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IFAC-PapersOnLine 49-30 (2016) 314–319

Extension of a telemedicine framework for analysis of industrial machinery data

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Abstract: To extend our system for teleoperation and telemaintenance of industrial machinery we combine it with a rule based analysis framework from our telemedicine system. The goal is to provide a remote expert the ability to analyze industrial machinery data for failure diagnosis or optimization of production processes. We describe the changes we made to the rule based system to be able to fulfill given tasks for data analysis. We processed every task with data recorded from a machine during production and show the results and insights from analyzing the data.

Keywords: Telematics, Manufacturing, Rule-based systems, Manipulators, Fault diagnosis

1. INTRODUCTION

Special machine manufacturers, especially robotics companies, sell their technology worldwide. Some factories, for example in emerging economies, lack qualified personnel for repair and maintenance tasks. When a severe failure occurs, an expert of the manufacturer needs to fly there, which leads to long down times of the machine or even the whole production line. With the development of data networks, a huge part of those travels can be omitted, if appropriate teleoperation equipment is provided.

This paper describes the extension of a telemaintenance system, which was established in an active production lane for research purposes. The costumer production site of Braun, which belongs to Procter & Gamble, consists of a six-axis cartesian industrial robot by Kuka Industries, a two-component injection molding system and an assembly unit. The plant produces plastic parts for electric toothbrushes.

In the research project 'MainTelRob', during which this plant was utilized, the Zentrum für Telematik e.V. (ZfT) and its project partners, Kuka Industries and Braun P&G, develop novel technical approaches and procedures for modern telemaintenance. The term 'telemaintenance' hereby refers to the integration of computer science and communication technologies into the maintenance strategy (Chowdhury and Akram (2011)). It is particularly interesting for high-grade capital-intensive goods like industrial robots. Typical telemaintenance tasks are for example the analysis of a robot failure or difficult repair operations. Currently such tasks are offered via phone support and service staff which travels abroad. Telemaintenance and teleoperation have high demands, especially regarding the security infrastructure. In addition, the facility of Braun in Marktheidenfeld has to keep up with the high standards of Procter & Gamble and wants to minimize the downtimes and optimize the machine utilization. Like 71.6% of all German companies (Spath et al. (2013)), Braun P&G sees a huge potential for early information on their production system, but complains about the insufficient quality and the lack of currentness of the data.

In this work we present a framework that collects data from different sources inside the production facility, processes the data and provides the results to an expert. For the process of knowledge extraction out of the collected data we use a rule based data mining approach. Therefore we integrated the *TARDIS* (Telemedical Applications with Rule-based Decision- and Information Systems) software (Michael Albert (2015)), that allows creation and execution of rules, into our work. In the concept figure 1 the *TARDIS* software and the use cases are added to the data mining process. The results are reused for pattern recognition in a graphical user interface (GUI) for knowledge extraction.

2. STATE OF THE ART

There is an increasing interest on data mining approaches in the production industry (Wang (2007)). But there are several reasons, why the development of data mining for the automation industry is approaching only slowly: On the one hand the majority of the scientists having

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⋆ Funding for this work was provided from the Bavarian Ministry of Economic Affairs, Infrastructure, Transport and Technology in its R&D program 'Information and Communication Technology'. The authors gratefully acknowledge the production plant and personnel provided by Braun (Procter & Gamble), the facilities and personnel provided by KuKa Industries and the colleagues who worked on the MainTelRob project.

10.1016/j.ifacol.2016.11.154

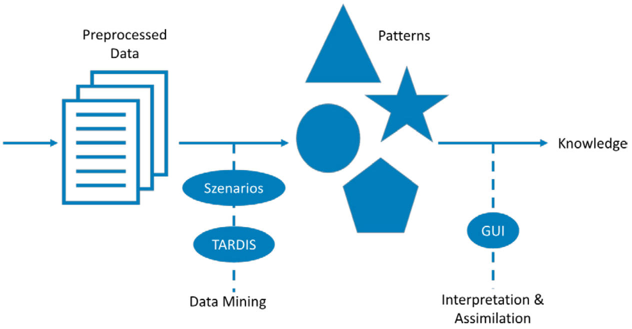

Fig. 1. Overview DataMining

knowledge in the industrial domain are inexperienced in data mining algorithms and data mining software. On the other hand data mining scientists lack the detailed knowledge of complex plants and production processes. The few experts with knowledge of both domains often are not allowed to access the sensible and protected factory data (Wang (2007)). But especially the use of sensor information for process control has a huge potential for optimization (Shen et al. (2007)). The semantic analysis of the data of several plants is expected to provide more information than the analysis of only one plant (Wang (2007)). So a huge room for maneuver for optimization is expected on a large scale Wang (2013)). Experiences from other application domains (Karahoca et al. (2012)) show, that on a complete system data mining techniques can help to detect pattern which lead to abrasion and material fatigue. So the lifespan of the different elements can be estimated for an optimal predictive maintenance. With the high product quantity in the manufacturing trade, already small improvements have significant influence (Harding et al. (2006)).

3. SCENARIO CONTEXT

Handling large amounts of data is a difficult task for every user. Even experts require tools to reduce the amount of data into smaller chunks of data, containing the essential information. The raw data is collected directly from machines and could be collected erroneous. In the MainTelRob project the raw data is collected from two different types of data sources: data is generated from some parts of the industrial robot while other data is collected by humans at so called "Visual Control Points". Both data sets are stored in a joint database.

The MainTelRob project is realized with an industrial robot from KUKA Industries. The robot can acquire information from other parts of the production unit via different in- and outputs. The data is divided into three groups: integer variables, position variables and floating point variables. Most recorded values are discreet scanned, continuous values. Sometimes binary values, that represent categorical data, are stored in integer variables.

The industrial robot, used in the research project, has four axes. The axes one to three are translational axes while the forth axis with the gripper is a rotational one. The tool has further degrees of freedom, but these are controlled by other means. Some of the data sets are labeled similar for each axis. These values are extended with indexes for the different axes, e.g. _RACTUAL_POS[1] for the current position of axis one.

Each measurement records 54 variables. The measurements are repeated in irregular intervals between 10 and 12 milliseconds. The robots clock is 10.8 milliseconds. There are different delays in the recording of the values. One production cycle of the robots process takes about 35 seconds. This results in about 3000 measurements per cycle with 54 variables each. In one hour about 133 megabytes of robot data is recorded.

4. TARDIS

We built a generic telemedicine system which we wanted to be flexible, easy to use, reduce the workload of the medical personnel and involve the patient into the treatment. To meet these conditions we integrated a rule-based approach to provide intelligent assistance for the physician and a smart component for the patient that can adapt to changing environments and give feedback about the treatment to the patient. The rule-based decision system was intentional held flexible, modular and platform independent to allow reusing the system in other fields of application such as industrial telemaintenance. It is used to model individual behaviors of the system, depending on the patients disease, treatment and the used devices. It allows to add autonomous functions to the patients mobile device, data preprocessing and feedback to the user even without an active data communication to the medical center. In the Tele-Service-Center the framework can be used to filter and analyze data or adapt the treatment of each individual patient. The system was implemented and tested in real life with patients suffering from chronic obstructive pulmonary disease with a very good feedback. TARDIS comes with a graphical editor that allows an easy creation and editing of rules while showing the flow of data visually.

4.1 M-Data / V-Data

We added the M-Data block to the rule editor (see figure 2) to allow loading and usage of machinery data. The input source can be constrained with two parameters: cycle and time. If none of the constraints is defined, the complete period of all cycles will be processed. For every given cycle the function returns an array of $[t, x(t)]$ pairs: $[t, x(t)] \cdot n$, with $t \in \mathbb{N}$ is the point in time, $x(t)$ the value from the database for the chosen variable and $n \in \mathbb{N}$ the number of chosen cycles. The value $x(t)$ is represented as boolean, integer or double variable.

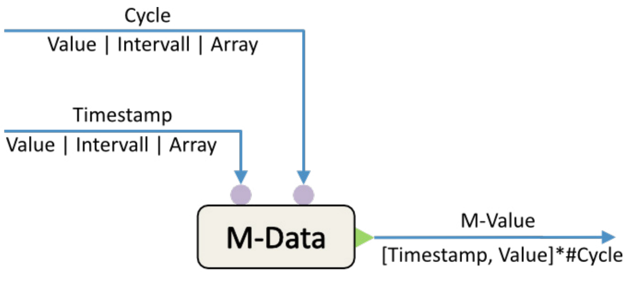

Fig. 2. Component M-Data