

CONNECTING
EXPERTS.

CHILLVENTA eSPECIAL

Refrigeration | AC & Ventilation | Heat Pumps

13.–15.10.2020

NÜRNBERG MESSE

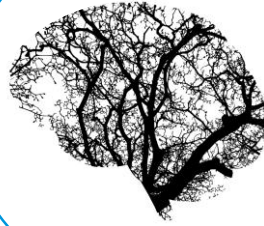
How Artificial Intelligence (AI) can save on installation & operating costs of refrigeration systems

Presentation at Chillventa eSpecial 2020

DR. CARSTEN SPIEKER, 2020-10-15, BERLIN



Cloud Based Real Time Anomaly Detection with Artificial Intelligence

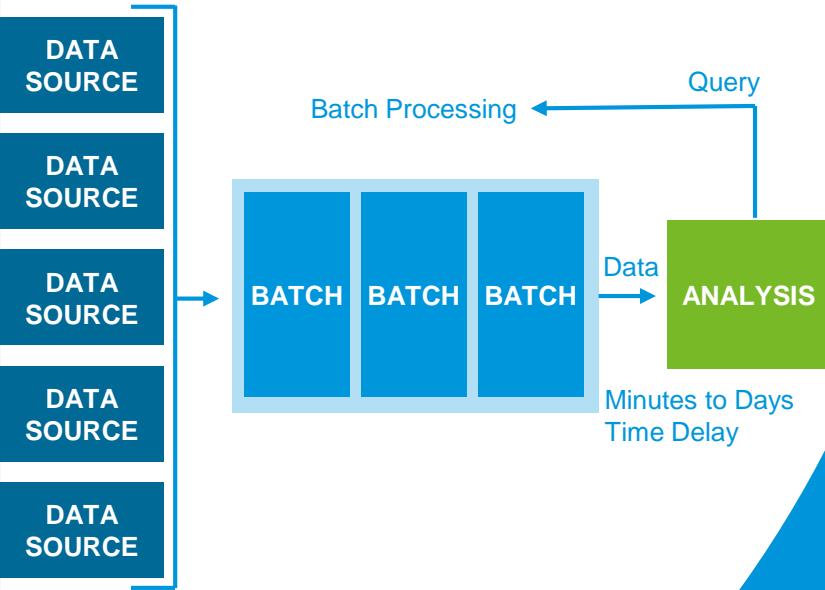


Chillventa eSpecial 2020

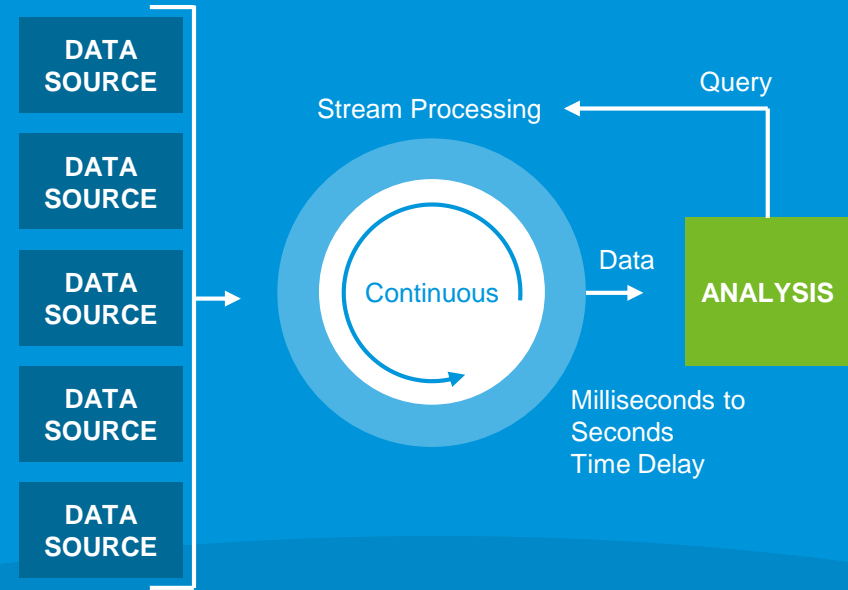


Stream Processing instead of Batch Processing

BATCH PROCESSING

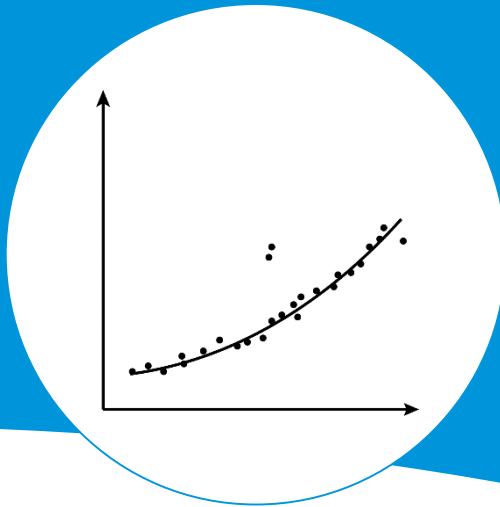


STREAM PROCESSING

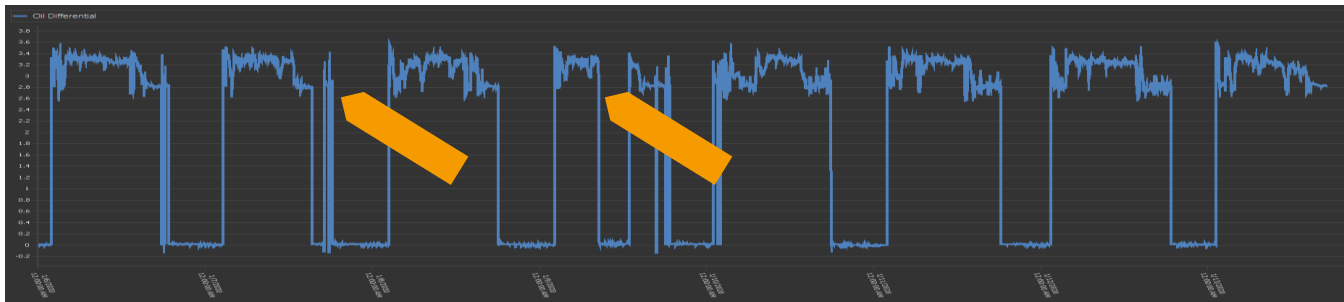


Anomaly Detection: Definition & Example

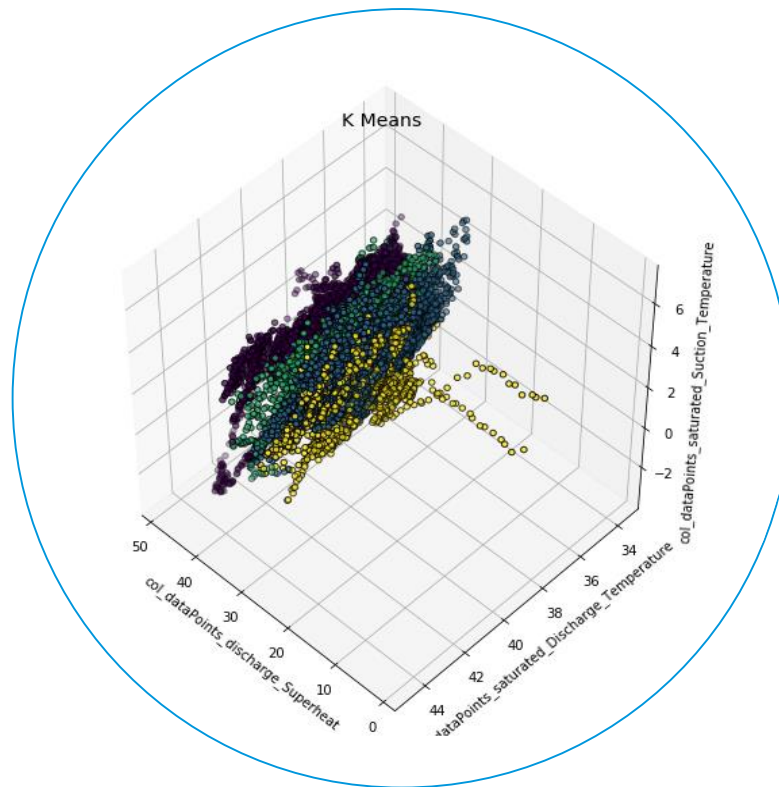
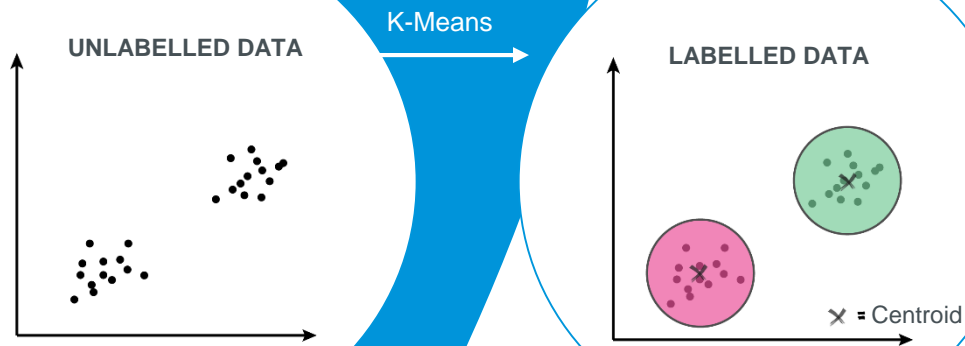
Anomaly:
Something, that deviates from what is standard,
normal or expected



7 DAYS OF DATA: OIL DIFFERENTIAL PRESSURE



Anomaly Detection: Clustering

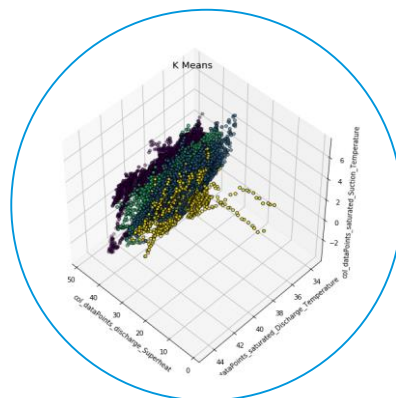
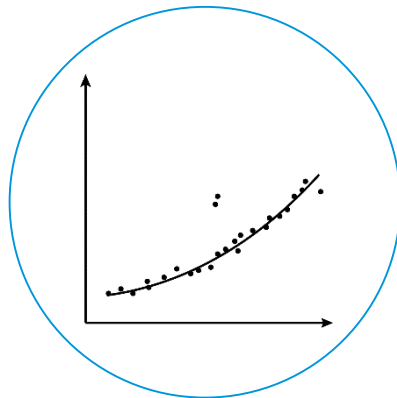


Anomaly Detection: GEA Omni Historian Data File

- Time consuming to do even simple analysing manual -

Time	43763.83	Current Capacity Step	-1	Start Permissive	FALSE
Loop Time [ms]	4	Compressor Actual Runtime [h]	12	Auxiliary Shutdown	TRUE
Oil Differential Pressure [barD]	0.01	Motor Speed Input [rpm]	0	Compressor Motor Protection	TRUE
Saturated Suction Temperature [Å°C]	11.9	Cylinder Head Temperature 1 [Å°C]	20.8	Low Oil Level	TRUE
Saturated Discharge Temperature [Å°C]	11.7	Cylinder Head Temperature 2 [Å°C]	20.8	Clear Annunciations	FALSE
Suction Superheat [K]	9.1	Cylinder Head Temperature 3 [Å°C]	21.1	Set Point Selection	FALSE
Discharge Superheat [K]	7.2	Cylinder Head Temperature 4 [Å°C]	21.2	Gas Leak Detection Input	TRUE
Run Time Hours [h]	12	Cylinder Head Temperature 5 [Å°C]	22	Compressor Blocked	FALSE
Number Of Compressor Starts	127	Cylinder Head Temperature 6 [Å°C]	21.6	Oil Cooling	FALSE
kW Total Usage [kWh]	0	Cylinder Head Temperature 7 [Å°C]	21.6	Unloaded Start	FALSE

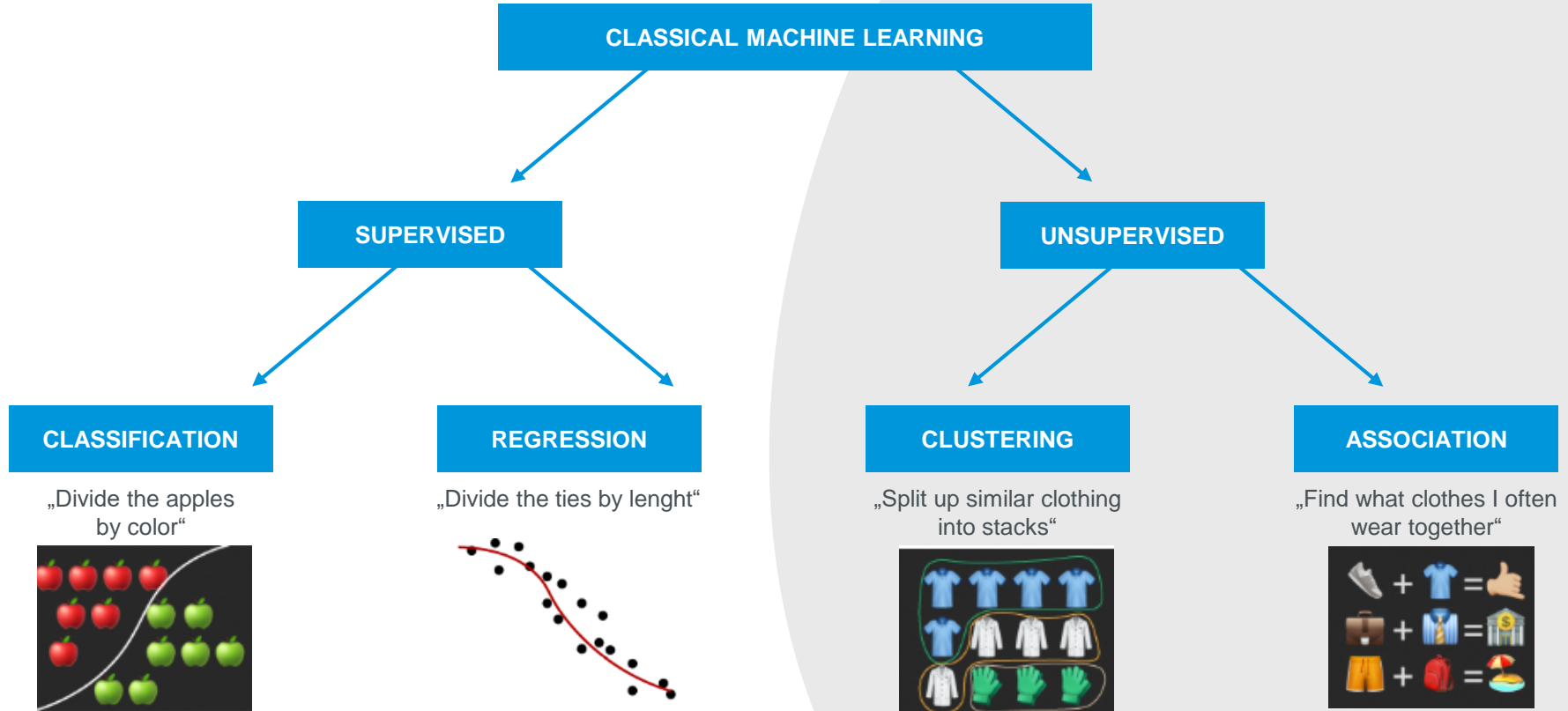
Current Capacity [%]
Motor Speed [rpm]
kWh Demand [kW]
Suction Pressure [barA]
Discharge Pressure [barA]
Oil Pressure [barA]
Motor Current [A]
Suction Temperature [Å°C]
Discharge Temperature [Å°C]
Oil Inlet Temperature [Å°C]
Oil Separator Temperature [Å°C]
Slide Or Capacity Output [%]
Crankcase Pressure [barA]
Pressure Ratio [D/S]
Compressor Control Mode



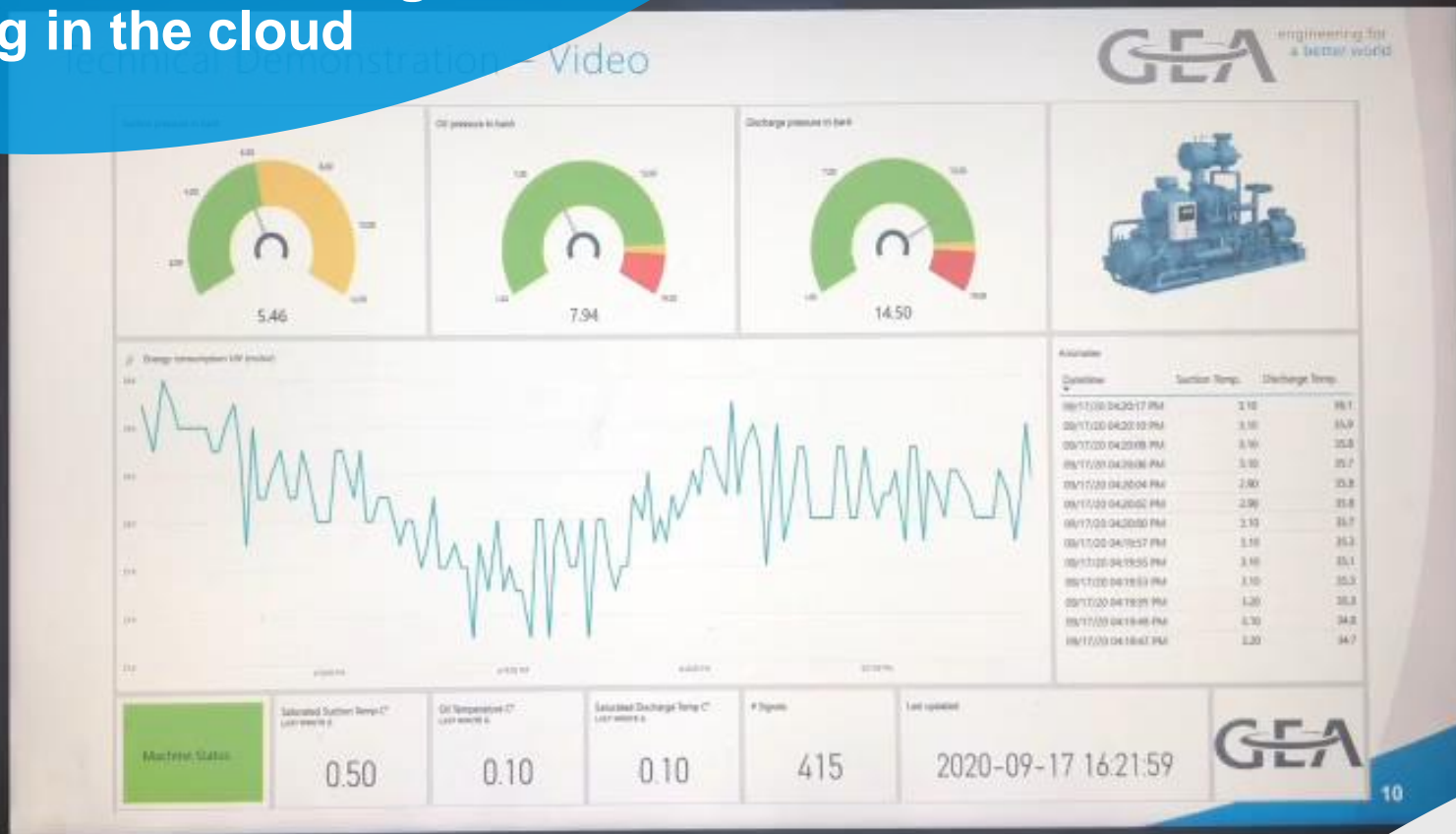
Unsupervised Learning: Labelled Datasets

equipment	projectNumber	sourceTimestamp	motor Running	discharge Superheat	saturated Discharge Temperature	saturated Suction Temperature	suction Superheat	motor Current	discharge Pressure	suction Pressure	oil Pressure	anomaly
Compressor1	DenBosch_01_RC1	9/12/2020 8:38	1	23.4	39.8	3.4	10.1	33.6	15.26	5.54	7.97	0
Compressor1	DenBosch_01_RC1	9/12/2020 8:38	1	23	40.3	3.2	10.3	33.8	15.45	5.52	7.94	0
Compressor1	DenBosch_01_RC1	9/12/2020 10:59	1	28.9	37.1	2	12.1	32.8	14.26	5.31	7.73	0
Compressor1	DenBosch_01_RC1	9/12/2020 10:59	1	28.3	37.7	2	12.1	32.8	14.48	5.31	7.72	0
Compressor1	DenBosch_01_RC1	9/11/2020 12:27	1	27.6	37.8	5.2	8.6	35.1	14.52	5.87	8.43	1
Compressor1	DenBosch_01_RC1	9/11/2020 12:27	1	27.1	38.2	5	8.8	34.2	14.65	5.83	8.43	0
Compressor1	DenBosch_01_RC1	9/12/2020 8:38	1	23.6	39.8	3.1	10.3	33.9	15.26	5.49	7.92	0
Compressor1	DenBosch_01_RC1	9/12/2020 8:38	1	22.8	40.7	2.9	10.5	33.9	15.59	5.47	7.9	0
Compressor1	DenBosch_01_RC1	9/12/2020 8:38	1	23	40.7	2.8	10.5	33.8	15.58	5.44	7.85	1
Compressor1	DenBosch_01_RC1	9/12/2020 8:38	1	23.6	40.2	2.7	10.6	34.4	15.41	5.43	7.84	1
Compressor1	DenBosch_01_RC1	9/12/2020 8:38	1	22.5	41.5	2.5	10.7	34.1	15.9	5.4	7.81	0
Compressor1	DenBosch_01_RC1	9/12/2020 8:38	1	22.2	41.9	2.4	10.8	34.2	16.06	5.38	7.8	0
Compressor1	DenBosch_01_RC1	9/12/2020 8:39	1	23.3	41	2.5	10.6	32.5	15.71	5.39	7.79	0
Compressor1	DenBosch_01_RC1	9/12/2020 8:39	1	23.1	41.3	2.5	10.5	28.4	15.82	5.4	7.83	0
Compressor1	DenBosch_01_RC1	9/12/2020 8:39	1	23.5	41.3	2.5	10.6	27.7	15.82	5.39	7.86	0
Compressor1	DenBosch_01_RC1	9/12/2020 8:39	1	24.2	41.2	2.4	10.7	27.9	15.8	5.37	7.88	0
Compressor1	DenBosch_01_RC1	9/12/2020 8:39	1	24.1	41.7	2.1	11	27.9	15.98	5.33	7.88	0
Compressor1	DenBosch_01_RC1	9/12/2020 8:39	1	24.8	41.5	2.2	10.9	27.7	15.91	5.34	7.88	0
Compressor1	DenBosch_01_RC1	9/12/2020 8:39	1	25.7	41.7	2	11.1	28.1	15.97	5.31	7.88	0
Compressor1	DenBosch_01_RC1	9/12/2020 8:39	1	26.9	41.6	2	11.1	28.3	15.93	5.31	7.88	0
Compressor1	DenBosch_01_RC1	9/12/2020 8:39	1	27.9	41.1	2.3	10.8	28.1	15.75	5.35	7.88	0
Compressor1	DenBosch_01_RC1	9/12/2020 8:39	1	29	41	2.3	10.8	28.3	15.72	5.35	7.89	0
Compressor1	DenBosch_01_RC1	9/12/2020 8:39	1	29.3	41.2	2.3	10.8	27.7	15.78	5.35	7.89	0
Compressor1	DenBosch_01_RC1	9/12/2020 8:39	1	30.8	40.6	2.7	10.4	28.1	15.56	5.42	7.91	0
Compressor1	DenBosch_01_RC1	9/12/2020 8:39	1	31.2	40.5	2.7	10.5	27.5	15.5	5.43	7.93	0
Compressor1	DenBosch_01_RC1	9/11/2020 9:49	0	0	19.7	0.2	0	0	9.01	5.01	1.9	0
Compressor1	DenBosch_01_RC1	9/11/2020 9:49	0	0	19.7	0.2	0	0	9.01	5.01	1.9	0
Compressor1	DenBosch_01_RC1	9/12/2020 8:39	1	32.3	40.2	2.6	10.6	27.7	15.41	5.41	7.95	0

Machine Learning Calibration



Real time data streaming & analyzing in the cloud



Summary and our Vision

Anomaly Detection is the first step

Anomalies in practice could be:

- Unusual fast increase of oil differential pressure
- Compressor failure in switching cylinders on/off
- Significant change in starts per day



- Efficiency loss by long running in part load
- Unusual noise or vibration level

Anomaly Detection is regardless from having a plausible explanations!

The aim is of cause, to give clear hints to act!

1. Step: Unsupervised Learning

2. Step: Supervised Learning:

- supported by manufacturer
- **supported by contractor/end user**

Message: “Oil differential pressure is still within the limits. But over the last 6 week an relatively fast increase was detected. It is recommended to check the system.”

Aim to avoid: “... I remember, we had a similar problem some years ago ...”

Continous improvement of labeling the data!



**This journey is just
getting started ...
Feel invited to join us!
Your inputs are welcome
and needed, to
serve you best!**

**Thank you for your
attention.**

**CONNECTING
EXPERTS.**

