AI-ROT

Artificial Intelligence Optimization for Production Lines Deploying Rotating Machinery

Mechatronics Circus
Thursday 7th April 2022

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Overview of the consortium

Machine direction analysis

Rotating machine elements cause imperfections in the end product.

From measured end product quality variation:

- Separate repeating signals caused by rotating machine elements
- Order machine elements in order of significance (effect on end product quality)
- Obtain average pattern produced by single revolution of machine element
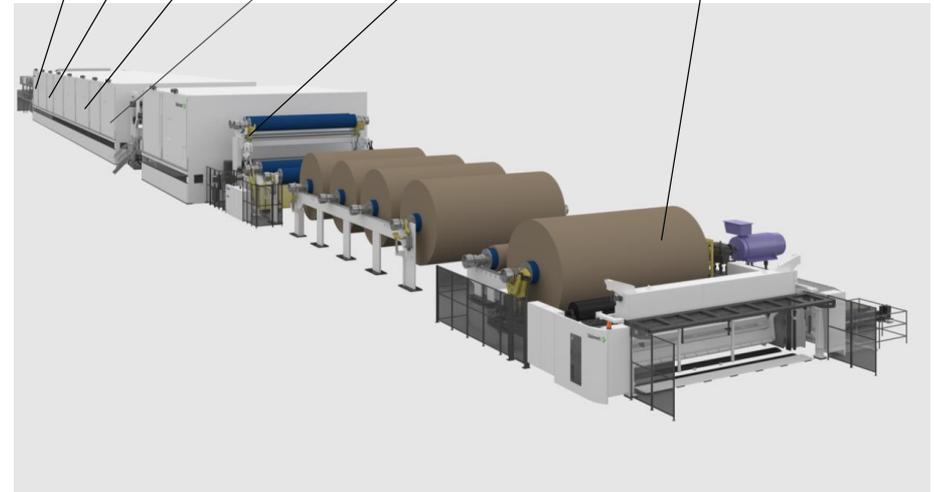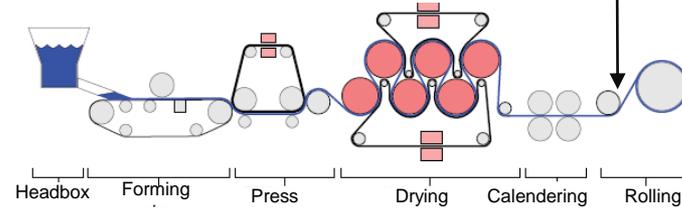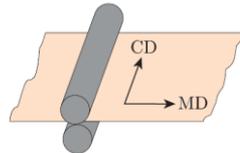

Measurement of end product

Headbox | Forming wire | Press | Drying | Calendering | Rolling

Image: Valmet

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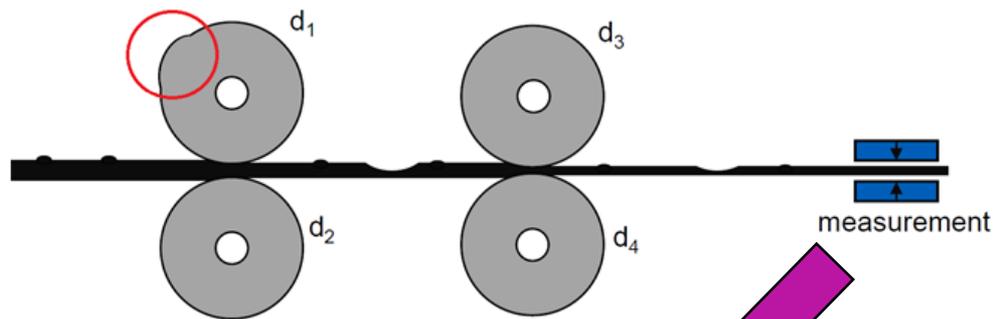# The punchline

Monitor the condition of multiple rolls based on a single measurement.

measurement

I am to blame!
Repair me!!!

Video: Valmet QCS
https://www.youtube.com/watch?v=XUKLlGlySp4

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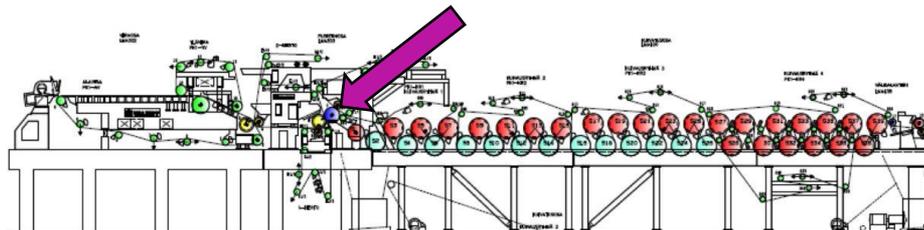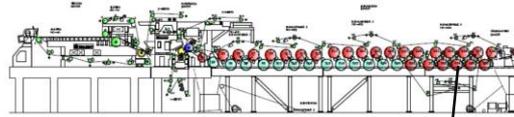
Patterns produced by rolls
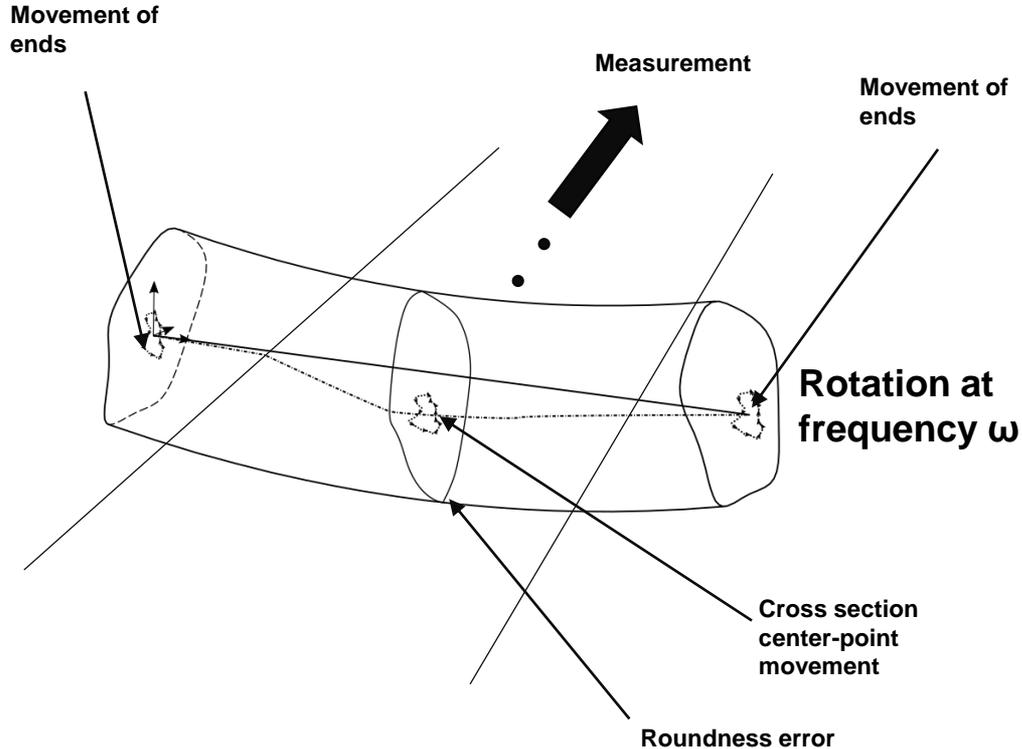
Source of error	Cause	Frequencies	Significance
Cross-section center-point movement	**Unbalance**, straightness error of the roll, movement caused by loads and bending stiffness variation, vertical component of end movements	ω 2ω (due to BSV)	High
Roundness errors	Roundness error due to manufacturing, wear, **damages in the coating**	ω, 2ω, 3ω ... Harmonic series	Low / High
Movement of ends	Bearing geometry errors, flexing of the support structures, stochastic motion due to interplay between components	ω, 2ω, 3ω ... Higher frequencies	Low

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Optimal filtering

Rotating frequencies

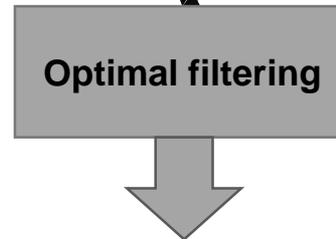**MD variation (QCS data)**
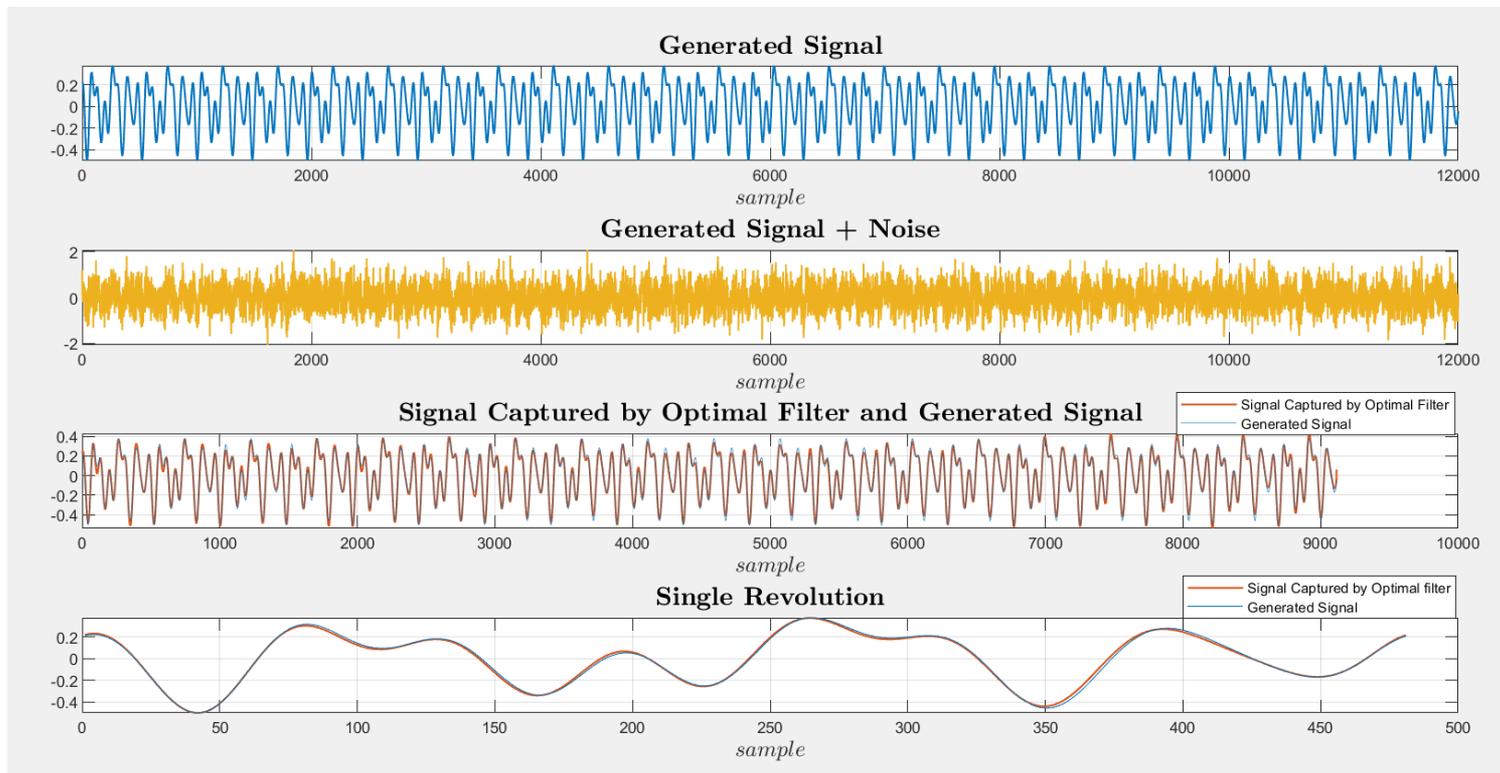

Roll	Rotating frequency [Hz]
Former	2.33
1.Press.up	5.34
1.Press.low	4.67
2.Press.up	6.75
2.Press.low	1.21
1.Dry	3.49
...	...

- **Method for extracting repeating patterns from noisy data**

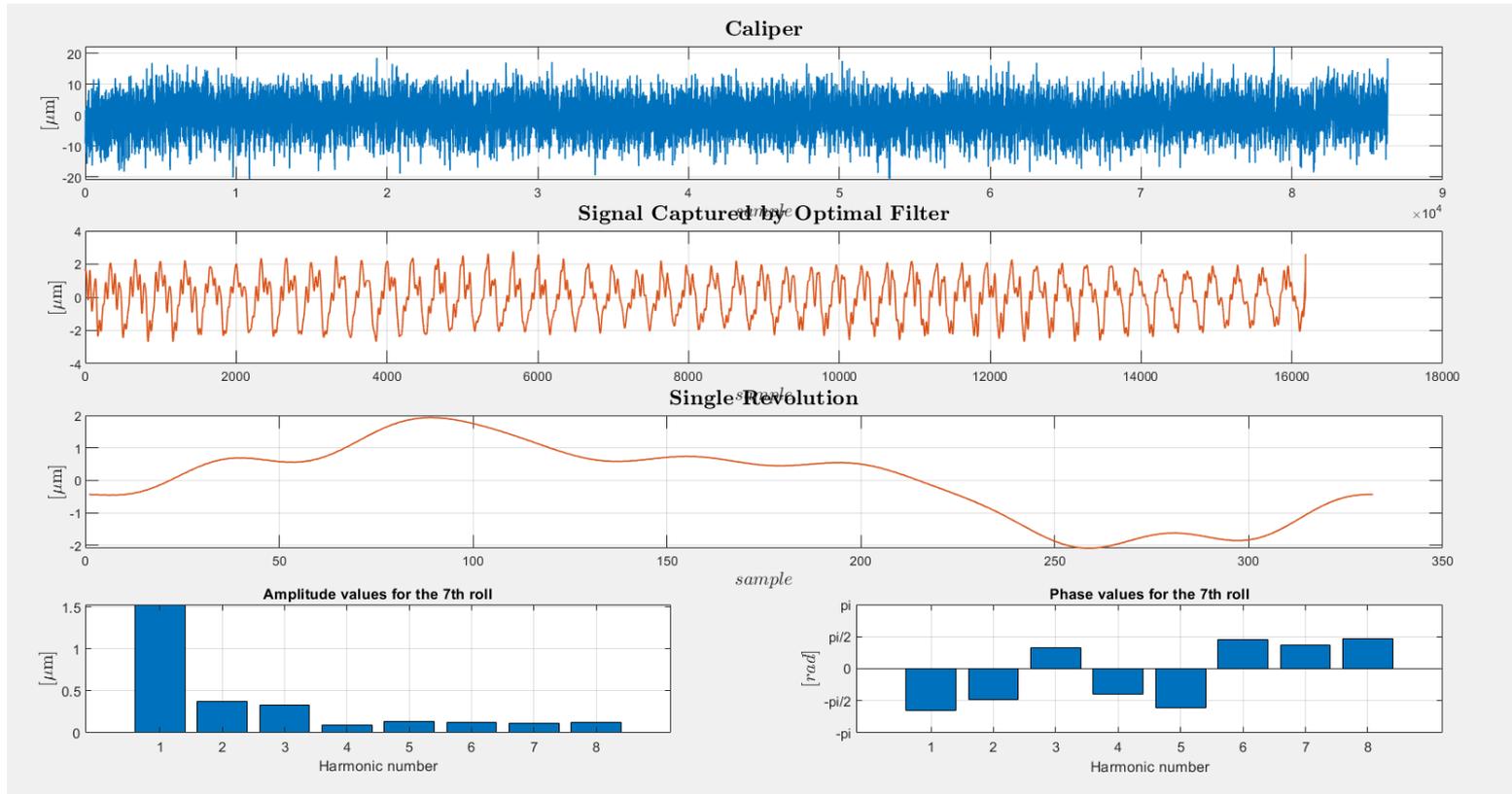- **Filter function is created considering harmonic signal model with noise, not just multiples of frequencies [1]**

Optimal filtering

1. Separate repeating patterns
2. Identify components causing most variation

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[1] Christensen, Mads & Jakobsson, Andreas. (2011). Optimal Filter Designs for Separating and Enhancing Periodic Signals. Signal Processing, IEEE Transactions on. 58. 5969 - 5983. 10.1109/TSP.2010.2070497.
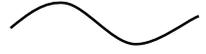
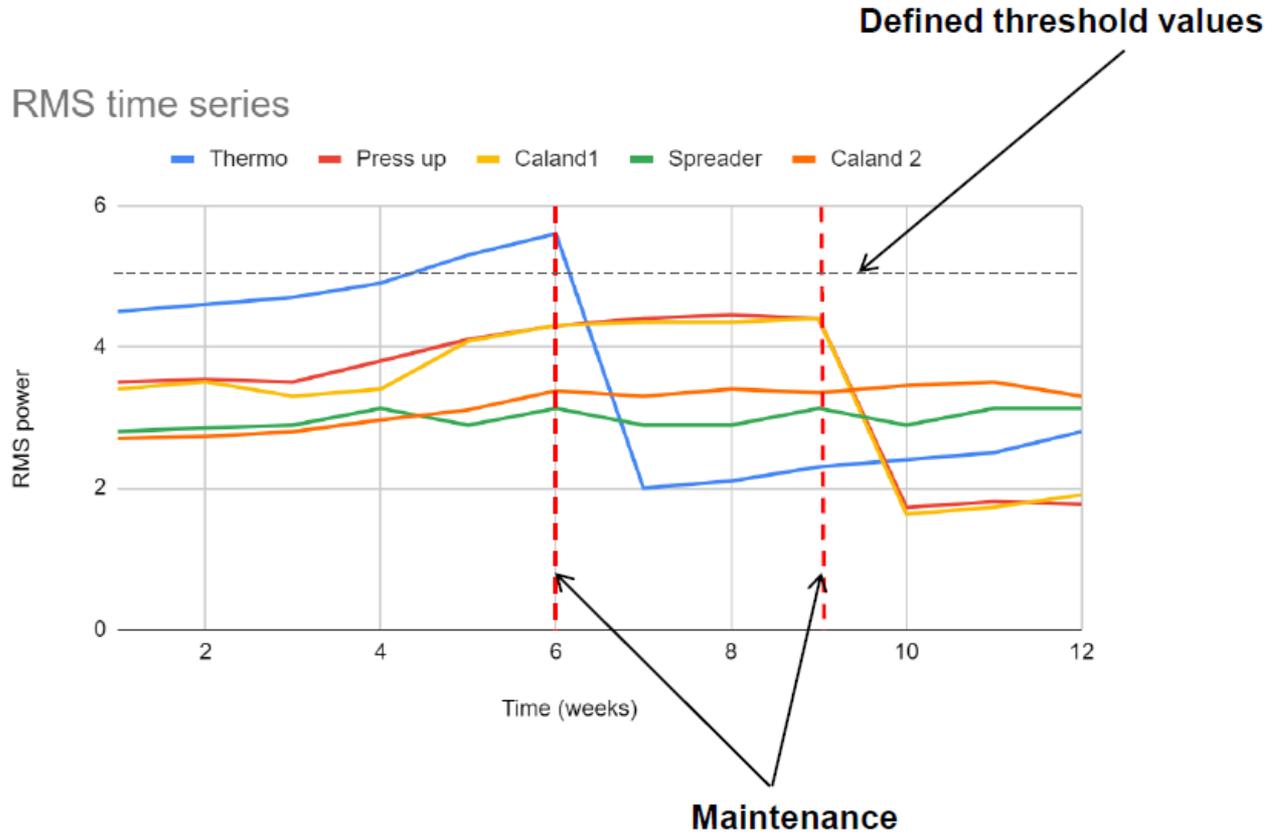# Preliminary results – artificial data

Preliminary results – real data

Application

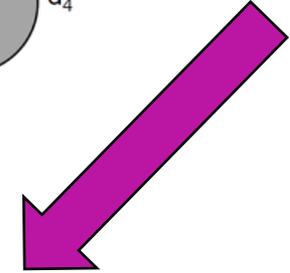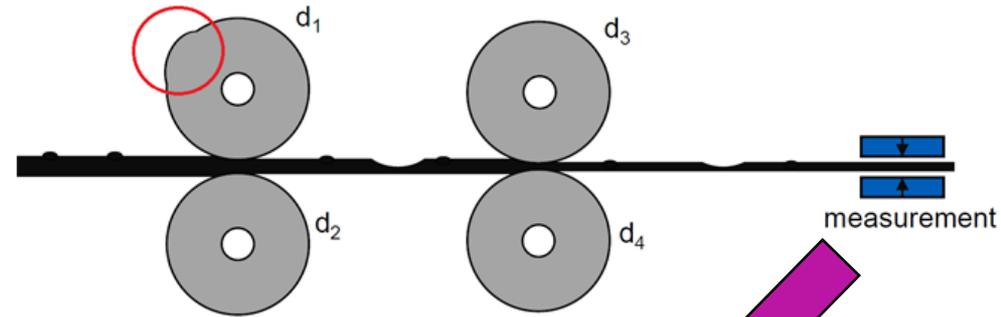| Roll	Rotating frequency [Hz]	Pattern RMS power	Pattern	Harmonics
Thermo	2.54	4.5		1 2 3 4 5
Press up	5.34	3.5		1 2 3 4 5
Caland1	2.12	3.4		1 2 3 4 5
Spreader	5.10	2.8		1 2 3 4 5
Caland2	4.65	2.7		1 2 3 4 5

Component effects over time

Conclusions

Develop tools for machine direction data analysis.

Monitor the condition of multiple rolls based on a single measurement at end of process.

I am to blame! Repair me!!!
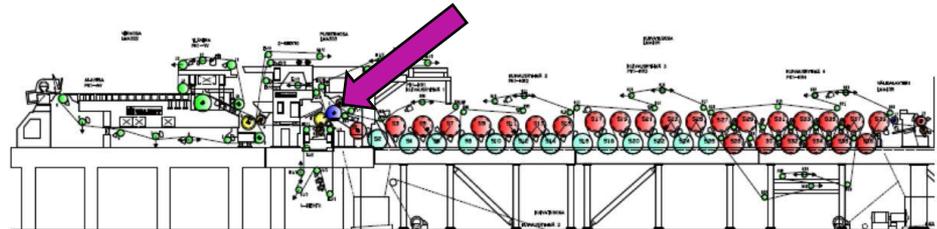
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