Documentation on forecasting algorithm selection

This project is further development of the Lab 3 ESP32 based soil moisture monitoring system to include forecasting methods to determine future soil moisture levels. Forecasting techniques are key components of current IoT systems, as they inform decision-making methods by predicting future conditions based on actual historical data and trends.

In this project we assessed and implemented two forecasting approaches using Google Apps Script – Exponential Moving Average (EMA) and Linear Regression.

1. Exponential Moving Average (EMA):

EMA is a smoothing technique that weights the most recent recorded data points more than older data points and therefore affects sudden changes in measured soil moisture levels. An example of calculating EMA is:

$$\mathbf{EMA_t = \alpha \cdot x_t + (1 - \alpha) \cdot EMA_{t-1}},$$

where $\mathbf{x_t}$ is the recent moisture reading, $\mathbf{EMA_{t-1}}$, is the previous EMA reading, and $\boldsymbol{\alpha}$ is the smoothing constant (0.1-0.3). EMA is a powerful predictor because it reacts faster to recent changes, which means it can be used to track more sudden moisture variations. However, it does not always capture long-term trends as it weighs most recent changes more heavily than later changes.

2. Linear Regression :

Linear Regression is used to model the relationship between time and soil moisture, assuming a linear trend. It is based on the equation:

$$\mathbf{y = mx + b},$$

where **y** is the predicted moisture, **x** is time, **m** is slope (change rate) and **b** is the intercept. This method is useful for observing long-term wetting or drying trends as a function of time. Linear Regression, however, presupposes linear trend constant, which is not always true for the natural fluctuation of soil moisture in reality.

Both algorithms were written using Google Apps Script and the output was visualized in Looker Studio. The visualization produced in Looker Studio contains sensor data in real time, and includes historical trends and outlooks, allowing users to see how the soil moisture levels have changed over time.

EMA and Linear Regression were used for very different purposes, therefore both algorithms were chosen to handle such different forecasting needs. EMA has the ability to respond to short-term fluctuations of the data, while Linear Regression primarily acted as a longer-term block trend indicator. Each algorithm works together as collaborative inputs into a larger data forecasting solution that is able to strategize shorter term and long-term trends planning.