Sudan University of Science and Technology

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Implementation of Automatic Detection Algorithm for Vehicles Accidents

A Research Submitted In Partial fulfillment for the Requirements of the Degree of B.Sc. (Honors) in Electronics Engineering

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بسم الله الرحمن الرحيم

" يَرْفَعِ اللَّهُ الَّذِينَ آمَنُوا مِنكُمْ وَالَّذِينَ أُوتُوا الْعِلْمَ دَرَجَاتٍ

وَاللَّهُ بِمَا تَعْمَلُونَ خَبِيرٌ"

سورة المجادلة- الآيه (11)

To our Beloved Parents

ACKNOWLEDGMENTS

First and Foremost, All the praise to all mighty Allah, for bestowing us with the knowledge, health and wisdom to carry out this project. We are greatly indebted to our parents, for their endless patience, moral support and prayers. Special thanks to our mothers for their limitless love and chocolate cakes.

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Abstract

Intelligent Transportation system (ITS) takes a vital part in global world. It is a novel field that interoperates in different fields of transportation system. Traffic control is one of the important applications of ITS. As the problem of overpopulation worsens, traffic control becomes a grand challenge. Among the main technologies used to implement solutions for this challenge is the Video-based traffic surveillance system. Of late the focus of video-based traffic surveillance has shifted to detect incidents at Highways such as vehicle accidents, traffic congestion, and unexpected traffic blocks.

This project aims to detect accidents automatically by implementing a vision-based Automatic Accident Detection (AAD) Algorithm. After detecting and tracking vehicles from surveillance videos, centroids and bounding boxes are used to determine the occurrence of accident. In case of an accident, it will be reported immediately.

This research discusses the implementation of the proposed AAD algorithm using image processing and computer vision toolboxes of MATLAB. And also the results of offline testing.

As a result, AAD can detect and track vehicles and notify when accident occurs.

المستخلص

نظـــام النقـــل الـــذكي هـــو نظـــام حـــديث يـــتم دمجـــه فـــي مختلـــف مجـــالات النقـــل، ومـــع زيـــادة الكثافـــة الســـكانية أصـــبح الـــتحكم فـــي النقـــل يمثـــل تحـــدي كبيـــر .مـــن التقنيـــات المســـتخدمة لإيجـــاد الحلـــول لهـــذا التحـــدي هـــي اســـتخدام نظـــام مراقبـــة الطـــرق، مـــؤخرا تـــم التركيـــز علـــى نظـــام المراقبـــة فـــي اكتشـــاف الأحـــداث مثـــل حـــوادث السيارات ، ازدحام الطرق ومعيقات الطرق.

يهـــدف هـــذا البحـــث إلـــى اكتشـــاف الحـــوادث آليـــا مـــن خـــلال تطبيـــق خوارزميـــة اكتشـــاف الحـــوادث آليـــا، بعـــد اكتشـــاف و تتبـــع العربـــات باســـتخدام نظـــام مراقبـــة الطـــرق يـــتم اســـتخلاص معـــاملات (مربـــع محـــيط بالعربـــة و النقطـــة الوســـطى للعربـــة) و اســـتخدامها للتحقـــق مـــن وجـــود الحـــادث، و فـــي حالـــة وجـــود حـــادث يـــتم إجراء لحظي.

فـــي هـــذا البحـــث يـــتم مناقشـــة كيفيـــة تطبيـــق الخوارزميـــة المقترحـــة (AAD) والتـــي تـــتم باســـتخدام أدوات معالجـــة الصـــورة الرقميـــة و رؤيـــة الكمبيـــوتر الموجـــودة فـــي الماتلاب، و يتم اختبار أداء الخوارزمية منفصلة عن النظام.

و في الخلاصة، خوارزمية اكتشاف الحوادث آليا تقوم باكتشاف و تتبع العربات و الإشعار عند حدوث حادث.

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LIST OF ABBREVIATIONS

ITS	Intelligent Transport System.
AID	Automatic Incident Detection.
AAD	Automatic Accident Detection.
GMM	Gaussian mixture models.
MVs	moving vehicles
FCC	Federal Communications Commission
CDR	correct detection rate
CCTV	Closed Circuit Television Camera
GPS	Global Positioning System
ARRS	Accident Recording and Reporting System
CCD	Charge Coupled Devices
TMC	Traffic Monitoring Centre
VPN	Virtual Private Network
ROIs	Regions of Interest

CHAPTER ONE

INTRODUCTION

1.1 Introduction

Transportation or transport sector is a legal source to take or carry things from one place to another. With the passage of time, transportation faces many issues like high accidents rate, traffic congestion, traffic and carbon emissions air pollution, etc. In some cases, transportation sector faced alleviating the brutality of crash related injuries in accident. Due to such complexity, researchers integrate virtual technologies with transportation which known as Intelligent Transport System. The idea of virtual technologies integration is a novel in transportation field and it plays a vital part to overcome the issues in global world.

ITS is the conventional of the development of next-generation technologies. It is a novel field that interoperates in different fields of transportation system, such as transportation management, control, infrastructure, operations, policies and control methods, etc. There is a wide range of reimbursement that obtained from ITS deployments. ITS can play a major role in reducing risks, high accidents rate, traffic congestion, carbon emissions, air pollution and on the other hand increasing safety and reliability, travel speeds, traffic flow and satisfied travellers for all modes[1].

Traffic control is one of the important applications of ITS. As the problem of overpopulation worsens, traffic control becomes a grand challenge. Among the main technologies used to implement solutions for this challenge is the Video traffic surveillance system.

Nowadays, Video traffic surveillance systems are increasingly being deployed across city centers, motorways, Highways and car parks[2]. surveillance systems are widely used for incident management, real-time traffic management, traveler information, and hazard evacuation. Some of the most widely used methods are closed circuit television systems, driver reports processing, highway crew patrols, and automatic incident Detection (AID) systems[3].

Video traffic surveillance systems have decreased the need of human presence to monitor activities captured by video cameras. And also one of the advantages of Video traffic surveillance system (as shown in figure 1.1) is videos can been stored and analyzed for future reference. Extensive research has been done in the field of video traffic surveillance. Video traffic surveillance systems are used for vehicle detection, tracking, traffic flow estimation, vehicle speed detection, vehicle classification, etc.

One of the widely used applications of traffic surveillance systems is vehicle detection, which can detect vehicle's velocity, trajectory, traffic density, etc. and if there is any abnormality, the recorded information, which contains video images of traffic parameters, can be send to the traffic authorities to take necessary action [4].

Many systems have been proposed for accident detection by researchers. The detection technique is known as Traffic-incident detection-algorithm[5].

Figure1.1 Video traffic surveillance system

The videos from surveillance cameras are transmitted wirelessly to the Traffic monitoring center where the occurrence of the accident is determined. An Automatic Accident Detection (AAD) algorithm will be developed to achieve that task, suitable thresholds are defined to determine the occurrence of accidents. In case of accidents, it will be reported immediately. After analyzing the frames, the system identifies the moving vehicles in the image and tracks them. After the vehicles are tracked correctly in each frame, centroids and bounding boxes are used to determine the occurrence of accident. Once an occurrence of accident is detected, the system issues an alarm via the alert aid to the operators and displays the accident on the monitors.

1.2 Problem statements

Recent approaches used built-in vehicle automatic accident detection and notification systems. Also the studies show that an operator is very unlikely to focus on more than 10 to 15 screens efficiently. Traffic surveillance cameras are mostly used to verify accidents only after they have been reported through other channels.

1.3 Proposed Solution

An AAD algorithm is to be implemented to detect accidents on highway roads. The proposed algorithm is based on vehicle detection and tracking techniques. The AAD algorithm will process the video from the Traffic surveillance cameras. In case of an accident, it will be reported immediately.

1.4 Aim and Objectives

The aim of this project is to detect car accident automatically.

The objective of this project is:

- To implement an automatic accident detection algorithm.

1.5 Methodology

The problem addressed in this research is preliminary approach to implementation of automatic accident detection algorithm at traffic highway. Image sequences are extracted from the video camera, mounted on the pole at highway. The image sequences are fed to the accident detection module system where the occurrence of the accident is determined. The automatic accident detection algorithm consists of vehicle detection, vehicle tracking, vehicle parameter extraction and accident detection sections. After analyzing the image sequence, the system identifies the moving vehicles in the image and tracks them using low-level features. After the vehicles are tracked correctly in each frame, the vehicle parameter extracted which used to determine the occurrence of accident. In case of an accident , the system signals the detection of accident to the user.

Figure 1.2 the overview of the AAD algorithm

An AAD algorithm as shown in figure 1.2 will be implemented to achieve that task, which consists of four main steps. After extracting frames from the input video, a foreground detector based on a Gaussian mixture models will be initiated and trained to detect moving regions. The difference image is further thresholded to detect the vehicle regions in the frame. The next step is vehicle tracking can be defined as the process of segmenting an image of interest from a video scene and keeping track of its motion, orientation, occlusion etc. After tracking vehicles in frames includes parameter extraction and accident detection. Based on the centroid and suitable threshold are defined to determine the occurrence of accidents. In case of accidents, it will be reported immediately.

1.6 Thesis outlines

Chapter 2 includes a review of publications related to this research. It also discusses difference techniques of vehicle detection and tracking in order to implement automatic accident detection systems. Chapter 3 includes the research methodology that will be used and the AAD algorithm. Chapter 4 includes testing and results. Chapter 5 includes the conclusion of this research and recommendations.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

Intelligent Transportation system (ITS) takes a vital part in global world. It is a novel field that interoperates in different fields of transportation system, such as transportation management, control, infrastructure, operations, policies and control methods, etc. ITS can play a major role in reducing risks, high accidents rate, traffic congestion, carbon emissions, air pollution and on the other hand increasing safety and reliability, travel speeds, traffic flow and satisfied travellers for all modes [1].

Traffic control is one of the important applications of ITS. As the problem of overpopulation worsens, traffic control becomes a grand challenge. Among the main technologies used to implement solutions for this challenge is the Video-based traffic surveillance system [2].

For the last two decades researchers have spend quality time to develop different methods that can be applied in the field of video-based traffic surveillance. Some of the applications of video-based surveillance include vehicle tracking, counting the number of vehicles, calculating vehicle velocity, finding vehicle trajectory, classifying the vehicles, estimating the traffic density, finding the traffic flow, license plate recognition, etc.

Of late the focus of video-based traffic surveillance has shifted to detect incidents in roadways such as vehicle accidents, traffic congestion, and unexpected traffic blocks. From researches and surveys it was found that there is more necessity to detect accidents in highways and roadway intersections, as vehicle accidents causes huge loss to lives and property [4]. Therefore the objective of video -based traffic surveillance of present is to detect accidents in highways and intersections such that necessary action can be taken promptly without losing any quality time, so that lives of the injured can be saved.

Apart from video-based systems, researches have also been done to detect incidents in roadways using other systems such as sensors, acoustic signal and others. These systems basically use physical detectors to collect the traffic parameters and apply machine learning and pattern recognition algorithm to detect the occurrence of an incident. Spot sensors such as inductive loop sensors were employed. All of these systems showed varying amount of detection performance [4]. Table 2.1 shows the performance comparison of various incident detection technologies [4].

Table 2-1: Performance Comparison among Existing Incident Detection Technologies

Type	Advantages	Disadvantages
Inductive loop detector	• Low per-unit cost • Large experience base •Relatively good performance	• Installation and maintenance require traffic disruption • Easily damaged by heavy vehicles, road repairs, etc
Microwave (Radar)	• Installation and repair do not require traffic disruption • Direct measurement of speed • Multilane operation • Compact size	• May have vehicle masking in multilane application • Resolution impacted by Federal Communications Commission (FCC)−approved transmit frequency • Relatively low precision

Laser	• Can provide presence, speed, and length data • May be used in an along-the-road or an across-the-road orientation with a twin detector unit.	• Affected by poor visibility and heavy precipitation • High cost
Infrared	• Day/night operation • Installation and repair do not require traffic disruption • Better than visible wavelength sensors in fog • Compact size.	• Sensors have unstable detection zone • May require cooled IR detector for high sensitivity • Susceptible to atmospheric obscurants and weather.
Ultrasonic	• Can measure volume, speed, occupancy, presence, and queue length	• Subject to attenuation and distortion from a number of environmental Factors (changes in ambient temperature, air turbulence, and humidity) • Difficult to detect snow-covered vehicles.

Magneto-meter	• Suitable for installation in bridge Decks or other hard concrete surfaces where loop detectors cannot be installed.	• Limited application • Medium cost
Video image Processing	• Provides live image of traffic (more information) • Multiple lanes observed • No traffic interruption for installation and repair • Vehicle tracking	• Live video image requires expensive data communication equipment. • Different algorithms usually required for day and night use. • Possible errors in traffic data transition period. • Susceptible to atmospheric obscurants and adverse weather

Other advantages of utilizing the vision-based systems besides the above mentioned are: [4]

1. Their ability to collect diverse information such as illegally parked vehicles, traffic violations, traffic jams and traffic accidents.
2. The crashes can be recorded and analyzed which can be used to enhance the safety features at roadways and intersections.
3. The automated reporting of accident can be used to reduce the emergency response time .

2.2 Literature Review

This section summarizes previous studies on different accident detection techniques as follows:

Thomas Wells , Eric Toffin , 2005, have decided to test a video-base incident detection system in order to quickly and efficiently warn Traffic Operators of incidents occurring on the roads. A video-based incident detection system was deployed on 8 existing PTZ cameras monitoring the San Mateo-Hayward Bridge in the San Francisco Bay. The self-learning system image-processing algorithm analyses movement and automatically warns Traffic Operators of any vehicle stopped within the field of view of a given camera. The test showed that the system proved to be efficient in detecting accidents or incidents on traffic lanes [6].

Y. K. Ki , D. Y. Lee 2007, This work suggested a vision-based traffic accident detection algorithm and developed a system for automatically detecting, recording, and reporting traffic accidents at intersections. A system with these properties would be beneficial in determining the cause of accidents and the features of an intersection that impact safety. This model first extracts the vehicles from the video image of the charge-couple-device camera, tracks the moving vehicles (MVs), and extracts features such as the variation rate of the velocity, position, area, and direction of MVs. The model then makes decisions on the traffic accident based on the extracted features. In a field test, the suggested model achieved a correct detection rate (CDR) of 50% and a detection rate of 60% [7].

Wang Wei, Fan Hanbo, 2011, the authors introduced An automatic alarm device for traffic accidents. It can automatically detect a traffic accident, search for the spot and then send the basic information to first aid center within two seconds covering geographical coordinates, the time and circumstances in which a traffic accident takes place. By means of satellite navigation system, first aid rescuers can accurately locate the place with maximum error controlled by 10 meters, so that they can save the injured people as soon as possible [8].

Takehiko Kato and others 2011, the authors have developed the automatic incident detection system with improved environment resistant properties that can be applied to the open section as well as the conventional tunnel section. Popularization of CCTV cameras and progress of video compression transmission technology including IP networks have increased the coverage of surveillance areas. Accordingly, detecting sudden incidents in the open section is expected to be utilized to increase safety [9].

Hi-ri-o-tappa, K. And others, 2012, proposed a traffic incident detection system that can report the occurrence of traffic incidents, which occur between detectors. Based on the previously proposed dynamic time warping algorithm, this incident detection system monitors and assesses changes at upstream and downstream sites. Then, if the upstream-downstream changes are associated with traffic incidents, the system raised an alarm and report CCTV images on site, which are sent to traffic operators to further response. Performance evaluations are conducted using real-world traffic data where it is shown that the incident detection algorithm used in the proposed system achieves 94% detection rate and low false alarm rate [10].

Patel K.H., 2013, the author has developed an android application that is used to sense the accident using only the accelerometer sensors in the Android Smartphone. After sensing the accident, application automatically generates the geographical information by GPS and sends location information via pre-recorder voice message to 108-ambulance emergency response service that is running in India. The key assumption of this application is that the mobile phone should not be kept along with the person who is driving the vehicle; it must be docked inside the vehicle and the validation of the accelerometer sensor is performed by tilting the mobile left or right or frsee fall motion. The main issue with system is the Smartphone may tilt or fall in any time inside the vehicle accidentally without having a real accident and thus, the probability of false positive will be increased and false alarm will be reported [11].

Md. Syedul Amin and others 2013, proposed a system that detect an accident from the map matched position of a vehicle by utilizing the GPS speed data and map matching algorithm and send accident location to an Alert Service Centre. The GPS provides speed and position. The position data used in the map-matching algorithm to locate the vehicle on the road. The system generates an accident situation. It checkes the vehicle location from map matching module and generates an accident situation if the vehicle is found outside the road network. This reduces the false accident detection drastically. The map matched accident location is then sent by utilizing the GSM network. The proposed system saves many accident victims with timely rescue [12].

Gayathri Elumalai, O.S.P.Mathanki, S.Swetha, 2015, This research proposed a traffic accident detection system that is vision based. This system is called the traffic Accident Recording and Reporting System (ARRS). This system can detect, record, and report traffic accidents. It uses the idea of picture queuing that is highly applicable to intersections that are widely prone to deadly accidents. This picture queuing is brought by extracting images of the vehicle from video image of the Charge Coupled Devices (CCD) cameras. The main attention is given to the change in the rate of velocity, position, direction, and angle of the moving vehicle. These criteria are taken into account by this accident detection algorithm for making decisions. These images are a replacement for crash data. The interoperability is improved by a metadata registry. The metadata registry is maintained by the Traffic Monitoring Centre (TMC) via Virtual Private Network (VPN).The proposed system was placed at two intersections in Seoul, Korea. During the test period, 4 traffic accidents were detected and recorded by the AARS [13].

K.N.Dongre and others 2015, this project is mainly used to track the position of the Vehicle by the owner with the help of GSM technology and location keys. In case of any accident, the system sends automated messages to the pre-programmed numbers. It can send messages to any number of mobiles. The owner of the vehicle, Police to clear the traffic, Ambulance to save the people can be informed by this device. This uses a location keys to know the exact position of the vehicle with an accuracy of a few feet.GSM is used to receive SMS from the user and reply the position of the vehicle through a SMS.A 8051 microcontroller is used to control and coordinate all the parts used in this system. When there is any accident, the vibration sensor gives the signal to the microcontroller, which sends the information to the LCD display through GSM network. The automatic accident tracking system module uses an IR pair. The transmitter circuit transmits the IR waves towards the target and in receiver section, receiver receives the IR signals with variations and gives suitable output to the microprocessor. If there is an occurrence of fire during accident, the smoke detector detects the smoke, which in turn activates the location keys to tract the position of the vehicle to give a suitable input to the microcontroller. The microcontroller circuit processes the input and sends the appropriate output according to the programming done [14].

Prasad P. Pingle and Others, 2016, the authors developed an automatic alarm device for vehicle accidents. This design of system has accuracy, which can detect accidents in significantly less time and sends the location information to medical centre within a fraction of seconds covering the time, geographical coordinates and angle in which a vehicle accident had occurred. When the accident occurs, the alert message is sent automatically to the rescue team and to the police station and family members. The message is sent through the Internet Dongle and the location of the accident is detected using GPS module. The optimum solution is provided by this application with the help of the emergency facilities, which is provided to the roads accidents in the most feasible way [15].

2.3 System Configuration Overview

When surveillance is conducted manually, it is not possible to watch more videos than the actual number of monitors (video display devices), which may lead to delay of accidents detection. In addition, the surveillance staff may not be able to constantly maintain concentration to detect accidents. Since the automatic accident detection system constantly processes image data, there is no restriction of the number of monitors, and an accident can be detected in real time.

Surveillance staff can closely check the incident location or the circumstances before and after the occurrence of the incident based on the information provided by the system and by the use of the zooming and turning functions of the surveillance cameras. This makes it possible to effectively provide information quickly notify the police and patrol cars of the accident [16]. Figure 2.1 illustrates the main components of the system

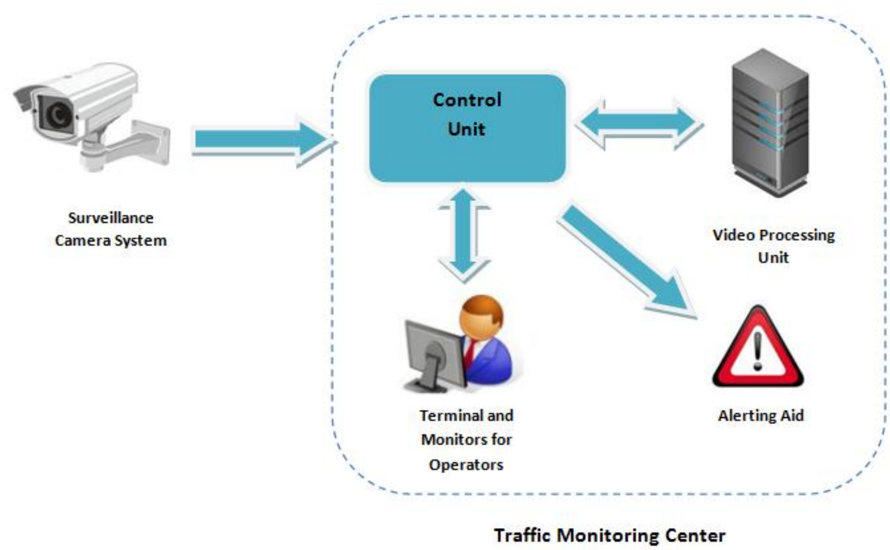

Figure 2-1 System overview

2.3.1 Surveillance Camera System

The Camera System contains a group of cameras to monitor specific areas and also record videos from them. Cameras used can be analogue or digital. However, analogue cameras suffer from low resolution, storage limitations and difficulty in searching through captured images. So digital cameras are more preferred [2].

2.3.2 Control Unit

The control unit receives videos from the Surveillance cameras and forwards it to the processing unit and the monitors. it also receives the accident notification from the video processing unit and issues an alarm signal to the alarm unit and automatically displays the accident images to the operators.

2.3.3 Alert Aid

The alert aid displays the alarm signal from the control unit.

2.3.4 Terminal for operators

The Terminal provides a platform for traffic operators to interact with the system. The surveillance videos can be viewed in real-time or recorded for later review. On-site operators can review and confirm accidents directly on monitors.

2.3.5 Video Processing Unit

The processing unit detects a sudden accident by processing video frames via automatic Accident detection (AAD) algorithm, which will be discussed in details in the following sections.

2.4 Automatic Accident Detection algorithm

There are basically four major steps involved in the video-based crash detection algorithms, various researches have been done on each individual section separately and good performance have been obtained. These are the following step: [4]

1. Motion segmentation and vehicle detection.
2. Vehicle tracking.
3. Processing the results of tracking to compute traffic parameters.
4. Accident detection using the traffic parameters.

2.4.1 Motion segmentation and vehicle detection

Identifying moving objects from a video sequence is a fundamental and critical task in many computer-vision applications [17]. Motion segmentation is the process of separating the moving objects from the background. It is an essential step for detecting the vehicles in the video frame sequence.

There are four main approaches to detect vehicle regions are:

- Frame differencing method.
- Background subtraction method.
- Feature based method.
- Optical flow method.

2.4.1.1 Frame differencing method

The frame differencing is the process of subtracting two subsequent frames in image sequence to segment the moving object (foreground object) from the background frame image [18].

- **Pros:** works well in case of uniform illumination conditions, easy to implement and calculate.
- **Cons:** frame differencing method does not work well if the time interval between the frames being subtracted is too large ,and does not give accurate results in case of non-uniform illumination conditions, in which it creates non-vehicular region [4].

2.4.1.2 Background subtraction method

The process of extracting moving foreground objects (input image) from stored background image (static image) or generated background frame form accumulated the image sequence (video frames) is called background subtraction [18].

- **Pros:** it can provide the most complete object information when the background is already known.
- **Cons:** non-adaptive background frame method is sensitive to the changes in the external environment such as changes in lighting and the climatic situation, and may result in non-vehicular regions [19].

Therefore, to generate a background that is dynamic to the illumination and weather conditions. A significant contribution suggested statistical and parametric based techniques, such as using the Gaussian probability distribution model for each pixel in the image. The Gaussian distribution model is updated with the pixel values from the new image frame in the image sequence. After enough information about model has been accumulated, each pixel (x, y) is classified either belonging to the foreground or background.

Some robust background modeling techniques use more than one Gaussian (Mixture of Gaussians), to overcome the problem of shadows and non - important moving regions (e.g., tree branches) in the background.

However, these techniques have a high computational complexity making them difficult to operate in real-time [4].

2.4.1.3 Feature based method

This method made use of sub-features such as edges or corner of vehicles. The moving objects are segmented from background image by collecting and analyzing the set of these features from the movement between the consecutive frames [20].

- **Pros:** feature based methods support occlusion handling between overlapping vehicles, and have less computational complexity compared to background subtraction method. Moreover, the sub-features can be further analyzed for classifying the vehicle type.

- **Cons:** May fail to detect vehicles correctly if the features are not grouped accurate, also some of the systems are computationally complex and need fast processing computers for real-time implementation [4].

2.4.1.4 Optical flow method

Optical flow methods calculate the image optical flow field and do cluster processing according to the optical flow distribution characteristic of the image.

- **Pros:** This method can get the complete movement information and detect the moving object from the background relatively well.
- **Cons:** large quantity of calculation, sensitivity to noise, and poor anti-noise performance, make it not suitable for real-time implementation [19].

2.4.2 Vehicle Tracking

Tracking the physical appearance of moving objects such as the vehicles and identify it in a dynamic scene, can be done by locating the position of the objects, estimating the motion of the blobs and follow their movements between consecutive frames in video scene [21].

Several vehicle-tracking methods have been illustrated and proposed by several researchers for different issues, such as:

- Region-Based Tracking Method.
- Contour Tracking Method.
- 3D Model-Based Tracking Method.
- Feature-Based Tracking Method.
- Color and Pattern-Based Method.

2.4.2.1 Region-Based Tracking Method

In this method, the image frame containing vehicles is subtracted from the background frame, which is then further processed to obtain vehicle regions (blobs). Then these vehicle regions are tracked. This method worked on series of traffic scenes recorded by a stable camera for automobiles monocular images and provided position and speed knowledge for each vehicle as long as it is visible [4][17].

Techniques based on this method usually have difficulty in handling shadows and occlusion.

2.4.2.2 Contour Tracking Method

This method depends on contours (the boundaries of vehicle) which are updated dynamically in successive images of vehicle [17].

Techniques based on this method provide more efficient descriptions of objects than Region-Based Methods than region-based tracking, and have a reduced computational complexity. But the disadvantage of the method is the inability to accurately track occluded vehicles and tracking need to be initialized on each vehicle separately to handle occlusion better (automatic initialization of tracking are difficult to handle and tracking precision is limited by a lack of precision in the location of the contour).

2.4.2.3 3D Model-Based Tracking Method

In this method, vehicles are localized and tracked by matching a projected 3D model to the image data. The 3D model-based vehicle tracking methods can handle interference between nearby images and also be applied to track vehicles which greatly change their orientations. However, they have high computational cost and they need detailed geometric object model to achieve high tracking accuracy.

2.4.2.4 Feature-Based Tracking Method

In feature-based tracking method, suitable features (i.e. edge points and corners) are extracted from the vehicle regions which are processed to track the vehicles correctly.

Algorithms based on this method have low computational complexity, can operate in real-time, and can handle occlusions well. However, recognition rate of vehicles using two-dimensional image features is low, because of the non-linear distortion due to perspective projection and the image variations due to movement relative to the camera [4].

2.4.2.5 Color and Pattern-Based Method

This technique is used to analyze color of image series of traffic videos. Through the practical experiments, this system proven to work well under several weather situations, and it is insensitive to light variations. The pattern-based system is used for real-time traffic supervision for continuous visual tracing and classification of vehicles for busy multi-lane highway scene [17].

2.4.3 Parameters extraction and Accident detection

After detecting and tracking vehicles in video frames, low-level features such as area, centroid, orientation, luminance and color of the extracted vehicle regions are computed. These features are used because of their low computational capacity.

2.5 Simulation

2.5.1 MATLAB

MATLAB (matrix laboratory): is a numerical computing environment and fourth generation programming language. MATLAB allows matrix manipulations, plotting of functions and data, implementation of algorithms, creation of user interfaces, and interfacing with programs written in other languages, including C, C++, Java, and FORTRAN. Image processing Toolbox provides a comprehensive set of reference-standard algorithms, functions, and apps for image processing, analysis, visualization, and algorithm development. users can perform image enhancement, image deblurring, feature detection, noise reduction, image segmentation, geometric transformations, and image registration. Visualization functions let users explore an image, examine a region of pixels, adjust the contrast, create contours or histograms, and manipulate regions of interest (ROIs). With toolbox algorithms users can restore degraded images, detect and measure features, analyze shapes and textures, and adjust color balance.

Computer Vision System Toolbox™ provides algorithms, functions, and apps for designing and simulating computer vision and video processing systems. It can perform feature detection, extraction, and matching; object detection and tracking; motion estimation; and video processing. For 3-D computer vision, the system toolbox supports camera calibration, stereo vision, 3-D reconstruction, and 3-D point cloud processing. With machine learning based frameworks, it supports training object detection, object recognition, and image retrieval systems. Algorithms are available as MATLAB® functions, System objects™, and Simulink® blocks.

For rapid prototyping and embedded system design, the system toolbox supports fixed-point arithmetic and C-code generation.

2.5.2 OpenCV

OpenCV (Open Source Computer Vision) is a library of programming functions mainly aimed at real-time computer vision.

OpenCV is written in C++ and its primary interface is in C++, but it retains a less comprehensive though extensive older C interface. There are bindings in Python, Java and MATLAB/OCTAVE. The API for these interfaces can be found in the online documentation.

OpenCV's application areas include 2D and 3D feature toolkits, Facial recognition system, Gesture recognition, Human–computer interaction (HCI), Mobile robotics, Motion understanding, Object identification, Segmentation and recognition, Motion tracking and other applications.

2.5.3 Comparison between Matlab and OpenCV

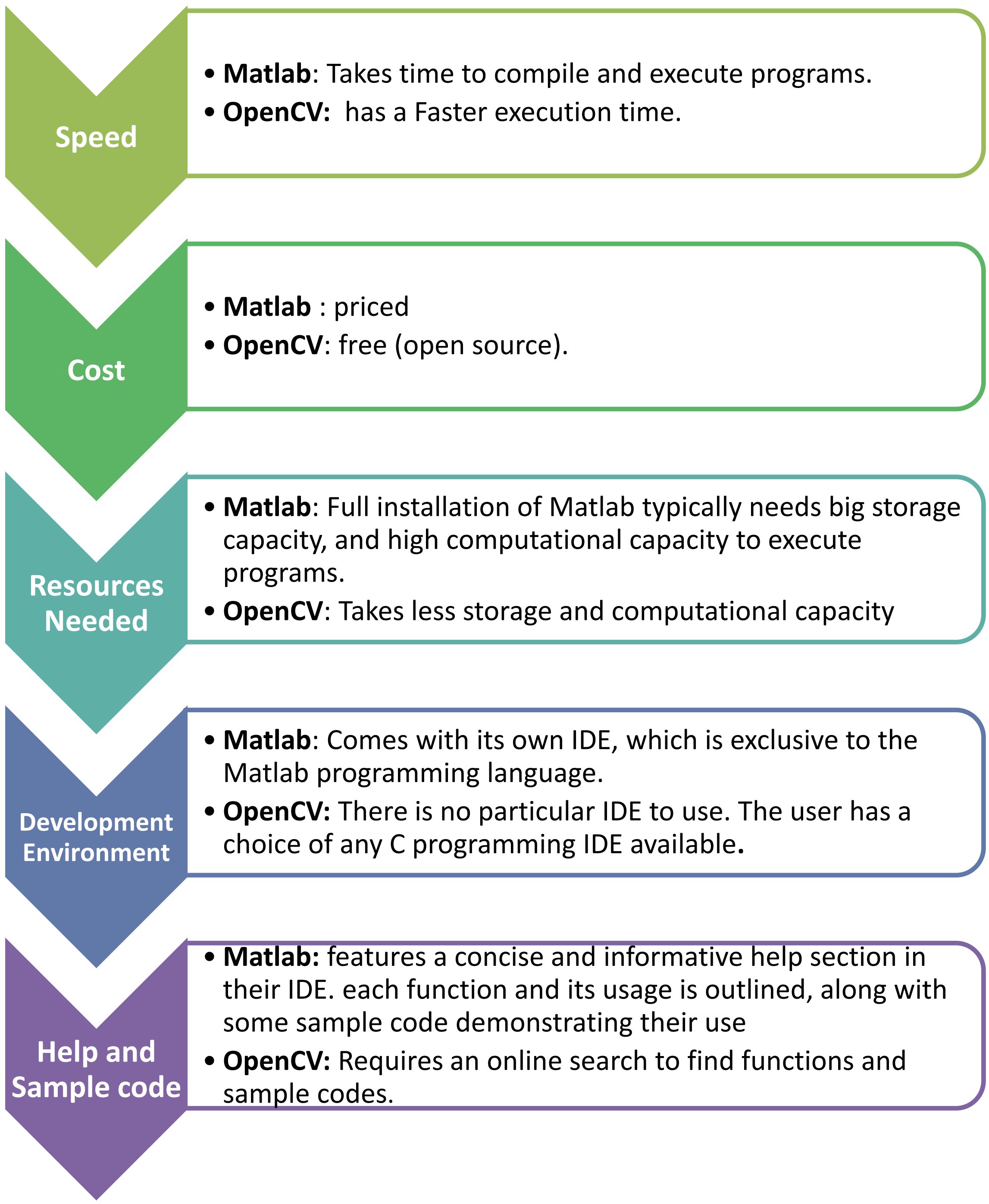

Figure2-2 Comparison between MATLB and OpenCV software

2.6 Challenges

Implementing a system that does vehicle detection and tracking can be quite challenging. Numerous difficulties need to be taken into account while designing and implementing the systems. The following are some of the challenges that can be faced while implementing real-time vehicle detection and tracking in order to detect accidents [4] :

- Vehicles can be of different size, shape and color. Furthermore, a vehicle can be observed from different angles, making the definition of a vehicle broader.
- Automatic segmentation of each vehicle from the background and from other vehicles so that all vehicles are detected.
- Lightning and weather conditions vary substantially. Rain, fog, daylight and darkness must all be taken into account when designing the system.
- Occlusion of tracked vehicles by other vehicles or structures.
- Traffic conditions may vary, and many of the tracking algorithms degrade with heavy traffic congestion, where vehicles move slowly, and the distances between the vehicles are small.
- Ability of the system to operate in real-time.

CHAPTER THREE

METHODOLOGY

3.1 Approach

As shown in the Figure 3-1, image sequences (video Frames) are extracted from the video surveillance. The automatic accident detection algorithm processes the image sequences where the occurrence of the accident is determined. As mentioned in the last chapter, the accident detection algorithm consists of vehicle detection, vehicle tracking, parameters extraction and accident detection steps. After analyzing the image sequence, the system identifies the moving vehicles in the frames and tracks them. After the vehicles are tracked correctly in each frame, some parameters are extracted which are used to determine the occurrence of accident. Once an occurrence of accident is detected, the system signals the detection of accident.

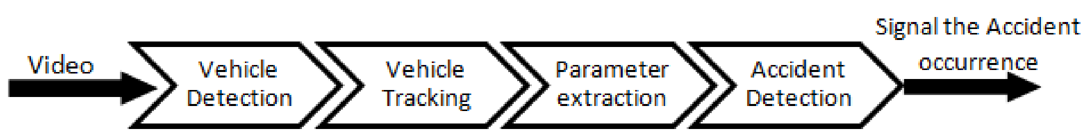

Figure 3.1 Accident Detection steps

3.2 Motion Segmentation and Vehicle Detection

The detection of moving objects uses a background subtraction algorithm based on Gaussian mixture models. Morphological operations are applied to the resulting foreground mask to eliminate noise. Finally, blob analysis detects groups of connected pixels, which are likely to correspond to moving objects. Figure 3-2 shows the steps of vehicle detection.

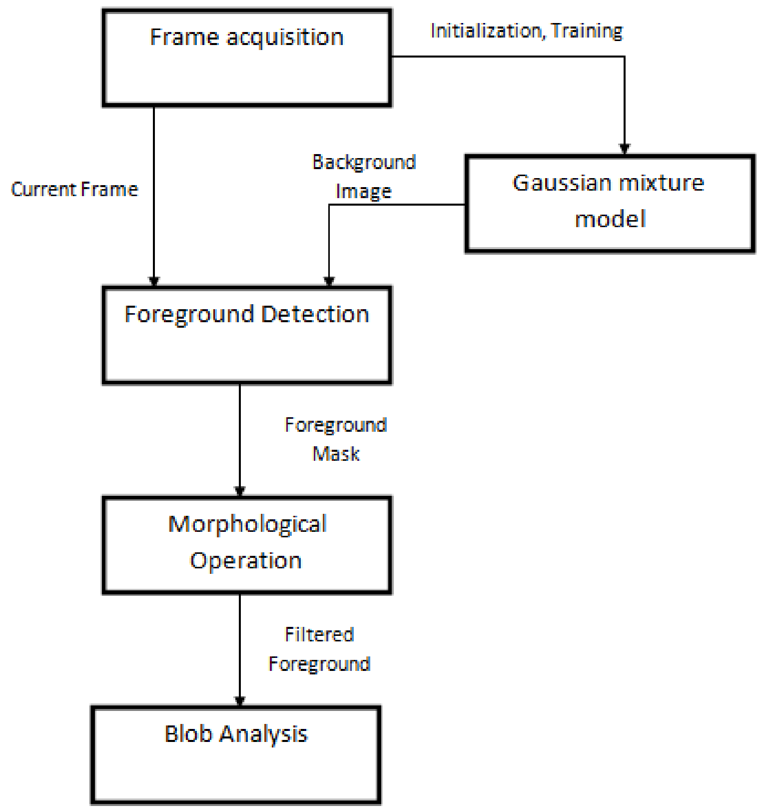

Figure 3-2 Flowchart of Vehicle Detection

Step 1 : Import Video and Initialize Foreground Detector

The foreground Detector compares a color or grayscale video frame to a background model to determine whether individual pixels are part of the background or the foreground. It then computes a foreground mask using Gaussian mixture models (GMM). It requires a certain number of video frames in order to initialize the Gaussian mixture model. After the training, the detector begins to output more reliable segmentation results. Figure 3-3 shows an example of detecting the foreground in a video frame and the resulting foreground mask computed by the detector.

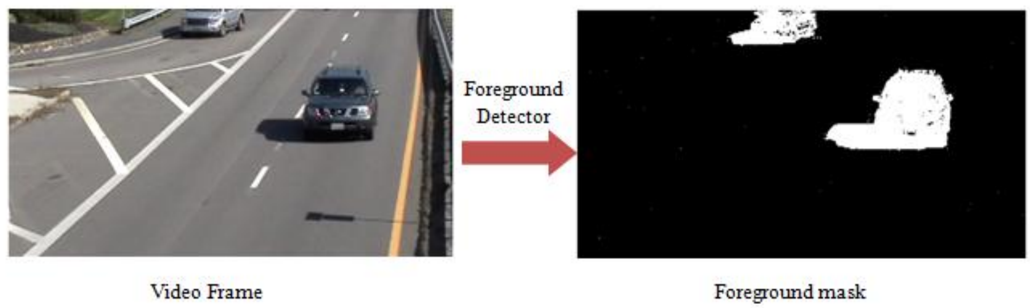

Figure 3-3 Example of Foreground Detection

Step 2 : Apply Morphological operations to remove noise

The foreground segmentation process is not perfect and often includes undesirable noise. Therefore, morphological opening is used to remove the noise and to fill gaps in the detected objects.

Figure 3.4 shows an example of removing noise from the foreground mask

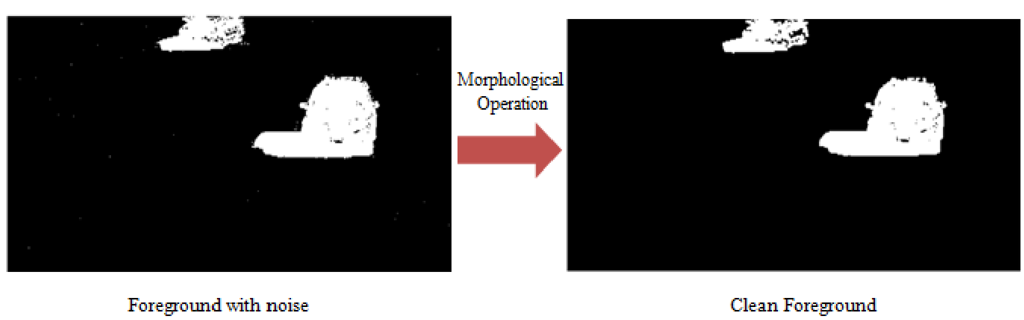

Figure 3-4 Removing noise from foreground

Step 3: Blob Analysis and Bounding Box

The Blob Analysis computes statistics for connected regions in a binary image (called 'blobs' or 'connected components') and computes their characteristics, such as area, centroid, and the bounding box.

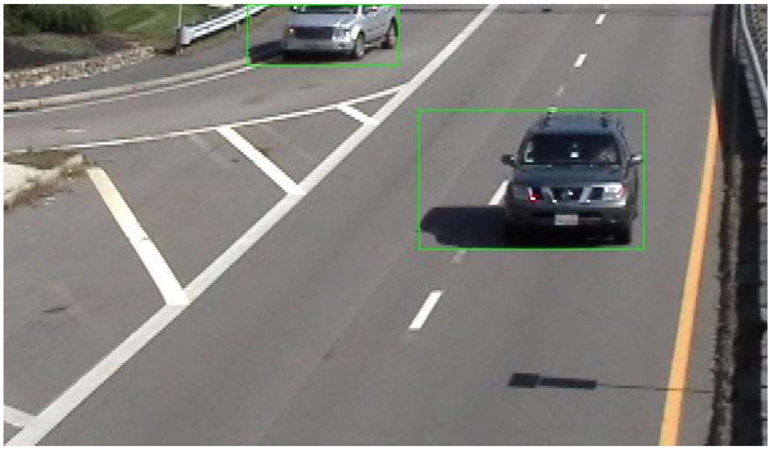

Figure 3-5 Detected Cars

3.3 Vehicle Tracking

After detecting the vehicle using the foreground detector in the initial frames and drawing the bounding box, the vehicles are tracked across the video by processing the rest of the video frames.

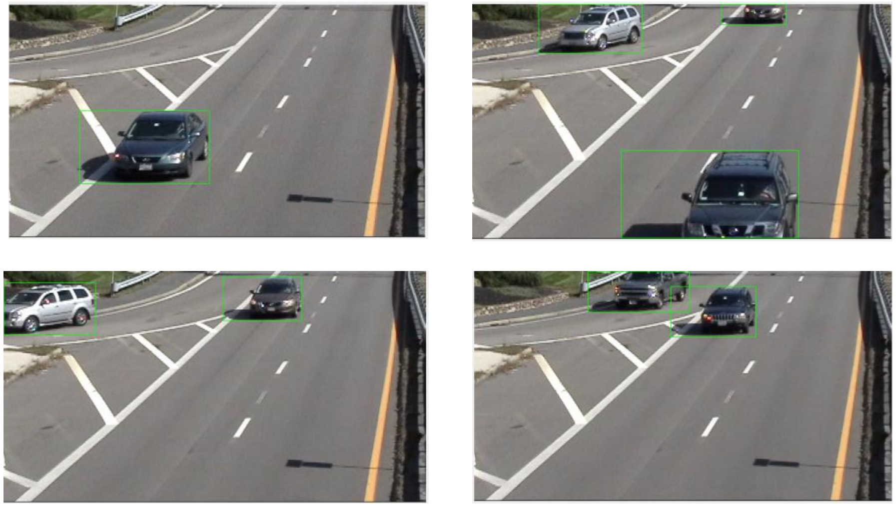

Figure 3-6 Vehicle Tracking

3.4 Parameters Extraction

From the connected component image, the bounding box coordinates of each vehicle region is calculated. These bounding box coordinates are used to calculate the features of a particular vehicle region.

In this proposed AAD algorithm, the centroid is computed in order to detect accidents.

3.4.1 Centroid

Let f (X_i) denote the area of region X_i. Centroid is defined as the centre of mass of the region X_i. The expression for f (X_i) is given by:

$$\boldsymbol{f\ (X_i) = \left(\frac{x1+x2+\cdots+xn}{N}, \frac{y1+y1+\cdots+yn}{N}\right)} \quad \textbf{(3.1)}$$

$$\boldsymbol{f\ (X_i) = (\tilde{x}\ ,\ \tilde{y})} \quad \textbf{(3.2)}$$

where x_1, x_2,…. x_n denote the points along the horizontal plane of the image and y_1, y_2,…. y_n denote the points along the vertical plane of the image. Figure 3.7 shows an example of location of centroid of vehicle regions.

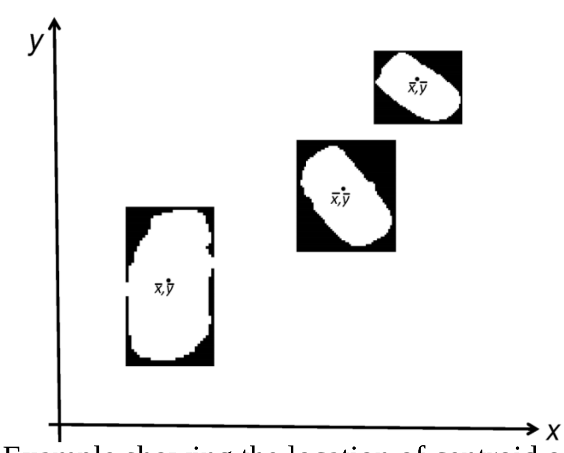

Figure 3-7 Example showing the location of centroid of vehicle regions

3.5 Accident Detection

Once the vehicles are detected and tracked correctly in the frames, the next step in the process is to determine the occurrence of accident using the extracted feature. Figure 3-8 shows the flowchart of the accident detection algorithm.

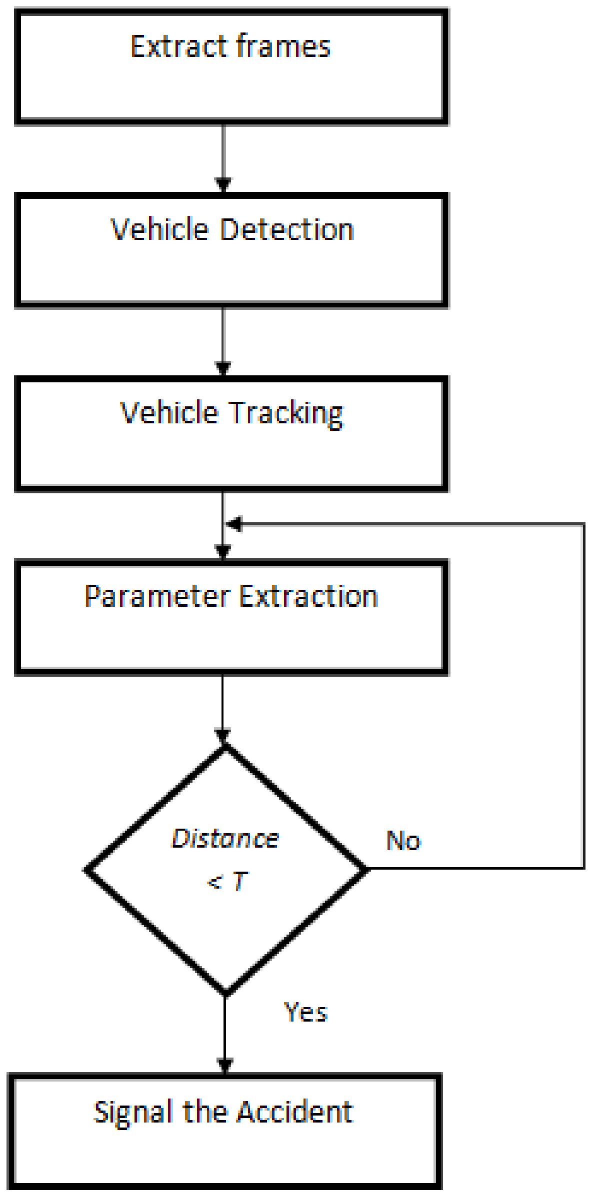

Figure 3-8 Flowchart of the accident detection algorithm.

3.5.1 Distance between centroids

When an accident occurs, the bounding boxes of two vehicles intersect. Therefore the distance between centroids is used as an indicator for accidents.

Let , ($\tilde{x}_{1,}$ $\tilde{y}_1$) denote the centroid of the first region, ($\tilde{x}_{2,}$ $\tilde{y}_2$) the centroid of the second region, The expression for the distance between the two regions is given by:

$$\textbf{Distance} = \sqrt{((\tilde{\boldsymbol{x}}\,\mathbf{1} - \tilde{\boldsymbol{x}}\,\mathbf{2})^{\mathbf{2}} - (\,\tilde{\boldsymbol{y}}\mathbf{1} - \tilde{\boldsymbol{y}}\mathbf{2})^{\mathbf{2}})} \qquad \textbf{(3.3)}$$

3.5.2 Accident Signal

After computing the distance between regions, the value is compared with a threshold. If the distance is less than the threshold , then an occurrence of accident is signaled, otherwise the algorithm determines that there is no accident and the process is repeated until an accident is detected.

`

CHAPTER FOUR

RESULTS AND DISCUSSIONS

4.1 Introduction

The algorithm was implemented using the Image Processing and Computer Vision Toolboxes in MATLAB, since MATLAB environment is convenient for testing purposes.

For the purpose of testing the AAD algorithm, indoor experimental setup was made with daylight conditions from a top-down view, while using mini remote control cars to detect the occurrence of accidents. The video camera used for this purpose was a 16 MP 1080p mobile camera. The testing was done offline.

Figure 4-1 testing setup

4.2 Vehicle Detection and Tracking Performance

Test videos were used to test the performance of vehicle detection and tracking process. Figure 4-2 shows detection results from one of the videos where the vehicle is detected and tracked correctly.

Figure 4-2 Vehicle Detection and tracking Example

4.2.1 Vehicle Detection Rate

The detection rate is the ratio of the number of detected vehicles by AAD algorithm to the actual number of vehicles. Table 4-1 shows the results of detecting and tracking from two test videos.

Table 4-1 Vehicle Detection Results from two test videos

	Test1	**Test2**
No. of Frames	352	360
Number of vehicles	2	18
Detected Vehicles	2	13
False Detection	8	5
Detection Rate	100%	72.2%

4.2.2 Vehicle Tracking Rate

The tracking rate is the ratio of the number of tracked vehicles by AAD algorithm to the actual number of Detected vehicles. Table 4-1 shows the tracking results for the same test videos.

Table 4-2 Vehicle Tracking Results from two test videos

	Test1	Test2
Number of vehicles	2	18
Detected Vehicles	2	13
Complete tracks	2	8
Tracking Rate	100%	61.5%

4.2.3 Errors in Vehicle Detection and Tracking

An error in detection occurs when the algorithm detects an object and there is none, or when it does not detect all Vehicles.

Errors in vehicle tracking are primarily caused by wrong vehicle detection. Wrong vehicle detections were caused by occlusion, small size of the vehicles and shadows.

Figure 4-3 shows an example of false detection. The moving car was detected and tracked correctly, but because of non-uniform illumination conditions, it creates non-vehicular regions.

Figure 4-3 false detection of non-vehicular regions

Figure 4-4 shows a sample form a test video. The moving vehicle was detected and tracked correctly, but there were false regions because of shadows and illumination. Moreover the static vehicle was not detected correctly.

Figure 4-4 Detection and Tracking error

Figure 4-5 shows an example of false detection Due to the problem of merging of closely moving vehicles and vehicles moving away from the camera.

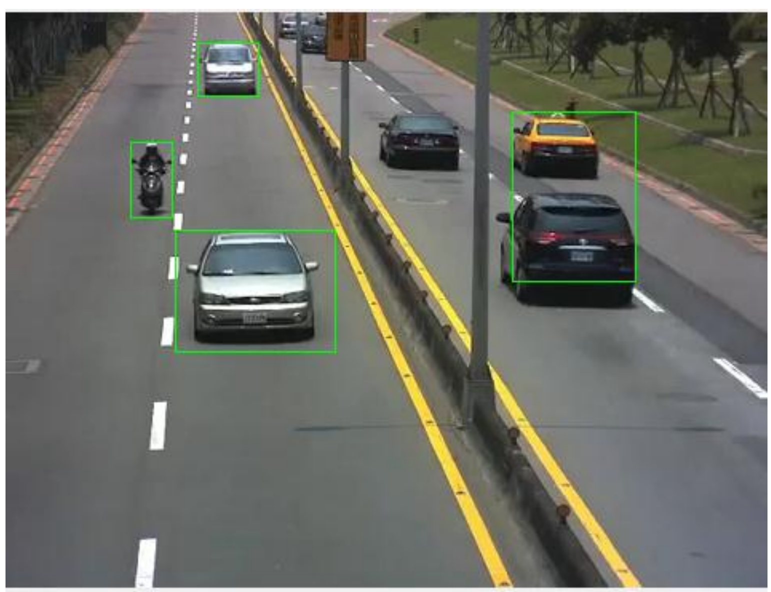

Figure 4-5 Detection and Tracking error due to merging objects

4.3 Accident Detection Performance

4.3.1 Threshold Value

To determine a suitable value for threshold T as a minimum distance between centroids of vehicles which is measured in pixels, two test videos with a single accident was used. Table 4-3 shows the results of accident detection using different Threshold values.

Table 4-3 Accident Detection Results for different Threshold values

Threshold	No. of alarms for video 01	No. of alarms for video 02
T=50	14	18
T=40	11	13
T=30	8	10
T=20	5	7
T=10	2	3
T=8	1	2

Table 4-3 shows that the value T=8 yields the best results for the test video in terms of number of false alarms.

Figure 4-6 and Figure 4-7 shows the results from test video for T=8.

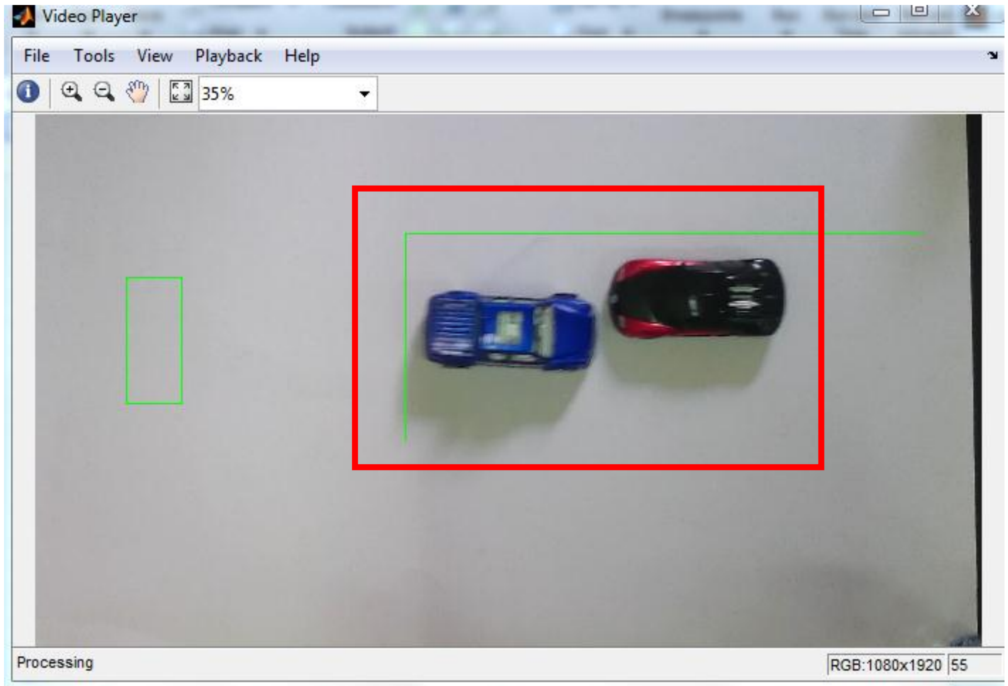

Figure 4-6 Accident occurrence in test video

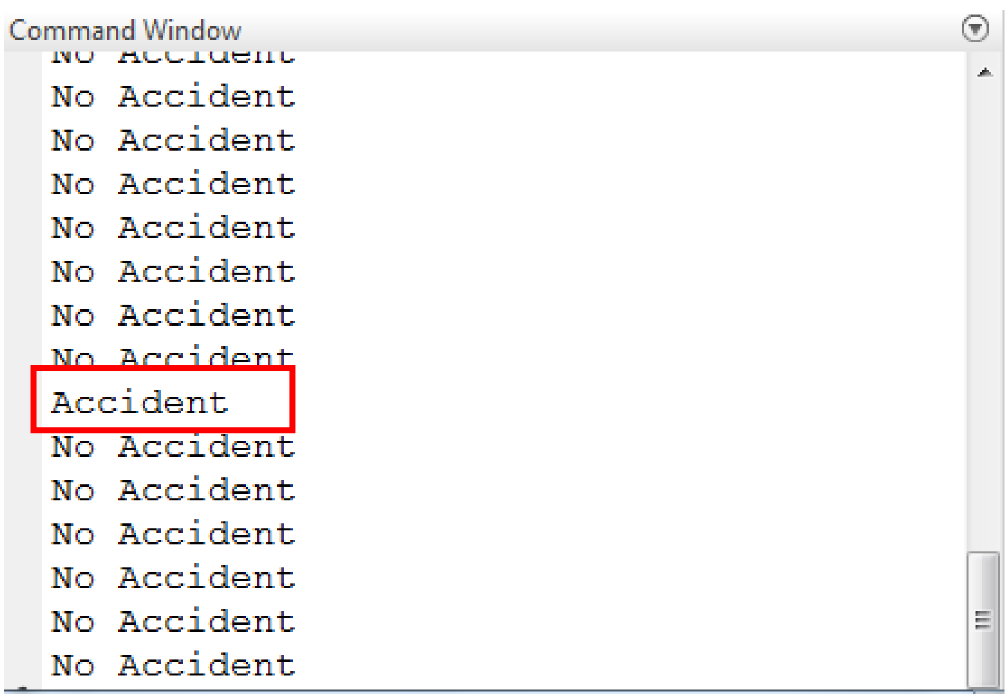

Figure 4-7 alarm from test video

CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusion

This research presented an Automatic Accident Detection algorithm. The work has been divided into four stages: object detection, object tracking, parameter extraction and Accident Detection.

The implemented algorithm is able to distinguish foreground from background in dynamic scenes, detect and track objects and generate object information in video frames. A Gaussian mixture models method was used for foreground detection since it's easy to implement and has a low computational complexity compared to other method. The algorithm has a good performance in object tracking, and successfully tracked objects in consecutive frames .The results of testing videos show that using region-based scheme gives promising results. But the algorithm doesn't handle object occlusions well (object merges and object splits), and gave inaccurate foreground object segmentation due to shadows, reflectance and occlusions. The algorithm also presented false cases in tracking, especially when the vehicles are moving together due to the problem of merging of closely moving vehicles. Moreover, the algorithm works only in daylight conditions (The performance has not been evaluated in night conditions), and uniform illumination conditions, otherwise it creates non-vehicular regions.

5.2 Recommendations

More complex background modeling techniques can be used to enhance the results of detection and tracking and. Also, this algorithm can be improved to handle shadows, sudden illumination changes, night conditions and partial object occlusions. In addition, more features can be extracted as parameters such as direction, area and acceleration to determine accidents. Moreover, the algorithm was tested offline but it can be developed for real time implementation by using other programming languages such as C++ language and by integrating other subsystems such as Optical tracking system and Human Visual System (HVS).

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Appendix A

Appendix A

```
function AccidentDetection()

clc,clear,clf, close all

% create system objects used for reading video,
%detecting moving objects, and displaying the
%results

obj = setupSystemObjects();

% detect moving objects, and track them across
%video frames

while ~isDone(obj.reader)
    frame = readFrame();
    [centroids, bboxes, mask] =
detectObjects(frame);

    test()

    displayTrackingResults()

end


  function obj = setupSystemObjects()
    % Initialize Video I/O
% create objects for reading a video from a file,
%drawing the tracked objects in each frame, and
%playing the video.

      % create a video file reader
obj.reader = vision.VideoFileReader(VideoName);
```

```
 % create two video players, one to display the
video, and one to display the foreground mask

obj.videoPlayer = vision.VideoPlayer('Position',
[10, 200, 700, 400]);

obj.maskPlayer = vision.VideoPlayer('Position',
[680, 200, 700, 400]);

% Create system objects for foreground detection
and blob analysis
% The foreground detector is used to segment
moving objects from the background. It outputs a
binary mask, where the pixel value of 1
corresponds to the foreground and the value of 0
corresponds to the background.

obj.detector =
vision.ForegroundDetector('NumGaussians', 5, ...
'NumTrainingFrames', 20, 'MinimumBackgroundRatio',
0.7);

 % Connected groups of foreground pixels are
likely to correspond to moving objects.  The blob
analysis system object is used to find such groups
(called 'blobs' or 'connected components'), and
compute their characteristics, such as area,
centroid, and the bounding box.



obj.blobAnalyser =
vision.BlobAnalysis('BoundingBoxOutputPort', true,
'AreaOutputPort', true, 'CentroidOutputPort',true,
MinimumBlobArea', 400);

 end
```

```
function frame = readFrame()
        frame = obj.reader.step();
 end

 function [centroids, bboxes, mask] =
detectObjects(frame)

 % detect foreground
 mask = obj.detector.step(frame);

% apply morphological operations to remove noise
and fill in holes

mask = imopen(mask, strel('rectangle', [3,3]));
mask = imclose(mask, strel('rectangle', [15,15]));
mask = imfill(mask, 'holes');

% perform blob analysis to find connected
components

 [~, centroids, bboxes]=
obj.blobAnalyser.step(mask);


 end


    function test()
     if(size(centroids,1)>1)
       if(size(centroids,1)==2)
         a=centroids(1,:);
         b=centroids(2,:);
         dis=distance(a,b);

      elseif(size(centroids,1)==3)


          a=centroids(1,:);
```

```
            b=centroids(2,:);
            c=centroids(3,:);
            dis1=distance(a,b);
            dis2=distance(a,c);
            dis3=distance(c,b);
            dis=[dis1 dis2 dis3];
 elseif(size(centroids,1)==4)


   a=centroids(1,:);
   b=centroids(2,:);
   c=centroids(3,:);
   d=centroids(4,:);
   dis1=distance(a,b);
   dis2=distance(a,c);
   dis3=distance(c,b);
   dis4=distance(a,d);
   dis5=distance(b,d);
   dis6=distance(c,d);
   dis=[dis1 dis2 dis3 dis4 dis5 dis6];
   end



 if (min(dis)<10)
       disp('Accident')

            else
             disp('No Accident')

               end
           end
    end


 function displayTrackingResults()

     result = insertShape(frame, 'Rectangle',
bboxes, 'Color', 'green');
```

```
% display the mask and the frame
     obj.videoPlayer.step(result);
     obj.maskPlayer.step(mask);

end

end
```