Enhanced Crime Scene Analysis with HOG-Integrated Deep Residual Networks

[1]A. RizwanBasha
Department of CSE
Amrita School of Computing
Amrita Vishwa Vidhyapeetham Chennai

[2]R. Annamalai
Department of CSE
Amrita School of Computing,
Amrita Vishwa Vidhyapeetham Chennai

Abstract— **Crime scene investigation is an important and challenging work for detecting suspects from the incident. Investigations begin from collecting various objects, markings, location, and scalability of the incident. Evaluation of artificial intelligence helped a lot in creating automated investigation models. To detect the crime scene objects, markings impacts a lot in making decisions. Investigation scenario is highly sensitive hence, detection of crime scene objects as early as possible is important. The proposed approach considers crime scene videos collected from CCTV camera as prime input. Video to image conversion is implemented initially. Visual HOG Histogram of orientation gradient feature (VHoG) is extracted from the image. Based on feature, the background subtraction is done. The semantic object is extracted from the image through Morphology factor as well as HoG feature matching. The correlated semantic object shades are compared with the training images. Deep resilient net (DRN) is created to make training and testing process. Various images of the objects are separately training using the neural network. Using the hidden layers of neural perceptrons, the similar blob of the object is continuously compared with all the salient objects in the database images. Based on the correlated score, the confusion matrix is formulated. The calculation of true positive, true negative, false positive and false negative rate is evaluated. The novel structure is validated with repeated iterations of comparisons and further the achieved the accuracy of 91%. Reduction of false similarty issues are considered here to avoid occluded images, rejection of false image are adopted steps here.**

Keywords— Deep learning, anomaly detection, crime scene investigation, Image processing, security systems.

I. INTRODUCTION

As the criminal activities in the society has keep on increasing it is being required to collect valuable evidences and make the investigation process in a proper way to attain the criminals as soon as possible. Detection of information in the crime scene is a demanding work in recent days. Automated detection of crime scene objects needs to be highly efficient[1]. In order to have a narrow scope of investigation, the evidences around the crime scene is highly important. The recent technological developments such as image processing, video processing, computer vision and statistical analysis improve the automated investigation of crime scene objects based on CCTV camera videos. The main problem of detecting objects in the crime scene object analysis is highly helpful to have a secure and efficient surveillance system [2]. Specific object detection system focused initially in computer vision based detection technique than manual interventions. In recent years, the surveillance systems are enhanced using artificial intelligence algorithms that includes machine learning algorithms, neural networks, recurrent networks, also various feature analysis models[3]. Many existing systems provide the detection of anomaly in the CCTV footages. The forensic department plays an important role in collecting the evidences from the surroundings. The finger prints are commonly used identification technique to have the criminal identification and understanding the Crime Scene better[4].

Crime Scene object detection is an interesting area of research where various information are analyzed automatically with the help of computer vision and statistical analysis techniques. It is also racket to detect the crimes in objects in a short span of time. The technologies such as artificial intelligence cloud computing enable the system to work faster than manual process. Face detection is an important factor in

Crime Scene object detection. In terms of any face, detected in the camera, the emotions need to be analyzed [5]. In the existing system, drones and unmanned aerial vehicles are used for the detection of crime scene where the human intervention is not feasible. The reasons for adaptive systems in objects detection with highly reliable techniques are used to investigate the crime scene in a more accurate way. The objects that are not visible to the human eye can be detected by the systematic process, which ends the crimes in object detection become deeper than usual.

The technical steps taken to collect the Crime Scene objects enhance the relationship between the Crime Investigation experts and the public. CCTV cameras are available to record the videos. Only advance cameras can automatically interpret the anomalies while recording the videos. These videos based investigation samples are compared with the manual interventions from CCTV camera.

- The proposed work is focused on reading the crime video collected from CCTV camera. Videos are having numerous frames associated with that. The foremost step of proposed approach is to convert the video into frames.
- From the converted frame randomly the highest feasible frame is selected and preprocessed using image processing toolbox. Visual Hog (VHoG) based feature extraction technique is used here. 90%of the data is considered as training feature, 10% is considered as testing feature.
- On the other hand, based on feature points, semantic object is selected and segmented using Morphology structural elements extraction
- The VHoG feature provides the shape of the objects present in the Crime Scene accurately. Various training images with objects are provided for processing, further it is applied to the resilient network (ResiNet). The visual HoG feature is also used to cross validate the presence of semantic object.
- The semantic object is nothing but the highly refractive object seen from the Crime Scene. The initial process of a proposed approach started by detecting the semantic object present in the Crime Scene and further classifying the same using the images available in the database.
- The DRN using the supportive Visual HOG features are used to validate the presence of semantic object.

The rest of the paper is formulated as making detailed literature study in Section II. The system tool selection, problem identifications are discussed in Section III. The system architecture, detailed system design steps are discussed in Section IV. The rest of the paper is concluded with future enhancement.

II. BACKGROUND STUDY

C.Baber et al., (2005) presented a system, where RF ID tag enabled evidence bags are collected and analysed. Numerous log information is collected for analysis. These data provides the association between the each evidences collected. The log data contains description on evidences in the form of objects. The images captured using digital camera is processed in order to stamp the log data of time, location, and subsequent hint in the form of data. The author presented a system where the prototype of a device can be used to support the process of evidences recovery system from the time scene. The key elements enabled here with the proposed approach are the radio of frequency identification tags (RFID) that are affected to evidence bags. Where log information is collected from the CCTV camera, further the synchronisation of manual system is analysed. The captured information on the log data is also compares the speech data. Wearable devices are highly reliable to record the Crime Scene data. The concept of Bags of Evidences (BOE) is discussed here completely.

A. Gur et al., (2020) the author presented a system where Crime Scene is analyzed with respect to collection of evidences. Securing the investigation data is highly important. In order to improve the security concerns, feature extraction techniques are utilized autonomous Drones. The camera is placed in front of the Drone to collect various features around the crime scene where the human interventions are not feasible. The drones can allow to collect various aspects of data. Further processed in order to have the relativity between the Crime Scene and the environment being developed by the real time software and

artificial intelligence (AI) algorithms. Many interruptions of flying Drone can disable the process are divert the drones to collect the information from the Crime scene this acts as a drawback in the presented approach. .

W. Liu et al., (2019) the author presented a system in which multi-class classifier is used to collect the query image and label the data effectively. Various types of datasets are utilised such as small data set, subsequent dataset large dataset etc. databases are accessed through Query based(QB) image accessing approach. Image retrieval system to rank the fusion model and further sort out the drawback of large database handling issues in a reliable and fast way. Various kinds of images are classified and accessed through automated system program such as query by example QBE approach. Further these data analysed using machine learning algorithm to have an effective investigation metrics.

Y. Liu et al., (2017) the author presented a system where large scale of data are being used for investigation. Various images are collected for investigation thus the extraction of unique features present in the images is highly important. Detection of feature using manual technique is not always recommended hence utilization of discrete cosine transform (DCT) for texture feature extraction is used. Descriptive histogram based colour feature extraction technique is utilised here to collect the various critical information from the Crime Scene objects. The presented approach is also helpful to investigate the image retrieval process.

J. Cross et al., (2007) the author presented a system in which methods to support shared analysis for mobile investigators are utilized. The presented approach used mobile as a device for prototypic approach to retrieve the support system on crime scene. Various findings are combined together to have a minimal interaction and shared information on the cloud that provides the forensic data for using simple investigation process. The presented approach is developed using machine learning system support, with various feature based cross correlated values are used for investigation process in a proper way

Mahesha et al., (2021) the author presented an approach contains MSCOCO datasheet for automated Crime Scene detection using highly reliant deep learning algorithm. In case the Crime scene images are directly passed into the analysis models, the raw information is directly analysed by the computer vision system and hence the images of segmented into various types of models to generate different crimes scene object class using the deep learning models such as inception V3, long short term memory network (LSTM) to detect the highest scores of detection

M. Petty et al.,(2019) the author presented an approach utilized a SIFT based feature detection algorithm and compared with various image data points collected from different registration techniques. The SIFT feature is used to detect the real time objects present in the Crime Scene photography. The presented approach is comparatively tested with the other feature extraction techniques such as SIFT and ASIFT etc.

III. SYSTEM DESIGN

The system design is focused by utilizing the tool boxes applicable for image processing, video processing, image segmentation, etc. The ultimate goal of the system is to detect the Crime Scene objects present in the CCTV camera recorded videos as well as detection of anomaly present in the scene. MATLAB software is utilized here to achieve the goal of semantic object segmentation. Image processing tool box provides comprehensive set of reference standard algorithms and graphical tools for image processing analysis, visualisation and algorithm development for the image enhancement, image deep learning feature detection, noise reduction, image segmentation, special transformations, and registrations are helpful to analyse the Crime scene objects in a different way and to analyse the structure parameters of the objects present in the crime scene effectively. Image processing toolbox is helpful to analyse the images in terms of colour texture pixel points and even the small objects are analysed from the Crime scene images. Various techniques such as contour techniques, Histogram analysis are used to manipulate the region of interested area using simple commands.

- The main problem persist with the crime scene detection is how fast the system can automatically detect the Crime Scene objects and further how accurately it can classify the object within the given database.

- The minute objects present in the crime scene which is not visible to the manual interventions need to be analysed in deep to have accurate investigation.

IV. METHODOLOGY

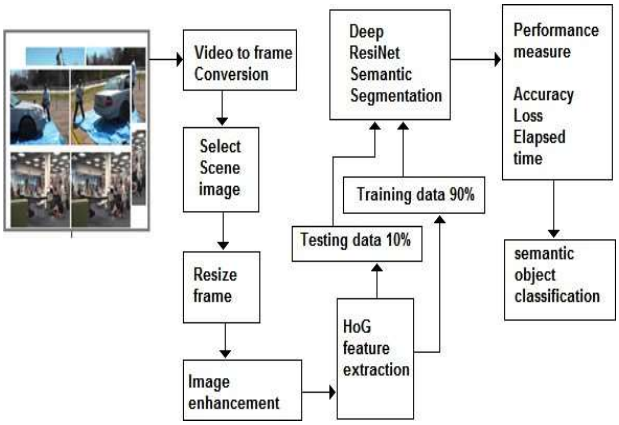

Fig. 1. System architecture of Proposed Semantic object detector

Deep learning is the advancements in machine learning (ML) algorithm that enable us to make the computer understand the information provided by images where the system need to detect the things faster and accurately than the human interventions. Deep learning algorithm is derived from neural network (NN) algorithms to learn useful representations of features directly from the captured real time data. Neural networks are combined with multiple combinations of layers in which the input is being processed special features are extracted and further classified using classification layer. This is the common technique used in deep learning algorithm. Transfer learning is commonly used in deep learning approach in which the specific neural network architecture is being repeatedly used for the pre-trained network to make the classification even better. The advantage of transfer learning approach of similar task in a different perspective at every iteration. The repeated analysis may take longer time and create a robust model that can accurately detect the objects. Feature extraction allows the system to investigate deeper data using machine learning algorithm such as support vector machine(SVM), neural networks(NN), transfer learning(TL), linear regression(LR) etc. The machine learning algorithms are helpful to analyse the data in feature based approach. Further the fine tuning of features is helpful to have the high accurate feature mapping.

Deep learning on unstructured data utilizes large GPU space because of the parallel processing and cloud utilisation. Continuous accessing of cloud takes time and lots of GPU memory to be utilised and hence in order to reduce the GPU utilization problem, the planning algorithms are run with unique features extracted from the major reduction in data dimension will reduce the time taken for the complete analysis.

Performance measure

The performance analysis of proposed approach is measured through calculation of accuracy. As the estimation of true values present in the given system with respect to the total number of analysis rates such as true positive value, true negative value, false positive value, and false negative values are discussed.

The amount of true data present similar to the detected images as true value is the consequence of negative result where the positive result should be expected please stop it the false negative value is the anticipation of false data as a class where the data is supposed to have positive. Using the formulas on accuracy true positive, true negative, false positive and false negative the performance measure is evaluated for the processing time is calculated.

$$Accuracy = \frac{Tp + Tn}{Tp + Tn + Fp + Fn} \quad (1)$$

V. RESULTS AND DISCUSSIONS

A. *Input test image*

Fig. 2. Shows the system

Fig. 2. Shows the sample images under training.

Fig. 2. Shows the sample images under training. Some of the static images are considered for analyses are compared with ground truth.

B. *Image processing results*

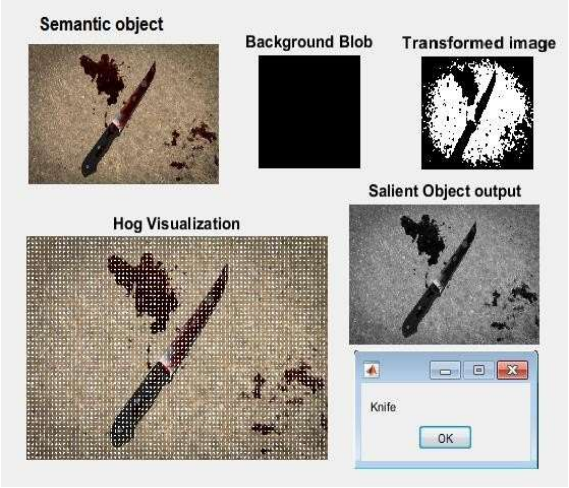

Fig. 3. Image processing results

Fig.3. Shows the image processing results, such as background subtraction, transformed image, Visualization HoG feature, Salient object detection etc.

C. *Training Accuracy*

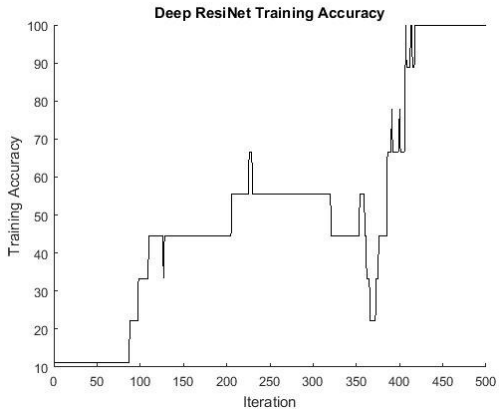

Fig. 4. DRN Training accuracy

Fig. 4. Shows the DRN training accuracy with respect to maximum of 500 epochs run within the network.

D. Testing Accuracy

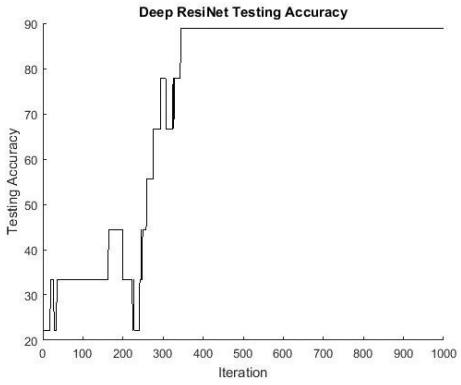

Fig.5. DRN Testing accuracy

Fig. 5. Shows the DRN testing accuracy graph with respect to number of epochs reaching the maximum of 1000, in spite the proposed system reaches consistent accuracy of 89% at the epoch=350 approximately.

E. Training Loss

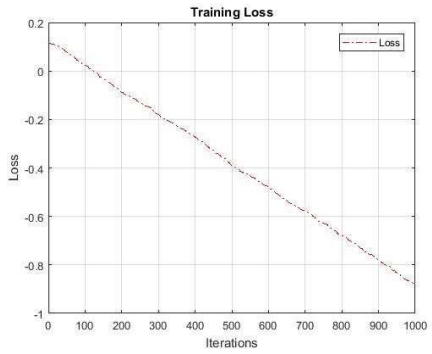

Fig.6. Training Loss

Fig.6. shows the training loss happens within the DRN model for the total of 1000 epochs. As the number of iterations increases, the training loss degrades further accuracy improves.

F. Testing Loss

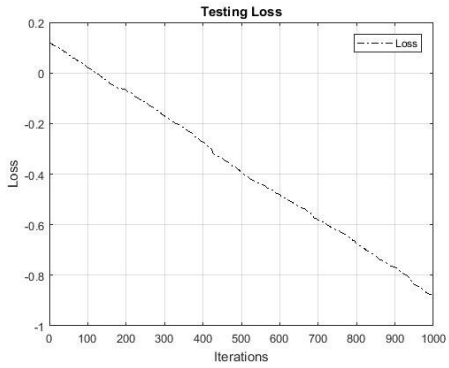

Fig.7. Testing Loss

Fig. 7. Shows the testing loss acquired from the DRN model. As the testing process improves, the accuracy is getting improved by suppressed loss status in testing.

G. Validation Loss

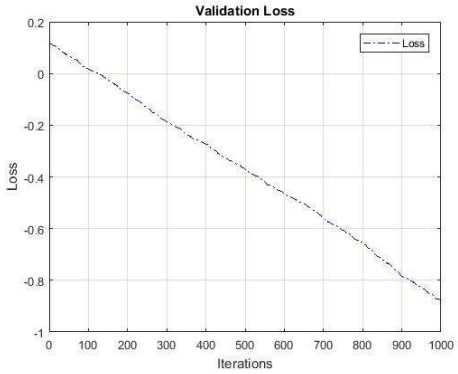

Fig.8. Validation Loss

Fig.8. Shows the validation loss of the proposed DRN model.

The validation data of 10% from the training data is considered, hence the cross validation add up concrete strength to the proposed process.

Table 1. Comparison of existing implementations with proposed DRN model

SlNo	References	Dataset	Method	accuracy
1	Saikia, S., et al., 2017	MSCOCO	RCNN	74.33%
2	S. Sani, et al., 2022	MSCOCO	YOLO	81.20%
3	Proposed	Real Time CCTV footage	DRN	91%

Table.1. shows the comparison of existing implementations using MSCOCO pretrained dataset using RCNN [4] achieved the accuracy of 74.33% on scene object detection, with YOLO you look only once model, with pre-trained dataset achieved the accuracy of 81.20%. The proposed approach implemented with real time CCTV footage extracted images. The accuracy of 91% is achieved.

VI. CONCLUSION

Detection of crime scene objections in short time is important to make the investigation straight forward. The delay in detection, accurate mapping of semantic objects is the prime motive of the proposed approach. Here real time footage of crime scene video is collected. Video is converted into image frames. Randomly

selected image frames are trained and tested with commonly available crime scene objects. Further the classified object names are validated. The proposed approach implemented with real time CCTV footage extracted images. The accuracy of 91% is achieved. Further the elapsed time taken to complete the detection process took 55 seconds. The proposed methodology is further improved using inspired heuristic algorithms with deep learning architectures for enhancing the accuracy.

REFERENCES

[1] H. Farhood, M. Saberi and M. Najafi, "Improving Object Recognition in Crime Scenes via Local Interpretable Model-Agnostic Explanations," 2021 IEEE 25th International Enterprise Distributed Object Computing Workshop (EDOCW), 2021, pp. 90-94, doi: 10.1109/EDOCW52865.2021.00037.

[2] Proceedings of the 2019 Federated Conference on Computer Science and Information Systems, M. Ganzha, L. Maciaszek, M. Paprzycki (eds). ACSIS, Vol. 18, pages 391–396 (2019)

[3] H. Sun, Z. Meng, P. Y. Tao and M. H. Ang, "Scene Recognition and Object Detection in a Unified Convolutional Neural Network on a Mobile Manipulator," 2018 IEEE International Conference on Robotics and Automation (ICRA), 2018, pp. 5875-5881, doi: 10.1109/ICRA.2018.8460535.

[4] Saikia, S., Fidalgo, E., Alegre, E. and Fernández-Robles, L., 2017. Object Detection for Crime Scene Evidence Analysis Using Deep Learning. Image Analysis and Processing - ICIAP 2017, pp.14-24.

[5] P. Espinace, T. Kollar, A. Soto and N. Roy, "Indoor scene recognition through object detection," 2010 IEEE International Conference on Robotics and Automation, 2010, pp. 1406-1413, doi: 10.1109/ROBOT.2010.5509682.

[6] S. Masuda, Y. Kaeri, Y. Manabe and S. Kenji, "Scene Recognition Method by Bag of Objects Based on Object Detector," 2018 Joint 10th International Conference on Soft Computing and Intelligent Systems (SCIS) and 19th International Symposium on Advanced Intelligent Systems (ISIS), 2018, pp. 321-324, doi: 10.1109/SCIS-ISIS.2018.00062.

[7] C. Tankard, ``Advanced persistent threats and how to monitor and deter them," Netw. Secur., vol. 2011, no. 8, pp. 16_19, Aug. 2011.

[8] P. Araújo, J. Fontinele and L. Oliveira, "Multi-Perspective Object Detection for Remote Criminal Analysis Using Drones," in IEEE Geoscience and Remote Sensing Letters, vol. 17, no. 7, pp. 1283-1286, July 2020, doi: 10.1109/LGRS.2019.2940546.

[9] M. Nakib, R. T. Khan, M. S. Hasan and J. Uddin, "Crime Scene Prediction by Detecting Threatening Objects Using Convolutional Neural Network," 2018 International Conference on Computer, Communication, Chemical, Material and Electronic Engineering (IC4ME2), 2018, pp. 1-4, doi: 10.1109/IC4ME2.2018.8465583.

[10] S. Sani, “Object Detection for Crime Scene Evidence Analysis”, 2022 Journal of Software Engineering and Simulation, Volume 8 ~ Issue 7 (2022) pp: 44-53, ISSN(Online) :2321-3795 ISSN (Print):2321-3809

[11] S. Aarthi and S. Chitrakala, "Scene understanding — A survey," 2017 International Conference on Computer, Communication and Signal Processing (ICCCSP), 2017, pp. 1-4, doi: 10.1109/ICCCSP.2017.7944094.

[12] Tasci, T., & Kim, K. (2015). Imagenet classification with deep convolutional neural networks.

[13] K. Simonyan and A. Zisserman, "Very deep convolutional networks for large-scale image recognition", International Conference on Learning Representations, 2014.

[14] Y. -R. Chen et al., "Forensic Science Education by Crime Scene Investigation in Virtual Reality," 2021 IEEE International Conference on Artificial Intelligence and Virtual Reality (AIVR), 2021, pp. 205-206, doi: 10.1109/AIVR52153.2021.00046.

[15] P. Mahesha, K. J. Royina, S. Lal, Y. Anoop Krishna and M. P. Thrupthi, "Crime Scene Analysis Using Deep Learning," 2021 6th International Conference on Signal Processing, Computing and Control (ISPCC), 2021, pp. 760-764, doi: 10.1109/ISPCC53510.2021.9609350.

[16] M. Petty, S. W. Teng and M. Murshed, "Improved Image Analysis Methodology for Detecting Changes in Evidence Positioning at Crime Scenes," 2019 Digital Image Computing: Techniques and Applications (DICTA), 2019, pp. 1-8, doi: 10.1109/DICTA47822.2019.8945934.