

FAKULTI TEKNOLOGI KEJURUTERAAN ELEKTRIK DAN ELEKTRONIK

REPORT LAB 1

PBL FORECASTING

BVI 3114 TECHNOLOGY SYSTEM OPTIMIZATION 2

GROUP NUMBER: NO. 5

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Forecasting Algorithm Selection and Implementation Report

Project: Ultrasonic Sensor Forecasting to Google Sheets

Prepared For: ESP32 Sensor Logging System **Sensor Used:** Ultrasonic (distance measurement) **Forecast Duration:** Next 24 hours (hourly)

♦ Part 1: Research and Selection of Forecasting Technique

Q Techniques Reviewed

1. Simple Moving Average (SMA)

Basic Principle:

SMA calculates the average of a specific number of the most recent data points (the "window size"). As new data becomes available, the window shifts forward.

Formula:

$$SMA = \frac{X_t + X_{t-1} + \dots + X_{t-n+1}}{n}$$

Strengths:

- Very easy to implement
- Smooths out short-term fluctuations
- Reduces noise

Limitations:

- Lags behind trends (delayed response)
- All data in the window has equal weight
- Poor for capturing sudden changes

Suitability for Ultrasonic Sensor:

Good for short-term forecasting of stable distance data

Less reactive to rapid changes in sensor environment

2. Exponential Moving Average (EMA)

Basic Principle:

EMA assigns exponentially decreasing weights to older observations. Recent data has more influence, enabling the model to respond more quickly to changes.

Formula:

$$EMA_t = \alpha \cdot X_t + (1 - \alpha) \cdot EMA_{t-1}$$

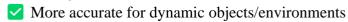
Strengths:

- Reacts faster to recent changes
- More suitable for time-sensitive data
- Better performance in dynamic environments

Limitations:

- Slightly more complex to implement
- Needs careful tuning of α\alphaα

Suitability for Ultrasonic Sensor:



⚠ May overreact to noise in very fluctuating data

✓ Selected Technique: Exponential Moving Average (EMA)

Justification:

- Ultrasonic data may experience fluctuations due to environmental factors (e.g., people passing by).
- EMA offers better responsiveness to short-term variations.
- Can be implemented in **Google Apps Script** efficiently.

***** Part 2: Implementation in Google Apps Script

Forecasting Setup

- Script reads historical ultrasonic distance data from "Sheet1"
- Forecasts next 24 hourly values using EMA
- Results stored in a new sheet named "Forecasts"

Forecast Output Format

Timestamp	Forecasted Value	Upper Bound	Lower Bound
YYYY-MM-DD HH:mm	152.46 cm	167.71 cm	137.21 cm

• **Upper Bound:** +10% (confidence interval)

• Lower Bound: -10%

Key Script Functions

Generate Forecasts()

- Extracts recent historical distance values
- Applies EMA forecasting
- Writes 24 predictions to the "Forecasts" sheet

Calculate EMA(values, alpha)

- Performs exponential smoothing
- Returns the most recent forecasted value based on alpha

Nart 3: ESP32 Configuration Summary

Ultrasonic Reading

- Sampling interval: every 10 seconds
- Validates distance readings before sending to Google Sheets
- Sends data in JSON format to Google Apps Script Web App

Validation Logic

```
cpp CopyEdit bool validateSensorReading(float reading) { if (isnan(reading)) return false; if (reading < 2.0 \parallel reading > 400.0) return false; // Based on HC-SR04 range return true; }
```

Part 4: Looker Studio Dashboard (Optional)

Suggested Components:

- Time-series chart: Historical + Forecasted distances
- Confidence bands using Upper/Lower bounds
- Real-time current reading card
- Accuracy metric chart (if actual vs forecast is tracked)

★ Summary

Criteria	EMA	SMA
Reactiveness	<u>~</u>	X
Ease of Use	<u> </u>	<u> </u>
Suitability for Sensor	<u> </u>	<u> </u>
Feasibility in Apps Script	✓	~

★ Conclusion: EMA is more suitable due to its adaptability and faster response to the ultrasonic sensor's data pattern.