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Research Article

A Web-based Application for Detection and Recognition of Armed Persons using Convolutional Neural Network

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Abstract

This study investigated a web-based application for detection and recognition of armed persons using convolutional neural network. This has become imperative due to the rising security challenges, especially, on the use of illegal firearms. The study developed a model based on Convolutional Neural Networks (CNNs). A thermal camera images which capture individuals with concealed weapons were used as the CNN input data and to analyze the transformed data. Results reveal an accuracy of 96% from the CNN model. Findings further show that the investigated model demonstrates improved detection rates compared to conventional methods, offering a unique solution for application in concealed weapon detection. Based on these results, the study recommended that the integration of the model with existing security infrastructure and data systems is essential for its effective deployment in real-world scenarios.

Keywords: Web-based, Detection, Recognition, Armed persons, CNN.

Introduction

In recent years, the increasing concerns regarding public safety and security have driven the development and deployment of advanced technologies to detect concealed weapons [1-2]. The ability to identify armed individuals, particularly those concealing weapons beneath their clothing, has become a paramount objective for law enforcement agencies, security personnel, and public safety advocates [3]. The development of a model for the detection and recognition of armed persons is critical for the prevention and mitigation of potential threats.

Concealed weapons pose a significant challenge in maintaining public safety, as individuals carrying concealed firearms, knives, or other dangerous objects can evade conventional security measures

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and endanger the lives of others. Traditional security methods, such as metal detectors and X-ray machines, have limitations when it comes to detecting weapons that are hidden on a person's body. As a result, there is a pressing need for innovative and reliable technologies that can effectively identify concealed weapons and potential threats.

Breakthroughs in computer vision and deep learning have created new possibilities for addressing this challenge. Convolutional Neural Networks (CNNs) have displayed unprecedented performance in image analysis, facilitating the development of robust object detection and recognition systems. By leveraging the power of CNNs, it becomes possible to build a model capable of identifying armed individuals by analyzing visual data, such as images or video footage.

Thermal imaging is a great way to increase clarity of objects in dark settings. It works by identifying the infrared radiation emitted by all objects as a function of their temperature, known as their heat signature [4]. A thermal camera is capable of recognizing minute differences in temperature, appearing as various shades of grey or colors such as orange, blue, yellow, red and purple. Millimeter wave (MMW) imaging is particularly effective for security screening due to its non-invasive capabilities; no artificial source of MMW radiation is required [4]. Instead, images are formed from the ambient MMW radiation that cannot be seen with the human eye. This type of radiometric imaging can detect objects even through thicker clothing, making it more advantageous than traditional infrared cameras [5].

While conventional Red, Green and Blue (RGB) images captured from Closed Circuit Television (CCTV) cameras offer valuable data sources for this purpose, the model's capabilities can be further enhanced by considering alternative image types. In addition to standard RGB images, thermal images, which capture heat signatures, can be utilized. Thermal imaging technology is particularly useful in detecting concealed objects, as it can reveal temperature anomalies associated with concealed weapons. Integrating thermal imaging into the model's architecture provides an additional layer of information, enhancing its overall effectiveness in recognizing armed persons. This multi-modal approach can offer superior accuracy and reliability, especially in low-light or challenging environmental conditions.

Different studies exist in the literature on weapon detection. The authors in [6] proposed a framework for detecting firearms in images using the Speeded Up Robust Features (SURF) algorithm, a popular feature extraction method in computer vision. Their framework showed an accuracy of 90%. Similarly, the authors in [7] presented a method for detecting abnormal crowd behavior in video surveillance systems. The authors propose a method based on tracklets, which are short tracks of objects in a video sequence, that are formed by associating object detections over time. By analyzing the tracklets of multiple objects, the authors aim to identify patterns of behavior that indicate abnormality in the crowd. The results showed that their method outperformed the other methods in terms of accuracy and efficiency. Overall, this paper presents a promising approach for detecting abnormal crowd behavior in video surveillance systems, which has potential applications in public safety and security.

Though a lot has been done by other researchers [8-9] in the area of deep learning, specifically CNN and detection of objections, the use of thermal imagers and the application of Benford's law to our model on image pixel distributions will help solve the current problems. To this end, a web-based application for detection and recognition of armed persons using convolutional neural network is investigated.

Research Method

A thermal camera, consisting of 1062 JPEG thermal images of dimension 2976 x 3968 with different temperature ranges was used in the collection of data in this study. The camera provided valuable insights into temperature variations and heat signatures. During the collection of the experimental data, the temperature was set to a range of 28.4 °C to 42.3 °C; the imaging speed was set to 10 frames per second (FPS); emissivity of 0.95, and the imaging distance was about 0.6~1.0 m. This method was chosen for its direct and in-depth insights, aligning perfectly with the project's focus on detection and recognition of armed persons. To prepare for training and evaluation, the collected images went through a series of preprocessing steps. These steps were essential for refining the data captured by the thermal camera, ensuring it is optimized for subsequent model training and analysis in the context of designing a model for detection and recognition of armed persons using CNN. The dataset was annotated with bounding boxes to mark the concealed weapon's location within each image. To account for real-world variations, the data augmentation techniques was applied, such as random rotations and translations, to create a robust and representative dataset. A confusion matrix, which utilizes True Positives (TP), False Positives (FP), True Negatives (TN), and False Negatives (FN), was used to evaluate the performance of the proposed system. This matrix helps in understanding how well the system is classifying the data by showing the number of correct and incorrect predictions for each class. Key performance metrics such as accuracy, precision, recall, and F1 score can be derived from the confusion matrix to assess the system's overall effectiveness.

Results and Discussion

The summarized results of the training are given as follows.

Table 1. Results of Model Training

S/N	Matrix	%
1.	Accuracy	96
2.	Precision	94
3.	Recall	92
4.	F1 Score	93

Testing the model

To test the program, different sizes of RGB camera images of .jpg format were used. Some of the images contained a concealed weapon in different positions. However, for evaluation purposes three standard images were tested. The images were taken from camera input. The following are the images used:

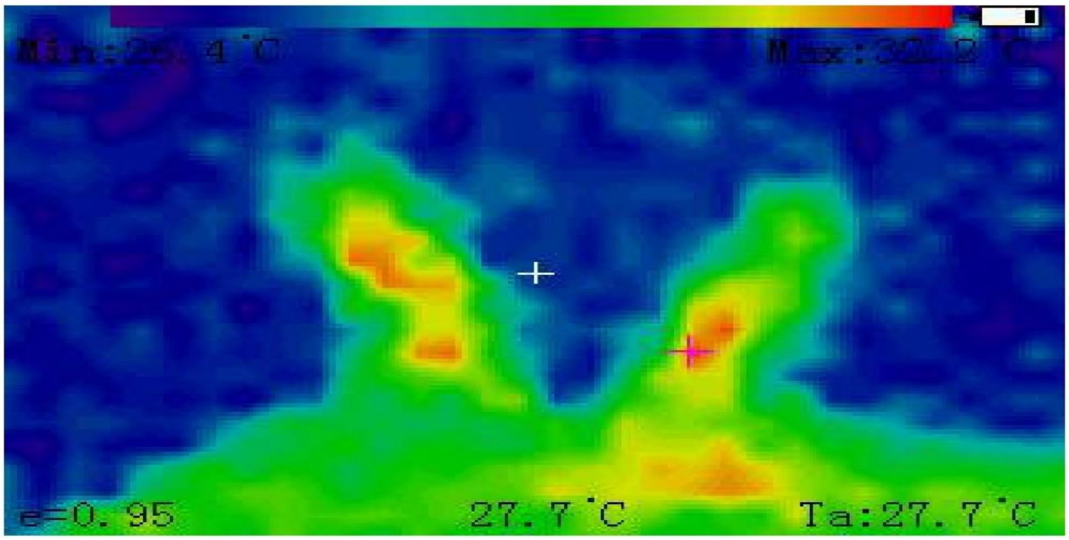

Figure 1. Test 1 input image

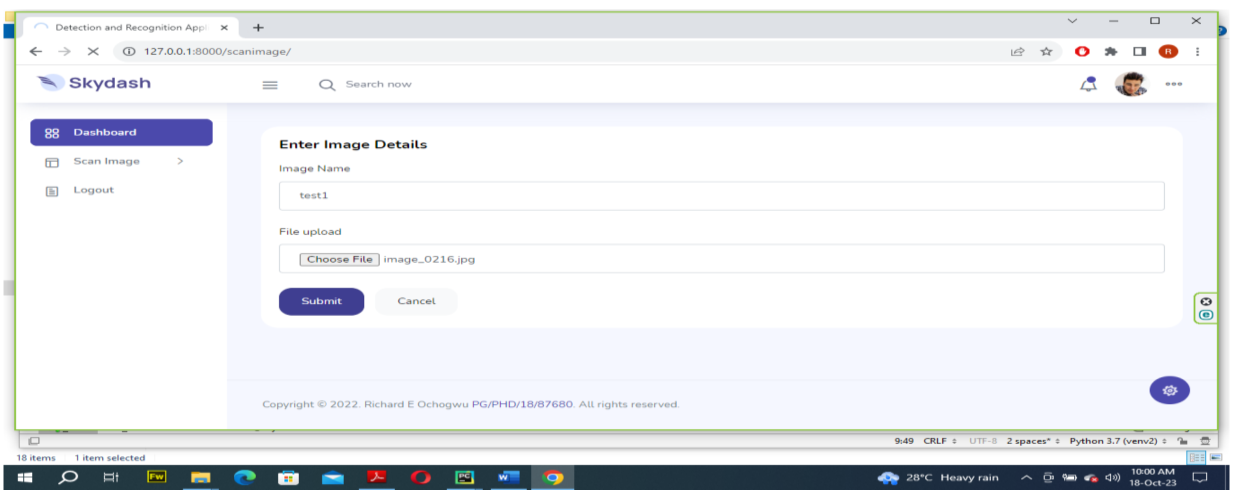

Figure 2. showing the selected image labeled test1

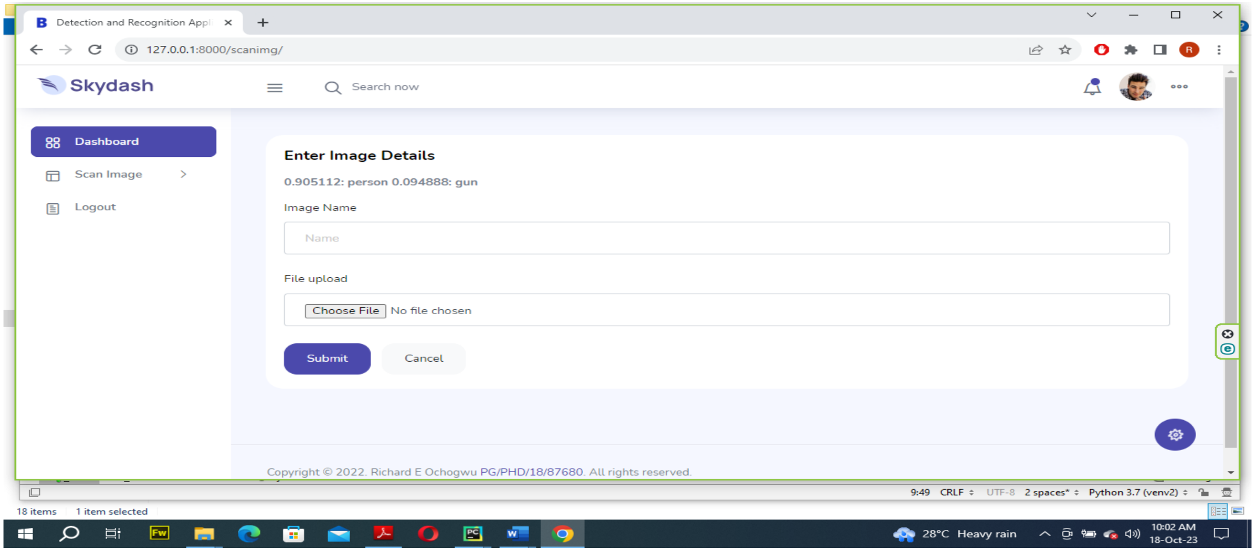

Figure 3. showing the result of test1 image.

Figure 3 above shows the result of the analysis of the image labeled test1. The result states that the probability of the image being a person without a gun is 0.905 while the image containing a gun is 0.094.

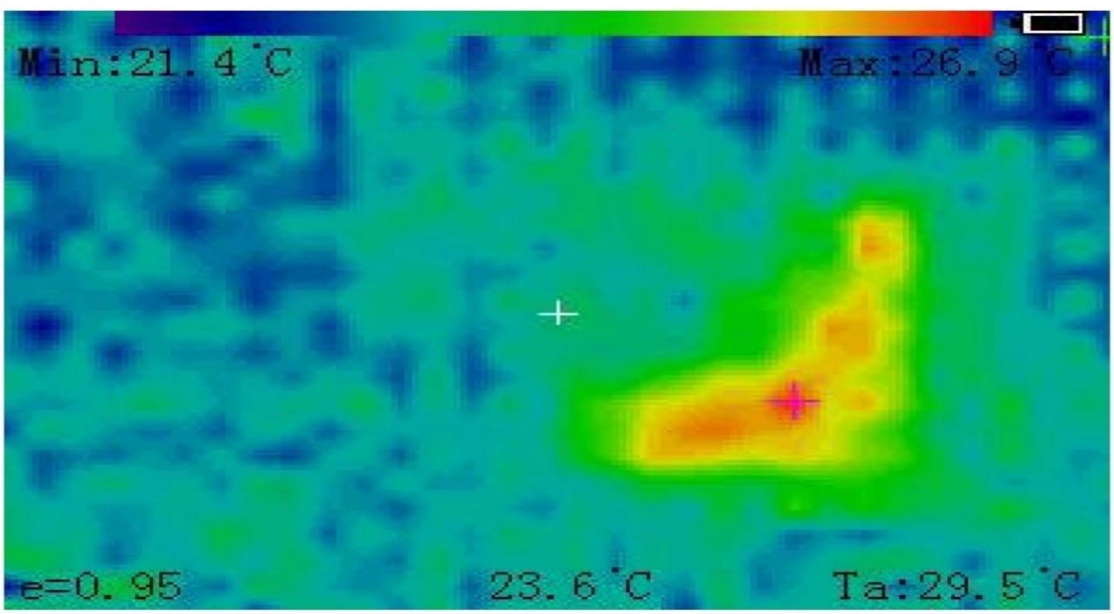

Figure 4. test2 input image

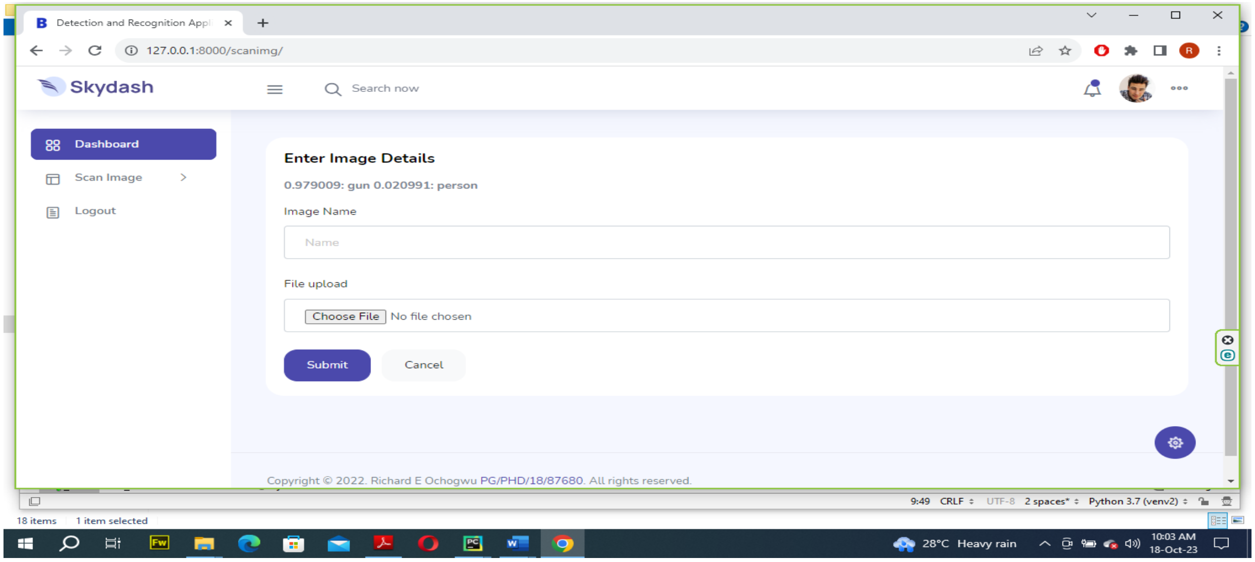

Figure 5. showing result of test2

Figure 5 above shows the result of the analysis of the image labeled test2. The result states that the probability of the image being a person with a gun is 0.979 while the likelihood of the image not containing a gun is 0.02.

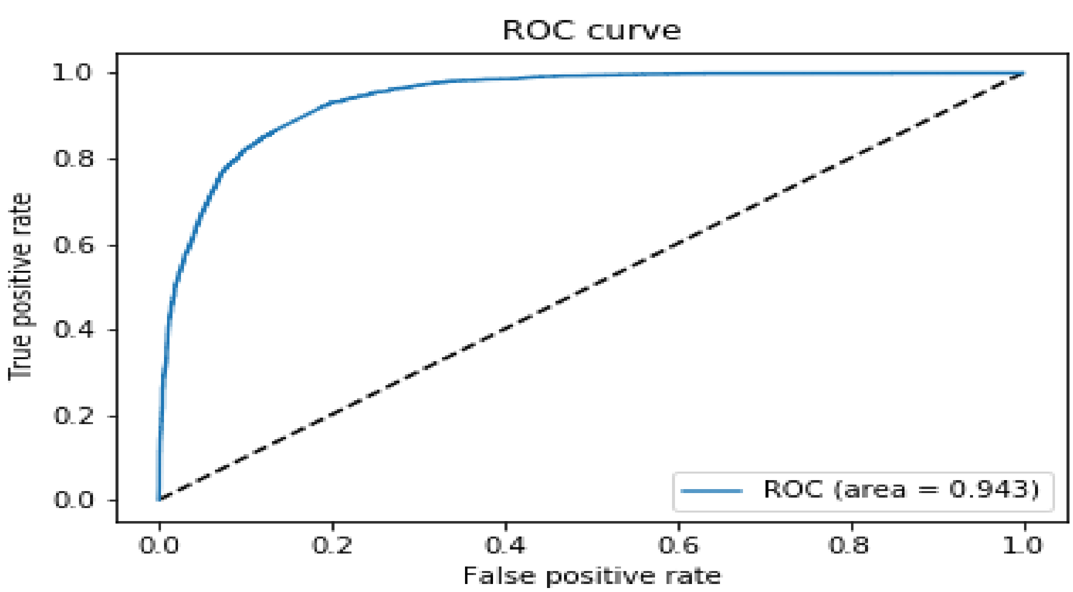

Figure 6. ROC and AUC of the CNN model

Discussion of Results

The results of the study show an accuracy of 96.00%. Findings also reveal that the CNN model gives the highest precision and lowest error rate of 0.94 and 0.021 respectively. This is particularly important since a model is better if it has higher precision and lower error rate. These results showed an improvement when compared with similar works by [9,10]. Hence, CNN + Tensorflow algorithm was used in developing the detection and recognition of armed persons system because of its highest accuracy and precision score, lowest error rate value and highest area under curve (AUC) value of 94.30 as shown in Figure 6.

Conclusion

This study has presented a comprehensive exploration into the development and application of a Convolutional Neural Network (CNN) model for the detection and recognition of armed individuals, addressing a critical and timely issue in the domains of security and law enforcement. Results show that the model in this study demonstrated remarkable accuracy in detecting and recognizing armed individuals, particularly in complex and challenging settings. Based on the results, it was therefore recommended among others that the model's integration with existing security infrastructure and data systems is essential for its effective deployment in real-world scenarios. Compatibility and seamless interaction with other security tools should be a priority.

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