SOUND PARAMETER ESTIMATION IN A SECURITY SYSTEM

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Abstract: In this paper, the signal processing approach is applied to the sound parameter estimation using adaptive microphone arrays. The simulation scenario describes a situation where three sensors generate three different sound signals (warning, alarm and emergency) and a car is the source of natural noise. The results obtained demonstrate that the parameter estimation can be used for recognition of the type of abnormal situations arisen in the area of observation in order to be taken the corresponding solutions for control of the security system.

1 INTRODUCTION

The sensors used for protection are activated in the event of an adverse situation in the protected space. In case of fire, smoke, vibration, and breakage of glass or opening the car the sirens of sensors give a loud beep for a few minutes. The assessment of the direction and parameters of the incoming sound signals can be used to guide the camera that records the situation in the most dangerous direction. The algorithm described in (Benesty, 2008; Godara, 1997; Trees, 2002; Vouras, 1996; Moelker, 1996; Behar,2010) is intended to locate the direction of sound signals coming from sensors or other sources of sound using microphone arrays. Microphone arrays represent a set of microphones arranged in a geometric configuration. In fact, they can be realized or linear microphone arrays, where the microphones are positioned in a straight line or circular microphone arrays, where the microphones are placed in a circle or rectangular microphone arrays, where the microphones are arranged in the shape of a rectangle plate.

After the analysis of parameters of such sound signals that arrived from the detected directions the video cameras are directed in such directions, from where have been arrived the signals having the most important priority (emergency, alarm and warning). In modern security and surveillance systems, the operational control of protective and warning means is based on the analysis of alarms received from different sensors installed in the observation area. In this paper we consider a situation where the operational control of a video camera is based on sound parameter estimation.

The simulation scenario includes three sensors, which generate three types of signals (warning, alarm and emergency), and one source of natural noise (car). The parameters of three sound generators produced by three well-known companies SoniTron, E2s and Sensor Systems are used in simulation. The results obtained demonstrate that the sound parameter estimates are very close to real sensors parameters. The paper evaluates both the duration of the sound pulse and the signal frequency spectrum by using the FFT.

In this paper, a possible signal processing algorithm is proposed for sound parameter estimation. We consider the case, when the sound source is located in the array's far-field, and the sounds generated by sound sources propagate through the air. After analysis of parameters of all signals received from the detected directions, a

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video camera is directed in such a direction, from where has been arrived the signal having the most important priority (emergency, alarm and warning).

2 SENSORS AND SIGNALS

In this work are tested the signal generated by sensors of several companies SONITRON, E2S and SYSTEM SENSOR (Behar, 2010). Two main signal parameters of such sensors are the sound power and the sound frequency (Table 1).

Table 1: Sensors parameters

Company	Sound power [dB]	Sound frequency [Hz]
SONITRON	96	2500
E2S	100	1000
SYSTEM SENSOR	103	2400

Depending on the non-normal situation the sensors emit different sound signals (continuous, intermittent) with the parameters given in Table2.

Table 2: Signal parameters

Sensor signals		
Continuous (warning)	Intermittent-I (alarm)	Intermittent-II (emergency)
$f_{int} = 0$ Hz $T_{sig} = 10$ s	$f_{int} = 5$ Hz $T_{sig} = 30$ s	$f_{int} = 1$ Hz $T_{sig} = 60$ s

The security sensors, using the mounted sirens, that generate special beeps, warn on abnormal situations that arise in the protected space, “warning”, “alarm” and “danger”. The sound signal “Warning” is a continuous harmonic sound signal with duration of 10s. The signal “Alarm” is an intermittent signal with the frequency of interruption of 5 Hz and duration of 30s (type-I). The different devices generate various sound signals of type “alarms”. In figures 1-3 (on the left), are shown the sound signals of type “warning”, “alarm” and “danger”. On the same figures (on the right) are presented their frequency spectra. The plotted sound signals are generated by the sensors of the well-known companies SONITRON, E2S and SYSTEM SENSOR.

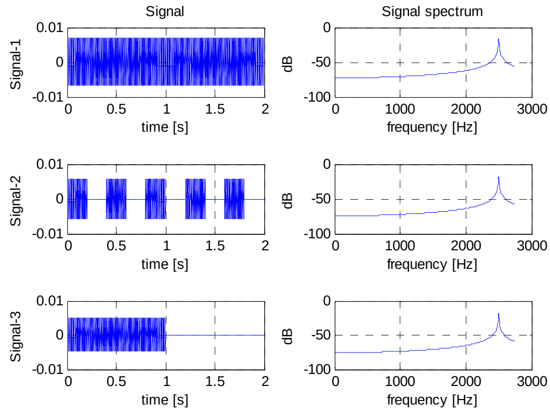

Figure 1: SoniTron signals and spectrums

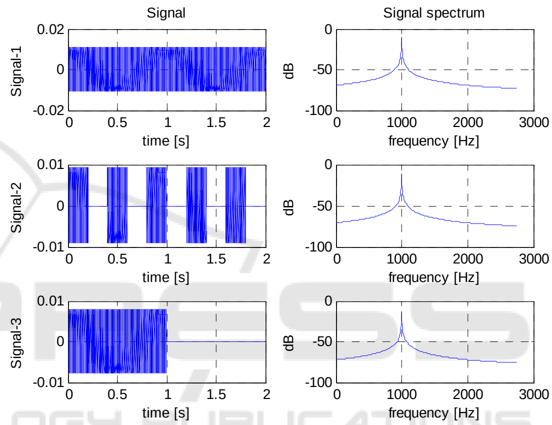

Figure 2: E2S signals and spectrums

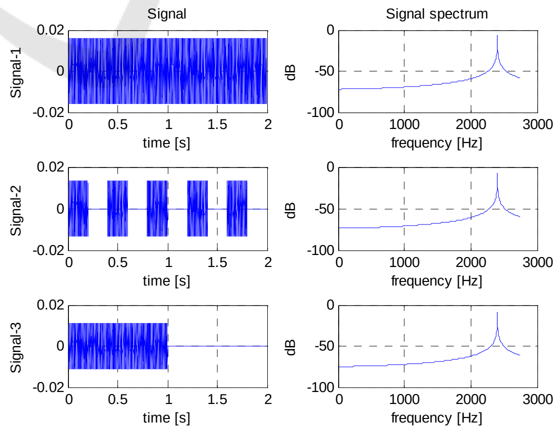

Figure 3: System signals and spectrums

3 SIGNAL PROCESSING

Many sensors for fire detection or building surveillance are equipped with sound alarm devices. In case of alarm event (smoke, flame, intrusion, glass breaking, and unauthorized car opening) the alarm device emits powerful sound signal with various duration. For the sake of simplicity, let's assume that a set of sensors and one microphone array are installed for the object protection in the observation area and a video camera can be located above a microphone array (Fig.4).

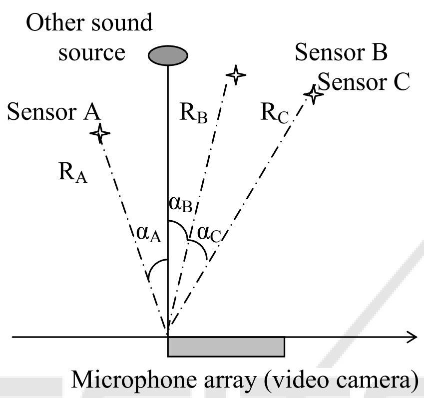

Figure 4: The security system topology

In a security system, the sound direction localization could be used for pointing the additional video surveillance devices (video cameras), which record the additional information and send it to control center of a security system. The priority direction for pointing of a video camera is estimated on the base of a parameter analysis of the signals received from the detected sound sources. The general block-scheme of signal processing in a security system is shown in Fig.5.

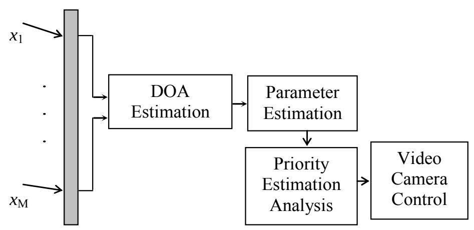

Figure 5: Signal processing in a security system

We assume that the adaptive beam pattern thresholding (CFAR) is performed and, finally, the direction of-arrival (DOA) estimates are found as directions where the local maximum exceeds an adaptive threshold.

The block-scheme for sound parameters estimation is shown on Fig. 6. The duration of the sound pulse is obtained after comparing the envelope of the signal with a threshold that is 80% of the average envelope. The estimation of the carrier frequency of the sound signal is received again compared with a threshold value of -10 dB (Fig. 6).

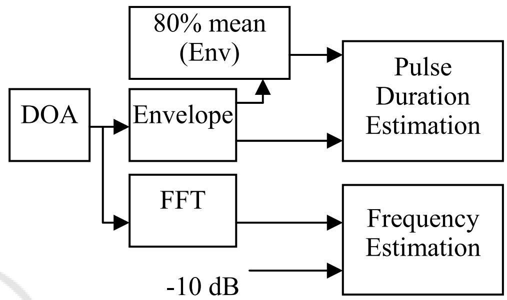

Figure 6: The block-scheme of sound parameters estimation

4 SIMULATION RESULTS

The computer simulation is performed in order to demonstrate the capability of the presented algorithm to estimate sound parameters. The scenario of simulation includes three sensors (A, B and C) located respectively at a distance of 50m, 60m and 70m from the microphone array (Fig. 4). The bandwidth of the used microphones is [100 - 5000] Hz. During the experiment, we simulated the sound of a car, which is a broadband noise signal, filling the entire bandwidth of the microphones. Power of the sound signal generated by a car is 110dB. In the scenario of simulation, the azimuth of a car is zero relative to the microphone array and the car is located at 90 m from the microphone array (Fig.4).

In Fig. 7, 9 and 11 are shown the sound signals of type "warning", "alarm" and "danger" together with the corresponding thresholds of detection. These signals are generated by sensors manufactured by the well-known companies SONITRON, E2S and SYSTEM SENSOR.

In Fig 8, 10 and 12 are presented the corresponding frequency spectra of these signals.

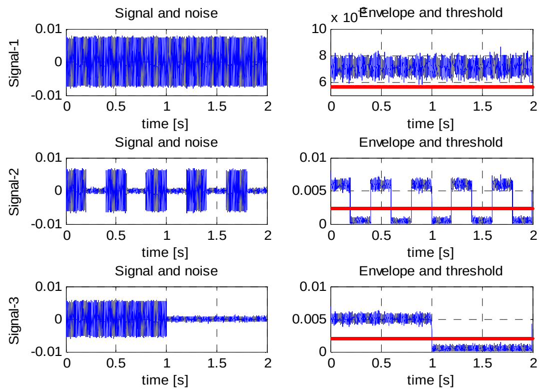

Figure 7: SoniTron signals and threshold

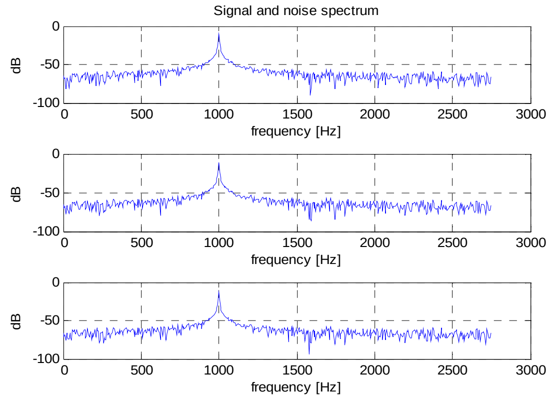

Figure 10: E2S signals spectrum

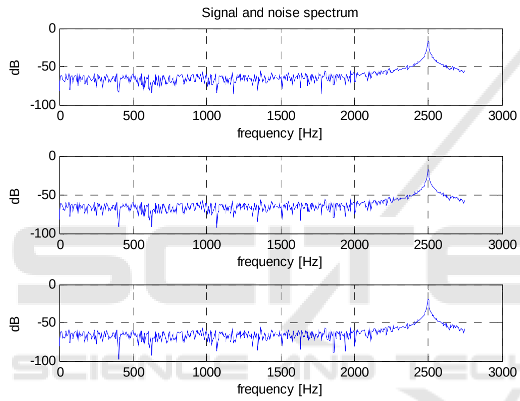

Figure 8: SoniTron signals spectrum

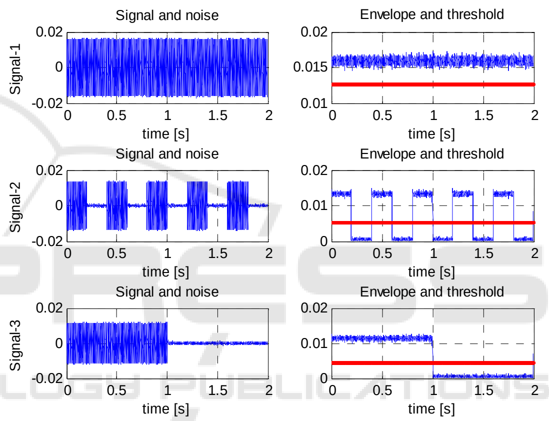

Figure 11: System Sensor signals and threshold

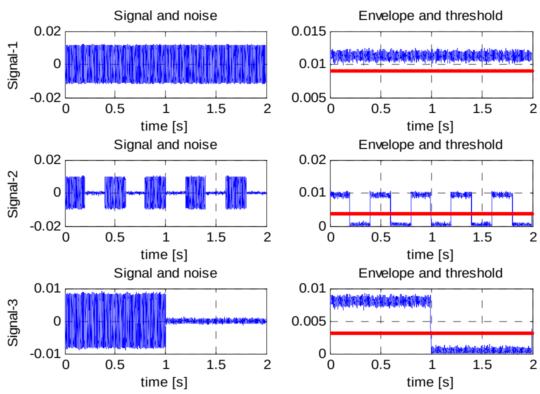

Figure 9: E2S signals and threshold

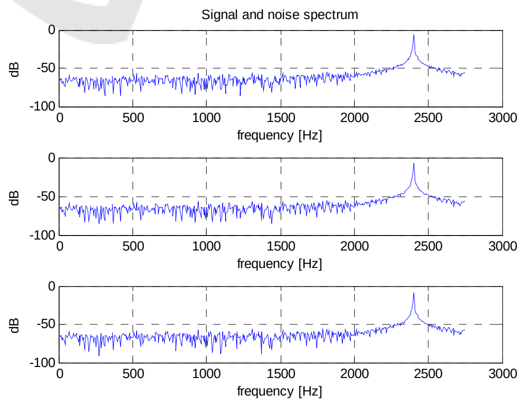

Figure 12: System Sensor signals spectrum

In Fig.13 are shown the broadband interference signal generated by a car and the internal noise of a microphone noise of the microphone array. In Fig.14 are presented the corresponding frequency spectra of these signals.

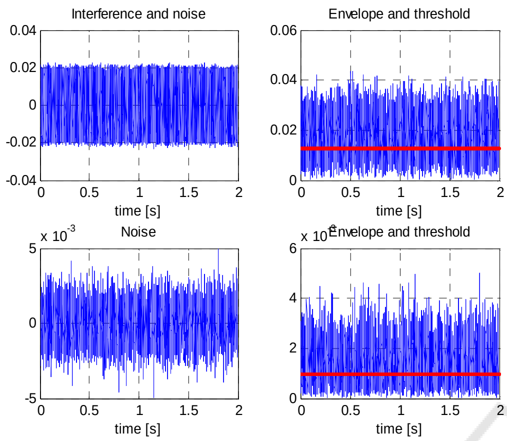

Figure 13: Interference and noise

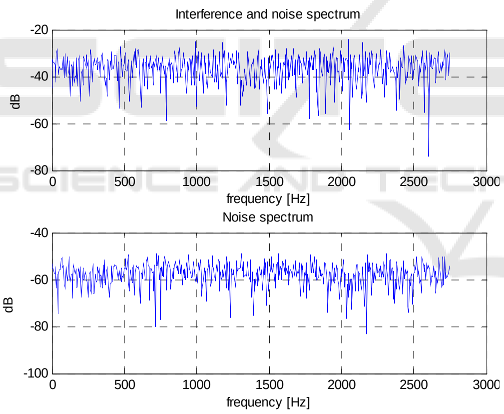

Figure 14: Interference and noise spectrum

The results obtained demonstrate that the signals from different sensors can be estimated and there parameters are equal to real sensors parameters. The presence of interference and noise does not affect significantly the estimation of signal parameters.

5 CONCLUSIONS

It is shown that the obtained estimates of the sound signal parameters are close to the actual parameters of the signals. The algorithm presented enables to recognize the type of abnormal situations arisen in the area of observation in order to be taken the corresponding solutions for control of the security system. Thanks to the adaptive microphone array processing, the presence of interference signals does not influence significantly the determination of the signal parameter estimates.

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