Visual Digital Diagnostics of the Production Machinery Online

Elena Filippova, Nikita Besednyi, Nikita Harziya, Vyacheslav Dimitrov, Dmitry Korzun

Petrozavodsk State University (PetrSU)

Petrozavodsk, Russia

{filippova, besednyi, harziya, dimitrov, dkorzun}@cs.karelia.ru

Abstract—The presented demo is part of the developed system for multi-parameter monitoring of production equipment. The equipment unit is mounted with several sensors for measuring physical parameters (temperature, rotation frequency, current strength, vibration). The system converts the data into digital form and transfers it to a local server. The server launches a corresponding data processor (program module) for each sensor and analyzes the data stream using the original signal and its frequency spectrum (obtained by the fast Fourier transform algorithm). As a result of the analysis, envelope spectrum of the signal is accumulated for a certain period of time, which is used to plot a spectrogram - a graph of the dependence of the amplitude (color) on frequency and time. The resulting image of the spectrogram is transmitted to the defect detection module, which determines the presence of anomalies at a specific equipment unit using a neural network.

Vibration analysis and diagnostics of machinery bearings is an essential part of condition monitoring of equipment units. It is the bearings that are more susceptible to dynamic and static loads that appear while operating.

Before the advent of monitoring systems, the maintenance of plant equipment was carried out using scheduled service. But during operation, any piece of equipment may fail at any time. For such cases, the plant had a repair department, and in case of serious breakdowns, it had to contact the equipment manufacturer. Both cases led to downtime which affected the efficient operation of the plant.

Since then computer technologies have been used in all areas of human life, it has generally been the responsibility of computers to keep plant equipment running apart from humans. Moving from a traditional maintenance strategy to condition monitoring helps maintain operational control of production machinery such as engines, turbines, generators, etc. Thus, a tool is needed for timely diagnostics and predicting the failure of expensive equipment.

This paper focuses on diagnostics of bearings using spectrogram images. The essence of the solution lies in the use of neural networks to determine anomalies in the images.

The spectrum of the signal envelope [1] is used to plot the image. The vibration envelope allows you to identify and analyze the low-frequency components of the signal, separating them from the overall vibration level of the machine. That enables early detection of developing defects in elements or machine parts. The envelope is the magnitude of the analytic signal computed by Hilbert transform.

Spectrum is a signal processing method that allows you to identify the frequency components of a signal. In this repre-sentation, it is easy to distinguish individual frequencies that describe defects. The Fast Fourier Transform (FFT) algorithm is used to plot the spectrum.

The architecture of the system is shown in Fig. 1. The signal processing module is engaged in plotting the envelope spectrum. The module splits the signal into pieces of equal duration. For each piece, an envelope spectrum is computed and recorded in the database. The service for plotting spectrograms [3] builds an image of the spectrogram every five seconds for the last 20 minutes.

The resulting spectrogram image is saved to the file system, and information about the location and time of saving is transmitted to the RabbitMQ message broker. The sent message will be delivered by the "neural defect detection service" for the analysis of the plotted spectrogram. The result of the spectrogram analysis will be saved to the MongoDB database. An online service view is implemented based on data from MongoDB, Clickhouse and RabbitMQ message broker.

The TensorFlow [2] and Keras libraries are used to implement the neural network. TensorFlow is used to build and train a neural network to find and classify patterns.

A dataset with spectrogram images is used to train the neural network. Before training the network, the dataset was processed by filters (converting to b/w format). The dataset was divided into two classes: images that contained a defect component and without one. The class of images with defects contained several types of defects (for example, a defect in a separator or an inner ring).

The trained model achieved 95% classification accuracy. After training the model, the neural network received a spectrogram image every 5 seconds to diagnose anomalies. On the test dataset, the defect detection accuracy averaged 97%.

References

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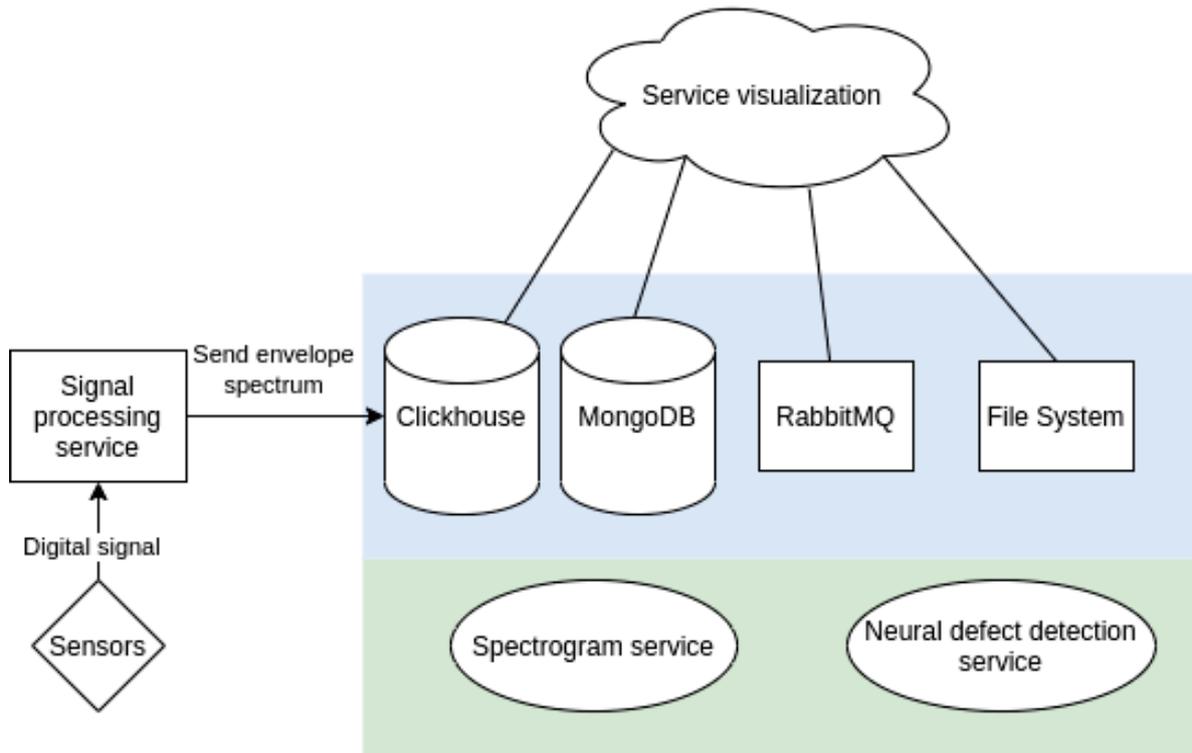
Fig. 1. Visual digital diagnostics model

[2] Gad, Ahmed. (2017). TensorFlow: A Guide To Build Artificial Neural Networks Using Python.

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