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Artificial Neural Network using Image Processing for Digital Forensics Crime Scene Object Detection

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***Abstract*— Digital forensics science places a significant emphasis on the detection of objects as one of the most vital areas of study. Several industries and institutions may benefit from the object detection method, including those concerned with medical diagnostic scanning, traffic monitoring, airport security, law enforcement, and data rescue on a local and global scale. This study aims to detect weapons in video surveillance images by using various enhancement, segmentation, feature extraction, and classification methods by Artificial Neural Network to improve the detection accuracy. Yet, several mathematical and algorithmic models are computed to provide the appropriate approaches.**

Keywords*— *Artificial Neural Networks; Back Propagation; Histogram Oriented Gradients; Gun Detection; Knife Detection; surveillance camera

I. INTRODUCTION

Since there has been a steady increase in the number of crimes perpetrated on the streets of our city, it is very necessary to install security cameras inside and outside of public areas. As a consequence of the capability of surveillance cameras to detect immoral behaviour in a fraction of a second, people are better equipped to keep a watchful eye on their surroundings.[1] In addition, the surveillance cameras may be beneficial for additional investigative objectives, such as tracing the identification of a criminal or a victim, which is one of the things that can be investigated further. Despite this, more and more surveillance cameras are being put in public buildings.[2] The purpose of these cameras is to monitor the ethical and immoral behaviour of individuals working in the building, as well as visitors to the property, for example. It is not feasible for everyone to take part in the process of identifying minute particulars, such as whether or not a firearm or a knife was used in the commission of a crime.[3]. This is because the procedure requires a great deal of precision and attention to detail. As a consequence of this, a small number of experiments were carried out in order to evaluate whether or not a weapon might be recognised based on video taken from security cameras.

The growing need for surveillance cameras that are used for reasons related to monitoring, on the other hand, may be stressful for the staff who are responsible for managing multiple screens of these surveillance cameras[4]. Throughout the course of the last few years, a number of surveillance cameras have been installed with the intention of providing surveillance; despite this, Everyone struggles to monitor each camera's function[5].

The number of monitoring monitors was doubled, yet each screen showed fewer people. The appropriate authorities came to the conclusion that there was a growing need for surveillance cameras to be utilised for the purposes of surveillance, and as a result, they decided to hire professionals to work on creating automated surveillance algorithms[6].

When used to surveillance cameras, how precisely do these algorithms for automated surveillance function.[7] The automated surveillance algorithms give the authorities with aid by spotting circumstances that violate ethical standards. These situations may include the following: injuring a person or their personal property; bringing an unsuitable thing in baggage; stealing a vehicle or a mobile phone from the street; making a disturbance in public areas; and other similar scenarios[8].

The radiology and traffic monitoring departments in the health and public transportation sectors have just lately started using these automated algorithms[9]. This is despite the fact that the application of automated algorithms has only been introduced within the past few years, and that similar algorithms are now commonly used in radiography in the health industry and traffic monitoring in the local shipping industry[10].

Despite this, not everyone has the capacity to recognise even apparently little particulars, such as whether or not a firearm or a knife was used in the commission of a crime. [11]. One example of this is whether or not a particular crime was committed with a knife or a weapon. As a consequence of this, A few trials were done to see whether video surveillance footage might identify a weapon. The results of these testing were mixed. In order to fulfil the criteria of the proposed research work, an object recognition algorithm has been proposed to detect a knife present inside a camera image[12]. This will allow to fulfil the requirements of the proposed research work but this necessitates a right visual quality as well as the high resolution of a camera.

II. RELATED WORKS

Computer vision has created several object identification methods to improve surveillance systems. The goal of these algorithms was to improve the accuracy of the systems' ability to identify and track moving targets. These algorithms have been included into a variety of software packages and hardware configurations[13]. Applications for object detection algorithms may be found in a wide variety of domains, including traffic monitoring, person identification, anomaly detection, and even deterrents.

The authour developed a three-dimensional millimetres (mm) wave imaging approach for concealed crime detection (CWD) at airports and other secure regions within the body. The proposed a CWD technique using fusion-based multi-scale decomposition. This method merges a visible colour picture with an infrared (IR) image[14]. The security camera object tracking and detection capabilities in their article. The writers described how to track an object using several security cameras. Another author used proximity and interaction to locate opaque objects. Their study also considered mean fluctuation partitioning. They showed how mean segmentation of shifts might assist identify items. They tracked the object using a Bayesian Kalman filter and simplified Gaussian mix (BKF-SGM). J.S. Marques proposed several methods for assessing object recognition algorithms . B. Triggs et al.[15] proposed histogram-oriented gradient (HOG). HOG is a new architecture for character extraction. Their installations mostly detected humans. Micha-Grega et al. proposed surveillance camera blade and gun detection. Even though they used MPEG-7, principal component analysis, and the sliding window approach, they claimed adequate accuracy on their test dataset. For real-time conditions, their work may have been done faster. Despite using these procedures.[16] Classification and detection were considered when obtaining the numerous distinct datasets. Each difficulty has unique needs that must be addressed to complete the present duties.[17] Real-time implementation requires accuracy, mean average precision, and a specific frame rate. Object categorization and detection are built on object recognition. Object recognition includes categorization and detection.[18][[19]. Object localisation and object classification may solve any detection difficulty by supplying the class name and frame location of our desired item. By defining the frame region. All detection difficulties may now be detected. Figure 1 shows four processes for object detection:

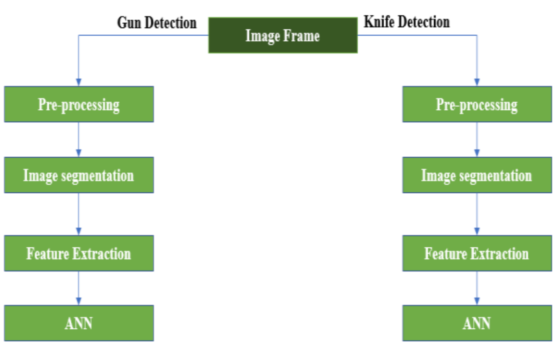


FIG.1 PROPOSED METHODOLOGY

III. OBJECT DETECTION METHODS

Working on the theory of neural networks is going to be one of the things I do to be ready for my experiment. The workings of a neural network are organised into layers, with each layer being built up of numerous linked nodes that are each in charge of a certain task. The neural network receives pattern representations as input, which are processed by hidden layers and then displayed as a result by an output layer. In other words, the neural network is taught by examples. The fields of artificial intelligence and machine learning both make use of neural networks.

A. *Image Enhancement*

Picture enhancement, often known as noise reduction, may enhance a fuzzy image. The highest-quality FIR Kolmogorov Filter will be utilized for picture enhancement. This filter removes picture noise without altering the final outcome. The best FIR Kolmogorov filter suppresses fuzzy picture noise. The most crucial function is perfect. This filter reduced image noise significantly. This filter used a static value after calculating a noisy procedure to increase picture loudness. This reduced noise.

B. *Segmentation*

Segmenting an image into smaller sections allows each block to have a different pixel value. This makes complicated images possible. Clustering-Based Segmentation will be utilised during segmentation. The left-side vector is often scalar Clustering-Based Segmentation. With this technique, we can switch an image's location from left to right, or from up high to down low. This method is used as it linearly splits a frame in order to look for relevant details.

C. *Feature Extraction*

"Feature extraction" is the process of identifying an item in a picture by its distinctive traits. Geometric and appearance traits may be included. An object's geometry and visual attributes determine its size, shape, and location in a photograph. Appearance attributes define the intended object's look. Nonetheless, a good feature vector is needed for effective object identification tests. "HOG" (histogram oriented gradient) is a technique for extracting object identification properties. Navneet Dalal and Bill Triggs invented it.[20]. This approach describes and examines the object's shape using intensity gradients or edge directions. Figure 2 shows how this approach cuts the picture into squares and analyses each cell's attributes.

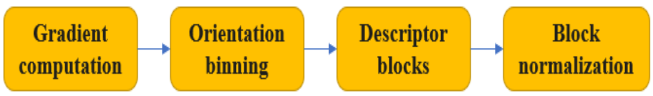


FIG.2 HOG IMPLEMENTATION

D. *Performance Assessment of a Classifier*

Table 1's iterations, neurons, learning rate, and training samples help assess neural network performance. Table 2 lists total iterations. Back-propagation techniques build the neuron network, but parameters and the receiver operating characteristics graph must be plotted to develop a variety of neural networks. Back-propagation builds the neuron network. The receiver operating characteristics graph selects, organises, and visualises a classifier's performance by classifying positive and negative data[21]. It also shows neural networks with high true positives and low false positives. After validating the testing dataset, the trained classifier will present four potential outputs.

Neural Networks for Classification Neural networks may be useful for knife recognition. A histogram of directed gradients feature vector may categorise a picture. The calculated feature vector value allows this (HOG). This value is a classification vector input. Classification begins with one output layer neuron. This neuron values items based on their presence. This lets you identify a certain object in an image: The number 1 means the object exists, whereas 0 means it does not.

IV. IMPLEMENTATION

Our experiment requires 500 x 500, 650 x 450, or 900 x 650 pixel photos. The method will be evaluated using low-resolution Google images of individuals wielding knives and MATLAB software. Both will be done during the trial.

A. Kolmogorov Filter Picture Enhancement Our study aims to enhance the visual quality of foggy pictures using a noise-reduction filter, which may also make low-resolution photos seem higher-resolution. To improve image quality, the Kolmogorov Filter will be used throughout image enhancement. This improves the product ..Picture Partitions with Clustering-Based Segmentation Matrix, a plot of an image on its x and y derivatives, divides a picture into four planes for initial segmentation. I used a Clustering-Based Segmentation of 100 by 100 pixels. As a result, image segmentation may get underway. This will allow me to divide up the market.

So, the Clustering will begin at the top left pixel and test each segment for classification in an image of 400x400 pixels for knives and weapons. Repeat until objective is reached.

Histogram-Oriented Gradient Extraction follows. After classifying each segment of the 100 x 100 pixels using a clusturing, The x and y derivatives of the histogram-oriented gradient feature will be used to tally each segment in advance of the knife and gun identification procedure. The 100 x 100 pixels will be divided into 8 x 8 rectangular blocks of 64 pixels using unsigned orientation from 0 to 180 degrees by counting x and y derivatives. After dividing the 100 × 100 pixels into 8 by 8 pixels rectangular cells, this will be done.

Classifiers are created using training samples and hidden layer neuron counts. These two factors allow the system to accurately identify blades and guns. Figure 4 shows how Classifier A, B, C, and D may be used to categorise various arrangements. The method and calculation phase of testing and training may go quicker with more neurons in each hidden layer.

TABLE I. DATASET OF KNIEF AND GUN

Classifier A	Classifier B	Classifier C	Classifier D
• 40 neurons of first layer	• 45 neurons of first layer	• 65 neurons of first layer	• 65 neurons of first layer
• 50 neurons of second layer	• 55 neurons of second layer	• 60 neurons of second layer	• 60 neurons of second layer
• Positive images 4000	• Positive images 4000	• Positive images 2100	• Positive images 520
• Negative images 3200	• Negative images 3200	• Negative images 2000	• Negative images 400

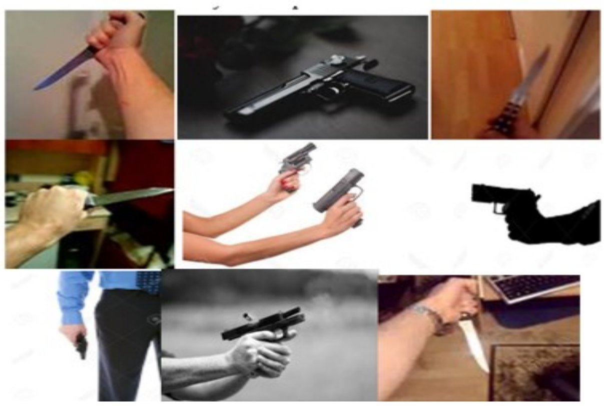
TABLE II. TOTAL ITERATIONS

Type	Training	Testing
Positive image	4500	3600
Negative Images	3800	3300

A. Detection of Knife and Guns

Table 3 of this article show instances of knives and weapons identified using the classifier B, which was created specifically for this assignment (both of which may be found below).Figure 4 demonstrate the traing and testing data sets used for the analysis . Neural networks identified the knife and pistol in the picture with a "1" result. The neuron's output controls activity at 0.4. This assignment requires identifying the knife and rifle using the rectangle box in picture 7. The neural networks learned to use 0.5 between "1" and their initial point. The threshold is 0.6, and the neural networks are trained around "1."

Training dataset



Testing dataset

FIG.3 TRAINING AND TESTING DATA SETS

TABLE III. KNIVES AND WEAPONS IDENTIFIED USING THE CLASSIFIER B

Parameters	**Knife**	**Gun**
Number of Layers	5	4
Number of Neurons in Layers	6200	3800
Numberof Neurons in the 1st Layers	80	80
The number of neurons in the 2nd layer	70	70
The number of neurons in the Output Layers	1	1
Number of iterations	230	245
Learning Rate	0.04	0.04

V. RESULTS AND DISCUSION

Improving one's appearance is the major objective of the work that will be completed for this project. The use of the Kolmogorov filter, which will ultimately lead to an enhancement in the picture's overall quality, will be used to achieve this goal. The second objective includes the extraction of features through the application of a hog feature descriptor, the detection of weapons such as knives and guns through the application of a clusturing for image segmentation, and finally the classification of weapon detection through the application of neural networks.

Improvements Made to a Knife and a Gun as a Picture The use of a noise-reduction filter, such as the one seen in Figure 4, is the major focus of this inquiry, since its primary objective is to improve the overall visual quality of low-resolution photographs. Because of this, we will be able to notice more information in a photo of a knife and a firearm that was before unclear. For the whole of the process of refining the image, the Kolmogorov Filter, which may clean up a picture without diminishing its overall quality, will be used.

FIG.4 AUGMENTATION OF THE IMAGES OF A KNIFE AND A GUN

The area that is 640 pixels wide and 480 pixels high may be separated using the clustering that has dimensions of 120 by 120 pixels. When the segment was separated, a feature descriptor was used to ascertain those characteristics that are unique to each individual section. This was done by using a histogram-oriented gradient in Figure 5. In the photo, you can see a fraction of the feature value that the hog has for identifying bladed weapons and firearms.

TABLE IV.CONFUSION MATRIX FOR KNIFE AND GUN

Knife & Gun	**Non-Knife and Gun**	**Total Percentage**
6200 54.78	3800 36.65	89.78 91.52
959 62.32	870 78.21	88.25 89.72
93.54 76.68	76.50 29.91	87.80 39.82

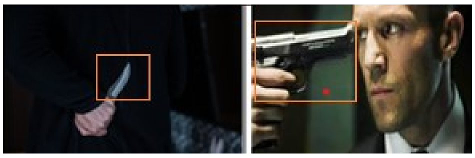


FIG.5 HOG DESCRIPTOR DETECTION OF KNIFE AND GUN

VI. CONCLUSION

Based on the findings shown above, I decided to make use of neural networks for my investigation since I found them to be more effective than support vector machines. In order to improve the accuracy of an artificial neural network and its overall performance, I used a few additional methods, such as image segmentation by applying a Clustering-Based Segmentation, extracting HOG features, and applying the application of the Kolmogorov filter to reduce background noise. Consequently, Object detection is affected by several elements, including the image's enhancement, segmentation, features, and classification, as well as the item itself. This is because object detection is a procedure used to identify things in pictures that shouldn't be there. Both training the algorithms and pre-processing the dataset will take much more time. The suggested method for the machine learning technology has a split of 80-45, with 80 percent of the data being used for training and 20 percent being used for testing.

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