DEMO: The Concept of Trend Build Module

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***Abstract*—The industrial Internet of Things (IIoT) applies to monitor technical state and utilization conditions for rotary machinery. Monitoring is based on multiple sensors that embed or surround the machinery under monitoring. The sensed data are used for diagnostics of machinery operation and utilization. Around the sensed data monitoring system could be build to process these data. The module decomposition approach for the monitoring system could be applied. In this work, we describe one of the possible modules of that system — the trend building module. We focus on the concept of the trend building module, its input and output parameters, and possible features.**

The monitoring system overview

The workflow of the required monitoring system for the trend build module could be described as follows and shown on Fig. 1:

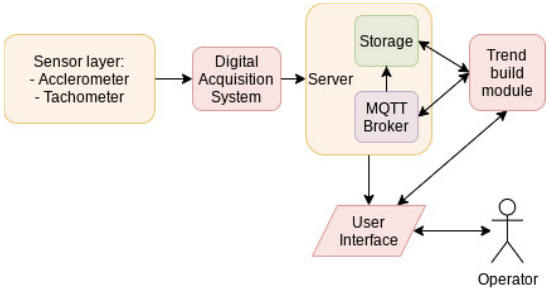

Fig. 1. The example of monitoring system with one module for trend building

The sensor layer performs data collection from various sensors, such as the vibration sensor (accelerometer) and tachometer installed on the rotary machinery unit. The next step is to collect the analog and digital signals from various sensors for further analysis. Analog to digital conversion is applied for the vibration signal with a data acquisition system (DAQ). The digital numeric values from DAQ are transmitted to the server, where the data from various sensors are pre-processed and stored. The MQTT message broker is used to deliver messages with sensory data and events between the user interface, database (storage), and modules. In the monitoring system the following types are used:

- value_changed — the body of this message contains a number of revolutions per minute;
- low_spectrum_changed — contains normalised Fourier spectrum;
- envelope_spectrum_changed — contains an envelope spectrum.

In the monitoring system the data flow from each sensor could be presented as an MQTT–publisher, thus any client may subscribe to the sensory data. This way, the system describes two publishers: vibration sensor data and tachometer data.

The monitoring module concept

The monitoring system may include different modules for monitoring and diagnostics of rotary machinery, especially rolling bearings. It is important to observe any degradation process in order to estimate the machinery failure time in the future. For that purposes, the trend build module is required. We assume that the degradation process of the rolling bearing could be described as a rising polynomial function. Hence, we propose the trend build module for the machinery unit degradation process in estimating the remaining useful life (RUL) for the rolling bearings [1], [2], [3].

The task of the module is to find the actual failure time at RUL=0%. In this failure state (RUL=0%) [3], an increase in the value of the specific spectrum amplitude could be observed. Using this knowledge, we can find the time for a certain value of the frequency amplitude that will be reached. Denote this value as the trend border. However, if the bearing is still new, the bearing lifetime may be long, and the spectrum amplitude value change is not so significant. In this case, the module checks the trend border will not be reached within the time interval specified by the operator. Denote this time interval as the static border.

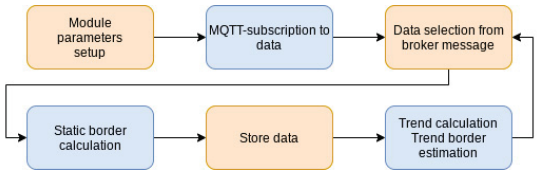

Fig. 2. The concept of for the trend build module

The workflow of the proposed trend build module is shown on Fig. 2 could be described as follows:

1) Configuring module parameters by operator with user interface. The parameters are stored in the server's database;
2) Subscribing to data stream from sensor through server, using MQTT;
3) Required values selecting from MQTT-messages, according to module settings;
4) Storing required data;
5) Trend building, until at least one of the two borders would be reached

The next list of parameters is used to configure the module:

- Vibration sensor MQTT–service ID;
- Tachometer MQTT–service ID;
- Spectrum type. Selection from envelope spectrum or frequency spectrum;
- Observable spectrum amplitude selection by constant revolutions per minute value (RPM), or tachometer RPM value by the multiplier;
- Data mode selection for trend building: using maximum value (each observation for the trend is bigger than previous), or average value from time windowed function;
- Static border value. If the trend rises slowly, the static border is used to limit time for the trend build function;
- Trend border value. If the the value of the harmonics is bigger than this parameter the module sends a notification by a broker to the operator's interface;
- Window size for trend function build performs selection N measurements of spectrum amplitude observation values to build a trend function.

After the module starts, it subscribes through MQTT–broker to tachometer and vibration sensor data publishers. When the subscription is done, the module receives events from these two publishers and parses events from them. The machinery unit status determination is required. It is archived by evaluation of instant RPM value from the tachometer. If the value is non-zero, the machinery unit is running, monitoring data describes the unit respectively. Parsed messages from the vibration sensor contain frequency or envelope spectrum amplitudes. In accordance with constant RPM value, or tachometer instant RPM value by multiplier, the required spectrum amplitude value is selected from the appropriate type of spectrum. After the spectrum amplitude value is selected we apply a comparison between the current spectrum amplitude and the previously received value, or average value from the time windowed function. Hence we select a spectrum amplitude value that is bigger than the previous and is store it in the database. Further, trend building from stored data with a window size of N measurements is applied. For trend building, we use an approximation of the table-represented function with 5th power polynomial. The trend build function performs up to the estimation of one of the static or trend borders. The trend border describes the maximum allowable value spectrum amplitude value for the machinery unit under the normal operation mode. The estimation of the static border determines the impossibility of the trend border attainment at a given period of time. The trend data, including plot and polynomial coefficients, are sent to the operator's interface or dashboard.

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