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Amal Mtibaa

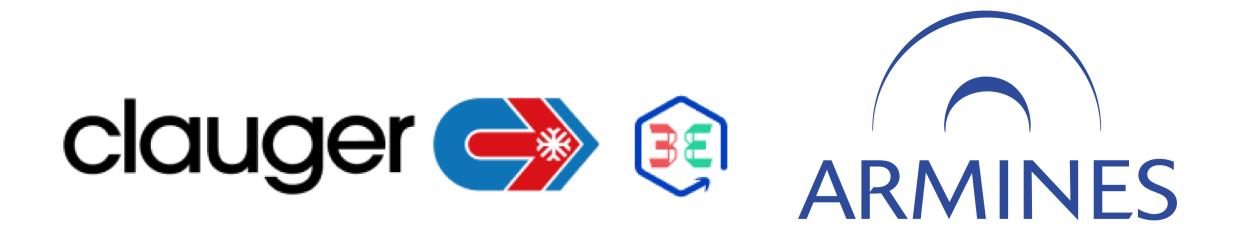
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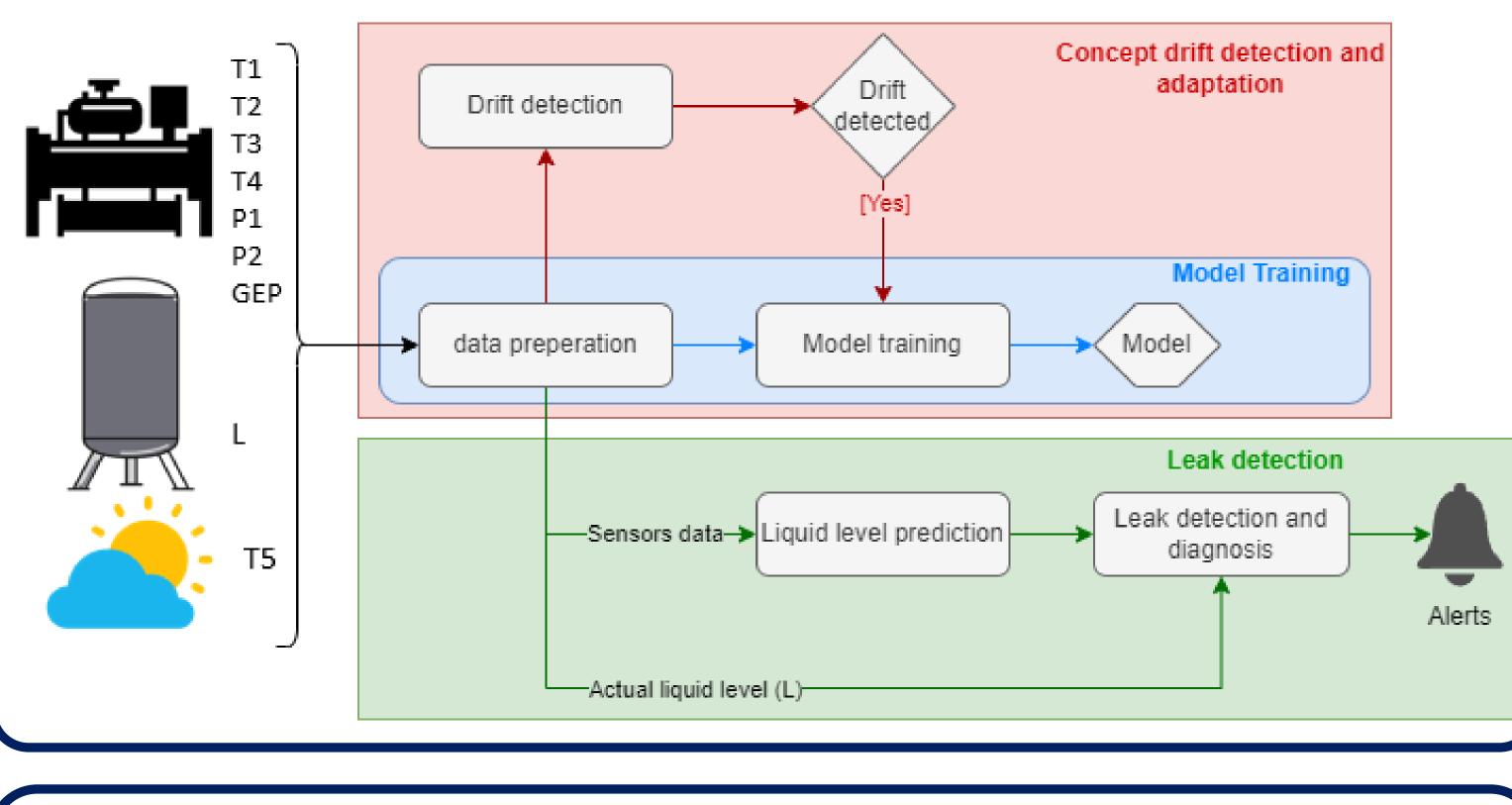
Refrigerant leak detection in industrial vapor compression refrigeration systems using machine learning *Amal Mtibaa, PhD student at CMA, Research engineer at Clauger 3E*

- Efficient detection of refrigerant leakage is utmost importance for Heating, Ventilation, Air conditioning and Refrigeration (HVAC& R) systems, particularly in industrial refrigeration systems due to its potential to cause substantial impacts on system performance and the environment.
- Research has given considerable attention to maintaining HVAC& R systems using Fault detection and diagnosis (FDD) techniques, often conducted in laboratory data or specific settings.
- A data-driven refrigerant leak detection method for industrial vapor compression refrigeration systems is proposed to predict the fault-free liquid level in the receiver. Real-world data obtained from operational installations are used for feature and model selection, as well as validate the effectiveness of the method.
- The proposed approach can detect gradual leaks regardless of the physical installation characteristics and regardless of the operation condition (steady-

1. A vapor compression refrigeration system Condenser 1 TEMPERATURES [°C] **6** T5 $\sim\sim\sim$ **High pressure** Condenser 2 (HP) **T1** – Compressor suction temperature Т3 **T2** – Discharge outlet temperature **T3** – Refrigerant temperature at condenser outlet Condenser k T2 **T4** – Liquid temperature in high pressure P2 **T5** – Ambient temperature The presence of a receiver enables the system to compensate for the PRESUUES [°Csat, bar] GEP lost fluid during the occurrence of **P1** – Compressor suction pressure a refrigerant leak, resulting in less **P2** – Compressor discharge pressure Receiver Cp n Cp 2 Cp 1 immediate variation in system LIQUID LEVEL [mm] performance indicators. T1 L – Refrigerant liquid level in receiver Evaporator 1 Expansion valve 1 P1 $\sim\!\!\sim\!\!\sim\!\!\sim\!\!\sim$ POWER [Kw] Evaporator 2 Expansion valve 2 T4 Low pressure **G_elec_power** – General electric power (LP) Evaporator m Expansion valve m elec_power(Compressor_k) k=1

2. Data-driven approach

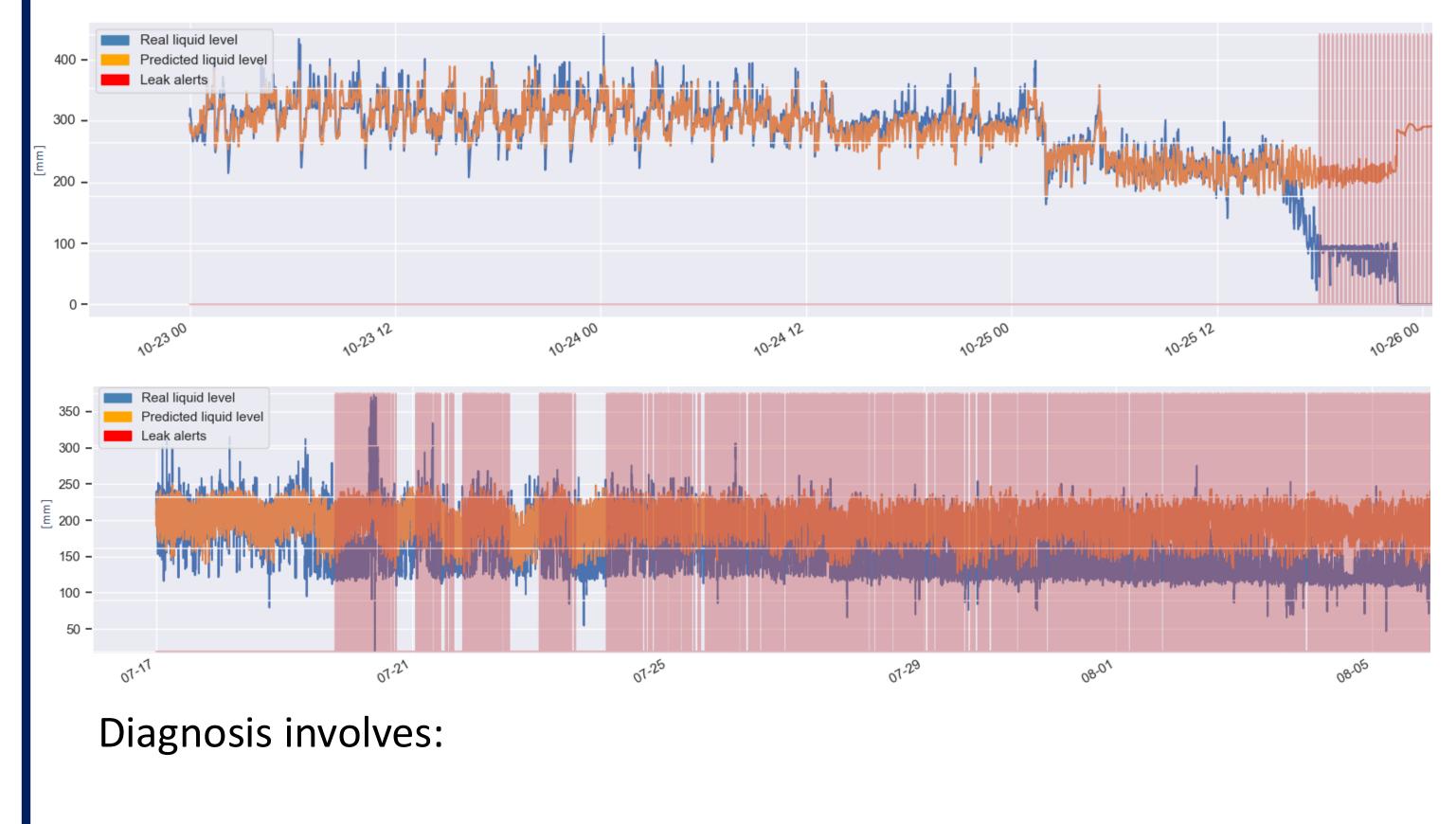
3. Model training

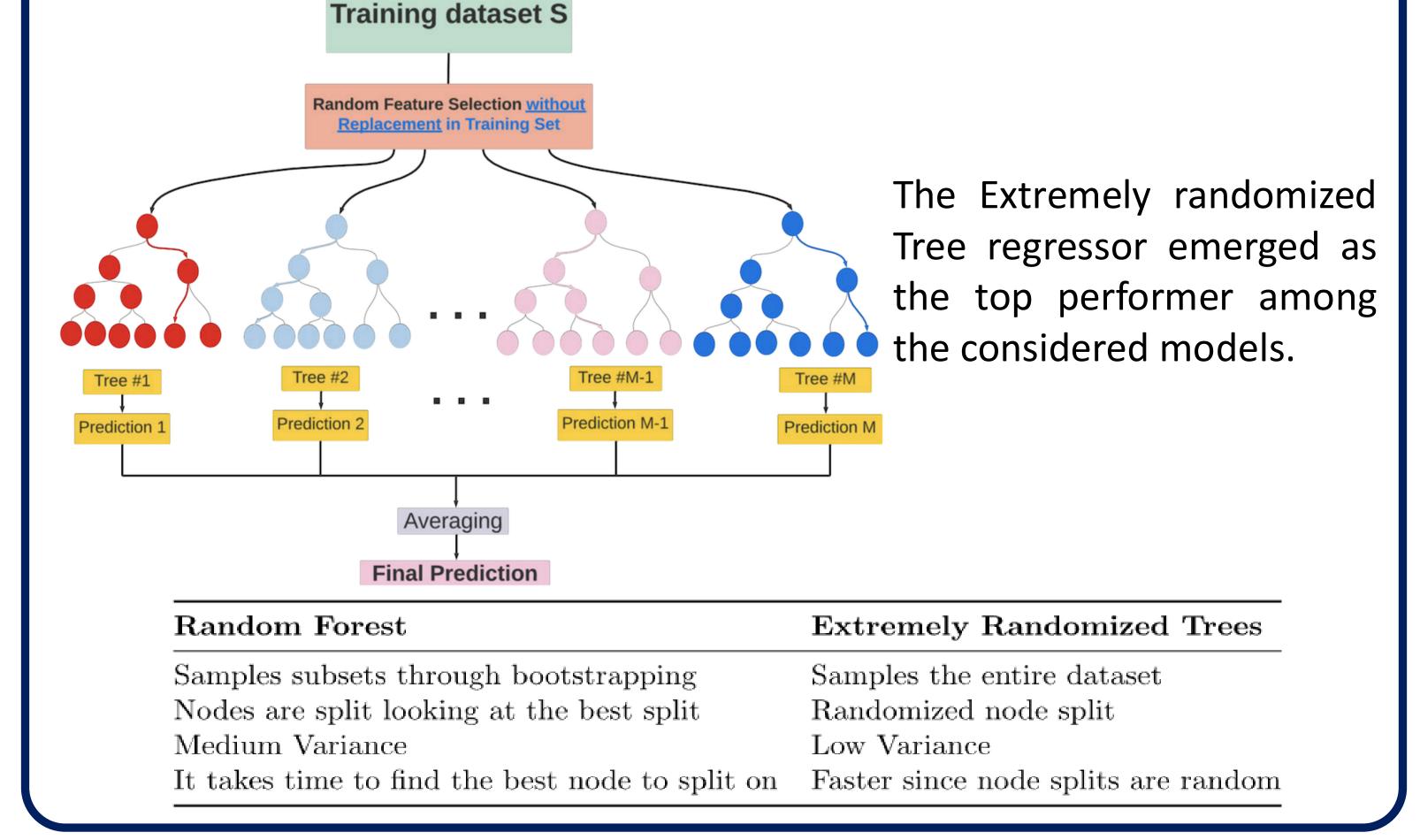


4. Leak detection and diagnosis

The predicted liquid level is compared to the actual liquid level in the receiver. A leak is identified when the measured liquid level drops in comparison to the predicted one.

A dynamically calculated threshold based on the standard deviation around the mean of a moving window of the predicted values is used for anomalous points detection. A leak alert is activated when a certain percentage of consecutive points are identified as anomalous.





- Leak severity estimation
- Confidence level in detection.
- Fluid loss quantification

Mtibaa, A., Sessa, V., Guerassimoff, G., & Alajarin, S. (2024). Refrigerant leak detection in industrial vapor compression refrigeration systems using machine learning. *International Journal of Refrigeration*.