Wrocław University of Science and Technology

Faculty of Geoengineering, Mining and Geology

Abstract

Doctor of Philosophy

Environmental Engineering, Mining And Energy

Fault Detection Procedures for Belt Conveyor Maintenance Based on AI-Driven Multisource Data Analysis

By Mohammad Siami Araghi

The raw materials industry is currently undergoing a significant transition from manual processes for system condition monitoring to fully automatic approaches. This thesis addresses the critical topic of developing artificial intelligence-based fault detection methods that can be used for condition monitoring of raw material transportation systems using inspection mobile robots. The information captured by non-contact measurement systems, including audio signals, RGB, and IR images, is beneficial to performing condition monitoring tasks, as such systems can be carried by inspection mobile robots and provide useful information for supervisors. The knowledge of a human inspector is an integral part of the traditional condition monitoring approaches, as an experienced worker can reliably monitor and recognize damaged machines. Therefore, the most difficult question to address in this context is: how can we integrate human judgment into automated systems? The challenges here are that the mining industry is categorized by small series and significant customization of transportation systems, which makes it difficult to prepare a universal solution for robotic-based condition monitoring of them. More importantly, the harsh environment of mining sites makes the data collection procedure by the inspection robot very difficult, as the presence of impulsive noises and negative environmental factors can reduce the precision of the sensors. Belt conveyors are the main means of transportation of raw materials in mining sites, as their length can reach thousands of meters. Therefore, stationary systems cannot be employed to monitor the different rotating components. As a practical case study in this thesis, an inspection mobile robot is employed to move alongside the belt conveyor networks and capture different sources of information from rollers (idlers), which are responsible for carrying the weight of the belt. Considering the challenges in analyzing the information, here advanced preprocessing methods are introduced to improve the overall quality of the gathered data. Due to the circumstances of the examination, limited information has been gathered where the number of faulty components in the studied belt conveyor systems was so small compared to healthy cases. The artificial intelligence-based methods need to have access to many samples to learn the fault pattern; therefore, to address this issue, some novel methods are proposed that can be beneficial when it comes to working with such case studies. To take advantage of the different sources of information captured through the experiments, an information fusion approach is proposed that can identify fault belt conveyor idlers more accurately than single-sensor condition monitoring approaches.

Keywords: Fault Detection, Inspection Mobile Robot, Belt Conveyor, Idler, Artificial Intelligence, Machine Learning, Non-Contact Measurement