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# India SMART UTILITY Week 2025

**Session : DEEP DIVE SESSION ON AI, ML AND ROBOTICS USE CASES FOR UTILITIES**

**NOVEL METHOD FOR ALARMING SYSTEM BASED ON OPTICAL CHARACTER RECOGNITION AND MACHINE LEARNING**

*Presented By*

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## Leveraging OCR, OpenCV, and Local LLMs for Fault Detection and Proactive Maintenance in HVDC Converter Stations

- In power systems, data drives decision-making, fault analysis, and maintenance.
- Utilities rely on data to monitor, control, and optimize complex systems like power-grids including FACTS.

- One of our HVDC station commissioned in 2005 lacks an operator intuitive interface, audible alarms and dedicated historical data processing.
- For an instance, the absence of an audible alarm in the existing HMI poses a significant operational risk. Visual alerts alone may not capture the operator's attention during high-stress scenarios, leading to delayed responses.
- Replacing legacy systems is often prohibitively expensive and are also limited by complexity of technology , OEM support and Obsolescence.
- To address the above difficulties, a Raspberry Pi 4-based system was developed, utilizing a camera module, OpenCV for image processing, OCR for text extraction, and AI-based keyword detection. Upon identifying fault-related keywords, the system triggers an audible alarm .
- This solution enhanced the observability of critical events and improved the overall reliability of the HVDC converter station. The presentation also explores the integration of AI for training the fault detection system to improve accuracy and adaptability.

## **Challenges in Power Systems:**

- Complexity: FACTS devices and HVDC systems are highly complex to operate and maintain.
- Legacy Limitations: Legacy systems cannot handle modern requirements for real-time monitoring and predictive maintenance.

## **Need for Advanced Tools:**

- Integration of ML, and LLMs to enhance system observability and reliability.
- Modernizing legacy systems without costly replacements.

## **Relevance:**

- Our project Demonstrated how AI, ML, and LLMs can bridge the gap between legacy systems and modern requirements.
- Provides a cost-effective, scalable solution for fault detection, predictive maintenance, and operational efficiency.

## AI Integration for Enhanced Fault Detection

### Data Collection

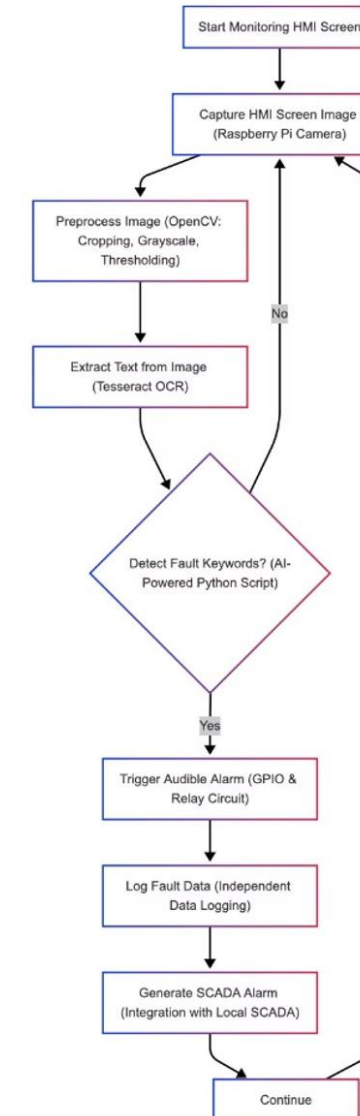
Create a dataset of HMI screen images, including both normal and fault conditions.

### Model Training

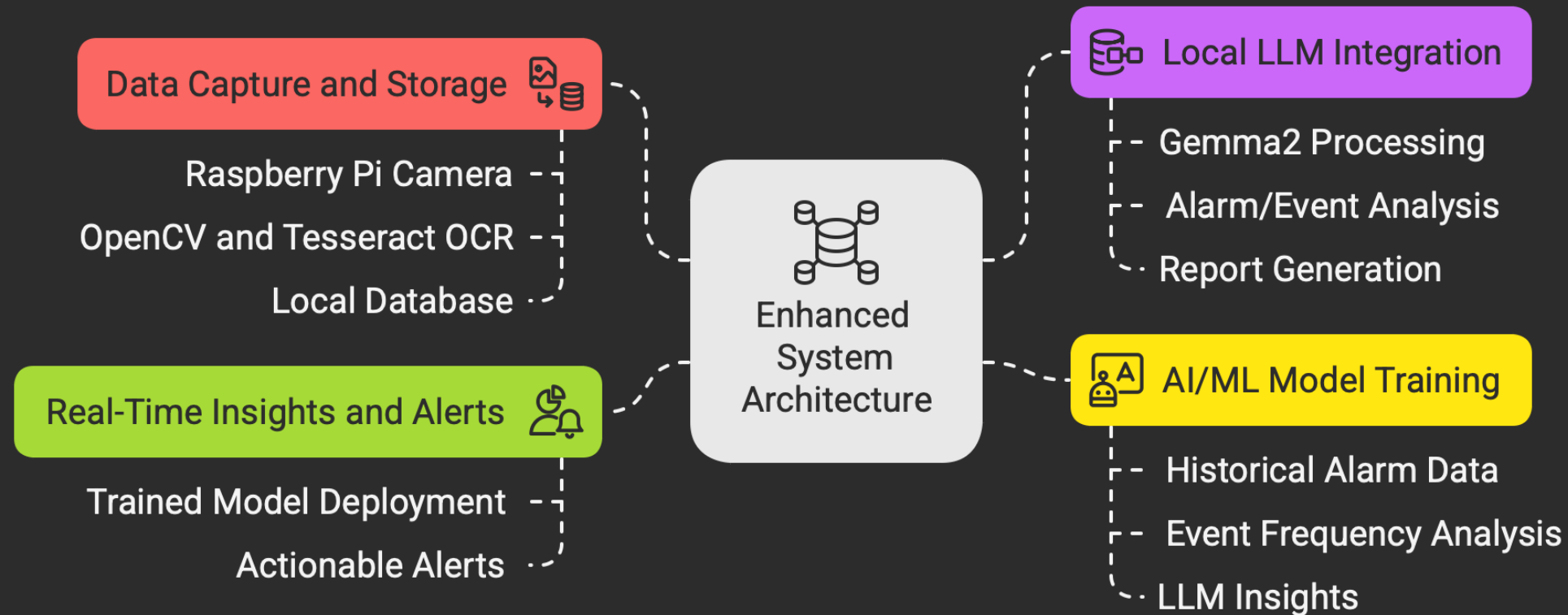
Train a machine learning model to identify fault-related keywords.

### Integration

Integrate the trained model into the Python script to enhance keyword detection.



## Enhanced System Architecture for Fault Detection





# LIVE DEMO – VIZAG HVDC TERMINAL 2



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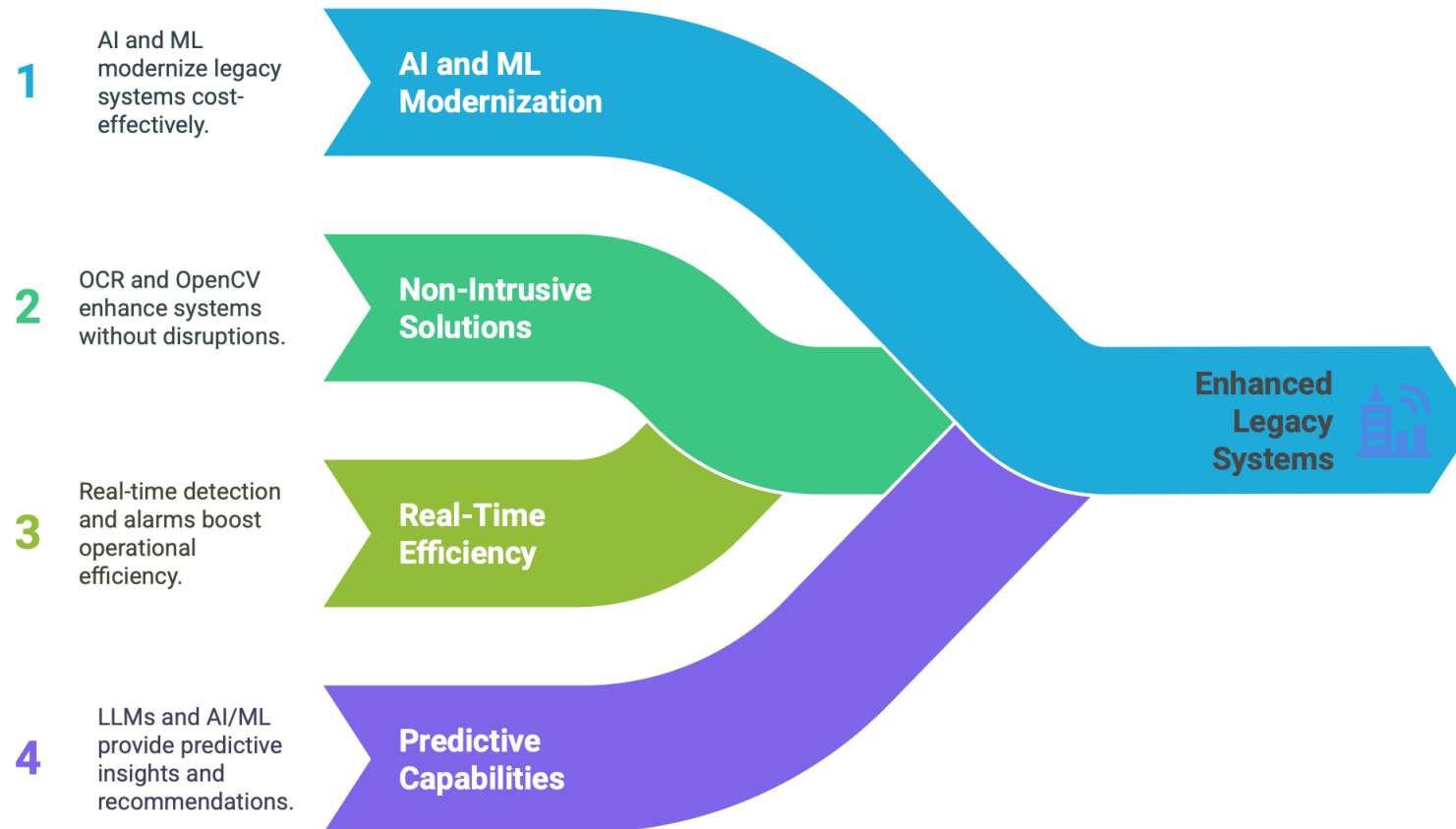
System [HELP] Eventarchive S1 00 % TFR Files T1 05 % Local disc C

Sys POINT GROUP

	EVENT
8:243* P2B Converter Transformer, South	Low Oil Flow Alarm in Phase L3
12:711 W1B AC Filter Breaker	WA1.Z11.Q4 Breaker failure Detected
10:032 W1B AC Reactor Breaker WA1.Z11.Q4	SF6 Gas Replenish Alarm
11:005 W2A AC Reactor Breaker WA2.Z11.Q4	Phase L2, Relay Circuit Faulty
11:005 W2A AC Reactor Breaker WA2.Z11.Q4	Phase L3, Relay Circuit Faulty
17:077 P2A Valve Cooling Tower E4.E7	Faulty
27:024 P2A Valve Cooling Tower E4.E6	Faulty
50:535 W1A Auxiliary Transformer	Transformer Feeder 1 Trip
50:535 W2A Auxiliary Transformer	Transformer Feeder 1 Trip
56:614 P2A Converter Transformer, East	Motor Start Failure Ind Alarm in Phase L3
56:599 P2A Converter Transformer, East	Back-up Supply Ind Alarm in Phase L3
35:100 W2B AC Bus Breaker WA2.W1.Q3	Phase L2, Relay Circuit Faulty
35:088 W2B AC Bus Breaker WA2.W1.Q3	Phase L1, Relay Circuit Faulty
01:408 P2A Converter Transformer, East	Auxiliary Supply A Alarm in Phase L2
28:768 P2B Converter Transformer, East	Motor Overload Alarm in Phase L1
56:075 W2B AC Reactor Breaker WA2.Z11.Q4	Phase L3, Relay Circuit Faulty
56:074 W2B AC Reactor Breaker WA2.Z11.Q4	Phase L1, Relay Circuit Faulty
53:738 W2B AC Reactor Breaker WA2.Z11.Q4	Phase L2, Relay Circuit ****
52:755 W2A AC Reactor Breaker WA2.Z11.Q4	Phase L1, Relay Circuit ****
34:937* W2B AC Reactor Breaker WA2.Z11.Q4	Control Switch Local
34:937* W2B AC Reactor Breaker WA2.Z11.Q4	DC Supply 1 Faulty
34:937* W2B AC Reactor Breaker WA2.Z11.Q4	DC Supply 2 Faulty
34:937* W2B AC Reactor Breaker WA2.Z11.Q4	Permit open Blocked
34:046* W2B AC Reactor Breaker WA2.Z11.Q4	Phase L3, Relay Circuit Faulty
26:843* W2B AC Bus Breaker WA2.W1.Q3	Motor Failure
23:890* W2B AC Bus Disconn. WA2.W1.Q13	OLTC Oil Level Max Alarm in Phase L1
22:247* P2A Converter Transformer	Auxiliary Supply B Alarm in Phase L1
19:731* P2B Converter Transformer, East	Motor Failure
15:063* P2B AC Bus Disconn. WA2.WIN1.Q11	AC Supply Faulty
15:469* P2B AC Bus Breaker WA2.WIN2.Q1	WA2.Z11.Q4 Breaker failure Detected ****

FAULT LIST LIVE EVENT LIST ALARM LIST

## Modernizing Legacy Systems





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## THANK YOU

For discussions/suggestions/queries email:  
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