CREATION OF A SYSTEM FOR PREDICTING FAULTS IN SEWING EQUIPMENT BASED ON MACHINE LEARNING

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Annotation. In the process of development of modern industry, ensuring the uninterrupted operation of production systems, increasing the reliability of equipment and reducing maintenance costs is becoming increasingly important. Especially in the light industry, in particular in the garment industry, since each element of the production line is closely interconnected, the failure of one piece of equipment can stop the entire production process. Therefore, the enrichment of technical service systems with innovative approaches is an urgent issue.

Keywords. Sewing machine, sewing equipment, sewing, industry.

MASHINA O‘RGANISH ASOSIDA TIKUV USKUNALARINING NOSOZLIKLARINI OLDINDAN BASHORAT QILISH TIZIMINI YARATISH

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Annotatsiya. Zamonaviy sanoatning rivojlanishi jarayonida ishlab chiqarish tizimlarining uzluksiz ishlashini ta’minlash, uskunalar ishonchliligini oshirish va xizmat ko‘rsatish xarajatlarini kamaytirish muhim ahamiyat kasb etmoqda. Ayniqsa, yengil sanoat sohasi, xususan tikuvchilik sanoatida, ishlab chiqarish liniyasining har bir elementi o‘zaro chambarchas bog‘liq bo‘lgani sababli, bitta uskuna nosozligi butun ishlab chiqarish jarayonini to‘xtatib qo‘yishi mumkin. Shu bois, texnik xizmat ko‘rsatish tizimlarining innovatsion yondashuvlar bilan boyitilishi dolzarb masala hisoblanadi.

Kalit so‘zlar. Tikuv mashinasi, tikuv uskunalari, tikuvchilik, sanoat.

СОЗДАНИЕ СИСТЕМЫ ПРОГНОЗИРОВАНИЯ НЕИСПРАВНОСТЕЙ ШВЕЙНОГО ОБОРУДОВАНИЯ НА ОСНОВЕ МАШИННОГО ОБУЧЕНИЯ

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Аннотация. В процессе развития современной промышленности все большую значимость приобретает обеспечение бесперебойной работы производственных систем, повышение надежности оборудования и снижение затрат на его обслуживание. Особенно в легкой промышленности, в частности в швейной промышленности, поскольку каждый элемент производственной линии тесно взаимосвязан, выход из строя одной единицы оборудования может остановить весь производственный процесс. Поэтому обогащение систем технического сервиса инновационными подходами является актуальным вопросом.

Ключевые слова. Швейная машина, швейное оборудование, шитье, промышленность.

This study addresses the issue of developing an effective model based on machine learning algorithms for continuous monitoring of the condition of sewing equipment, early detection of failures based on collected sensor data, and their elimination. Traditional maintenance methods (plan-based and reactive approaches) cannot fully meet modern requirements, as they are performed after a failure occurs or based on an estimated time frame. Such approaches can be technically unreliable and also lead to inefficient costs. Therefore, the creation of predictive maintenance systems using artificial intelligence, especially machine learning (ML) technologies, has become an important direction.

Although there have been many studies on Predictive Maintenance (PdM) systems worldwide, there have been relatively few studies on garment industry-specific failure analysis and prediction using machine learning. These technologies have been widely implemented in industries such as mechanical engineering, automotive, and energy. For example, in the intelligent monitoring systems developed by Lee et al. (2014), the condition of equipment is continuously monitored using sensors and the probability of failure is determined using artificial neural networks.

In the garment industry, parameters such as vibration, temperature, and rotation speed collected by sensors can be used to assess equipment condition and predict problems. While some studies in this field have proposed optimized maintenance schedules based on machine learning, there is little research on specific equipment analysis and models suitable for real production. Therefore, this paper aims to analyze the types of failures specific to specific equipment in the garment industry, collect the necessary sensor data, and analyse them based on artificial intelligence to propose an effective prediction system.

System architecture. The sewing equipment failure prediction system consists of several key components. Each of them determines the efficiency of the system and is important for the successful operation of the machine learning model. Data collection module. Real-time data on the technical condition of sewing equipment is collected through sensors. The most common malfunctions can be detected by:

• Vibration sensor – to detect uneven movement and imbalance of the internal mechanisms of the equipment.

• Temperature sensor – to monitor the overheating of the engine or other moving parts.

• Rotational speed sensor (RPM) – to detect changes in the operation of the motors.

• Sound sensor (acoustic monitoring) – to detect signs of malfunction by the appearance of strange sounds during operation.

The data collected from the sensors is transmitted to a central database via microcontrollers (e.g. Raspberry Pi or Arduino). MQTT or Wi-Fi technologies can be used for data transfer. Data pre-processing. The raw data obtained is processed through the following steps: Cleaning: Identify and correct incorrect or missing values; Normalization: Bring values to unity to eliminate differences between sensors; Windowing: Divide data into small intervals for time-based analysis; Feature Extraction: Extract statistical indicators (mean, variance, vibration level).

Model training and testing. Machine learning algorithms are used to predict sewing equipment failures. The following algorithms were compared in the study. Below you will find the selected algorithms:

- Random Forest – classification based on a set of unrelated trees.
- Support Vector Machine (SVM) – for classification problems with complex boundaries.
- Gradient Boosting (XGBoost) – for cases where high accuracy is required.
- LSTM (Long Short-Term Memory) – for predictions based on time series (if real-time analysis is required).

Training and testing process: Dataset creation: A data set is formed, collected by sensors and with predefined fault states (labels); Train/Test split: Usually 70% is allocated for training, 30% for testing; Model training: Algorithms learn, that is, they learn to predict whether the device is healthy or faulty based on various features; Accuracy indicators: confusion matrix, precision, Recall, F1-score and ROC-AUC curve (if necessary).

Initial results showed that the Random Forest algorithm worked with high accuracy. It was found that vibration and temperature parameters play a key role in the model. The LSTM algorithm was useful in detecting changes in the real-time flow, but required more computational resources. The prediction system developed in this study was tested on the basis of experimental equipment close to real industrial conditions. Approximately 10,000 data samples of equipment operation in different conditions were collected based on 3 weeks of monitoring data collected using sensors. The following machine learning algorithms were compared with each other and the following performance indicators were recorded:

Algorithm	**Accuracy**	**F1-score**	**ROC-AUC**
Random Forest	94.7%	0.93	0.96
SVM	89.3%	0.87	0.91
XGBoost	95.1%	0.94	0.97
LSTM (Recurrent NN)	92.5%	0.91	0.95

The XGBoost algorithm also demonstrated the highest accuracy and stability. However, in cases where real-time performance was required, the LSTM algorithm showed advantages, as it allowed for deeper analysis of time-varying patterns.

Feature Importance. Using the Random Forest and XGBoost algorithms, important features were identified, and the following were identified as the most important input parameters of the model:

- Average value and variance of vibration variation
- Motor temperature variation
- Rotational speed fluctuations
- Changes in the sound spectrum during operation

These features made it possible to determine with high reliability whether the equipment is healthy or faulty. This study investigated the possibilities of early detection of sewing equipment failures using machine-learning technologies. Experiments showed that: Based on real-time data collected by sensors, failures can be reliably predicted; Boost and Random Forest algorithms work with high accuracy and are suitable for industrial conditions; such systems can optimize the maintenance schedule, increase equipment reliability, and prevent production interruptions.

Integrate the system with a wider sensor base (e.g. pressure, current sensors). Expand the database and create a deep model based on Deep Learning. Launch a pilot project at real industrial enterprises and assess economic efficiency. Develop a mobile application or web platform for providing services based on artificial intelligence.

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