# Edge AI for Predictive Maintenance in High Value Manufacturing

## Background:

- High Value Manufacturing is the backbone of our whole economy.
- Machine breakdowns cause massive losses in production and efficiency. Predicting them is challenging.
- Traditional non-AI-based solutions cause
  - Unplanned downtime & reduction in productivity
  - Severe accidents and reduced lifetime of machines
  - Financial losses
- AI has the potential to solve the above. However, current solutions rely on cloud computing, and suffer from
  - High power consumption and increased carbon footprint
  - Data Privacy Issues
  - High Cost


**Fig 1. Kuka KR6 robotic arm**

**Fig 2. Edge Processing System**

## Objective:

- This project aims to create low-powered embedded system solutions that uses AI to predict and prevent machine breakdowns with high data privacy and at a fraction of the cost
- The solution designed must utilise Edge AI computing using microcontroller devices and low-cost sensors.

**Fig 3. Teensy 4.1**

**Fig 4. ISM330DLC**

**Fig 5. Raspberry Pi 4.0**

## Setup:

- 1 week of machine data was collected from a PCB assembly process using the Kuka KR6 robotic arm presented in Figure 1 at the MTC research factory.
- The AIRS ML Edge Processing System presented in Figure 2 was used for collecting the data.
- This system consisted of the Teensy 4.1 MCU (Figure 3), the ISM330DLC (Figure 4) as the 3 axis MEMS accelerometer and a raspberry pi 4.0 was used as the sensor hub (Figure 5).
- The entire setup for the pilot is presented in Figure 6.

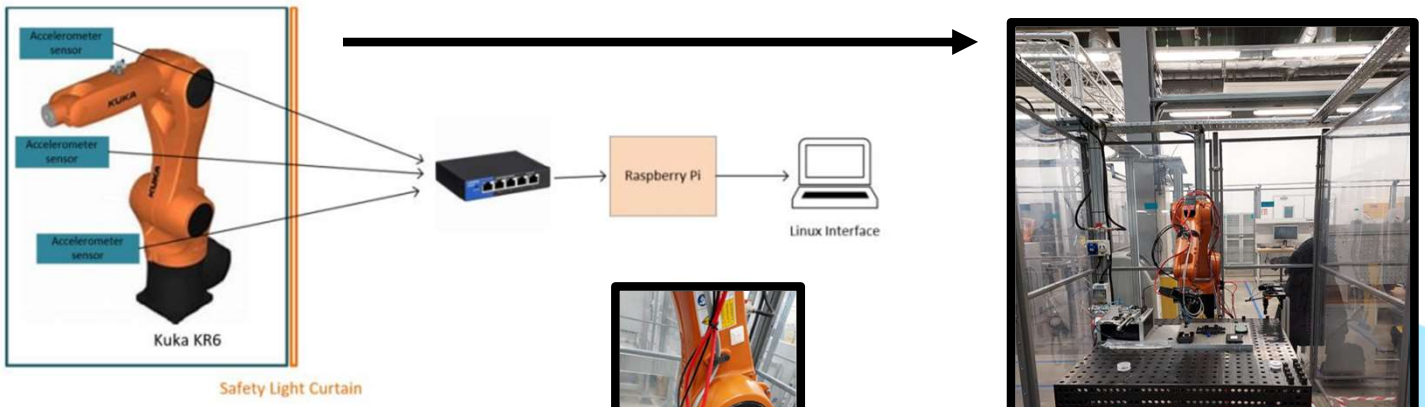


**Fig 6. Kuka KR6 test setup at MTC factory floor**

## Machine Learning:

- The collected data was used to create an unsupervised anomaly detection system that does not require failure cases to train.
- The trained model was quantized and pruned to reduce the size. The implemented system is shown in figure 7.
- The model performance is presented in the confusion matrix below, displaying high accuracy at predicting anomalous operation.

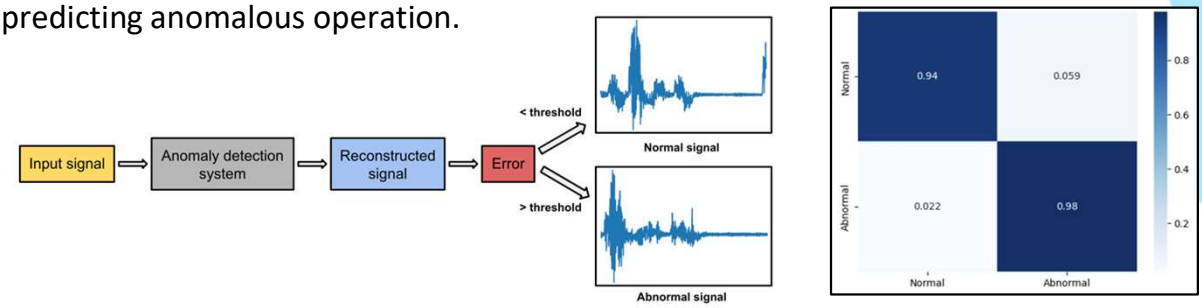


**Fig 7. Unsupervised Anomaly Detection**

## Conclusion:

- The Edge Processing System (EPS) has now been advanced to a more robust monolithic solution as shown in Figure 8. The EPS is capable of interfacing with 24 sensors. It can sample at a frequency of 4 KHz and communicates at 1.5 Mbps.
- The trained AI model shows a very high accuracy of 96% and a high sensitivity of 94.1%. The model also has a high specificity of 97.8% which will help reduce the instances of a false alarm.
- The solution is capable of thus interfacing with a wide variety of machines. It can help collect high fidelity data which can be processed using advanced AI and ML techniques at the edge using the EPS and Sensor Hub.

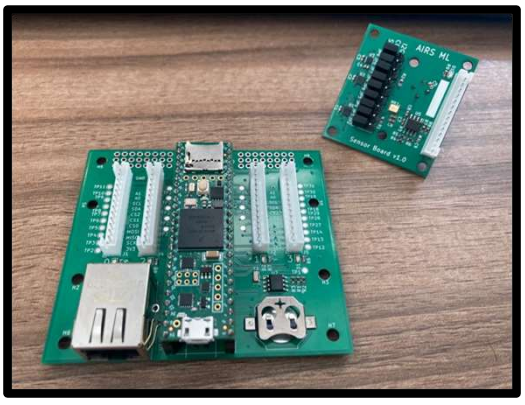


**Fig 8. Monolithic Edge Processing System**

## Testimonial:

Reza Faghih, Technical Specialist, Data & Information Systems, Manufacturing Technology Centre

***"This marked the first phase of development by AIRS … The defined use cases and scenarios serve as examples of industrial applications, and advanced predictive maintenance models can contribute to increasing process efficiency."***