Armed and Partially Covered Face Related Robberies Alerting System Using Computer Vision

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***Abstract*— Robbery is the completed or attempted theft, directly from a person, of property or cash by force or threat of force, with or without a weapon, and with or without injury. Armed robbery is a serious crime that can traumatically that emotionally and mentally profoundly traumatize its victims. Armed robbery is usually motivated by a desire to acquire money, which is then commonly used to buy drugs.** [1] **However, some armed robbers are associated with the crime.** [2] **In the current decade, armed robbery is one of the major issues in society. According to Statista research department, there were more than 0.25 million armed robberies happened in the USA in 2018.** [3] **Moreover, these robberies accounted for an estimated $438 million in losses.** [2] **. Moreover is the USA there were more than 10000 murders, victims, by weapons in 2018.** [4]**When analyzing most of these armed robberies have happened locations are Banks, Gas or Service stations, and commercial houses in the USA. To monitor and act accordingly to the issue still, there is no proper method. Present in most places there are several security officers to monitor these robberies within 24H using CCTV cameras.**

In this research, the authors propose a novel approach to prevent this issue using a computer vision-based armed robberies alerting system. Here this system is able to detect the weapons of the robbers. Since most of the time robbers come with partially covered faces. In this research, the proposed system is able to detect partially covered faces also. When the system identified weapons or a partially covered face in a bank or a commercial house, it will send an alert by notifying the risk of the robbery to the in house security officers and relevant authorities. The proposed solution used an object detection model and a facial landmark identification based approach to detect robbers. Because of this system, no longer the security officers need to monitor CCTV cameras by themselves

Keywords – Yolo, Object Detection, Image processing

1. Introduction

Essentially, robbery is theft accomplished by violence or the threat of it. Robbery can do with or without a weapon and with or without an injury. [5] Unlike theft or burglary, the crime of robbery almost always requires the presence of a victim who is threatened with bodily harm. If a weapon like a gun or a knife is used for the victim that is charged as armed robbery. [6] [7]However, armed robbery can be identified as the most serious one of these and it is also caused for the crimes. Armed robberies are usually motivated by a desire to acquire money and steal other valuable things like cars, gold..etc. In most of the African countries, armed robberies are commonly used for drug-related activities. [8]These armed robberies are a major issue in society. According to the statistics in the USA robberies and murders have done using firearms is rapidly growing within the past decade.

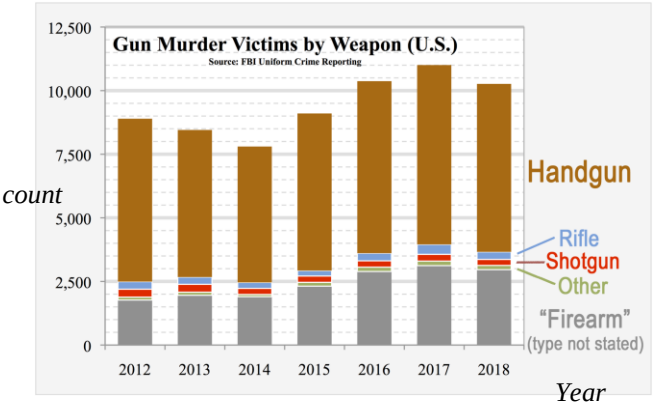

Fig.1. USA Robberies and murders using firearms. [4]

By the above statistics(Figure-1), it can clearly understand the growth of the robberies and murders using firearms. Other than firearms, robbers or murders use knives and partially covered face techniques.

When analyzing the statistics in most cases, robberies in the USA are done indoors. According to the Crime database in the USA indoor robberies and crimes are more than 40% present from all the robberies and crimes.

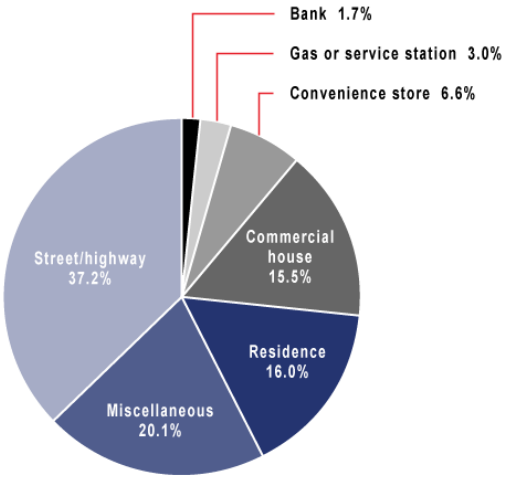

Fig. 2. Robberies by the location [2]

By the above chart, it will clearly describe the percentage of indoor robberies. However, from past to present there is no proper solution to avoid, minimize, or monitor these robberies or make a quick attendance by alerting. What the relevant security authorities do is after the robberies they will do an investigation and take action. Sometimes they will take too much time to identify victims.

As we know present most public places and houses are protected from the CCTV camera system. And there are special security members to monitor these cameras in real-time. So this is the main technique and most common technique used to identify robberies. Therefore in this research authors proposed a novel approach to identify robbers and send alerts to the in-house security officers and relevant authorities. In most of the cases, robbers come with partially covered faces. And most of the time they are ready for an armed attack. Therefore here in the proposed research approach authors suggest identifying robberies using arms detection and partially covered detection techniques using a video deep learning-based computer vision approach.

Here for the implementation as the main techniques, authors will use deep learning and facial landmark recognition. Moreover, the authors hope to integrate the system with the CCTV camera systems. By using the proposed system no longer, the security officers need to monitor CCTV cameras by themselves. When the system identifies a risk of robbery it will automatically send an alert to the security officers' mobile.

The above mentioned are the identified problem statement in this research and the brief introduction about the proposed solution. The authors hope that this will be a novel approach to minimize the harm of the armed robberies and this will be a good solution for the identified social issue. In the next chapter, it will discuss the competitive works and how the proposed system differs from those.

2. Literature Review

In the past two decades armed and partially covered face-related robberies, become a huge problem for society. In the USA, these robberies accounted for an estimated $438 million in losses and annually there were more than 1000 murders reported. [2] [4].In case of that to avoid or minimize this social problem there were several researchers have done. In this chapter, it will discuss how the most recent competitive researches and how the proposed system by the authors differs from those briefly.

A research by Giorgio Morales and Itamar Franco Salazar Reque named Detecting Violent Robberies in CCTV using Deep Learning proposed a competitive solution to the proposed solution. Here they used a video dataset calle UNI-Crime and using a convolutional Long-short Terr memory model (ConvLSTM) they trained the model. Here they were able to get a 96% percent accuracy [9]rate. However, the proposed system is for detecting armed and partially covered face related robberies identification. Moreover, it will use deep learning approaches to the process.

Gun and Knife-Detection on Faster R-CNN for video surveillance is a competitive research by M.Milagro and his team. In this research, they used a pre-trained Faster R-CNN model-based approach to detect firearms and knives. Here they use CNN base two architecture approaches to detect each firearm and knife. Here they obtained an 85.4% accuracy rate for firearms detection using SeequenzeNET architecture. And 46.68 % for knife detection using GoogleNET architecture. [10] However, as a problem authors identified that the accuracy of the knife detection is low.

Automated detection of firearms and knives is research by four Poland researchers. In this research, they used an image processing based approach using pattern recognition and fuzzy classification approach to identify knives and firearms based robberies.

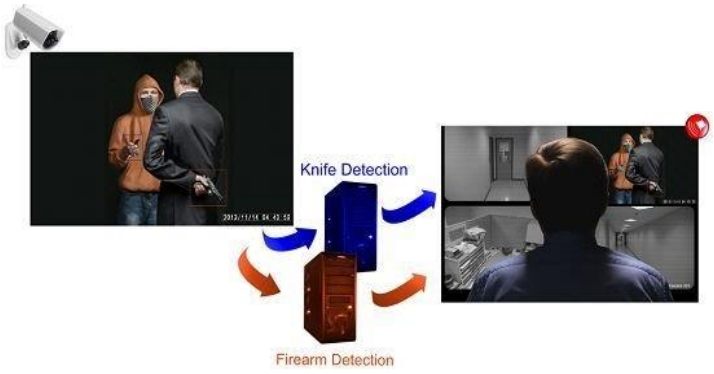

Fig .3. Main Components of the application

The above image clearly shows the methodology they used. There are two separate components to identify firearms and knives. So their application was a combination of those two components. [11]However, in the proposed solution by the authors, it will detect all the arms using a single image processing based component and it will be identified partially covered face related robberies.

When analyzing the past works there were several pieces of research done to identify armed robberies using human pose detection techniques. Five Indian researches did great research using Image processing based human pose detection technique. Here they trained a model to identify poses like firing, Fighting and
Knives attacks..etc. As the technology here they used MATLAB.

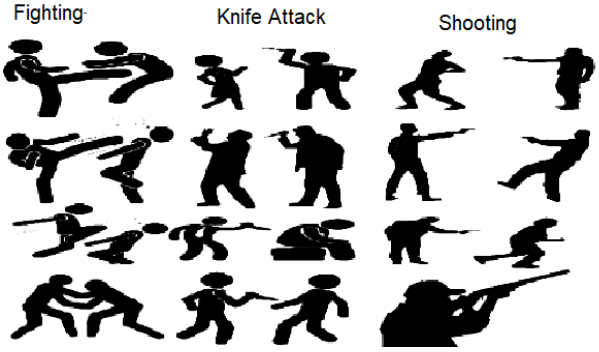

Fig. 4. Sample human activity classes used in the research

The above image (Figure-4) shows the sample of human activity classes they used in the implementation process. [12]

There was another research named Automatic Visual Recognition of Armed Robbery, which was done by three researchers in the University of Central Florida who proposed a video segmentation and human pose identification base approach to identify armed attacks.
In their proposed algorithm, there were 4 main stages. They are

1. Identifying peoples in the scene
2. Determine individual segments of the Skelton
3. Identifying poses
4. Detect arms and final output

In this approach, they were able to get good results. [13] However, the proposed system by the authors differs from these human pose based works because to detect armed based attacks it will use object detection technique.

As mentioned in the introduction chapter partially covered face related robberies are combined with armed robberies. Therefore, the authors propose that a partially covered face detection component is a core feature of the application. There was very few researches done to detect partially covered faces. Research named Partially Covered Face Detection in the Presence of Headscarf for Surveillance Applications proposed an OpenCV and a classification-based approach to this. For the feature extraction, they used the Local Binary Pattern Histogram approach (LBPH). A large dataset of a crowded office environment in the Middle East is collected and used for evaluation of their system. [14]However, in the proposed system to detect partially covered faces authors will use the facial landmarks detection-based approach because that approach is less weight and the performance of the application is also increased.

ATM Crime detection suing image processing integrated video surveillance - a systematic review is a research by three Malaysian researchers. This research reviews the research works on all possible image processing applications that can be used in the ATM surveillance camera. In this system, they prosed armed recognition based system as a good approach. Moreover, they mentioned the abnormal gestures and covered face detection. However, there is no implementation process mentioned in this article. [15] According to the statistics and ability to get good accuracy and performance authors chose armed and partially covered face detection as the core component of the system

Research by Arif wars and his team named Automatic Handgun Knife Detection Algorithm – A review is categorized and reviewed various algorithms and datasets that can use for handgun detection and knife detection. Moreover here they mentioned the strength and weaknesses of each approach. For the review process, they used algorithm like CNN, Faster R-CNN, R-FCN, SVM classifier..etc. Further, they did this review by dividing each approach into Non-Deep learning and Deep-Learning algorithms. [16] This research will be helpful to identify the most suitable algorithm for the future enhancements of the Firearms and Knife detection researches.

So above mentioned are the most competitive works to the proposed solution by the authors. However, it can clearly understand how the proposed solution differs from those. Since the proposed application uses CCTV videos in this research authors concentrate more on the performance of the application and accuracy. In the next chapter, it will discuss the methodology of the proposed solution briefly.

3. Method and Materials

The objective of this research is to build a computer vision-based alerting system for armed and partially covered face related robberies. For the armed based robberies, authors monitor the robberies done using firearms and knives. Here the main input is to get using the CCTV cameras. In the implementation process of the system, there are two main data science components. They are

1. Fire Arms and Knife Detection
2. Partially Covered Face Detection

Finally, these two components will join the alerting system, which can give an alert to the relevant indoor security officers.

For the Firearms and Knife, detection authors will use an object detection model. There are several object detection algorithms in image processing. For this research, the authors chose the YOLO v3 object detection algorithm since it gives better accuracy, and the system detects weapons from the videos the identification process needs to be fast. When it compares YOLO and R-CNN algorithms YOLO is 1000 times faster than R-CNN. [17].

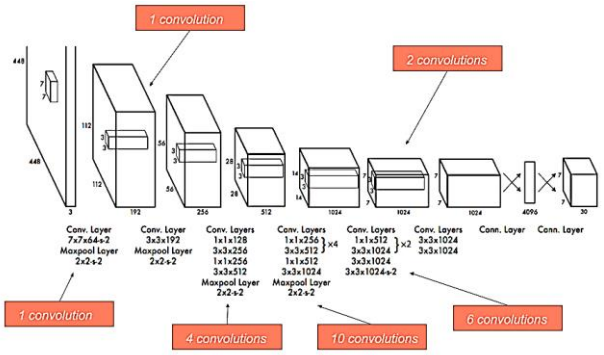

Fig. 5. Architecture of the YOLO

YOLO is able to work as a pre-trained object detector for several objects and it can use to make custom object detection models. So in this research authors make a custom two-class object detection model using YOLO for the weapon detection component. For the training process, the authors used GOOGLE Colab as the IDE because it takes heavy GPU power. As the inputs, authors prepare a custom dataset, which includes images of knives and firearms. Moreover, for YOLO there is a special data input format. To convert images into that format authors used an application named labelmg.In the next chapter, it will discuss the datasets briefly.

In this research, a key point that the authors identified is most of the robbers came with partially covered faces. So here, the authors proposed a component, which is able to identify those also. For the implementation, process authors going to use OpenCV and dlib.To detect partially covered face detection. Python is the man programming language, used for the implantation of this component also. The authors are going to implement an algorithm using facial landmarks. For identity, facial landmarks it will use a pre-trained dlib 68- point iBUG 300 data set. [18]

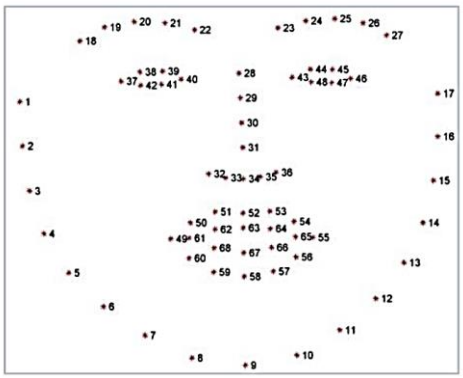

Fig. 6. Facial Landmarks

Most of the time if a face is partially covered that means the parts of the face such as eyes, nodes, and eyes are covered. In a robbery most of the time this could be nose and mouth.

[19].Therefore authors apply this theorem to detect partially covered face identification using their own algorithm. This algorithm made by the authors uses the above pre-trained landmark detection model and it analyzes the eyes, mouth, and nose of a person and detects whether if each two or more facial parts are covered. To improve the accuracy and minimize the processing speed of the component authors used OpenCV haar cascade files to detect human faces. Those detected human faces are going through the pre-trained landmark detection model and the algorithm proposed by the authors to determine whether there is a partially covered face or not.

These two components work as a single unit. So if it detects a person with armed items or a partially covered face or both it the system will capture the relevant person's image and send details to the alerting system. In the initial stage of the implementation, the authors hope to send an alerting message with the captured image of the person for the indoor security officers' mobile phone. For sending the message here authors are going to use the well-known cloud communication platform Twilio.

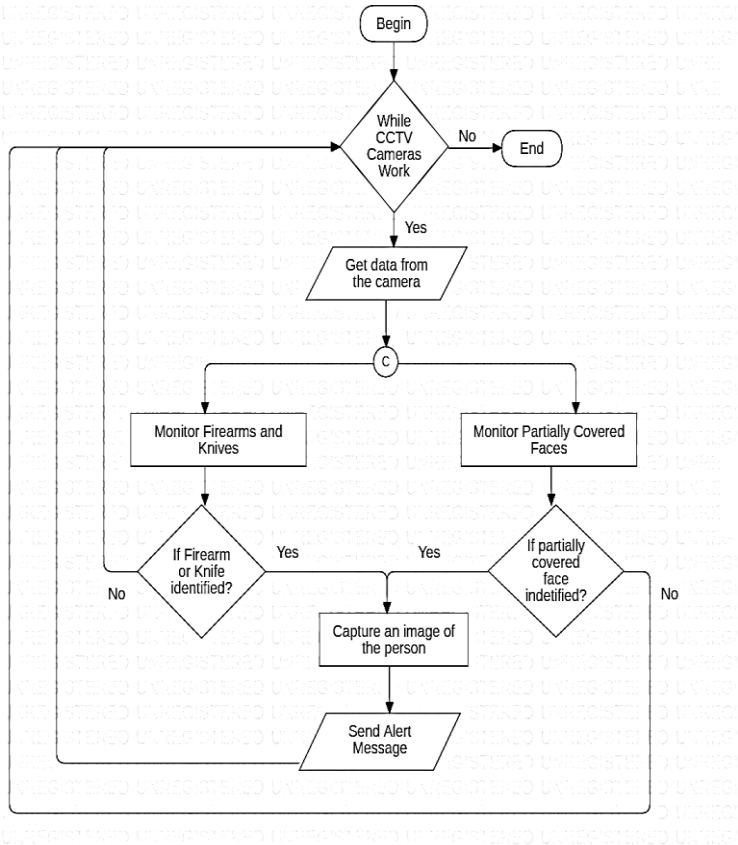

Fig. 7. Flow of the system

The above flow diagram(Figure-7) described how the proposed system works after the implementation briefly

So these are the method tech materials used to develop the main components of the research. This chapter had described all the flow of the implementation in a very descriptive way. Moreover, it will clearly be described how this research will be different from the competitive researches. The next chapter, there will be discussing the result of the research, data used for the implementation process, and the accuracy of each component.

4. Data and Result

For the Implementation of the research, mainly two datasets were used. Both of them were used to train the weapon detection model using YOLO. From the Internet, authors get Knife and firearms dataset and by integrating them authors make a two-class dataset. Thereafter using labelmg tool authors get the image format, which is used in the YOLO algorithm. This format specifies the absolute position of the object and its class that we need to train in the training dataset. The below image (Figure-8) describes how to convert an image to the YOLO format.

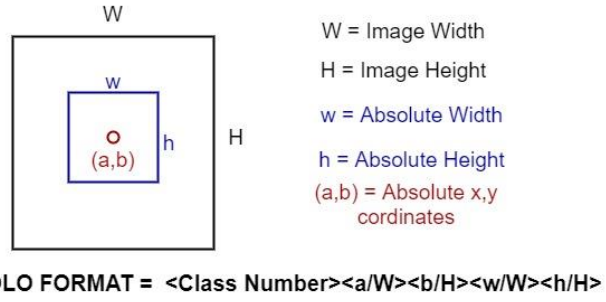

Fig. 8. Yolo Text file format

This image shows how to transform an image into the Yolo format. After transforming a set of images the dataset file seems like below. (Figure-9)

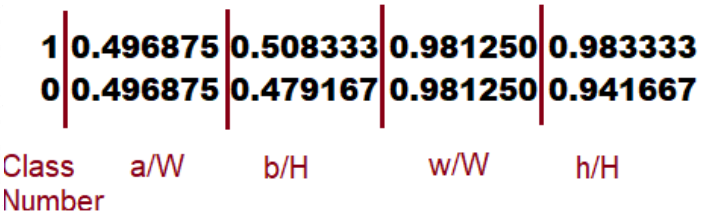

Fig. 9. Yolo Text file format Example

Thereafter as mentioned in the methodology chapter authors trained a two-class YOLO object detection model using Google colab. As the result, authors were able to get more than 70% present accuracy rate for the knife and firearm detection model. Thereafter this model is integrated into the Twilio based alerting message sender service.

The next component of the research is a partially covered face detection component. As mentioned in the methodology chapter for this authors used a facial landmark identification technique using a pre-trained dlib 68-point iBUG 300 landmark detection model and an algorithm made by authors on top of that dlib model. To verify the accuracy of the component authors use several images, which include partially covered faces. So from those verification authors get a satisfactory level of accuracy for the partially covered face detection component. As mentioned in the Methodology chapter using OpenCV haar cascades files to detect faces makes the processing speed of the application fast

So these are the data and results that get authors in the implementation process of the main data science components of the research. From those results, it is clear that the final outcome of the research is at a satisfactory

level. Moreover in the future authors hope to add several optimizations to this prototype such as improve the prediction accuracy in low light conditions..etc. The next chapter will discuss the future enhancements and issues that the authors faced

5. Discussion

The main aim of this research is to monitor armed and partially covered related robberies in CCTV protected areas and alerting about them in real-time. To achieve this goal author proposed a system that uses a deep learning-based classification model for armed robberies identification and a Facial landmark-based algorithmic approach to partially covered face detection in the research. Moreover, for the alerting system, it used the Twillio cloud communication platform to send alert messages to indoor security officers mobile. The proposed system is fully autonomous and as mentioned in the Methodology chapter it is able to work in both day and night time with a good accuracy rate.

The prototype of the research works as a desktop application and for the verification, it gets videos taken from the CCTV cameras as the inputs. However, in the future authors hope to connect the system with the actual CCTV system as a real-time process. For that authors hope to use IoT technology to connect the alerting system with the CCTV cameras.

In the development process of the application, authors have to pay attention to social and legal issues. Since this application monitor humans, faces, and objects which they carry authors have to ensure the privacy of them. Therefore in the prototype if and only if the system identified a firearm, knife, or a partially covered face only it captures the relevant person's image and sends it to the indoor security officers.

Moreover to ensure privacy and avoid social and legal issues authors won't store the monitored data into a database or any other data storage method. Moreover according to the Law if a place has CCTV monitoring there needs to notify people about that. [20]Therefore in the future when the application will be integrated into a security camera system there needs to display a notice about the monitoring system according to Law.

So this is the way how authors concentrate on the social, legal, and privacy issues when developing the prototype of the research. Finally, this research is able to give alerts about the partially covered and armed related robberies in a novel way. Moreover, the authors hope this will be a good approach to minimize the above discussed social issue, increment of the armed and partially covered related robberies.

6. Conclusion

This research is done to give alert messages about the armed and partially covered face related robberies to the indoor security officers. The main objective of this system is to minimize the increase of the armed and partially covered face related robberies and make it easier to identify the victims. To achieve this goal there are two main data science components in the prototype. They are

1. Firearms and Knife Identification component
2. Partially covered face detection component.

In the prototype, these two components are integrated into the Twillio based alerting system.

In the implementation of the prototype, there were some limitations identified. They are

1. The accuracy of the system depends on the quality of the CCTV videos.
2. The prototype is working as a desktop application and it's not connected to a real CCTV application
3. Because of the Covid-19 situation, identifying partially covered face related robberies is hard.

So these are the identified limitations of the prototype of the research. Then it will discuss the future enhancements of the system.

1. Improve the accuracy based on the quality of the CCTV video.
2. Integrate system with actual CCTV system in real-time using IoT
3. Improve the algorithm implemented to detect partially covered faces.
4. Improve the accuracy of the model in low light conditions.

So this is the way how this research was done, its limitations, and its future enhancements. The authors hope this will be a good solution to alert and identified victims easily for armed and partially covered face related robberies.

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