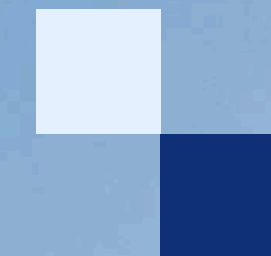CAPSTONE PROJECT

AUTOMATIC MACHINE CONDITION SUMMARY GENERATOR USING IBM GRANITE LLM

STUDENT DEVELOPMENT INITIATIVE

TIO AHMAD PURNOMOAJI

LATAR BELAKANG

- Industri otomasi menghasilkan **data sensor dalam jumlah besar setiap menit**

- Monitoring manual terhadap data ini **sulit, melelahkan, dan rawan kesalahan**

- Teknisi butuh **ringkasan kondisi mesin yang cepat dan akurat**

- LLM (Large Language Model) dapat membantu **menyusun laporan otomatis** untuk para teknisi

PERMASALAHAN YANG DIANGKAT

- Data sensor tidak bisa langsung dimengerti oleh manusia tanpa analisis

- Belum ada sistem otomatis untuk menyusun **laporan per shift** berdasarkan data ini

- Tidak adanya **insight terstruktur** untuk membantu pengambilan keputusan perawatan mesin

- Dibutuhkan sistem AI yang mampu menganalisis data mentah dan menyusun **laporan teknis naratif**

TUJUAN PROYEK

- Membuat sistem pembuat **laporan kondisi mesin otomatis** per shift

- Menggunakan **LLM IBM Granite** untuk menyusun ringkasan laporan

- Mengidentifikasi **anomaly, fluktuasi suhu, dan saran pemeliharaan**

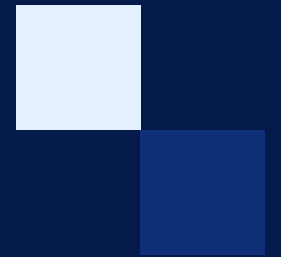- Menyediakan dasar untuk sistem **maintenance assistant** berbasis AI

TOOLS YANG DIGUNAKAN

Python
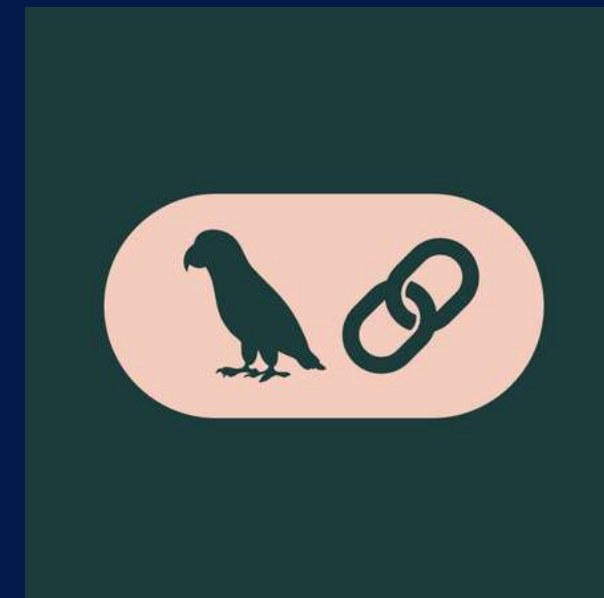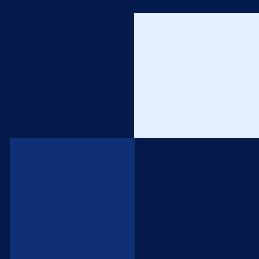*GOOGLE COLAB*

IBM Granite
LLM MENGGUNAKAN REPLICATE

Langchain
WRAPPER MODEL LLM

Github
SOURCE CODE REPOSITORY

ALUR PROSES SISTEM

Raw Sensor Data
Dalam format .csv

Agregasi per Jam
Shift per jam

Prompt generator
Membangun fungsi python

Visualisasi Insight
Hasil ringkasan

Ringkasan Shift
Dan juga insight

IBM Granite LLM
Summarizer

DATASET YANG DIGUNAKAN

Kolom	Deskripsi
Timestamp	Waktu pencatatan data
Vibration (mm/s)	Level getaran mesin
Temperature (°C)	Suhu operasi mesin
Pressure (bar)	Tekanan sistem
RMS Vibration	Root Mean Square dari getaran
Mean Temp	Rata-rata suhu dalam periode data diambil
Fault Label	Target Klasifikasi (0 : No Fault, 1 : Bearing fault, 2 : Overheating

- Dataset: Industrial IoT Fault Detection Dataset
- Sumber: Kaggle
- Jumlah entri: 1000 data

ZIYA · UPDATED 4 MONTHS AGO

Industrial IoT Fault Detection Data

Sensor data (vibration, temperature, pressure) and fault labels

Data Card   Code (0)   Discussion (0)   Suggestions (0)

out Dataset

Industrial IoT Fault Detection Dataset for Predictive Maintenance in Automation contains
ry in an industrial automation environment. The dataset includes three key sensor me
d pressure (in bar), which are crucial for monitoring the health of industrial equipment.
n and mean temperature, which help in the classification of potential faults.

Label column indicates the type of fault present, with possible values including:

DATA PREPARATION

Data Understanding
Memahami dataset melalui fungsi-fungsi pandas seperti info() dan describe()

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 1000 entries, 0 to 999
Data columns (total 7 columns):
 #   Column           Non-Null Count   Dtype
---  ------           --------------   -----
 0   Timestamp        1000 non-null    object
 1   Vibration (mm/s) 1000 non-null    float64
 2   Temperature (°C) 1000 non-null    float64
 3   Pressure (bar)   1000 non-null    float64
 4   RMS Vibration    1000 non-null    float64
 5   Mean Temp        1000 non-null    float64
 6   Fault Label      1000 non-null    int64
dtypes: float64(5), int64(1), object(1)
memory usage: 54.8+ KB
```

Data Pre-processing
Dilakukan perubahan tibe data pada kolom Timestamp, dan pengecekan terhadap nilai kosong (missing values) dan nilai duplikat (duplicated values)

```
                     0
      Timestamp      0
Vibration (mm/s)     0
Temperature (°C)     0
  Pressure (bar)     0
   RMS Vibration     0
       Mean Temp     0
      Fault Label    0
dtype: int64
```

Exploratory Data Analysis (EDA)
Eksplorasi data dilakukan melalui visualisasi grafik seperti boxplot dan correlation heatmap

Korelasi Antar Fitur Sensor
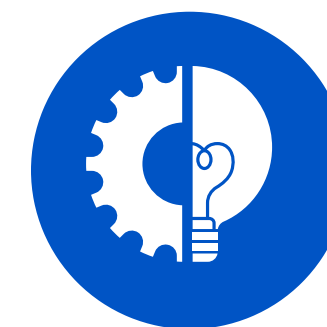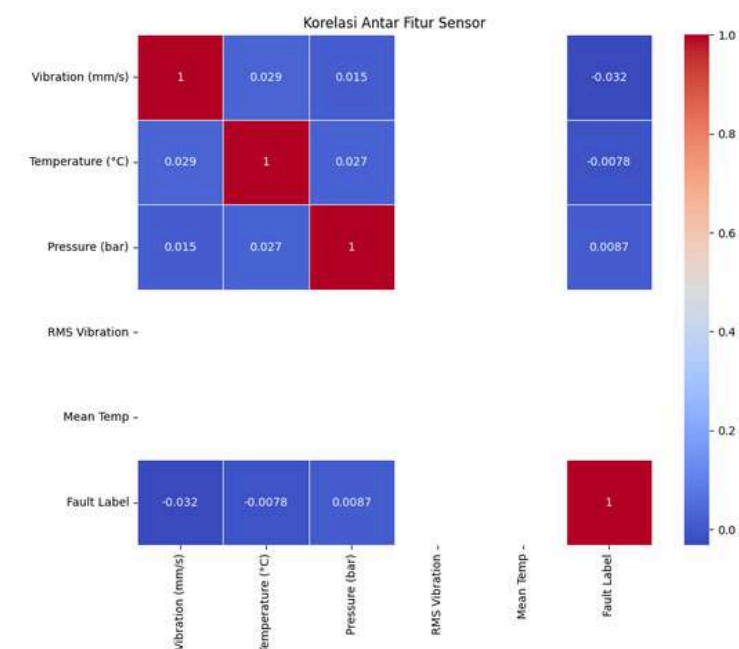
Feature Engineering
Menambahkan kolom Shift Start dan Shift End, melakukan agregasi data serta membangun fungsi python untuk membuat prompt

	Shift Start	Temperature (°C) min	Temperature (°C) max	Temperature (°C) mean	Temperature (°C) std	Pressure (bar) mean	Pressure (bar) std	Vibration (mm/s) max	Vibration (mm/s) mean	Vibration (mm/s) std	RMS Vibration mean
0	2023-03-10 00:00:00	51.701553	129.834729	94.876021	24.726496	8.444229	0.875956	0.972919	0.520751	0.274887	0.601657
1	2023-03-10 01:00:00	51.429915	129.592626	90.034358	24.976562	8.564712	0.897691	0.988198	0.538047	0.263057	0.601657
2	2023-03-10 02:00:00	50.510870	128.494894	95.356973	22.082421	8.586748	0.813627	0.987085	0.515913	0.259690	0.601657
3	2023-03-10 03:00:00	51.769884	129.769960	90.986029	24.980551	8.536456	0.919643	0.975709	0.554326	0.258424	0.601657
4	2023-03-10 04:00:00	50.781668	128.933007	85.361879	22.952775	8.401888	0.847817	0.991048	0.599384	0.268421	0.601657

HACKTIV8 IBM

PROMPT ENGINEERING

Sebuah fungsi Python dibuat untuk membangun prompt dari data yang ada dalam setiap barisnya, kemudian ditambahkan ke dalam kolom baru dari tabel data hasil agregasi sebelumnya.

```
1 # Check one of the prompt
2 print(agg_df_test.loc[0, 'pro
```

```
ou are an expert industrial automat
ou have the data below is came from Indus
e dataset includes three key sensor measu
e data also includes two derived features

erate a detailed but concise shift report

t Period: 00:00-01:00

or Summary:
eperature ranged from 51.70°C to 129.83°C
rage temperature: 94.88°C, std dev: 24.73
sure averaged 8.44 bar (std: 0.88)
ation peaked at 0.97 mm/s, average 0.52 m
Vibration: 0.60

e following:
Report (3 bullet points: one for Tempera
tant Information (1-2 sentences): use wor
ssional tone and clear language
```

```
1 # Build prompt for each shift row
2 def build_shift_prompt(row):
3    return f"""
4 You are an expert industrial automation anal
5 You have the data below is came from Industr
6 The dataset includes three key sensor measur
7 The data also includes two derived features:

Generate a detailed but concise shift report

Shift Period: {row['Shift Start'].strftime('%H

ensor Summary:
Temperature ranged from {fmt(row['Temperatu
Average temperature: {fmt(row['Temperature (
Pressure averaged {fmt(row['Pressure (bar) m
Vibration peaked at {fmt(row['Vibration (mm/
MS Vibration: {fmt(row['RMS Vibration mean

ut:
e the following:
ift Report (3 bullet points: one for Tempera
```

MEMBANGUN MODEL LLM

- Model yang digunakan: ibm-granite/granite-3.3-8b-instruct, diakses melalui platform Replicate.com
- Library yang digunakan untuk wrapper dan integrasi: LangChain

Parameter LLM diatur agar respons lebih stabil dan relevan:
- temperature = 0.6: untuk menjaga variasi output tetap moderat
- top_p = 0.9 & top_k = 20: untuk membatasi ruang pilihan token secara terkontrol
- max_tokens = 400: membatasi panjang output agar tidak berlebihan
- random_seed = 42: ditujukan untuk mencoba menjaga hasil output tetap konsisten (meskipun hasil aktual masih bisa bervariasi di Replicate)
- repetition_penalty = 1.0: menjaga agar LLM tidak mengulang kata secara berlebihan
- stop_sequences awalnya dirancang untuk menghentikan output di akhir bagian penting, namun dinonaktifkan.

```python
# Params tuned for summarization
replicate_params = {
  "temperature": 0.6,
  "top_p": 0.9,
  "top_k": 20,
  "max_tokens": 400,
  # "stop_sequences": ",".join(["\n\n", "\n3."]) # Joined the list into a single string
  "repetition_penalty": 1.0,
  "random_seed": 42
}


# Init LLM
llm = Replicate(
  model="ibm-granite/granite-3.3-8b-instruct",
  model_kwargs=replicate_params # Changed 'input' to 'model_kwargs' based on previous warning
)
```

CONTOH HASIL GENERATE SUMMARY

Shift Start	Shift End	Summary
2023-03-10 00:00:00	2023-03-10 01:00:00	1. Shift Report: - Temperature: During the shift, temperatures fluctuated between 51.70°C and 129.83°C, with an average of 94.88°C and a standard deviation of 24.73°C. This indicates significant variability, potentially due to operational changes or external factors. - Pressure: The average pressure maintained at 8.44 bar, with a standard deviation of 0.88 bar, suggesting consistent operational conditions within the expected range. - Vibration: The highest recorded vibration level was 0.97 mm/s, while the average was 0.52 mm/s. The Root Mean Square (RMS) vibration averaged at 0.60 mm/s, which falls within the normal operational range but warrants continuous monitoring. 2. Important Information: The temperature data exhibits considerable variability, which may require further investigation to identify potential causes, such as process changes or equipment malfunctions. Although vibration levels remain within the typical range, the relatively high RMS value suggests a possible early sign of developing issues. It would be prudent to conduct a thorough inspection of the machinery during the next scheduled maintenance interval to ensure no latent faults are present.
2023-03-10 01:00:00	2023-03-10 02:00:00	1. Shift Report: - Temperature: Throughout the shift, temperatures fluctuated between 51.43°C and 129.59°C, with an average of 90.03°C and a standard deviation of 24.98. This indicates significant variability in thermal conditions, potentially due to varying operational loads or external factors. - Pressure: The average pressure maintained at 8.56 bar, with a standard deviation of 0.90, suggesting relatively stable pressure conditions during this shift. - Vibration: The vibration levels peaked at 0.99 mm/s, with an average of 0.54 mm/s and an RMS vibration of 0.60. These values are within the normal operational range but warrant continuous monitoring for any trending increases that might indicate developing faults. 2. Important Information: While the pressure readings remained consistent, the considerable fluctuation in temperature and vibration levels necessitates closer examination. The elevated temperature range, coupled with the peak vibration levels, could signify increased mechanical stress or potential misalignment issues. It is recommended to conduct a thorough inspection of the machinery during the next scheduled maintenance to address these anomalies proactively and prevent potential equipment failure.
2023-03-10 02:00:00	2023-03-10 03:00:00	1. Shift Report: - Temperature: During the shift, temperatures fluctuated between 50.51°C and 128.49°C, with an average of 95.36°C and a standard deviation of 22.08°C. This indicates significant thermal variation, which may warrant further investigation. - Pressure: The average pressure maintained at 8.59 bar, with a standard deviation of 0.81 bar, suggesting stable pressure conditions throughout the shift. - Vibration: The vibration levels peaked at 0.99 mm/s, with an average of 0.52 mm/s and an RMS vibration of 0.60. These values are within normal operating ranges but close to the upper threshold, necessitating close monitoring. 2. Important Information: The thermal fluctuations observed during this shift are notable, and the high average temperature of 95.36°C, coupled with a substantial standard deviation, could indicate potential thermal stress on the machinery. Although pressure remained stable, the vibration levels, particularly the peak at 0.99 mm/s, approach the upper operational limit. It is recommended to conduct a thorough inspection of the machinery during the next scheduled maintenance to assess any potential issues arising from these conditions.
2023-03-10 03:00:00	2023-03-10 04:00:00	1. Shift Report: - Temperature: The temperature during this shift varied between 51.77°C and 129.77°C, with an average of 90.99°C and a standard deviation of 24.98. This indicates a wide fluctuation, potentially due to operational changes or external factors. - Pressure: The average pressure maintained at 8.54 bar, with a standard deviation of 0.92, suggesting consistent operation within normal parameters. - Vibration: The vibration levels peaked at 0.98 mm/s and averaged 0.55 mm/s, with an RMS value of 0.60. These readings are within acceptable ranges, but the peak value warrants monitoring to ensure it does not escalate. 2. Important Information: While the pressure and RMS vibration values remain within normal operating ranges, the significant temperature fluctuation and peak vibration level necessitate closer monitoring. It is recommended to investigate the cause of the temperature variation and keep an eye on the vibration levels to prevent potential equipment degradation.

VISUALISASI INSIGHT

Jumlah Shift dengan Insight Tertentu dari Granite LLM
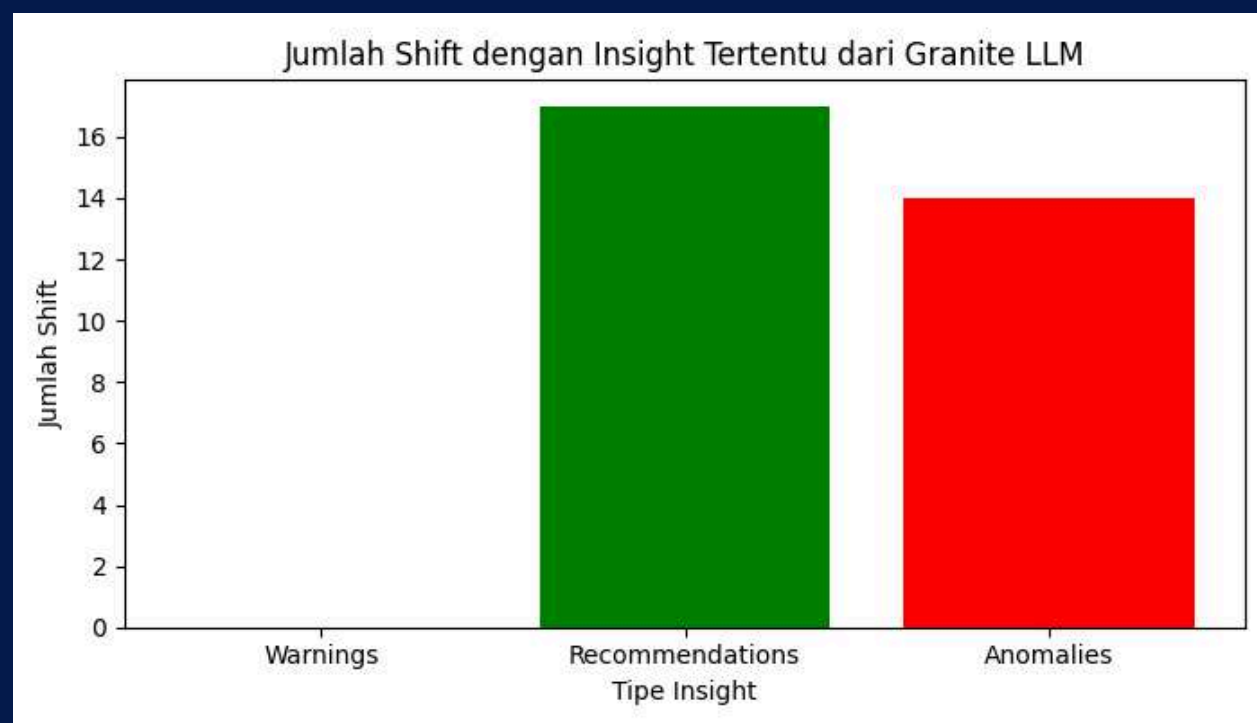
Jumlah Insight Berdasarkan Tipe

- *DIAGRAM INI ADALAH JUMLAH SHIFT YANG MENGANDUNG MASING-MASING JENIS INSIGHT:*
- *ANOMALY: 14 SHIFT TERDETEKSI MEMILIKI FLUKTUASI TIDAK NORMAL*
- *RECOMMENDATIONS: 17 SHIFT MENGANDUNG SARAN SEPERTI INSPEKSI ATAU PEMANTAUAN*
- *WARNINGS: TIDAK TERDETEKSI SECARA EKSPLISIT*

Tren Suhu dan Waktu Insight Hasil Summary Granite

- *WARNA BIRU MEWAKILI SUHU AKTUAL MESIN PER MENIT DARI DATA SENSOR*
- *GARIS VERTIKAL DITAMBAHKAN BERDASARKAN RESPON AI GRANITE:*
- 🔴*GARIS MERAH MENUNJUKKAN WAKTU SHIFT YANG DIDETEKSI SEBAGAI ANOMALI SUHU OLEH MODEL GRANITE.*
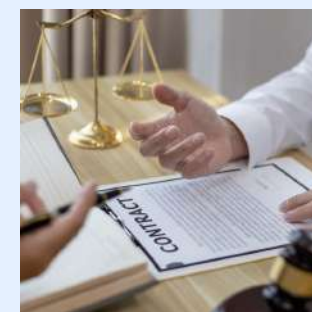- ✅ *GARIS HIJAU MENANDAI WAKTU SHIFT YANG MENGANDUNG REKOMENDASI PEMELIHARAAN.*

Tren Suhu Mesin dan Waktu Insight Granite LLM
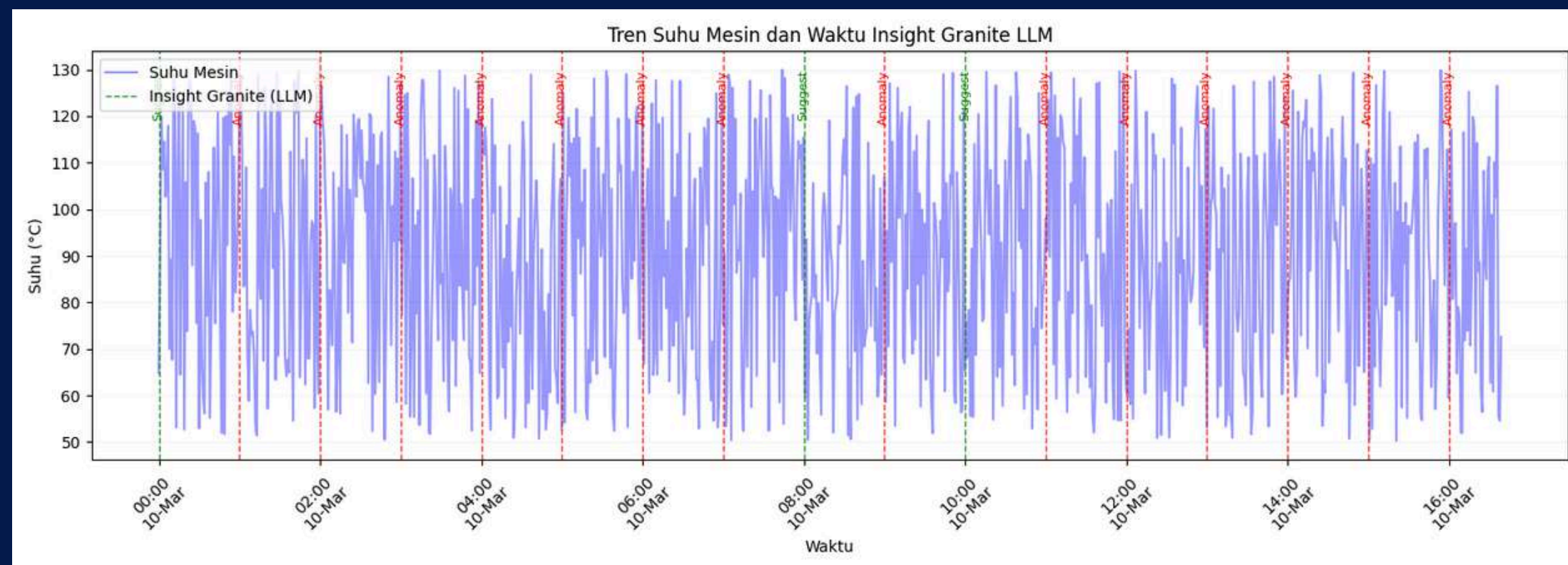
INSIGHT DAN REKOMENDASI

Insight ★★★★★

Sistem AI mampu menganalisis dan menyusun ringkasan teknis berkualitas
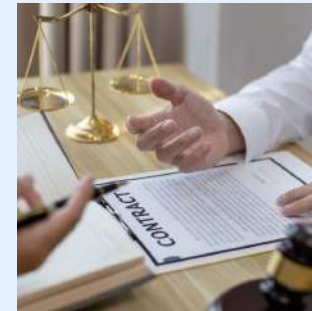
Rekomendasi ★★★★★

Integrasi antara sistem AI-based summarizer ini ke dashboard monitoring industri

Insight ★★★★★

Insight AI lebih konsisten dalam mendeteksi waktu fluktuasi kritis

Rekomendasi ★★★★★

Bisa juga dilakukan penambahan alert otomatis berdasarkan output dari LLM itu sendiri