To adapt, or not to adapt: adapt but with caution

Petr Kadlec
11.12.2011
Different expectations in the academia and in the industry

**Academia:** Knowledge is power

**Industry:** Time is money

Let’s process it a bit:

\[
K = P \quad \text{and} \quad t = \$
\]

\[
E = P \cdot t
\]

\[
\rightarrow t = \frac{E}{P} \rightarrow \$ = \frac{E}{K}
\]

At constant energy level:

\[
\lim(K \rightarrow \infty): \quad \$ \rightarrow 0
\]

\[
\lim(K \rightarrow 0): \quad \$ \rightarrow \infty
\]
Introduction

Adaptation scenarios – when to adapt and when not to adapt

Conclusions
Evonik Industries produces specialty chemistry

Our group – **Supply Network and Production Management** – is a subgroup in the Process Technology department.

We offer services mainly to other groups within Evonik:

- Six Sigma
- Supply network management
- **Data analysis**
- Continuous Process Improvement systems
- Etc.
Software Sensor:

Predictive or explanatory models in the process (chemical) industry.
Where does our data come from?
- From chemical processes

http://www.emeraldinsight.com/journals.htm?articleid=850808&show=html
Characteristics of the recorded data

Some characteristics of the chemical processing plant data:

- Missing values
- Noise
- Outliers
- Co-linearity
- Different sampling rates
Some characteristics of the chemical processing plant data contd.:

- Changes in data – “Drifts” and “sudden changes”
Result of using this kind of data for predictive modelling
A practical environment for the maintenance of adaptive soft sensors
Conclusion: adaptation is necessary, isn’t it?

No way ahead without model adaptation!

No **blind adaptation** because the way is **rocky** and one has to be careful **not to fall off the cliffs!**
Introduction

Adaptation scenarios – when to adapt and when not to adapt

Conclusions
From process to a data-driven soft sensor

Bottom line for the modelling: \( y \approx y' \approx y'' \)
Two types of models can be distinguished:

- Predictive
- Explanatory
Two types of models can be distinguished

**Predictive models:**
- We are interested in accurate prediction of \( y \)
- Goal is to minimise the prediction error \( e(y'', y''_p) \)

**Explanatory models:**
- We are interested in understand the relationship between \( X \) and \( y \) – at the process level
- Goal is to find accurate \( "m()" \) which represents that relations well, i.e. \( e(m(X), f(X)) \)

Reminder: \( y''_p = m(X'') \)
Locations in the data flow, where changes may occur

Chemical Processing Plant → Sensors: Data acquisition system → Process database: Data storage system → Data driven modeling techniques

Changes in the processing plant → Changes in the data acquisition

\[ D = \{X, y\} \quad \Rightarrow \quad D' = g(D) \]

"Change" means occurrence of a new data context - i.e. relation between X and y!
Examples of possible changes

Plant level:
- Mechanical abrasions effects
- Gradual pipe blockage
- Equipment maintenance (e.g. reactor cleaning)
- New operation states of the process

Data acquisition level:
- Sensor calibration
- Sensor failure
- Changes in sensor configuration
Effects and implications of changes in the plant and data acquisition

Change of context of D or D’ has also influence on the context of D”

Observing D” - it is not possible indentify the origin of the changes (D or D’)

What are the implications for the two model types?
Implications of the changes on predictive models

The change of context of D” has an influence on predictive performance of the model

The changes need to compensated by the model, i.e. model adaptation required: $m() \rightarrow m_n()$

It doesn’t matter, where the changes originate from (D or D’), it has always to be compensated for
The change of context of $D''$ has an influence on predictive performance of the model

It has to be distinguished between the different sources of the changes:

- Changes at the plant level, i.e. $f() \rightarrow f_n()$
  - **Model needs to be adapted**
- Changes in the data acquisition, $f()$ const.
  - **Model must not be adapted**
Introduction

Adaptation scenarios – when to adapt and when not to adapt

Conclusions
Conclusions

Chemical processing plants are an environment where frequent changes are happening.

These changes call for model adaptation in order to keep the models up to date.

So, what is the answer to the question: To adapt or not to adapt?
Conclusions

The answer is: it depends …

<table>
<thead>
<tr>
<th>To adapt, or not to adapt?</th>
<th>Changes in processing plants</th>
<th>Changes in data acquisition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Predictive models</td>
<td>√</td>
<td>√</td>
</tr>
<tr>
<td>Explanatory models</td>
<td>√</td>
<td>X</td>
</tr>
</tbody>
</table>
www.infer.eu

- Computational INtelligence Platform For Evolving and Robust Predictive Systems
- EU-FP7 Marie Curie IAPP
- Members: Bournemouth University (GB), Research and Engineering Center (Poland), Evonik Industries (Germany)