A sensor data-based approach for the definition of conditions taxonomies for a hydraulic pump

Caroline König (1,2)

Carlos Gil Buigues (1,2)

1. Department of Computer Science, Universitat Politècnica de Catalunya, UPC BarcelonaTech, Spain

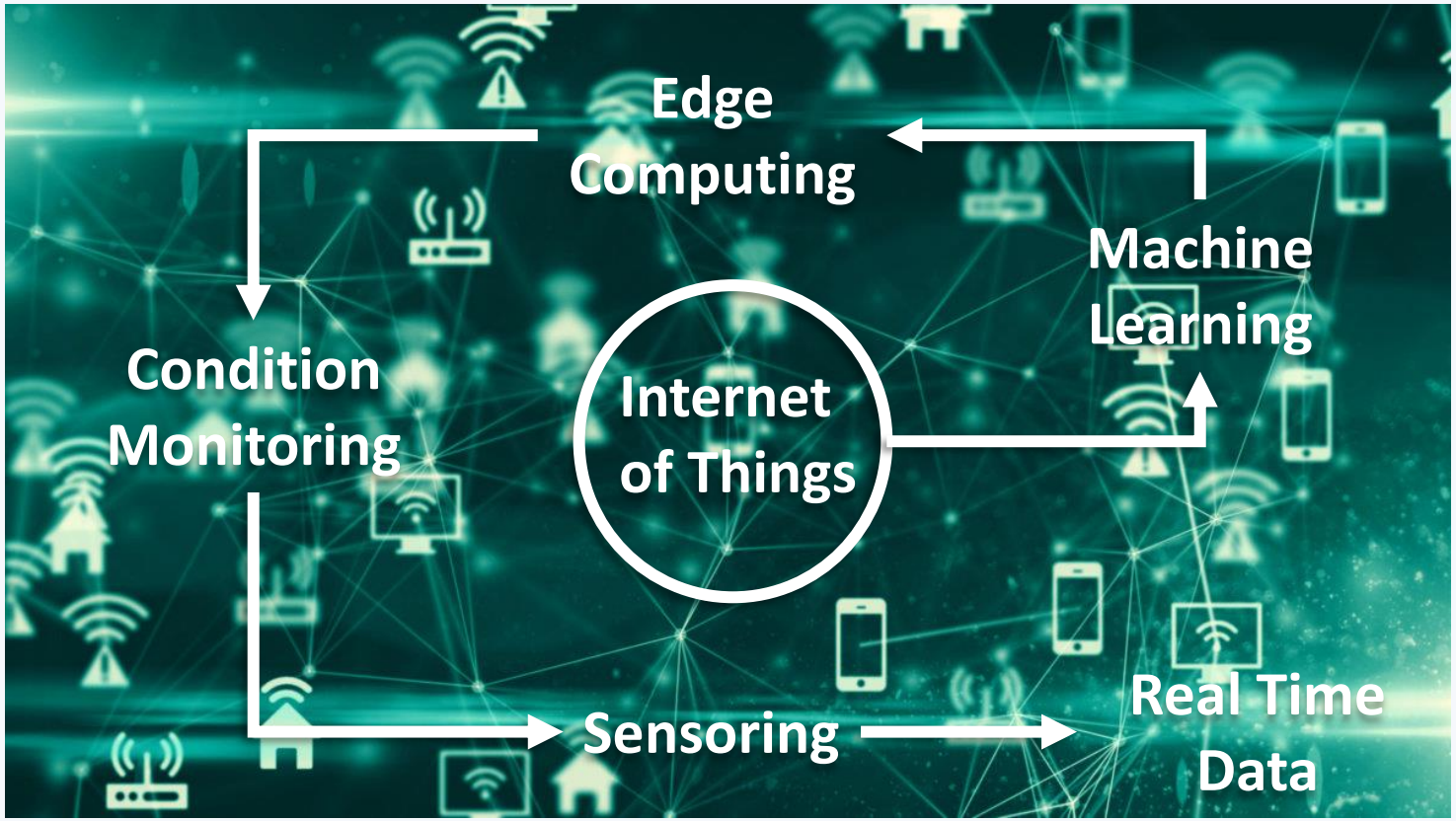
2. ISA DATA S.L, 08970 San Joan Despi, Barcelona, Spain

OUTLINE

1. Introduction
    1. Core Concepts
    2. Cavitation
2. Experimental Bench
3. Data ingestion
4. Measurements
5. Exploratory data analisys – PCA
6. Results
7. Conclusions

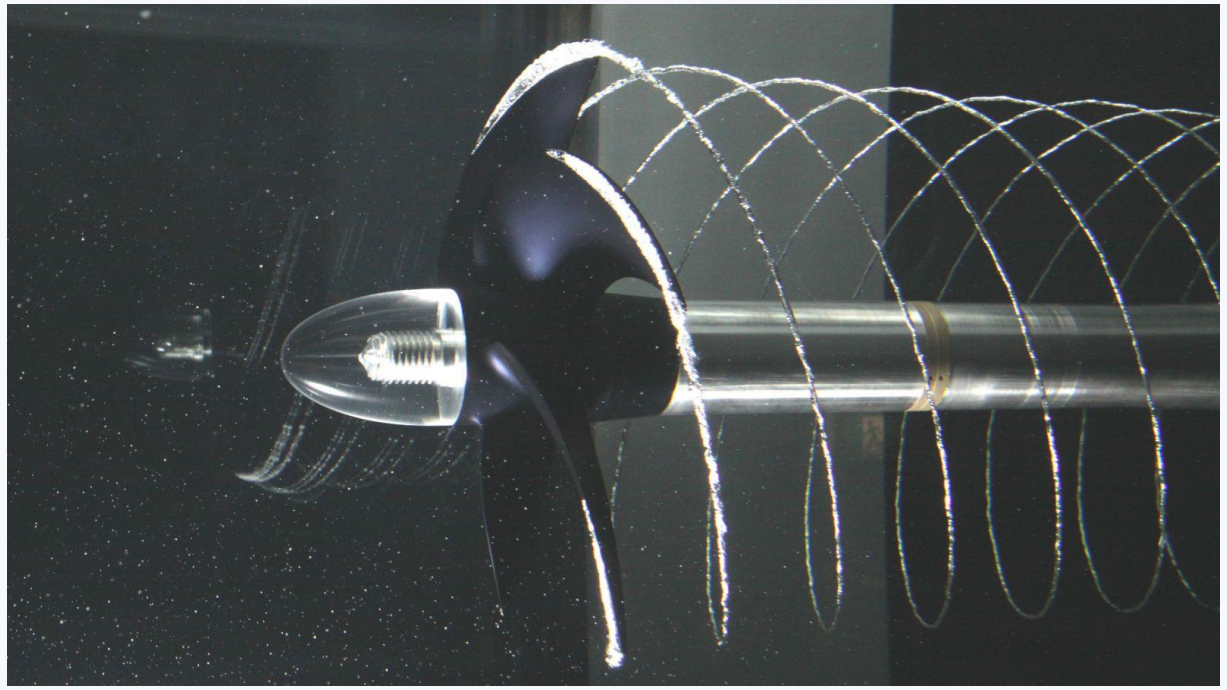
INTRODUCTION – CORE CONCEPTS

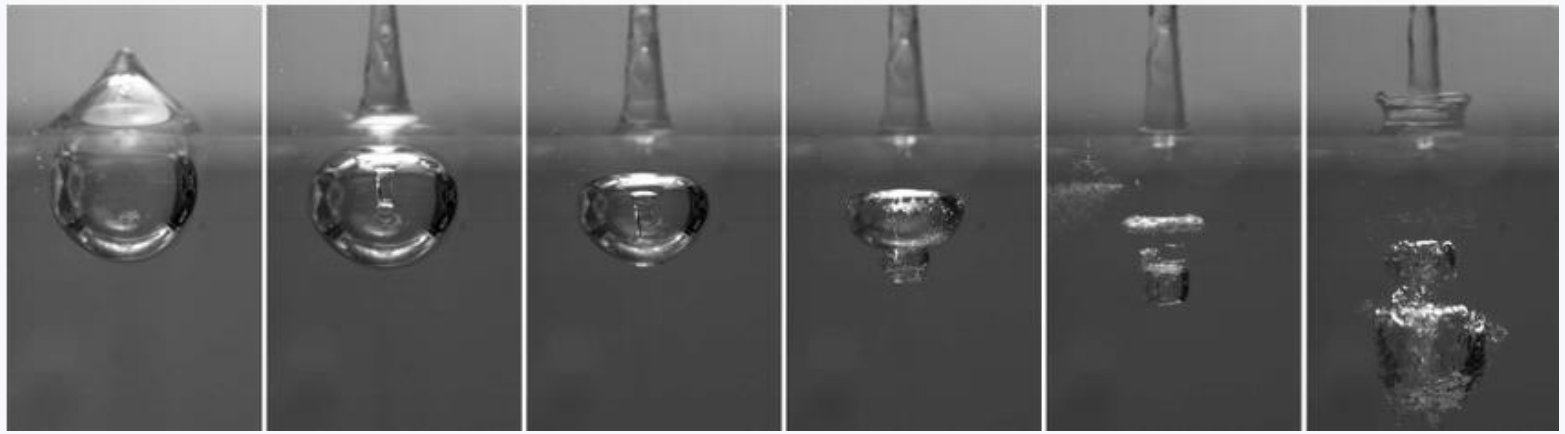
1. Internet of Things
2. Machine Learning
3. Condition monitoring
4. Sensoring
5. Real-Time Data



INTRODUCTION - CAVITATION

$$v\uparrow$$
$$P\downarrow$$
$$T_B\downarrow$$





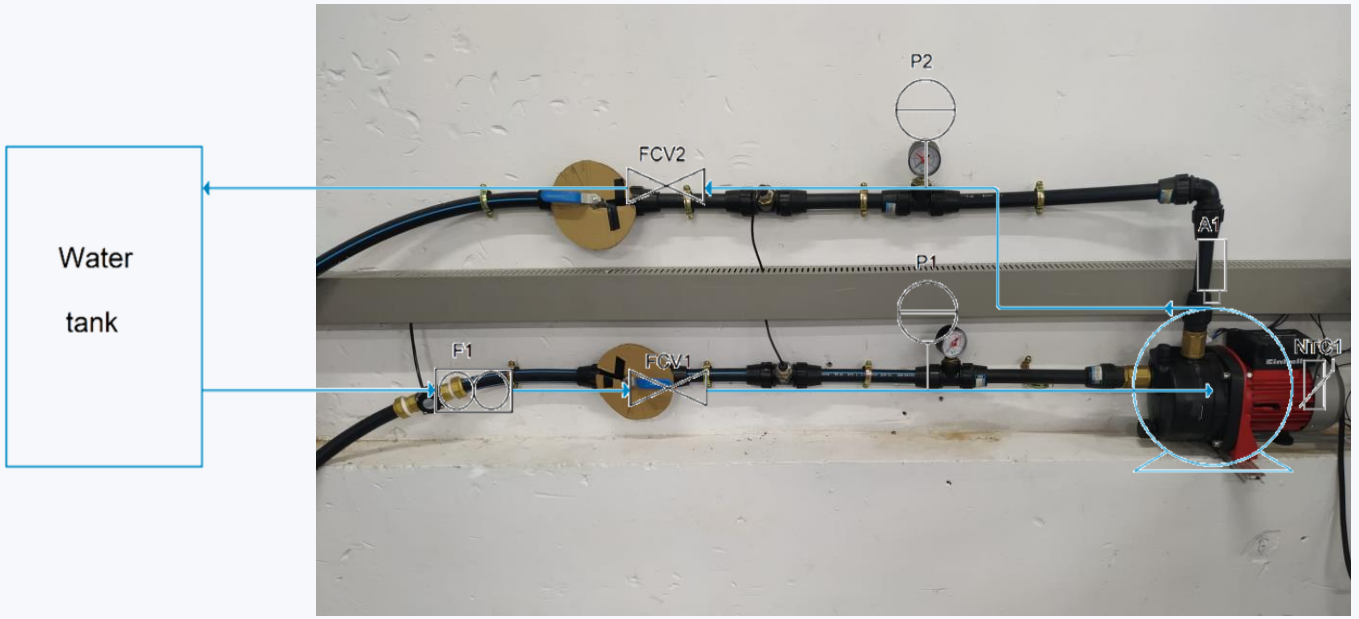
EXPERIMENTAL BENCH

		Outlet valve			
		0%	20%	50%	80%
Inlet valve	0%	NO1/NO2	OV1	OV2	OV3
	20%	IV1	IO11	IO12	IO13
	50%	IV2	IO21	IO22	IO23
	80%	IV3	IO31	IO32	IO33

1. Closed-loop circuit
2. Sensors
    1. Pressure
    2. Flow
    3. Vibration
    4. Temperature
    5. Consumption
3. Valves
4. Experiment

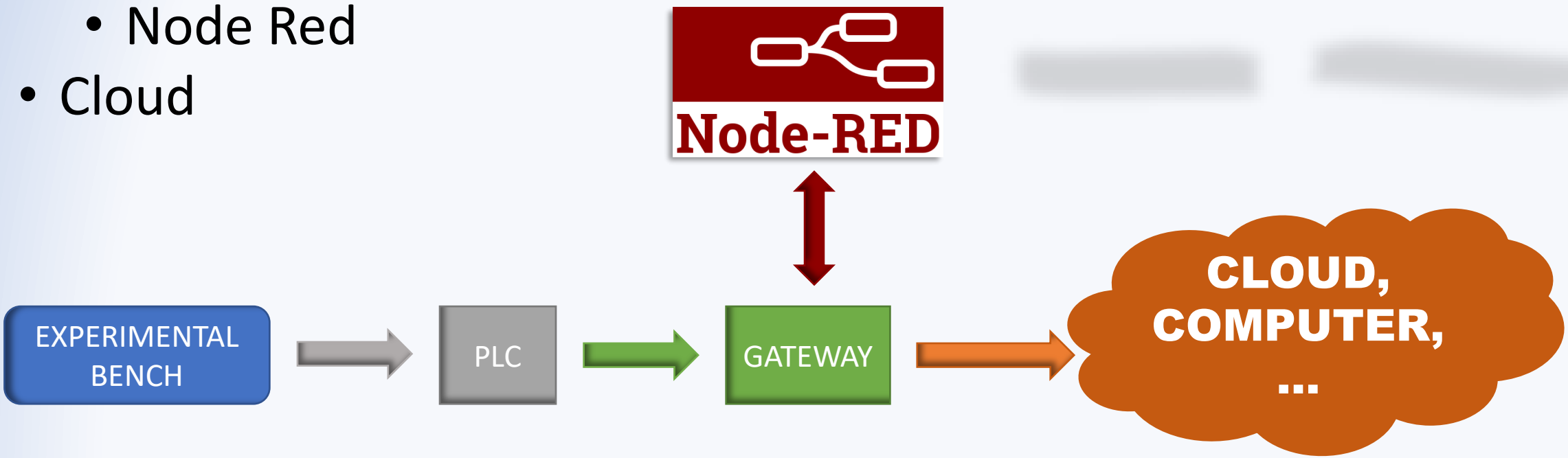
Table 1. Description of sensors.

Sensor tag	Model	Range	Measured variable	Unit
P2	Walfront 1PC G3/8 0-2 BAR	0-2 bar	Outlet pressure	bar
F1	FS300A	1-60L/Min	Flow rate	L/s
A1	ADXL335	L/s	One axe vibration	%
NTC1	MF52B NTC	200°C	Pump cage temperature	°C
PC1	SZT 15-CH-10	0-10A	Pump power consumption	A



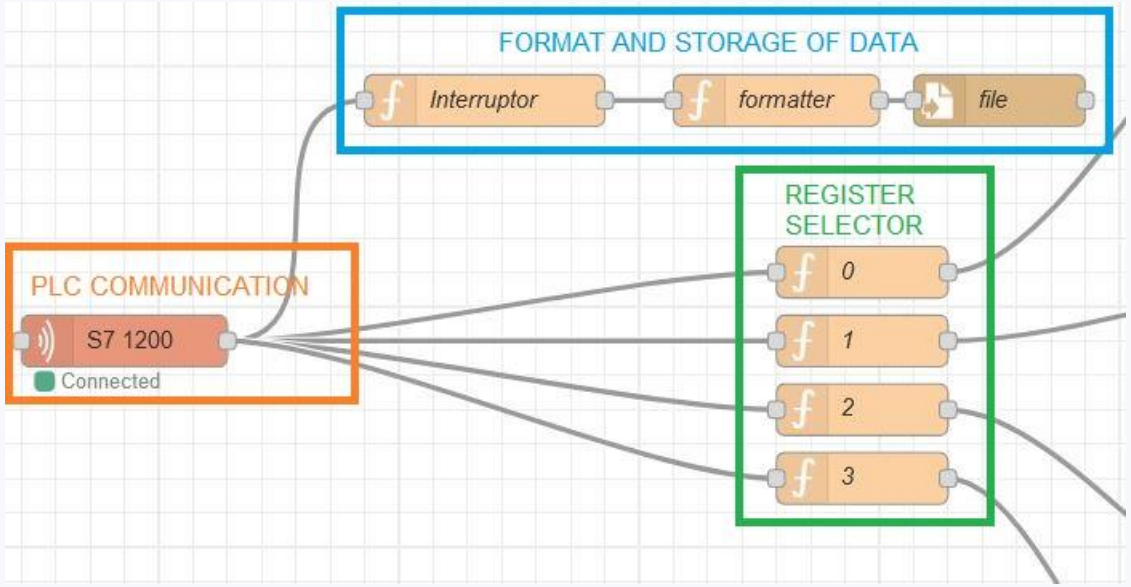
DATA INGESTION

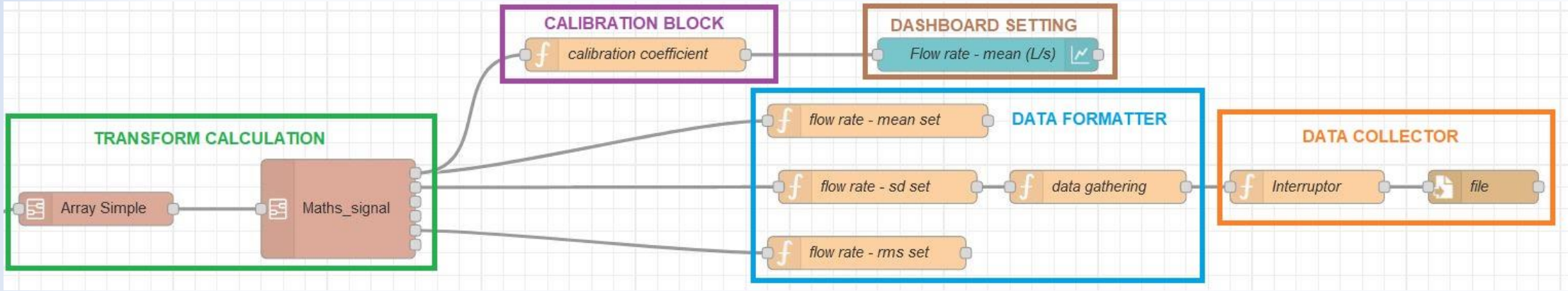
- Experimental bench and sensors
- PLC
- IoT Gateway
  - Node Red
- Cloud



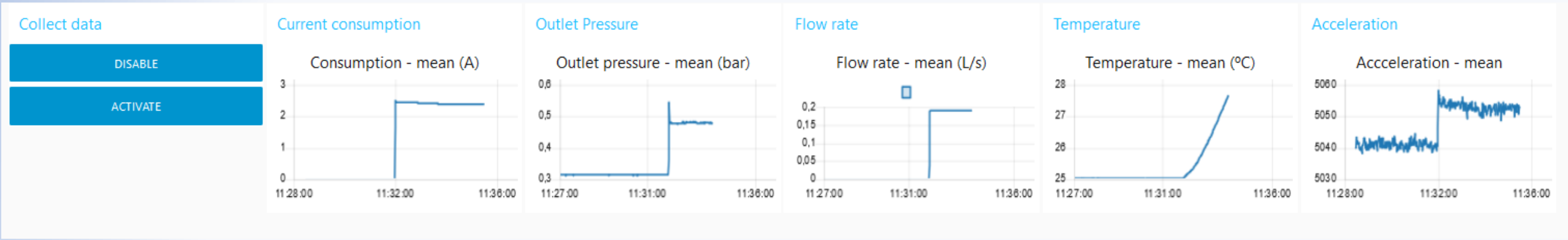
DATA INGESTION – NODE RED

- Comunication with PLC
- Selection of registers
- Transform calculation
- Signals calibration
- Data formatter
- Data collector

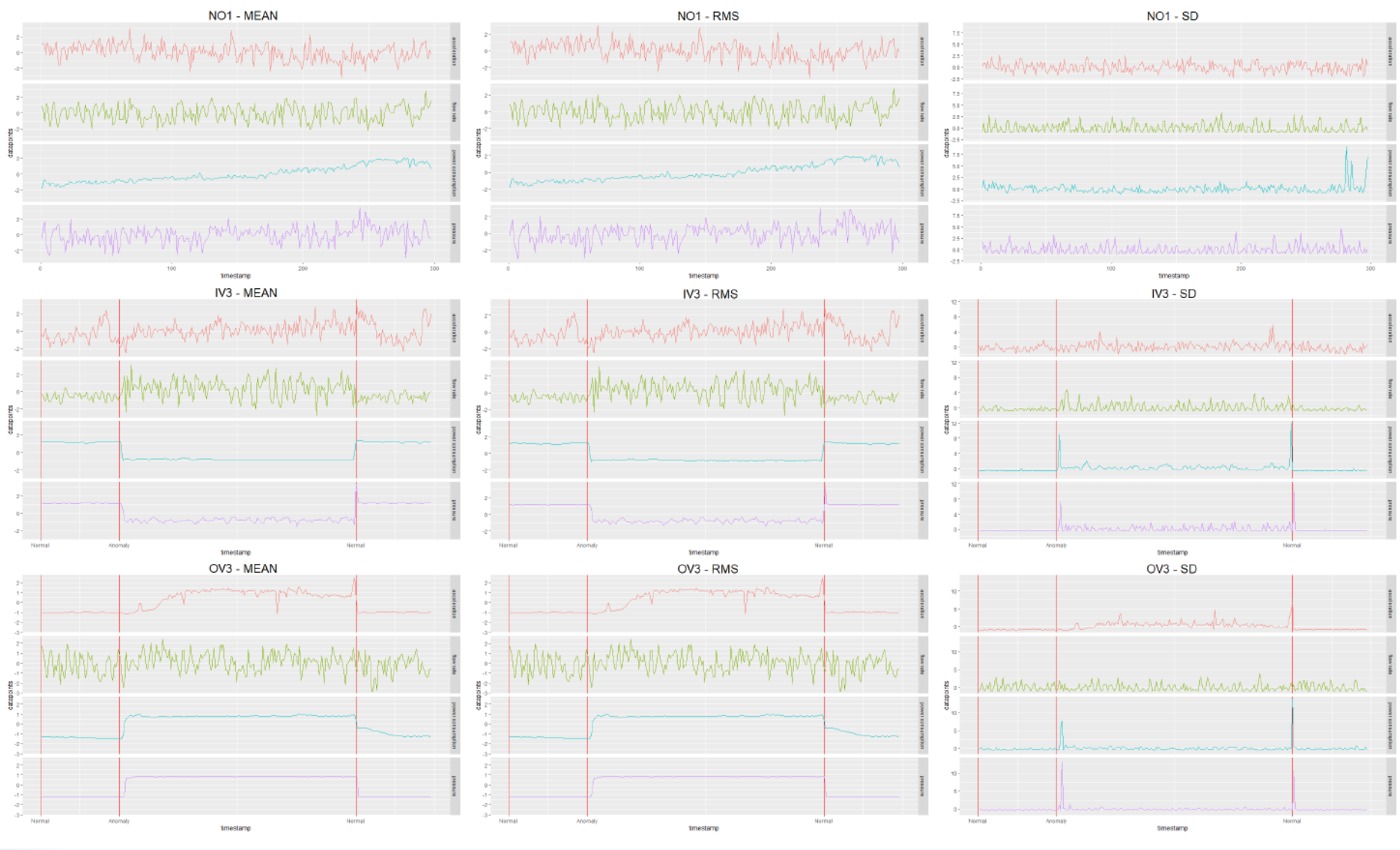




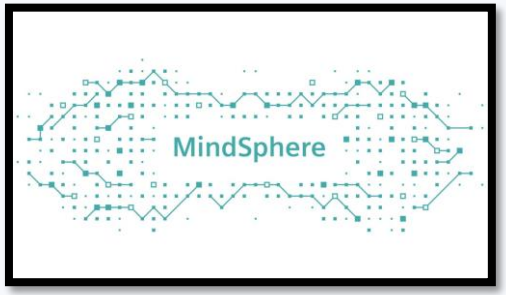
MEASUREMENTS



MEASUREMENTS



MEASUREMENTS



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Hydraulic Circuit

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Info | Aspects

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- mySim_asset — isadata.mySim_type
- Node-red — core.mclib
- Training_data — isadata.Training_data

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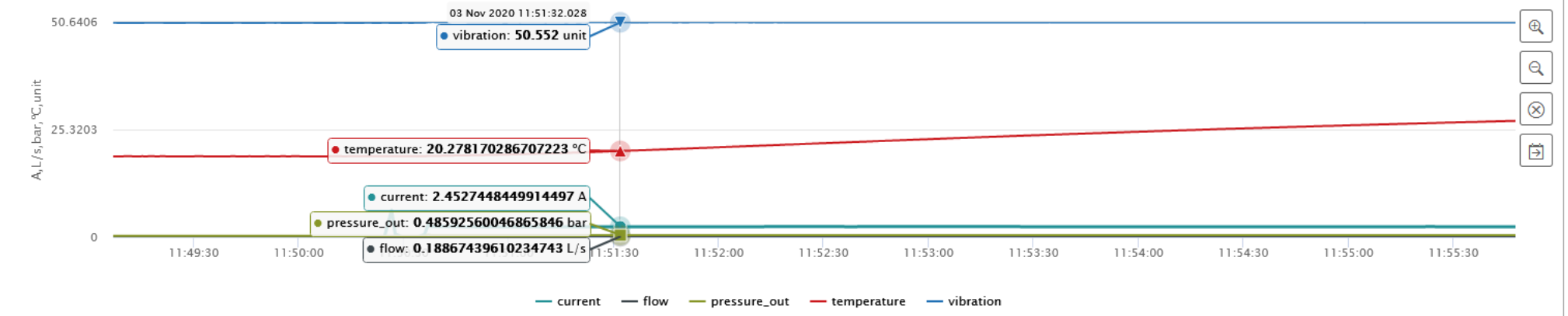

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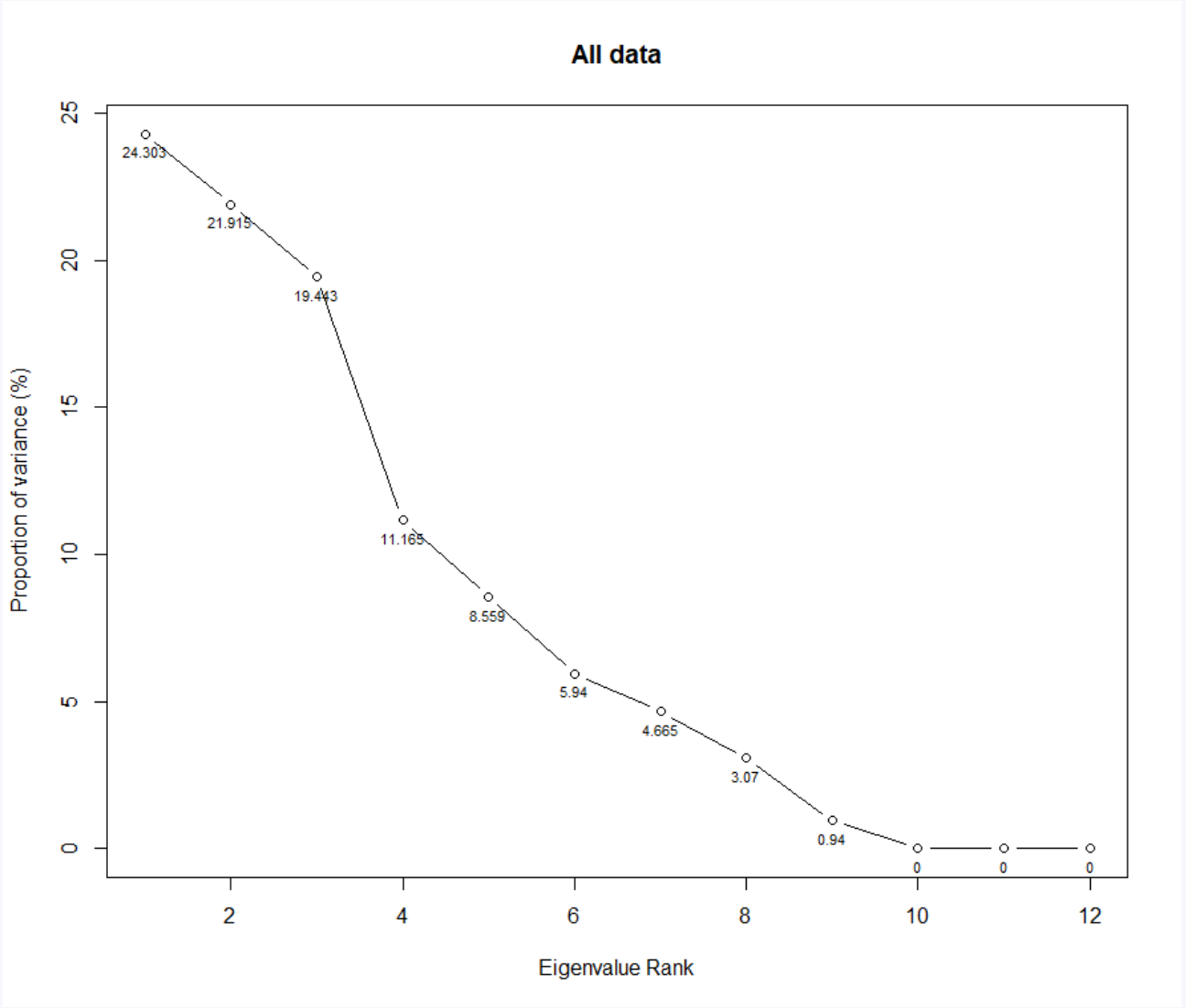
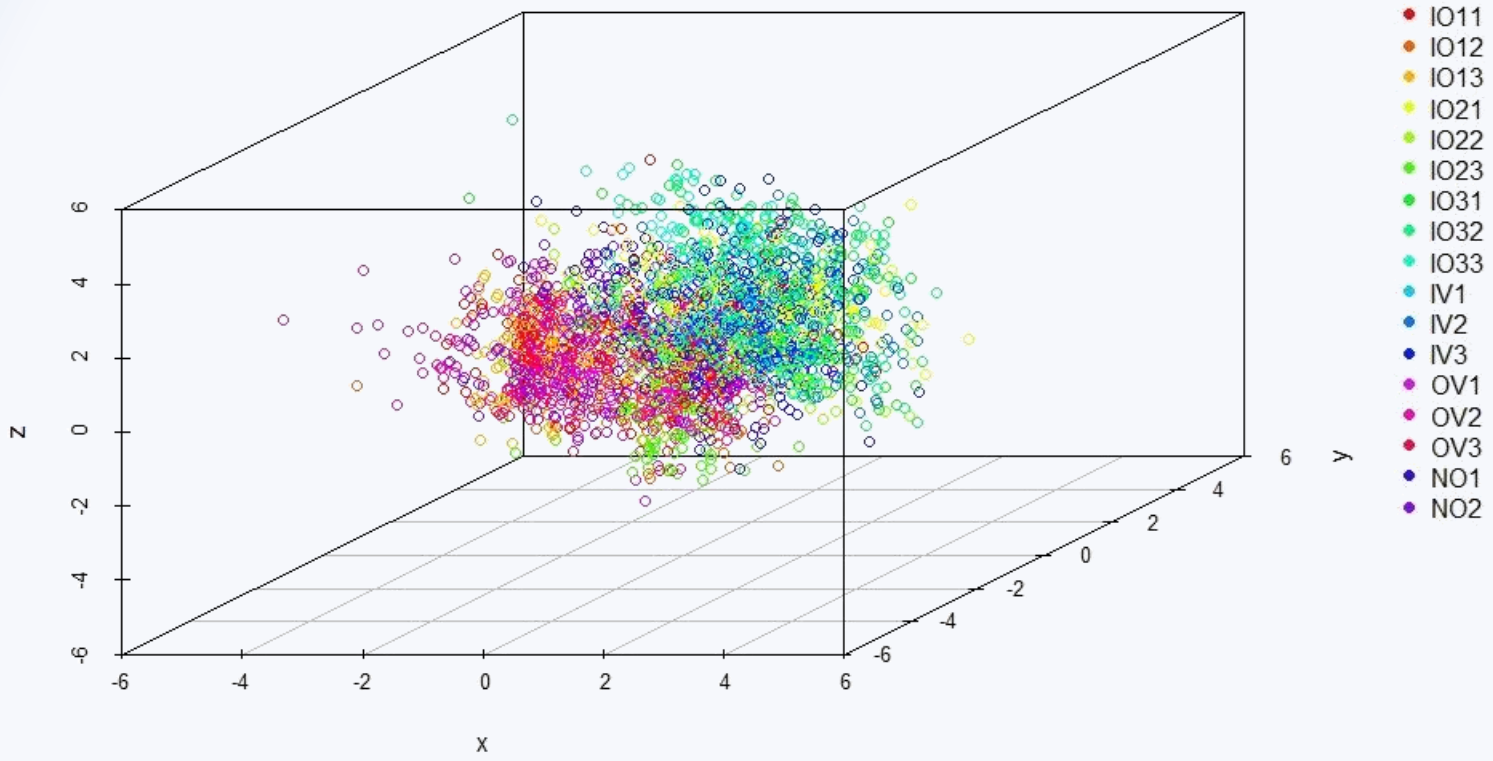
EXPLORATORY DATA ANALISYS

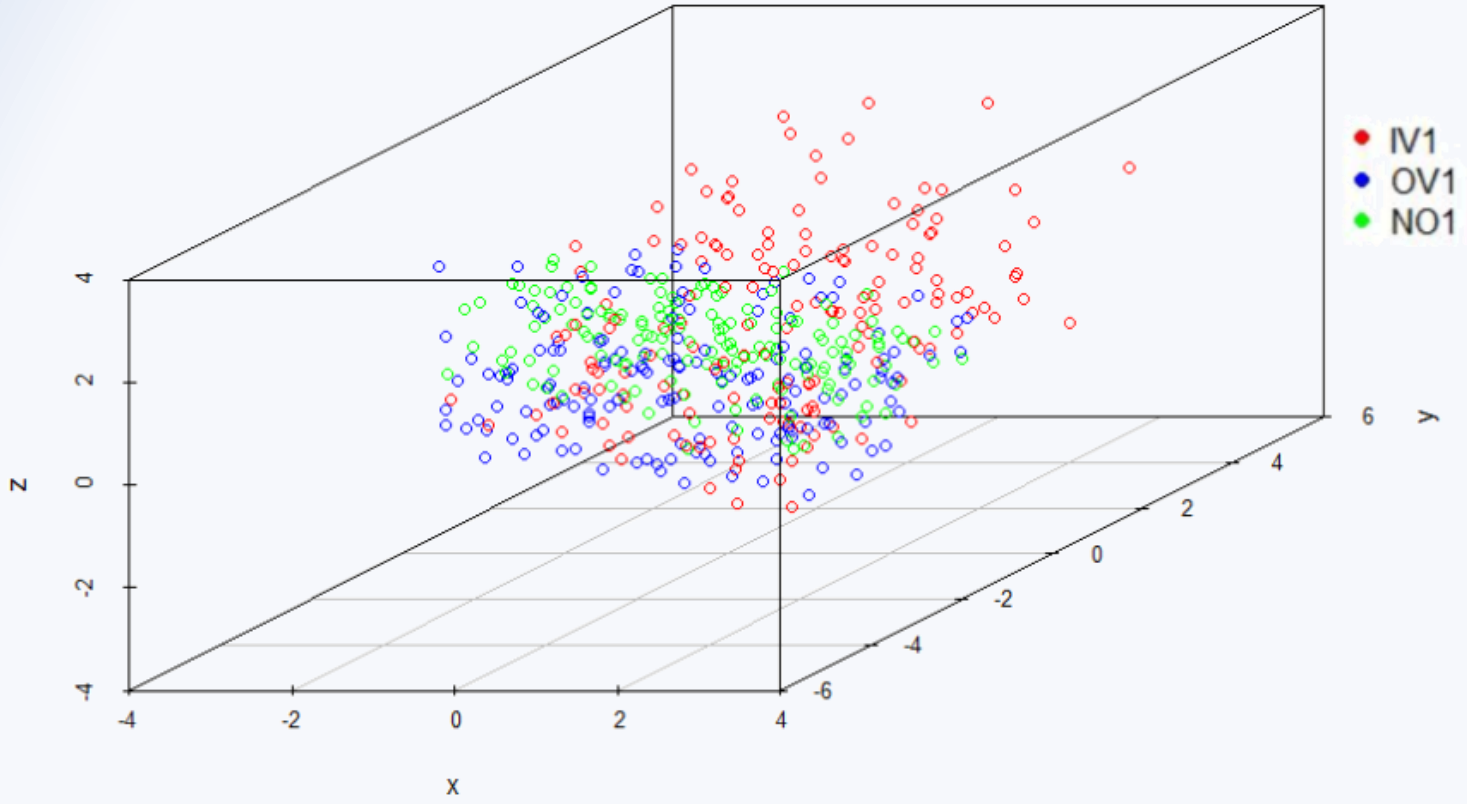
1. Validation of data
2. Blockage states
3. 12-dimensional data
4. PCA



RESULTS - TOTAL



RESULTS – SOFT BLOCKAGE



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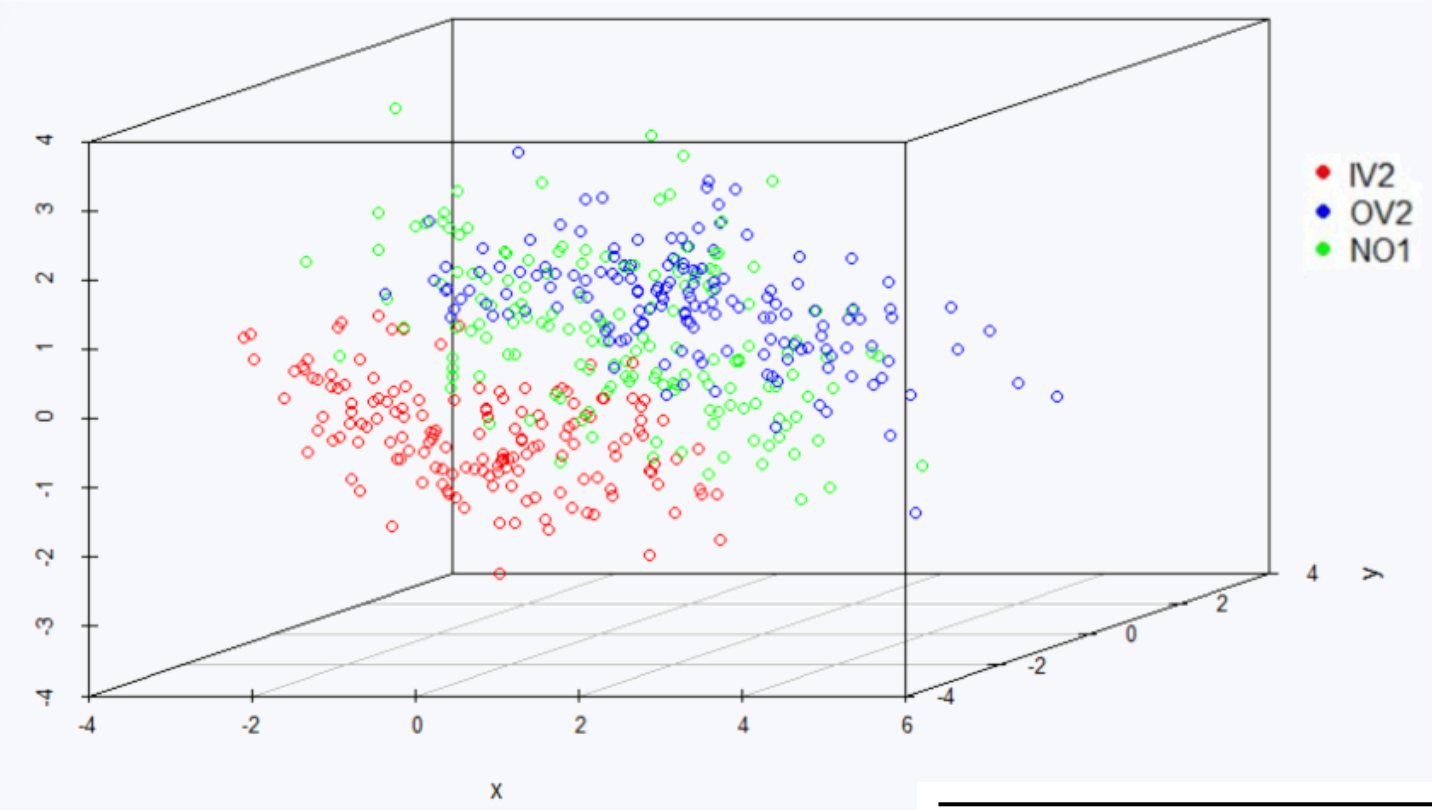
		0%	20%	50%	80%
Inlet valve	0%	NO1/NO2	OV1	OV2	OV3
	20%	IV1	IO11	IO12	IO13
	50%	IV2	IO21	IO22	IO23
	80%	IV3	IO31	IO32	IO33

RESULTS - MEDIUM BLOCKAGE



		Outlet valve			
		0%	20%	50%	80%
Inlet valve	0%	NO1/NO2	OV1	OV2	OV3
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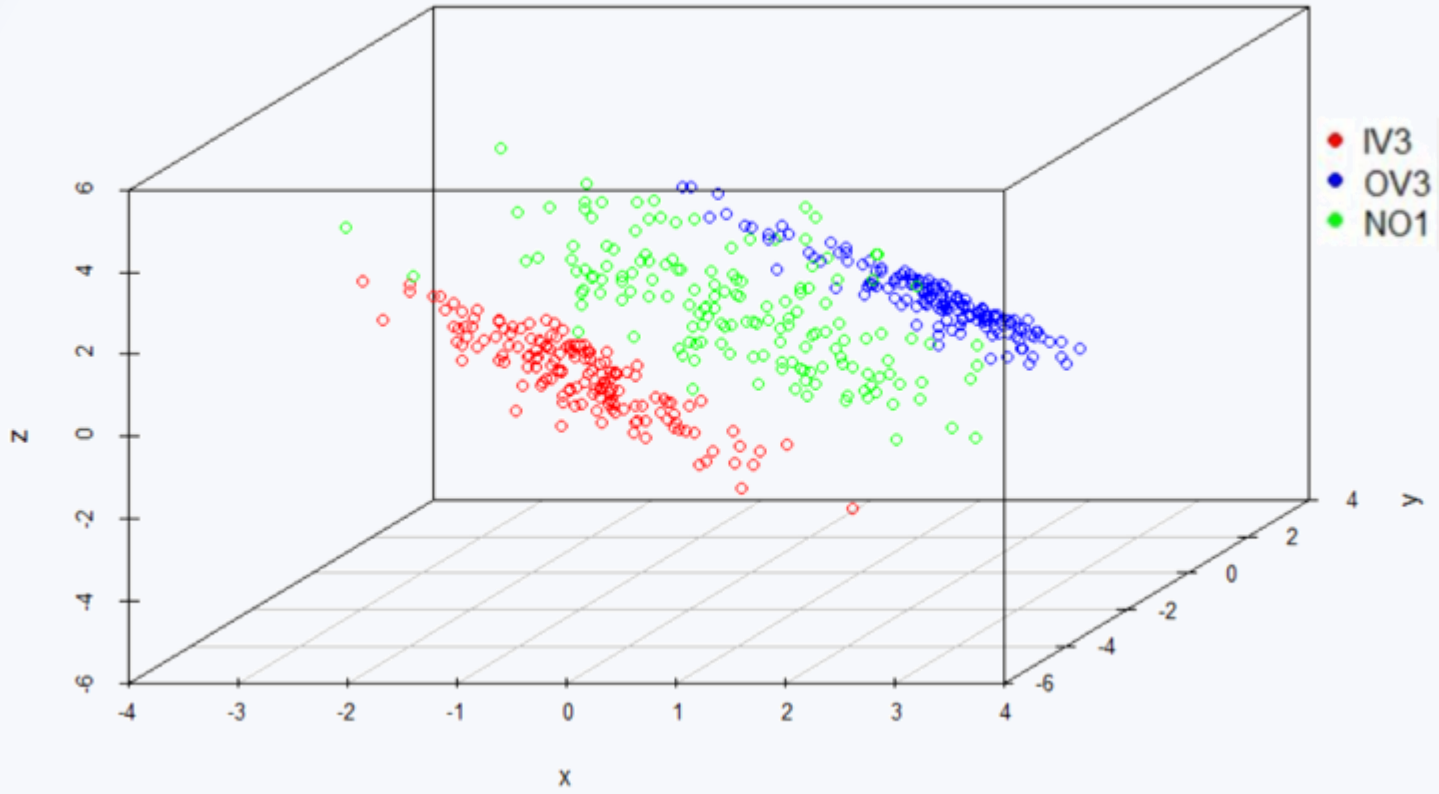
	50%	IV2	IO21	IO22	IO23
	80%	IV3	IO31	IO32	IO33

RESULTS – HEAVY BLOCKAGE



		Outlet valve			
		0%	20%	50%	80%
Inlet valve	0%	NO1/NO2	OV1	OV2	OV3
	20%	IV1	IO11	IO12	IO13
	50%	IV2	IO21	IO22	IO23
	80%	IV3	IO31	IO32	IO33

CONCLUSIONS

- Dataset of different blockage states
- Data have been enough accurate to show results despite the use of
  - Cost-effective sensors
  - Open-source software (node-RED)
  - Slow sampling frequency
- Differences among blockage states have been identified with PCA
- Future research on a condition monitoring system.
  - Training of a supervised learning model for the detection of different blockage states.

Thank you for your attention !

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