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FORENSIC VIDEO/IMAGE ANALYTICS – A DEEP LEARNING APPROACH

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Abstract: Forensic video/Image analysis techniques are used many times to perform visual data analysis. Video/Image forensics analysis is considered to be important to show that images and videos which are to be used as potential evidence in court of law are verifiably true / authentic. The popularity of digital devices such as smart mobile devices and also due to increasing number of low cost surveillance systems, several forms of visual data are widely being used in digital forensic investigation. Digital videos are used most of the times as key evidence sources in evidence identification, analysis, presentation, and report. A Deep Learning based forensic video/image analysis framework can be developed that employs an efficient video/image processing techniques using deep learning, such as object detection framework YOLO V3, CNN based summarization of videos, enhancing algorithm for the low quality of video footage analysis which consists of adaptive video enhancement algorithm based on Contrast Adaptive Histogram Equalization (CLAHE) technique, Contrast Exposure Fusion Algorithm, Dynamic Histogram Equalization (DHE) which are termed to be useful in order to improve the quality of visual data for the use of digital forensic identification & investigation. The technique of Video/Image tampering detection using state-of-art techniques and textual enhancement are also termed to be important in order to assist in truthful analysis of visual data evidence. The framework would deploy recent techniques and algorithms which will assist examiner to perform visual analysis of evidence data**.**

Index Terms **- Video/Image Analysis, deep learning, object detection, Enhancement Algorithm, CNN based Video summarization, tampering detection.**

I. INTRODUCTION

The field of computer vision is emerging and growing rapidly which has many more computational processing power, memory & digital resources today involved. Videos today are termed to be the most popular media for communication and entertainment. Whereas these popularity would demand automatic analysis and understanding the content of a video through technology, which is termed to be one of the important goals of computer vision. One of the very basic problems of computer vision is to model & detect the appearance and behavior of several objects and subjects in a video. Such kind of models mainly & mostly depends on the problem definition. In the growing digital world today more than 1 Billion new users visit YouTube each month, whereas watching 6 billion hours of videos, and are uploading 100 hours of video for each minute. Meanwhile cameras today are hence termed to be ubiquitous and are sifting through this ocean of data, which not only pose a major global challenge but also demand understanding the content of these data in a truthful and right way. This widespread visual digital media data, today in recent years has made the automated analysis of its content necessary in several various fields of its application. Videos may be analyzed for the tracking, detection and recognition of several human activities in a variety of applications, ranging from indoors environments to outdoors locations, such as videos in the wild situations. As the subject is termed to be widespread and visual data is being used in several real aspects of life, content analysis of such visual data is termed to be important.

The proposed framework is divided into four parts. The first part consists, of deep learning based video analysis methodologies such as YOLO object detection technique. The second part consists of Video and Image Tampering (Forgery) detection techniques using deep learning. The third part consists of CNN based summarization of videos. Whereas the fourth part consists of image enhancement module including Contrast Limited Adaptive Histogram Technique (CLAHE), Dynamic Histogram Equalization, Contrast Exposure Fusion technique and wiener filter textual enhancement, hashing modules.

II. LITERATURE REVIEW

The paper ”Video-Based Evidence Analysis and Extraction in Digital Forensic Investigation”[1] elaborates about many digital forensic image/ video analysis techniques such as deep learning object detection framework using YOLO technique, CLAHE image enhancement technique, color and shape based object detection methodologies. The paper not only addresses several forensic visual data analysis problems and solutions in order to perform digital video based analysis in forensic environment but also describe about several latest techniques of visual data analysis. Several experimental results of object detection and image enhancement techniques are displayed which can conclude that YOLO as object detection can be used to detect the several crime objects and suspects and can also be used to establish link between several crime scene objects and suspects. The CLAHE image enhancement technique is termed to be useful technique in enhancement of natural and artificial images in many low light and poor visual data scenarios. [1].

J. Redmon, " YOLOv3: An Incremental Improvement". [29] Authors describe some updates to YOLO! They made a bunch of little design changes to make it better. The article compares the several results of multistage and single stage detectors of object detection. The results conclude that YOLO V3 of object detection outperforms other object detectors in terms of speed and accuracy.

Due to availability large volume of visual data indexing, management and retrieval of such a data becomes challenging. The technique of video summarization is used to detect important visual data from the visual stream and can help in efficient retrieval and indexing of required data from the surveillance datasets. The paper proposes an efficient CNN based summarization method for videos of resource constrained devices. Shot segmentation is an efficient technique and backbone of video summarization techniques and which also affects the overall quality of the generated summary. Thus here an effective shot segmentation method is proposed using deep features. Also the technique maintains the interestingness using entropy and memorability. The technique works on the methodology where the frame within each shot with highest entropy score and memorability is considered as a key frame. Several benchmark datasets can be used to state-of-art video summarization. [4]

Tampering detection involves several set of techniques which perform the task of identification of manipulated / forged videos. In a tempered (forged) video, consecutive frames of video can be inserted, deleted, duplicated or shuffled. To perform this task of identification techniques such as optical flow, correlation between suspicious frames and consistency of velocity field intensity can be used. [17] There exists many techniques for detection of inter frame forgery. [18], [19], [20] which uses technique of optical flows to detect inter frame forgery, in this technique when there will be a discontinuity in the optical flow variance sequence in cases or where the frames have been replaced, deleted or inserted. [21] The detection this kind of forgery is done by analyzing velocity filed consistencies. [22] Even the technique such as double MPEG compression can be used to detect frame manipulations. These includes block matching techniques and key point matching techniques [23] [24]. Splicing detection is also addressed via different approaches. [25] All these techniques mostly depend on the assumption that the spliced area will be different in terms of a several fundamental aspects of analysis. [26] These techniques uses DCT (Discrete Cosine Transform) coefficients to detect double quantization effect of JPEG compression. [27]

The new technique such as Image Contrast Enhancement using Exposure Fusion Framework is termed to be an important technique for enhancement of color properties of a dark image. [30] The key challenge with Forensic Video/Image processing (analysis) system is that, the analysis techniques involved in visual data analysis should not change/alter the original objects & subjects of visual data. In forensic video analysis, the quality of video is always an important challenge. The enhancement of the low quality of video is very important for assisting & conducting efficient forensic investigation.

III. PROPOSED METODOLOGY

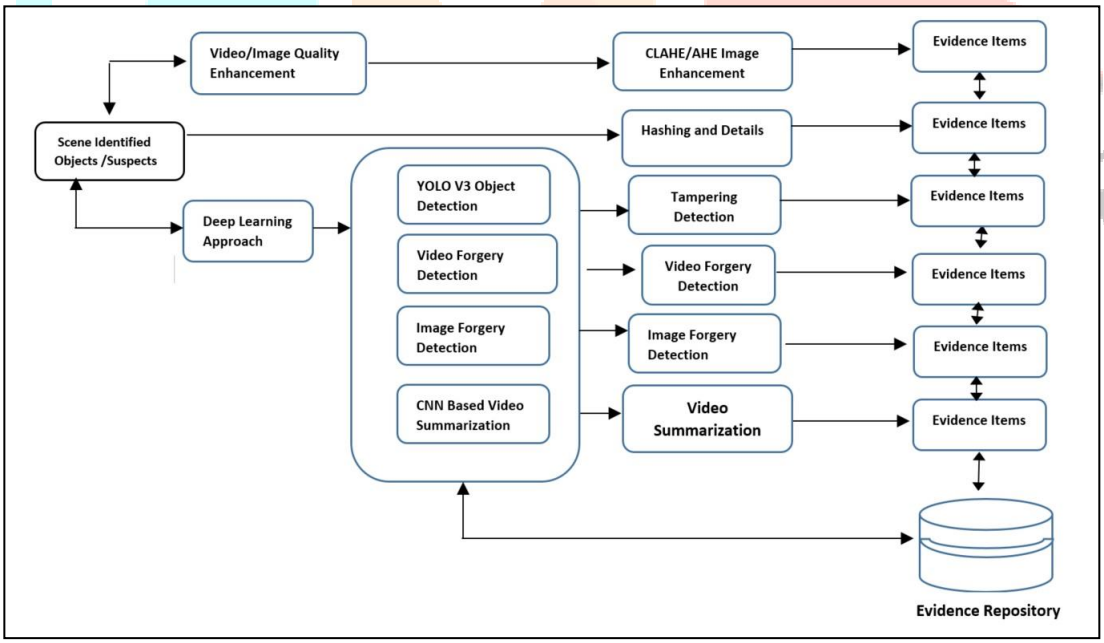
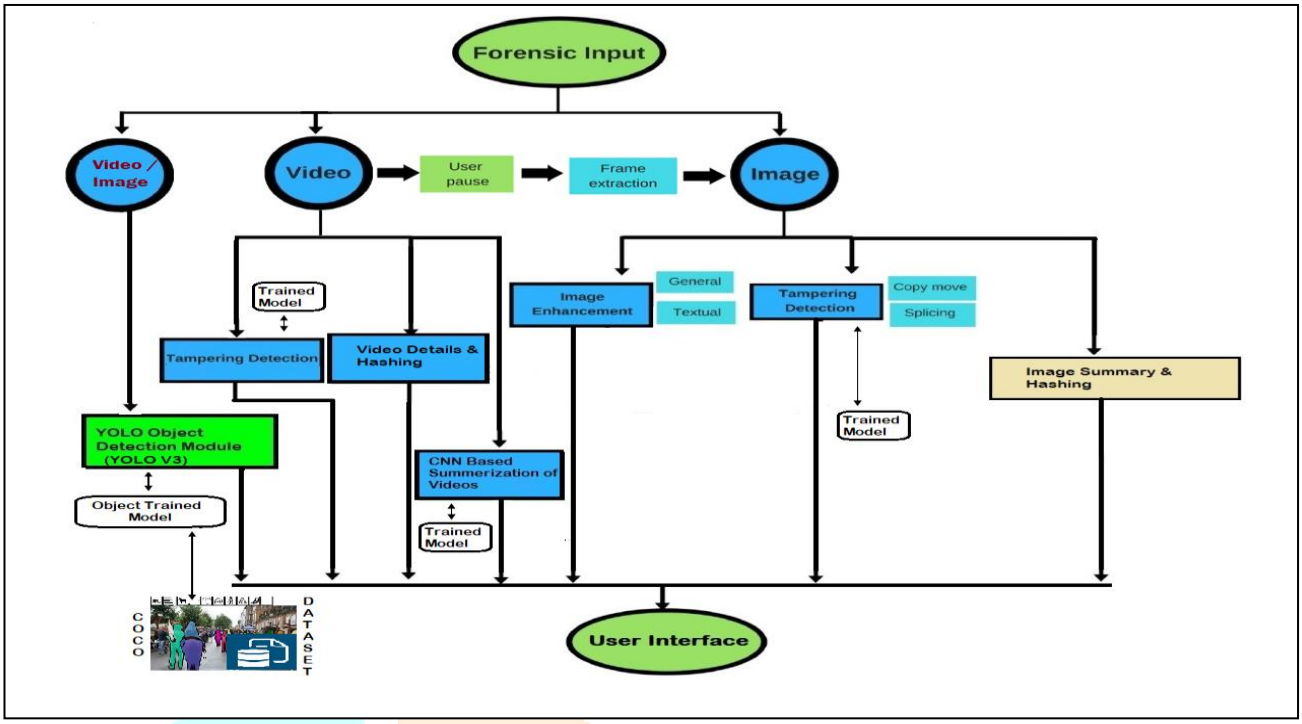


Fig1. Framework for Forensic Video/Image Analysis System

In proposed framework, to achieve the goal of truthful visual data analysis and also in order to adapt the new techniques of visual data analysis, new modules are implemented which address the several problems of visual data analysis from forensic perspective of visual evidence analysis. Forensic visual data analysis today lacks adaption of new visual data analysis technique such as deep learning. The proposed framework can be used to solve the several problems of diversified nature of visual data analysis and could assist an examiner to perform truthful analysis of visual data.

IV. PROPOSED SYSTEM

Fig2. Proposed System



Here we propose to develop truthful forensic Video/Image analysis system with proposed system. The system is divided into several subparts involving deep learning based video/image analysis, tempering detection of visual data and image enhancement.

1) YOLO V3 Object Detection: This part of framework consists of a trained model for a purpose to detect several objects and suspects of visual data. The model can be trained on larger number of iterations in order to perform the task with greater accuracy. Here we have implemented the model trained on larger iterations of COCO dataset.

2) CNN Based summarization of videos: Shot segmentation is an efficient technique and backbone of video summarization techniques and which also affects the overall quality of the generated summary. Thus here an effective shot segmentation method is proposed using deep features. Also the technique maintains the interestingness using entropy and memorability. The technique works on the methodology where the frame within each shot with highest entropy score and memorability is considered as a key frame. Several benchmark datasets can be used to state-of-art video summarization.

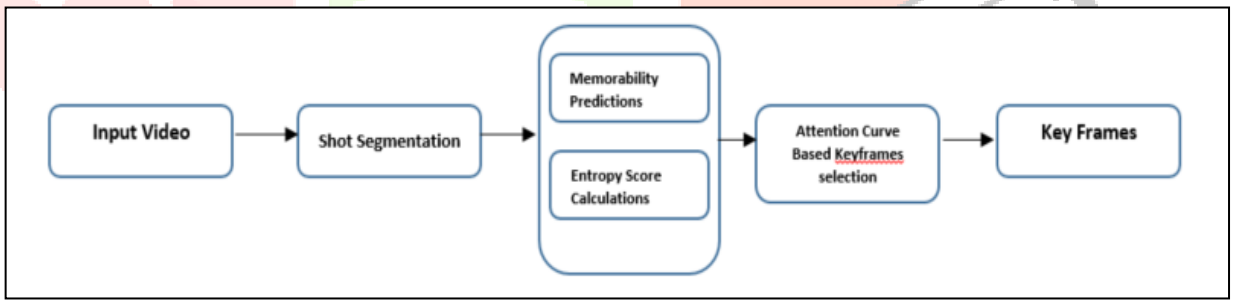


Fig3. Proposed Methodology. [4]

3) Image Enhancement Methods: Several techniques such as CLAHE, CEFFA, DHE perform the task of image enhancement specially for low light, low quality kind of situations. These algorithms are used for enhancement of several color properties of image, these algorithms give positive state –of –art results and are further divided into three different algorithmic image enhancement techniques such as i) Contrast Exposure Fusion Framework Algo, ii) Dynamic Histogram Equalization Algo. iii) Contrast Limited Adaptive Histogram Equalization Algo., alsoTextual image enhancement based on Weiner filter perform the task to eliminate noise and blur of a given image. In many situations of motion blur involved in visual data Weiner filter is termed to useful technique in order to visualize blurred motion text.

4) Tampering Detection Methods: The techniques of inter-intra frame tempering detection can be used for video and image forgery detection. The technique such as inter frame forgery detection based on technique of optimal flow can be used for video tempering detection. Whereas techniques of intra frame detection are based on clustering and threshold, which are used towards detection of copy move and splicing type of image forgery. These techniques determine the truthfulness of visual data. Although these techniques are termed to be passive techniques of forgery detection towards visual data, these are termed to be important authentic techniques of tampering detection of visual data.

5) Hashing and detailing: This methodology is core part of any forensic analysis system which is used to generate hash value of image and video file, it also determines crucial metadata of a given file. Hash value function determine the authenticity and integrity of digital data and are termed to be digital fingerprint of digital data, also hash values are considered as crucial part of digital forensic analysis.

V. FLOWCHARTS:

1) Flow charts for Image Enhancement Techniques:

i) Contrast Exposure Fusion Algorithm:

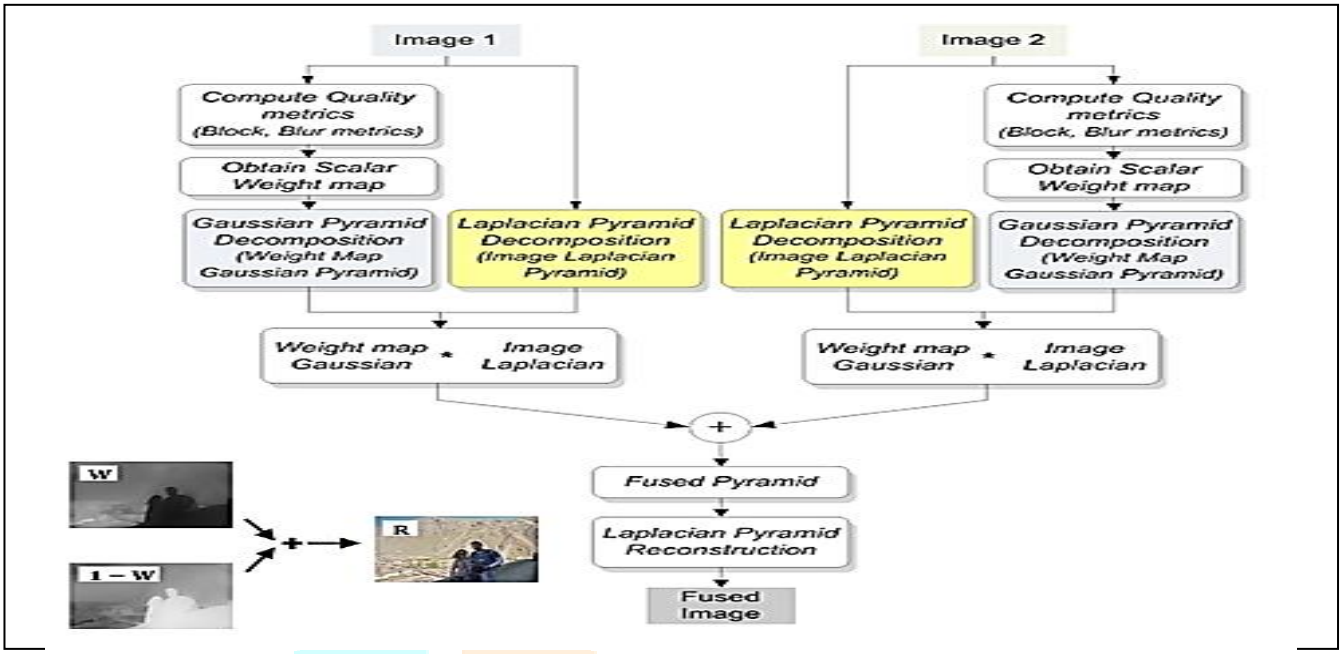


Fig.4 Flowchart for CEFA

ii) Contrast Limited Adaptive Histogram Equalization and Dynamic Histogram Equalization (DHE):

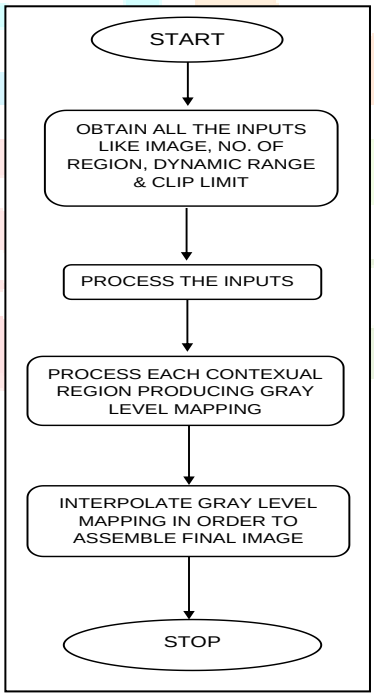


Fig. 5 CLAHE Algo

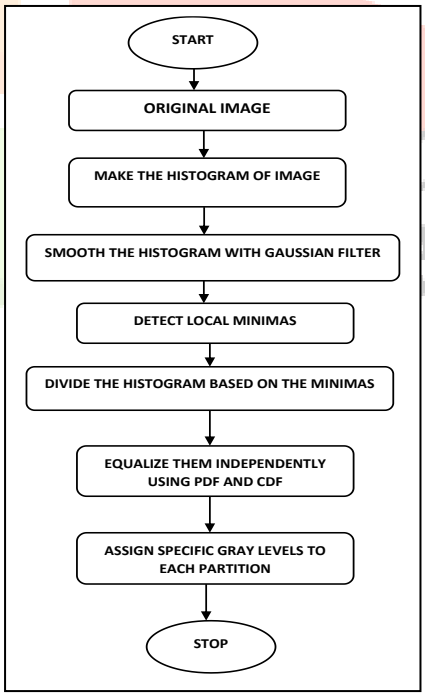


Fig. 6 DHE Algo.

VI. ALGORITHMS:

1) Algorithm for object detection and tracking :[1]

Input: Video or camera input V
Output: Labeled V
1: v video_capture(V)
2: vg video_group(v)
3: for each frame fi 2 vg do
4: fhsv covColor(fi; COLOR_RGB2HSV)
5: fshsv split(fhsv)
6: for each channel c 2 fhue; saturatin; valueg do
7: threshld(fshsv[c]; dth[c]; low[c]; upper[c])
8: end for
9: fresult bitwise_and(dth[0]; dth[1]; dth[2])
10: end for
11: V update(v; vg)

2) Algorithm for video image enhancement using AHE (Adaptive Histogram Equalization): [1]

Input: Video or camera input V
Output: Labeled V
1: v video_capture(V)
2: vg video_group(v)
3: for each frame f 2 vg do
4: Initialize array Hist to zero;
5: for every contextual pixel j do
6: Hist[g(j)] D Histl [g[j] C 1
7: end for
8: CHistl D
Pl
kD0 Hist(k)
9: l0 D CHistl _ L=W2
10: vg update(f ; l0)
11: end for
12: V update(v; vg)

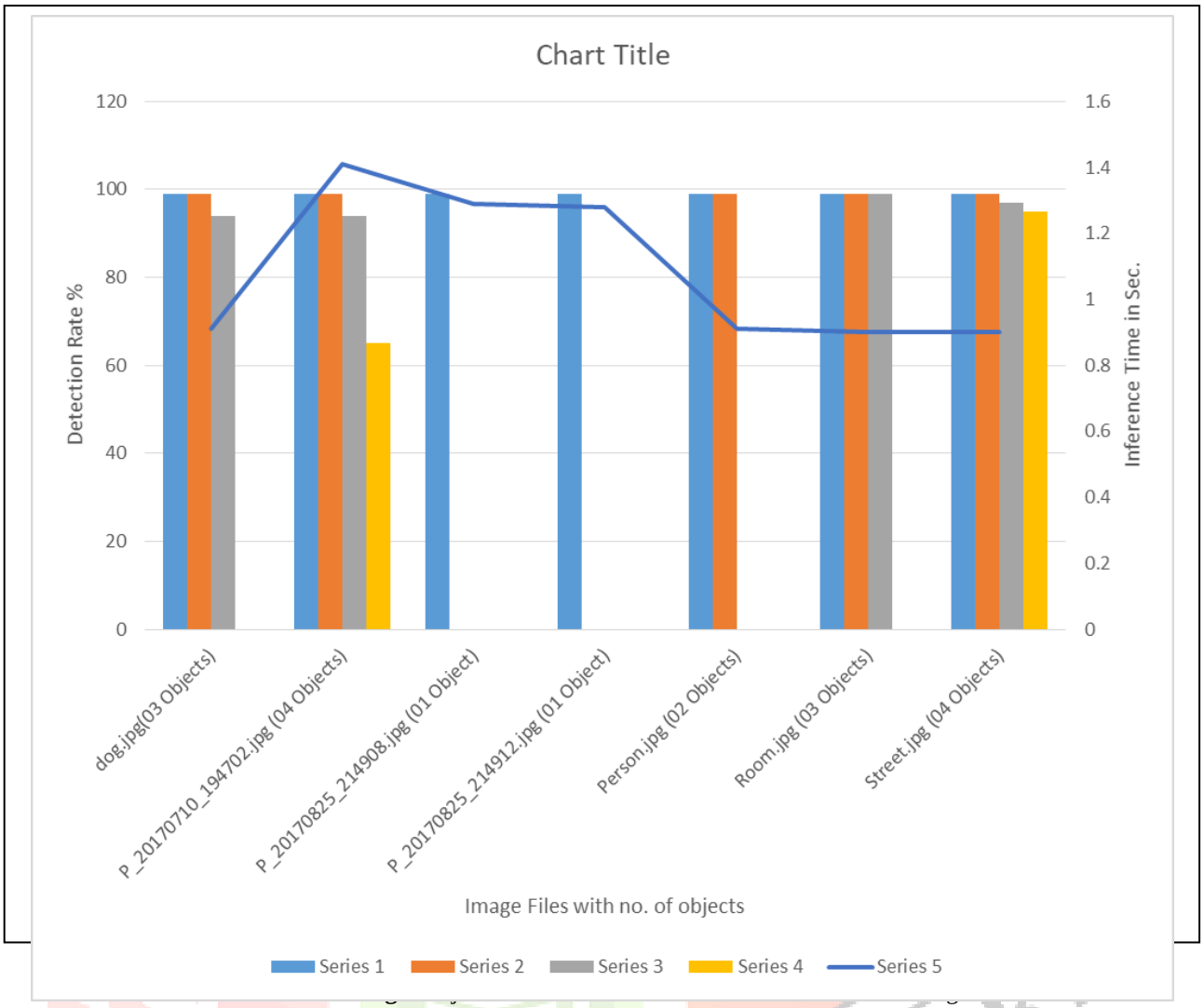
VII. RESULT AND DISCUSSIONS:

1) Object Detection Results for YOLO V3 Framework:

Sr.no.	Image	Inference Time (sec)	Detection Rate (%)			
			Object1	Object2	Object3	Object4
1	dog.jpg	00.91	99	99	94	
2	P_20170710_194702.jpg	0.88	99	99	94	65
3	P_20170825_214908.jpg	01.29	99	-	-	-
4	P_20170825_214912.jpg	01.28	99	-	-	-
5	Person.jpg	00.91	99	99	-	-
6	Room.jpg	00.90	99	99	99	-
7	Street.jpg	00.99	99	99	97	95

Fig.7 Table for Object Detection Values

The above table and chart show the detection results for YOLO V3 framework on COCO dataset on several images performed using trained model on COCO dataset. The results show detection results on several images with several objects detected with greater accuracy and inference time.



2) Image Enhancement results using several color based enhancement Techniques:

The image enhancement performed on sample images using several image enhancement techniques like Contrast exposure fusion algorithm, Dynamic histogram equalization (DHE) algorithm and Contrast limited adaptive histogram equalization technique (CLAHE) are shown below, the results are obtained using histogram analysis method determining the color variation and pixel distribution of sample image and output enhanced image.

The results show that these techniques can be efficiently used in many low light and poor visual data conditions and are useful to improve the quality of visual data up to marginal extent. The histogram chart in which the x axis represent the pixel values, whereas y axis represent the color variance from dark to light.

i) Contrast Exposure Fusion Algorithm:

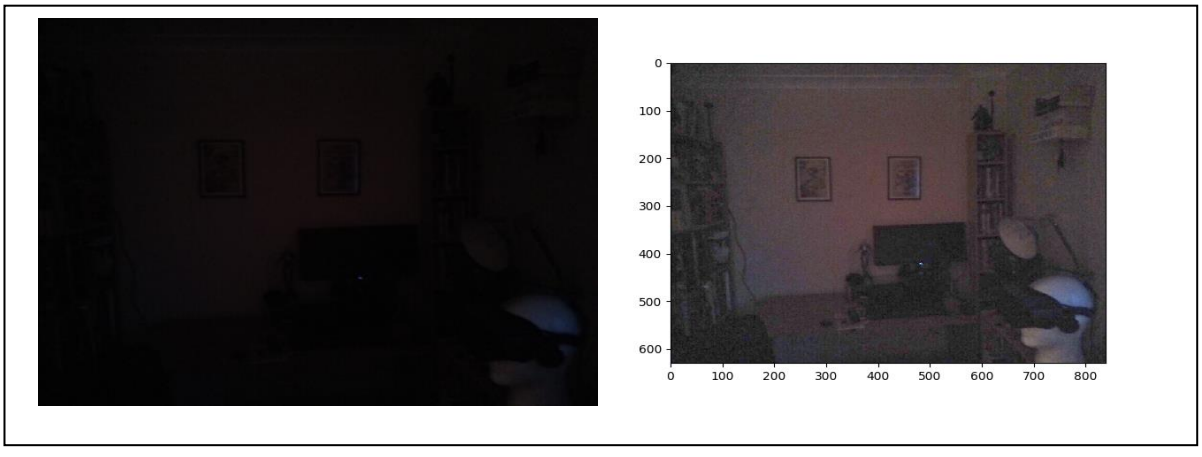


Fig.9 Result for CEFA.

ii) Dynamic Histogram Equalization (DHE):

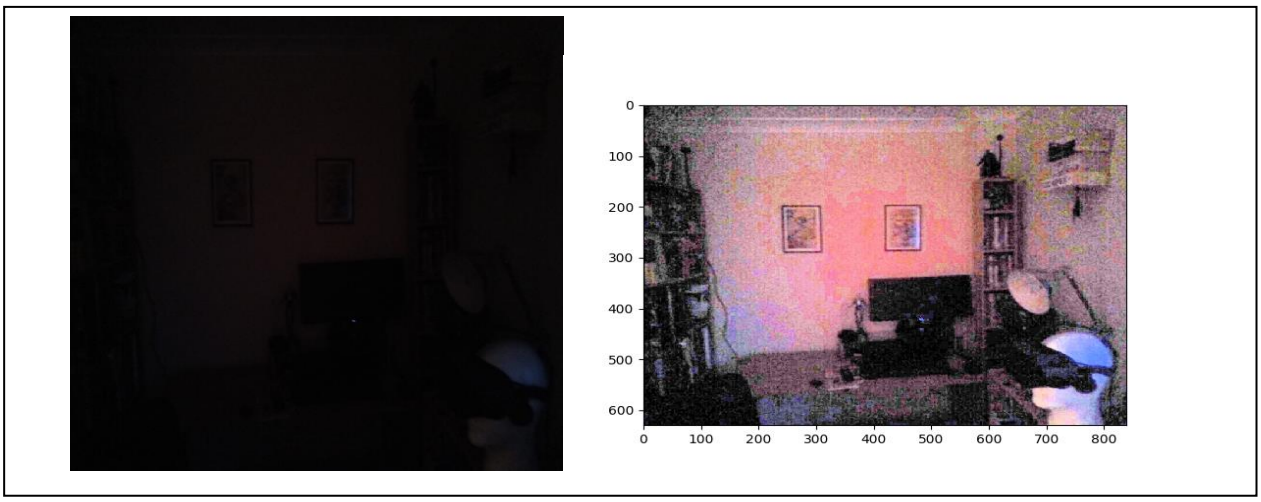


Fig.10 Result for DHE.

iii) Contrast Limited Adaptive Histogram Equalization (CLAHE):

FFig11 Result for CLAHE.

VIII. CONCLUSION:

Here we propose to develop a forensic video/Image analysis framework in order to perform truthful forensic analysis of visual data. The results of few techniques such as of object detection using deep learning Darknet YOLO3 framework on COCO dataset, various contrast and histogram equalization algorithms for the purpose of image enhancement especially in low quality / low light type of image enhancement are displayed above. The CNN based summarization of videos can be useful in extracting the relevant and useful frames of video. Also the techniques of inter-intra frame tampering detection can be used to determine that the available visual data is verifiably true. The above mentioned techniques can be used to perform visual data analysis in different scenarios of forensic analysis of visual data, surveillance areas, deep learning modules can even be used in robotics. The results until show that Yolo V3 detection model is termed to be the best detection model in single stage detectors, whereas the techniques like Contrast Limited Adaptive Histogram Equalization and Contrast Exposure Fusion Framework outperforms the other image enhancement techniques.

In the future work, the different techniques and architecture of deep learning can be combined to gain more accurate, conclusive and fruitful results. The future artificial intelligent (AI) systems in this specified area could reduce the gap between the human perception of visual data processing and artificial systems of visual data processing.

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