Smart maintenance

Per Mattsson

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About me...

- Studied Teknisk Fysik at Uppsala University.
- PhD, "Modeling and identification of nonlinear and impulsive systems".
- Currently work at University of Gävle.
“Maintenance is defined as a combination of all technical, administrative and managerial actions during the life cycle of an item and, intended to retain it in, or restore it to, a state in which it can perform the required function.”
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- Maintenance cost are increasing.
- Second biggest part of operational budget in many industries (after energy).
- Unplanned downtime can be very expensive.
Maintenance in industry

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Maintenance in industry

- Reactive maintenance (early days): "Run until it breaks"
- Preventive maintenance (1950s): Schedule and/or usage based.
- Total productive maintenance (1970s): Maintenance prevention / Preventive maintenance / Autonomous maintenance
Smart maintenance?

According to Sustainability circle:

▶ Use digital techniques to collect, analyze and visualize data.
▶ Use human competence to communicate development possibilities.
▶ Aims for a zero vision regarding technical errors and industrial sustainability.

"Maintenance is at the moment changing completely. This is due to digitalization and the need for a smart industry"
Smart maintenance?

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- But how can they use all this data to improve their maintenance activities?
- Different strategies for vibration data, acoustic data, temperature data, pressure etc.
- Most signals come from dynamical system – why not try system identification?
Example: Heat exchanger at SSAB

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```
2 temperatures
2 flows
Heat exchanger
```

\[ y(t) = \Theta \phi(t) \]
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First try a linear model: \[ y(t) = \Theta \varphi(t) \]
We first try a linear ARX-model: $y(t) = \Theta \varphi(t)$. 

![Temperature vs Time graph]
Heat exchanger linear model

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![Graph showing temperature over time](image-url)
Heat exchanger linear model

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- Can we improve it by also adding nonlinearities?
Nonlinear identification

- Lets try a model on the form

\[ y(t) = \Theta \varphi(t) + Z\gamma(t), \]

where \( \gamma(t) \) depends on the data in a nonlinear way.
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\[ y(x) \]

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Regularization

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\textsuperscript{1}Mattsson, Per, Dave Zachariah, and Petre Stoica. "Recursive nonlinear-system identification using latent variables." \textit{Automatica} 93 (2018): 343-351.
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  \]

- Statistically motivated criterion:
  \[
  \|Y - \Theta \Phi - Z\Gamma\|_2 + \|w \odot Z\|_1
  \]
  where \(w\) is adaptively adjusted to measured data!

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Heat exchanger att SSAB

Linear model
Heat exchanger att SSAB

Nonlinear model with 1024 elements in $\gamma(t)$, but only 5 non-zero in $\mathcal{Z}$
Need maintenance?

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Goal: Detect maintenance needs due to blunt tool.
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12/14

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Initial results from Svenska Fönster

Number of details after tool change

$T_i(0)$

Number of details after tool change
Thank you for listening!