

# Accident analysis of a surveillance camera system through a frequency-based processing

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*Abstract:* - The surveillance camera systems are commonly used in detecting the traffic violation on the roads. A key requirement in most detection systems is the ability for rapid automated analysis to identify the accidents. This paper describes an accident analysis based on frequency information for detecting the accident, identifying the cause of the accident and storing the accident scene. When an accident happens, the surveillance system analyzes the accident sound and stores the accident scene in real-time. The proposed system utilizes the sound magnitude (dB) and frequency analysis (FFT) in order to increase the accuracy of accident assessments. In addition, this system accomplishes a continuous buffering without the presence of an accident. It stores the prior accident scene, accident scene and post accident scene. When this system is applied to the actual crossroads, it can detect the accident presence and save the inspection expense. Results of applying the proposed technique to data obtained from the detection of accidents are presented and compared.

*Key-Words:* - Traffic accident surveillance system, accident scene, sound analysis, frequency information, accident presence, accident inspection.

## 1 Introduction

Currently the road traffic incident statistics are decreasing despite the increase on the automobile diffusion ratio. In comparing to that of tunnels and bridges, the accident ratio near crossroads is increasing every year [1]. There tends to be some ambiguity in apportioning responsibility for traffic accidents.

In Table 1, the box shows the number of traffic accidents based on various road types - near crossroads, tunnels and bridges. In order to prevent accidents or reduce the accident ratio, it is necessary to utilize the surveillance camera system. However, the effectiveness is decreasing due to the extensive footage as compared to the number of accidents. Since the previous camera was usually used in 24 hours surveillance systems, it requires a long

inspection period and vast storage space to analyze the accident.

In addition, the existing surveillance camera system when detecting motion, has exhibited difficulty in capturing the accident scenes only. In order to improve on existing problem, we have considered new technology to detect, identify and store the accident scene. In this paper, we have reviewed and proposed the sound analysis and surveillance camera system.

We introduce the related works on the surveillance camera system and analysis method in section 2. The developed system is explained in section 3 and the experimental results are described in section 4. Finally, we conclude with discussions and future works in section 5.

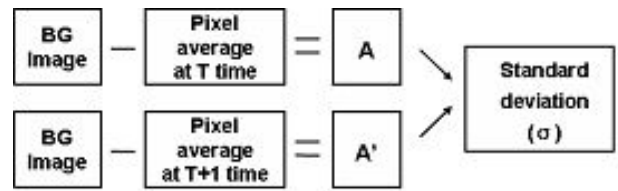
## 2 Related Works

In a surveillance camera system, generally, the key role is detecting for the traffic violation. The conventional monitoring camera system describes the motion information from the background.

### 2.1 The Motion Monitoring Camera

The monitoring camera detecting the motion distinguishes the motion with pixel changes of the background and present image as shown in Figure 1. The average intensity values of an input image at the time of T and T+1 are first computed. Once the

standard deviation has compared the difference the threshold value, the monitoring system regards the motion as happened and saves the scene.



$$Accident(BG, A) = \begin{cases} True, & Threshold < \sigma \\ False, & \sigma < Threshold \end{cases} \quad (1)$$

Table 1. The number of traffic accidents based on various road types [1]

연도	총계(건)	교차로	소계	단일로			기타	건널목	서비스구역
				교차로 부근	터널	교량			
1990	255,303	26,758	223,271	16,970	259	3,159	202,883	113	5,161
1991	265,964	31,946	229,110	21,301	297	4,013	203,499	90	4,818
1992	257,194	33,127	219,765	22,916	202	3,085	193,562	98	4,204
1993	260,921	41,058	216,731	23,913	205	2,863	189,750	105	3,027
1994	266,107	40,974	223,177	19,583	162	2,629	200,803	88	1,868
1995	248,865	44,858	202,522	17,106	165	1,878	183,373	84	1,401
1996	265,052	50,672	212,749	17,906	220	2,095	192,528	46	1,585
1997	246,452	46,132	199,103	16,139	250	2,025	180,689	31	1,186
1998	239,721	48,464	189,279	15,255	224	2,046	171,754	12	1,966
1999	275,938	56,550	215,893	15,550	319	1,541	198,483	31	3,464
2000	290,481	57,027	230,867	16,862	301	1,429	212,275	9	2,578
2001	260,579	47,767	210,093	16,926	292	1,395	191,480	8	2,711
2002	231,026	48,771	179,813	16,228	259	1,805	161,521	10	2,432
2003	240,832	62,314	168,956	29,718	453	1,715	137,070	159	9,403
2004	220,755	57,268	147,724	29,066	382	1,291	116,985	176	15,587

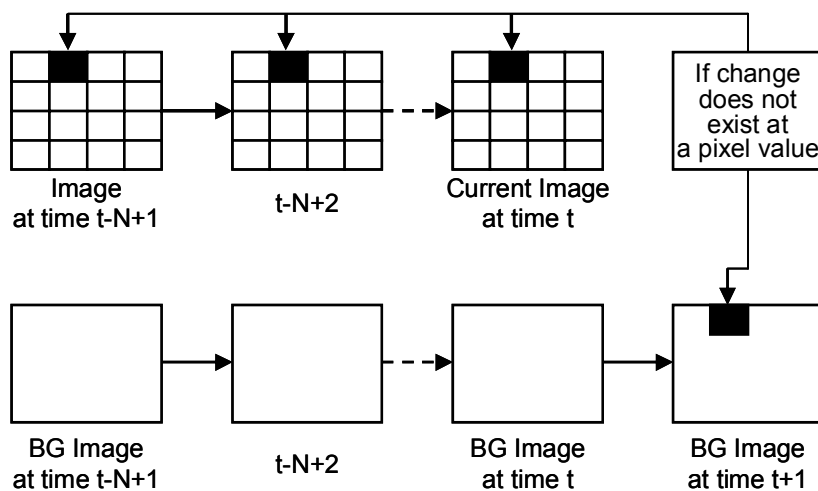


Fig. 1. The principle for the motion monitoring [2][3].

Various resulting images can be generated by a user defined threshold value. In other words, we can define the motion presence based on the difference in value between the present and background images as shown in Eq. (1). The application of this method is the monitoring camera using the motion in Fig. 2 produced by XYview [4].

Since these kinds of system can detect the movement of an object, they can be applicable in preventing the trespassing or robberies. This system can be utilized efficiently in storage areas when the motion occurs [5]. In the case of crossroads where activity is frequent, the effectiveness of the detection camera system is reduced due to the continuous motion.

### 2.2 Fixed Traffic Speed Camera and Sound Analysis

Fixed speed camera sites are installed on a proactive basis to reduce the risk of speed related collisions and dramatically increase the likelihood of detection in support of road safety objectives. This camera system can monitor one to four lanes in the same direction. Fig. 3 describes a fixed traffic speed camera system. Fixed cameras operate using a sensor array consisting of a conventional inductive loop positioned between two piezoelectric sensors (i.e. strips). They have the ability to measure the driving time between two sensors.



Fig. 2. The motion detecting application [4].

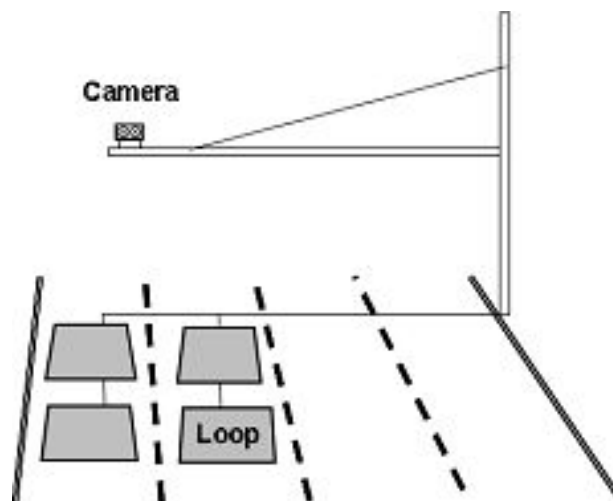


Fig. 3. A fixed speed sensing camera.

This system is commonly used (Fig. 4) and it can prevent the speed accidents even if the sensors are installed on the road. However, since this system inspects only the speed not the accident scene. In order to accomplish a sound analysis, we generally introduce a frequency analysis. The common window function is described in Eq. (2).

$$W_n = \begin{cases} 0.54 - 0.46 \cos\left(\frac{2\pi n}{M}\right), & 0 \leq n \leq M \\ 0 & \text{otherwise} \end{cases} \quad (2)$$

### 3 The Proposed System

The proposed system does not require a post-structure as is the case with the fixed speed camera. Since the system analyzes the accident sound on the crossroad and captures the accident scene, it can be applied by attaching a microphone to the existing camera system. Fig. 5 describes the overall system flow.

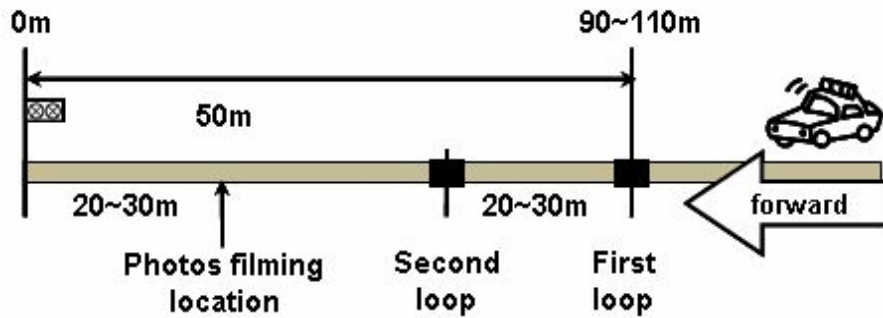


Fig. 4. The piezoelectric sensor location.

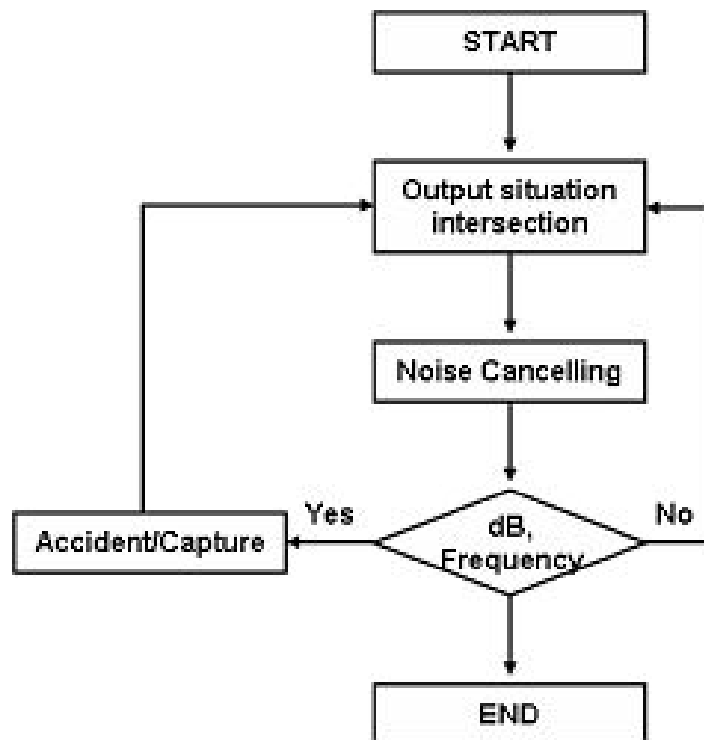


Fig. 5. The overall system flow.

#### 3.1 Camera Module

One of the key roles of a surveillance camera is storing the accident scene. In our research, we

utilized the VFW library of Intel, Corp., in order to use the camera module. Each scene is stored by 10 frames per second in BMP file format. If the camera

system stores only the post accident scene after identifying the accident sound, it is not possible to store the actual accident scene. In order to correct this kind of problem, the camera system should always be buffering the present scene. Once the accident has happened, the camera system can store the prior/post accident scene. Fig. 6 describes the buffered accident prior/post scenes based on the present accident scene.

### 3.2 Sound Analysis

The sound analysis utilizes first the sound magnitude, namely decibel (dB). In order to avoid an improper response, e.g., of a big automobile horn,

the system makes use of the frequency analysis using the FFT and it detects an accident presence. The following formula shows the dB measurement. The decibel (dB) is a logarithmic unit of measurement that expresses the magnitude of an acoustic power (measurement value,  $X$ ) relative to a specified or implied reference level ( $X_{ref}$ ). It means the relative value compared to the surrounding sound.

$$dB = 10 \log_{10} \left( \frac{X}{X_{ref}} \right)^2 = 20 \log_{10} \left( \frac{X}{X_{ref}} \right) \quad (3)$$

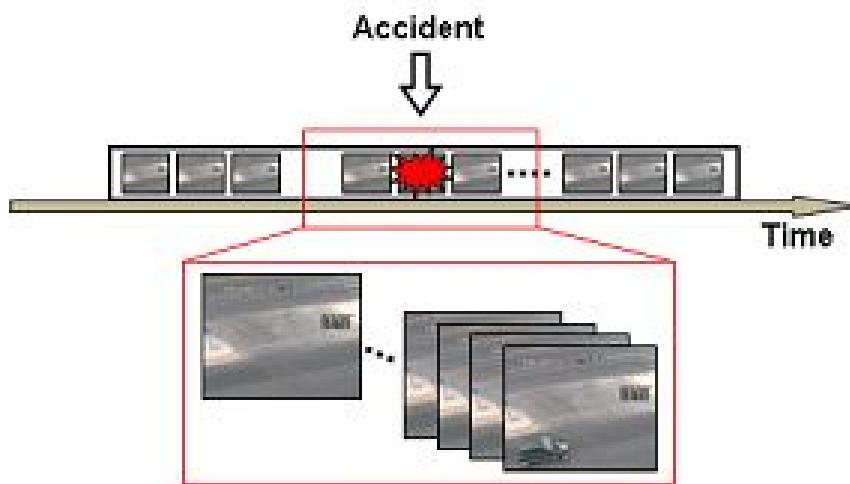


Fig. 6. The buffering sequence of accident scenes.

Table 2 shows the general noise status on the highways around the Han River (Fig. 7) in Seoul. In our experiment, we set up the threshold value, 60 dB to detect an accident presence at over 70 dB. It could also be possible to implement variable values depending on the application.

$$Accident = \begin{cases} True, & Amplitude > Threshold \\ False, & Amplitude < Threshold \end{cases} \quad (4)$$

After the magnitude analysis, the data over the threshold is implemented in the frequency analysis for the noise filtering. The frequency analysis first examines the accident signal wave and then figures out the frequency component of the maximum value on the spectrum.

Table 2. The noise status on the highways around Han River in Seoul ('06. 11. 2) [6]

Road Name	Noise (dB)
Gangbuk riverside road	71
Olympic highway	80
Dongbu highway	74
Seobu highway	74
Nambu belt highway	72

Fig. 7 describes the procedure for the accident analysis. If the value of an accident sound is greater than the threshold, the system activates and perceives it as an accident sound.

### 4 The Experimental Results

In our experiment, we utilized the Intel Pentium 4 with Windows XP (sp2) and UMPC (Samsung Sense Q1) and implemented user interface using MFC of Visual C++ 6.0 for the application development. We also used a SM58K microphone by Shure Corp., for the sound input. Due to the

difficulty in recreating the actual accident scene, we replicated the overall procedure by installing and replaying the accident sound file on the surveillance camera program for the sound analysis. Fig.8 shows the overall system configuration, which processes the input sources, camera image and microphone sound, onto the UMPC.

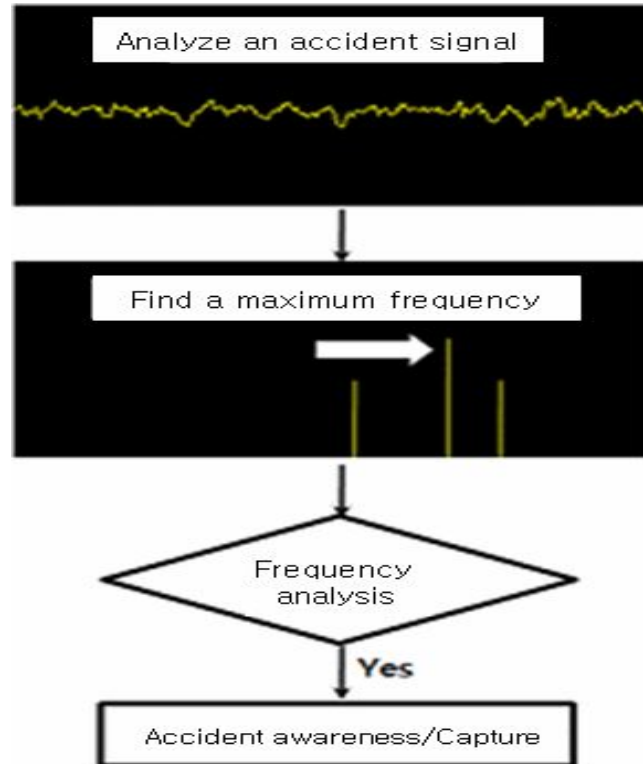


Fig. 7. The procedure for an accident analysis.

Fig. 9 explains the execution processes - camera view, environment setting and sound/frequency analysis. Table 3 shows the accident sound samples in our experiment. Because we couldn't capture the real accident sound, we used the accident sound

from a video. The audio file information on each sample file is 16 bits, 2 channels (stereo), and 44 KHz sampling rate. We estimated the general road noise was below 5 KHz for the frequency analysis.

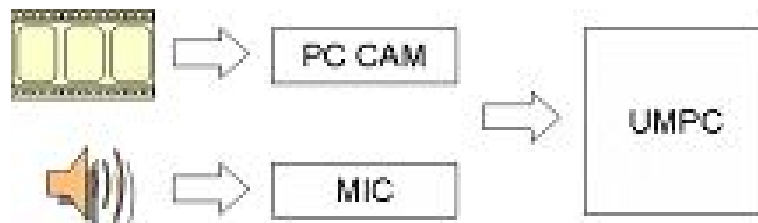


Fig. 8. The overall system configuration.





Fig. 9. The application program. (First row: screen shots before and after an accident, Second row: sound and frequency environment setting, Third row: a normal signal and frequency spectrum of an accident signal).

Table 3. The awareness rate of an accident

Data	Awareness/Trial	Rate(%)
sample 1	10 / 10	100 %
sample 2	8 / 10	80 %
sample 3	6 / 10	60 %
sample 4	9 / 10	90 %
background sample 1	0 / 10	0 %
background sample 2	0 / 10	0 %

In Fig. 10-(a), the spectrum shows the automobile sound of an emergency stop and indicates the automobile engine sound within 10 KHz, the skidding sound within 15 KHz, and the crashing sound around 20KHz. Fig. 10-(b) shows the similar frequency information. However, the accident sound tends to get muffled when the surrounding sound is larger than the accident sound as shown in Fig. 10-(c). We can figure out the accident around 15 KHz in Fig. 10-(d) since the frequency spectrum is similar to Fig. 10-(a) and (b). As compared with the accident sounds, the background sounds in Fig. 10-(e) and (f) have been enveloped by the surrounding noise. It is not possible to confirm the accident even though the spectrum shows the uniform distribution.

Fig. 11 and Table 3 show the experimental results with a data set. Sample 1, 2, and 4 represent the accident awareness with an average of 90% but sample 3 registers 60% due to the mixed frequency information. Since an accident holds both magnitude and frequency analysis, the awareness rate results in 0% with background samples.

### 5 Conclusions

In this paper, we proposed a surveillance camera system to store traffic accident scenes. The previous camera system on crossroads is limited, but the proposed system can determine both the accident

type and appropriate the responsibility for the traffic accident.

For the future works, various problems can be identified in the following:

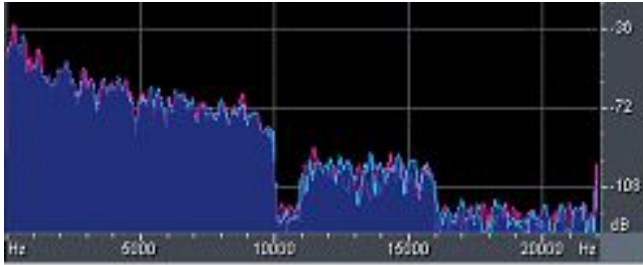
- (1) prevention for the traffic congestion [9] and the accident patterns.
- (2) buffering and the high-capacity data processing [10] for accident scenes.
- (3) mobile sensing and networking [11].
- (4) motion quality and analysis [12]

In order to increase the accuracy and effectiveness of an analysis, in addition, the optimization of the proposed technique should be considered. Even though we couldn't use the actual accident data, it shows the possibility of utilizing this system on crossroads with a more varied experiment and analysis.

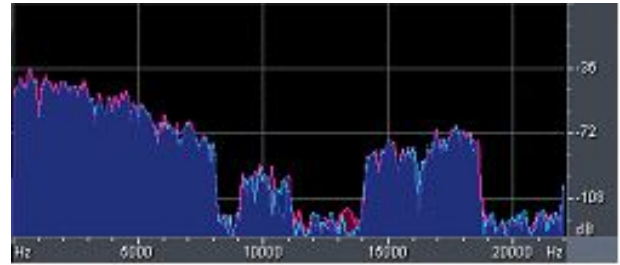
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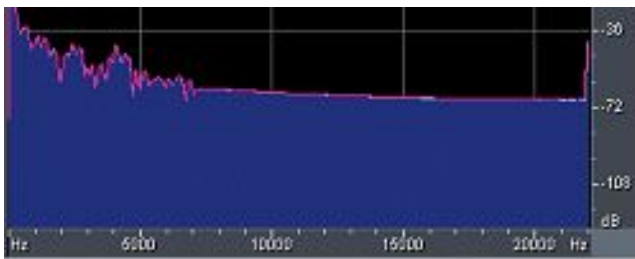




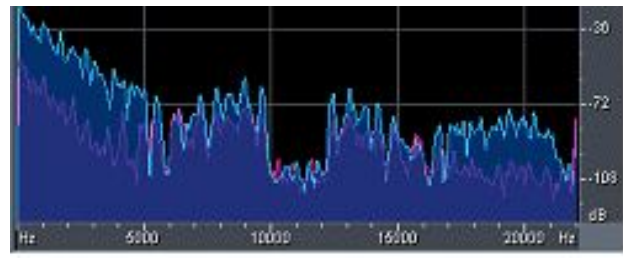
(a) The accident sample 1



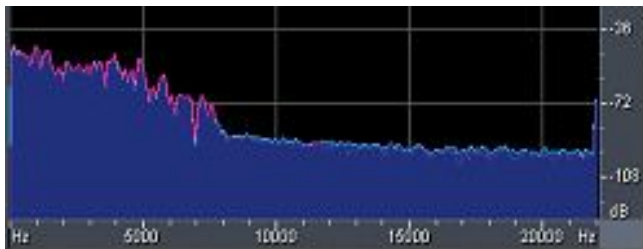
(b) The accident sample 2



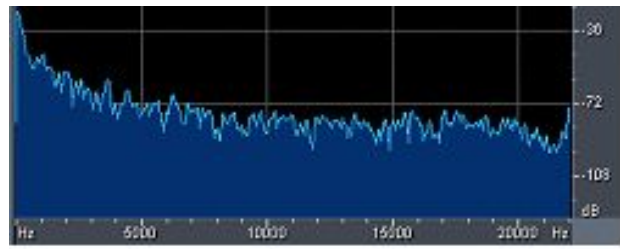
(c) The accident sample 3



(d) The accident sample 4

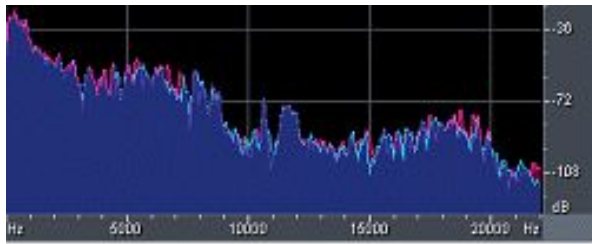


(e) The background sound sample 1

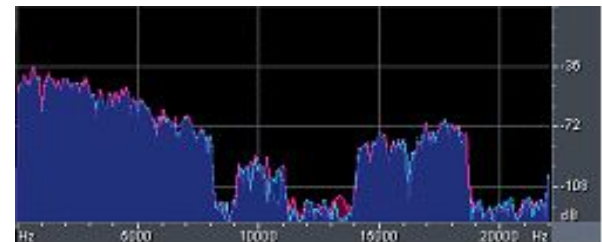
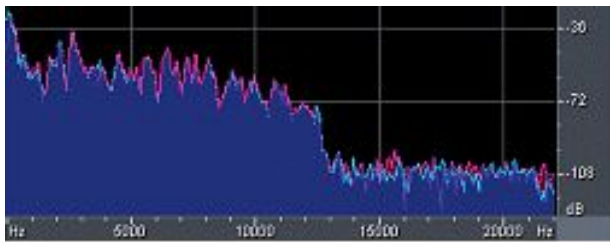


(f) The background sound sample 2

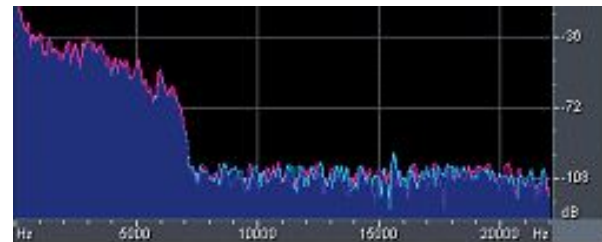
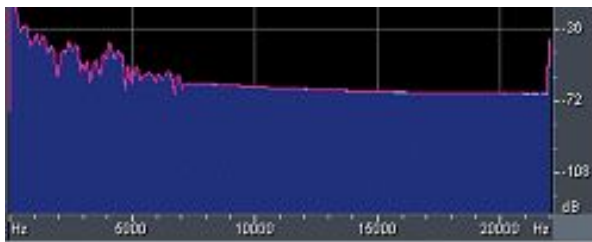
Fig. 10. The accident sound samples [7][8].



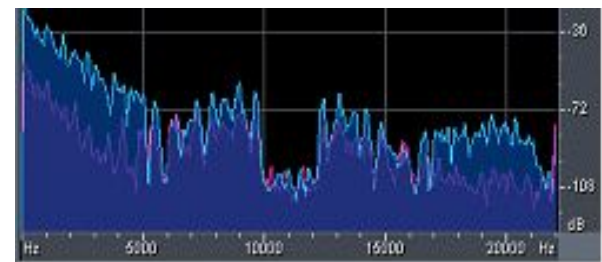
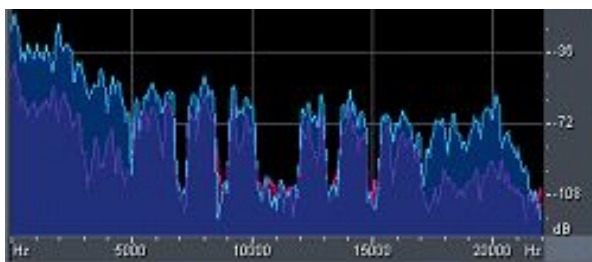
(a) Before/after the accident of sample 1



(b) Before/after the accident of sample 2



(c) Before/after the accident of sample 3



(d) Before/after the accident of sample 4

Fig. 11. The results of frequency analysis.