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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

🔍 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:

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

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

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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:
✅ More accurate for dynamic objects/environments
⚠️ 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

🔧 Part 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 || 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	✅	❌
Ease of Use	✅	✅
Suitability for Sensor	✅	⚠️
Feasibility in Apps Script	✅	✅

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