CO$_2$ Emission Detection and Verification Targeting Offshore Oil Rigs Using AI and ML

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Introduction

Problem Statement

Regulatory authorities lack a portable, reliable tool to verify CO$_2$ emissions on offshore rigs. Existing systems are bulky, costly, rely on self-reported data, and struggle in harsh conditions.

Project Objective

To design a portable and cost-effective system that uses machine learning to accurately verify CO$_2$ emissions on offshore rigs

Constraints & Specs.

Constraints

- Data transfer latency 100ms-500ms
- Operate in 0°C to 125°C, and 10-100% humidity
- Ensure no dust infiltration after 1 hour in a dust chamber
- Ensure data bias representation ratio (0.8–1.25)

Specifications

- Microcontroller have at least 8-16 I/O pins
- Weight < 2.3 KG
- Withstand a 1-meter drop onto a concrete surface
- AI model accuracy >75%

- Plotting data over different time periods down to 1s
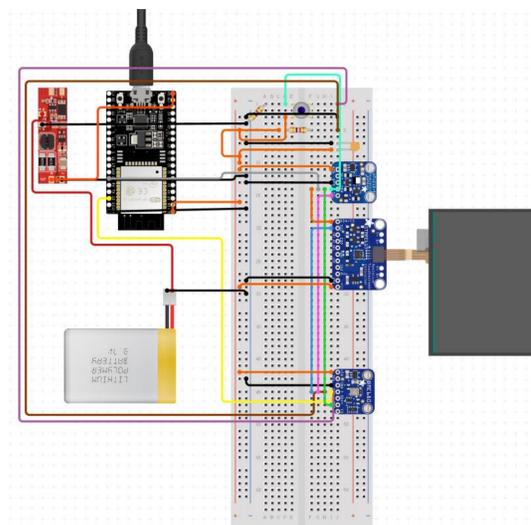- Pass salt spray test with less than 5% surface corrosion

Integrated Specifications

- Time to use < 10 minutes
- Cost less than 5,000 SR
- Measure CO2 emissions of 100 ppm and above

Prototype Design

116.00   98.00
80.00
170.00
16.90
20.00   40.00
29.31
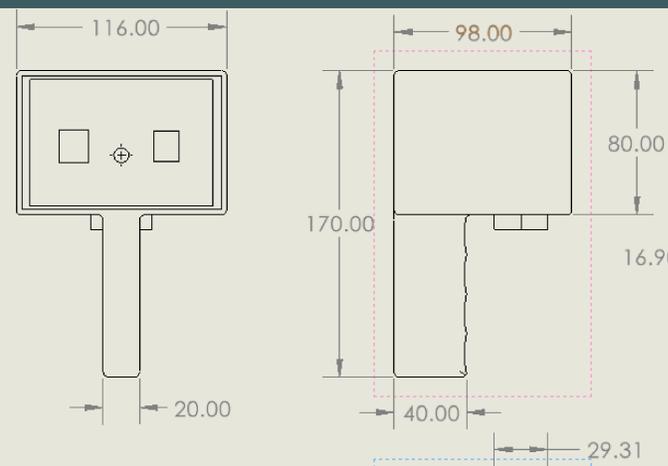
Prototype Circuit Design

Validation & Verification

1. **Boiling Water Bath (~100 °C, 95% RH):** Sensor readings remained accurate under high humidity.
2. **Heat Source (~125 °C):** Device exposed to indirect flame; all components functioned reliably near the upper temperature limit.


The complete handheld prototype weighs **0.391 kg**, comfortably below the 2.3 kg project limit.

Training final RandomForest_50 model
Final model performance on test set:
RMSE: 1851.2325
R²: 0.9231
Tournament winners by round:
Round 1: GradientBoosting_50
Round 2: RandomForest_100
Round 3: RandomForest_50

AI accuracy of 92%, and CO$_2$ Measurement ≥100 ppm

Weak points simulation for the prototype structure, validates the strength integrity
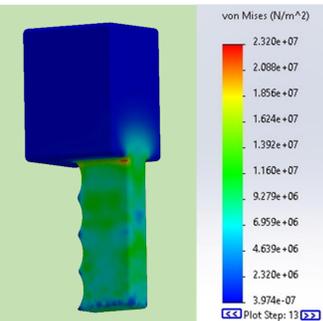
Ensured data latency 100ms-500ms

insertion_time: "2025-04-24T01:26:34.425+03:00"
sensor_data: Object
timestamp: 2025-04-24T01:26:34.000+00:00

_id: ObjectId('680969121f2432eed318e24d')
metadata: Object
    company: "RR"
    location: "abha"
    uuid: "3c:8a:1f:af:1b:20"
    insertion_time: "2025-04-24T01:26:24.484+03:00"
sensor_data: Object
timestamp: 2025-04-24T01:26:24.000+00:00

Deviation Ratio (Predicted CO$_2$) with Rolling Baseline
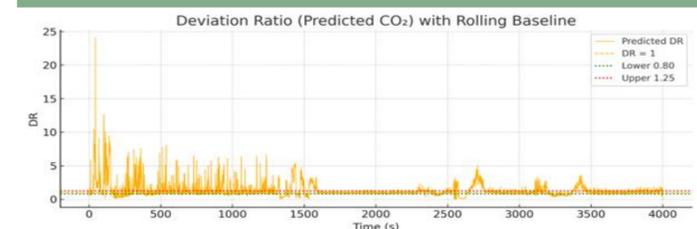
1. **Dashboard** refreshes every second with high consistency and accuracy.
2. **Data Bias/Deviation:** Half of AI predictions stay within defined bias limits.

Conclusion

The project delivered a portable handheld CO$_2$ monitoring system for offshore rigs. It achieved 92% prediction accuracy, weighs 0.391 kg, and costs less than 750 SAR, while operating reliably in harsh conditions.