DNV·GL

DeepWind 2021

Development and Validation of Automatic Data Quality Control Algorithms

Research at Alpha Ventus (RAVE)

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- Data Scientist
- Digitalization & Research Projects
- Almost 3 years with DNVGL
- More than 4 years in Germany

15.01.2021

Agenda

- Introduction
- Project Data – Research at Alpha Ventus (RAVE)
- General Background
- Automatic Data Quality Control
- Future Works
- References

Introduction – Standard data quality control of measurement data

Disadvantages

- Time consuming process
- High measurement operational cost
- Impossible to check the high frequency measurements
- Immediate detection of measurement errors are not possible
- Extended measurement campaign
- Added uncertainty

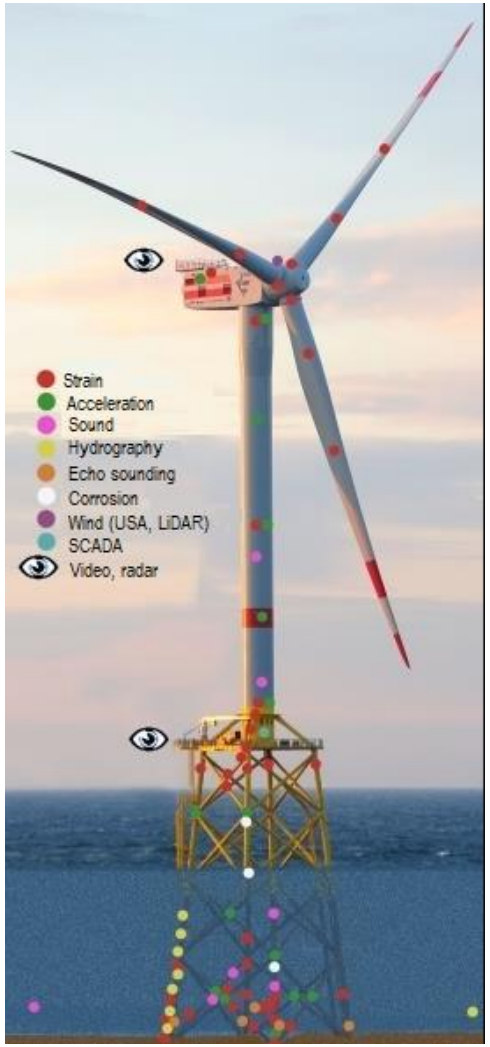
Project data - Research at Alpha Ventus (RAVE)

- The research Initiative RAVE carries out research and development work on the offshore test field alpha Ventus.
- RAVE is funded by the Federal Ministry for Economic Affairs and Energy (BMWi) and coordinated by the Fraunhofer Institute for Wind Energy Systems (IWES).
- In more than 30 research projects, more than 60 partners from science and industry have been working on a wide range of research questions since 2008.
- The financial support from the BMWi so far amounted to more than 50 million euros.

Wind Farm Outlook

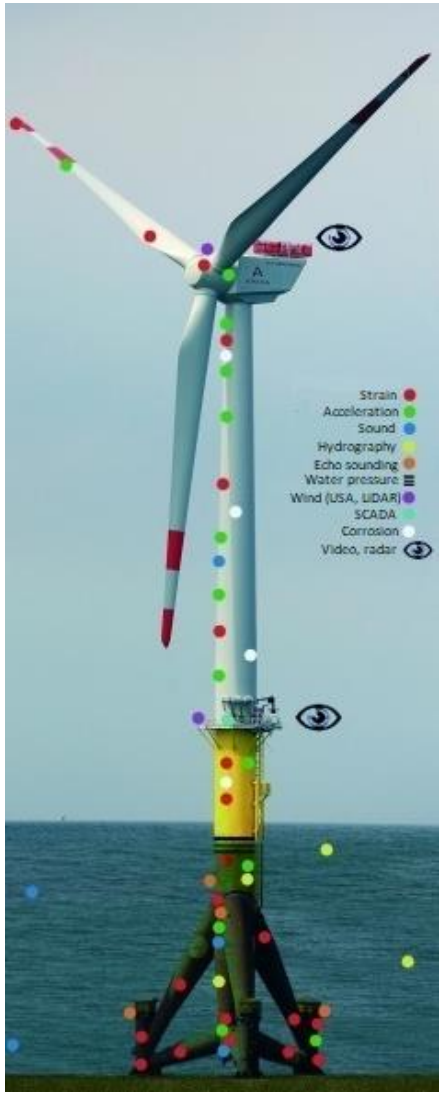
- 45 Km North von Borkum
- 30 m water depth
- 12 Wind turbines
  - 6 AREVA WIND M5000
  - 6 Senvion 5M
- CAPEX : 250 Million Euros
- More than 10 years of measurement data

Project data - Research at Alpha Ventus (RAVE)



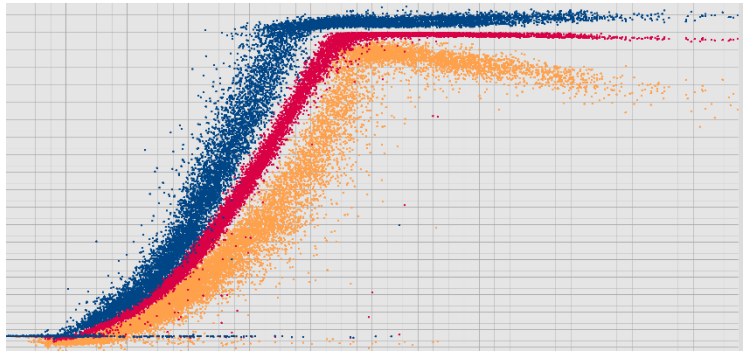
Available Measurements

- Controller Signals
- Acceleration sensors on the tower and blades
- Multiple strain guages on the tower and blades
- Wind measurements
- Atmospheric measurements
- Sea-State Measurements
- Other critical structural measurements
- Other electrical signals

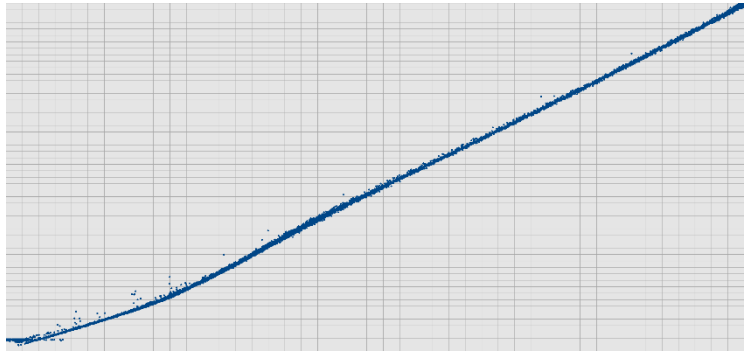


General Background - Standard Visual check procedure

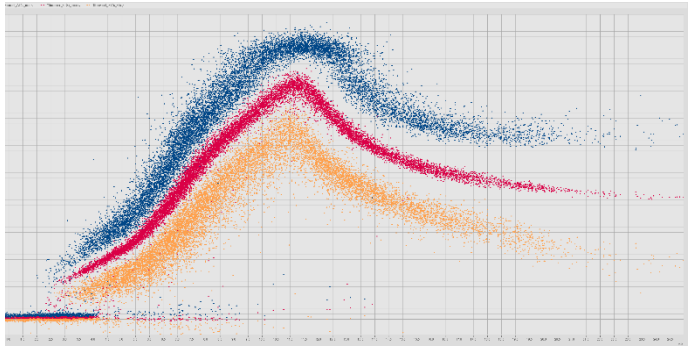
Plausibility Check



Wind Speed vs Electrical Power



Main shaft torsion vs Electrical Power

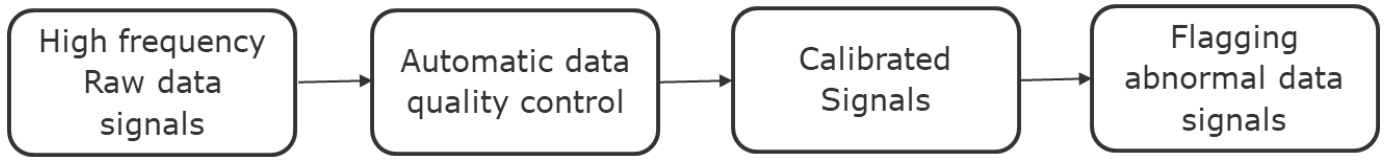


Tower tilt moment vs Electrical Power

Conventional Procedure

- High frequency data is converted into 10-mins statistics
- Standard combination of signals are plotted to check for data plausibility
- When some abnormal behaviour (for example :outliers, drifts, offset etc.) is identified, the particular data set is flagged.

General Background – Automatic data quality control

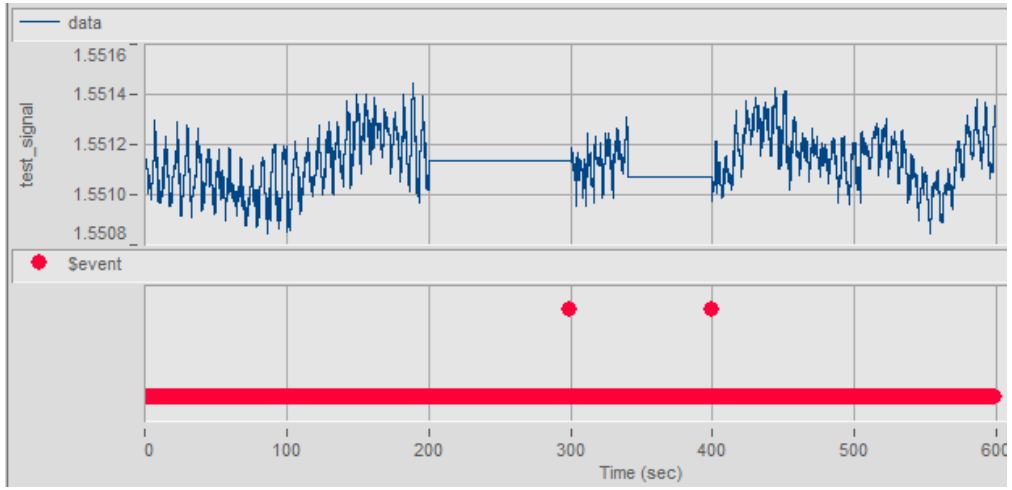


Objective

- Control the data collected from RAVE wind farm
- Plausibility check on raw signals (0.2 to 50 HZ signals)
- Automating the control and flagging process
- Independent to sensor and measurement system
- Minimal input parameters (Robust model)
- Save time and operational cost
- High quality data for future applications

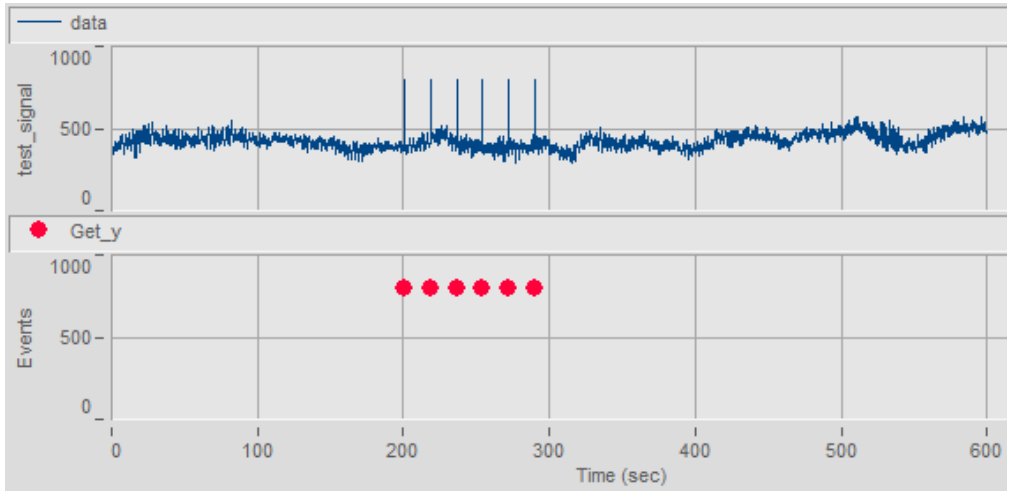
Position	Test Type	Meaning	Thresholds	Description
1	Length	Reduced data length	N_{crit}%	Data of length of some value N_{crit} deviating from N 100%
2	Flat Line	Constant Signal	N/A	All values the same (e.g. bad if sensor is strain gauge, Ok/Check if machine data)
3	Flat Line	Partially Constant	t_{crit}	Constant values for a period of > t_{crit} seconds (e.g. signal dropouts)
4	Pre-defined Limits	Measurement Range	$\sum (x_i > x_{crit}) > 0$	At least one value outside the measurement range (e.g. ±10 V)
5	Spike	Spike events exceeded	n_{crit}	Number of spikes found in signal exceeds critical value.
6	Spike	Low Correlation	r_{crit}	Despiked signal poorly correlated with uncorrected signal.
7	Visual/ Qualitative	Qualitative assessment	N/A	Data assessed manually (e.g. poor correlation with wind speed).
8–16	-	- *Spare* -	-	Further tests included here.

Automatic data quality control – Case Study



Master Flag

Flags : 001000/1

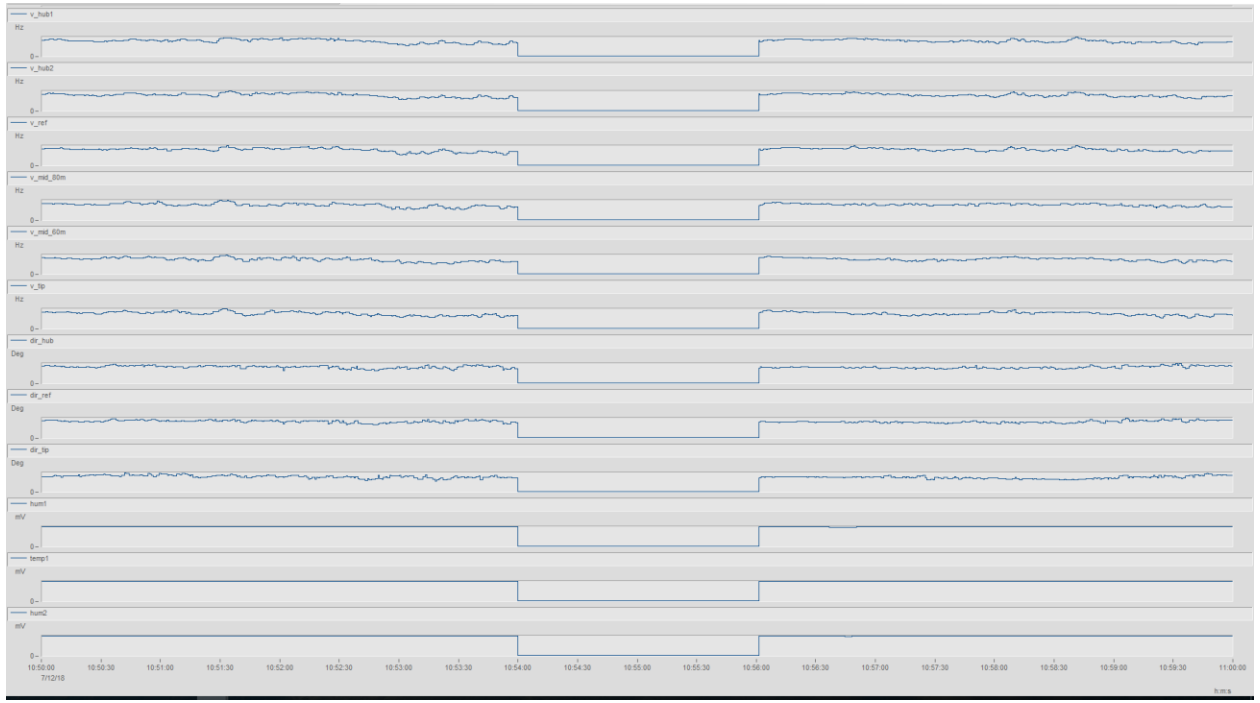


Master Flag

Flags : 000100/1

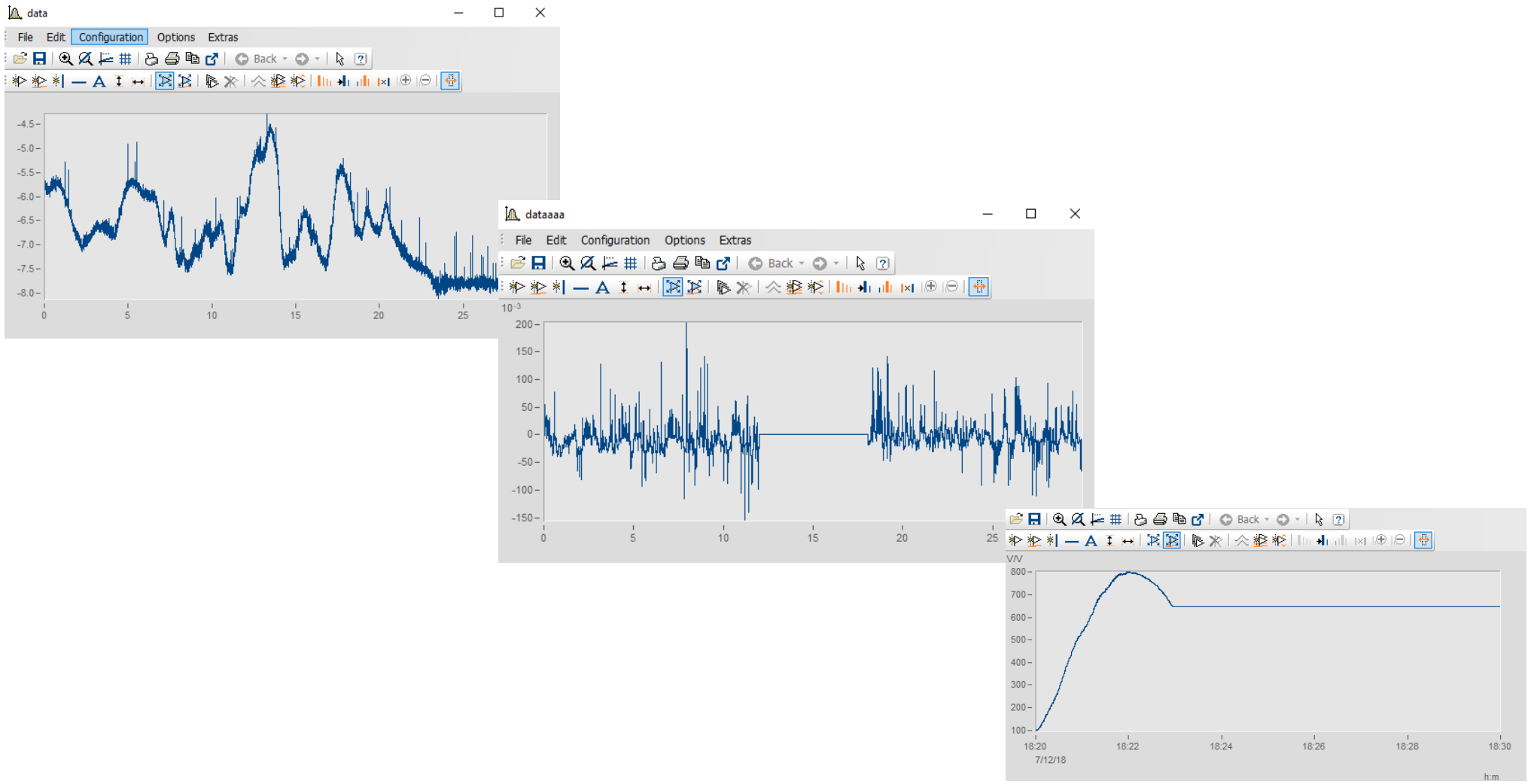
Automatic data quality control – Result outlook

7/12/2018 18:00	000000	Good	000000	Good	000000	Good	000000	Good	000000	Good	000000	Good	000000	Good
7/12/2018 18:10	000000	Good	000000	Good	000000	Good	000000	Good	000000	Good	000000	Good	000000	Good
7/12/2018 18:20	000000	Good	000000	Good	000000	Good	000000	Good	000000	Good	000000	Good	000000	Good
7/12/2018 18:30	001000	Fail	001000	Fail	001000	Fail	001000	Fail	001000	Fail	001000	Fail	001000	Fail
7/12/2018 18:40	001000	Fail	001000	Fail	001000	Fail	001000	Fail	001000	Fail	001000	Fail	001000	Fail



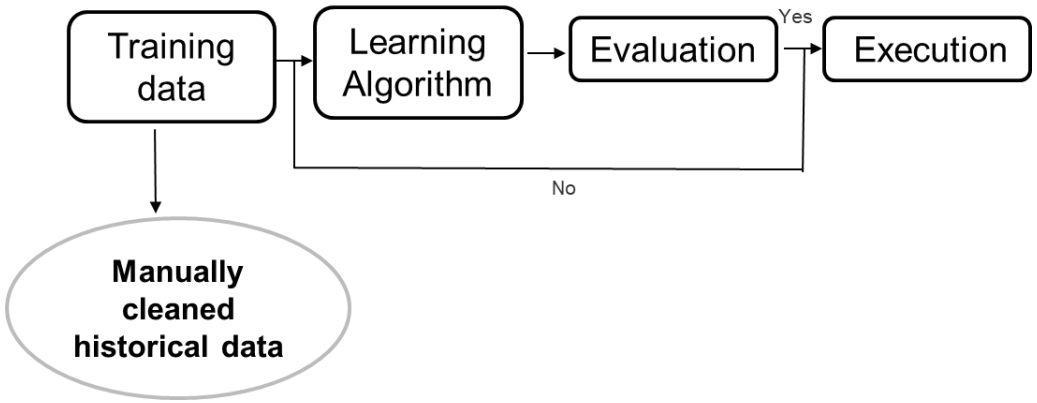
Automatic data quality control – Result outlook

DQ	DR
Trot_hss_Nm	Master_check
000111	Fail
000111	Fail
000111	Fail
000111	Fail
000111	Fail
000111	Fail
000111	Fail
000111	Fail
000111	Fail
000111	Fail
000111	Fail
000111	Fail
000111	Fail
000111	Fail
000111	Fail
010110	Fail
000111	Fail
000111	Fail
000111	Fail
000111	Fail
000111	Fail

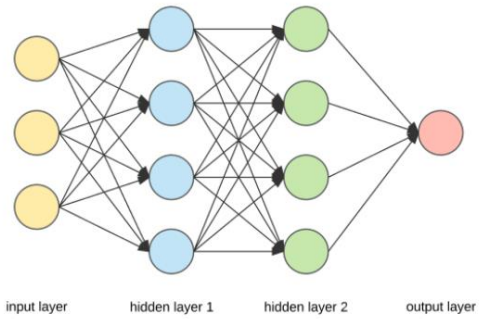


Future works

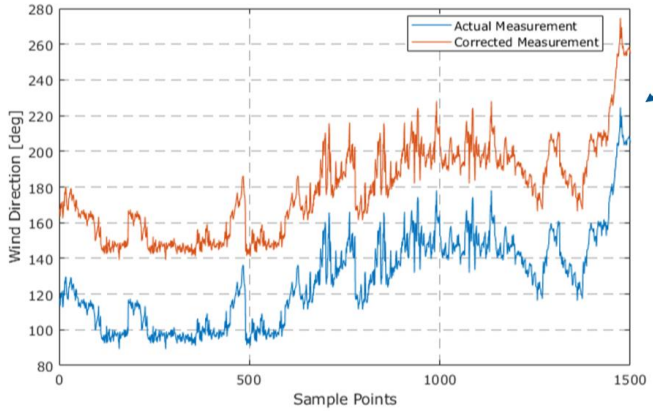
With help of Machine Learning…..



Deep Neural Networks

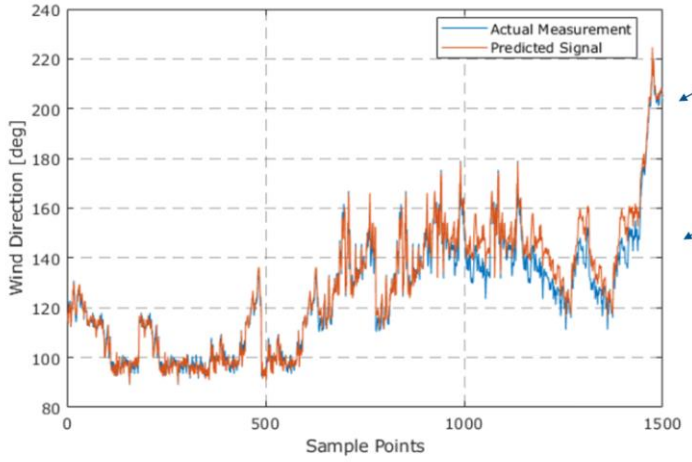


Undetected errors in data (offset, drifting of sensors…)



50 degrees offset

ADQC Output
000000 – No events found



ADQC Output
000000 – No events found

RAVE-ML
0 - Pass

* ADQC- Automatic data quality control

Reference

1. Quality Control of RAVE Measurements from AV00, AV04, AV05, AV07–AV12 and FINO1 Version 1.0 (Report) *BSH - Publikationen - Quality Control of RAVE Measurements from AV00, AV04, AV05, AV07–AV12 and FINO1*
2. Vickers, D., and Mahrt, L. "Quality Control and Flux Sampling Problems for Tower and Aircraft Data." Journal of Atmospheric and Oceanic Technology 14 (1997): 512–526.

Partners & Sponsors

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Thanks for your attention

Any Questions ?

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