IMAGINE THE POSSIBILITIES...
INTERNET OF THINGS

Enabling Automatic Gunshot Detection and First Responders Dispatch for Safer Communities

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Identifying the Current Problem

- Gunshot detection has become a key focal point for city officials as part of deployment of smart city solutions.

- Current state-of-the-art detection mechanisms still require a person in the loop (through an operation center) and may introduce delays of up to 10 minutes between gunshot detection and alerting first responders.

- Seconds are crucial in an active situation.

- Response time and latency introduced by these solutions cannot be reduced as the operations centers in the loop introduces a human factor that needs to listen to the scene before calling and dispatching first responders.

- Spectrum’s solution fully automates gunshot detection and localization with gun identification, source recognition and first responder alerting and dispatch in under two seconds.
Solution Overview

- Spectrum's approach consists of a hardware and software platform with integrated algorithms that enable:
  - Detection, classification, and localization of gunshots
  - Source recognition
  - Recording the scene from different angles
  - Real-time dispatch of first responders to appropriate and accurate location
- Spectrum's invention leverages machine learning algorithms at the edge to detect gunshots from indoor/outdoor ambient sound.
  - When N consecutive shots are detected, the sound direction is given by the far-field microphone array
  - Security cameras follow direction of sound to capture the scene and identify, store and send faces associated with the scene to a 911 dispatch center or closest first responder vehicle
Spectrum’s Hardware Platform

- The hardware platform is comprised of:
  - Compute element (CPU/MPU)
  - Memory for internal storage
  - Networking: Ethernet, WiFi and cellular
  - Accelerators enabling different algorithms: GPU for image processing, FPGA for audio and mic-array management.
  - M-FFMA: M-element far-field microphone array
  - PTZ (Point, Tilt, Zoom) Camera: to enable dynamic scene acquisition
  - PoE: to enable simultaneous communication and power delivery
  - GPS: to localize the HW platform and fine timestamp events of active shooting
Spectrum’s HW Platform
Spectrum’s software algorithm flow is described by the following diagram:

1. Audio samples are acquired thru a FFMA (far field microphone array).
2. Given that the gunshots have spike-like behavior in the audio temporal domain, the solution uses the algebraic detector (AD) as both a detector and an ANC for the audio captured by the microphone array.
3. Spectrum applies a pre-trained ML model on gunshots over the cleaned audio signal.
4. If a gunshot is detected, a counter and a timer kick-in. These conditions have been set to further ensure robustness of the solution, as it does not trigger an alert with each shot. Rather, the solution requires to aggregate N shots within few seconds.
5. If the algorithm registers the N shots, it triggers an active shooting event. The algorithm will keep a counter increment of each shot it is detecting in the background.

Start

1. Acquire audio sample thru FFMA
2. Apply Audio enhancement technique
3. Apply inference model to detect gunshot
4. Detected N shots?
5. Yes
   Register active shooting incident
   End
6. No
5. Register active shooting incident
6. Extract AoA and DoA
7. Move cameras PTZ in accordance to AoA/AoD data
8. Identify gun
9. Send incident information to 911 dispatch center and closest FRs
End
Spectrum’s Software and AI Stack (Cont’d)

6. Using the FFMA capabilities to run AoA and DoA, the system infers the angle and direction from which the shots are being fired.

7. The system issues PTZ OnVif commands to the camera to pan and tilt to the direction of the active shooting. The zoom is calibrated thru the RSSI of the audio track to estimate how far the shooting is from the camera and the microphone array.

8. Another differentiator of Spectrum’s approach is the capability to recognize guns by correlating the noise-free sound provided by the AD and ANC to an on-device database containing the sound signature of the X most sold guns.

9. A standardized report is created by the system and sent to either a 911 center or the closest FR patrol.

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4. Detected N shots ?

   No

   5. Register active shooting incident

   Yes

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End
Metric 1: shots detection through AD - Noise reduction capability

- Acquired noisy audio signal
- Ground truth for shot detections
- Estimation of gunshot timings using AD
Metric 2: ROC curve for AD vs SoTA detectors

ROC curve associated with AD outperforms both NEO [1] and Wavelet [2] detection algorithms


Conclusion

- Spectrum presented a unique and novel approach to an AI-assisted automatic gunshot detection and reporting system.
- The approach enables fully-autonomous isolation of gunshot sounds and recognition of gun types as well.
- The solution has been deployed and tested in the Spectrum lab using recorded gunshots to test the resiliency of the algorithms and test the end-to-end performance and latency of the solution.
- Tests show conclusive results on the detection time: near real-time detection with under two seconds to detect an active shooting situation, take photos of the likely source and the scene, and send them to first responders and police for dispatch.
- Future work includes testing the system using real gunshots in the shooting range, as well as collecting more gun sound samples to enhance the model.
Thank You!

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