The ProKInect Showcase – Part 1: Business Opportunities Through Collaborative Condition Monitoring

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Note: This is a preliminary, shortened version. The full version of this white paper will be published in November 2024.

Abstract

Today's modern machine tool operators demand the highest levels of machine availability and reliability. Quality deviations in the manufacturing process due to incipient wear or malfunction cannot be clearly assigned to a part or component using traditional approaches to preventive and predictive maintenance. Manufacturers, operators, and users of modern machine tools therefore need to understand the quality-determining interaction of many installed components and the machine tool itself, to detect changes in condition at an early stage and to proactively avoid production downtimes. The aim of the BMBF joint project "ProKInect" is to increase the availability and reliability of production machines through automated condition monitoring with distributed and cross-company AI agents. Increased machine availability results directly from the avoidance of unplanned downtime due to machine or component defects that were previously not detected automatically. Using a 2D laser cutting machine as an example, the project implements an automated, manufacturer-independent condition monitoring system and a concept for predictive maintenance. The goal is to diagnose the condition and predict failure probabilities within the overall system based on a cooperative evaluation of initially fragmented and proprietary operating data of a rack and pinion drive system comprising motor information and a sensorized planetary gear box.

1. Introduction

Digitalization in production technology enables efficient machine condition monitoring through sensors and IoT. Data analysis reduces costs by enabling precise maintenance planning and minimizing machine downtime. Collaborative condition monitoring fosters new business opportunities and improves production processes through shared data and insights. A major obstacle to data sharing is the concern for data privacy and security, as companies are reluctant to share sensitive information with potential competitors. Additionally, the lack of standardized data formats and interoperability issues between different systems can significantly hinder effective data exchange.

The BMBF-funded joint project "ProKInect", one of 17 ProLern initiatives, aims at implementing a cross-manufacturer condition monitoring system. Objectives include developing new collaborative business relationships beyond traditional bilateral partnerships, secure and trustworthy data exchange in protected data spaces, and integrating expert and user knowledge into AI models. Within the project, a 2D laser cutting machine was chosen as a technical demonstrator for the development of a collaborative condition monitoring system. Figure 1 shows the 2D laser cutting machine.

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Figure 1: Technical demonstrator TruLaser 3060 fiber with 6 m lengths
(Source: TRUMPF Gruppe)

As quickly became clear, several aspects must be considered when realizing a collaborative condition monitoring system. This paper provides an overview of newly arising business opportunities through collaboration also mentioning the roles and perspective of the project partners of “ProKInect”.

2. Business Opportunities

When analyzing the lifecycle costs of a production machine, maintenance, inspection, and unplanned repairs account for over 37 % of the total costs [1]. Condition monitoring systems can be used to reduce total cost of ownership as they continuously and automatically monitor machine conditions, proactively identify potential issues, prevent breakdowns, minimize downtime, and optimize maintenance schedules.

The Plattform Industrie 4.0 (German Industry 4.0 platform) identifies three main stakeholders who have a legitimate interest in implementing a condition monitoring system [2]. Various component manufacturers produce parts such as different drives, each equipped with appropriate sensors. The machine supplier constructs a machine that incorporates components from various manufacturers. The factory operator employs this machine in their production system.

In traditional business models, the machine supplier acquires the required components from suppliers, who in return receive a stream of payments for providing the physical goods. Subsequently, the machine supplier integrates these components into his machine and sells it as a capital expenditure (CAPEX) at a one-time price to the plant operator. From the perspective of corporate finance, this is unfavorable, as it leads to a concentration of risks in uncertain business developments or in economically weak times due to the high investment sums. During the lifecycle of the machine, the machine supplier maintains a contractual relationship with the machine operator through the service business and receives contract-dependent payments for this. The traditional business model is illustrated in Figure 2.

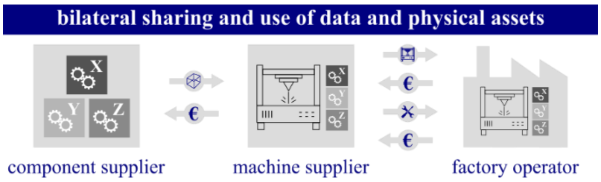

Figure 2: Traditional business models following BAUER [3]

It involves a bilateral relationship between partners, characterized by the flow of value and the stream of payments. Due to the unidirectional flow of value, component manufacturers have only limited contact points with the products they produce, which are integrated into machines. Therefore, they often have little knowledge about their performance or downtime in application. In collaborative business models, capital expenditures (CAPEX) are converted into operational expenditures (OPEX), which is referred to as "CAPEX-to-OPEX Shifting." Customers can thus avoid high capital expenditures and significantly reduce the associated financial risk both at the initial investment and in later machine and plant operations [4].

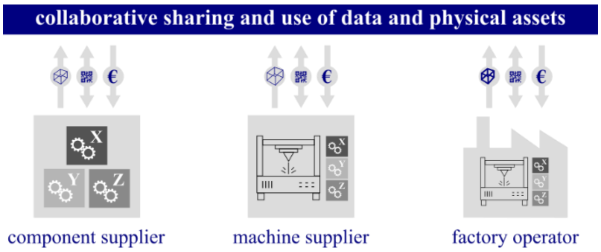

Figure 3: Collaborative business model following BAUER [3]

One way to generate additional economic value within the digital ecosystem is through “collaborative condition monitoring” (cf. Figure 3). It can increase the reliability and lifespan of components and machines. However, to achieve this, consistent and comprehensive collection of operational data from components and machines across the entire value creation network, including various machine manufacturers, integrators, and machine operators, as well as a joint evaluation of this data, is required [3]. Only when sufficiently large data sets with appropriate data quality are processed can recurring patterns in the operational behavior of individual components and machines be identified, or long-term wear under specific operational conditions be analyzed. The lifespan of components or machines cannot be determined by single measures. However, these benefits can only be achieved through comprehensive collaboration. Here, component manufacturers, machine suppliers, and factory operators must work together across corporate and competitive boundaries [3].

Without limiting the foregoing, the realization of a collaborative condition monitoring system in “ProKInect” integrated the following stakeholders and their respective objectives: As a machine manufacturer TRUMPF pursued the goal of monitoring the 2D laser cutting machine, while being provided by component-specific condition information of the other partners. Being a component manufacturer, WITTENSTEIN aimed at monitoring the condition of their gearboxes, while being provided with context specific environmental parameters of the 2D laser cutting machine by TRUMPF. As a research partner, Fraunhofer LBF accompanied the AI engineering process involving both system and maintenance experts as well as AI engineers and data scientists. Beyond that, Fraunhofer LBF contributed explainable AI models capable of integrating expert knowledge. As an established company in the field of industrial AI, TVARIT provided the digital infrastructure to realize secure dataspaces, collaborative and federated learning, as well as real-time signal processing and visualization. In total, this allowed for the realization of a comprehensive solution for detailed diagnosis and the potential reduction of unplanned downtime through collaborative condition monitoring.

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