AUTOMATIC DETECTION SYSTEM MEASURING ACOUSTICALLY THE ROTATION RATE AND FAULTS IN A ROTATING ENGINE

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Abstract
This work presents an automatic detection system measuring acoustically faults in a rotating engine. We have developed an application that should acquire the signal from a microphone. Faults of the small air fan are simulated by adding intrusive objects into the fan. The project has been realized on PC with LabView and a sound card of myRIO. When the application is executed, we recognize the faults in the PC air fan by analyzing the acquired acoustic wave from the microphone using signal processing. We have performed several tests in order to check the reliability of our implementation.

I. INTRODUCTION
In these days, Gliders, AUVs (autonomous underwater vehicles) and ASVs (autonomous surface vehicles) are increasingly becoming more popular autonomous vehicles, which are used to collect data with a good spatial-temporal resolution and with low costs [1]. The most important part of these vehicles is propulsion. However, no device is foolproof. These vehicles are unmanned and a failure of their rotating engine is difficult to monitor. This work discusses the possibilities of fault detection of a rotating engine by acoustic methods. We describe the simplest solution of the rotating engine mechanical failure detection using an acoustic sensor. The proposed fault detection method of a rotating engine is tested using LabView and Compact RIO [2]. Unfortunately, the sound card sensitivity doesn't allow us to recognize the rotational frequency in the spectrum.

II. THE IMPLEMENTATION IN LABVIEW
In LabView we collect acoustic waves emitted by a fan thanks to a microphone connected to myRIO module. Then, the amplitude of the measured signal is amplified by factor 1000. Afterwards, we apply the fast Fourier transform (FFT) to this signal [3].

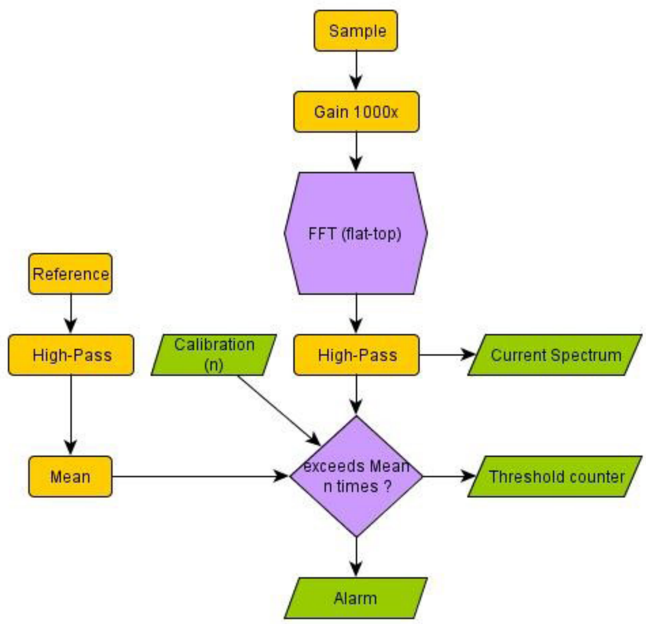

Figure 1. Block diagram of the detection system

The FFT is used in digital signal processing to transform discrete time domain data in the frequency domain. The spectrum obtained is compared to the prerecorded reference sample spectrum. When an object is stuck in the fan, the amplitude of the harmonics higher than 1000 Hz increases. We count how many times the amplitude of the current spectrum exceeds the average value of the reference sample spectrum. If the value of the counter exceeds the threshold value indicated by the control button, the alarm goes off. Once the fan is no longer blocked by the object, we can reset the alarm. The block diagram of the proposed solution is presented in Figure 1.

III. EXPERIMENTAL RESULTS
In order to check the reliability of our approach, several tests were conducted. The setup of the tests included myRIO, a microphone (in our case the position of the microphone is near the center of the fan), a voltage-controlled PC fan and several intrusive objects (Figure 2). The objects consisted of different materials which allowed us to observe its effects on the captured spectrum.

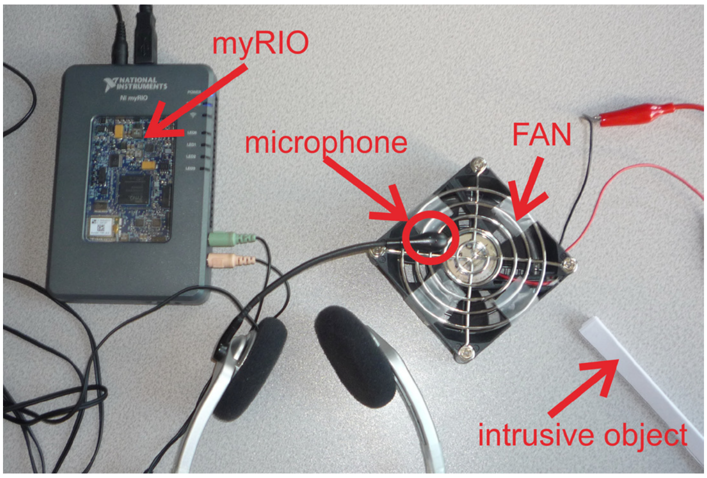

Figure 2. Testing layout

The reference sample spectrum Figure 3b) was recorded previously using the same layout as during the experiment. We tuned the threshold counter using the calibration knob in such a way that no false alarm was detected when no object was inserted into the fan (Figure 3a). After this procedure several objects were placed in the grid of the fan. When the object touched the blades of the fan, a significant spectral response was detected (Figure 3c). The program proved to trigger the alarm for different materials while temporary random noise sources didn't cause any response.

IV. CONCLUSIONS
In accordance with our expectations, the proposed solution detects the presence of frequencies caused by an intruding object. The reliability of this method can be adjusted using a calibration knob. The program monitors frequencies, therefore most of the short-time random noise doesn't affect the fault detection. The drawbacks of the principle are mainly connected with the acoustics of the surrounding environment and with the sensitivity of the microphone.

In underwater applications of this principle, the microphone would have to be substituted by a sophisticated acoustic sensor whose placement is not a subject of this project and should be considered in other works.

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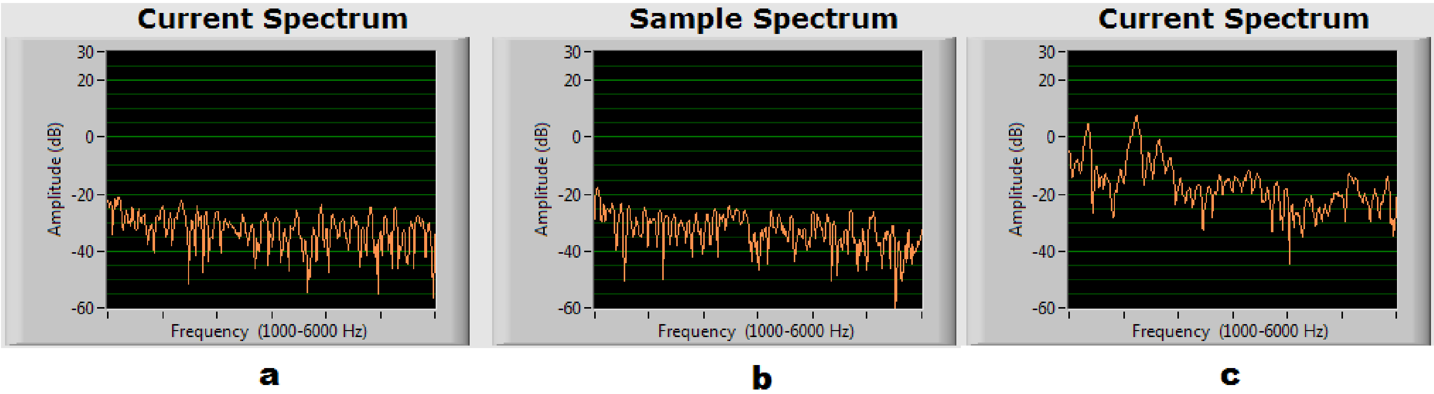

Figure 3. Spectrum of the fan without fault (a), the pre-recorded sample for comparison (b), spectrum of the detected fault (c)