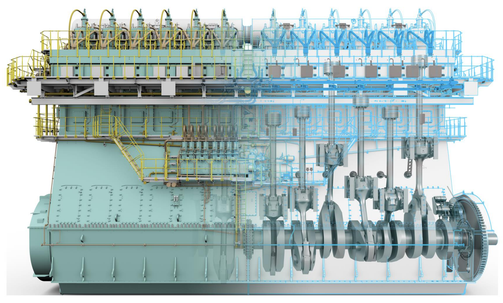

Sensor-Based Anomaly Detection for Marine Engines with LSTM Auto-Encoders

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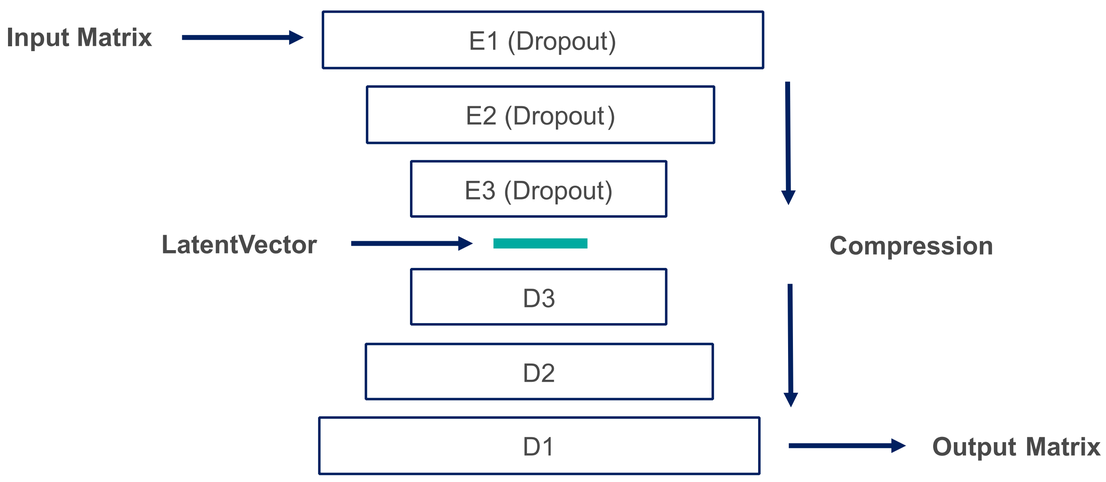
Introduction

To verify multiple sensor signals for several cylinders and engines on board, computer algorithms are helpful because multidimensional capture often exceeds the capability of human perception and staff on board is limited. In addition, however, engines faults have to be avoided at all time because they lead to dangerous situations in open water as well as to expensive delays in the vessels' schedule.

The following contribution describes a data-driven approach for mapping the behavior of common subsystems from marine engines and anomaly detection of e.g. liner damage based on the corresponding real-world measurement signals and shows various steps from data analysis to preprocessing and modeling. This will help to find engine issues and thereby support e.g. troubleshooting abilities.

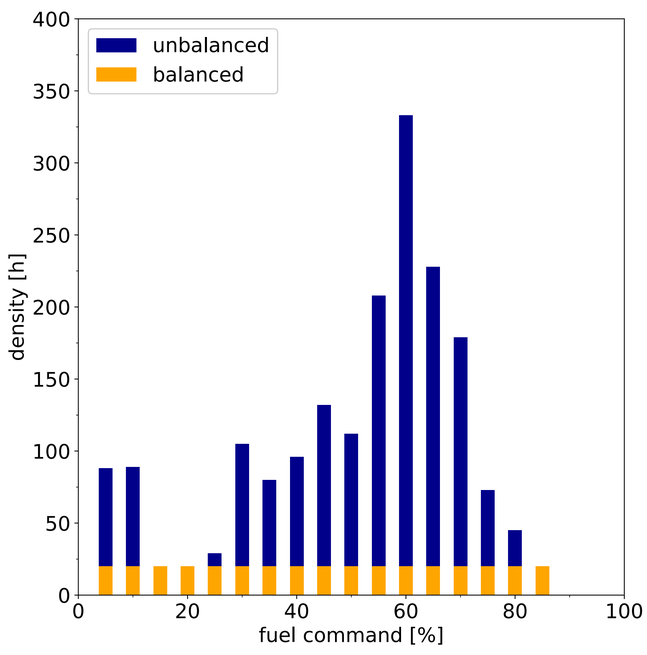
Encoder-Decoder



- Inputs to describe vessel condition + outputs
- Outputs to describe subsystem condition

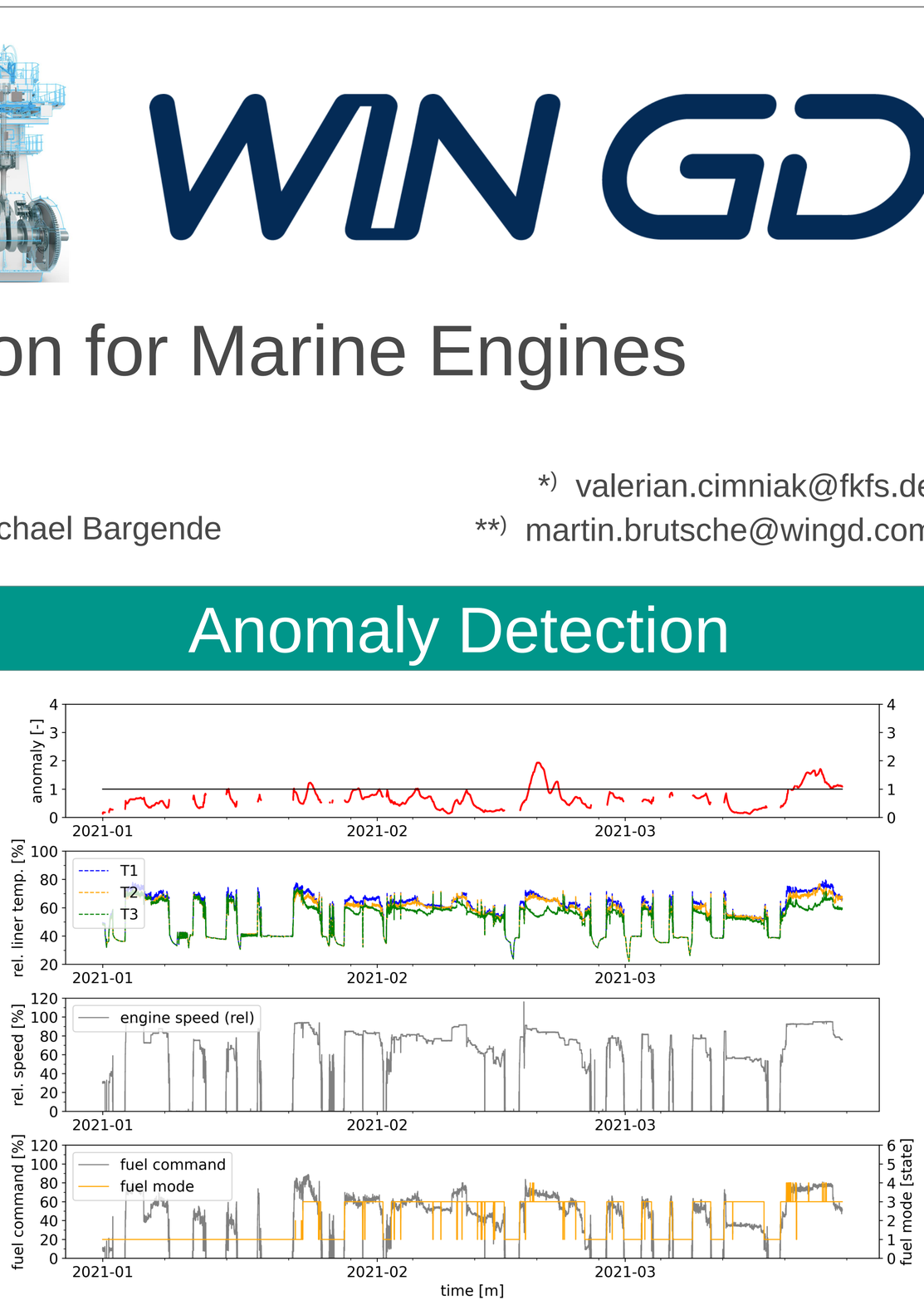
Data Balancing

- Classify available vessel data
- Balance train data over vessel conditions
- Data augmentation for less represented windows

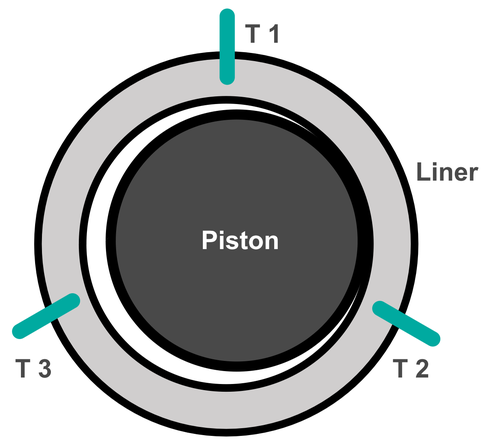


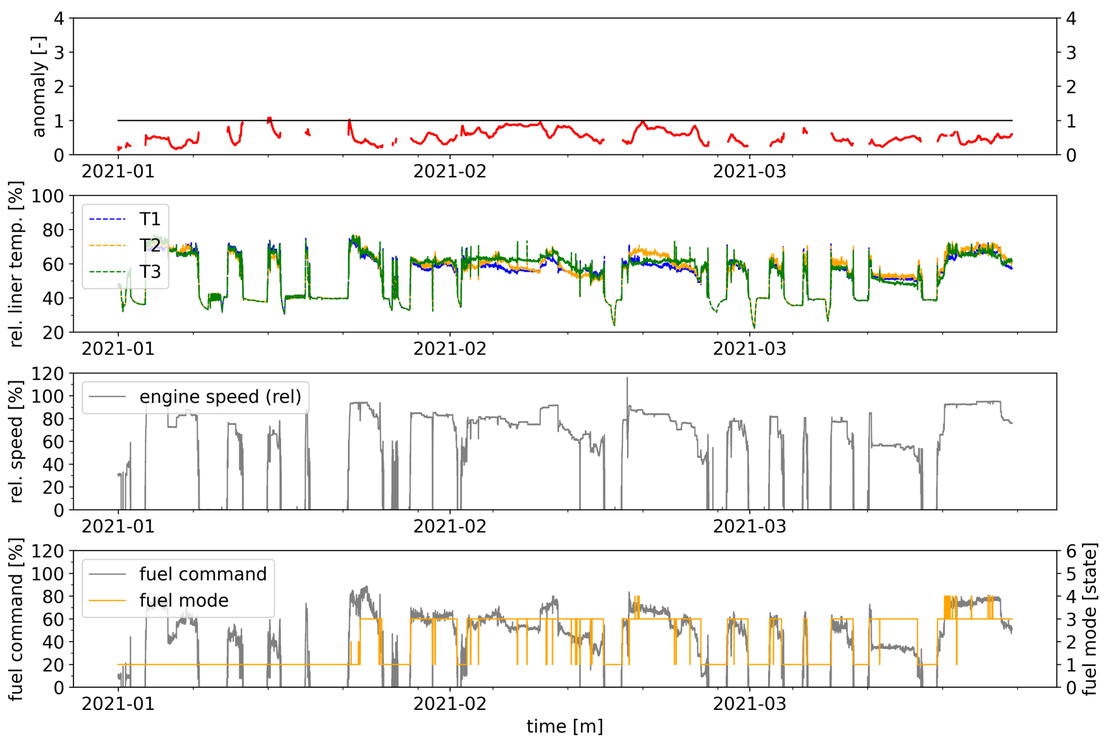
Ramp	Frequency
5-10	4
5-30	1
…	…
5-50	1
…	…
60-40	1
60-60	338
60-70	4

Anomaly Detection



- Common behaviour until mid of February
- T1 and T2 start to rise T3 falls
- Piston contact between T1 and T2





- Common behaviour of liner wall temperatures
- $\overrightarrow{e_R} = |\overrightarrow{in} - \overrightarrow{out}|$
- $\vec{a} = \frac{\overrightarrow{e_R}}{\vec{t}} \quad (critic\ threshold\ t)$
- $a'_t = \frac{a_t+(1-\alpha)a_{t-1}+(1-\alpha)^2 a_{t-2}+\cdots+(1-\alpha)^t a_0}{1+(1-\alpha)+(1-\alpha)^2+\cdots+(1-\alpha)^t}$

$$\alpha = \frac{2}{T+1}, for\ T \geq 1 \quad (exp.\ moving\ average)$$