Researchers propose AI-based approach to contactless machine failure detection

November 29 2021

Prof Rytis Maskeliūnas, Faculty of Informatics, Kaunas University of Technology, KTU. Credit: Kaunas University of Technology

The world's largest manufacturers lose 1 trillion dollars per year to machine failure. Many problems lie in the noisy factory

environment—working equipment and processes produce high sound, consequently, machinery faults are often unheard or for that reason detected too late. Researchers from the Kaunas University of Technology (KTU) have proposed an artificial intelligence-based method for different mechanical failures detection in a noisy environment. The new solution is not only sustainable—equipment can be easily digitalised, without remodeling it—but also relatively low cost.

Anomaly detection of industrial machines is a method that relies on different data—temperature, pressure, electric current, vibration, and sound—all from sensors installed within the machine itself. Even though sensors are essential in capturing basic diagnostics, they are difficult to set up in older generations of factory lines as the machinery is very "mechanical" and "not digital."

"For factories with low automatisation levels, many of which remain much larger than autonomous manufacturing lines, failure detection without employing new sensors for each industrial machine is extremely important. As the sound data is easy to collect because of the relatively low installation cost of contactless microphones to existing facilities, sound data-based methods are of great interest," explains KTU researcher Rytis Maskeliūnas, the co-author of the invention.

However, in highly noisy factory environments, the sound data gets contaminated and interrupted, resulting in misinterpretation of the sounds and mistakenly indicated mechanical failures. The team of multimedia and software engineers from KTU suggested deep machine learning (ML) method that relies on real-life sound data from working industrial machines and can be used for machine diagnostics with no unnecessary installations of new sensors. According to Maskeliūnas, failure detection is based on training algorithms with real-life sound data within real industrial machinery sound information.

"The new software solution is cheap and easy to use—the only equipment needed is a microphone pool and a processing device. Artificial intelligence allows acoustic anomaly detection with no additional sensors," explains Prof Maskeliūnas.

A sustainable solution to help digitize the industry

"The purpose was to improve the robustness of anomaly detection in the domain of mechanical motion. This is a perspective field, because of sustainability and the opportunity to digitize the industry without getting rid of old equipment as new factory installations require a lot of resources and will not happen any time soon in a lot of poorer countries" says Maskeliūnas.

The experiments were carried out on the Industrial Machine Inspection and Inspection Malfunction Investigation and Inspection (MIMII) – a sound dataset of industrial machine sounds. According to Maskeliūnas, this data set comprises four distinct types of machinery: valves, pumps, fans, and slide rails. The waveform audio file (.wav) format was used to store the data that comprised machine sound and noise.

"The noise is real manufacturing environment sound that was intentionally blended with pure machine sound at three different SNR—signal-to-noise—levels: 6 dB, 0 dB, and 6 dB. The machine sound was recorded for both normal and abnormal conditions. As a result, we proposed an anomaly detection system for the analysis of real-life industrial machinery failure sounds," says Maskeliūnas.

Machine failures are time-dependent

According to him, the incorporation of acoustic new sensor technologies combined with deep learning methods can be used to avoid unnecessary

replacement of equipment, reduce maintenance costs, improve work safety, increase the availability of equipment, and maintain acceptable levels of performance.

"Early warning can be obtained through the predictive maintenance system based on acoustic failures recognition. The ability to detect weak signals may have a strong strategic impact. Their key benefit is real-time management and planning, which helps to cut down on the costs of production downtime," says Maskeliūnas.

The team of KTU researchers plans to detect more types of failures: "Like most artificial intelligence researchers, we are limited by the amount of data we have. A partnership with a manufacturing company would allow us to gather different scenarios and apply the method more widely. Our solution is particularly relevant in countries with little digitisation where companies do not have resources for new equipment."

The novel approach towards acoustic anomaly detection has already received inquiries for implementation in industrial environments. Maskeliūnas notes that its greatest advantage is low cost and no installation required—only a recording is needed.

More information: Yuki Tagawa et al, Acoustic Anomaly Detection of Mechanical Failures in Noisy Real-Life Factory Environments, *Electronics* (2021). DOI: 10.3390/electronics10192329

Provided by Kaunas University of Technology