Politechnika Śląska
Wydział Automatyki, Elektroniki i Informatyki
Instytut Informatyki

ROZPRAWA DOKTORSKA

SYSTEM WIZALIZACJI I DIAGNOSTYKI PRACY URZĄDZEŃ BAZUJĄCY NA BEZPRZEWODOWJ SIECI CZUJNIKÓW WIBROAKUSTYCZNYCH I METODACH EKSPLORACJI DANYCH

Autor: mgr inż. Krzysztof Szczyrba
Promotor: dr hab. Marek Sikora prof. Pol. Śl.
Promotor pomocniczy: dr inż. Łukasz Wróbel

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Abstract of the doctoral thesis

Author: mgr inż. Krzysztof Szczyrba
Supervisor: dr hab. Marek Sikora prof. Pol. Śl.
Auxiliary supervisor: dr inż. Łukasz Wróbel

Topic: **A visualization and diagnostic system for equipment based on a wireless network of vibroacoustic sensors and data mining methods.**

This paper presents a complete machinery diagnostic system comprising both hardware and software layers. The design process of the system was carried out in its entirety, from requirements gathering and analysis, through system architecture design, construction and testing, to the development and implementation of diagnostic methods launched based on this system. The system's purpose is to support decision-making processes in the maintenance departments of industrial plants, regarding current diagnostics of machine bearing nodes, as well as implementing predictive maintenance strategies.

The developed system is based on a wireless network of vibroacoustic sensors. As part of the work, energy consumption optimization was carried out for sensors with battery power sources. Communication protocols between sensors and data acquisition layers were selected and implemented, taking into account the system's energy efficiency requirements. The implemented system is expected to significantly improve the accuracy and efficiency of machinery diagnostic processes, leading to better maintenance decisions and reduced downtime.

Solutions for individual components of the system's software layer were developed and implemented. The SCADA environment responsible for the system's SCADA functions was selected and adapted, taking into account scalability, openness to closed and cloud-based variants, and the ability to integrate with data analytics tools.

The entire system architecture, including the analytical engine, was incorporated into the SCADA platform. The analytical engine serves as an environment for running and monitoring diagnostic models and is entirely based on open-source solutions. It implements the full processing cycle, compliant with the CRISP (Cross Industry Standard Process for Data Mining) methodology.

An analytical database was developed, with a structure allowing for the storage of appropriately processed and aggregated sets of features, collecting information about the model in terms of forecasts generated by the model, actual values of the object of forecasting, model configuration data, object configuration data subject to forecasting, acceptable forecast thresholds, training and validation data on which the models were trained and optimized.

Unique diagnostic methods were developed to perform PdM (Predictive Maintenance) tasks for selected deployment problems: based on trend analysis and analysis of outliers. In both cases, diagnostic variables were identified, appropriate diagnostic procedures were developed, and a way to present model results to the user was developed. Both models were tested on data from real-world objects on which the system was installed: on selected bearing nodes of an overhead crane used to transport ladles of molten steel in the steelworks department of a steel mill, as well as in the context of a system for monitoring coal crushers operating in a fuel feed system to a fluidized bed boiler in a coal-fired power plant.

An important element of the developed diagnostic methodology is adding explainability elements to the results of diagnostic models. Diagnostic systems based on machine learning algorithms are a novelty in the maintenance services environment. It should also be noted that the current stage of development of these tools does not yet allow for uncritical acceptance of their results. They currently serve as decision support systems. Therefore, the user must have the ability to assess the "probability" of the presented forecast before taking actions, such as stopping the production process.

As part of the work, explainability methods were implemented to explain the decisions made by the diagnostic model. The prepared model allows for a graphical illustration of the degree of influence of a selected model feature on the processing result.