Autonomous Robot for Motor Heat Anomalies and Gas Leak Detection in Thermal Power Plants

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Introduction

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- Thermal power plants contribute **69.6%** to Ghana's energy mix through the use of natural gas.

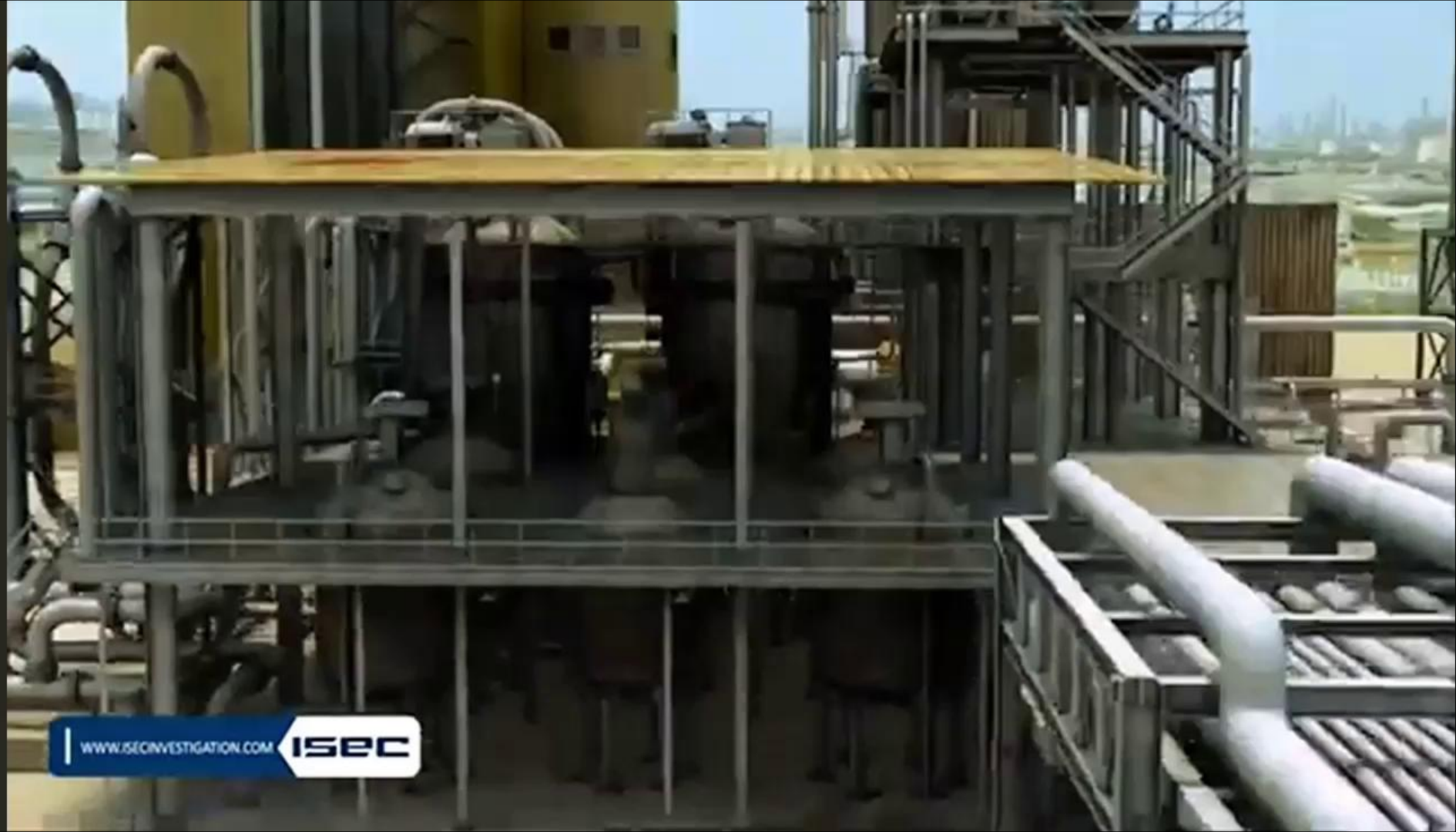
NATIONAL ENERGY STATISTICAL BULLETIN, 2024

Figure 3.1: Installed Generating Capacity (2000-2023)

Introduction

- High temperatures in these plants can indicate equipment overheating or failure, underscoring the need for efficient monitoring.

- To reduce downtime caused by such issues, various strategies for quicker inspections and enhanced safety for personnel have been developed for gas leakage detection and equipment condition monitoring.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Problem Statement

- Our analysis reveals the dangers of personnel-led monitoring in thermal power plants, where gas leakages and thermal irregularities can occur
- Monitoring the conditions of industrial motors is crucial and can cause serious risks posed by its absence.
- Gas leakages are significant contributors to fire incidents, endangering both equipment and personnel safety.
- Abnormal thermal conditions in industrial motors indicate potential failures, leading to costly downtimes if not addressed on time.

Objectives

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To design and build a heat anomaly detection unit using thermal imaging

4

To design and build a mobile app to provide real-time data and control


9
INDUSTRY, INNOVATION
AND INFRASTRUCTURE

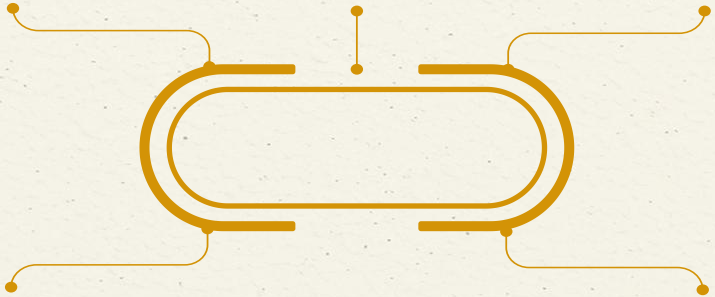

13
CLIMATE
ACTION

Scope of the Project

Four-wheeled ground bot

Thermal Power plant

Data Logging with iot



Visual Feedback & Control with a mobile app

Autonomous Navigation with computer vision

Literature Review

What existing research shows

AUTHOR(S),TITLE & YEAR	METHODOLOGY, STUDY SYSTEM, SIMULATION TOOL	RESULTS	COMMENTS/ DRAWBACKS
Olivier Janssens et al 2017 ***Deep Learning for Infrared Thermal Image Based Machine Health Monitoring***	i. The objective of this paper is to investigate the possibility and how Convolutional Neural Networks (CNN) could be applied to infrared thermal video for automatically determining the condition of a machine. ii. They trained their model using deep networks and applied transfer learning.	*i.* *Feature learning* ***86.67%*** *ii.* *Feature engineering* ***80.00%***	i. Their results showed that CNNs could be used for detecting fault conditions in machines and its potential to improve online condition monitoring. ii. Their work however is stationary for the inspection hence applications will require more thermal cameras. This can be avoided by having a mobile robot navigate the plant.

AUTHOR(S),TITLE & YEAR	METHODOLOGY, STUDY SYSTEM, SIMULATION TOOL	RESULTS	COMMENTS/ DRAWBACKS
Aitor Ibarguren et al 2013 ***Thermal Tracking in Mobile Robots for Leak Inspection Activities***	i. Their objective was to make an autonomous robot for pipeline inspection to detect leaks early. ii. The proposed approach was tested in a robotic platform RobucarTT.	*i. The algorithm found all leakages labeled by human operators and found six more that were missed by operators, obtaining **100%** sensitivity.* *ii. Results show a better performance of the particle filter with a set of 1,000 particles, improving the mean error and standard deviation in almost all the configurations*	i. Being limited to a simulation environment there maybe deviations in their result should it be implemented. ii. Their research does not use CNN for detection which has proven to be very efficient in detecting thermal anomalies.

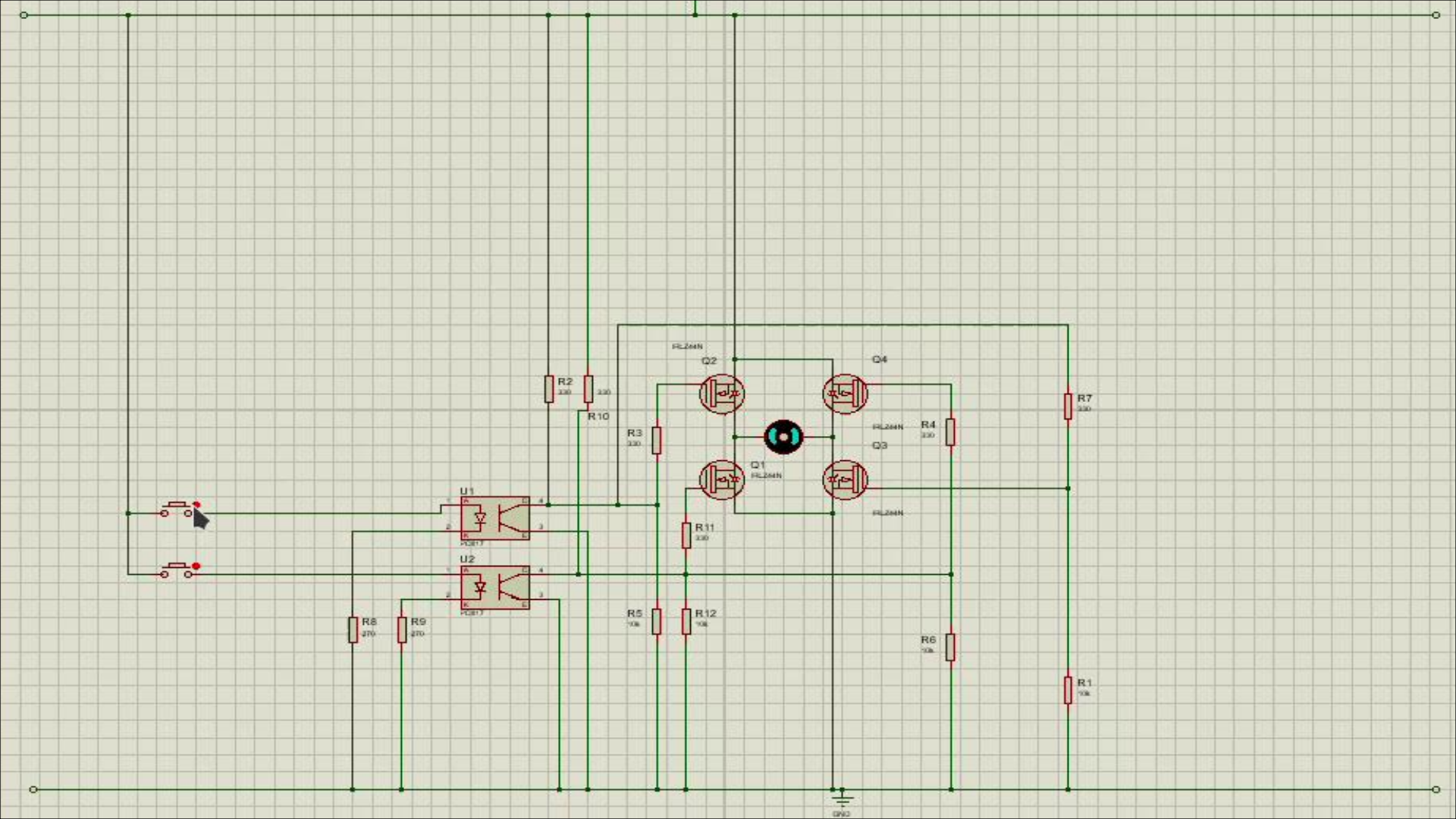
AUTHOR(S),TITLE & YEAR	METHODOLOGY, STUDY SYSTEM, SIMULATION TOOL	RESULTS	COMMENTS/ DRAWBACKS
Jun Yang et al 2017 ***Infrared Thermal Imaging-Based Crack Detection Using Deep Learning***	i. The objectives of this paper was to use Convolutional Neural Networks (CNN) as a way to detect cracks using infrared thermal imaging. ii. The methodology this paper presents is the use of a thermal camera to analyze the abnormal condition of the temperature change law at the location of the crack. . iii. They checked for various crack types including penetrating cracks, shallow surface crack and non-penetrating cracks and recorded their thermal results after the excitation process, to create a databank of thermal images iv. They also used transfer learning in training their model.	*i. Their results showed a detection accuracy of more than **92%** for each of the cracks tested for.* *ii. The system was tested against another to compare the accuracy of detection of both.*	i. Their R-CNN proved to be more accurate at detecting cracks than the other which mistook some of the cracks for others. ii. Their research focused on just vertically distributed cracks hence may not perform as good for other forms of cracks.

AUTHOR(S),TITLE & YEAR	METHODOLOGY, STUDY SYSTEM, SIMULATION TOOL	RESULTS	COMMENTS/ DRAWBACKS
Changjie Xia , MingRen et al , 2023 ***Infrared thermography-based diagnostics on power equipment: State-of-the-art***	i. This paper aimed to highlight the development of infrared thermography-based diagnostics, its limitation in fault inspection and give insights on machine assisted fault diagnosis as well as image intelligent fault identification. ii. The paper talked about the fundamental working principles of an IRT. iii. The paper mentioned some faults that could be checked using IRT. iv. The paper mentioned limitations of IRT such as low resolution ,heterogeneity and low signal to noise ratio.	*i. The paper provides a comprehensive scope on the evolution of infrared thermography camera* *ii. It also shows detailed technical foundation through underlying strong scientific principles.*	i. The paper provides limited quantitative comparisons or performance benchmarks among the different diagnostic approaches ii. It offers less emphasis on practical strategies to overcome these issues in industrial settings.

AUTHOR(S),TITLE & YEAR	METHODOLOGY, STUDY SYSTEM, SIMULATION TOOL	RESULTS	COMMENTS/ DRAWBACKS
Olivier Janssen , Raiko Schulz et al, 2015 ***Thermal Image Based Fault Diagnosis For Rotating Machinery***	i. The paper aimed to develop a novel automatic approach to fault detection system through the use of infrared imaging on bearings of rotating machinery. ii. An experimental set-up was established in a controlled dark environment to eliminate extraneous noise, where a thermal camera recorded the temperature evolution of bearings under various fault conditions. iii. Data was collected through recording and used for training their detection model.	*i. The system achieved an overall classification accuracy of **88.25%**, demonstrating its effectiveness under controlled conditions.*	i. Feature overlapping may lead to misclassification in real world scenarios which might pose a challenge in real time monitoring and deployment

AUTHOR(S),TITLE & YEAR	METHODOLOGY, STUDY SYSTEM, SIMULATION TOOL	RESULTS	COMMENTS/ DRAWBACKS
Ravi K Kodali , Kusuma Nimmanapalli et al , 2018 ***IOT Based Industrial Plant Safety Gas Leakage Detection System***	i. This paper focuses on using a gas leakage detection mechanism which sends SMS to concerned individuals when there is a leak for either evacuation or further precaution. ii. ESP32 controller, MQ-6 gas sensor, MQ-135 gas sensor, IFTTT and UBIDOT are the tools used to carry out the experiment in the project. iii. ESP32 was programmed with threshold value of gas readings which when exceeded sends an HTTP GET protocol to the IFTTT web, where URL is examined, triggering the sending of warning messages to various contacts on the working field.	*i. Through incorporation of IoT elements (ESP32, UBIDOTS, and IFTTT), the system enabled remote monitoring and instant SMS alerts for fast real time communication to concerned workers* *ii. The system was able to detect leaks as wanted.*	i. The system relies on the proper calibration of sensors to accurately measure gas concentrations which means slight deviation in the sensors calibration will affect the overall performance of the system. ii. the system is efficient for a localized area, its fixed sensor configuration may not be sufficient to cover larger industrial plants comprehensively without additional sensors or a more distributed setup. iii. The alert mechanism of the system depends on the ESP32's Wi-Fi connectivity and the IFTTT web service. Any interruption in network connectivity could delay or prevent timely SMS notifications, potentially compromising safety

Progress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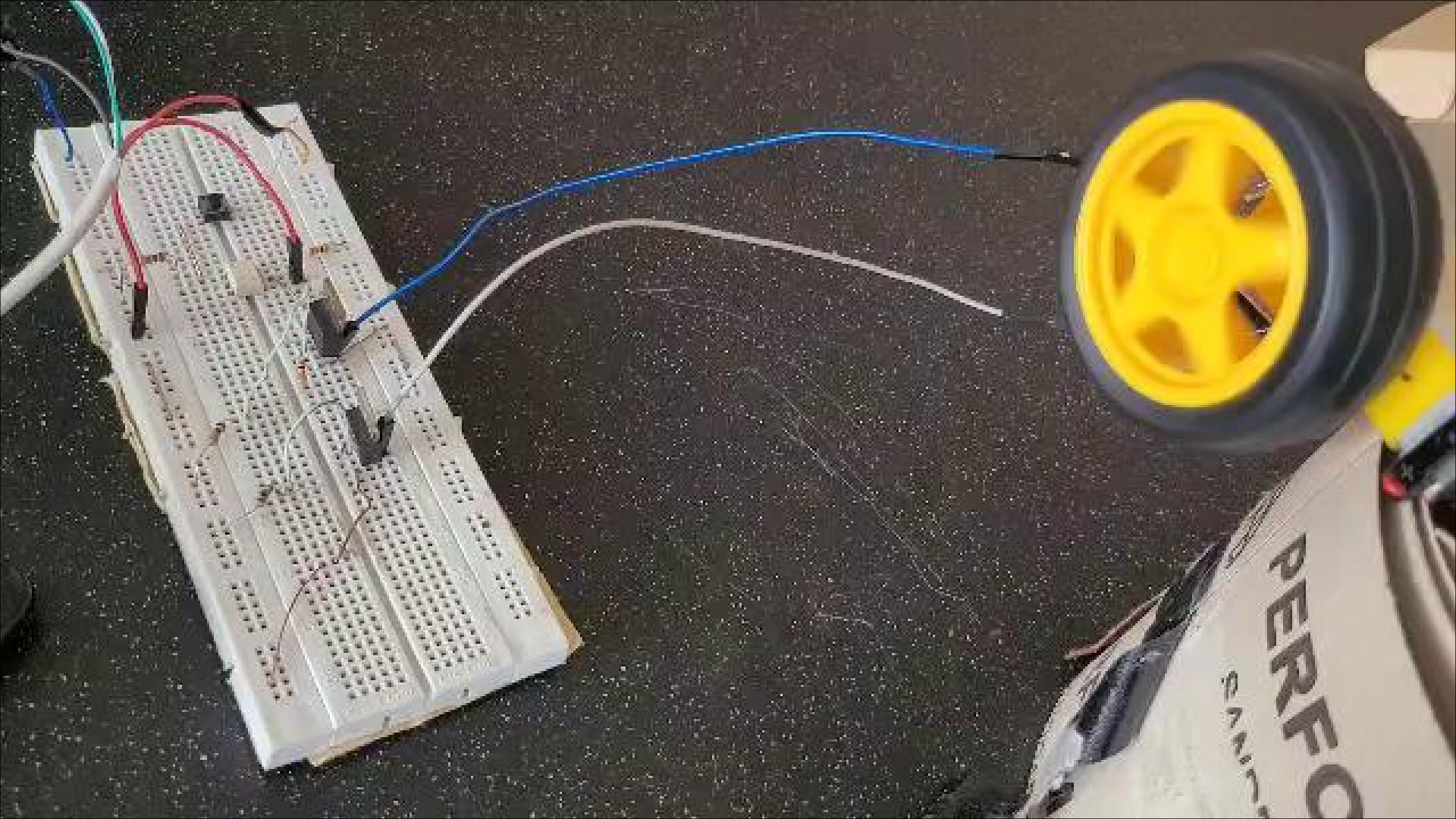

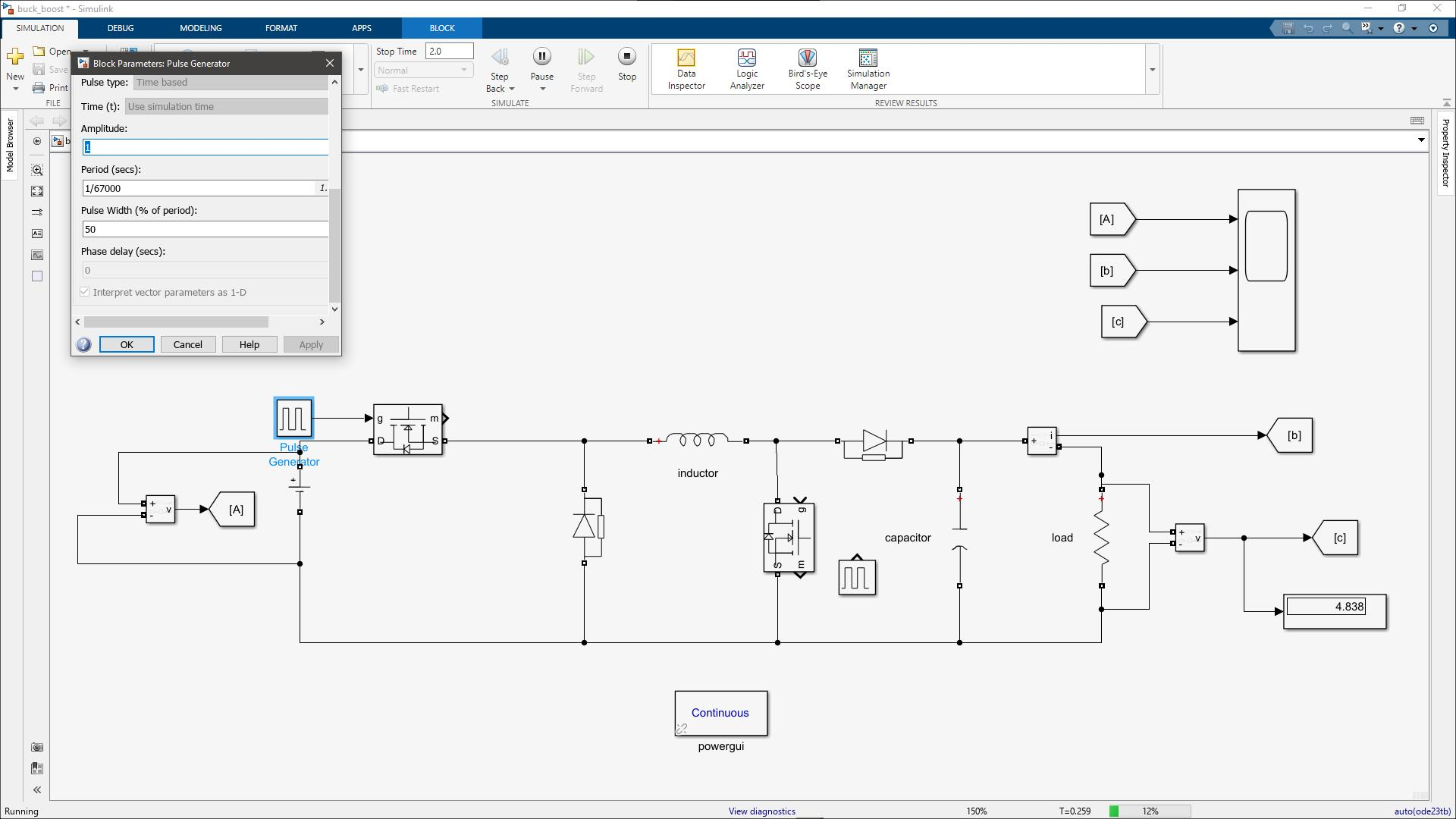
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Help
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Pause
Step Forward
Stop
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Logic Analyzer
Bird's-Eye Scope
Simulation Manager
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REVIEW RESULTS
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Property Inspector
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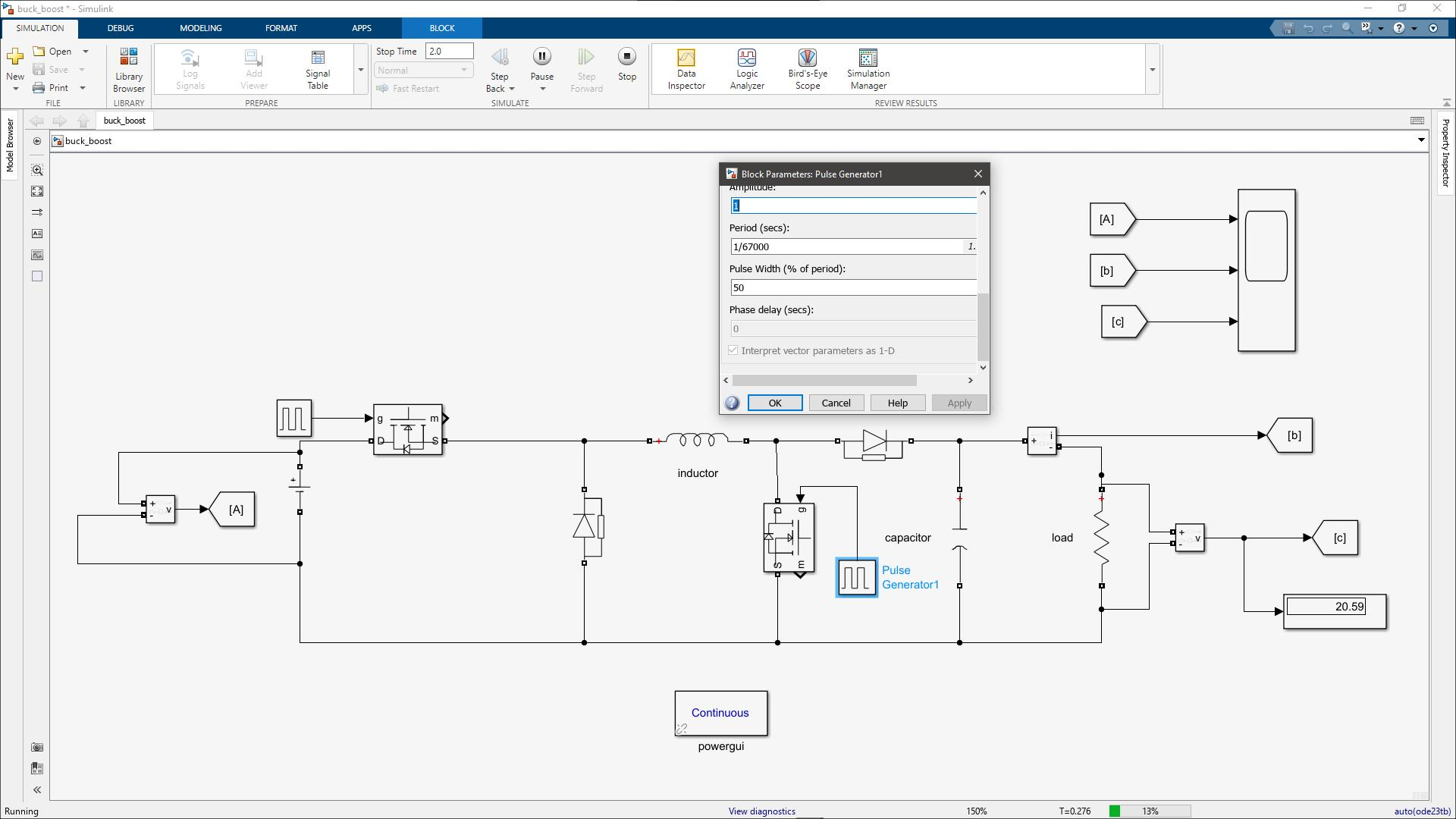
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Library Browser
LIBRARY
Log Signals
Add Viewer
Signal Table
PREPARE
Stop Time
2.0
Normal
Fast Restart
Step Back
Pause
Step Forward
Stop
SIMULATE
Data Inspector
Logic Analyzer
Bird's-Eye Scope
Simulation Manager
REVIEW RESULTS
Model Browser
Property Inspector
buck_boost
Block Parameters: Pulse Generator1
Amplitude:
1
Period (secs):
1/67000
Pulse Width (% of period):
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Phase delay (secs):
0
Interpret vector parameters as 1-D
OK
Cancel
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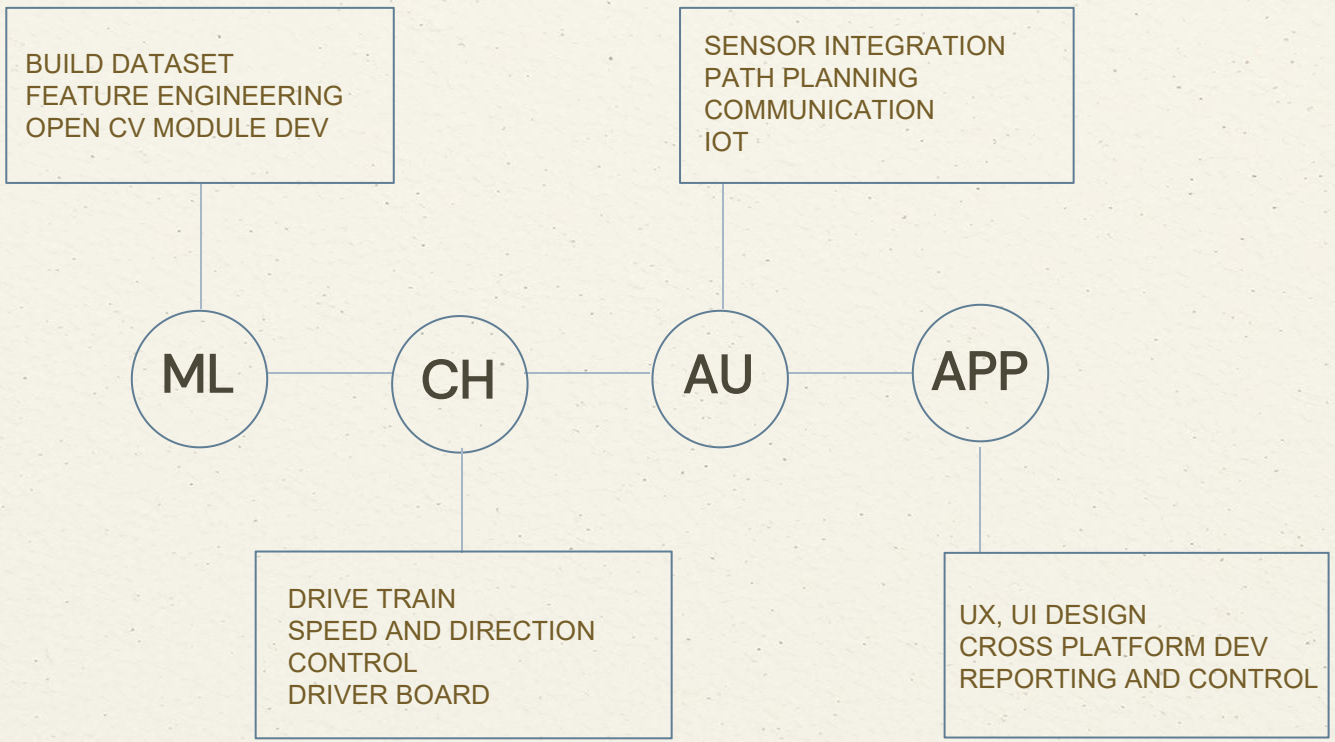
Methodology



Next Steps

UI &
COMMUNICATION
SYSTEM

SENSOR & AI
INTEGRATION

TESTING &
DEPLOYMENT

References

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Thank You!

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