Gun Detection Using Convolutional Neural Network

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***Abstract*—Development of effective gun and weapon detection systems has become an increasingly important area of research, particularly in the context of enhancing public safety and security. We give a thorough analysis of the creation of a gun detecting system in this research article. We have talked about the methods, machine learning algorithms, and system design and implementation utilized to analyse the image data.. We have evaluated the performance of the system through a series of experiments and tests, and compare its performance to existing gun detection systems. The outcomes of this study have important consequences for the development of effective and efficient weapon detection systems, which can play a critical role in maintaining public safety and preventing incidents of violence.**

Keywords*—CNN, Deep Learning, Gun Detection, Object Detection

I. INTRODUCTION

The increasing threat of violence in public spaces, such as schools, airports, and shopping malls, has led to a growing demand for effective gun and weapons detection systems. Such systems are critical in preventing incidents of violence, enhancing public safety, and saving lives. Among the various approaches to weapon detection, infrared-based systems have gained significant attention due to their ability to detect concealed weapons and provide real-time monitoring.

Due to an increase in crime in crowded events and unsettling lonely areas, always security is the main priority in all fields. Computer vision is largely used in abnormal detection and supervision to solve various issues[1]. Every year, a large portion of the world's population laments the gun violence. [2].

In applications involving weapon detection systems, and other systems, object recognition in images is essential. It is essential to be able to perform tracking and object recognition throughout the entire day, but at night particularly when there is less light and it is darker[3].

The paper begins by giving a summary of the literature that is already available on gun/weapon detection systems, including a review of the machine learning as well as deep learning algorithms used in previous studies. This is followed by a detailed description of the proposed weapon detection system, including data acquisition and processing techniques, and ML and DL algorithms used to analyse and make decisions.

The paper also presents the results of number of tests carried out to judge the effectiveness of the system in various scenarios and under various conditions. These experiments include tests to assess the system's ability to detect different types of guns, its performance in low light conditions, and its sensitivity to various environmental factors. Finally, the paper concludes with a discussion of the key findings and their implications for the development of effective and efficient guns detection systems. The study's findings have important implications for enhancing public safety and preventing incidents of violence in a range of contexts, including schools, airports, and other public spaces. The development of gun and weapon detection systems has the potential to significantly

improve public safety, and this paper provides an important contribution to this rapidly evolving field of research.

This system has benefits which include

- Enhanced Public Safety: The primary benefit of a weapon detection system is that it can enhance public safety by detecting potential threats in real-time, thereby preventing incidents of violence
- Improved Security: A gun and weapon detection system can improve the security of various public spaces, including airports, schools, and government buildings.
- Rapid Detection: Machine Learning algorithms provides rapid detection of weapons, which can help security personnel respond quickly to potential threats, thereby minimizing the risk of harm to individuals and property.

II. LITERATURE SURVEY

The use of ML and DL for weapon detection has been studied extensively in the past few years, and a significant body of literature exists on this topic. In this section, we provide a detailed literature survey on weapon detection systems, focusing on the processing techniques, and ML and DL algorithms used in previous studies.

Gun detection is critical and has numerous applications for the general public's protection. It is also, without a doubt, a challenging task that can be problematic when carried out automatically or using certain AI model[4].

For successful SAR robots, visual object recognition and object detection is a fundamental challenge since their eyesight might be hampered by harsh sunlight and other environmental variables in disaster scenes which is like detecting weapons from images[5].

There have been many studies done in the past few years weapon detection systems, focusing on different aspects of the system design and implementation. For example, Images taken by various image sensors can offer additional details about the scene. Infrared (IR) or millimetre wave imagery, for instance, might disclose suspicious images that may include concealed weapons, whereas visual imagery can reveal traits that can be used to identify a person, such as facial patterns[6].

Machine Learning is used on a wide scale in weapon detection systems due to their ability to detect the signature of weapons. In recent years, several advancements have been made in the field of infrared sensor technology and machine learning and deep learning fields, including the development of multi-sensor arrays, which can provide higher resolution and greater accuracy.

Several techniques have been proposed in previous studies, including image segmentation, feature extraction, and classification algorithms. These techniques can be used to identify the unique signature of weapons, distinguish them from other objects, and provide accurate and reliable detection.

Machine learning and deep learning algorithms have become an increasingly important component of weapon detection systems, providing advanced decision-making capabilities based on the analysis of large datasets. Several algorithms have been proposed in previous studies, including deep learning, support vector machines (SVM), and decision trees. These algorithms can be used to analyse the data and identify potential threats based on specific patterns and features. There are two types of algorithms for detecting guns and other weapons: Deep learning and non-deep learning algorithms. The quality of the image is very important for the non-deep algorithms[7].

A deep learning-based object detection algorithm is SSD (Single Shot Multi Box Detector). It may significantly increase detection speed and guarantee detection accuracy as one of the most common detection methods[8].Rapid R-CNN leverages prior research to speed up training and improve detection accuracy.[9]

III. METHODOLOGY

The development of an effective and reliable weapon detection system using Convolutional Neural Networks requires a comprehensive methodology that includes several key steps, including the selection of appropriate metrics and parameters, and the implementation of effective machine learning algorithms. This section offers a thorough explanation of methodology for a CNN based model system for detecting guns as depicted in Fig.1.

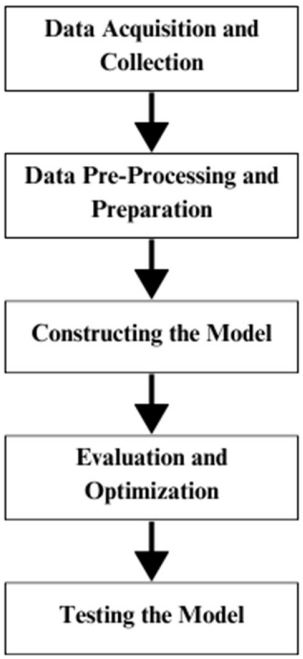

Fig.1. Block Diagram for Weapon Detection

Step 1: Data Acquisition and Collection

The first step in the weapon detection system development is the selection of appropriate image dataset. This involves the acquisition of large number of images containing weapons as well as images not containing weapons and taking care of several factors, including the required resolution, sensitivity, and cost.

Step 2: Data Pre-Processing and Preparation

The second step in the weapon detection system development is the pre-processing of image data. This involves splitting the data into training, validation, and test sets. Pre-processing of the images to ensure the images are of same and format size. To expand the dataset and decrease overfitting, it is also usual to use data augmentation techniques like rotating, flipping, and zooming the photos.

Step 3: Constructing the Model

The third step in the weapon detection system is the selection of the ML models and putting the chosen machine learning model into practice to provide advanced decision-making capabilities based on the large amount of data. This involves the training of machine learning model using labelled data to identify specific patterns and features associated with the potential threats. In our study, we use a DL model, namely Convolutional Neural Network (CNN) to classify the data and detect potential threat causing guns.

Step 4: Evaluation and Optimization

The fourth step in the weapon detection system development is the evaluation and optimization of the model's performance. This involves evaluation of the model's effectiveness by applying the model on the validation set. In our study, we evaluated the system's performance through a series of experiments to test its ability to detect guns, its sensitivity to different lighting. Finding effective means to guarantee the safety of the people is turning into a top priority for the authorities as the threat of terrorism around the world intensifies. The examination of scanning and detecting concealed weapons with potential applications in high-risk places like airports[10].

Step 5: Testing the Model

The final step in the weapon detection system development is the testing of the model against the testing dataset. Using metric such as Loss, Accuracy, Mean Square Error (MSE), Area Under Curve (AUC) to measure the model's performance.

As per the studies already conducted, SSD algorithm gives the accuracy of 73.8% with a good speed of 0.736 s/frame[1].

IV. RESULT DISCUSSION

In order to simulate the CNN algorithm and detect guns, the dataset used consists of images of guns. The size of the dataset is around 200MB with 333 files of JPEG file formats. The images used are in RGB colour scheme. After running 200 epochs on the training dataset and testing the model.

Google Colab notebook, which supports libraries such as TensorFlow and Keras and other Python libraries required for the model was used in running the CNN model for training the dataset.

The loss in training and loss in testing for the CNN model after 200 epochs around 0.62 and 0.65 respectively which is visualised in the figure Fig.2.

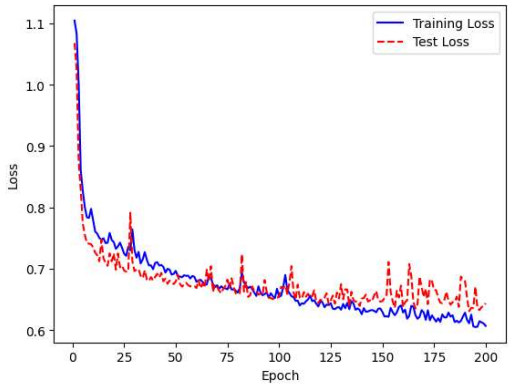

Fig.2. CNN Model Loss

The training accuracy and testing accuracy for the CNN model after 200 epochs around 79.23% and 79.26% which is visualised in the figure Fig.3.

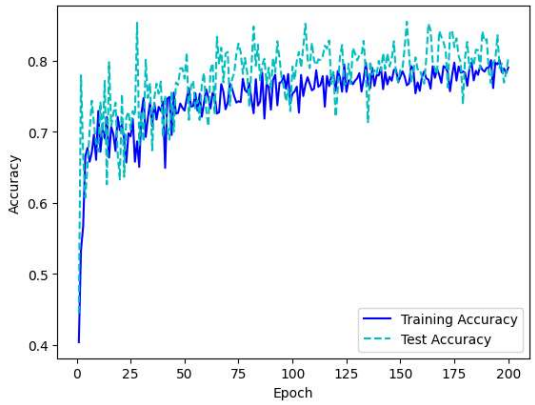

Fig.3. CNN Model Accuracy

The training MSE and testing MSE for the CNN model after 200 epochs 0.125 and 0.120 which is visualised in the figure Fig.4.

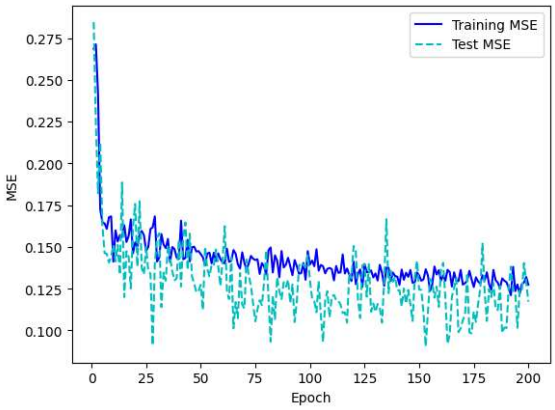

Fig.4. CNN Model MSE

The training AUC and testing AUC for the CNN model after 200 epochs 0.900 and 0.88 respectively which is visualised in the figure Fig.5.

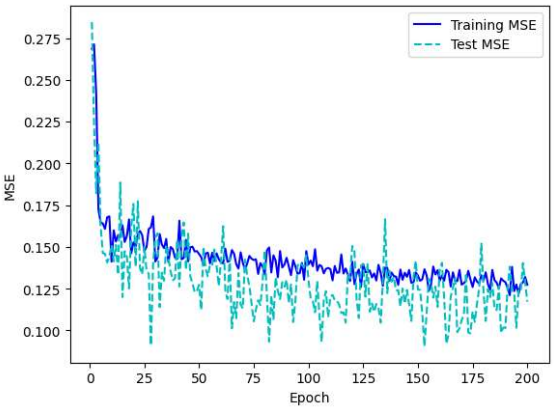

Fig.5. CNN Model AUC

Fig.6 and Fig.7 show the results after applying CNN model on the dataset by highlighting objects like guns in the images.

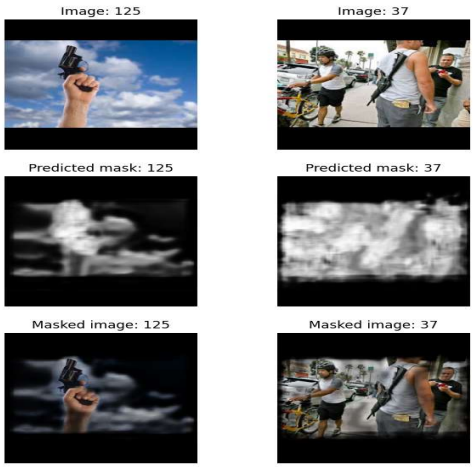

Fig.6. Result after using CNN model

Fig.7. Result after using CNN model

V. CONCLUSION AND FUTURE SCOPE.

In conclusion, CNN models for detecting and mitigating threats in various environments prove to be more accurate and leads to lesser loss compared to SSD algorithm conducted in the previous studies.

In the end CNN appears to be more suitable compared to SSD algorithm for the given dataset for detecting guns in the dataset of images. This paper demonstrates how the CNN model can be used to detect guns in image dataset based on various metric such as Loss, Accuracy, Mean Square Error (MSE), Area Under Curve (AUC).

To improve the effectiveness of the gun detection system infrared or thermal images can be used for detecting weapons instead of using normal RGB Images.

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