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ІНТЕЛЕКТУАЛЬНІ ТРАНСПОРТНІ ТЕХНОЛОГІЇ

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V МІЖНАРОДНА НАУКОВО-ТЕХНІЧНА КОНФЕРЕНЦІЯ

ПРОГРАМА КОНФЕРЕНЦІЇ

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Збірник містить тези доповідей науковців вищих навчальних закладів України та інших країн, підприємств транспортної та машинобудівної галузей за чотирьма напрямками: розвиток інтелектуальних технологій при управлінні транспортними системами; транспортні системи та логістика; інтелектуальне проектування та сервіс на транспорті; функціональні матеріали та технології при виготовленні та відновленні деталей транспортного призначення.

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МЕТОДИ МОНІТОРИНГУ ПРОМИСЛОВОГО КОНВЕЄРУ ІЗ ЗАСТОСУВАННЯМ МОДЕЛЕЙ МАШИННОГО НАВЧАННЯ

METHODS OF INDUSTRIAL CONVEYOR MONITORING WITH APPLICATION OF MACHINE LEARNING MODELS

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In the context of *Industry 4.0* concept, widely accepted and implemented, the real-time monitoring of the industrial processes and measurement became a crucial task. Among others, short-distance transport lines are of great importance, including the belt conveyor systems. These can be considered the most common type of conveyors due to their relatively low costs and easiness of maintenance [1]. However, the belts themselves are the most complex components and thus they are the most difficult to diagnose [2]. Monitoring and diagnosis of the belt conveyors is to ensure safety and to eliminate the unplanned shutdowns in order to avoid significant losses [3]. Thus, the belt conveyors must be continuously monitored, and the real-time data collected from various sensors must be properly processed and analyzed [4]. It is expected that by the end of 2024, worldwide expenses on the conveyor monitoring equipment can be as high as USD 0.25 trillion [5].

Among the most popular methods of the belt conveyor monitoring ones, the non-destructive measurements can be named. These methods allow for supervision of the surface condition of the belt as well as its inner structure, classifying the actual state of the belt, its layers, and adhesion between the layers [6]. A wide range of sensors can be involved in data collection, including optical, acoustic (including ultrasonic), electromagnetic, magnetic, radiographic (X-ray), thermographic, and strain gauge methods.

Machine learning methods are widely applied in decision-making process of the real-time conveyor monitoring. For instance, Zheng with co-authors used phase-sensitive optical time domain reflectometry technology and ultra-weak fiber Bragg gratings to capture idler vibrations [7]. The collected data underwent an automatic fault classification using an algorithm based on self-supervised learning, which required a small number of samples. The authors demonstrated ability of the system to extract efficiently latent features and to reach diagnosis accuracy of 95.37%. Chamorro with team [8] implemented multiple sensors system including camera, speed sensor, and load cell, along with machine vision. Data was transferred to a remote receiver using IoT gateway. Information from the sensors and machine vision systems were sent to the cloud to monitor the actual condition of the system and to detect any potential failure. Andrejiova with colleagues [9] reported results of experimental research on identification of the correlations between a significant damage occurring in conveyor belts and the measured parameters. They used four classification models, and assigned two determined degrees of damage (a significant or insignificant one) to the conveyor belt tested specimens. The classification models included machine learning methods, such as a decision trees, logistic regression, regression analysis, and the Naïve Bayes classifier. The results indicated that the tested classification models provided similar results, but the Naïve Bayes classifier showed the best prediction and classification abilities. In turn, our team performed own experimental research with the strain gauge based monitoring system described elsewhere [10]. For the collected data, we tested more than 30 machine learning algorithms available in the *Classification Lerner* application in the MatLab environment. The correct classification of 3 and 5 cuts, and of the undamaged belt, was obtained in the case of decision tree models, but also *Quadratic* and *Cubic SVM*.

From the increasing number of relevant publication it can be concluded, that interest toward conveyor belt monitoring systems is growing, and many researchers apply machine learning methods to classify faults of the belt conveyor systems. Correctly classified damages in progress, belt deviation or overlapping, can prevent from breakage or fire, increasing security and reducing the reparation costs.

[1] Moran, S. Process Plant Layout, 2nd ed.; Butterworth-Heinemann: Amsterdam, The Netherland, 2017.

[2] Kozłowski, T.; Wodecki, J.; Zimroz, R.; Błażej, R.; Hardygóra, M. A Diagnostics of Conveyor Belt Splices. Applied Sciences 2020, 10, 6259.

[3] Zheng, H.; Wu, H.; Yin, H.; Wang, Y.; Shen, X.; Fang, Z.; Ma, D.; Miao, Y.; Zhou, L.; Yan, M.; Sun, J.; Ding, X.; Yu, C.; Lu, C. Novel mining conveyor monitoring system based on quasi-distributed optical fiber accelerometer array and self-supervised learning. Mechanical Systems and Signal Processing 2024, 221, 111697.

[4] Chamorro, J.; Vallejo, L.; Maynard, C.; Guevara, S.; Solorio, J.A.; Soto, N.; Singh, K.V.; Bhate, U.; Ravi Kumar, G.V.V.; Garcia, J.; Newell, B. Health monitoring of a conveyor belt system using machine vision and real-time sensor data. CIRP Journal of Manufacturing Science and Technology 2022, 38, 38–50.

[5] Kirjanów-Błażej, A.; Jurdziak, L.; Błażej, R.; Rzeszowska, A. Calibration procedure for ultrasonic sensors for precise thickness measurement. Measurement 2023, 214, 112744.

[6] Fedorko G., Application possibilities of virtual reality in failure analysis of conveyor belts, Engineering Failure Analysis, 128, 2021, 105615.

[7] Hua Zheng, Huan Wu, Hao Yin, Yuyao Wang, Xinliang Shen, Zheng Fang, Dingjiong Ma, Yun Miao, Li Zhou, Min Yan, Jie Sun, Xiaoli Ding, Changyuan Yu, Chao Lu, Novel mining conveyor monitoring system based on quasi-distributed optical fiber accelerometer array and self-supervised learning, Mechanical Systems and Signal Processing, Volume 221, 2024, 111697.

[8] Jose Chamorro, Laura Vallejo, Cole Maynard, Santiago Guevara, Jose A. Solorio, Narciso Soto, Kumar Vikas Singh, Ujwal Bhate, Ravi Kumar G.V.V., Jose Garcia, Brittany Newell, Health monitoring of a conveyor belt system using machine vision and real-time sensor data, CIRP Journal of Manufacturing Science and Technology, Volume 38, 2022, Pages 38-50.

[9] Miriam Andrejiova, Anna Grincova, Daniela Marasova, Identification with machine learning techniques of a classification model for the degree of damage to rubber-textile conveyor belts with the aim to achieve sustainability, Engineering Failure Analysis, Volume 127, 2021, 105564.

[10] Bzinkowski ,D.; Ryba, T.; Siemiatkowski, Z.; Rucki, M. Real-time monitoring of the rubber belt tension in an industrial con-veyor. Reports in Mechanical Engineering 2022, 3(1), 1–10.