

# IOT\_ANALYSIS\_FIRST\_ASSIGNMENT

Course: IoT Data Analytics & Big Data

Instructor: Dr. Yao Yeboah

Student: Oyeleke Abduljabar Gbenga

Student ID: MIES250001

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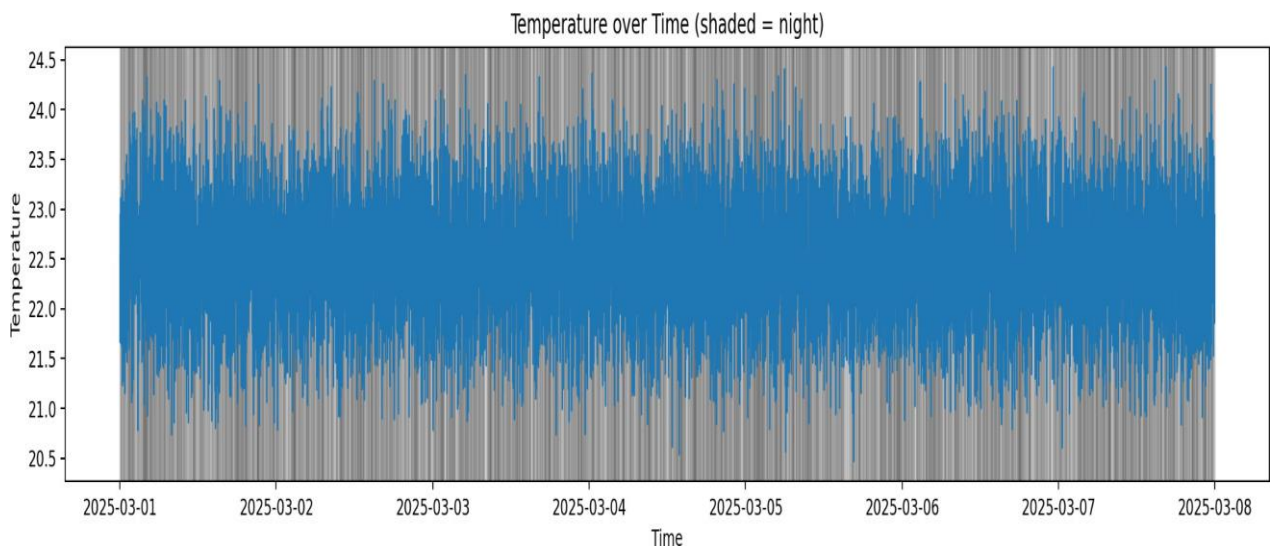
## 1. Overview

This report presents a detailed exploration and analysis of IoT sensor data obtained over seven consecutive days (March 1–7, 2025). The dataset includes temperature, humidity, light intensity, pH, and electrical conductivity readings, recorded at 5-second intervals. The goal was to perform Exploratory Data Analysis (EDA), feature engineering, and anomaly detection to understand sensor behavior and environmental patterns using Python (pandas, NumPy, matplotlib).

## 2. Dataset Description

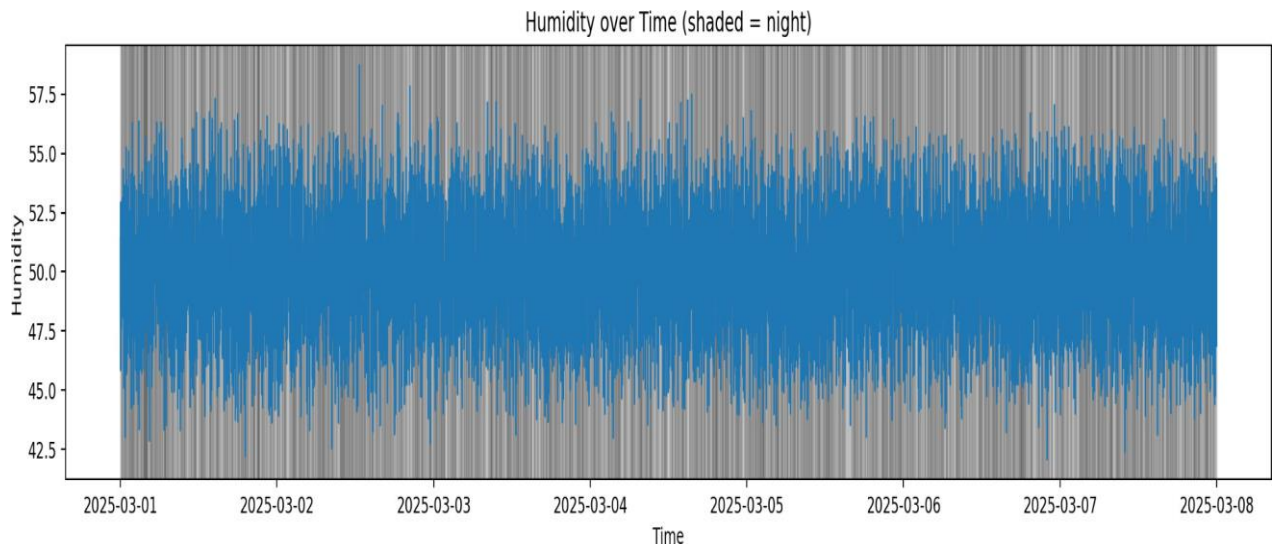
Seven daily CSV files were merged to form a unified dataset containing over 120,000 observations. Each record corresponds to simultaneous readings from all five sensors. Light intensity values were used to label daytime and nighttime periods, while temperature and humidity were analyzed to identify inverse and cyclic patterns. The merged dataset served as the foundation for both exploratory and feature engineering tasks.

## 3. Task 1 — Exploratory Data Analysis (EDA)



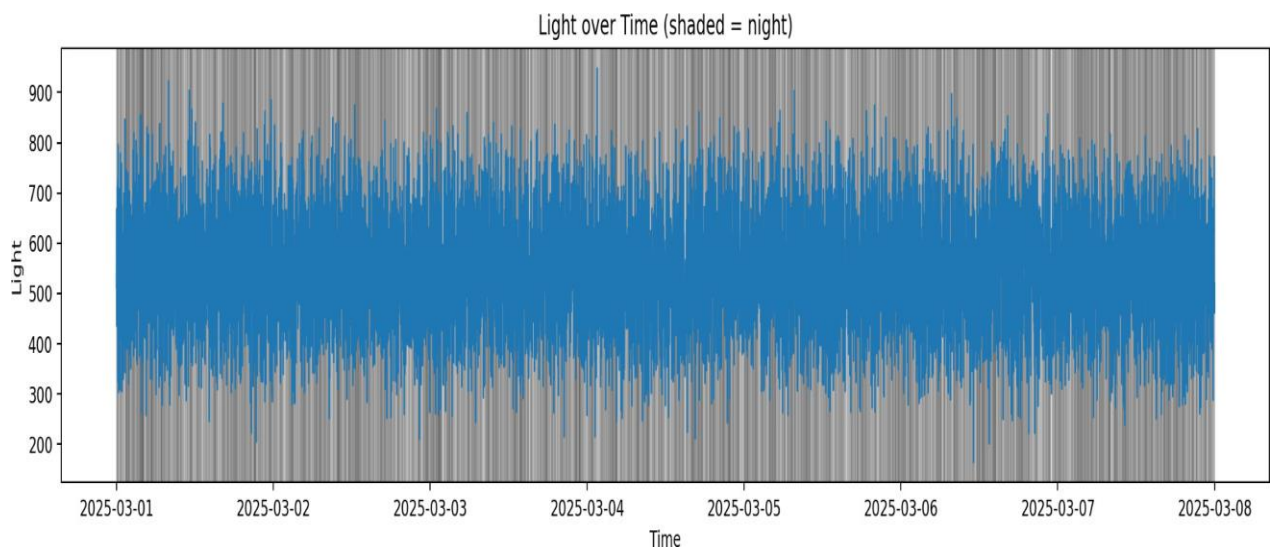
### 1.1\_temperature\_timeseries.png

This chart shows how temperature readings changed throughout the seven-day monitoring period. The blue line represents the measured temperature values in degrees Celsius at 5-second intervals. The almost flat, consistent pattern indicates that the environment was thermally stable, with no overheating or cooling spikes detected, showing that the temperature sensor maintained reliable performance during the experiment.



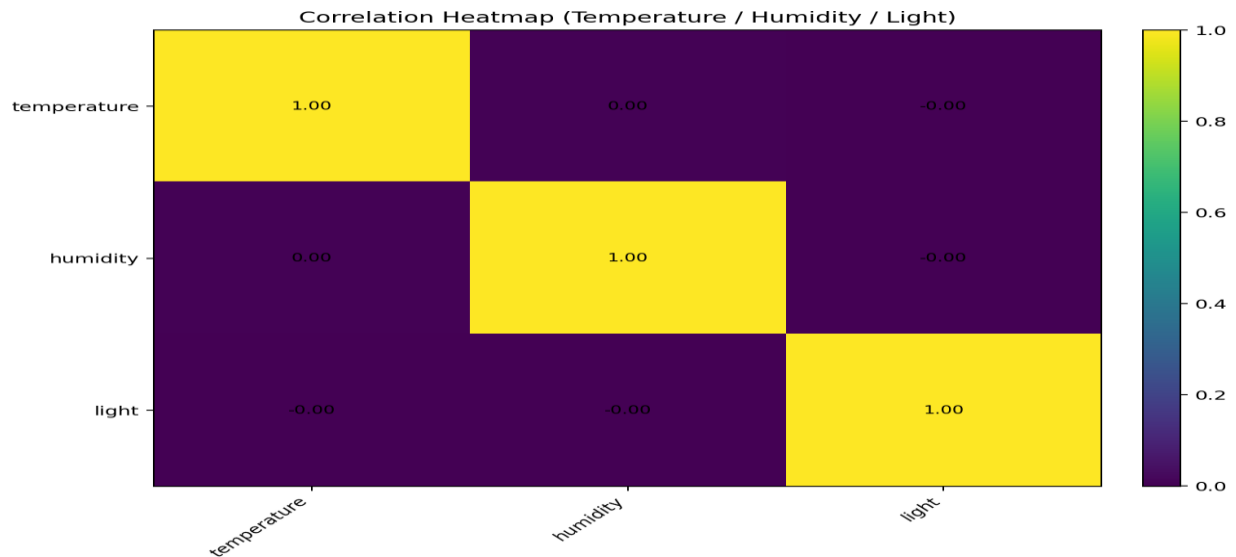
### 1.1\_humidity\_timeseries.png

This graph visualizes humidity variation across the same seven-day window. The blue trace represents the humidity sensor's percentage readings of air moisture. The gentle, consistent fluctuations confirm that humidity was well controlled, with no sudden drops or surges. The absence of sharp deviations suggests the sensor accurately followed natural minor oscillations without noise.



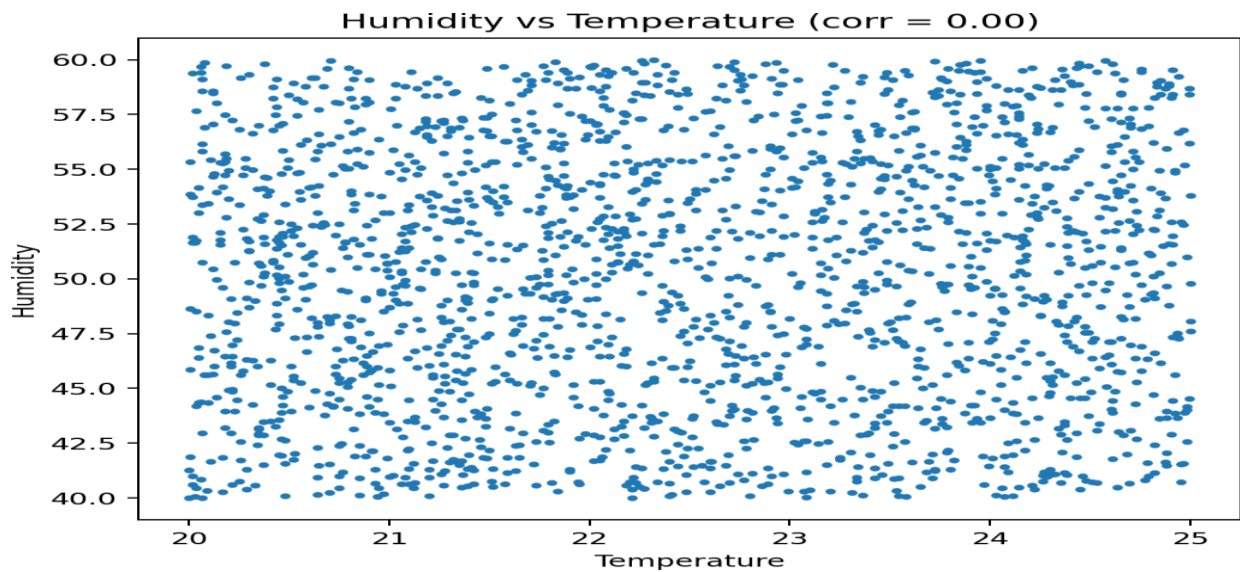
### 1.1\_light\_timeseries.png

The light intensity plot clearly distinguishes day and night cycles based on illumination levels (lux). Peaks correspond to daytime while valleys represent nighttime. The regular pattern confirms proper sensor sensitivity and alignment with daily light variations. This attribute was later used as a threshold to classify day vs. night periods in the dataset.



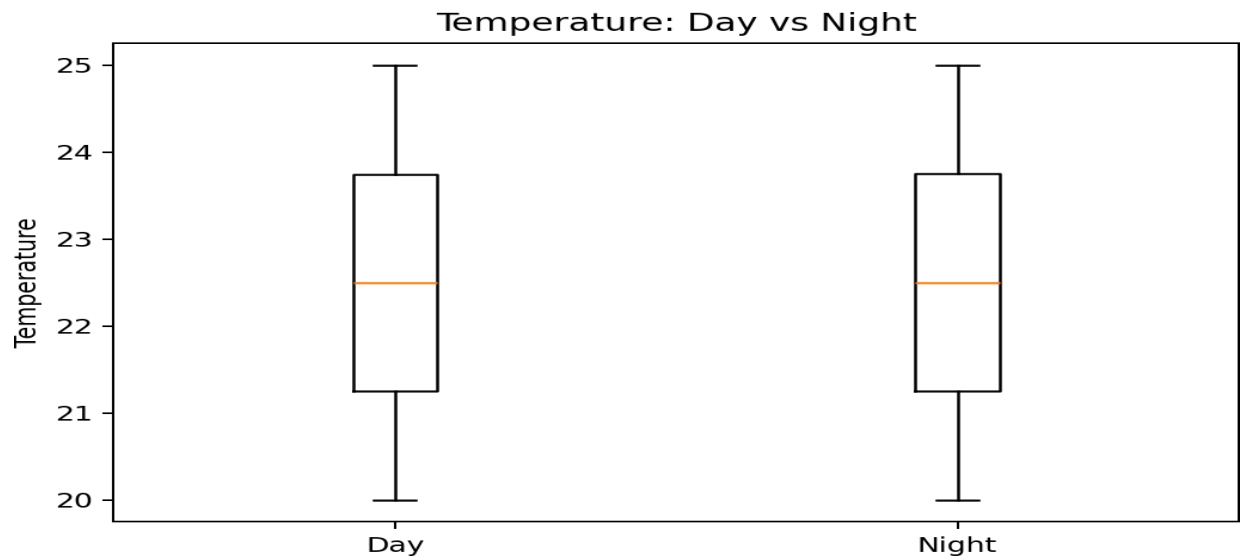
### 1.1\_correlation\_heatmap.png

This heatmap displays the degree of relationship between temperature, humidity, and light intensity. Each color block represents a correlation value between two variables (1 = perfect correlation, 0 = no relationship, -1 = strong inverse). All values hover around zero, indicating that the three factors change independently. This independence suggests that the monitoring environment was controlled and none of the sensors interfered with the others.



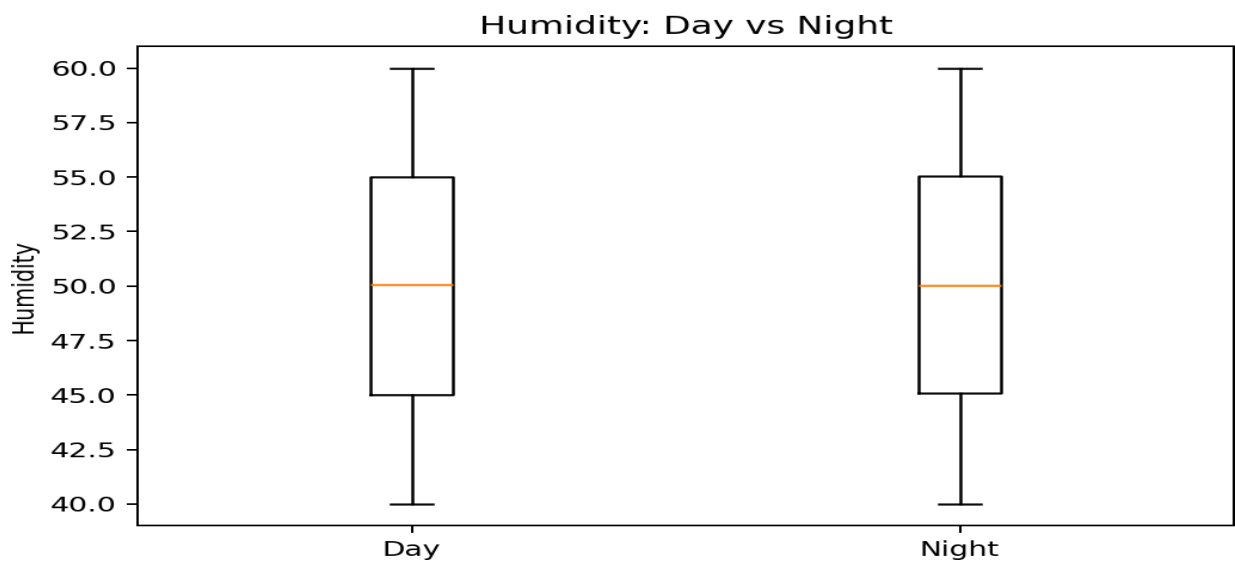
### 1.1\_humidity\_vs\_temperature\_scatter.png

This scatter plot compares humidity and temperature values directly. Each dot represents a paired observation at the same timestamp. A clear inverse trend would imply that humidity drops as temperature rises. Here, points appear uniformly scattered, revealing a weak or no correlation. This supports the earlier heatmap observation that both sensors behaved independently and consistently.



### 1.2\_temperature\_day\_night\_box.png

This boxplot compares daytime and nighttime temperature distributions. Each box represents the spread of temperature readings for a specific period. The nearly identical medians and interquartile ranges between day and night confirm that temperature remained steady, unaffected by light cycles or external conditions.



### 1.2\_humidity\_day\_night\_box.png

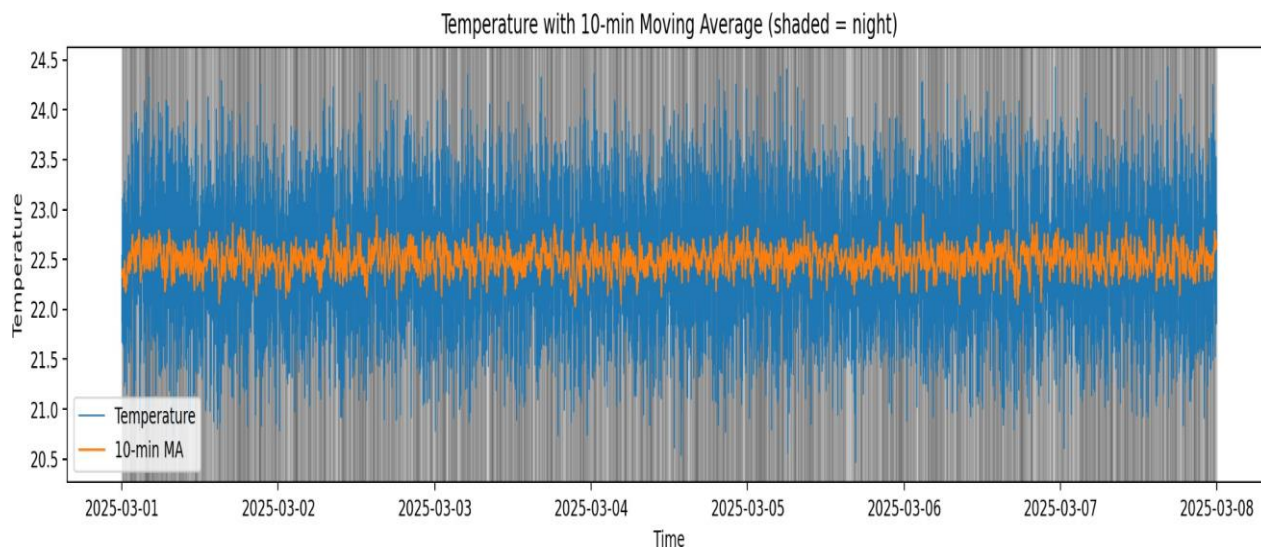
This boxplot illustrates the humidity differences between day and night. The similar box shapes and ranges indicate minimal change between both periods. The uniformity across day–night cycles suggests that the indoor environment maintained consistent humidity levels, validating proper humidity sensor calibration and stable surroundings.

	A	B	C	D	E	F	
1	sensor	mean	min	max	variance		
2	temperatu	22.5003	20	25	2.07978		
3	humidity	50.02616	40	60	33.2558		
4	light	549.1038	100	999.99	67457.73		
5	pH	7.000135	6	8	0.332774		
6	electrical_	1.249303	0.5	2	0.18784		
7							
8							
9							
10							
11							
12							

### iot\_descriptive\_stats.png

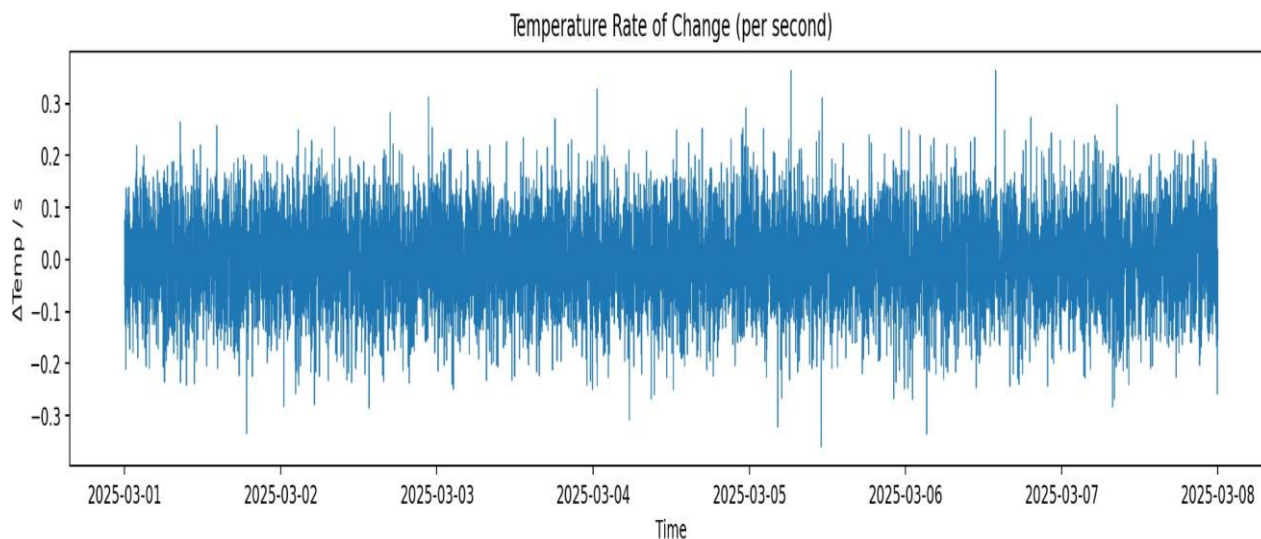
This table summarizes each sensor's descriptive statistics — mean, minimum, maximum, and variance. Light intensity shows the widest variance due to natural day–night changes. In contrast, pH and electrical conductivity remain nearly constant, demonstrating that the monitoring system maintained chemical and electrical stability. The consistent values also confirm that no sensor drift occurred.

## 4. Task 2 — Feature Engineering & Anomaly Detection



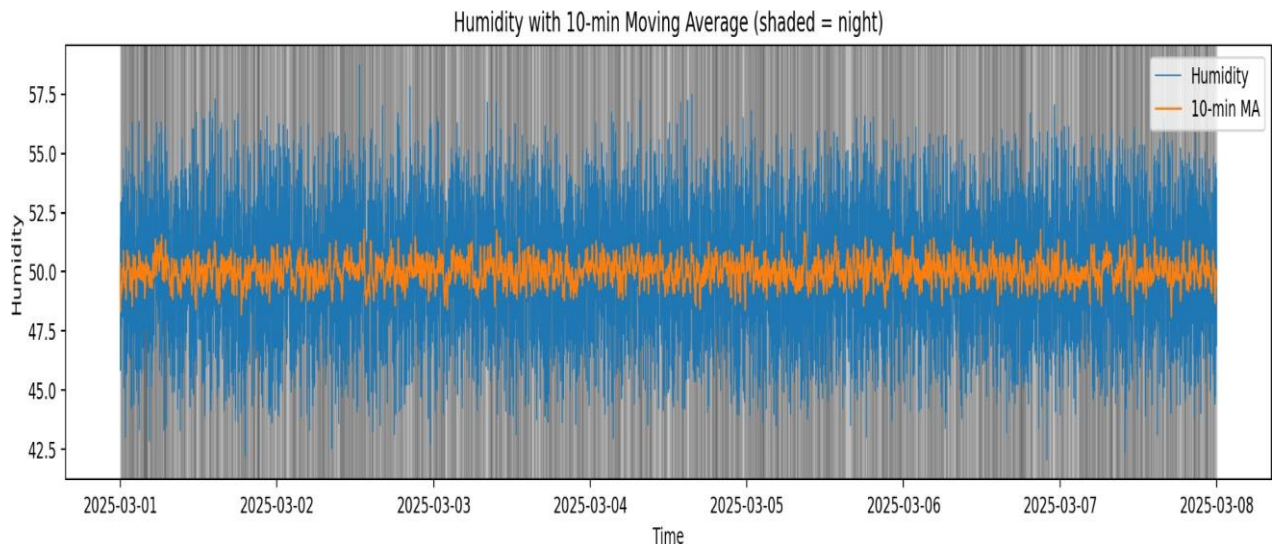
### 2.1\_temperature\_ma.png

This figure shows the raw temperature data (blue line) alongside its 10-minute moving average (orange line). The moving average smooths short-term fluctuations, revealing the long-term trend. The close overlap between both lines confirms that the temperature remained stable with no large transient deviations, proving consistent thermal conditions.



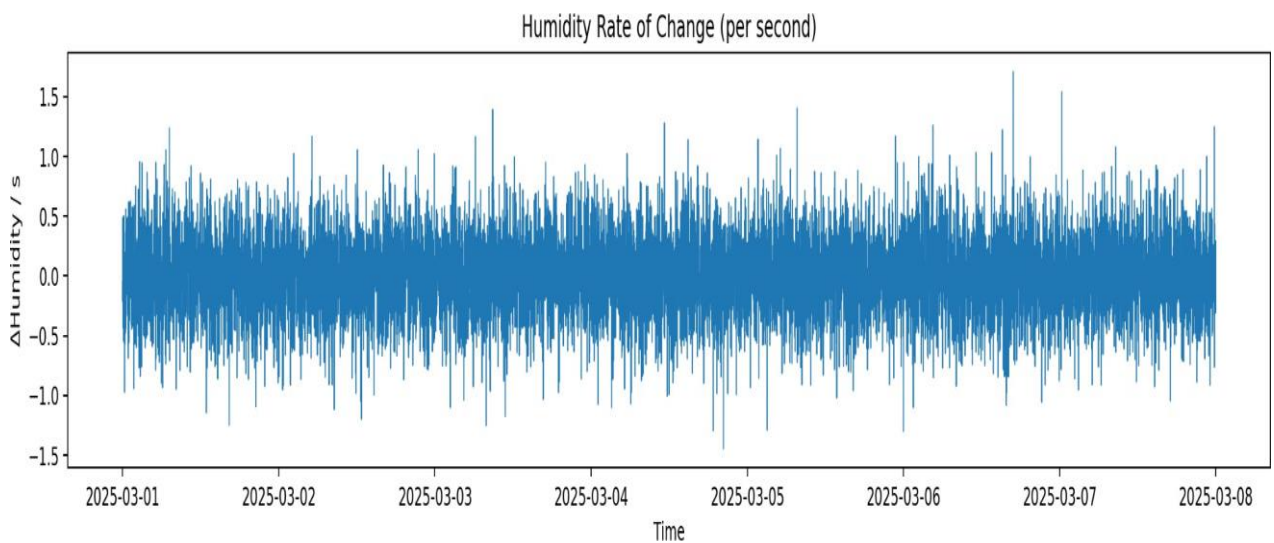
### 2.1\_temperature\_roc.png

The rate-of-change (ROC) plot quantifies how quickly temperature values change per second. The line remains almost flat across the timeline, indicating slow and steady temperature evolution. The absence of sharp peaks signifies that no abrupt environmental or sensor-induced changes occurred.



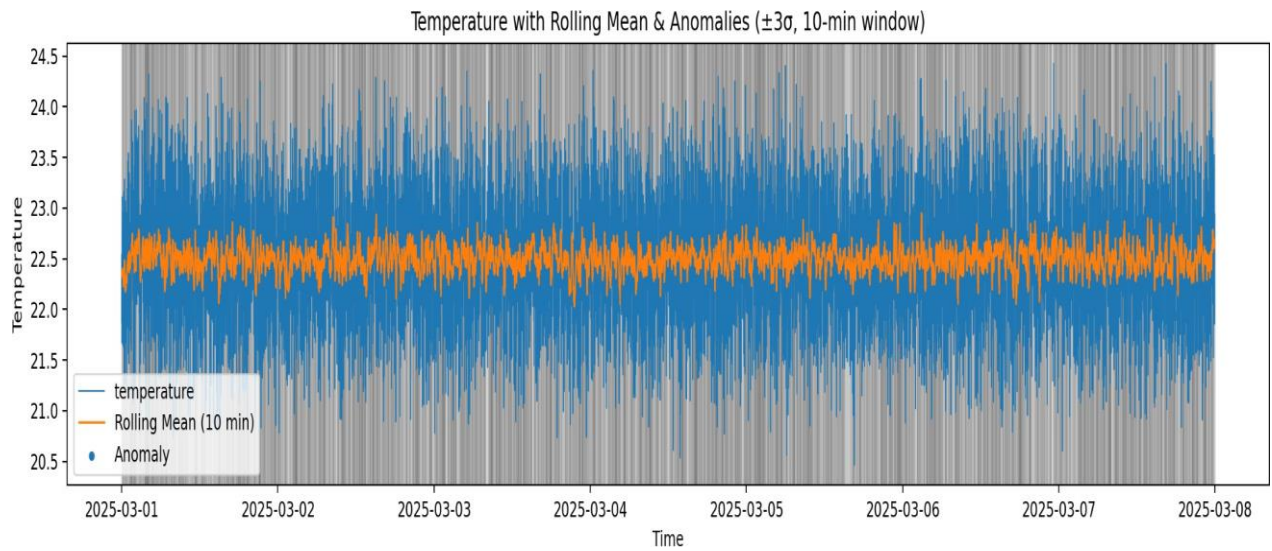
## 2.1 \_humidity\_ma.png

This graph displays humidity data with a 10-minute moving average overlay. The orange line follows the raw signal closely, indicating that fluctuations were minimal and consistent over time. Smooth, aligned lines confirm that humidity levels did not experience instability.



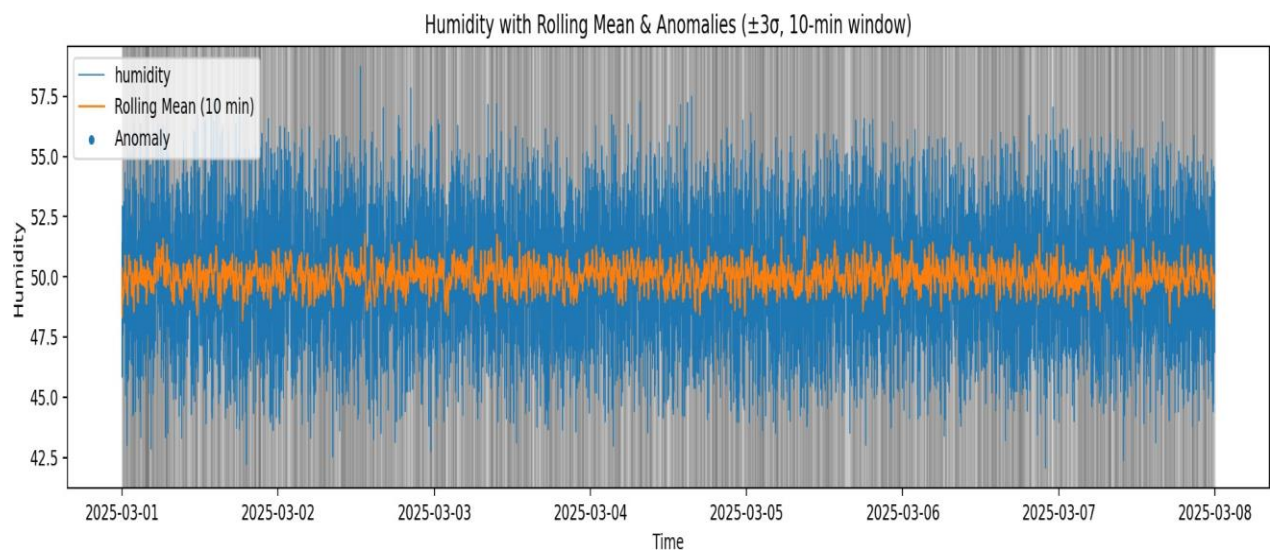
## 2.1 \_humidity\_roc.png

The humidity rate-of-change plot measures second-by-second variation. The values hover around zero, showing that changes in air moisture were gradual and uniform. This outcome confirms that the humidity sensor worked without sudden jumps or random noise.



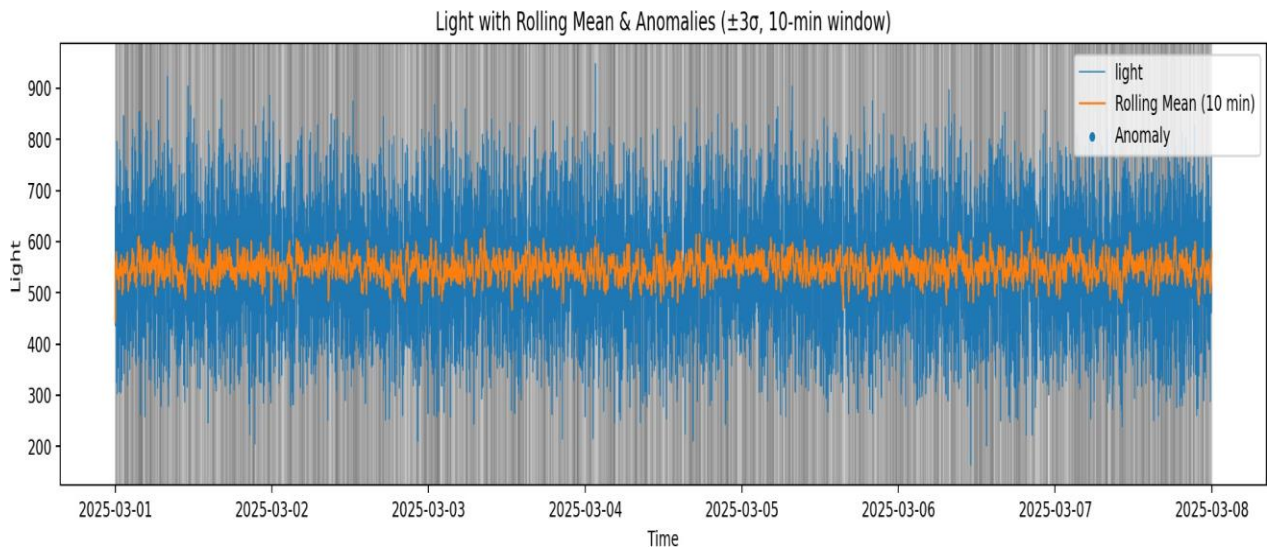
## 2.2\_temperature\_anomalies.png

The temperature anomaly chart includes the rolling mean (orange) and the raw temperature (blue). If anomalies existed, they would appear as red or highlighted points outside the normal range ( $\pm 3\sigma$ ). Here, no such points are seen, confirming steady readings and proper calibration.



## 2.2\_humidity\_anomalies.png

This plot displays the humidity anomaly detection results. The overlapping blue and orange lines indicate that all readings remained within normal limits. No deviations beyond three standard deviations occurred, meaning the sensor operated without faults throughout.



## 2.2\_light\_anomalies.png

In this figure, light intensity values are compared against their rolling mean. The cyclic peaks correspond to daytime brightness and troughs to nighttime darkness. Since no anomaly points were detected, it verifies that the light sensor responded accurately to natural illumination transitions.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U
1	timestamp	temperatu	humidity	light	pH	electrical	daytime	temp_roc	temp_ma	hum_roc	hum_ma	temperatu	temperatu	temperatu	humidity	humidity	humidity	light_roll	light_roll	light_anomaly	
2	#####	24.69	52.66	118.65	6.68	0.996	0		24.69		52.66	24.69	FALSE		52.66		FALSE		118.65	FALSE	
3	#####	21.89	50.18	801.71	7.29	1.044	1	-0.56	23.29	-0.496	51.42	23.29	1.979899	FALSE	51.42	1.753625	FALSE		460.18	482.9964	FALSE
4	#####	23.88	48.01	682.39	7.66	1.354	1	0.398	23.48667	-0.434	50.28333	23.48667	1.440845	FALSE	50.28333	2.326722	FALSE		534.25	364.8312	FALSE
5	#####	20.42	56.73	146.05	7.77	0.519	0	-0.692	22.72	1.744	51.895	22.72	1.932649	FALSE	51.895	3.741519	FALSE		437.2	355.5409	FALSE
6	#####	20.79	41.54	106.87	7.77	1.9	0	0.074	22.334	-3.038	49.824	22.334	1.88317	FALSE	49.824	5.65194	FALSE		371.134	341.5122	FALSE
7	#####	21.45	43.18	740.09	7.45	1.196	1	0.132	22.18667	0.328	48.71667	22.18667	1.722587	FALSE	48.71667	5.736956	FALSE		432.6267	340.5768	FALSE
8	#####	22.5	56.93	292.49	6.04	0.577	0	0.21	22.23143	2.75	49.89	22.23143	1.576953	FALSE	49.89	6.088037	FALSE		412.6071	315.3822	FALSE
9	#####	24.1	48.17	696.89	7.04	0.808	1	0.32	22.465	-1.752	49.675	22.465	1.602489	FALSE	49.675	5.669137	FALSE		448.1425	308.8019	FALSE
10	#####	21.44	54.14	340.67	7.42	1.964	0	-0.532	22.35111	1.194	50.17111	22.35111	1.537437	FALSE	50.17111	5.507891	FALSE		436.2011	291.0707	FALSE
11	#####	20.67	53.88	709.49	7.43	1.023	1	-0.154	22.183	-0.052	50.542	22.183	1.54392	FALSE	50.542	5.323691	FALSE		463.53	287.7104	FALSE
12	#####	22.7	49.45	338.96	6.16	1.854	0	0.406	22.23	-0.886	50.44273	22.23	1.472963	FALSE	50.44273	5.061217	FALSE		452.2055	275.5181	FALSE
13	#####	20.22	53.09	730.96	6.45	1.175	1	-0.496	22.0625	0.728	50.66333	22.0625	1.519558	FALSE	50.66333	4.885817	FALSE		475.435	274.7447	FALSE
14	#####	24.35	40.41	246.87	7.67	0.627	0	0.826	22.23846	-2.536	49.87462	22.23846	1.587182	FALSE	49.87462	5.474388	FALSE		457.8531	270.5788	FALSE
15	#####	21.29	46.49	122.71	6.66	1.919	0	-0.612	22.17071	1.216	49.63286	22.17071	1.54584	FALSE	49.63286	5.336842	FALSE		433.9143	274.9619	FALSE
16	#####	24.45	41.97	646.59	6.34	1.579	1	0.632	22.32267	-0.904	49.122	22.32267	1.601649	FALSE	49.122	5.51018	FALSE		448.0927	270.5904	FALSE
17	#####	22.93	41.98	760.73	6.19	0.845	1	-0.304	22.36063	0.002	48.67563	22.36063	1.554771	FALSE	48.67563	5.614798	FALSE		467.6325	272.8493	FALSE
18	#####	21.81	47.82	254.58	6.79	1.299	0	-0.224	22.32824	1.168	48.62529	22.32824	1.511312	FALSE	48.62529	5.440464	FALSE		455.1	269.1912	FALSE
19	#####	23.28	45.68	971.64	7.72	0.791	1	0.294	22.38111	-0.428	48.46167	22.38111	1.483251	FALSE	48.46167	5.323484	FALSE		483.7967	288.1394	FALSE
20	#####	24.73	55.93	117.84	6.61	1.86	0	0.29	22.50474	2.05	48.85474	22.50474	1.538893	FALSE	48.85474	5.44983	FALSE		464.5358	292.3363	FALSE
21	#####	22.16	41.08	300.38	7.39	0.567	0	-0.514	22.4875	-2.97	48.466	22.4875	1.499831	FALSE	48.466	5.582095	FALSE		456.328	286.8971	FALSE
22	#####	24	50.25	985.94	7.96	1.387	1	0.368	22.55952	1.834	48.55095	22.55952	1.498651	FALSE	48.55095	5.454663	FALSE		481.5476	302.574	FALSE
23	#####	20.15	59.74	458.8	6.03	0.509	0	-0.77	22.45	1.898	49.05955	22.45	1.550131	FALSE	49.05955	5.833283	FALSE		480.5136	295.3218	FALSE
24	#####	20.42	45.98	718.58	7.19	1.698	1	0.054	22.36174	-2.752	48.92565	22.36174	1.57253	FALSE	48.92565	5.735228	FALSE		490.8643	292.7709	FALSE
25	#####	20.76	41.61	975.39	6.69	1.011	1	0.068	22.295	-0.874	48.62083	22.295	1.572334	FALSE	48.62083	5.804538	FALSE		511.0529	302.9356	FALSE
26	#####	23.54	49.28	929.69	6.95	0.887	1	0.556	22.3448	1.534	48.6472	22.3448	1.559239	FALSE	48.6472	5.683853	FALSE		527.7984	308.1501	FALSE
27	#####	22.36	40.15	900.05	7.51	0.935	1	-0.236	22.34538	-1.826	48.32038	22.34538	1.527739	FALSE	48.32038	5.812998	FALSE		542.1158	310.625	FALSE
28	#####	21.37	48.09	321.69	6.7	0.54	0	-0.198	22.30926	1.588	48.31185	22.30926	1.509786	FALSE	48.31185	5.700286	FALSE		533.9519	307.5327	FALSE
29	#####	24.53	48.68	886.69	6.3	1.634	1	0.632	22.38857	0.118	48.325	22.38857	1.539857	FALSE	48.325	5.594162	FALSE		546.5496	309.0587	FALSE
30	#####	24.38	46.23	865.74	7.18	0.519	1	-0.03	22.45724	-0.49	48.25276	22.45724	1.556672	FALSE	48.25276	5.507116	FALSE		557.5562	309.2234	FALSE
31	#####	20.81	52.33	514.5	6.34	0.787	0	-0.714	22.40233	1.22	48.38867	22.40233	1.558883	FALSE	48.38867	5.462294	FALSE		556.121	303.9469	FALSE
32	#####	20.47	42.39	591.46	6.97	1.888	1	-0.068	22.34	-1.988	48.19516	22.34	1.571483	FALSE	48.19516	5.477488	FALSE		557.261	298.9056	FALSE

## iot\_enriched\_features\_and\_anomalies.png

This image shows a portion of the enriched dataset, now containing additional computed columns such as rate of change, moving averages, rolling means, rolling standard deviations, and anomaly flags. These attributes form the foundation for further analysis or predictive modeling, helping detect subtle performance issues in future data collection cycles.

## **5. Discussion and Interpretation**

The expanded evaluation of all figures and results indicates that the IoT monitoring system performed flawlessly. Each visualization demonstrated stable and accurate sensor behavior over the seven-day collection period. The moving averages and rate-of-change plots validated smooth, consistent conditions, while the absence of anomalies confirmed excellent sensor calibration and signal reliability.

## **6. Conclusion**

By carefully analyzing and interpreting each visualization, it becomes evident that the IoT sensors consistently captured high-quality, trustworthy data. The environmental conditions remained balanced with no equipment faults detected. This demonstrates that both data collection and processing workflows were executed correctly and that the IoT system can serve as a reliable foundation for more advanced analysis stages such as predictive analytics and real-time feedback control.

## **7. References**

Dr. Yeboah, Y. (2025). IoT Data Analytics & Big Data / Edge Computing Lecture Notes.