Metal Detectors versus Infrared Thermography to Search for Shell Casings

Nicole M. Richard
Faculty Mentor: Peter Massey, M.Sc.

Abstract
Within the field of Crime Scene Investigation, searching for evidence is both an art and a science. This is especially true when searching for expended shell casings. Currently, the use of various geometric search patterns, as well as, the use of metal detectors comprises the main methods of searching for shell casings. Modern technology is constantly evolving; therefore, it is crucial that these methods are revised and new ones explored. Utilizing Infrared Thermography or Thermal Imaging, the search and recovery of evidence can be greatly improved. Infrared or thermal cameras have the capability to detect the smallest of changes in an object's heat signature. This is observed visually utilizing specialized equipment and changes in colors displayed which identify the different temperatures. Utilizing this application, it will be determined if metallic shell casings can be located by their unique heat signature. In this study, thermal imaging will be used to locate expended shell casings and be compared to the effectiveness of a metal detector to do the same. When using the thermal camera, the results showed that it was a faster and more accurate method.

1. Background

The recovery and collection of evidence is one of the most critical aspects of Crime Scene Investigation. It can mean solving a case, or the conviction of a criminal. Take a shooting in an open field for example. When called to the crime scene, it is very possible that the ballistic evidence has been moved, destroyed or difficult to locate. It is not very common that a firearm is recovered at the scene and the only thing left to connect the suspect to the location might be an expended shell casing; police would have to spend hours searching the entire locality with the real possibility of finding no expended casings.

Currently, the use of metal detectors can be applied to find bullets, casings, weapons, and other metallic evidence on or beneath the surface[1]. More advanced detectors have the capability of detecting cars that are twenty feet underground[2]. Metal detectors are useful when examining small areas, however, they fall short when applied to a larger scene. When the area of the scene increases, and the terrain becomes more difficult to access, the amount of time it takes to search greatly increases.

Using the recent development of Infrared Thermography, differences in heat are easily seen with just the sweep of a specialized camera. Infrared Thermography is being used for a wide variety of things already such as searching for people, tracking of hunting prey, night vision, heating issues, and meteorology. Infrared Thermography has the ability to visually display the thermal profiles of objects in almost any environment. Metallic objects have a very distinct set of thermodynamic properties with respect to both heating and cooling, enabling contrast with the surroundings. This contrast makes the objects quickly noticeable and easy to find. This technology has the potential to expand the search radius while decreasing the time it takes to find metallic evidence. It has the potential to help investigators find more evidence in many different environments where other methods may fail. This project is designed to test the capabilities, limits and applications of Infrared Thermography in the forensic environment.

2. Methods and Materials

For this research, three types of expended shell casings were utilized. Each was made of brass and were rifle casings. The .305 caliber, .223 and the 5.56 caliber casings were all tested. Along with the casings, a standard thermometer, a high-grade metal detector, and a FLIR E6 Thermal Imaging camera were also utilized. Once images were collected, the FLIR computer application was used to analyze and assist in the interpretation of the results.

Preliminary testing was conducted initially. This included testing the hypothesis that the metal of the shell casing has a different heat signature than the surface it is deposited on. This was tested two ways. First, the casing was placed on concrete and allowed to sit for fifteen minutes in a sunny environment.

During these fifteen minutes, a thermometer was placed in the same area and allowed to come to equilibrium, giving the ambient temperature. After the fifteen minutes had elapsed, the thermometer was placed inside of the shell casing and allowed to sit for 5 minutes. The temperature inside the casing was recorded. Using the FLIR E6 Thermal Imaging Camera, the casing was again placed on concrete and allowed to sit for fifteen minutes. Once that time elapsed, the E6 camera was used to visually observe and record the heat signature of the casing and the surrounding areas.

Using a metal detector, shells were placed in various locations in a pre-determined area. The investigators did not know the locations. The investigator used the metal detector, started a timer, and began searching for the casings. Once all the casings were located, the time was stopped. Then using the IR Camera, the casings were placed in different locations unbeknownst to the investigator on the same medium. The same protocol as above was followed. The recorded times for each protocol were recorded and compared.

3. Results

The initial testing proved that the shell casings had the ability to heat to a higher degree than the surface it was deposited on. With the ambient temperature according to 'The Weather Bug' was 82°F with a relative humidity of 75%, the thermometer registered an ambient temperature of 88°F. When the casings were in direct sunlight for fifteen minutes, the thermometer placed inside the casings registered the temperatures as indicated in figure 4.

Figure 1: FLIR E6 Camera [3].

Figure 2: Casings placed on Concrete. Digital Image.

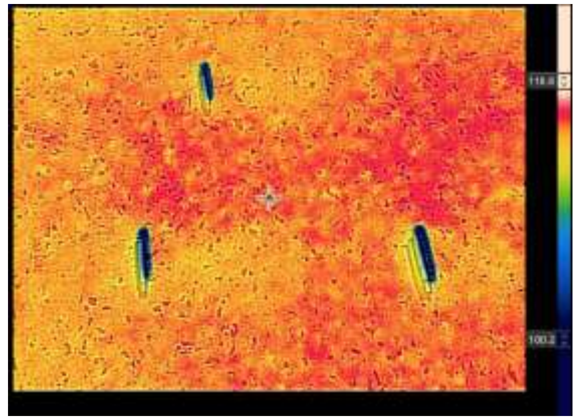

Figure 3: Casings placed on concrete. Thermal image.

Caliber	Inside Temperature (°F)
.308	116
.223	115
5.56	114

Table 1: Temperature readings.

Table 1 shows the temperature readings of the inside of the shell casings. This was recorded after the casings had been sitting in direct sunlight for 15 minutes. A thermometer was place inside of the shell casing and allowed to come to equilibrium. The temperature was then recorded.

Figure 5: Casing on grass. Digital image.

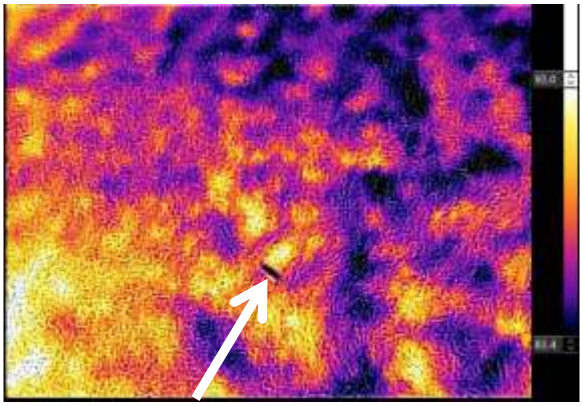

Figure 6: Casing on grass. Thermal image.

4. Discussion

The current method crime scene investigators use to search for metallic evidence, such as shell casings, is utilizing one of the standard geometric search patterns and the use of a metal detector. This not only takes a great deal of time, it also produces a great deal of false positives and can possibly be hazardous to the searcher. A typical metal detector emits an electromagnetic field onto the target surface. Once the signal penetrates the ground, metallic objects reflect the signal back to the receiver [4]. The receiver will then emit an audible warning alerting the operator. The concern with devices like this is that they have the capacity to misinterpret an object as metal. When utilizing a metal detector to search for expended shell casings, these false positives can cause great issues. For example, when searching for the blindly placed casings in this study, the metal detector reflected signals from everything buried under the surface. This included pipes, conduits, construction material and metal debris, as well as, the expended shell casings. In this case, and in a real time incident if the investigator is using their due diligence, every time the sensor sounded, the observer had to stop to see if it was a shell casing on the surface creating the signal or debris or some subterranean object. This consumed a lot of unnecessary time.

To combat the false positives produced by the metal detector, as well as convenience and possible safety concerns, the idea of using infrared thermography was proposed. Infrared thermography, also known as thermal imaging is a technology that has the capability to sense the heat emitted by any and every object. Currently, thermal imaging is very popular in both military and government projects and the construction industry. Often times, thermal imaging will be utilized to locate individuals at night, in areas where it is too difficult to search. This is evident through the use of FLIR technologies on military and law enforcement helicopters. The technology can also be used to locate explosives and gas leaks [5]. However, to date, it has not been used in searching for expended shell casings.

Once it was determined that there was a difference between the heat signatures of the expended shell casings and the ground, the thermal imaging camera testing commenced. Casings were set out in direct sunlight for a predetermined period of time. As the time had elapsed, the FLIR E-6 camera was used to record a thermal signature of the casings against the ground. As indicated in figures 2 and 3, it is observed that the casings do have a distinct thermal pattern compared to the ground. Once the proof of concept proved plausible, the testing switched to different surfaces. Grass proved to be the most difficult because of the uneven surfaces, which produced uneven temperatures, creating more interference. Divots in the ground, water in the dirt, and other variables produced different heat signatures as well. When searching for the expended shell casings, it was necessary to adjust to the camera and the relatively short learning curve to interpret the displayed image to detect the shell casings quickly.

While the thermal imaging produced better results, as indicated by the shorter search times with less false positives, than the metal detector, there are still some flaws in the system. These include the thought that the shell casing would have such a different signature than the grass surface that it would be easier to detect. However, the abnormalities in the surfaces proved to be more challenging than expected. Further testing will be conducted on different surfaces and search environments to include variable ambient temperatures, and a wider spread between the ambient air, ground and expended shell casing temperatures.

5. Conclusions

No previous studies have been performed testing the use of infrared thermography as a search tool for expended shell casings. The comparison of the accuracy of the metal detector against the accuracy of the thermal imaging camera was also a first time study. This study has shown that in preliminary phases, the thermal imaging camera was a more expedient and accurate method to locate expended shell casings. Further research still needs to be conducted to determine the accuracy in other types of environmental conditions. Research will also be continued on different types of shell casings, to include handguns, which typically have smaller casings.

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7. References

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8. Biography

Nicole M. Richard is currently a senior at the University of New Haven. This is her first publication as well as first year participating in the Summer Undergraduate Research Fellowship. She is persuing a Bachelor's degree in both Forensic Science and Chemistry. In the months to follow, she will be continuing her research on thermal imaging in the search of shell casings. She will be graduating in May of 2016, and plans to continue her education in graduate school.