Beyond Politics: Technology - A Rational Alternative to Prevent School Shootings

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Abstract

Centuries ago, guns were a necessity as they served important purposes in self-defense against wild animals and the frontier. While our society has progressed and eliminated that threat, these dangerous firearms still roam around the streets. AR-15s and other rifle-style weapons are commonplace. In 2023 alone, there have been 175 mass shootings, with over 240 dead and over 700 injured. Some of these end up in school shootings, taking innocent young lives. It starts with firearms falling into the wrong hands of mentally unstable people, mostly adolescents (CDC, 2020). No meaningful legislation has been made, and the problem of mass shootings remains unsolved. Despite the advent of new and more powerful technology, it is deplorable that it is not being used to solve such critical problems. The purpose of this paper is to describe a device that has the potential of stopping school shootings. The proposed device can alert law enforcement and other responsible parties when a firearm is in the vicinity of sensitive areas. The device uses elements of tracking and detection, early alerts, and deterrence. In the initial trials, the device was able to send alert messages to a cell phone when it detected a school inside a specified distance. Preliminary results indicate that the approach will work in real life. While this device can be used in a variety of sensitive locations, the primary focus is on schools, as that is dear to my heart as a high schooler. This paper entails a technological solution that is an add-on to the existing firearms and can be integrated in the design of future guns as well.

Introduction

The United States without guns will only remain a utopia (Baldwin, 2022), and to mitigate the preventable loss of life, alternate and less polarized, yet equally impactful solutions must be explored. One must always accept that there will be people who keep semi-automatic guns (Staff, 2018), (Williams, 2022) and these types of guns are the leading cause of most school/mass shootings. Notably, the AR-15 and other automatic rifles have caused 8 out of the 9 deadliest school shootings in our country's history (Reeping et al., 2022). To this date, we, as a nation, have witnessed 70 school shootings. This is an epidemic!

While any meaningful gun reform is politicized and made controversial (Kamara et al., 2021), there are some things that most Americans agree on. A great portion of the public agrees on stricter control of firearms, background checks, and raising the legal gun-owning age from 18 to 21 years, but these alone will not necessarily reduce school shootings. Table 1 lists school shootings that had 10 or more fatalities (Gun Violence Archive, 2023). Sadly, there have been over 70 shootings with more than one fatality (Gun Violence Archive, 2023). Almost all the deadliest school shootings, referenced in Table 1, have been committed by people who had some sort of underlying mental health condition (Deb & Gangaram, 2021), and in many cases, the person was an adolescent. If something can be done to warn the public of impending calamity, many lives can be saved.

In this paper, I propose a safety device that can be attached to the stock of such semi-automatic firearms. The device tracks the firearm and sends out alert messages to the authorities if the firearm moves too close to a school and breaches the school's defined safety zone. It is expected that responsible parents would attach this device to their firearms and prevent such incidents. I also envision these safety features being considered necessary additions to improve the design of future firearms. Although the paper talks about schools, this device is generic and can also be configured to send alerts if it is in the vicinity of other populous places such as hospitals, and malls.

Date	State	City	School	Fatalities	Injuries
May 24, 2022	Texas	Uvalde	Robb Elementary	22	18
May 18, 2018	Texas	Santa Fe	Santa Fe High School	10	14
Feb 14, 2018	Florida	Parkland	Stoneman Douglas High School	17	17
Oct 01, 2015	Oregon	Roseburg	Umpqua Community College	10	9
Dec 14, 2012	Connecticut	Newtown	Sandy Hook Elementary	28	2
April 16, 2007	Virginia	Blacksburg	Virginia Tech	33	23
March 21,	Minnesota	Red Lake	Red Lake	10	7

Date	State	City	School	Fatalities	Injuries
2005			Senior High School		
April 20, 1999	Colorado	Columbine	Columbine High School	15	21
Aug 01, 1966	Austin	Texas	University of Texas	18	31

TABLE 1. School shootings with 10 or more fatalities.

Related Work

Schools invest significant time and money in monitoring students' internet activities, general activities outside the school, and surveillance around the school (Johnson, 2020), (La Salla et al., 2018). They spend millions of dollars to deploy high-tech metal detectors, in hopes of preventing firearms from entering the school (Singer, 2022). Many companies such as 'Evolve Scanners' ("Evolv Technology - Safer Zones," n.d.) create detectors that can spot a firearm. Another product, 'Zero Eyes' tracks guns using image recognition software with security cameras ("AI Gun Detection Technology," n.d.). Most of the current solutions rely on the principle of detecting a gun on an individual who shows up at the school (Mohamed, Taha, & Hala, 2020). The current state of technology has the following issues.

1. Effectiveness: Even though schools are pouring upwards of millions of dollars in such systems, on a larger scale these are quite ineffective as we continue to have school shootings periodically (Gun Violence Archive, 2023), (Education Week, 2023). Current technology can detect guns when they are not concealed (Lim et al., 2019), (Salazar González, Zaccaro, & Álvarez-García, 2020). Furthermore, these machines are at the school entrance and hence they detect the gun when the shooter is right outside the door. This is already too late, as there is nothing really stopping the intruder from committing the crime at that point.
2. Practical feasibility: Most of the current solutions in the market are gun trackers/gun detectors, that are stationed through the main entry point of the school. They are expensive and have significant infrastructure needs ("Evolv Technology - Safer Zones," n.d.), ("AI Gun Detection Technology," n.d.). This setup has its limitations, as intruders can evade these machines by using a back or side entrance and gaining access to the school with relative ease. It is also unlikely that these machines can be set up at each entry location.
3. Economic burden: As stated before, the technology is expensive, making it unlikely that all schools, especially those in

underprivileged communities can afford them and hence these are far from being universally adaptable.

The remainder of the paper describes the set-up of the device, experiments conducted, results obtained, and conclusions of my results.

System Setup

In recent years, the Internet of Things (IoT) has seen meteoric growth. Every little piece of information can be monitored and tracked using wireless communication. My device uses the tenets of IoT and has three key elements - Global Positioning System (GPS), Google Map APIs, and automated alerts. The schematic of the device is shown in Figure 2 and the wiring diagram is shown in Figure 4.

Hardware: The chassis is designed in a rectangular shape that mounts on the firearm stock as shown in Figure 1. The position of the chassis is such that it does not obstruct the regular operation of the firearm. The chassis is designed with a flexible material capable of being molded into a desired shape. This type of material allows the device to be placed securely and to adjust to the shape of the firearm stock. A Force Sensitive Resistor (FSR) is positioned between the device and the firearm stock as shown in Figure.1. The chassis contains a Raspberry Pi module, a battery, a speaker, a GPS sensor, an IoT module, a LED and an accelerometer.

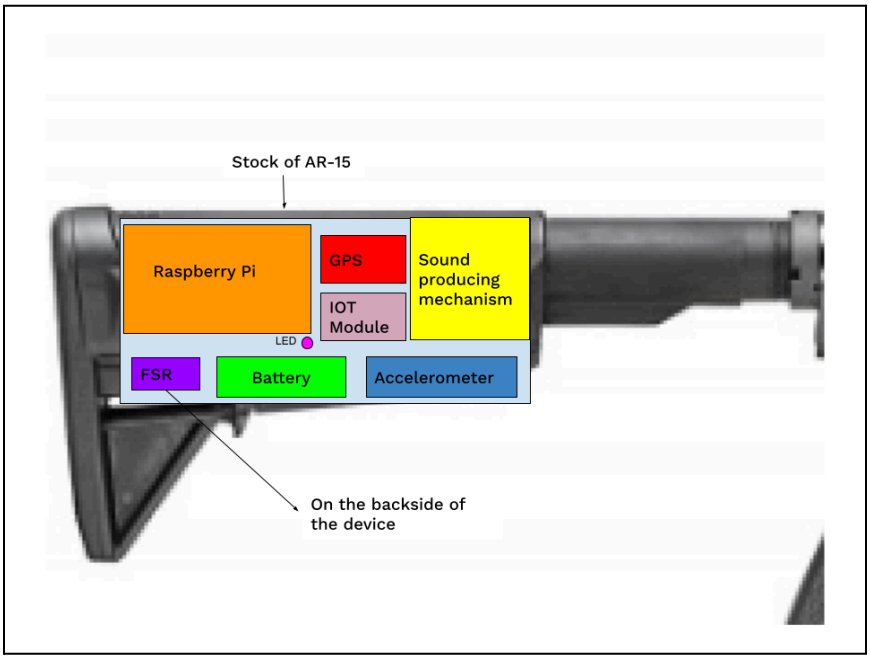

FIGURE 1. The device on the stock of a firearm.

Software: The Raspberry Pi module tracks the location of the firearm and is programmed to relay an alert to the school and law enforcement if the firearm is about to breach the school's safety zone. The software also

includes an app that can be installed on the owner's phone, and all alerts can additionally be directed to this app.

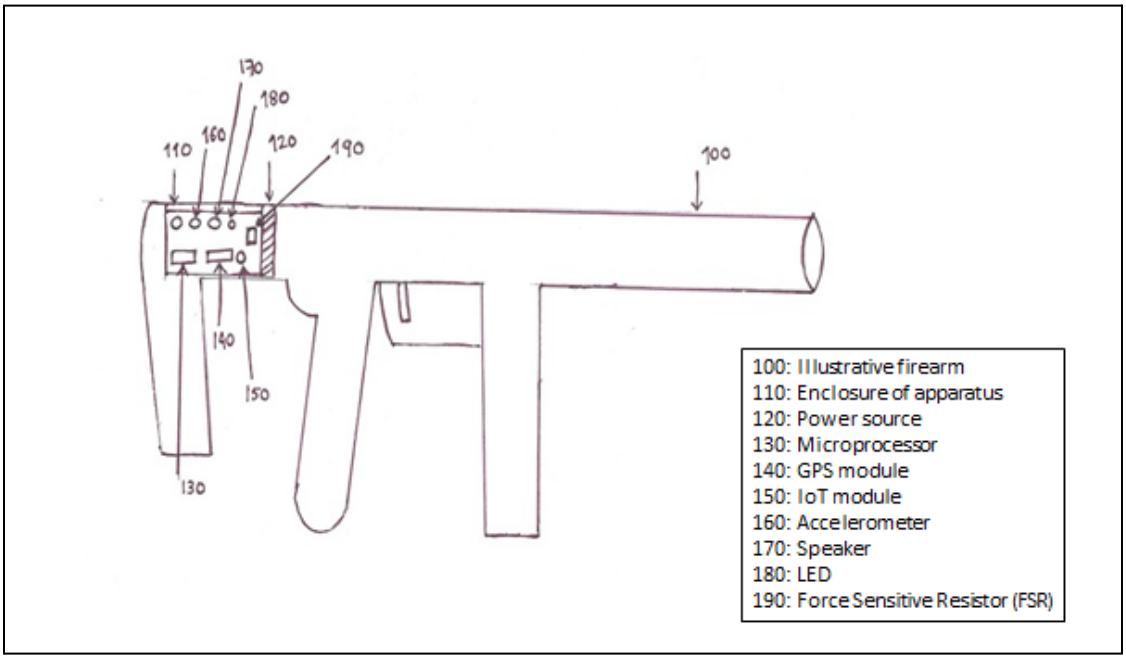

FIGURE 2. Schematic of the device.

Methodology

It is very important that the device be robust and fits securely on the firearm stock. FSR is therefore positioned between the device and the firearm stock as shown in Figure 1. The FSR senses that the device is connected to the firearm. In the event the device is ripped off the firearm, the software sends an alert to the owner who can then take action immediately. This is useful if some bad actor tries to intentionally remove the device with the intent of causing harm. The device has an in-built safety zone limit which is decided based on the approximate time that local law enforcement and the school administration will take to react to secure their premises (Kirby et al., 2016). This safety zone may additionally be enhanced to be dynamic where it varies based on conditions such as - traffic in the area, location of the nearest police station, etc. The device also allows the limit to be parameterized by having each school select its own safety zone based on its respective conditions. This can be part of the school set up and made available through the API. The flow diagram in Figure 3 explains the workflow of the operation of the device.

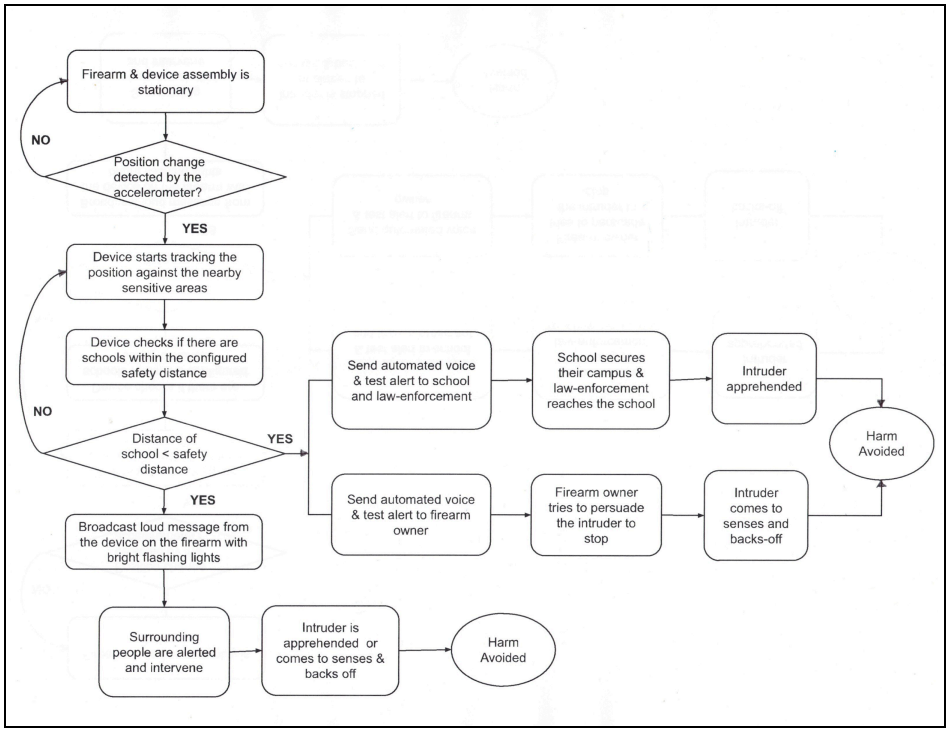

FIGURE 3. Workflow describing the functionality of the device.

Software within the device continuously polls the GPS sensor to get the coordinates of itself and in turn, the firearm on which it is mounted. The GPS sensor tracks the location of the firearm. If the location of the firearm is changing, which indicates that the firearm is in motion, the microprocessor then calls the Google Map APIs, acquires the distances of the nearby schools, and starts calculating the proximity of the firearm to the schools. The program checks if the firearm is approaching the safety zone limit for the respective school. In the event the safety zone is breached, the device sends alerts to the concerned school(s), law enforcement authorities, and the firearm owner. Upon receiving an alert, the school can immediately take proactive measures like ensuring their doors are locked, and the law enforcement teams can spring into action and reach the school before the intruder.

The device also continues to broadcast a loud message "YOU ARE TAKING A FIREARM WITHIN SCHOOL LIMITS - LAW ENFORCEMENT HAS BEEN NOTIFIED" on the firearm. This helps in alerting the people surrounding the intruder (Marufuzzaman et al., 2021), so that they can assist in confronting and stopping the intruder. Additionally, as psychology suggests, intervention at the right time is crucial in such mental health conditions. This alert might also help the intruder come to his/her senses and back off from causing violence.

System Architecture

Figure 4 shows the wiring diagram of my device. The GPS tracking sensor

can accurately track the location of a firearm. The Python code running on Raspberry Pi calculates its distance from nearby schools by using Google map APIs. If a school's safety zone is breached, the prototype successfully sends a message "Gun Near School" to a designated phone number.

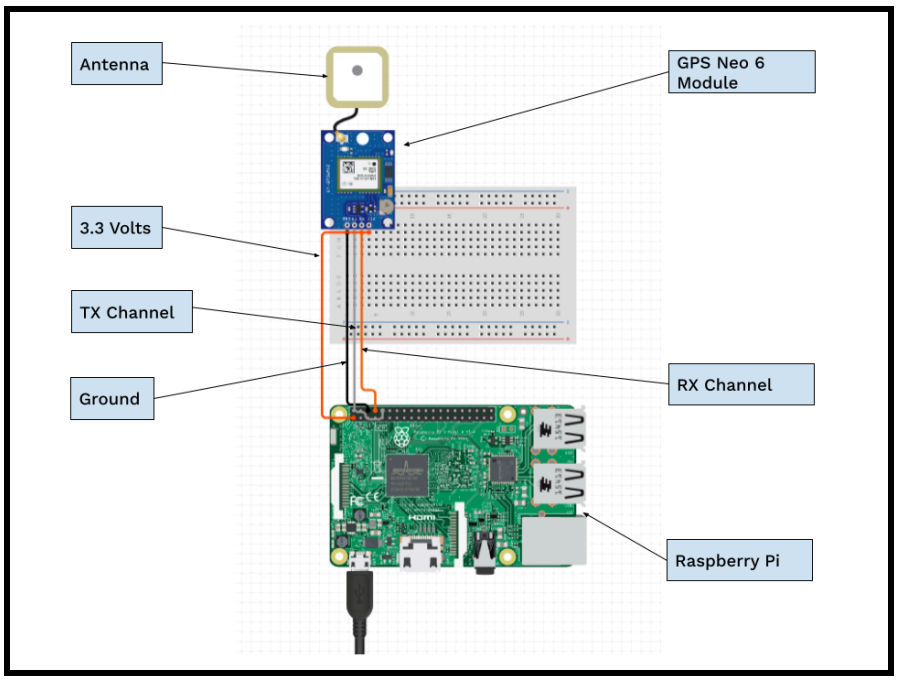

FIGURE 4. The circuit assembly of the device.

I have used a Raspberry Pi, and the GPS module Neo 6 (Sharma, 2017). The coordinates of the gun get computed every 15 seconds (this is a cycle), and then tracked with Google Map APIs (Battin & Markande, 2016). If no significant change has been made for the past 10 cycles, the interval of measurement will increase from 15 seconds to a minute, and it will keep increasing if there is no motion. This will ensure that power can be preserved if these firearms are kept in storage. After a maximum time of 10 minutes is reached, the cycle will reset automatically. However, if location changes are detected, the device switches to a tracking mode and monitors the location of the firearm with respect to the safety zones of nearby schools. If the device is crossing the safety zone of a school, it will start alerting. I have used a Twilio account for sending these alerts to a designated phone number.

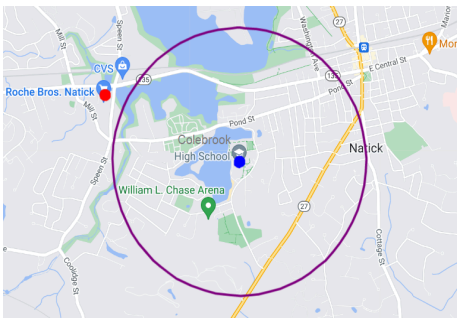

FIGURE 5. The safety zone of the school is not breached & the device continues to be in tracking mode

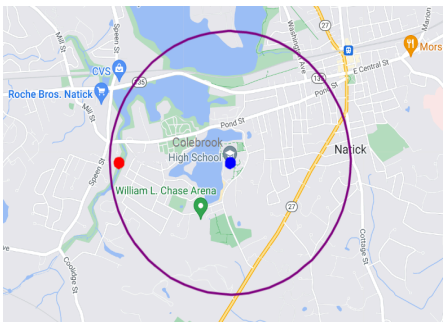

FIGURE 6. A school's safety zone is breached triggering the alert mechanism

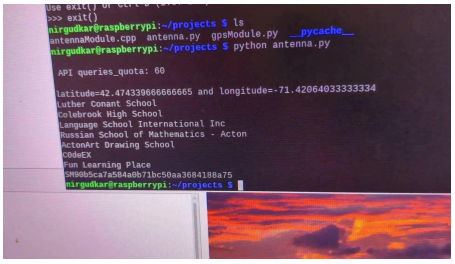

FIGURE 7. Python program console output

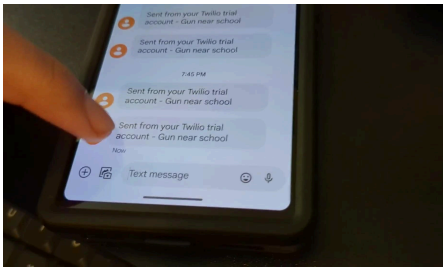

FIGURE 8. Alert received on personal cell phone

Figures 5 and 6 show a map of my area showing a school in the vicinity. The red dot indicates my device's location and therefore the location of the toy gun. The blue dot represents the school in the vicinity. The purple circle in the figures indicates the safety zone of the school. I have set this to 0.75 miles for my prototype. In Figure 5, the device is outside the school's safety zone and so the device is in tracking mode and does not trigger any alerts. Figure 7 indicates the screen print of my console output where my Python program has displayed the schools in the vicinity as the device continues to track. Figure 6 illustrates a scenario where the toy gun is approaching the school and has breached the safety distance set by the school. As soon as this happened, the device on the firearm triggered the text message alert to my personal phone. Figure 8 shows the alert that has been sent on my cell phone with the message 'GUN NEAR SCHOOL'. In the real world, these alerts will go to the school and law enforcement authorities as explained in the previous section.

Note: The locations on the Google Maps shown are purely for illustrative purposes and are not accurate. I have used a toy gun for my experiments.

Future Work

I have conducted the experiment indoors thus far. However, I plan to have mock trials in the field using toy guns. I want to evaluate false positives and negatives in the field and make improvements as necessary. The algorithm for extending the battery life is not yet implemented in my Python code which I am currently analyzing.

Additionally, I have reviewed my proposal with the local law enforcement authorities and am engaged with them. I have also shared my proposal with Massachusetts State Senator, and the State Congresswoman. I am working with them on the next steps and how some of this can get rolled into state-level government policies. I have submitted a patent for my device and subsequently, I would like to create a functional product for the same.

Conclusion

The present paper has demonstrated that technology can indeed come to the rescue, and we should not have to lose precious lives to mass shootings. The proposed device alerts the school before a perpetrator inflicts any harm and gives the stakeholders time to react and get prepared for the situation. In addition, the device not only alerts the school and law enforcement but tries to deter the perpetrator as well. We see that in most mass shootings, the perpetrators kill themselves. Knowing that this could be a mental disorder, this deterrence will help in getting such perpetrators some help. Other information like weapon type and owner can also be relayed back to law enforcement which can help them in deciding their plan of action. Another benefit is the cost. Because my device is added to the firearm by responsible firearm owners (mostly parents), schools will not have to spend a lot of money to enhance their infrastructure to keep their campuses safe. The underprivileged communities will therefore not have to compromise their safety due to monetary restrictions. Since my device is an add-on, it makes existing firearms automatically safe if used.

Even if the device prevents one potential shooting, I will consider it to be successful. I also envision that the firearm of the future includes all such safety features and more so that our nation doesn't keep getting gripped by such nonsensical violence and loss of precious lives.

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