Crime scene is always a complex setting. There are evidences spread across the crime scene. It is very difficult for the investigator to remember the scene as it is. Here comes the role of the Forensic Photographer who clicks series of images to present a visual narrative of the crime scene. The pictorial documentation of the crime scene is important to ensure a thorough investigation. The investigator sees the images over and over again to make some sense of it. The investigator then connects the trail left in the photographs. Many theoretical, legal and technical problems come along with any photography, especially the forensic photography. As this is very technical in nature, any error or mistakes in the photography effects the overall investigation. A number of poorly shot and displayed photographs have the potential to sabotage the entire investigation. Therefore, crime scene photography is very important. The crime scene photography sets forth a visual storytelling of the crime that happened. As a basic guideline, the photographer goes from the general to specific. He clicks the entire crime scene from different angles and then moves towards any specific aspect or trail in the crime scene. As per the FBI's Forensic Science Training Manual on "The Fundamental Principles and Theory of Crime Scene Photography", the photographer covers the crime scene with three kinds of Shots

1. The Long range- that captures the entire crime scene and its settings, it can be from a vantage point or an Ariel View.
2. The mid-range -This illustrates many objects around the victim or the Scene.
3. Close Up shots- these are detailed shots of any mark, object etc.

There are then Follow Up photographs, Autopsy photographs and photographs of a live victim or suspect that display bruises or wounds. The most important aspect is the photography of the Physical evidence at the crime scene. There may be broken glass, flowerpot, Sofa that has stains, etc. These components establish the chain of custody of items presented in the courtroom during the trials.

Due to large number of photographed clicked at the crime scene, they need to be arranged in chronological manner to determine the chain of events. It is very important to make a Log. This Log contains the entire record of the photographs captured at the crime scene. It is very time consuming for the photographer to prepare the Log or report. Also, it is equally tedious to read the Logs.

Now for the investigating officer to remember each and every object in the photographs or video are always a challenge. He has to look at the images multiple times or to read the Logs. This results in reduced efficiency. It certainly will be a boon for the investigators when a Machine would analyse the images and give a list of objects detected. This will give the investigators an edge in solving crime. This would save the time of the photographer as well as the investigating officer.

Most importantly out of many crime scenes, homicide is always a challenge. In Homicide, there are many evidences that are spread across the crime scene that a human eye may often miss. There may be broken Knife, Handguns, Bottles, Axes, etc., or any such objects that may be relevant but does not catch any attention. In homicide crime scene there may be a resistance by the victim or a display of brute force by the attacker that may disrupt the setting of the location. If a machine could identify the objects in the crime scene and prepare a report of the same there could be lot of time saving in the investigation. The investigator would not need to make multiple trips to the crime scene or look at the photographs and review them multiple times.

Homicide crime scene analysis has always been a humongous task. It certainly demands the investigator to assess voluminous images. Another challenge of a homicide is timely identification of the victim. It is found that the attackers destroy any sign of identification of the victim they take away any ids, papers, phone and wallet that could help the law enforcement with investigation. Most of the time they dismember the body in faith to cause hurdles in investigation. Therefore, an early identification is essential to crack the case faster. It would be really nice if the machine could pull out every detail of a person thus by recognizing its face.

In early days this just seem hopeful but today in the age of digitization and advanced technologies such as artificial intelligence it is very much possible to do so.

The application of object detection and facial recognition would impact greatly on the time and efficiency of the investigation. The proposed model is trained to look at the aspects of object detection in crime scene and early victim identification.

The proposed model is aimed to overcome human limitations of taking a note of every object that is seen in the images it processes. So, that early investigation is carried and justice is served.

Understanding the benefits of Object detection in Crime scene analysis, we propose an architecture for intelligent evidence detection and collection system using convolutional neural network.

A sample data set is procured to train the model to detect the possible evidences and objects. The model also runs a facial recognition to identify the victim and pull out details to help the investigator. This proposed system aims to reduce the human efforts and time taken to scan through the crime scene for evidences; instead, it gives the name of objects such as gun, knife etc. from the video or image of the crime scene. This also saves multiple trips to the location and brings minute details of the crime scene to the attention of the investigator. The early identification helps in understanding the motif, thus giving an edge to the investigation and increased efficiency.

1.1 Scope of the proposed study

The scope of proposed research work is as below:

- A comprehensive model can be developed to detect crime scene objects.
- The proposed model also carries a facial recognition for early identification of the victim.
- The present study will increase the efficacy and accuracy in solving the crime.
- The proposed study will also save time and resources in solving a homicide crime.
- The proposed system display the objects detected which saves time.

1.2 Review of work already done on the subject

Previous Related Work

Traditionally Photography and videography are used to collect visual data from the crime scene. (Seckiner, Mallett, Roux, Meuwly, & Maynard, April 2018) Today, there are many technologies that ease the process of collecting, analysing and process the data collected. Today most phone has good resolution camera that makes photographing a crime scene easy, and with technologies such as artificial intelligence, machine learning and object recognition the processing of the data and

the utilization of information has significantly improved the way a crime scene is looked at. Taking this idea ahead Kamenicky *et al.* introduced various video methods and tools for processing digital images and videos for criminal investigation (Kamenicky *et al*, July 2016). However, the researcher faced challenges to identify the source of the video and images. Many investigators today prefer to use their phones for recording videos and photos as its very handy and flexible. However, many phones produce noise to which Li (Li, Maa, & Wanga, November 2018) proposed an algorithm to extract Photo Response Nonuniformity (PRNU) noise from video that is shot by phone camera.

Today CCTV systems contribute as source of large amount of Visual data that is stored every day. These hidden surveillance cameras often record the whole crime right form its inception. CCTV footage plays Key role in digital forensics. The strength of the evidence relies on the visuals it has recorded (Seckiner, Mallett, Roux, Meuwly, & Maynard, April 2018). Therefore, the quality of the footage is very vital for the contents-based proofs recorded. Jenkins and Kerr (Jenkins & Kerr, 2013) proposed an images analysis using facial recognition that can be implemented on high quality recording devices, like smart mobile phones for better investigation. Today this automated image analysis from video is used for public security or detection of dangerous circumstances in many places around the world (Grega, Matiolański, Guzik, & Leszczuk, 2016).

Typically, CNN consist of multiple convolution layers, ReLU (Rectified Linear Units), pooling layers and fully connected layers. The last layers of a CNN generate activations that act descriptor for object detection and classification. Babenko (Babenko, Slesarev, Chigorin, & Lempitsky, 2014) named them as neural codes and proved that such activations can be used for image retrieval task. They also found that the descriptors perform competitively even if a CNN is trained for separate classification task. For instance, the objects in Imagenet (Russakovsky, Deng, Su, & al, 2015) datasets and MS-COCO (Lin, et al.) datasets can be used interchangeably for training the CNN model. Soon, Girshik (Girshick, 2015) proposed Fast R-CNN, that replaced SVM classifiers with neural networks. Ren *et al.* (Ren, He, Girshick, & Sun, 2015)introduced Faster R-CNN, a faster and upgraded version of Fast R-CNN, that replaced the region proposal method with RPN (Region proposal Network), it

also simultaneously predicted object bounds and scores. Joseph Redmon *et al*. (Redmon, Divvala, Girshick, & Farhadi, June 2016) in 2015 introduced a much efficient algorithm for object detection and especially facial recognition called You Only Look Once, a Real time object detection module that is much faster than the RCNN models. YOLO performed Object detection in single stage, thus increasing the inference time. In 2016, Redmon came up with YOLOv2 and in 2018 with YOLOv3 (Joseph Redmon ; Ali Farhadi; 2018) .These versions were bigger, faster and more accurate than its predecessors were. However, as of 2020 YOLO has had many upgrades making it a perfect option for multiple object detection within one scene. S. Saikia et al. (S, E, E, & L, 2017) in their paper have tested a crime scene dataset using the Faster R-CNN and achieved the accuracy of 74.33% and the time taken to detect an object was 0.12 secs.

Samson, Oladipo & Emeka (Francisca, Emeka, & Femi, 2020) have applied YOLO for crime scene evidence analysis. They have trained five classes' objects with 1,173 custom images common to indoor crimes. Further, they deployed it on to android-based forensic case documentation. However, they have only explored the object detection aspect only. Taking their work ahead, this thesis is aimed to make a comprehensive tool for Crime Scene analysis.

1.3 Research gaps identified in the proposed field of the Research

1. Every crime scene is different and has different clues, the foremost gap is training the model for multiple crime scene objects.
2. The next is shooting the video or image of crime scene under adequate lighting condition, the system may perceive the objects differently under different lighting.
3. The accuracy of the object detection and facial recognition may depend on the quality of image and resolution.
4. Detecting objects with similar features can also be a challenge.

1.4 Objective of the proposed study:

The specific objectives of present research are as below:

1. To identify the problems faced by the Investigators of a complex Homicide Crime Scene.
2. To develop a model using Object Detection algorithms to solve these problems.

3. To test the accuracy of the developed model.
4. To run facial recognition and identification of the victim.

1.5 Research Methodology & Detailed research plan

The proposed technology

The proposed model processes the crime scene Images and videos to detect objects and does a facial recognition on the victim to retrieve the records from citizen database. All identified objects are displayed as a list. The model is trained on few different classes of objects such as furniture, weapons, electronics, etc. Every detected object from the image has to belong to a single class of object. The Images for training the model are sourced from open-source platforms. The researcher then trains YOLO to identify objects of these classes and perform a facial recognition as well.

The researcher proposes the use of YOLO (You Look Only Once), as YOLO makes less than half the number of background errors compared to Fast R-CNN. It also learns generalizable representations of objects. (Juan, 2018) YOLO uses features from the entire image to predict each bounding box and also predicts all bounding boxes for an image consecutively. The system divides the input stream into a $S \times S$ grid. If the center of an object falls into a grid cell, that grid cell is responsible for detecting that object. Each grid cell predicts B bounding boxes and confidence scores for those boxes. These confidence scores reflect how confident the model is within the contained box. Based on this score the model predicts its accuracy. YOLO predicts an objectless score for each bounding box using logistic regression. Both image classification and object localization techniques are applied for each grid of the image and each grid is assigned with a label. Then the algorithm checks each grid distinctly and marks the label which has an object in it and also marks its bounding boxes. The labels of the grid deprived of object are marked as zero. By using Bounding boxes for object detection, only one object can be identified by a grid. In case of multiple objects where a bounding box overlaps the other YOLO uses Anchor boxes, anchor boxes have a definite ratio and they try to detect objects that nicely fit into a box with that ratio. YOLO uses a also comes with a complex feature extraction module, it uses a successive 53 convolutional layers of 3×3 and 1×1 layers called Darknet 53. The Yolo is trained with the custom weights to detect and scan a crime scene.

1.6 Chapter Scheme

Chapter 1 Introduction

This is the introductory chapter that gives an overview of the proposed idea. In this chapter the research plan and flow of the thesis is discussed. This chapter iterates the objective, scope and the limitation of the proposed research.

Chapter 2 Review of Literature

Review of literature is the first step to research. This chapter evaluates all the research and work done in the area of forensic photography, object detection and facial recognition. This chapter sets the base for conducting the research.

Chapter 3 Forensics photography

Forensic photography is a technique of photographing crime scene, searches and investigation stages. This keeps a visual record of the crime as well as the investigation. This technique tells a visual story of the crime scene. Since this research is based on images and videos of crime scene, it is very essential for us to explore the forensic photography. Understanding forensic photography and its limitations will help to shape the research better.

Chapter 4 Journey of object Detection

This chapter give a brief walk through in the journey of object detection. Object detection is a very essential aspect of computer vision and imaging. There are many algorithms that enable us to perform object detection and facial recognition. This is very crucial aspect of this research as the proposed research is based on detecting objects in crime scene and facial recognition.

Chapter 5 Experimental Setup and Evaluation

This chapter prepares the model for training and experimentation. The images for the training classes were collected, labelled and augmented. Using the Google Colab the model was trained with object classes and people classes; The images were prepared for training on various models of YOLO. Also, various Evaluation Metrics were discussed.

Chapter 6 Result and Discussion

The model was trained on various models of YOLO, to furnish results on said evaluation Metrics. Results for each class were evaluated and interpreted to compare the different models of YOLO in order to identify the best suitable model for real world application.

Chapter 7 Conclusion and Future Work

This chapter furnishes the results of the proposed research and briefs the research findings. This chapter also highlights the future prospects of the research. This research if implemented can certainly bring about a magnanimous change in the perspective of crime scene analysis. This research aims to multiply the efficiency and accuracy of investigation.