Police Assistance Device (PAD)

Section 1: Abstract

Today we live in a world where buying a gun or weapon can be done as easily as walking into a local pawn shop; one person has the power to cause immense destruction. While protecting the public from these people, one police officer on average dies every 61 hours. Along with the numerous deaths of these police officers, many other innocent lives have been lost in responding to these dangerous situations.

The Police Assistance Device (PAD) will give critical information through the use of visible light waves, terahertz light waves and artificial intelligence. Metamaterials will emit terahertz waves and eliminate the moving parts of the camera by bending light waves for a wider angle of imaging. Today's body camera only records, whereas our future device will provide information and assist with decision support. Our vision is to ensure the safety of everyone involved in any incident.

Section 2: Project Description

1. Present Technology

As citizens of the United States, we rely on our local police officers to keep our neighborhoods safe. Since 2006, a total of 521 police officers have been killed by firearms and many more innocent lives have been lost. The average body police camera gives a recording of what happened at the scene, yet it doesn't provide information before or during the situation to help the officers take the correct actions. Today's police body camera, as shown in Figure 1, uses digital technology. Digital cameras capture photons (light waves) utilizing a lense to focus on the pixels of an electronic chip, storing them on electronic media (SD Card). The lenses collect and focus the light on the pixels. Then, it reassembles pixels which are then shown on a monitor screen.

Figure 1. Police Body Camera

Body police cameras do not use terahertz technology since it's just recently been introduced to the world. Now used in airports, we are able to keep our travelers safer. We intend to use the same technology to keep our officers, suspects and civilians safer. Terahertz, also known as T-rays, is a wavelength between microwaves and infrared waves.

Terahertz technology is, unlike a x-ray machine, non-ionizing to people and only sees through clothes. This is part of the Electromagnetic Radiation Spectrum that includes different wavelengths and frequencies with different properties as shown in Figure 2.

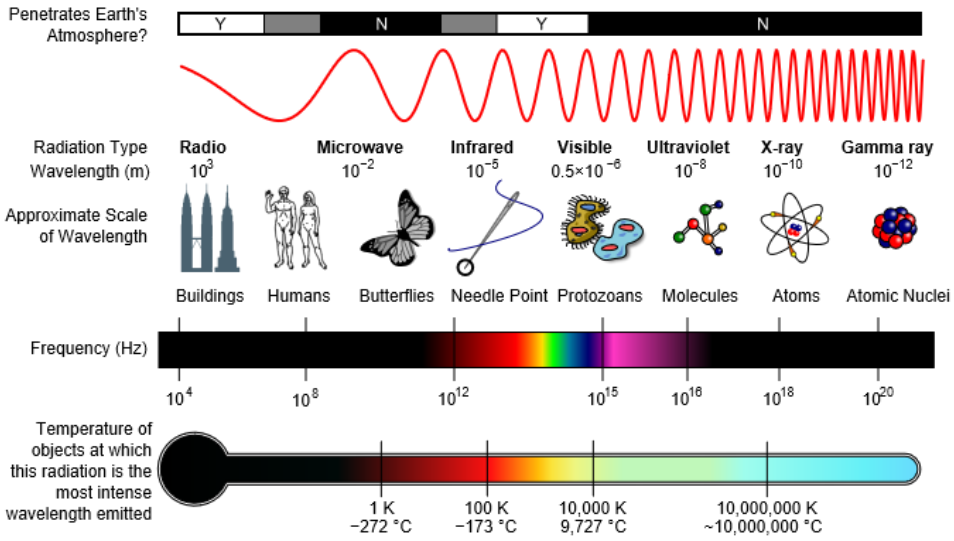

Figure *2.* Electromagnetic Spectrum

Artificial Intelligence (AI) continues to be a growing area. Each day, people are researching AI and making new advancements. AI uses computers to try and mimic human minds such as learning and problem solving. One area of Artificial Intelligence technology is facial recognition, which was invented in the 1960s. This technology uses the different facial features such as the eyes, nose, mouth and ears. Each face has different landmarks called nodal points, there are approximately 80 nodal points on a human face which help distinguish the person and their identity. Then once everything is measured the computer database compares to a other faces with similar traits.

2. History

The still camera was first created in 1685 by a man named, Johann Zahn. However, the first picture was not taken until 1814 by Joseph Nicephore Niepce. The first practical photo was created by Louis Daguerre. This practical photo took nearly ten years to achieve this goal. In 1889, George Eastman invented the flexible film. People started thinking about how to make a

digital camera in the early 1960s, but it wasn't until 1975 that the first one was created by Steven Sasson.

Artificial Terahertz was a collaboration between U.S., Japan and Turkey. These countries worked together on creating a small, compatible battery-controlled terahertz radiation source. In 2008, Harvard University engineers completed a room temperature emission of a few hundred nanowatts of a coherent terahertz radiation using a semiconductor source. In 2009, it was discovered that when you peel off adhesive tape it creates non-polarized terahertz radiation.

Metamaterials are man made materials exhibiting properties not found in nature. During the late 1940's, a scientist named Winston E Koch created a type of material that had several properties related to metamaterials that we use in our present day lives. Most commonly involving properties manipulating electromagnetic and acoustic waves, the non-natural properties are not based on the materials itself but on the structure. Based on materials, refractive index may also be negative as written by Victor Veselago in 1967. Then in the year 2000, the company Smith et al. also demonstrated negative-index metamaterials.

The first robot that used AI was created during World War ll by two British men, mathematician Alan Turing along with neurologist Grey Walter. In 1969, a robot named Shakey was invented. Shakey was able to analyze its surroundings and then make a decision best on the data it gathered. Although, Shakey was not very efficient because it was extremely slow in analyzing data. In 1997, a huge mark in the history on Artificial Intelligence, scientists were able to create a robotic machine that was able to beat the reigning world champion in chess. This robot was able to comprehend 200 million chess positions per a second. In 2008, Apple® created a tool for phones using voice recognition. AI department and developers had worked toward this

goal for years. Then in 2010, the NAO robot was created. This robot learned millions of things, and was perfected over years. This same year, a robot called Watson was able to beat a 74-game streak Jeopardy winner.

3. Future Technology:

With many new emerging technologies, we are able to further advance the current police body camera. We envisioned a device for the police officers which will provide critical information in a dangerous situation in addition to recording. The device will allow the officers to safely approach and respond. With our device, police officers will be given critical information through the use of visible light waves, terahertz light waves and artificial intelligence. Metamaterials will emit terahertz waves and eliminate moving parts for the camera by bending light waves for a wider angle of imaging. So far, all research has shown that these metamaterials will allow us to miniaturize the device and emit terahertz waves. Terahertz light waves and Artificial Intelligence have never been brought together to create a single device.

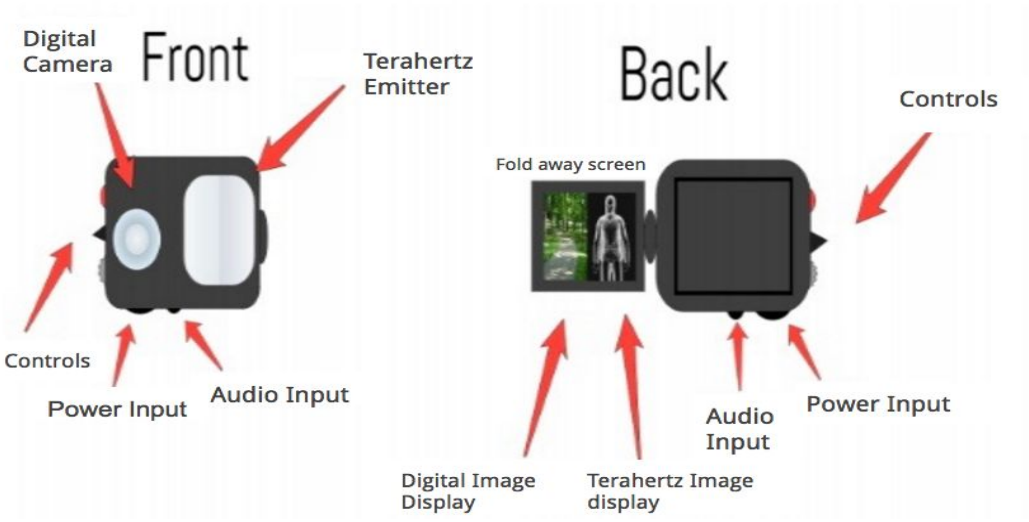

Figure 3. Police Assistance Device (PAD) Model

Our device will be able to emit terahertz waves by using a nanometer sized gold metamaterial, as shown in Figure 5. A femtosecond laser tuned to the same wavelength as the magnetic resonance of the metamaterial, which is the resonance at which photons are absorbed, is used to excite the metamaterial, causing it to emit terahertz rays. A femtosecond is a fraction of a second (1 fs=10^{-15} s). Figure 6 shows how the metamaterial using metal-coated vanadium dioxide on silicon and designed using cross-shaped openings. The metamaterial is placed in front of our other metamaterial in Figure 5 and is used to deflect the beams. Based on a research team led by UCLA electrical engineers, the beam's focus point can be deflected by as much as 44 degrees, both vertically and horizontally.

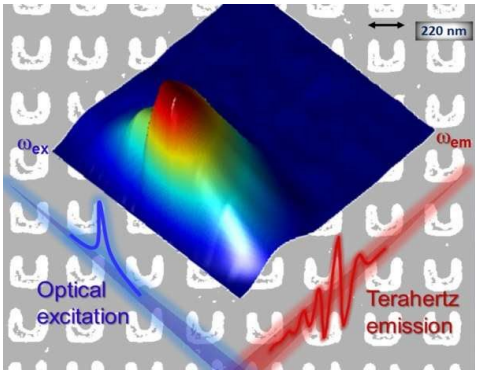

Figure 4. Image showing the emission of terahertz waves.

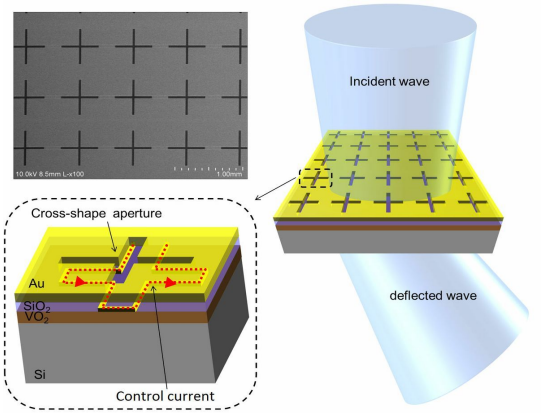

Figure 5. Image showing how to eliminate lenses and moving parts.

The terahertz and visible light images will go directly to the AI data base. We envision the AI will not only have facial recognition and immediate background checks and weapon permits, but have the ability to interpret body and facial expressions. To access the information

from police and FBI databases, our device would be equipped with a cellular data link. Figure 6 illustrates how the AI system uses depth and axis measurements to see the smallest details and matches against existing images to identify a person. In Figure 7, the terahertz image provides detail if a person is carrying a weapon. The AI will be able to provide this information to the officer to caution them on proceeding against an armed suspect.We also see the future with AI evaluating crowd behavior. This could help manage situations where large crowds gathering and protect against riots.

Figure 6. Facial Recognition Scan

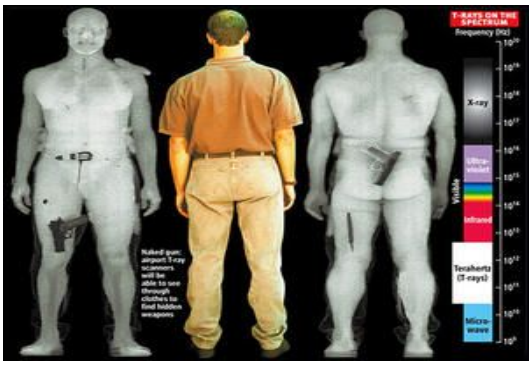

Figure 7. Terahertz Imaging

Our team worked on a conceptual design of how the PAD components will work together. Our team created a schematic flow to provide further details and information. In Figure 8, the components are numbered and are described below the figure.

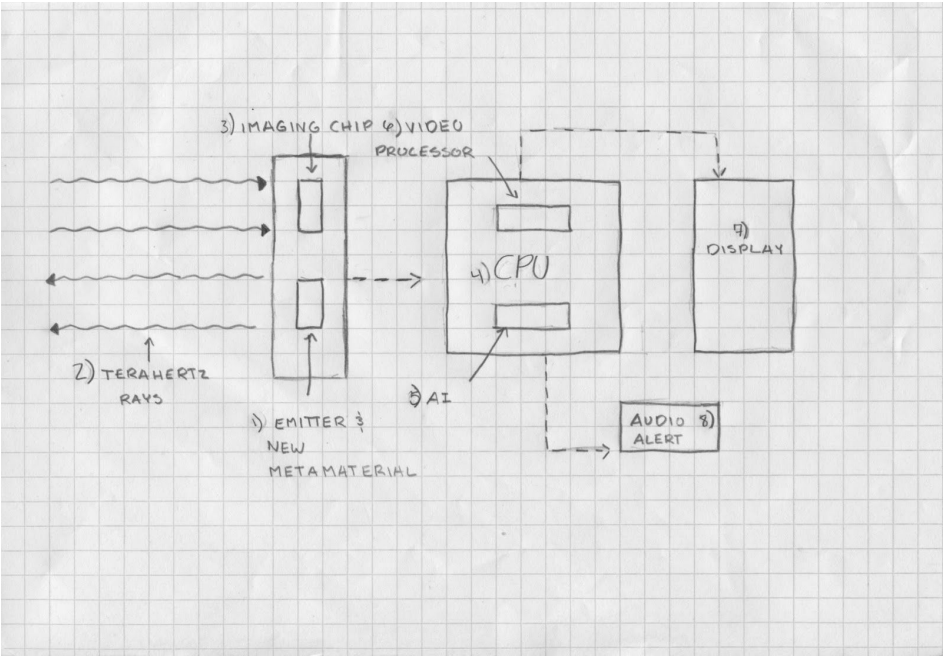

Figure 8. Schematic of the device

We are enhancing the current visible light camera as follows:

1. ADDING: Emitter and New Metamaterials – The emitter emits terahertz rays. The first metamaterial creates the terahertz light waves using a laser and metamaterials, while the second metamaterial will eliminate the moving parts by deflecting the waves at angle.
2. ADDING: Terahertz Waves – Terahertz waves are emitted from the emitter and then reflect off the people/objects. These waves only go through clothing and can identify objects underneath.
3. Imaging Chip – This chip captures the reflected terahertz photons and converts them to an electrical signal pixel by pixel.
4. Video Processor Input - This organizes the pixel's electrical signals into a video image.

5. ADDING: AI – Artificial Intelligence compares the video image to stored patterns. It also has data acquired from the police and FBI databases to identify people with outstanding criminal records.
6. Video Processor Output - This highlights people or weapons of interest based on the AI analysis. Also, provides visible camera images and places it on the storage device.
7. Display - the video processor output would then send the information to the display, which which would display it.
8. ADDING: Audio Alert - If the AI identified a weapon or person of interest, it would send an alert to the Audio alert system and the audio alert would beep in the officer's ear, telling him or her to check their screen.

Our device would be versatile, we could place our device on the officer's shoulder. We could also place our device in eye glasses, epaulette clip on camera, and binoculars containing our device. These opportunities would ensure safety to the officer, suspect, and public. We also see the potential of installing the device in schools, mall and airports.

4. Breakthroughs:

For our device to become a reality, we would need several breakthroughs. Our device would require the new metamaterials to become easily accessible. With terahertz technology, we would need to miniaturize the device that generates the terahertz waves. This would make our device lightweight and portable. This is important to the officers because then they can do their job without be encumbered by a large or heavy device.

Artificial Intelligence has several areas in which need to be advanced. AI would have to be more developed in areas such as identifying the emotion of the suspect and in addition the to providing information by assessing situations such as observing crowd behavior. AI needs to continue improving its accuracy.

Lastly, to perfect our design, it would be helpful for the quality of the terahertz image to be improved upon. Today a terahertz image is grainy and hard to make out details in, especially with environmental conditions. Based on the study of "Imagining through the atmosphere at Terahertz Frequencies" (Figure 9) by Mark J. Rosker and H. Bruce Wallace in 2007, they learned how terahertz waves can be absorbed or interfere with atmosphere whether such as fog, humidity, oxygen, and water vapor. Also, along with the how far the terahertz waves can perform to get a clear image. Figure 9 shows how well terahertz frequencies perform in different weather conditions.

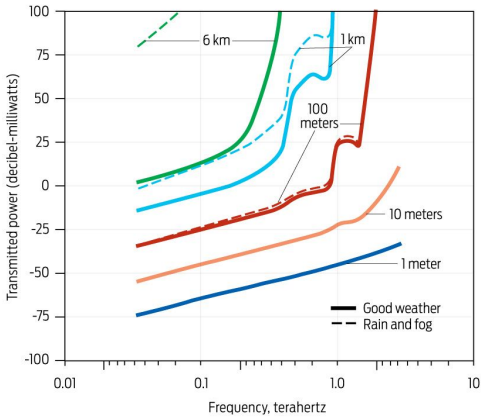

Figure 9. Imaging Through the Atmosphere

Our team will conduct the following study for our police assistance device. First, we would test how much power our device would need to create a clear image from a certain distance. The data we would collect is the amount of watts, (power) required to determine how many feet away the terahertz frequencies could reach to provide a quality image. To start this study we would begin with testing our device by providing it different amount of power to measure how far the terahertz frequencies would be able to reach and still create a good quality

image. Then, we would have to test how the device can receive the required amount of power to keep the device running through the day.

Based on study of the amount of power, we would need a lightweight power source. This would mean that the power source could either be portable or have a charging system that would connect to the car.

5. Design Process:

While brainstorming for this project, we first came up with the idea of a gun with AI in the handle. The AI system would be able to figure out what a person was doing next and tell the officer or another person whether they should use force. We initially liked the idea because it could reduce the number of deaths caused by guns each year. We then moved in a different direction, because we wanted officers to have information before having to pull out their weapon.

We decided to focus on the protection of police officers by providing the best information to them. We discussed a new device to advise them and we started learning about terahertz imaging. We thought our idea could work, because then the officer could quickly assess whether their suspect was armed or not.

Once we had chosen to use terahertz imaging, we decided to use AI for facial recognition, which could scan the suspect's face, give their name and do a quick background check along with finding whether the person has a gun permit or not. Then, the officer would be alerted by the AI data base if the person had a criminal record.

While interviewing a local Police Sgt, he addressed crucial features that would need to be implemented to support a police officer everyday. He suggested that we make the device more

versatile. This would include making the device able to be used on the shoulder more so on the epaulette clip instead of the chest, so the vision of the device would not be disrupted if the officer drew his or her gun. He also mentioned that making accessories like glasses, and binoculars would be better along with making it more compact and lightweight.

6. Consequences:

With the new device we have created, we face both positive and negative consequences that could affect the safety of the officer, public, and suspect. One of the main positive effects is how quick it is to bring up an accurate analysis of a situation and a thorough background check of the person being investigated. With AI, our device would be able to tell the officer the protocol, along with the many other features designed to keep everyone safe. Because of our device, we would be able to lower the amounts of injuries and deaths caused by guns and unnecessary force as a result of incorrect or no information.

The device could have drawbacks if it takes away from the officer using their own instincts or delays the officer in making decisions. Also, if the terahertz light waves misidentifies an object and tells the officer that the person has a weapon. This would be an extremely dangerous situation that could cause an officer to use force in a situation where it is unnecessary. One possible way that we can prevent this is by training officers how to use this device or how to respond to people with different weapons. Our device could possibly violate the Fourth Amendment and people might feel their privacy was being invaded. We would need video processing included in the device similar to the airports.

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Figure 1: "American Civil Liberties Union of Virginia Because Freedom Can't Protect Itself."*American Civil Liberties Union of Virginia RSS*. ACLU, n.d. Web. 20 Jan. 2017. https://acluva.org/bodycams/

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Figure 8: Self Drawn

Figure 9: George Retseck Source: Mark J. Rosker and H. Bruce Wallace, "Imaging Through the Atmosphere at Terahertz Frequencies," IEEE MTT-S International Symposium, June 200 **https://phys.org/news/2015-04-metamaterials-bright-terahertz-source.html#nRlv**

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Section 4: Web Pages

Web pages are uploaded separately.