C20 Acoustic Analysis of Gunshot Recordings Utilizing Frequency Selective Integrated Loudness Envelope Evaluation

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After attending this presentation, attendees will understand a unique methodology for the characterization of gunshot recordings in which the presence of gunshots from multiple guns is suspected but cannot be verified by other means. The testing process, findings based on the assassination of Robert F. Kennedy, and limitations of this methodology will be presented.

Although limited in applicability, this methodology has the potential of significant impact for cases in which gunshot recordings are of poor quality, obscuring the ability to identify the presence of gunshots from multiple guns. In one 40 year-old case of national scope, the assassination of Robert F. Kennedy, this methodology has uncovered evidence of the firing of two guns during that shooting.

This presentation will demonstrate the use of frequency selective inte- grated loudness envelope evaluation (FSILEA) methods in the analysis of a gunshot recording made during the assassination of Senator Robert F. Kennedy. Working with a poor quality recording, with limited frequency range and high noise levels, it is nonetheless sometimes possible to extract meaningful data regarding the number of shots fired and, in the case of multiple guns, differentiation between shots fired from those weapons.

The case involves the assassination of Robert F. Kennedy, wherein some of the original acquired evidence suggested the presence of a second gun. Due to premature destruction coupled with the circumstantial nature of evidence elements, that second gun presence could not be proven. A recently re-discovered audio recording (the only known recording of the actual shots) reveals the presence of two guns as a result of a unique forensic analysis methodology.

FSILEA exploits the acoustic principle of the directional distribution of radiated energy from a source as a function of frequency. Thus if two sources located close to each other, but in directionally opposite positions, alternately produce pulses of broadband noise, it might be possible to differentiate between those sources based on recorded analysis from a pickup device located a considerable distance from the sources and inline with one of them. This was the situation in the Kennedy assassination, wherein the two sources were low caliber handguns positioned close but directionally opposite to each other, with the microphone placed some 30 to 40 feet away, roughly inline with Sirhan's weapon.

Initial study of the recording involved the conventional use of time and frequency domain waveform analysis. These methods were useful to deter- mine timing locations of suspected muzzle blast shot sounds. These locations were correlated with what was known from the crime scene through substantial video and audio coverage before and after the shooting, together with eyewitness testimony. The use of spectrographic imaging was helpful in differentiating the less prominent muzzle blast sounds, but – partially due to the high ambient noise levels – was not useful to differentiate between weapons. By extracting multiple high frequency slices over the entire gunshot interval, with each slice representing a quite narrow frequency band, and then overlaying these individual slices, subsequent slice comparisons revealed markedly differing amplitude levels of some shot sounds. This measured phenomenon was consistent with the positioning of two known guns within the kitchen pantry of the Ambassador Hotel in Los Angeles, the scene of the crime. The resulting identification of which gun fired which shots was also consistent with the known number of shots fired from the Sirhan weapon, and the timing sequence of Sirhan's shots as recalled by the man who first apprehended him.

While the successful use of FSILEA is necessarily limited to cases involving a known set of positioning conditions as to sound sources and pickup device(s), it could also be used to exclude the possibility of such-positioned multiple sound sources. In addition, it is particularly useful under the conditions of poor recorded audio quality. In this particular recording, distinct shot sounds can be distinguished by the naked ear; but it is not possible to differentiate multiple muzzle blast sources simply by listening, due to the low grade of the recording equipment and the high ambient crowd noise.

This case study presents a specific practical application in the use of FSILEA wherein, after 40 years of unsuccessful attempts to conclusively establish the use of a second gun in the murder of a prominent U.S. senator, a long suspected aspect of that murder can now be firmly established. The test results are consistent with the consideration of multiple previously established fact sources such as the autopsy findings of Dr. Thomas Noguchi, recovered – but later destroyed - physical evidence, and the efforts of researchers through the years, such as those of Dr. Robert Joling.

Gunshot, Recording, Analysis