Gun Violence Control in Schools Using AI and Thermal Cameras

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Abstract

Gun violence is a multifaceted issue that continues to pose significant challenges in the world, Each day 12 children die from gun violence in America. Another 32 were shot and injured, Since Columbine in 1999, more than 338,000 students in the U.S. have experienced gun violence at school and who survived facing mental health problems.

Gun violence in schools refers to incidents involving the use of firearms that result in injury or death within educational institutions in the United States. It is a tragic and concerning issue that has gained significant attention due to its impact on the safety and well-being of students, teachers, and the broader community. In this paper, we would like to provide end-to-end solutions and architecture, and innovative ideas using AI.

Introduction

For a few years, there has been an alarming prevalence of gun violence in the United States. It emphasizes the high rates of firearm-related deaths and injuries, encompassing both homicides and suicides. Statistical data and notable incidents are used to underscore the magnitude of the problem and its impact on society.

It's evident that gun violence is a multifaceted nature of the problem but using advanced technology it can be stopped to some extent.

An advanced AI and thermal camera using temperature can prevent violence before it happens and stop the intruders with firearms in school. A thermal camera, also known as an infrared camera or thermographic camera, is a device that uses infrared radiation to create images based on temperature differences. Unlike traditional cameras that capture visible light, thermal cameras detect and measure the heat radiating from objects and convert it into a visual representation, this camera does not record objects face so it does not compromise with privacy of all students, it will only capture when there are some threats.

Thermal cameras work by detecting infrared radiation emitted by objects and converting it into an electronic signal. The camera then processes this signal and generates an image or video that displays the varying temperatures of

different objects or surfaces within the field of view. In the resulting image, warmer areas are typically represented by brighter colors (such as red, orange, or yellow), while cooler areas appear as darker colors (such as blue or purple). The ability of thermal cameras to visualize and analyze temperature differences provides valuable information for professionals in different fields, enabling them to make informed decisions, detect problems, and enhance safety. With advancements in technology, thermal cameras have become more affordable and accessible, leading to their increased utilization in a wide range of applications, we plan to build artificial-driven intelligence to detect subject mood, if having gun in hand on inside the body, measure with emotional using temperature and detect danger, this AI driven algorithm also able to identify different between police vs. normal subject.

AI based Threat Modeling

Threat modeling is a systematic approach used to identify, assess, and mitigate potential threats or risks to a system, subject, or school organization. It is a proactive process that helps schools understand and prioritize potential vulnerabilities and their associated impacts. By identifying threats early in the development or initial stages, schools can implement appropriate security controls and measures to mitigate those threats effectively.

Our approach of threat modeling typically involves the following steps:

- Identify the system: The first step is to clearly define and understand the system or subject under consideration. This includes identifying its firearms components, interactions, data flows, and boundaries.
- Identify assets and mood of the subjects: Identify the critical assets or resources that need protection within the system, as well as the external firearms involved. This could include sensitive spots, school property, user information, infrastructure, or reputation.
- Identify potential threats: Identify potential threats or attack vectors that could exploit vulnerabilities in the school system. This may involve considering various categories of threats, such as unauthorized access, breaches, denial of service attacks, social engineering, or insider threats.
- Assess vulnerabilities: Analyze the system and identify potential vulnerabilities that could be exploited by the identified threats.
- Rate and prioritize threats: Assign a risk rating or prioritize the identified threats based on their potential impact and likelihood of occurrence. This helps school administrators focus their resources on addressing the most critical threats first.
- Develop countermeasures: Based on the prioritized threats, develop appropriate countermeasures or security controls to mitigate the identified risks. This could include implementing secure gate lock practices, access controls, informing law well before, intrusion detection systems, or training and awareness programs.

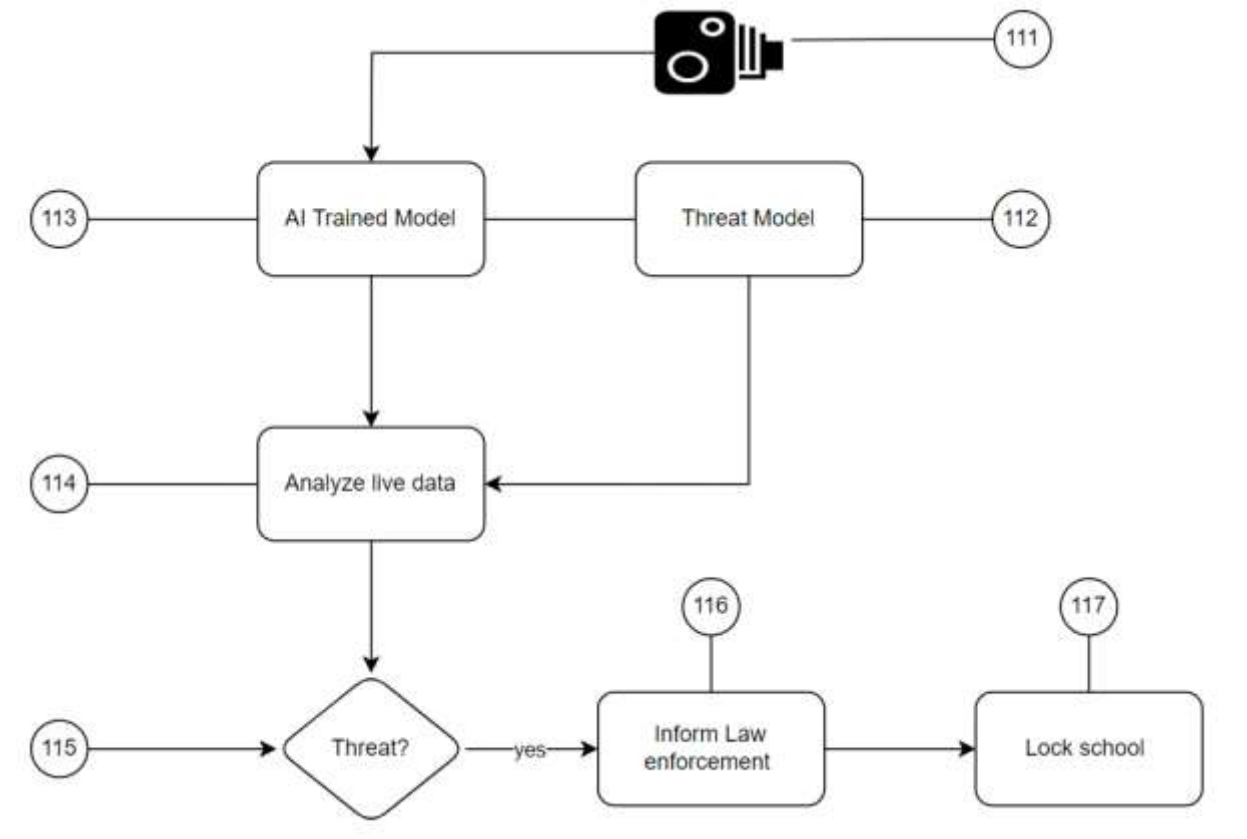
Validate and iterate: Continuously validate the effectiveness of the implemented countermeasures and regularly revisit the threat model to account for changes in the system, technology, or threat landscape. Threat modeling is an iterative process that should be revisited periodically or when significant changes occur.

Using this model and AI model gets training based on real time data, live thermal camera photographs to analyze and control stop the threats. In some cases, perpetrators may obtain firearms legally or illegally, making it crucial to address gaps in gun control but using well advanced AI based models, this will be possible in case of any student, subject found or even trying to enter a building with firearms which includes – gun, knife, or any harmful substance.

Architecture

We have many thermal camera with various power range, for this use case we will use range up to 15 KM radius, once thermal camera can scan and detect unwanted firearms based on body language of the subject, type of walk, driving pattern and parking style, based on all these parameters, AI engine will force camera to focus on subject, and any violation like having gun inside, any firearms or dangers elements, model will react and immediately information every concerned person to handle the scenario.

Note – due to privacy, the camera will not record for all subjects, it will only start recording when there is risk involved and send those images to the law enforcement department.



111 – Thermal camera equipment with scanning unwanted firearms near to school, range up to 15 KM

112 – Threat model, input to AI – artificial intelligence model, threat model will provide probability of having threat around subject based on condition.

113 – Trained AI model with all the real time data, Synthetic data training and real time tweaking.

114 – Based on real time data, getting from thermal camera input, analyze and inform in case of threat.

115 – Decision maker based on AI analysis.

116 – Update law enforcement department imminently before subject enters inside the school.

117 – Lock the school, update school authority immediately.

Thermal camera technical details

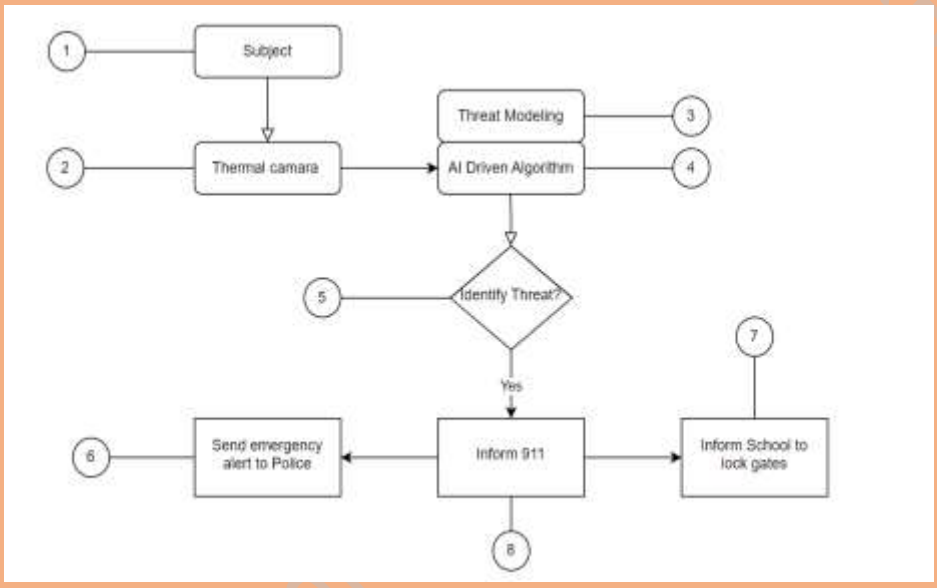
We evaluated thermal cameras with range – 15 KM. This camera can scan humans and detect temperature range, firearms detection and differentiate between normal vs law enforcement personnel.

- Cooled focal plane array photon detector operating in snapshot mode with (640 × 512) IR pixels
- Standard built-in 7.5x zoom lens with motor focus

Thermal camera will send live details to the AI model and, model will evaluate threat and risk levels.

Device design and flow

Flow of the device and identifying the subject and sending it to the model for next action, based on the situation and the dangerous situation, the model will initiate a call, alert the emergency team.



1- All the moving subjects, near the school area.
2- Thermal camera scanning subjects for any risk and firearms.
3- Threat modeling and AI trained model for detecting risk level.
4- AI driven model algorithm on action.
5- Decision by model to call for action in case of any issues, threat from incoming subjects.
6- In case of emergency, send an alert immediately to the law enforcement agency with details.
7- Inform school management to take immediate action.
8- Call 911 at the same time.

AI Model Details and Algorithm Principles

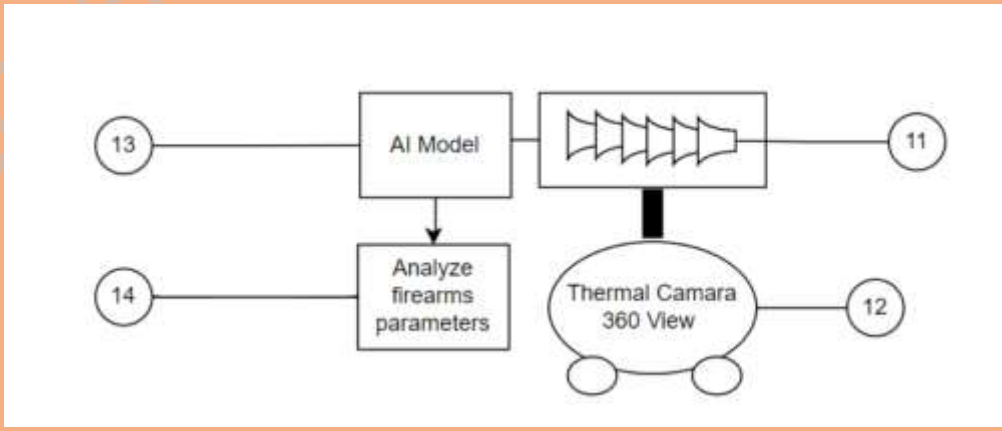
CNN model –Convolutional Neural Networks (CNNs) are a class of deep learning models primarily used for analyzing visual data, such as images and videos. They are widely used in tasks such as image recognition, object detection, and

image classification, and for our model to work CNN will be a major AI model to detect each subject which is integrated with thermal camera inputs.

At a high level, CNNs are designed to automatically learn and extract relevant features from the input data. The key idea behind CNNs is to exploit the spatial structure present in visual data. They achieve this using specialized layers: convolutional layers, pooling layers, and fully connected layers.

- Convolutional Layer: This layer applies a set of learnable filters or kernels to the input image. Each filter performs a convolution operation, which involves element-wise multiplication between the filter and local regions of the input, followed by summation. The result is a feature map that highlights the presence of certain features or patterns in the input.
- Pooling Layer: This layer reduces the spatial dimensions of the feature maps obtained from the convolutional layers. It achieves this by down sampling the input, effectively reducing the amount of information. The most common pooling operation is max pooling, which selects the maximum value within a defined pooling window, in our case this will detect all dangerous elements from the subject including firearms, knives or any other critical risk items.
- Fully Connected Layer: After several convolutional and pooling layers, the feature maps are flattened into a 1-dimensional vector. This vector is then connected to a traditional artificial neural network structure, where each neuron is connected to every neuron in the previous and next layers. These fully connected layers are responsible for making predictions or classifications based on the extracted features.

The power of CNNs lies in their ability to automatically learn relevant features from the data, rather than relying on handcrafted features. The learning process is achieved through optimization algorithms, such as backpropagation, which adjust the weights of the network based on the error signal during training. CNNs have revolutionized the field of computer vision and have achieved remarkable success in tasks like image classification, object detection, facial recognition, and more. Their ability to capture and analyze local patterns within visual data has made them a fundamental tool in deep learning, our idea is to use these features and mount them on thermal cameras.



11 – Thermal camera sensors, to scan all the subjects leading towards school.

12 – Thermal camera 360 views, to scan all the directions about objects coming towards school and going out.

13- AI – Artificial Intelligence – CNN based model, to receive inputs from thermal cameras.

14- Analyze firearms parameters from images received.

Prediction score for Firearms classification for different depths will be based on real time images gathered and AI model detection analysis.

Detection versus false alarm probabilities

Since false alarm can be risky with real time implementation, we will test with multiple syntactic data points, real time data points before implementing in real time, this will help to minimize false alarm up to 99% less, since having firearms detection is proved to be 100% correct in this model, we believe false alarm will not be major issue, as long as model works with best results.

Transfer learning capabilities and improvements

Transfer learning is a technique in machine learning where knowledge gained from training a model on one task is leveraged to improve performance on a different but related task. In other words, transfer learning allows the knowledge or features learned from one domain to be transferred or applied to a different but related domain.

Transfer learning is particularly useful when the amount of labeled data available for the target task is limited. Instead of training a model from scratch on the target task, transfer learning enables the use of pre-trained models that have been trained on large-scale datasets, typically for a different task.

The main capabilities of transfer learning are:

- **Feature Extraction**: This involves using a pre-trained model as a fixed feature extractor. The model's earlier layers, capturing low-level and generic features, extract relevant information from input data. These features then feed into a new classifier or model designed for the target task. By leveraging the pre-trained model's learned representations, knowledge gained during pre-training enhances the model's ability to detect subjects, heat exchange, etc.
- **Fine-tuning:** In addition to using the pre-trained model as a feature extractor, fine-tuning involves adjusting or retraining some of its layers on the target task. This process unfreezes specific layers in the pre-trained model and updates their weights using the target task's data. Fine-tuning allows the model to adapt pre-learned features to the nuances and patterns specific to the target task, potentially improving overall performance.

Transfer learning offers several advantages:

- **Streamlined Training:** Utilizing a pre-trained model in transfer learning significantly reduces the time and computational resources needed for the target task, as the model has already learned generic features on a large dataset.

- **Enhanced Performance:** Transfer learning can elevate model performance, particularly when dealing with limited labeled data in the target task. Leveraging the knowledge captured in the pre-trained model allows for better generalization and more accurate predictions.

- **Versatility:** Transfer learning fosters the development of models with generalized representations applicable to various related tasks. The pre-trained model's learned features, derived from a large dataset, prove relevant across different domains and tasks.

Transfer learning has been successfully applied in various domains, including computer vision, natural language processing, and speech recognition. It has become an essential tool for leveraging pre-existing knowledge and accelerating the development and deployment of machine learning models.

Conclusion

In conclusion, the pressing issue of gun violence, particularly its devastating toll on young students, demands our attention and action. As we navigate an era of continuous technological progress, it is crucial to explore innovative solutions. By leveraging advanced machine learning technology, we have an opportunity to not only control but also prevent acts of violence within school environments. This holds the promise of creating safer and more secure spaces for our students, ensuring that their lives are protected and allowing them to thrive in their educational journeys.

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