Application of Data Mining for Prospective Assembly Time Determination

Dortmund / 05.09.2017, Dr. Olga Erohin and Ralf Kretschmer
Miele Group and Business Unit Professional

Research Project „Pro Mondi“ and time data management

Knowledge discovery for prospective assembly time prediction

Assembly time prediction in the product development phase

Conclusion
Scope and goals of the research project Pro Mondi

Assembly oriented data model (product and process view)

Product data
- Identification and representation of process-relevant product properties

Process data
- Detection and description of product-characteristic process pattern

Mapping of product and process structure

Functional BOM
- Product planning

Engineering BOM
- Product development

Manufacturing BOM
- Process planning
- Production

Manufacturing

Cross-domain knowledge

Research project (2012-2015): „Prospective determination of assembly work content in digital factory (Pro Mondi)“

Source: Research project “Pro Mondi”, http://www.pro-mondi.de/
Assembly time is the basis for various processes

- 15-70% of production time is assembly time
- Manual assembly is a wide-spread assembly method for multi-variant products
- Time-related data are applied in manifold areas
- Time data management (e.g. time studies) is an essential task field of Industrial Engineering

Two results of the research project Pro Mondi

Assembly time prediction in the product development phase

ATP

ProWiZei

Knowledge discovery for prospective assembly time prediction

Product development

Production planning

Production

MTM-ProKon

MTM-Analysis

Time and motion study
Self-recording
Inquiry
Registering by devices
Work sampling study

Simulation (calculation)
Predetermined motion time systems
Comparative estimating
Time agreement
Standard data building blocks

Miele & Cie. KG
KDID in context of time data management

**Preparation**

1.1 Define the goals of knowledge discovery in time data management

1.2 Explore the processes of time data management

1.3 Explore relevant IT systems and TDM-data connections

**Data Mining**

2.1 Build a raw data matrix of TDM-data

2.2 Descriptive and explorative analysis of data

2.3 Preprocessing of raw data matrix of TDM-data

2.4 Create and apply data mining models

2.5 Visualize and interpret the results

**Realization**

3.1 Integrate KDID into planning processes and IT systems

3.2 Create an IT prototype

Realization of KDID and some prediction results

<table>
<thead>
<tr>
<th>Data Mining method</th>
<th>RapidMiner operator</th>
<th>Relative error</th>
</tr>
</thead>
<tbody>
<tr>
<td>Linear regression</td>
<td>Linear Regression</td>
<td>18.2%</td>
</tr>
<tr>
<td>Local polynomial regression</td>
<td>Local Polynomial Regression</td>
<td>33.1%</td>
</tr>
<tr>
<td>Regression model tree</td>
<td>W-M5P</td>
<td>33.4%</td>
</tr>
<tr>
<td>Regression tree</td>
<td>W-RepTree</td>
<td>29.5%</td>
</tr>
<tr>
<td>Support vector regression</td>
<td>LibSVM</td>
<td>17.1%</td>
</tr>
</tbody>
</table>

Continuity of time data determination along the product emergence process (PEP)

PEP

design phase  development phase  design freeze  process planning

designer  development  industrial engineer, assembly planner

iteration loop  iteration loop  iteration loop

Source: Personal research work by R. Kretschmer
Mapping of product and process data

- **Product data** (CAD, PDM, …)
- **Process data** (industrial engineering, assembly planning, …)

**Hierarchical product structure**
- Product
  - Component group 1
    - Component A
  - Component B
  - Component C
  - Component group 2
    - Component D
  - Component E

**Basic assembly time for component A**
- B-building-block(s) (joining processes)
- V-building-block(s) (connection processes)

**Assignment via ID**
- Product data
- Process data

Source: Personal research work by R. Kretschmer
## Concept for assembly time prediction

<table>
<thead>
<tr>
<th>Product data</th>
<th>Process data</th>
</tr>
</thead>
<tbody>
<tr>
<td>components 1-n</td>
<td>mapping via ID</td>
</tr>
<tr>
<td>data based on the past (model creation based on instances group)</td>
<td>B-building blocks (joining processes)</td>
</tr>
<tr>
<td>current data (model use)</td>
<td>V-building blocks (connection processes)</td>
</tr>
<tr>
<td>new component</td>
<td>predicted assembly time for a new component</td>
</tr>
</tbody>
</table>

- Identification of k-nearest-neighbours
- Connection process type(s) + number
- Prediction B-building block(s) (joining processes) + V-building block(s) (connection processes)

**Source:** Personal research work by R. Kretschmer
Evaluation: Validation and assessment of results

- Assembly-time prediction compared to system of predetermined time (MTM-TiCon) and other established time-determination systems

- Conclusion:
  - Best results for further development within the component family
  - Widely varying quality of results for complete new design and/or missing component family (⇒ small data amount for comparable components related to the past)

Source: Personal research work by R. Kretschmer
Conclusion

- Integration of data mining for prospective determination of assembly time leads to essential added value for planning and decision-making.

- … and supports the idea of simultaneous engineering to reduce the product emergence time.

- Current portfolio of methods for time determination can be successfully extended by new data mining methods.

- Fundamental factors of success are
  - Integration of specific know-how of the application area (especially at the beginning of knowledge discovery).
  - Overcoming the challenges of “historically evolved” IT infrastructures.
Thank you very much for your kind attention!

For further information please visit:

www.pro-mondi.de

Dr. Olga Erohin
Director Corporate Development
Professional Technology
Miele & Cie. KG
Mielestraße 2, 33611 Bielefeld
olga.erohin@miele.com
http://www.miele.com

Ralf Kretschmer
Director Segment Professional
Laundry Technology Lehrte
Miele & Cie. KG
Industriestraße 3, 31275 Lehrte
ralf.kretschmer@miele.com
http://www.miele.com