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A Vision-Based System Design and Implementation for Accident Detection and Analysis via Traffic Surveillance Video

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ABSTRACT: The goal of this study is to examine the issue of automatically and effectively identifying and analysing traffic accidents using surveillance cameras, and to implement the whole framework on an AI demo board. First, the motion interaction field (MIF) approach, which has the capacity to identify collisions in video, is used to find the wrecked cars based on the interactions of various moving objects. Second, the YOLO v3 model is used to pinpoint the position of the wrecked automobiles. A hierarchical clustering technique is employed to recover the vehicle trajectories prior to the collision, and the associated trajectories are recovered. Third, the trajectory is projected to a vertical view using a perspective transformation to aid traffic officers' judgement. The unbiased finite impulse response (UFIR) technique is used to estimate the vehicle velocity, which does not need statistical knowledge of the external noise. The estimated velocity and collision angle acquired from the vertical view may then be used to investigate the traffic accident. Finally, to demonstrate the usefulness and implementation performance of the suggested technique, an experiment is carried out using a Huawei AI demo board dubbed HiKey970, which is utilised to code all of the aforementioned algorithms. Several accident surveillance movies serve as the demo board's input. Accidents are effectively recognised, and the relevant vehicle trajectories are retrieved.

Keywords *–Accident detection, speed estimation, target tracking, unbiased finite impulse response (UFIR) filter, vehicles.*

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1. INTRODUCTION

Over the last several decades, there has been a growing emphasis on using traffic monitoring technology to identify and evaluate incidents. Crash detection at the traffic management centre is mostly relied on human observation (TMC). Although manual observation is often trustworthy, it has a number of flaws. On the one hand, it is impossible for people to identify all of the accidents in the whole city promptly, which means that in many situations, the wounded in a traffic accident may not be treated appropriately. Manual examination of the reason of a traffic collision, on the other hand, is sometimes wrong since it is difficult to get the trajectory and speed from surveillance footage. As a result, systems for automatically recognising and analysing traffic accidents are required.

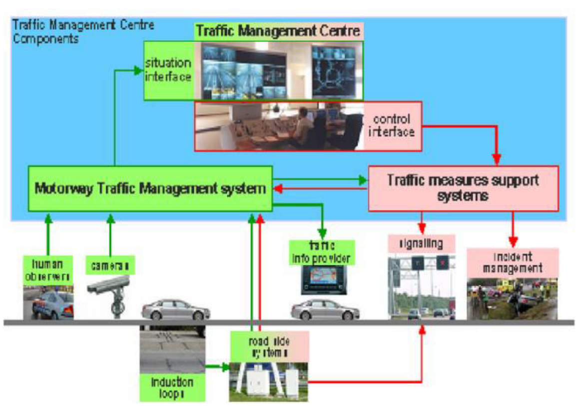

Fig.1: Example figure

Vision-based collision detection approaches have evolved in three ways during the last two decades: modelling of traffic flow patterns, assessing vehicle behaviours, and modelling of vehicle interactions [1]. The first technique models normal traffic patterns using traffic regulations from big data sets. If a vehicle's trajectory deviates from usual trajectory patterns, it is classified as an accident [5]-[7]. However, detecting collisions is challenging due to the scarcity of collision trajectory data in the actual world. The second technique identifies accidents by analysing vehicle motion parameters [8-[10], such as speed, acceleration, and distance between two cars, implying that all vehicles must be continually monitored. As a consequence, the method's accuracy in a congested traffic scenario is frequently restricted by processing power. In the third technique, vehicle interactions are represented using the social force model [11] and the intelligence driver model [12]. This approach requires a large number of training samples, yet its accuracy is low since it identifies collisions only based on changes in vehicle speed.

2. LITERATURE REVIEW

Video analytics for surveillance: Theory and practice:

In the past two decades, video analytics, informally defined as autonomous knowledge of events happening in a scene monitored by several video cameras, has been quickly growing. Despite this effort, real surveillance systems used today are not yet capable of autonomously analysing complicated events in camera view. This is a severe shortcoming since video feeds from millions of surveillance cameras throughout the globe are not examined in real time and so cannot aid in accident, crime, or terrorist prevention and mitigation, all of which are important concerns in today's society. Today, these feeds are only recorded to aid with post-event video forensics.

Using the visual intervention influence of pavement marking for rutting mitigation—Part II: Visual intervention timing based on the finite element simulation

Visual intervention has a considerable impact on driving behaviour, which may result in the redistribution of wheel tracks, reducing stress from the concentration of axial stresses, and mitigating rutting, as described and verified in a companion work (Part I). A three-stage intervention strategy with reasonable visual intervention time may minimise rutting. An initial development rate approach is suggested in this article, and a rutting prediction method based on a finite element model is created. The rutting depth data is segmentally fitted to get the rate curve of rutting deformation, which is used to predict the intervention timings of three types of typical pavement structures. It is discovered that SUPERPAVE pavement is the most recent to establish intervention, while AC pavement is the oldest. The research also reveals that the stronger the resistance to rutting deformation, the longer the rutting deformation reaches the second stage (stationary state), implying that intervention is delayed. The intervention of the longitudinal slope segment is sooner than that of the flat slope section for the identical pavement construction. Furthermore, an intervention cycle may increase the service life of asphalt pavement by 16-31%.

Synergies of electric urban transport systems and distributed energy resources in smart cities

Within cities, transportation systems and buildings use the most energy. There has been a lot of study done on these systems (facilities and transport). However, synergies between them are often neglected, failing to capitalise on the potential advantages of their combined coordination and management. This study proposes a linear programming model for determining the best operation and planning of distributed energy resources (DER) in a residential zone while taking into account electric private and public transportation systems, including electric automobiles and metro. As a result, the major contribution of this research is an examination of the synergies of such a linked architecture. It is expected that some of the metro's regenerative braking energy may be stored in the batteries of electric vehicles (EVs) and utilised subsequently for other trains or the EV itself. Several case studies based on data from a Madrid residential neighbourhood and a metro line have been offered. The acquired findings reveal considerable cost reductions in the total system, particularly a large decrease in power costs for the metro system.

Motion interaction field for accident detection in traffic surveillance video

This research describes a new approach for simulating the interaction of many moving objects in order to identify traffic accidents. The motion of water waves in response to moving items on the sea surface inspired the suggested approach for modelling object interactions. The Motion Interaction Field is used to describe the contour of the water surface in a field form using Gaussian kernels (MIF). We identify and pinpoint traffic accidents using the MIF's symmetric features without having to solve difficult vehicle tracking issues. Our solution beats current methods in identifying and localising traffic accidents, according to experimental data.

Bridging the past, present and future: Modeling scene activities from event relationships and global rules

This study discusses the detection of activities in complex surveillance scenes and the underlying dynamics that determine their occurrence across time. To that purpose, we present a unique topic model that takes into consideration the two key elements influencing these occurrences: (1) the presence of global scene states that govern which activities may occur spontaneously; (2) the existence of local rules that relate previous activity occurrences to present ones with temporal delays. These complementing components are blended in the probabilistic generating process due to the usage of a binary random variable that determines which of the above two criteria is relevant for each activity occurrence. A collapsed Gibbs sampling inference approach is used to efficiently infer all model parameters. Experiments on various datasets from the literature show that the model can capture temporal processes at multiple scales: the scene-level first order Markovian process, as well as causal relationships between activities that can be used to predict which activity can happen after another, and with what delay, providing a rich interpretation of the scene's dynamical content.

A Markov clustering topic model for mining behaviour in video:

The subject of completely automated mining of public place video footage is addressed in this study. A new Markov Clustering Topic Model (MCTM) is presented that improves on current Dynamic Bayesian Network models (e.g., HMMs) and Bayesian topic models (e.g., Latent Dirichlet Allocation) in terms of accuracy, resilience, and computing efficiency. Our approach specifically characterises complicated dynamic situations by consistently grouping visual events into activities, and these activities into global behaviours, and then correlating these behaviours across time. A collapsed Gibbs sampler is developed for offline learning with unlabeled training data, and an online Bayesian inference approximation is developed to allow dynamic scene interpretation and behaviour mining in fresh video data in real-time. Unsupervised learning of dynamic scene models, mining behaviours, and recognising salient events in three complicated and congested public scenarios highlight the model's power.

A system for learning statistical motion patterns:

Analysis of motion patterns is an excellent method for detecting anomalies and predicting behaviour. Current techniques to motion pattern analysis rely on known situations in which objects move in predictable patterns. It is extremely desired to automatically generate object motion patterns that represent scene information. Based on a suggested technique for successfully monitoring numerous objects, we provide a system for autonomously learning motion patterns for anomaly detection and behaviour prediction in this study. Foreground pixels in the tracking process are grouped using a fast accurate fuzzy k-means algorithm. The growing and prediction of foreground cluster centroids ensures that each cluster centroid is connected with a moving item in the picture. Trajectories are grouped hierarchically utilising geographical and temporal information in the method for learning motion patterns, and each motion pattern is represented by a chain of Gaussian distributions. Statistical approaches are used to identify anomalies and forecast actions based on the learnt statistical motion patterns. Our approach is evaluated using picture sequences obtained from a packed actual traffic scenario and a model traffic scene, respectively. The experimental findings demonstrate the tracking algorithm's durability, the algorithm's efficiency in learning motion patterns, and the

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promising performance of algorithms for anomaly detection and behaviour prediction.

3. METHODOLOGY

Several deep learning-based algorithms for autonomous traffic accident identification have been presented. To identify collisions in films, these systems need extensive training with vast volumes of data and use complicated neural networks. However, because to the scarcity of training data and the high computing costs, these frameworks are challenging to deploy in practise. Furthermore, with an increase in the amount of traffic surveillance films, identifying and analysing accidents throughout the whole city with a centralised system is tough. A distributed architecture comprised of embedded devices placed in every block of the city is required. As a result, a lightweight framework capable of being deployed on embedded devices is needed.

Disadvantages

1. However, because to the limited quantity of training data and the high computing costs, these frameworks are challenging to deploy in practise.
2. Furthermore, with the increased amount of traffic surveillance footage, identifying and analysing accidents throughout the whole city with a centralised system is tough.

In this paper, we offer a system for accident detection and analysis that may be deployed on AI demo boards. In order to identify and locate traffic incidents quickly, a motion interaction field (MIF) model is used. In order to determine the trajectory of the car before to the collision, we employ a YOLO v3 model and hierarchical clustering. Before determining the speed and contact angle of cars in an accident, we use unbiased finite impulse response (UFIR) filtering and perspective transformation to correctly assess the event. Furthermore, in terms of system implementation, we validated the framework on HiKey970, a Huawei AI showcase board.

Advantages:

1. To demonstrate the usefulness and implementation performance of the suggested technique, an experiment is conducted using a Huawei AI demo board termed HiKey970, which is utilised to code all of the aforementioned algorithms.
2. Several accident surveillance movies serve as the demo board's input. Accidents are effectively recognised,

and the relevant vehicle trajectories are retrieved.

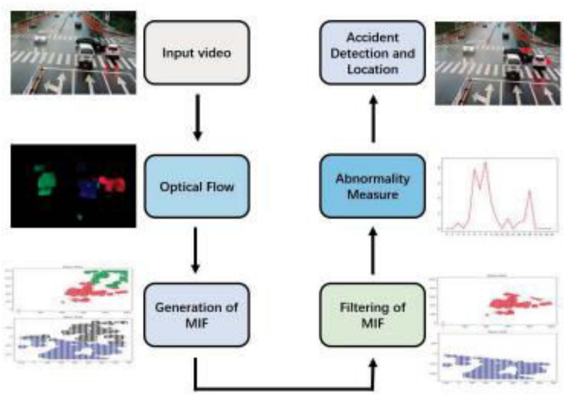

Fig.2: System architecture

MODULES:

To carry out the aforementioned project, we created the modules listed below.

- Data exploration: we will put data into the system using this module. Processing: we will read data for processing using this module.
- Using this module, data will be separated into train and test groups.
- Model generation: Create a YOLOV5 model.
- User signup and login: Using this module will result in registration and login. User input: Using this module will result in prediction input.
- Prediction: the final predicted value will be presented.

4. IMPLEMENTATION

ALGORITHMS:

YOLOV5:

YOLO, which stands for "You Only Look Once," is an object identification technique that splits photos into grids. Each grid cell is in charge of detecting items inside itself. Because of its speed and precision, YOLO is one of the most well-known object detection techniques. YOLO (You Only Look Once) models are used for high-performance object identification. YOLO splits a picture into grids, each of which identifies things inside itself. Based on the data streams, they may be utilised for real-time object detection.

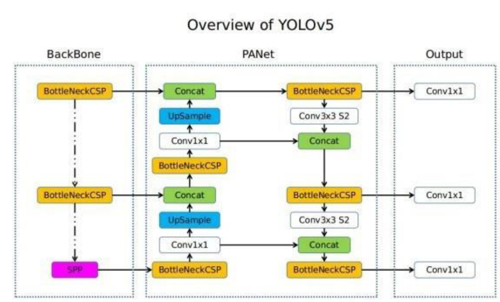

Fig.3: YOLOv5 architecture

The YOLOv5 Architecture as a Convolutional Neural Network Scheme (CNN). The BackBone,

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Neck, and Head are the main components. CSPNet is used in the BackBone to extract features from the photos used as input images. The Neck is used to create the pyramid feature.

5. EXPERIMENTAL RESULTS

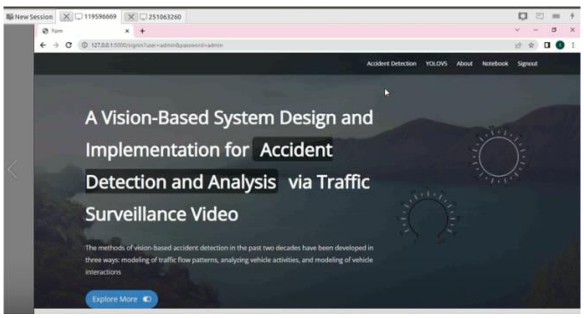

Fig.4: Home screen

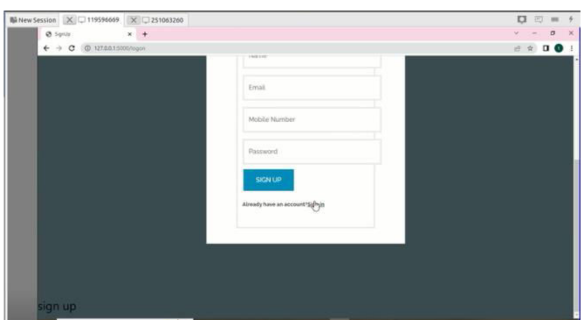

Fig.5: User registration

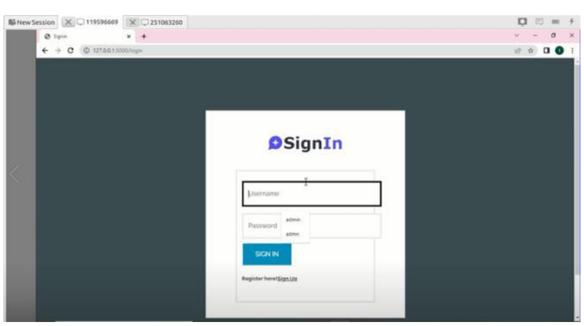

Fig.6: user login

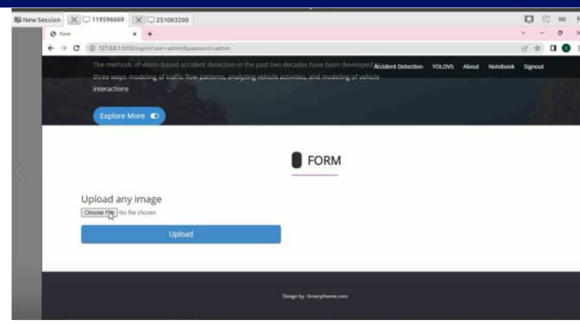

Fig.7: Main screen

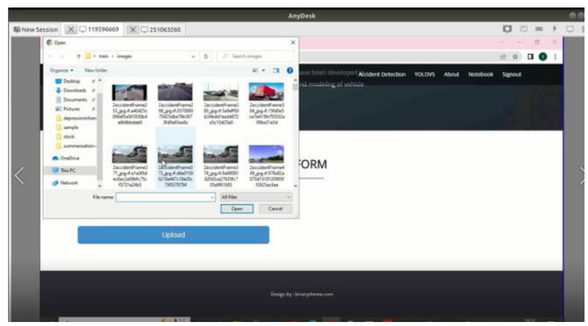

Fig.8: Input images

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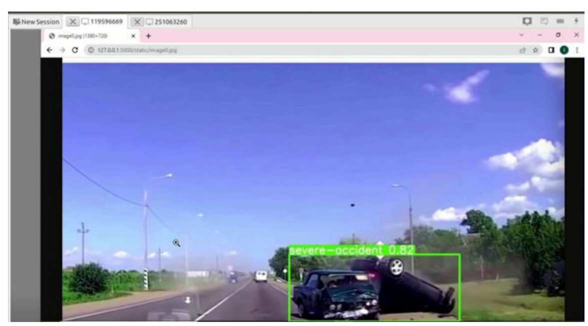

Fig.9: Prediction result

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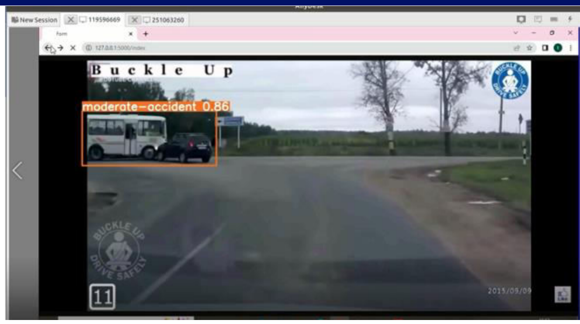

Fig.10: Prediction result

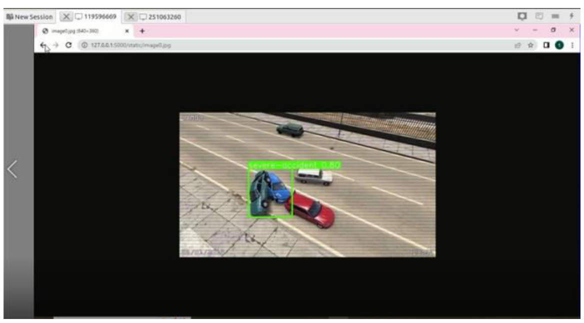

Fig.11: Prediction result

6. CONCLUSION

In this paper, a methodology for automatically identifying and analysing traffic accidents using surveillance footage was suggested. First, the MIF model approach was used to identify and find crashes in movies. Second, for the identification of wrecked automobiles, a YOLO v3 model was used. Third, before the collision, the trajectories were recovered using the hierarchical clustering approach. The trajectories were projected to a vertical image by perspective transformation to aid traffic officers' judgement. The trajectories were filtered using UFIR filtering, and the vehicle velocity was determined. The estimated velocity and the acquired impact angle from the vertical perspective were then used to evaluate an accident. Finally, a hardware practise test for coding all of the aforementioned algorithms on HiKey970, a Huawei AI demo board, was performed. The demo board's input was an accident surveillance video. The accident was successfully recognised, and the associated vehicle trajectories were collected. HiKey970 outperformed the Intel Core i7-9750H CPU @ 2.60-GHz machine by 28.85%-45.72%.

7. FUTURE WORK

However, there are certain issues that must be addressed in the future. To begin, another deep learning model may be attempted to increase recognition accuracy when the automobile is obstructed. Second, several picture enhancement techniques may be used to improve accident detection effectiveness in diverse climatic circumstances or when the quality of surveillance recordings is inadequate. Third, the licence plate of the collision car may be identified for further investigation. In the future, we will concentrate our efforts on course tracking control and attack detection for autonomous vehicles.

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