Prevent and Reduce Damage from Gun Related Crime, Violence, and Mass Shootings: White Paper on the Accuracy of CIVIL Security's Standard Gun Detection System

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Abstract

A great deal of Americans have become victims in situations where firearms are involved, such as mass shootings and assaults with weapons. Numerous suggestions have been made as to how to prevent these events from happening, such as banning high-capacity magazines for firearms and installing metal detectors in buildings like schools. However, there is a lack of research indicating whether these prevention efforts work. One method that has been used to prevent events like those described above from happening is surveillance monitoring. However, both traditional surveillance monitoring and automatic surveillance monitoring have several problems associated with accurately identifying threats. Therefore, Pye Tech LLC has developed a type of automatic surveillance system (named the CIVIL Gun Detection System) that can accurately and reliably detect threats and alert authorities when the detection is made. A description of how the system works along with results from accuracy tests are provided.

Problem Statement

Many Americans die and are wounded each year in events that involve firearms. Because of this, many suggestions have been made about how to prevent firearm violence, mass shootings, and active attacks. Some of these suggestions include: banning assault weapons, passing "red flag" laws in all states, gun buyback programs hosted by police departments, banning high-capacity magazines, universal background checks for all gun sales, metal detectors at schools, armed police officers on school campuses, and stricter access control for schools (Campus Safety Magazine, 2010; Cranley, 2019; Fox & DeLateur, 2014; Muschert & Peguero, 2010; Newman, Fox, Roth, Mehta, & Harding, 2004; Rocque, 2012; National Issues Forums, 2019). However, the problem with many of these ideas is the lack of research supporting the effectiveness of these methods (Borum, Cornell, Modzeleski, & Jimerson, 2010; James & McCallion, 2013; Jonson, 2017).

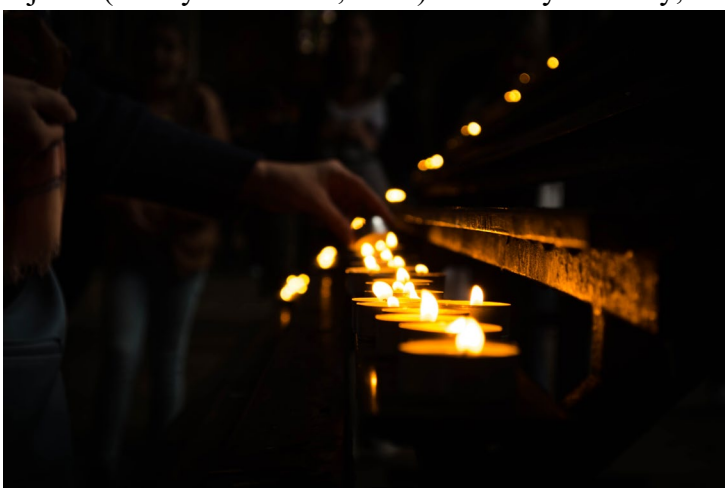
Surveillance systems have been used to prevent situations involving gun violence. Surveillance systems, such as Closed Circuit Televisions (CCTV), have been useful in fighting crime and have been regarded as one of the best tools in the security armory (Ainsworth, 2002; Dadashi, 2008). However, the use of traditional surveillance systems is not perfect.

Overall, an improved method useful in preventing or mitigating attacks like the ones described above is needed in order to stop people from becoming victims in these attacks. This method also needs to be thoroughly tested to ensure that the system functions as intended when used in a real-world setting.

Background

Gun Violence/Active Attacks in the United States of America

On the morning of August 3, 2019, a male, who's name shall not be mentioned in this paper as to not bring fame to him (see ALERRT, n.d.), carrying an AK-47 type rife went inside a Walmart store located in El Paso, Texas and began firing at the shoppers inside (Danner, 2019). By the time the chaos was over and the gunman had fled the scene, 22 people would ultimately be killed and twenty-five more would be injured (Bedoya & Garcia, 2019). The very next day, on August 4, 2019, a male would create a scene of chaos at a bar in Dayton, Ohio with an AR-15 type pistol (Knight, 2019). In less than a minute, nine people would die and twenty-seven people would be wounded before police officers killed the shooter (De La Garza & Zennie, 2019). On August 31, 2019, a male gunman went on a shooting spree that spanned the cities of Midland, Texas and Odessa, Texas after he was pulled over by a Texas State Trooper (Danner & Raymond, 2019). Before the gunman would be cornered and killed by law enforcement officials, seven people would end up being killed and twenty-two people, including three police officers, would be wounded (Danner & Raymond, 2019; Law, Mansoor, & Aguilera, 2019).

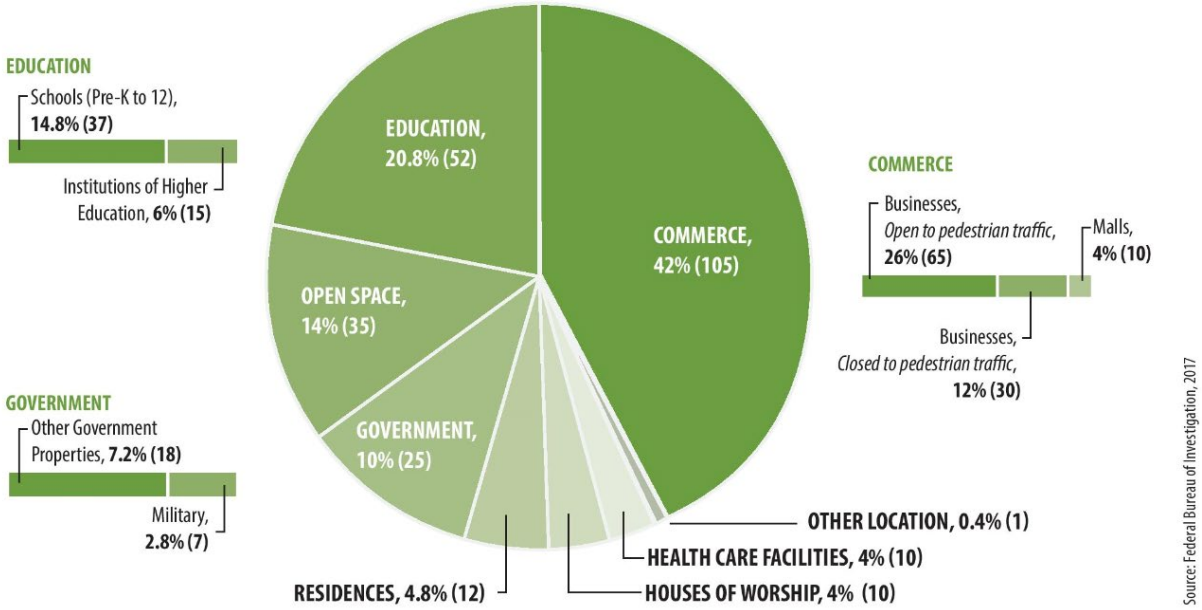


Mass shootings like those described above continue to impact the country. According to the Federal Bureau of Investigation (FBI), there have been a total of 250 active shooting events (where at least one person is actively killing or attempting to kill people in an area) in the United States of America between 2000 and 2017 (Federal Bureau of Investigation, 2017). A total of 799 people were killed and 1,418 people were wounded during these attacks (Federal Bureau of Investigation, 2017). As Figure One illustrates, just above a quarter of these events took place at a business that was open to pedestrian traffic (Federal Bureau of Investigation, 2017). Malls and business that were closed to pedestrian traffic made up 16% of the places where these attacks occurred (Federal Bureau of Investigation, 2017). About 21% of the attacks took place at schools (Pre-K through 12th Grade) or institutions of higher education (Federal Bureau of Investigation, 2017).

Although focused on active attacks, which is similar to the active shooter definition with the main difference being that the attacker does not necessarily have to commit the attack with a firearm, the research team at ALERRT (Advanced Law Enforcement Rapid Response Training) produced similar results to those of the FBI. Between 2000 and 2018, a total of 316 active attacks took place in the United States (Advanced Law Enforcement Rapid Response Training,

2019). Almost half of these attacks occurred at places of business and 20% of the attacks took place at educational facilities (schools) (Advanced Law Enforcement Rapid Response Training, 2019). Of those events, 289 of the attacks were carried out with a firearm (e.g. handgun, rifle, shotgun, etc.) (Advanced Law Enforcement Rapid Response Training, 2019). The most powerful firearm used by attackers was a handgun (57%) followed by a rifle (27%) (Advanced Law Enforcement Rapid Response Training, 2019).

Figure One: Location Categories of 250 Active Shooter Incidents in the U.S. from 2000 to 2017



*Reproduction of this graphic was granted by the Federal Bureau of Investigation.

As shown above, schools make up a little over one-fifth of the locations where active shootings have taken place (Federal Bureau of Investigation, 2017). If the definition is expanded, the occurrence of gun-related violence at schools increases. For instance, 76 out of 116 students died due to gunshot wounds between 1999 and 2006 during school-related incidents (Center for Disease Control and Prevention, 2011). Between 2010 and 2014, 80 school shootings led to the death of 86 people (Duplechain & Morris, 2014). A total of 344 people (including the shooter) have died between 2000 and 2018 from incidents that took place at a school where a gun was fired, displayed, or a bullet hit school property (K-12 School Shooting Database, 2019).

Many researchers have suggested that general and violent crimes have been decreasing in the United States in recent years (Burns & Crawford, 1999; Elsass, Schildkraut, & Stafford, 2016; Fox & Burstein, 2010; Fox & DeLateur, 2014; Fox & Fridel, 2016; Madfis, 2016; Wike & Fraser, 2009; Zhang, Musu-Gillette, & Oudekerk, 2016). However, it is difficult to ignore the extent of gun violence in the country. Although the numbers will vary depending on how calculations are made, it is possible to estimate how much gun violence has occurred in the United States over the past decade. Between 2009 and 2011, a total of 1,326,100 incidents of fatal and nonfatal firearm violence took place in the United States (Planty & Truman, 2013). During each of those years, homicides made up about 2-3% of the total firearm-related incidents (Planty & Truman, 2013). Using data provided by the Centers for Disease Control (CDC) for the period of 2013 to 2017, a total of 113,108 people, on average, are shot each year with 36,383 of these incidents leading to fatalities (Brady: United Against Gun Violence). It has also been suggested that 100 Americans die each day due to firearm-related incidents (Everytown for Gun Safety, 2019).

Surveillance Systems

Traditional surveillance systems rely on human operators to interpret what is happening via a video feed. This creates problems because most operators of traditional security cameras perform reactive monitoring (passive monitoring after some type of alert) instead of proactive monitoring (constant monitoring to detect, predict, and prevent incidents from happening) (Dadashi, 2008; Keval, 2006). Some researchers found that only 35% of the total detection of incidents was due to proactive monitoring (Norris & McCahill, 2006). Additionally, the performance of human operators tends to decrease the longer they view the video feed. It has been found that CCTV operators cannot recognize objects in the video feed after twenty to forty minutes of active monitoring (Velastin, Boghossian, & Vicencio-Silva, 2006). Ainsworth (2002) found that video monitoring operators miss up to 45% of screen activity after twelve minutes of continuous video monitoring, which increases up to a 95% miss rate after twenty-two minutes of continuous monitoring.

Automatic surveillance systems remedy many problems associated with traditional surveillance systems by reducing the reliance on human operators to constantly analyze a video feed. Automatic surveillance systems can detect objects, track objects, and analyze

situations to determine the behaviors of targets (Valera & Velastin, 2005). However, a major problem with automatic surveillance systems is that the algorithms used to detect and track objects work really well in laboratory settings, but tend to produce less reliable results in real-life situations, which renders them primarily useful in post-incident investigations (Dadashi, 2008; Dee & Velastin, 2007). Therefore, before an automatic surveillance system is used, the accuracy and reliability of the system should be tested in a non-laboratory setting.

Solution

What is it?

The main goal of CIVIL Security, Inc. is to prevent mass shootings, active shootings, and mitigate the damage that is a result of these events with an automatic surveillance system. The system named the CIVIL Security's Gun Detection System (CIVIL System) has been designed to detect threats (e.g. weapons and knives) in an area, produce an alert when this detection occurs, and generate an organized response to deal with the threat. The artificial intelligence technology that is employed by the CIVIL System uses a multilevel system configuration (machine learning, deep learning, and a neural network) to quickly identify threats and send alerts to authorities or other designated parties, which is a component that is configured by each client.

The CIVIL System adds a layer of security when it comes to the prevention of dangerous events, such as active shootings and mass shootings. The system has been designed in conjunction with security specialists and loaded with state of the art artificial intelligence, object detection capabilities, and behavior detection capabilities in order to create a security system that actively identifies a threat and notifies authorities in real time. The use of the CIVIL System can help reduce the threat of an attack, such as a mass shooting, as well as assist authorities in capturing criminals.

The CIVIL System uses artificial intelligence (AI) algorithms to analyze multiple data points in order to detect criminal activity faster and more accurately that systems that rely exclusively on human recognition. The system can also be configured to call local law enforcement officials and send them a live video feed of the event. Some of the main features of the system include: being able to detect about 900 different types of firearms, recognizing threats in under three seconds, and identifying threats with extreme accuracy.

Focusing on firearms, the CIVIL System currently recognizes a firearm as being in one of three different states: concealed, holstered, and drawn. A concealed firearm is one that is not visible. A holstered firearm is one that is visible, usually on the waist, and usually found in some sort of firearm holster. A drawn weapon is a firearm that is visible and held in a manner that allows the person holding the firearm to begin shooting. The main goal for the CIVIL System is to produce accurate and reliable detections of firearms in the drawn state. This is because a drawn firearm will usually indicate a potentially dangerous situation. Firearms that are holstered are usually worn by active law enforcement officials, military personnel, or security personnel. Concealed firearms are usually worn by civilians who have legal privileges to carry the firearm in public spaces (e.g. have a license to carry a firearm). Therefore, firearms in a concealed or holstered state are less likely to be attributable to a dangerous situation.

How it works

The CIVIL Security's Gun Detection System is a real-time threat detection system. The system detects threats, such as firearms, knives, and aggressive action, through a video feed and sends an alert after the detection. The CIVIL Security's Gun Detection System is a highly sophisticated artificial intelligence (AI) technology that connects directly to an already established security camera system (e.g. CCTV system) and delivers fast and accurate threat detection alerts to a party (e.g. security staff or an administrator) that has been pre-established by the client. The CIVIL System will work on cameras made by different manufacturers. Additionally, the software works off the real time streaming protocol (RTSP) from a camera feed, a video management system (VMS), or a network video recorder (NVR). There are also three different ways of configuring the system: local only option, cloud only option, and a hybrid cloud option.

The CIVIL Security's Gun Detection System is integrated with a pre-existing security camera system and configured to the client's liking. If the CIVIL System detects a threat, it sends this information to a monitoring service in real time. The monitoring service then validates the threat. If the threat is determined to be a real threat, then local law enforcement is notified and made aware of the situation. If selected to do so with access control, the CIVIL System will then trigger a lock down. Examples of lockdown protocols include: preventing the use of elevators (without a manual override key), the locking of classroom doors in a school, the closing of parking gates, and sending alert messages via text to third parties.

Accuracy Tests

Multiple tests were conducted to determine the accuracy of the CIVIL Security's Gun Detection System. A total of six different accuracy tests took place at multiple locations. The tests took place on the following dates: August 30, 2019, May 7, 2019, May 9, 2019, and August 28, 2019. Three of the tests were conducted on August 28, 2019.

Procedures

For each accuracy test, the CIVIL System was set up to be used with one camera. An actor was used to play the role of a gunman who would walk into an area holding an object. The camera was set up to monitor the area that the gunman was walking around in. A second person was used to monitor whether the CIVIL System produced a correct alert (threat identified or no threat identified) and then recorded this observation. The gunman was instructed to walk and stop in front of the camera at the following distances: five feet, ten feet, fifteen feet, twenty feet, twenty-five feet, and thirty feet. Each five foot interval was marked by white tape. Once stopped, the gunman was instructed to perform one of the following actions: point the item to the left ninety degrees, point the item to the left forty-five degrees, point the item to the right ninety degrees, point the item to the right forty-five degrees, point the item straight at the camera, walk with the item, run with the item, turn their body clockwise with the item, and turn their body counter-clockwise with the item. All the actions were repeated for each distance. Three item positions were also used: having the item close to the gunman's body, having the item away from the gunman's body, and the gunman holding the item while multiple bystanders were in the area. Therefore, a total of 162 individual run-throughs were used to complete a round of testing with an item.

A total of eleven different items were used in testing: two weapons and nine non-threatening objects. The two weapons used included: an assault rifle and a Glock 9mm handgun. The nine non-threatening objects included: a laptop, a water bottle, a broom, an umbrella, a set of car keys, a coffee mug, a book, a back pack, and a purse.

Examples of some of the combinations of each individual run-through include: holding the assault rifle close to the gunman's body while pointing the rifle to the left ninety degrees at a distance of ten feet from the camera, holding a handgun away from the gunman's body while pointing the handgun straight at the camera at a distance of twenty-five feet from the camera, and holding a laptop while multiple bystanders are in the area while running at a distance of fifteen feet away from the camera. Images One, Two, and Three provide visual examples of some of the run-throughs.

Image One: Gunman with Handgun Pointed Out (Distance of Five Feet)

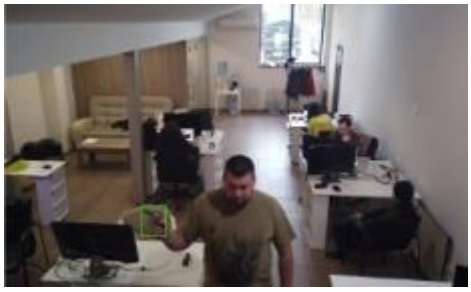


Image Two: Gunman with Handgun Pointed Out (Distance of Five Feet)

Image Three: Gunman with Handgun Pointed Upwards (Distance of Twenty Feet)

Equipment and Personnel

A total of three different cameras were used in the accuracy tests: Micro 7, Axis Model M3044, and Axis Model P3228. Multiple actors played the role of the gunman. Multiple people were also used to observe the alerts and record whether the alert was correct or incorrect. Other testing staff included: a test director and product specialists. The lighting condition during testing was set to a brightness of 140 Lux or more.

Safety

During testing, no ammunition or magazines were allowed at the testing site. Prior to testing, all the weapons were cleared and inspected to ensure no live ammunition was placed inside of the weapon. Cleared weapons were marked with yellow tape and an orange tip. The local police department was advised of the testing and was invited to observe and participate in the testing. The tenants of the building and others were informed of the testing. Signs were placed near the testing area to alert the public of the testing.

Coding of Alerts

The alerts were dummy coded where a value of one indicated that the CIVIL System responded in the correct manner. For weapons, this meant that a successful detection occurred and an alert was made. For non-threatening objects, this meant that no alert was made.

A value of zero indicated that the CIVIL System responded in the incorrect manner. For weapons, this meant that a successful detection did not occur and an alert was not made. For non-threatening objects, this meant that a detection (of a weapon) occurred and an alert was made.

Results of Accuracy Tests

Table One: Descriptives of CIVIL System Accuracy Tests (Rifle)

Distance[ab]	Position	n=2916	Percent Correct ID (Number Correct)[c]
5 Feet	Weapon Away	162	100.0 (162)
	Weapon Close	162	100.0 (162)
	Mult. Bystanders	162	100.0 (162)
10 Feet	Weapon Away	162	100.0 (162)
	Weapon Close	162	100.0 (162)
	Mult. Bystanders	162	100.0 (162)
15 Feet	Weapon Away	162	100.0 (162)
	Weapon Close	162	100.0 (162)
	Mult. Bystanders	162	100.0 (162)
20 Feet	Weapon Away	162	100.0 (162)
	Weapon Close	162	100.0 (162)
	Mult. Bystanders	162	100.0 (162)
25 Feet	Weapon Away	162	100.0 (162)
	Weapon Close	162	100.0 (162)
	Mult. Bystanders	162	100.0 (162)
30 Feet	Weapon Away	162	96.9 (157)
	Weapon Close	162	95.7 (155)
	Mult. Bystanders	162	98.1 (159)
			Total: 99.5 (2901)

[a] Nine different scenarios were tested for each distance and rifle position
[b] Multiple tests were conducted using different security cameras and actors
[c] Correct identification was coded as an alert was made

Table Two: Descriptives of CIVIL System Accuracy Tests (Handgun)			
Distance[ab]	Position	n=2916	Percent Correct ID (Number Correct)[c]
5 Feet	Weapon Away	162	100.0 (162)
	Weapon Close	162	100.0 (161)
	Mult. Bystanders	162	100.0 (160)
10 Feet	Weapon Away	162	100.0 (162)
	Weapon Close	162	100.0 (162)
	Mult. Bystanders	162	100.0 (162)
15 Feet	Weapon Away	162	100.0 (162)
	Weapon Close	162	100.0 (162)
	Mult. Bystanders	162	100.0 (162)
20 Feet	Weapon Away	162	100.0 (162)
	Weapon Close	162	100.0 (162)
	Mult. Bystanders	162	100.0 (162)
25 Feet	Weapon Away	162	100.0 (161)
	Weapon Close	162	100.0 (156)
	Mult. Bystanders	162	100.0 (157)
30 Feet	Weapon Away	162	100.0 (154)
	Weapon Close	162	100.0 (155)
	Mult. Bystanders	162	100.0 (151)
			Total: 98.6 (2875)[c]

[a] Nine different scenarios were tested for each distance and handgun position
[b] Multiple tests were conducted using different security cameras and actors
[c] Correct identification was coded as an alert was made

Table Three: Descriptives of CIVIL System Accuracy Tests (Objects)[a]

Distance[bc]	Position	n=4374	Percent Correct ID (Number Correct)[d]
5 Feet	Object Away	243	100.0 (243)
	Object Close	243	100.0 (243)
	Mult. Bystanders	243	100.0 (243)
10 Feet	Object Away	243	100.0 (243)
	Object Close	243	100.0 (243)
	Mult. Bystanders	243	100.0 (243)
15 Feet	Object Away	243	100.0 (243)
	Object Close	243	100.0 (243)
	Mult. Bystanders	243	100.0 (243)
20 Feet	Object Away	243	100.0 (243)
	Object Close	243	100.0 (243)
	Mult. Bystanders	243	100.0 (243)
25 Feet	Object Away	243	100.0 (243)
	Object Close	243	100.0 (243)
	Mult. Bystanders	243	100.0 (243)
30 Feet	Object Away	243	100.0 (243)
	Object Close	243	100.0 (243)
	Mult. Bystanders	243	100.0 (243)
			Total: 100.0 (4374)

[a] A total of nine different non-threatening objects were included in testing: a laptop, water bottle, broom, umbrella, car keys, coffee mug, book, back pack, and a purse

[b] Nine different scenarios were tested for each distance and non-threatening object position

[c] Multiple tests were conducted using different security cameras and actors

[d] Correct identification was coded as no alert was made

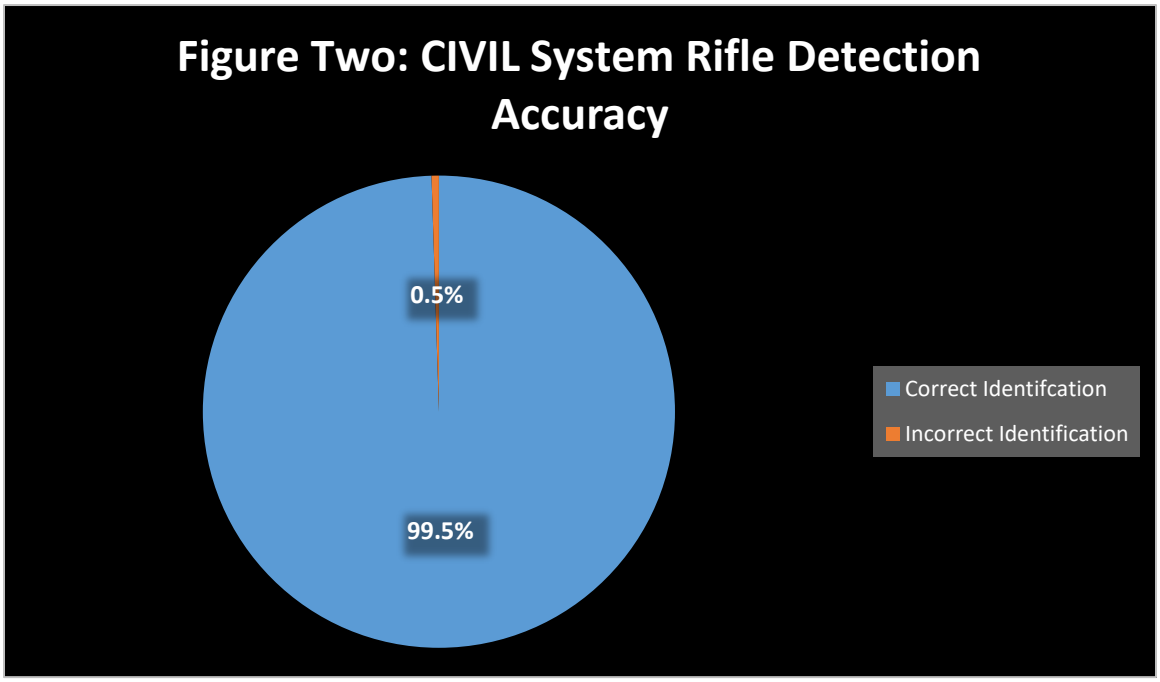


Figure Two: CIVIL System Rifle Detection Accuracy
0.5%
99.5%
Correct Identifcation
Incorrect Identification

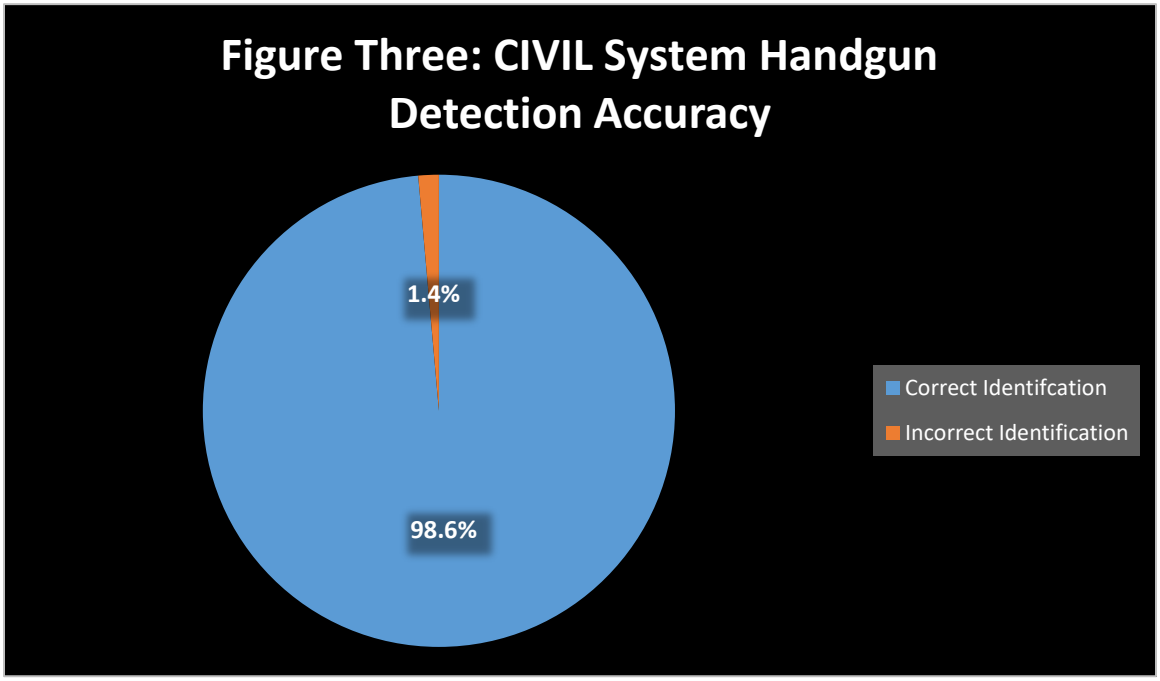


Figure Three: CIVIL System Handgun Detection Accuracy
1.4%
98.6%
Correct Identifcation
Incorrect Identification

Discussion of Accuracy Tests

As shown in Table One, all the individual run-throughs that were conducted with a rifle were combined to produce a total of 2,916 cases. In all but fifteen cases was the rifle correctly identified by the CIVIL Security's Gun Detection System. The CIVIL System correctly identified the rifle in over 99% of the cases. Similarly, as shown in Table Two, all the individual run-throughs that were conducted with a handgun were combined to produce a total of 2,916 cases. During testing, the CIVIL Security's Gun Detection System correctly identified the handgun in all but 41 cases, which means that the system correctly identified the handgun in over 98% of cases. Table Three shows that a total of 4,374 cases were identified when all the individual run-throughs with non-threatening objects were combined. The CIVIL System correctly identified the objects as non-threatening objects in all the cases.

Although not shown in the results, it was found that most of the incorrect identifications for both a rifle and a handgun occurred when the weapon was pointed straight at the camera. However, this should not be a major concern since it is very unlikely that a person holding a firearm will stay in one position and point the weapon straight at the camera during the entirety of their attack. Therefore, while the CIVIL Security's Gun Detection System may struggle to identify the weapon in this very specific case, it will probably only be a matter of seconds before the system will identify the weapon when the attacker moves his/her body or the weapon.

Limitations

The CIVIL Security's Gun Detection System is extremely accurate given the results from the tests conducted. However, no system is perfect. The system's accuracy may depend on many factors, such as the cameras being used in conjunction with the system, the distance of the weapon from the camera, and the light condition of the environment.

The following list provides some system specifications and environmental factors that are necessary in order to obtain a similar level of accuracy as described in the tests above when using the CIVIL Security's Gun Detection System: a camera with a range between 30 feet and 300 feet should be used, 100 pixels or more should be on the target, a lighting of 140 Lux or more should be in the environment, 60% of the weapon should be visible to the camera, and a camera capable of capturing eight frames per second or more should be used. A three second delay should also be expected before the system will provide an alert after it detects a potential threat.

Future Directions

The tests described above provide a strong foundation for establishing the accuracy of threat detection for the CIVIL Security's Gun Detection System. However, it is recognized that the environment in which a threat may be presented or the technology that is used in conjunction with the system may vary greatly from what was used in the current tests. Therefore, the team at CIVIL Security, Inc. is dedicated to continuing testing of the CIVIL Security's Gun Detection System. Future tests include using the system in low-light conditions, using the system in combination with infrared cameras, and using the system with cameras that are able to scan long distances.

Conclusion

The CIVIL Security's Gun Detection System offers an improved, accurate, and cost-effective method for the possible prevention of mass shootings and active attacks as well as the mitigation of damage that occurs as a result of these situations. The CIVIL Security's Gun Detection System can be used in a variety of settings that may be vulnerable to a mass shooting or active attack, such as a school or a business. Further research is needed in order to determine the accuracy of the system in different environmental settings, such as low-light settings, as well as ensuring that the system can identify a variety of weapons.

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