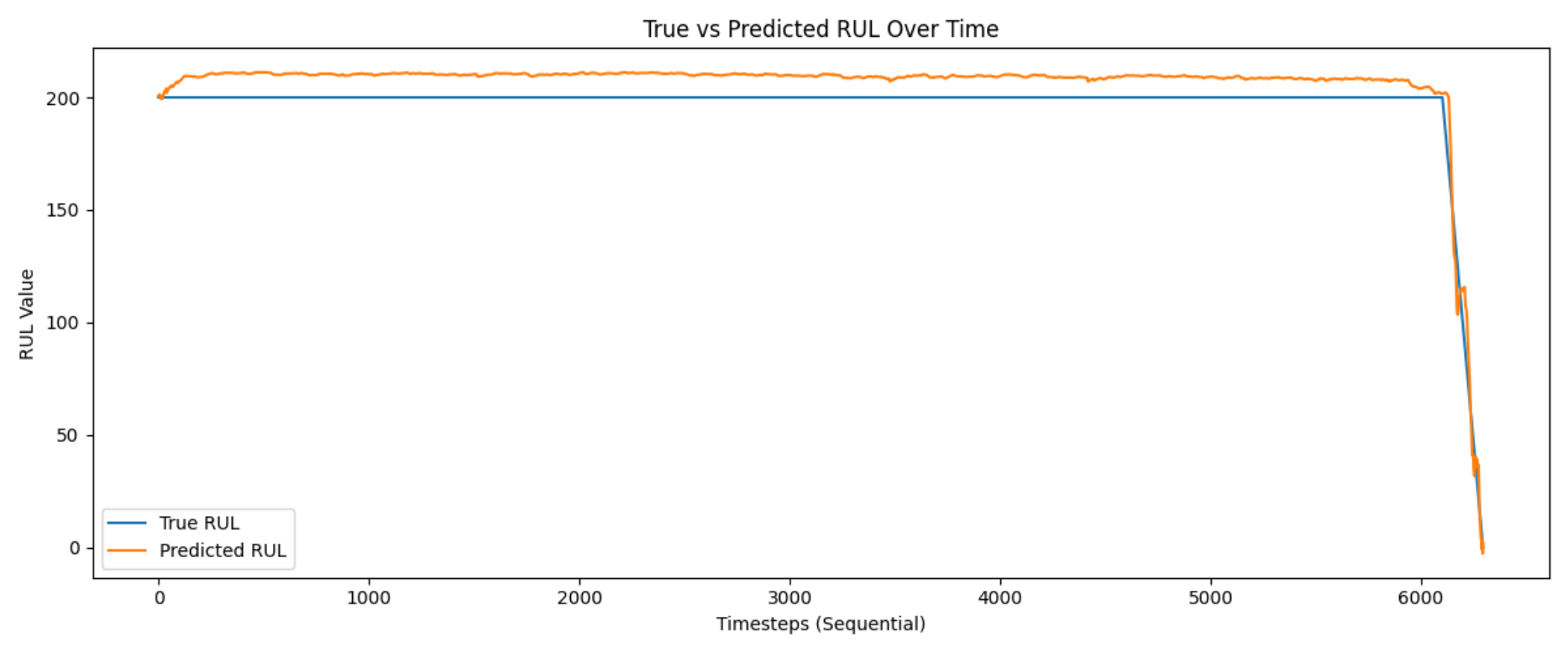
Binary Task Test Results

- Acc: 0.99, F1: 0.91, Precision: 1.00, Recall: 0.83

	Predicted Normal (0)	**Predicted Faulty (1)**
Actual Normal (0)	6101	0
Actual Faulty (1)	33	161

Regression Task Test Results

- RUL Task -> MAE: 15.48, RMSE: 15.76



Model Parameters

- LSTM:

- W_ih (input-to-hidden): shape (4*H, I)
- W_hh (hidden-to-hidden): shape (4*H, H)
- bias_ih: shape (4*H,)
- bias_hh: shape (4*H,)
- Per layer params = 4*H*I + 4*H*H + 8*H

- Layer 1: I=32, H=128
- 4*128*32 = 16,384
- 4*128*128 = 65,536
- 8*128 = 1,024
- Layer1 total = 82,944

- Layer 2: I=128, H=128
- 4*128*128 = 65,536
- 4*128*128 = 65,536
- 8*128 = 1,024
- Layer2 total = 132,096

Model Parameters

- Feature encoders (per feature): two linear layers: (1×16 +16) + (16×32 +32) = 576. With 4 features → 2,304.

- Fused Attention (embed_dim=32, heads=4):
- Q/K/V projections: 3 * 32 * 32 = 3,072
- output projection: 32 * 32 = 1,024
- biases: 128
- → 4,224

- Head Linear(128,1): 129