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Physical Properties and Environmental Effects on the Intensity of Gunshots: A Review

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Abstract- Gunshot detection technologies are widely used for security enhancement of public places. Although highly complex algorithms are implemented to detect gunshots i.e. implementation of Gaussian Mixture Model (GMM), Hidden Morkve Model (HMM), Neural Networks (NN), K-Nearest Neighbor (KNN), and Decision Tree algorithms, but still we are unable to achieve the desired results. There are many factors that affect the accuracy of the gun detection algorithm i.e. direction of weapon, distance between fire arms, types of ammunitions, type of environments, and diffraction of audio. This paper reviews the available information, on the physical properties and environmental effects on the intensity of gunshots. This work also discusses the issues and challenges in the detection of gunshot in indoor and outdoor environment and provide different options for managing them. The importance of weapon direction and diffraction from nearby objects are also technically discussed. The focused of this work is to highlight all the potential problems that directly affect the accuracy of gunshot detection algorithms. Knowledge of these basic physical properties and environmental effects on the intensity of gunshot could provide valuable information concerned with scene preservation.

Keywords- Diffraction; Direction; Distance; Gunshot; Indoor Environments; Outdoor Environments; Muzzle Blast, Shock Wave.

I. INTRODUCTION

Over the last few decades, the security situation of the world becomes more complicated. The terrorist usually target different organization and kill innocent people. The proper and timely management of terrorist attacks have become a great challenge and therefore researchers in the field have propose different techniques. Currently the simplest method is the deployment of security guards for counter terrorism. Moreover, due to complex attacks on different public places, advanced technologies are implemented to reduce security risk i.e. CCTV camera, metal detectors, concealed weapon detectors, and gunshot detection and localization algorithms [1].

For gunshot detection, different researchers implemented different algorithms to accurately detect gunshot and inform security forces with automatic alarms to handle abnormal situations. For the detection of abnormal events, Debmalya et al. used a hierarchal method. This hierarchical method consist of network of convolutional features and mixture of temporal trajectories (MTT). The proposed framework combines the supervised and unsupervised learning and uses robust plan to detect abnormal sound events in a subway station [2]. Tatsuya [3] proposed another method for event detection. The proposed method is called nonnegative matrix factorization (NMF). This method is based on acoustic event detection (AED) with mixtures of local dictionaries (MLD) and activation aggregation. The method uses MLD to allocate sub-groups of basis dictionaries to acoustic elements to obtain controlled activations and to minimize redundancy in the region. Pardeep [4] present a model for the detection of events. In the method events are detected using a Gaussian Mixture Model (GMM). The parameters for four different audio features (ZCR, LPC, LPCC and LFCC GMM) are optimized with GMM. For event detection in an incoming audio stream Clavel present a model which is based on feature extraction and a training module. For classification Clavel used Gaussian Mixture Models (GMM) classifier [5].

To localize gunshot source, Izabela et al worked on the direction of arrival of impulsive, wideband audio signals i.e. gunshot signals. To properly estimate horizontal and vertical angles, the proposed model implemented Generalized Cross-Correlation (GCC) algorithm in a tetrahedral microphone array [6]. Xia proposed frame-wise dynamic threshold approach for acoustic event detection [7]. Although different researchers proposed different methodologies for gun detection, but still there is a need of reliable event detection algorithm, because of different environmental effects as well as change in direction of weapon and types of weapon. Table 1 consists of algorithms implemented for detection of gunshots with their achieved accuracy. Table 1 shows authors of different research work in the area along with achieved accuracy. In general, each research work covers uses different types of classifiers to achieve best accuracy. As shown in the Table, the accuracy obtained in the work of Dufaux [8] is high using GMM and HMM classifiers. On the other hand, Conka [14] uses advance DNN classifier but the accuracy as low. Similarly, the accuracy of the work done by Chan [10] is also low by using GMM only.

Table 1 Existing algorithms and their obtained Accuracy

Authors with Paper References	Classifier name	Achieved accuracy
Dufaux et al. [8]	GMM+HMM	98% at 70 dB
Cai et al. [9]	HMM	86.88%,
Chan et al. [10]		93.4% at 30dB
Manwar et al. [11]	GMM	84%
Gerosa et al. [12]	GMM+GMM (Parallel)	93% at 10 dB
Saha et al. [13]	Neural Network (NN)	92.5%
Conka et al. [14]	Deep Neural Network (DNN)	88%
Suman et al. [15]	Artificial Neural Network (ANN)	95% for clear audios 85% for noisy audio
Saha et al. [13]	RANSAC	95.5%
Foggia et al. [16-17]	LVQ	95.89%
	BoAw	95.67%

There are many factors that caused uncertainty in gunshot detection algorithm, and cannot detect gunshot correctly. Here, we have focused on these uncertainty measures in detail. In this research we are trying to point out all related problems that has a direct effects on accuracy results. We will also provide a research gap for new researchers who are interested in gunshot audio processing.

Rest of the paper is structured as follows: Section 2 discusses the physical properties and types of audio that produces during firing; Section 3 elaborates on issues related to different effects through which accuracy of an algorithm got effected. Section 4 explores the different types of effects on the Intensity of Gunshots. Section 5 consists of the challenges and opportunities in the area while evaluation and discussion is provided in section 6. Section 7 conclude the paper.

II. Physical Properties and Environmental Effects

A sound is a form of energy which is produced in a medium through compression and refraction and travel from transmitter body to receptor in the form of waves. The minimum audible frequency for human ear is 20 Hz while, the maximum frequency for human ears to capture is 20 KHz [18]. Frequency which is less than 20 Hz cannot be listened through normal human ear is known as infrasonic wave [19]. If frequency of an audio increases than 20 KHz is known as ultrasonic wave [20]. Generally, normal human ears are unable to capture all the infrasonic and ultrasonic waves. Therefore, frequencies of infrasonic and ultrasonic waves are inaudible frequencies. Fig. 1 shows a simple diagram of waves. Before proceeding to environmental affects, first we have explain some general terms in the subsections.

A. Wavelength

The distance between successive troughs or crusts is known as wavelength. Wavelength is represented by λ. Wavelength of gunshot is very small as compared to normal audios. Because, in gunshots there are high number of cycle completed as compared to normal screams.

B. Amplitude

The maximum distance covered by a wave from its origin O, is known as amplitude of wave. Amplitude describe us pressure of audio signal [21]. High intensive audios has high amplitude as compared to low intensity audios, so the amplitude of gunshots are high and amplitude of normal audios are low and vice versa. Amplitude can be on both side's positive and negative, along origin.

C. Frequency

Frequency is the number of cycles completed per unit time, represented as

$f = \frac{1}{T}$[22]. Frequency of wave changes in medium per unit time, noise is generally composed of many frequency cycle combined together [21].

D. Time Period

Time period is the time taken by wave to complete one cycle. Time period of wave and its frequency are related to each other. Frequency and time period of wave are inversely proportional to each other, represented as $T = \frac{1}{f}$. It means that if frequency increases time period will be decreases and vice versa. In Figure 1, the time take by signal to move from 0 to 1 is time period of that audio wave.

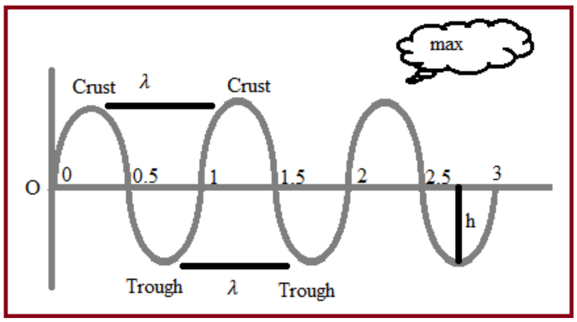

Fig. 1. Position plot showing a simple harmonic wave start from origin O and vibrates along x-axis. Amplitude "h" is the distance from the vertical middle to the crest or trough of the wave while wavelength “λ” shows the distance between two equal contiguous points within a signal.

E. Types of Environments

The growing demand of safety and security has led us to more research; e.g. in buildings and schools, we need more efficient and smart automated surveillance systems. The most challenging part for the detection of gunshots is their environments because, noise in audio signals are introduced due to environmental audio signals. When noise to signal ratio decreases we can easily classify audio as compared to mixed audio signals. The environments are divided into two basic categories that are; Indoor and Outdoor environments [23].

An environment not only has effects on audio detection but also has their effects on video capturing. Therefore, a robust sensor surveillance system is required with real-time computer algorithms. The system should also be able to perform with minimal manual redesigning on variable applications. Such systems should be highly flexible to regulate automatically and deal with changes in the environment like lighting, scene geometry or scene activity [24-25].

i. Indoor Environments

Indoor environments are the environments of different organizations like schools, colleges, offices, hospitals and home environments. These environments have least amount of signals to noise ratio. According to Dhawan et al [26], indoor systems are generally very challenging to model as a single standard model. With distinctions of doors and windows being opened and closed, as well as being opened at certain angles, the transmission model can be estimated to vary significantly. Indoor environment has a lot of echo; the echo depends on the size, material, and design of the room (environment). The echo amplitude of audio in indoor environment is inversely proportional to the distance travelled by audio [27]. The impulse response can be calculated at the listener position. This is performed by the summation of contributions from all sources. Each source contributes a delayed impulse (echo), whose time delay is equal to the distance between the source and the listener divided by the speed of sound [27]

In indoor environment acoustic characteristics vary considerably at each point. In the field of audio events detection, many researchers focused on indoor environments particularly smart-room monitoring applications [28].

ii. Outdoor Environments

Outdoor environments are open environments of a city like market places, railway platform and airports. In outdoor environments the signal to noise ratio are very high. For the detection of abnormal sounds at outdoor environments, there are many interesting audio events such as gunshots, glass breaking, scream, car-crashes and explosion. At outdoor background recordings, a lot of loud audio events occur which are important to explain because of decreasing the False-Alarm-Rate (FAR) [29]. The events are divided into the following categories:

a) Speech-based audio events - This group of events consists of all events, which are produced by human beings in the form of speech or scream and relates to threats, violence, dangerous situations and any other loud vocal expressions (cheering, etc.) [29].

b) Non-speech audio events - This group of events consists mainly of traffic sounds (including airplanes and helicopters), sounds accompanying threats (gunshots) and similar to them (fireworks), animal sounds (dogs, birds, etc.) [29].

c) Ambient noises – Ambient noise is usually produced by the abnormal weather condition. These weather conditions include strong rain, thunder storms and strong wind. Moreover, in the outdoor environment, audio input of the monitoring system like music, sounds produced by the abnormal weather conditions are also ambient noise [29].

III. SOUND TYPES PRODUCED DURING GUN FIRING

Gunshots are highly intensive audio signal produced during gun fire. When gun fires a bullet, it produces two types of audios. Muzzle blast and supersonic projectile (shock wave).

A. Muzzle Blast

Muzzle blast is the first audio generated due to explosion of chemicals, used in ammunitions [30]. The explosive wave and audio energy originating from gun barrel is referred as muzzle blast [31], or the muzzle blast is the "bang" that one catches upon gun firing [32]. Generally, the muzzle blast disappeared with in 3 milliseconds [31], so the duration of muzzle blast is enough short. Muzzle blast is the first sound generated during gun fire through expulsion of chemicals, used in ammunitions. When explosive chemicals burn abruptly behind the bullet, these abrupt explosion compel the bullet to leave the gun barrel and move away from the gun. Muzzle blasts are very high intensive sounds, these audios can be heard in 2-3 km away from location of firing. Figure1 shows the angular propagation of muzzle blast, spread out in air.

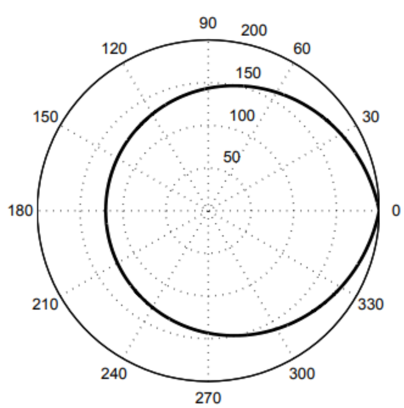

Fig. 2 Angular propagation of Muzzle Blast [33]

B. Supersonic Projectile (Shock Waves)

Supersonic projectile (shock waves) is the audio which is generated in air through very high speed of bullet. Supersonic projectile spreads out in three dimensions making a cone behind the bullet path [34]. Supersonic projectile produces with the crash of thunder, bang of a gunshot, boom of fireworks, and with the blast from a chemical and nuclear explosion. Shockwaves are the pressures waves of explosion [32] but shock waves are not loud sounds like muzzle blast. When bullets leave the gun, it passes through air sharply and generates a sound behind the bullet which is known as shock wave. The supersonic projectile is generated by a quick and uninterrupted "push," or by a body moving at supersonic speed [30, 32]. The shock wave spread out in three dimensions as a cone in air. Shock wave can be heard in very limited area, typically within 50-60 meters. The projectile shape is a two-dimensional wedge as shown in Fig. 3. The characteristic transverse length is $\sqrt{A\perp}$ and wedge half-angle is θ. The projectile is assumed to be traveling at supersonic velocities $V_p > V_s$, where V_s is the sound speed [35].

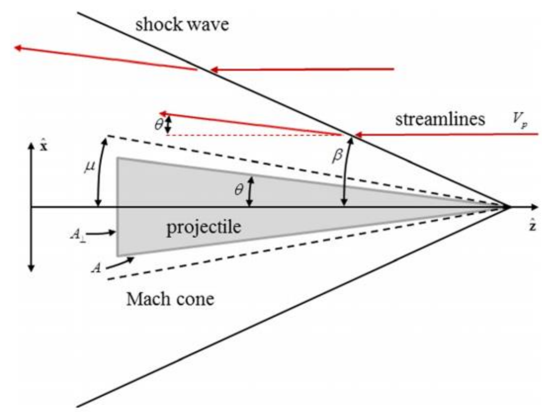

Fig. 3 Two-Dimensional wedge projectile moving with the projectile [35].

Muzzle blast carry information about shooter location, while shockwave detections carry information about the projectile trajectory [36]. Both, muzzle blast and shockwave can be used for localization of gun firing location.

IV. EFFECTS ON THE INTENSITY OF GUNSHOTS

Gunshot sound travel from one point to another point in the form of audio waves. These audio waves are propagated in some form of media. The medium may be gas, liquid or solid. Without medium gunshot waves cannot propagate. The acoustical behavior of gunshots depends upon the medium as well as types of firearm and ammunition, projectile parameters, distance from firearm, climate, and obstacles between firearm and receivers [37]. The following subsections consist of these acoustical effects on the detection of gunshot.

A. Distance Between Gun Firing Location and Microphone

Velocity of normal audios at standard temperature and pressure is 350 m/s [38]. When gun fire a bullet, its muzzle sounds passes through media to reaches different locations. When distance increase between audio sensor and audio origin, their sound will take more time to reaches the microphone. Hansen [37] state that, reduction will occur in the intensity of an audio at the rate of 6 dB by doubling the distance. Audacity of Gunshot waves, decrease quickly in strength with increase in distance from the point of explosion [32]. Many researchers used experimental data which are recoded at different angles and distances between microphone and gun barrel [39].

When the distance between firearm and microphone is changed, the intensity of audio also changes, because of variation in distance, the variance of the error between the predicted and measured values will decrease if the parameter values increase [37]. In gunshot detection algorithms if the distance increases then the detection of gunshot will also changes from original, to take better result from gunshot detection algorithms keep the distance smaller [40], between microphone and firearm.

For measuring the distance between microphone and gunshot, different techniques are proposed. If an event is heard by two or more microphones, De Bree et al [41] used time difference between these two microphones to calculate the direction of sound. The Microflown sensor is capable to measure the acoustic particle velocity in air [42]. The velocity of sound helps to calculate distance between gunshot location and microphone.

Let *I,* is the energy of the audio, as the distance between microphone increases, the intensity decreases. This relationship can be expressed in equation 1.

$$I = \frac{Energy\, of\ audio\, signal}{distance\ from\, Microphone} \tag{1}$$

As distance increases the audio intensity will decrease and vice versa.

B. Diffraction from Nearby Obstacles

Obstacles not only affect motion of normal bodies, but also effect motion of audio waves. When audio wave start traveling from source, propagates through air and reaches to the destination, where audio sensors are present. The sensors detect the audio signal. The auditability of audio depends upon the pathway between audio sensor and transmitter, because audio waves cannot penetrate solid bodies. Solid obstacles like wall and mountains reflect audio, while some of the audio passes through that obstacle but majority reflect back in the same medium. When audio signal reflect by obstacles its audacity energy reduces. The audio energy absorption in smooth and hard surfaces is less than rough surfaces. The rate of decrease in audio energy will be high when a solid obstacle obscures the line-of-sight between the microphone and the source [31].

When a gun fire a bullet and there is no direct acoustic path between the muzzle blast and the microphone, then the two gunshot audio recordings acquired from the same gun may considerably differ, even though the microphone is at the same fixed point with respect to the gun and the acoustical environments are alike [30]. This difference in audibility occurs because of obstacles in the path of audio and audio sensors (microphone). For calculation of diffraction of sounds from obstacle Stephenson [43] present ‘Detour law’, which state that the energetic transmission degree T around an edge of a half-infinite screen (or in general: obstacle) is approximately inversely-proportional to the detour the obstacle causes between source and receiver.

$$T = MIN\left\{\frac{1}{a + b.N}, 1\right\} \tag{2}$$

For “thin” screens a = 3 and b = 20

$N = Z/(\lambda/2)$ is the Fresnel number = detour / half wavelength, counted negative in the ‘visible’ region over the screen.

$$T = \frac{immitted\ intensity\, at\, the\, receiver\ with}{without\, obstacle} \tag{3}$$

As diffraction around an edge happens in 2D, the proportion T is the same in 2D and in 3D.

C. Wind Direction and Gunshot Sound

Air is a medium through which sound waves passes and reaches to the destination. These audio sounds produce through vibrating bodies and pass through some media. These vibrating particles collide with each other in direction of transition media. That’s the cause sound can travel in solids liquids and in air but, cannot pass through vacuum. Speed of sound depends on a medium. Wind interrupt audio transmission because of noise i.e. produced by wind speed and change direction of sound path, change in the direction of the sound path known as refraction [44].

D. Direction of Weapon

When a gun starts firing, it produces highly intensive audio waves in the direction of weapon barrel. In the barrel pointing direction, the sound level of the muzzle blast is high. On the other hand, the sound level is low as the off-axis angle increases between gun barrel and audio sensor [30, 45]. The audio signal travel at a finite speed, the time difference of audio signals arrival to audio sensors microphones, helps to get information of direction of gunshots [46]. Direction of arrival estimation of gunshot audio signals needs an automatic on-line detection of a gunshot [47]. The simplest solution of time difference of arrival by Vuegen [30] is by implementing cross correlation between microphones. Freire [48] state that at small distances between Gunfire location and microphone, a time-overlap of muzzle-blast and shockwave components may occur.

$$I = \cos\theta . G_d \qquad 90 < \theta \leq 0 \tag{4}$$

Where I is the gunshot intensity, $\overrightarrow{G_d}$ is the direction of gunshot (weapon) and $Cos\theta$ is the angle between bullet path and microphone (sensor). As the angle between weapon and gunshots become decreases the audio intensity will be high and if angle increases from 0° the gunshot intensity will be decreases. For explanation of the above equation (4), see Fig. 1. In the Figure, two bullets are fired at different direction, Bullet (A) is directed to the listener which makes angle 0° while Bullet (B) has some angle θ with listener location the intensity of gunshot for Bullet (A) is maximum from Bullet (B).

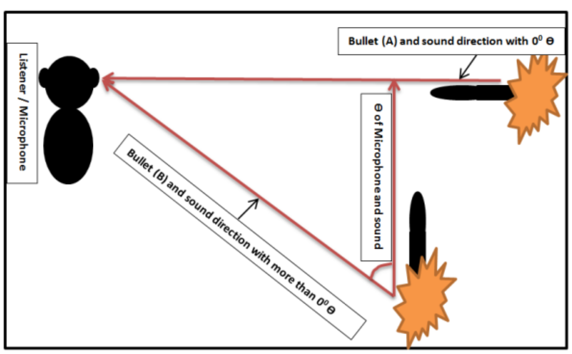

Fig. 4. Gunshot with different angles consists of two firing bullets, bullets A is in the direction to receiver with angle 0° the sound will be maximum because the sound expends in the direction of bullet path, while the sound of bullet B will be minimum as they are at angle θ.

When discharging a firearm the noise generated from the muzzle blast propagates spherically in all directions, and is approximately 10-15 decibels louder when heard in front of the gun (the direction of firing) [49].

The analysis shows that muzzle blast is not certainly a reliable acoustic source. In the direction of barrel, the sound level of muzzle blast is high while in the off-axis angle direction it is low. The blast may also be concealed by barriers and other obstacles blocking the direct path between the firearm and the microphone location [30]. Fig. 2 shows the angular variation of $Cos\theta$.

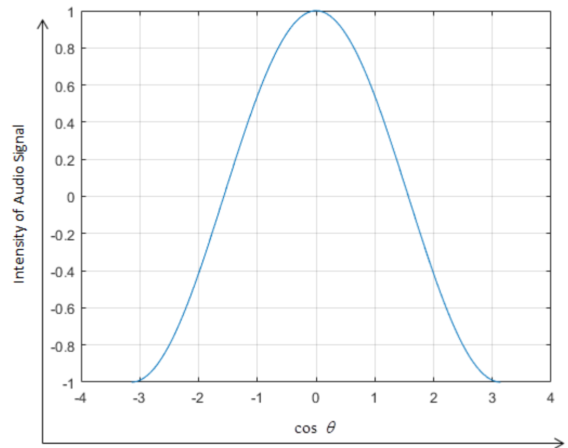

Fig. 5. In $Cos\theta$ at 00 degree the audio intensity is maximum [50].

For direction of gunshot the researcher present a simple method. Let's suppose there are 5 audio sensors in a series for audio recording. If the same audio recorded on different sensors located on different position then the sound must have variation in intensity, the direction of audio arrival direct the location of gunshot.

$$i_n(x) = \sum_{k=1}^{K} S^2(x) \tag{5}$$

i is audio intensity at each microphone, n is the series of microphones, x is the series of audio frames and S is the audacity of signal. The direction of audio signal can be calculated as follows:

Let's $i1$, $i2$, $i3$, $i4$, $i5$ be the recorded intensity on microphone $m1$, $m2$, $m3$, $m4$ and $m5$ respectively. If, $i1<i2<i3$ then it represents that the incoming signal is near to microphone $m3$. This phenomenon can be used for all microphones.

E. Types of Ammunitions

The AK-74 round, with a nominal muzzle velocity less than M193 has a smaller wind deflection than M193. The M855 is least affected by wind than the M193 and AK-74 Type PS projectiles [51]. In 1928, the war department issued a gun for 0.276 cartridge which used a 125-grain bullet and fired at a muzzle velocity of 2,700 feet per second (fps) [52]. The 0.30 M1 ball cartridge with a 172-grain boat-tail bullet having a muzzle velocity of 2,640fps. The 0.30 M2 ball cartridge with a 150-grain flat-based bullet traveling at a muzzle velocity of 2,700fps. In 1940, the muzzle velocity of the M2 round was raised to 2,800fps, so that it matched the ballistics of the 168-grain armor-piercing round [52]. Different types of gun use different types of ammunitions. Therefore, change in the types of ammunitions also affects muzzle blast. Table 2 enlist different firearms with their maximum audacity in DBs.

Table 2 Different types of Rifles and Pistols with their model and Audacity in DBs [53]

Rifles Name	**Model**	**dbSPL$_{pk}$**
Winchester Model 70 (w/BOSS)	7mm Magnum	166.5
Remington 742 carbine (18" barrel)	.30-06	162.6
Remington 742 std (22" barrel)	.30-06	161.6
Ruger Model 1	.45-70	160.1
Thompson/Center Encore	.50 (black powder)	159.7
M14	7.62 X 51mm (.308)	159.0
Colt AR-15	5.56 X 45mm (.223)	158.9
Auto-Ordinance Tommy Gun (w/comp)	.45 ACP	151.0
Marlin Model 60	.22LR	141
Remington 514	.22LR	139.6
Pistols Name		
Smith & Wesson 586	.357	169
Ruger GP 100	.38	164.7
Smith & Wesson 686 (.357)	.38	164
Glock 17	9mm	163
Sig Sauer P228	9mm	160
Smith & Wesson LR CTG	.22LR	157.9
Ruger MK	.22LR	157.5
Ruger Bearcat (4" barrel)	.22LR	154.0

Figure 6. bullets types .30 Pedersen (7.65 x 20), .30 Mauser (7.63 x 25), 9 x 19 Parabellum, 9 x 25 Mauser, .45 Auto (11.5 x 23), .45 Remington-Thompson (11.5 x 26), 5.7 x 28 FN, 4.6 x 30 HK, 5.8 x 21 DAP-92 [54]

V. Challenges, Issues, and Research Opportunities

The potential contributions of this paper include: Automatic detection and recognition of leaf related diseases in tomato crop. This will facilitate advancements in tomato crop by providing rapid, cost-effective and reliable monitoring system. Moreover, the proposed system will provide on the spot solution to the farmer and will lessen a huge labor of monitoring the large farms of crops, at a very early stage of its attack.

In previous sections we briefly discussed different issues that directly affect the accuracy of gunshot detection algorithm. Some issues are environmental and need to handle through some suitable filters. David et al. used long-term log spectral subtraction method to cover reverberation the proposed method are similar to cepstral mean analysis but this method uses longer analysis window to deal with the problem of reverberation [55]. Reverberation not only effect the accuracy of gunshot detection algorithm but it also has strong effects on normal sounds therefore reverberation removal has become a very strong area of research in the field of audio signal processing [56-59]. Diffraction handling is another challenge, diffraction also reduce the accuracy of algorithm. To handle diffraction researchers proposed different algorithms Inkyu et al. combine a ray tracing-based sound propagation algorithm with a Uniform Theory of Diffraction (UTD) model, which simulate bending effects by placing a virtual sound source on a wedge in the environment [60-61]. Diffracted audios cause a lot of problems in identification and recognition that's way it become a good area of research for new researchers [62-63].

Gunshot detection is a grooving technology for security purposes, therefore researcher works in different direction to implement gunshot detection algorithm. The idea of gunshot detection is unique in itself but, following are some new areas in gunshot detection for new researchers in the field of gunshot detection and recognitions.

1. Gunshot detection with features based approaches need to be recognized some new and least number of features to reduce processing time. To implement preprocessing stage in all types of features base approach will minimize processing time.
2. Gunshot detection at indoor environments face problem because of diffraction and reverberations to solve these problem and detect gunshot is an emerging and novel idea.
3. In open environments controlling of noise and gunshot detection. For that researcher need to install noise removal filter.
4. In forests areas detection of gunshots and recognition, to control illegal hunting of animals.
5. Distant gunshots has very low audio energy, to extant energy level of audio and then detect the audio is a good approach for detection of gunshot.

In order to develop an accurate algorithm for the detection of gunshot and to make it practical reality, the issues and challenges must be addressed. The contribution of this work is to highlight the physical properties and environmental effects on the intensity of gunshots. To the best of our knowledge, this paper also describes the first attempt to highlight the issues and challenges in the physical properties and environmental effects on the intensity of gunshots in a comprehensive manner. We have also made an effort to provide a comprehensive survey on the existing algorithms and their obtained accuracy in the area along with different types of rifles and pistols with their model and audacity. We have presented the main issues and challenges and their possible solutions in gunshot detection in general and on the physical properties and environmental effect in particular.

VI. Evaluation and Discussion

In this paper, we have discussed different types of problems that lead to false positive rate of an algorithm. Although these individual problems should be kept in mind during an algorithm development for gunshot detection, but here we point out that some of them are closely related with each other.

I. At indoor environment diffraction from nearby objects is more than outdoor environments.

II. At indoor environment direction of gun is not greater issue because of distance. Generally Indoor entrainment consists of limited area, so gunshot inside environment will provide highly audible sound and can be easily detected. The major problem is that algorithm will also provide more false positive alarms in case of fireworks or any highly audible sound. If a researcher works to design algorithm for indoor enjoinments. He need to develop such a recognizable algorithm that distinguish between gunshot and highly intensive audio by fireworks.

III. Outdoor environment is more challenging than indoor, in outdoor environment weapon direction and distance both are important. To handle outdoor environment we need parallel processing of multiple microphones and the designed algorithm should be trained with multiple background noises to distinguish between normal sounds and gunshot.

IV. To get more accurate results at outdoor environments the keep small distance between audio sensors and mount more audio sensors.

VII. Conclusions

The main purpose of this paper is to discuss different aspects of audios which have effects on gunshots detection algorithms. Normally, gunshots are highly intensive audios but there are many things which effect the accuracy of gunshot detection algorithms. Change in types of environments is one of the most affective things because indoor and outdoor environments have a clear difference, as signal to noise ratio increases its identification becomes difficult.

The distance between gun and microphone is inversely proportional to each other, as distance between gun and sensor increases the intensity of gunshot will decrease. The direction of weapon has a cosine effects i.e. if angle is smaller in line-of-sight the intensity of gunshot will be higher. Obstacles between gun and sensors also cause decrease in the intensity of gunshot. In future work, it is important to provide practical solutions for these effects through which intensity of gunshots decrease. It is also important to implement gunshot detection algorithms in both indoor and outdoor environments.

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