IOTWeek

Dublin — June 20-23, 2022

Virtual Sensors for the Internet of Things

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GLOBAL VISION:
IoT TODAY AND BEYOND

IOTForum

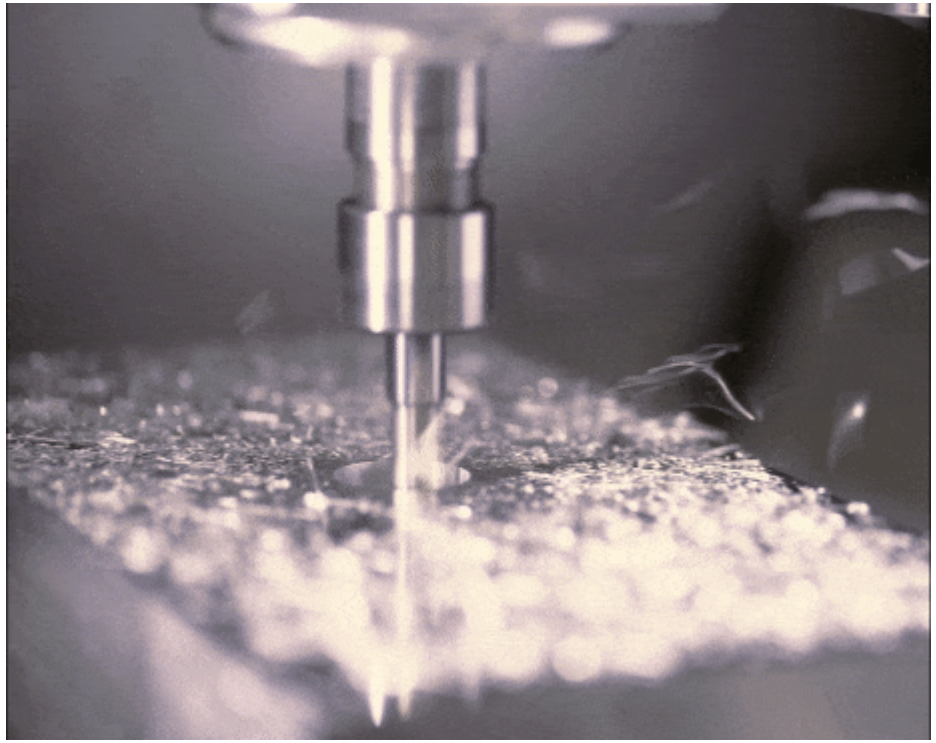
Motivation

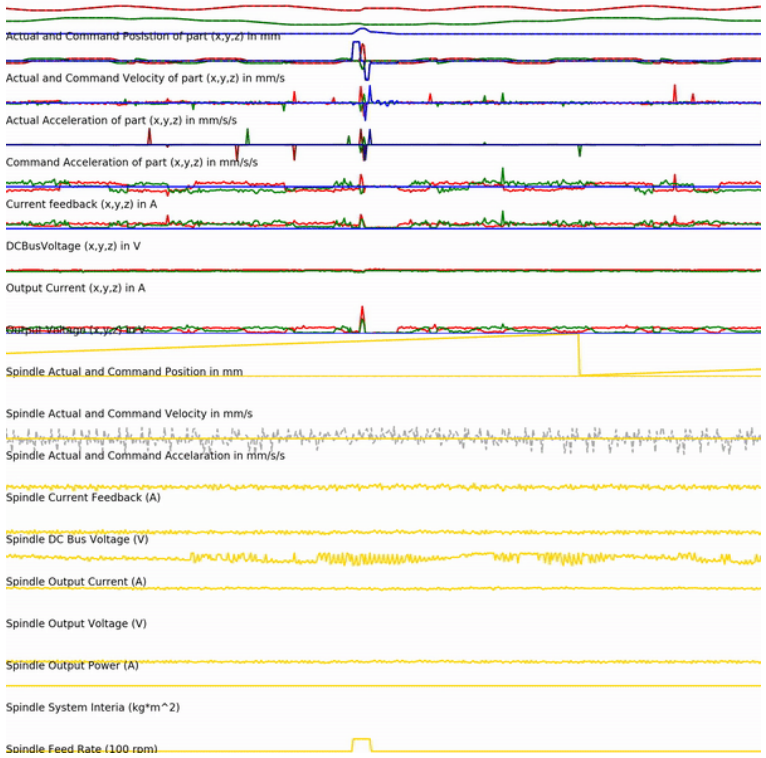
By 2030, half the cost of a car will be accounted for by its electronics, of which sensors with semiconductors will be a major part. With many sensors necessarily exposed to the elements, something is bound to break, leak or need upgrading. (Deloitte)

Motivation

Physical sensors are omnipresent in the Industrial Internet of Things

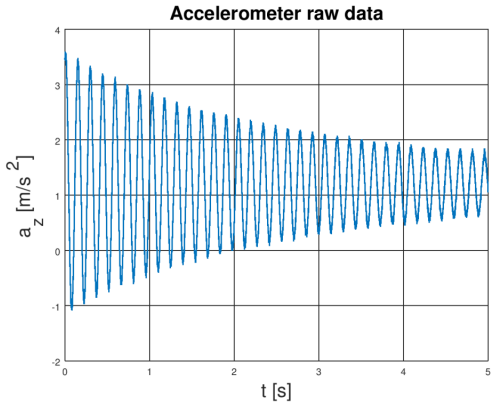
(E.g. accelerometers, temperature sensors, current sensors, torque sensors…)





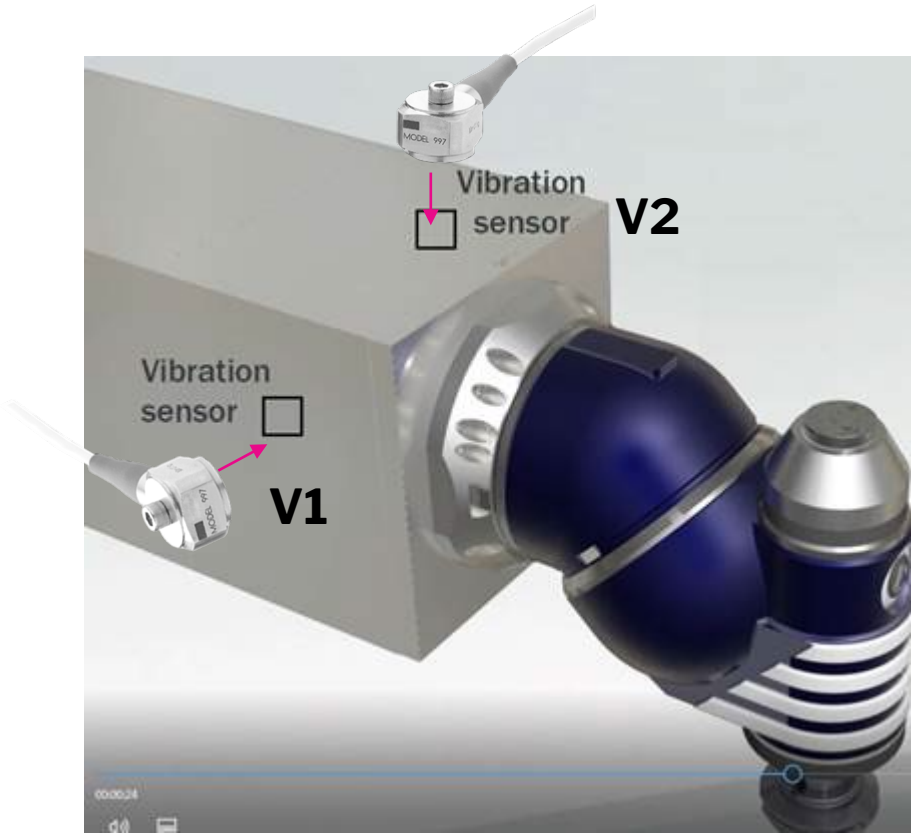
Challenges with physical sensors in the IoT

High-frequency accelerometer used to monitor vibrations



- Do not always provide direct actionable data
- Can degrade and fail due to electronic defects, errors in signal processing, and environmental noise
- Can be invasive and hard to install
- Can be accurate but also expensive

Vibration sensing on machines



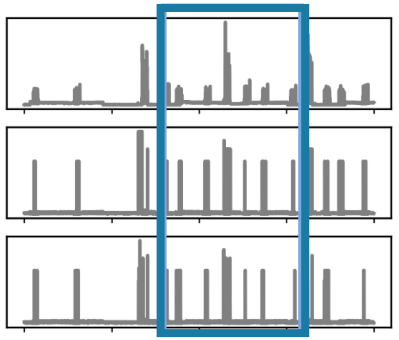
Can I estimate a **faulty accelerometer V2** using **V1** or vice versa?

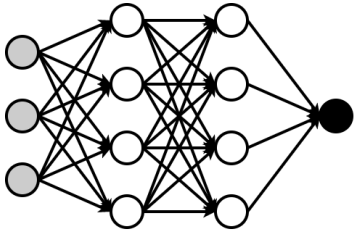
Why is a vibration sensor vulnerable?

- Electrical faults
  - Variable bias voltage
- Electromagnetic noise
  - Capacitive and galvanic coupling
- Signal processing errors
  - Aliasing
  - Jitter
  - Ski-slope problem
  - Spectral leakage
- Low Signal to Noise Ratio
- Generic Sensor faults
  - Drift
  - Bias
  - Freezing
  - Precision degradation

Virtual sensors to step-in for faulty sensors

Time series data from low-cost or redundant sensors

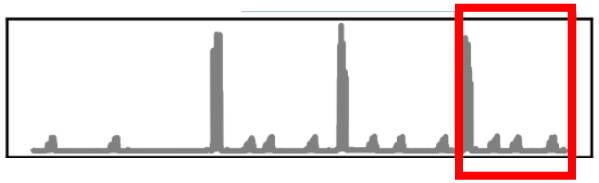




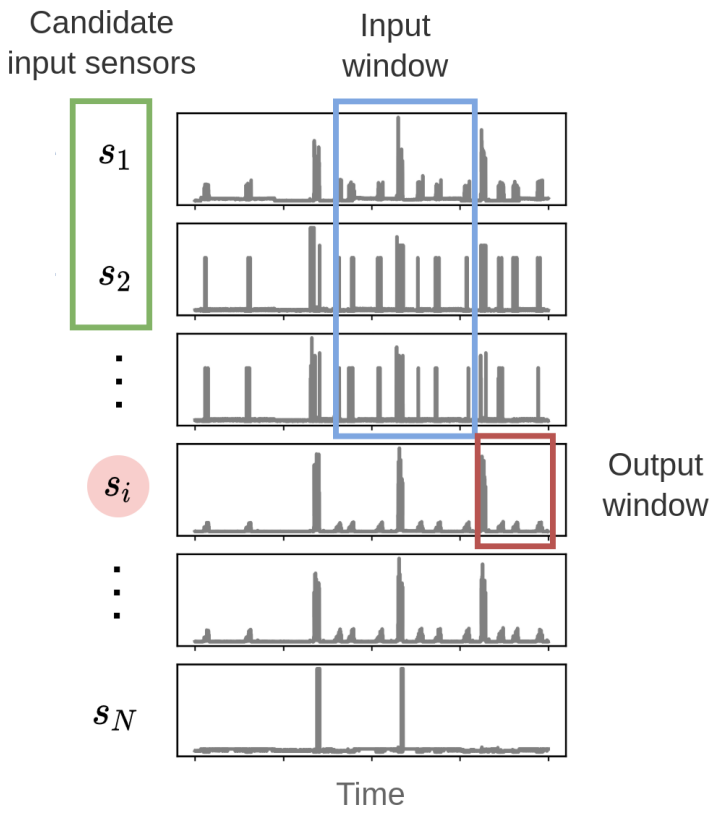
based on

Virtual Sensor

Data of faulty/expensive physical sensor



Our Approach



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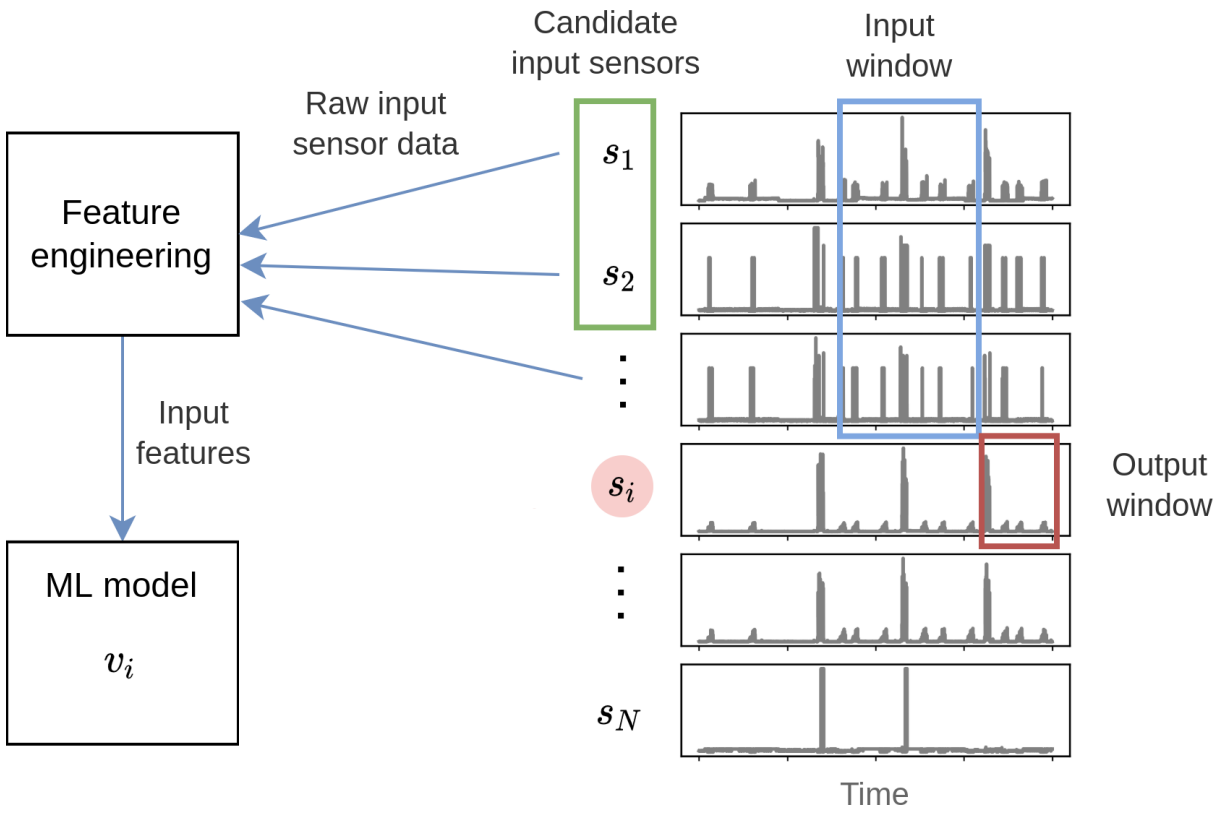

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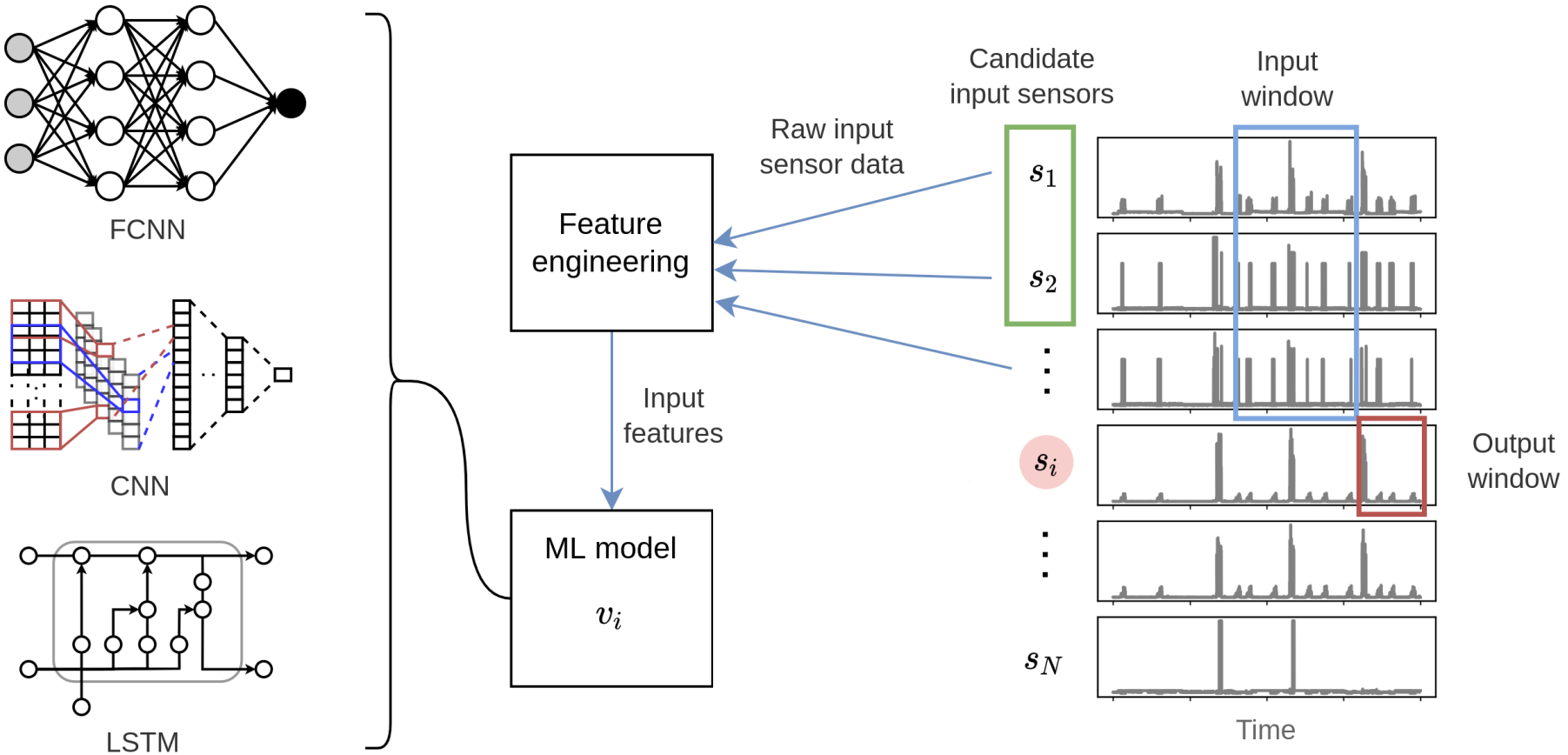

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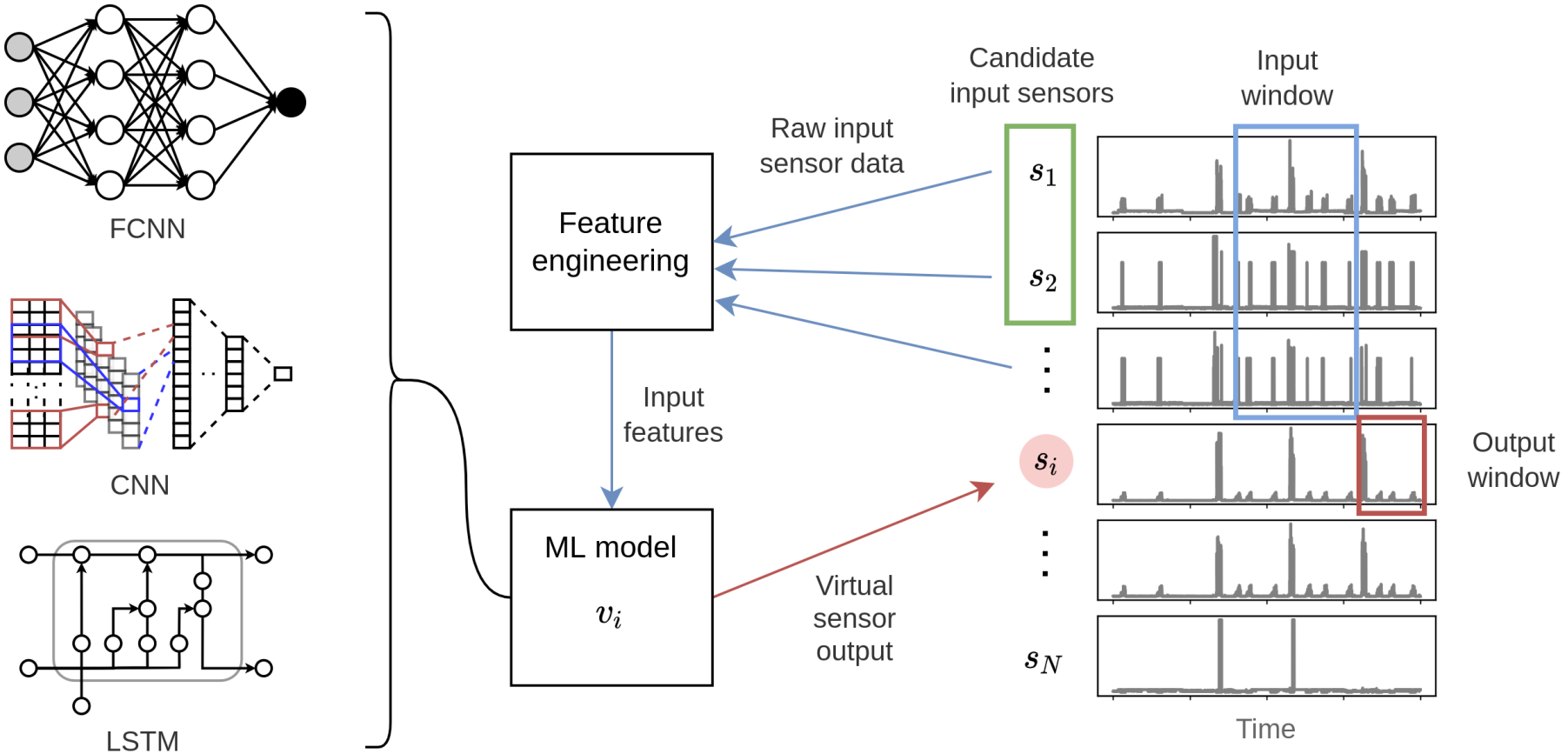

Technical Overview

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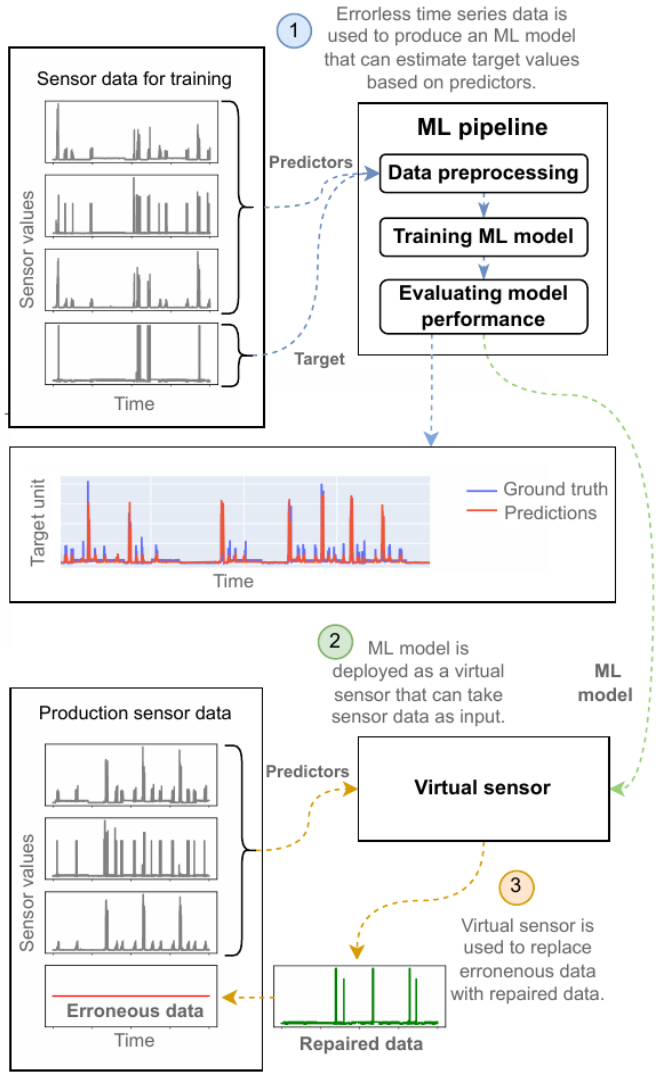
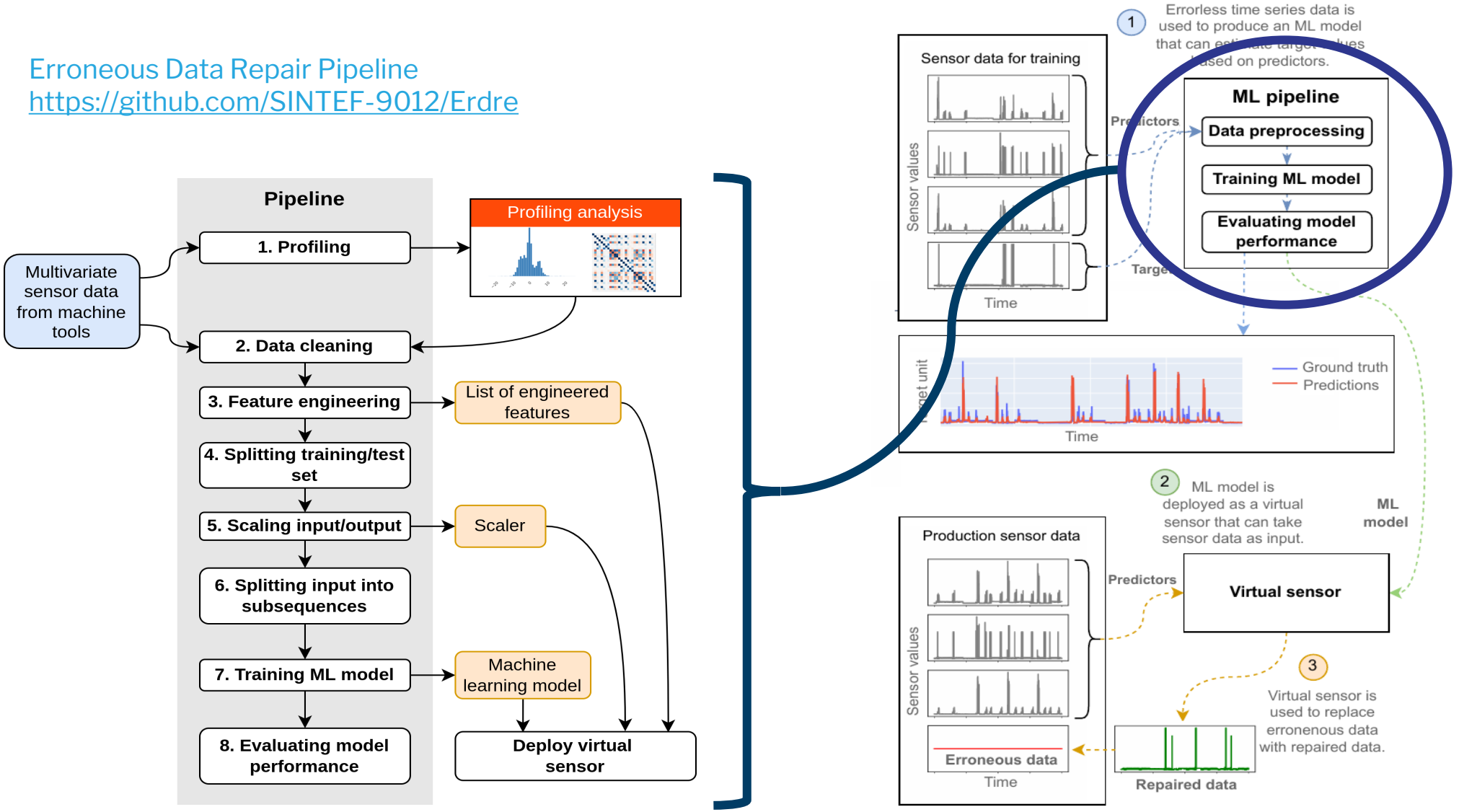
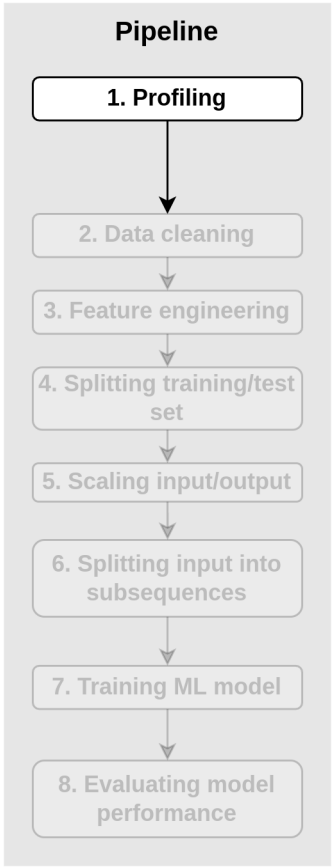


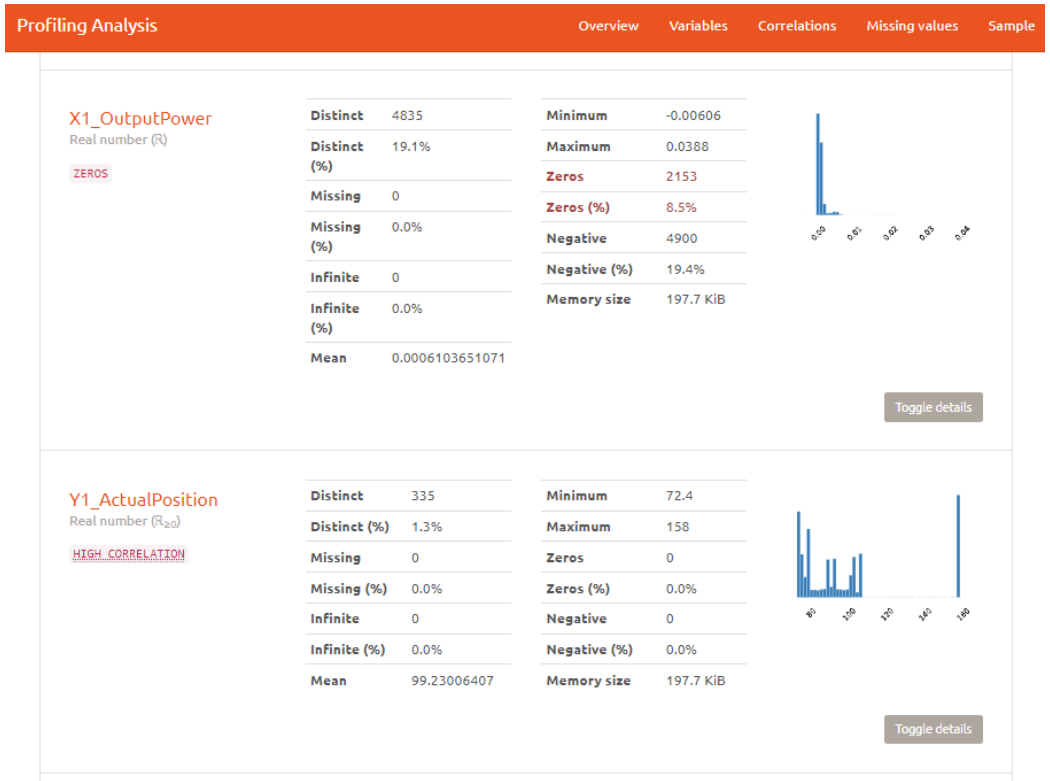
Technical Overview

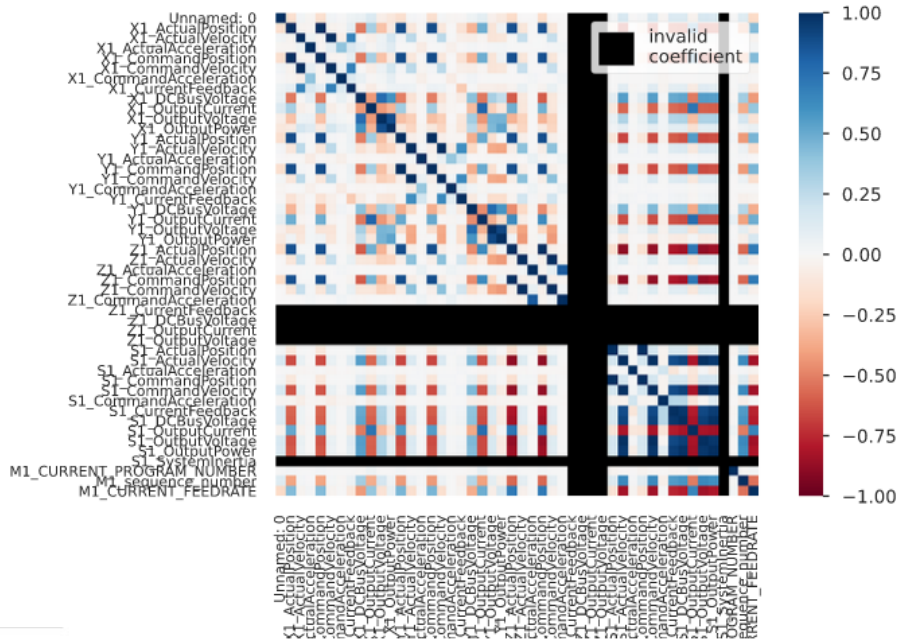
Erroneous Data Repair Pipeline
https://github.com/SINTEF-9012/Erdre



Technical Overview



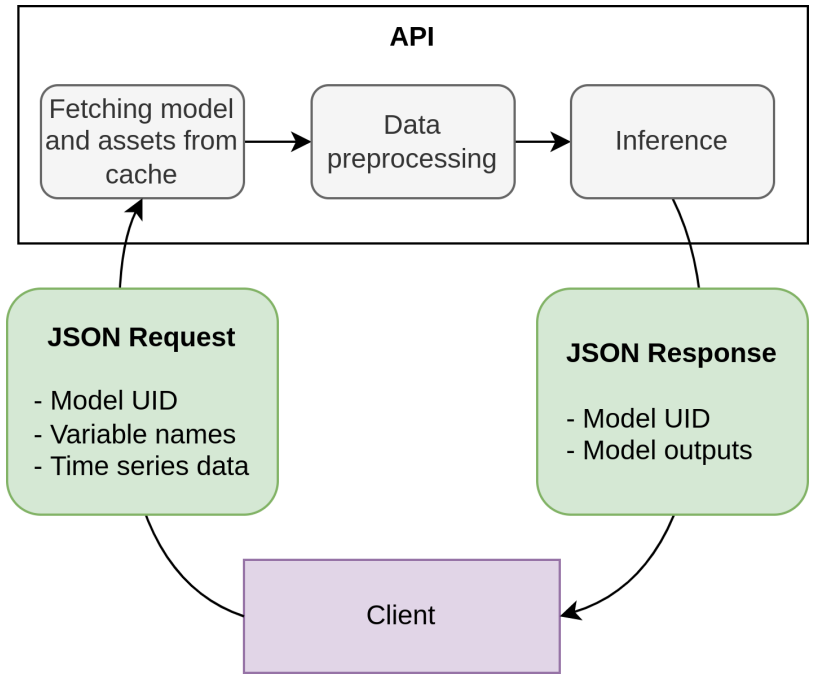




Alerts

Z1_CurrentFeedback has constant value "0.0"	Constant
Z1_DCBusVoltage has constant value "0.0"	Constant
Z1_OutputCurrent has constant value "0.0"	Constant
Z1_OutputVoltage has constant value "0.0"	Constant
S1_SystemInertia has constant value "12.0"	Constant
X1_ActualPosition is highly correlated with X1_CommandPosition	High correlation

Deploying a virtual sensor



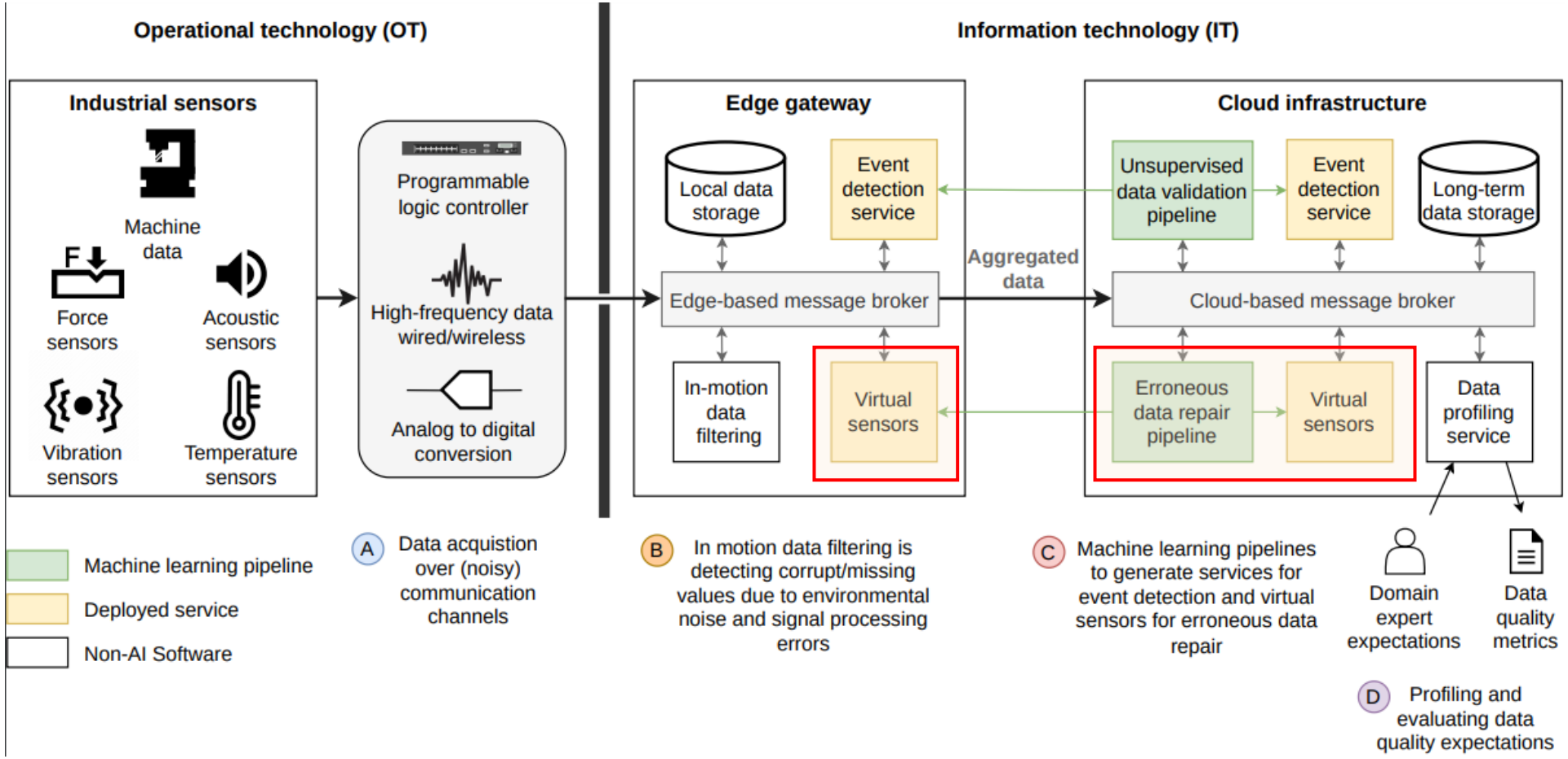
JSON request:

```
{
  "param": {"modeluid": "618b9b95-7805"},
  "scalar": {
    "headers": ["date","input_1", "input_2"],
    "data": [
      ["2017-08-23 17:57:00", 101.2, 30],
      ["2017-08-23 17:57:05", 101.3, 32],
      ["2017-08-23 17:57:10", 101.2, 30],
      ["2017-08-23 17:57:15", 101.3, 34],
      ["2017-08-23 17:57:20", 101.4, 29],
      ["2017-08-23 17:57:25", 101.5, 23]
    ]
  }
}
```

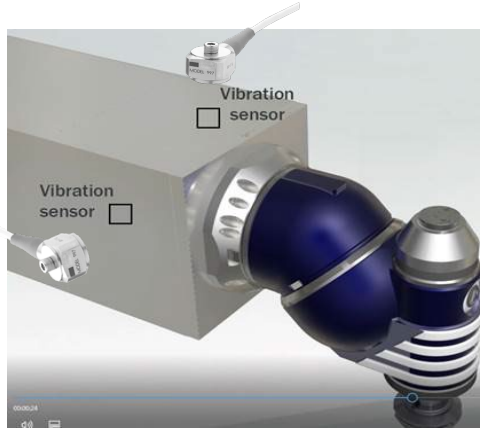
JSON response:

```
{
  "param": {"modeluid": "618b9b95-7805"},
  "scalar": {
    "headers": ["date","target"],
    "data": [
      ["2017-08-23 17:57:00", 101.2],
      ["2017-08-23 17:57:05", 101.3],
      ["2017-08-23 17:57:10", 101.2],
      ["2017-08-23 17:57:15", 101.3],
      ["2017-08-23 17:57:20", 101.4],
      ["2017-08-23 17:57:25", 101.5]
    ]
  }
}
```

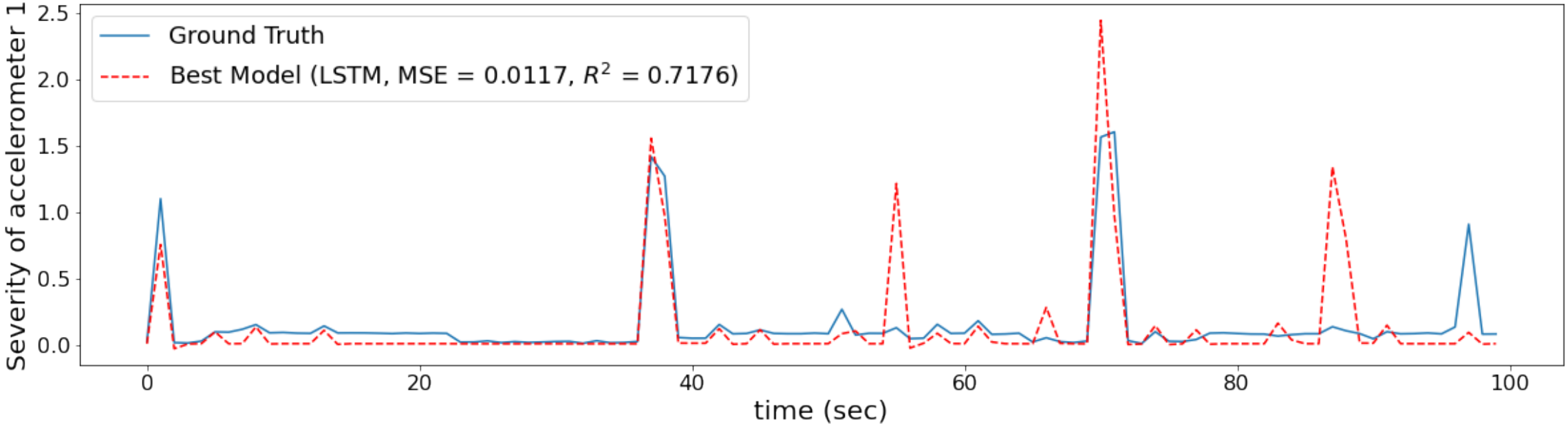
Deploying a virtual sensor



Performance of a virtual sensor

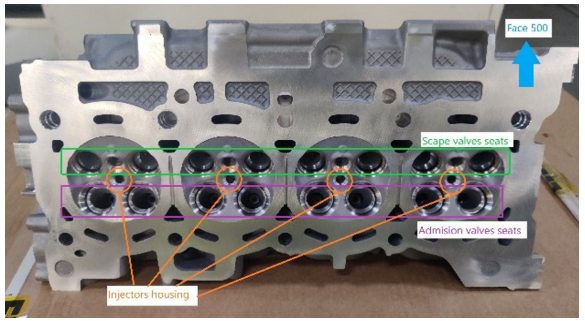


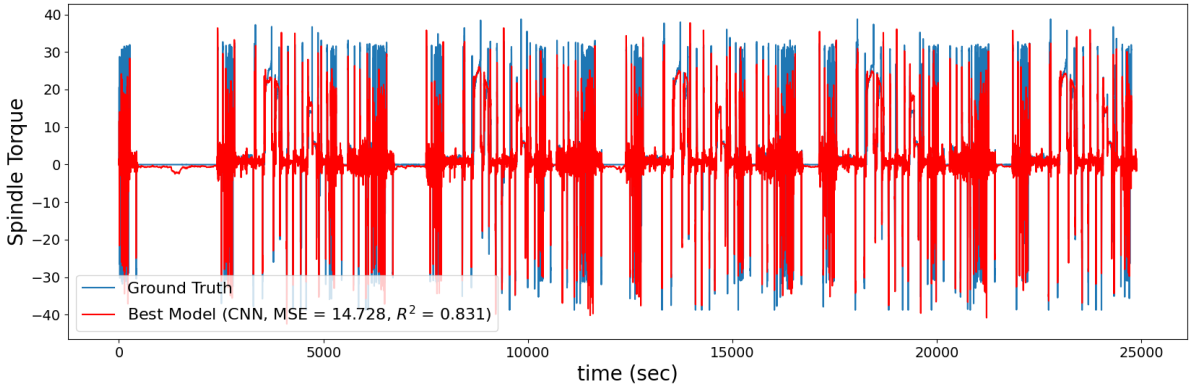
Predicting "Severity of acc. 1" from "Severity of acc. 2"



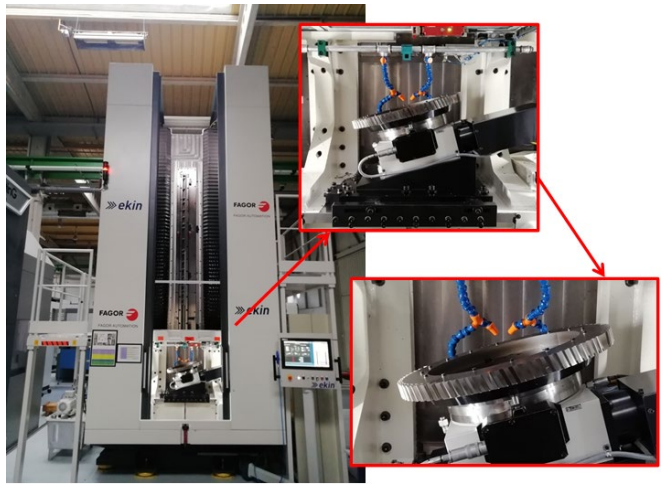
Other examples

Predicting **Spindle Torque** of CNC milling of Combustion Chamber (Renault) from **spindle position X, Y, Z**

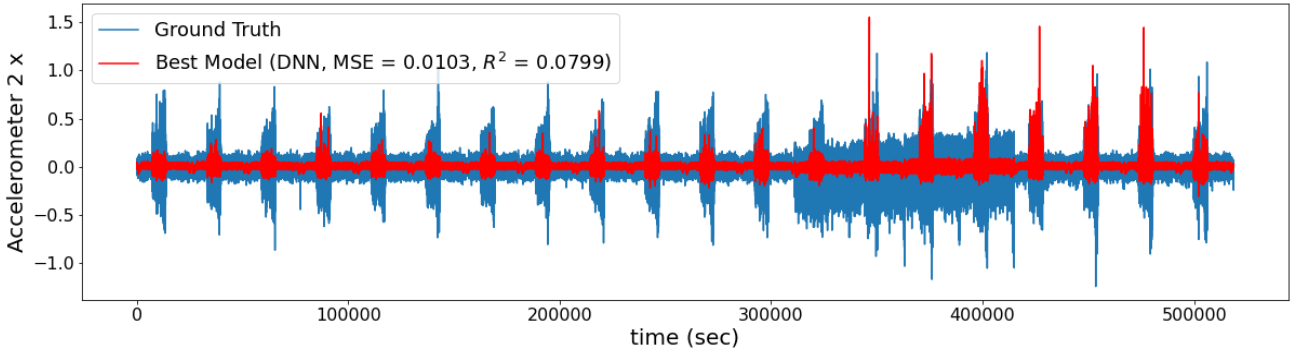




Predicting **accelerometer 2** (for vibration sensing) of Turbine disc broaching from **acclerometer 1**



Predicting "X-axis of acc. 2" from all axes from acc. 1



Conclusion and future work

- Physical sensors are vulnerable when exposed to the elements
- However, redundancy in physical sensors can be used to create virtual sensors to repair erroneous data.
- Virtual sensors can help improve data quality both in real-time and long-term data
- Environments and processes change with time. Therefore, we need to quantify uncertainty in virtual sensors
- Virtual sensors must learn to improve continually and for a lifetime.

Credits

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Anticipate & Save

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Thank you!

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