School

of

Electronics and Communication Engineering

Mini Project Report

on

Forward Collision Avoidance System Using Monocular Camera for Autonomous Vehicle

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-The project Team 12

ABSTRACT

This study of a monocular camera-based forward collision warning system is presented in this report. The system is designed to detect and alert the driver of an impending collision within a certain range. The technology makes use of a front-mounted camera to detect objects on the road ahead. The camera captures images of the environment and uses image processing techniques to detect the objects. The system is then able to calculate the distance to the object and alert the driver if a collision is imminent. The system is tested in various simulated scenarios and results are presented. The results show that the system can detect objects at ranges up to 10 m and can accurately alert the driver of an impending collision. The system is also shown to be robust to varying lighting conditions and objects of different shapes and sizes. The results demonstrate that the system can be used to provide the driver with an early warning of an impending collision.

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Chapter 1

Introduction

The advanced driver-assistance system is a well-liked topic at the forefront of the commercial and analysis communities. Automated driving raises novel challenges since vehicles carry with them a number of complicated systems with the increasing process and communication needs, although enhancing safety by totally or partly in favor of making intelligent vehicles. Vehicle detection was one of these duties, and it is a major half of driving help systems. Therefore, contributions towards reliable, robust, help systems as well as collision-avoiding systems are highly desired. These safety systems ought to understand the surroundings and warn the driver regarding other vehicles or take steps to avoid accidents before they occur.

1.1 Motivation

According to research done by the World Health Organization (WHO), between twenty and fifty million people are injured and an estimated 1.3 million individuals each year die in automobile accidents. According to studies, drivers are seen to be the primary cause of all collisions, with environmental factors and increased driver distraction making up the other two. Accident prevention will be made easier by the driver's prompt awareness. Therefore, the requirement for a forward collision avoidance system will contribute to a reduction in accidents.

1.2 Objectives

In the real world, autonomous cars come across vehicles where it needs to detect and calculate the distance to the forward vehicle and warn the driver.

The camera sensor should work in any environmental conditions to avoid collisions.

It warns the driver of the potential risk of a forward accident by detecting unexpected movements of the vehicle ahead in the same lane.

1.3 Literature Survey

In forward collision avoidance systems, The speed of light is constant , in direct Time-of-flight a very short light pulse is emitted towards the Object, it is reflected and is finally captured by a sensor, and the depth is then inferred from the total travel time. It employs a periodic light modulation and determines the depth information from the phase difference between an internal reference signal and the incoming light[1].

For highway safety, use the vision-based forward collision warning (FCW) system. The algorithm provided in this paper predicts time to contact (TTC) and a potential collision route directly from the size and positioning of the cars in the image, eliminating the requirement to create a 3D representation of the scene. The use of a single low-cost image sensor enables a system that is affordable and simple to implement.[2].

The use of a naturalistic driving data set for the evaluation of collision avoidance algorithms is the paper's key innovation. We first manually gather the data, smooth it using Kalman smoothing, and then identify the data sets based on vehicle brake and vehicle range. In this literature, five collision avoidance algorithms were published. These algorithms' performance is assessed using performance criteria that are often employed in signal identification and data from unbalanced data populations[3].

A vehicle's size and location in the image are determined using an object detection algorithm, which also determines the distance between the vehicle and the virtual horizon. A forward collision warning system based on vision has been put into place, and film footage of traffic on highways and in cities is used to assess the effectiveness of the suggested approach[4].

The stereo camera comprises of two parallel optical axis sensors that are spaced apart horizontally by what is known as the baseline. Depending on how far apart the objects are in both images, we can calculate the distance between the cameras and the object from their positions[5].

1.4 Problem statement

Monocular camera-based real-time forward collision avoidance system for autonomous vehicles

1.5 Organization of the Report

We are summarising the topics of each chapter, our organization of the report is as follows :

In Chapter 2: We describe the proposed system design, functional block diagram, distance calculation with a monocular camera, and final design.

In Chapter 3: We describe implementation details, the algorithm of the proposed model, the specification, and the flow chart.

In Chapter 4: Result Analysis.

In Chapter 5: Project conclusion and Future scope.

Chapter 2

System Design

The process of defining a system's modules, interfaces, components, and data in order to meet predetermined requirements is known as system design. It can be viewed as the product development application of systems theory. Conceptual, logical, and physical design are all aspects of system design.

2.1 Functional Block Diagram

The functional block diagram is a graphical language for describing the function between input and output variables in the programmable logic controller architecture. The working of the forward collision avoidance system using a monocular camera is given below. Forward collision avoidance technology uses a camera sensor to capture the image, the captured image is then given as input to the Haar cascade classifier, which uses a series of simple classifiers to detect vehicles in the image. This algorithm will detect regions of interest, classify them as vehicles, and shows a rectangular box around the detected vehicle, after the vehicle is detected it calculates the distance between the identified vehicle and the ego vehicle, as shown in Figure 2.1.

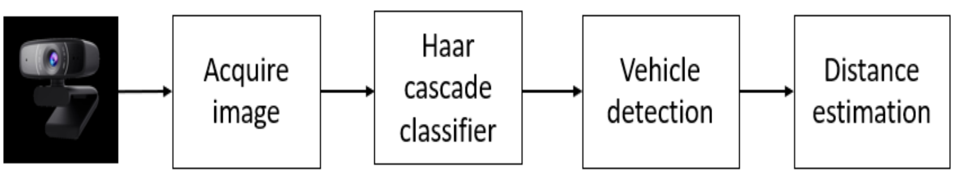

Figure 2.1: Functional block diagram

2.2 Specification

A specification is often a type of technical standard, our specification of the camera is as follows:
Camera :Asus TUF f15 webcam
Resolution:720p
Image size in pixels:1280×720
Pixels per image:921,600
Aspect ratio:16:9
Range:1 to 1.5meters

2.3 Distance Calculation with Monocular Camera:

Monocular camera based forward collision avoidance system is a form of advanced driver assistance system that uses a camera sensor to capture the image of the front vehicle and calculates the distance from ego vehicle to the front vehicle and warns the ego vehicle of a potential collision, as shown in Figure 2.2.

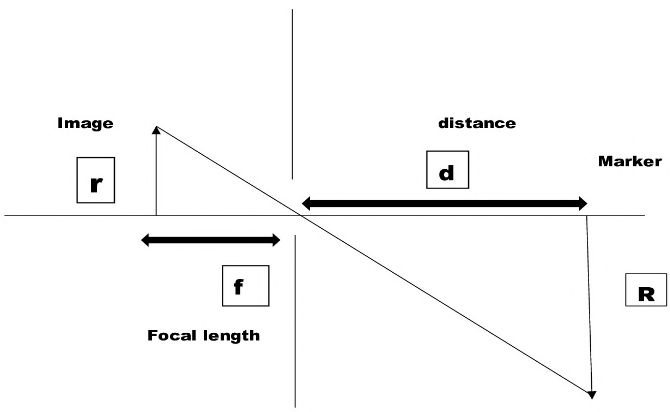

Figure 2.2: Monocular camera distance calculation

Monocular camera can be used to measure the distance between two points. This involves taking two photos in a slightly different angles, and then using triangulation to calculate the distance. This technique is often used in robotics, navigation systems, and other applications where precise distance measurements are needed.
We outline a technique for calculating an unknown vehicle's width using camera geometry. The geometric relationship between the world and camera coordinate can be expressed using the pinhole camera model, as shown in Figure 2.3 and Figure 2.4. This geometry allows for two different ways to calculate following distance. The first approach is vertical triangulation, which is well-known for monocular ranging and can quickly calculate the following distance. It is depicted in Figure.2.3. However, the vehicle's own pitching frequently leads to estimating inaccuracies.

Horizontal triangulation is less susceptible to vehicle pitching than vertical triangulation because parameters W and w do not correspond to vertical parameters. However, adopting the statistical mode value for vehicle width would lead to range inaccuracies (for example, 1.7 m)citedist because the real width of a vehicle, n, is unpredictable.

W is the actual width of the target vehicle in Figure 2.3 and Figure 2.4, Z is the following distance, Hc is the mounting height for the camera, and h = yb-yv and w = xR-xL are the projected camera heights.

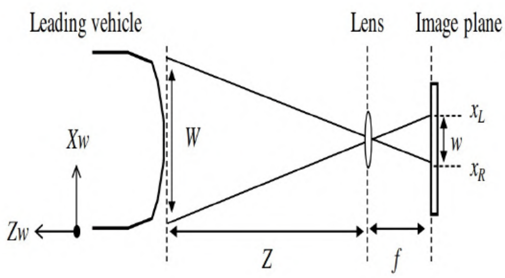

Figure 2.3: (a):Top view camera geometry

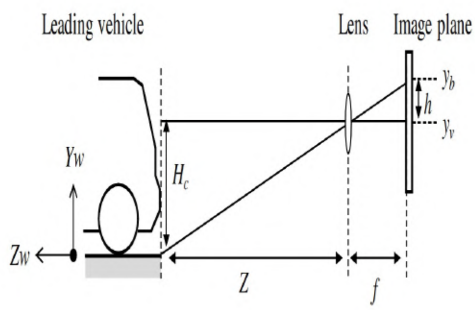

Figure 2.4: (b):Side view camera geometry

The distance 'd' is calculated by

$$d = (f \times W \times H) / (C \times P)$$

Where, 'f' is focal length
'W' is the width of the object
'H' is the height of the object
'C' is the size of the object in pixels
'P' is the pixel size of the camera

2.4 Final Design

We chose one of the best solutions based on how well it works and how simple it is to apply. Because it has two options to carry out our project, we choose the Forward collision avoidance system using a Monocular camera answer for our project. It is preferred for the Forward collision avoidance system since it detects the objects(Vehicles).

Chapter 3

Implementation Details

This chapter includes the Algorithm, Specification, system architecture, and flowchart.

3.1 Monocular camera

Single-lens cameras with hand-held applications are known as monocular cameras. In general, monocular cameras cost less than other types of cameras and are smaller and lighter.

Distance estimation, also known as monocular depth estimation, is frequently done with monocular cameras. It involves measuring the distance with only one camera. The procedure involves analyzing the image for details like color, texture, and shape, and using these details to estimate the vehicle's distance.

3.2 Dataset

A collection of data is known as a data set (or dataset). Our dataset is a collection of reference images.The data set includes values for each of the variables, such as the vehicle's height and width, for each set member. Figure 3.1 shows reference images which have been used as a dataset.All the reference images are taken at day time, we used a 12 MP wide camera with 3024x4032 resolution for the images.

Figure 3.1: Reference images

3.3 Haar cascade algorithm

Haar cascade classifier is a type of machine learning algorithm used for object detection. It is a type of supervised learning algorithm that is used to detect objects in images or videos. It takes an image as input and They are also used then uses a series of simple classifiers to detect objects in the image.in distance measurement, as they can detect certain features in the image and then use them to measure the distance between two objects. In distance measurement, Haar Cascade classifiers can be used to detect the size of an object and then calculate the distance between it and another object in the image. The classifier is trained to recognize certain features, such as edges and corners, which are then used to calculate the distances.In order to detect the vehicles in the image, we load the pre-trained XML classifier file.

3.4 Haar Cascade Feature extraction

The below figure 3.2 shows the block diagram of how Haar cascade classifier detects vehicles. It uses an image as its input, calculating the difference between the average pixel values at the lighter and darker regions, and then displays a rectangle box around any detected vehicles. At each image scale, the scale factor indicates how the image size is changed. "Feature scaling" is a process of normalizing the data so that it can be processed and compared more accurately. The data is broken down into a set of characteristics, such as the width, height, depth and distance . These characteristics are then measured and scaled according to the size of the car.

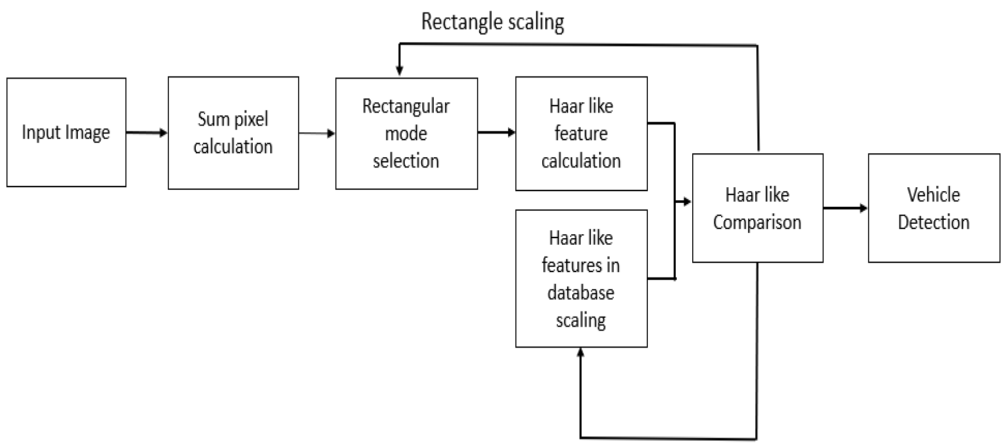

Figure 3.2: Haar cascade classifier

An image or a real-time video can be used to identify vehicles using the Haar cascade classifier technique..

There are three types of haar like features:
1. Edge features
2. Line features
3. Center-surronded features

In this case, the goal is to calculate the total of all the image pixels located in the haar feature's darker and lighter areas, respectively. then determine which makes them different. The haar value will be closer to 1 if there is an edge in the image separating light pixels on the left from dark pixels on the right. In other words, if the haar value is closer to 1, we declare that an edge has been found..

Edge features: Used for Edges of feature, as shown in Figure.3.3.

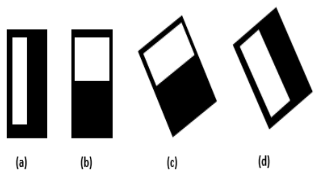

Figure 3.3: Edge features

Line features: Used for detecting lines, as shown in Figure.3.4.

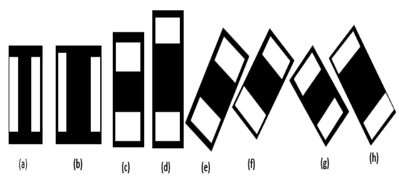

Figure 3.4: Line features

Center-surrounded features: Used for finding diagonal feature, as shown in Fig.3.5.

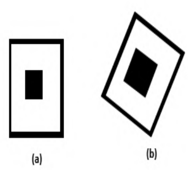

Figure 3.5: Center-surround features

3.5 Multi scale detection function

The objects are found using the detectMultiScale function. This function will produce a rectangle around the identified car with the coordinates (x, y, w, h).
It requires the input image, scaleFactor, and minNeighbors as its 3 common parameters. The scaleFactor argument displays the image size decrease for each scale. In a traffic photograph, some cars may be nearer to the camera than others. Naturally, such vehicles would be more noticeable than background vehicles. This component makes up for it. The very minimal amount of neighbours (minNeighbours) that a rectangle has to have to be kept. We might need to make these adjustments to get the best results. This option specifies the minimum number of neighbours a rectangle needs to be considered a vehicle. We obtain these values after testing and trailing over a particular range.

3.6 Algorithm for distance measurement

Step 1: Start with video capture.
Step 2: Use Haar-cascade to perform feature extraction from the captured frame.
Step 3: Use a multiscale detection function to detect the vehicle in the frame.
Step 4: Distance calculation from ego vehicle to the detected vehicle.
Step 5: Display the distance.

3.7 Flow chart

The flow chart of forward collision avoidance using a monocular camera is shown in Fig. 3.6. We start by capturing an image or video using a monocular camera, and to detect the vehicle in the image or video we use the Haar-cascade classifier, which performs feature extraction. and a multiscale detection function that detects vehicles in the frame, if the vehicle is detected it calculates distance and displays it, if there is no vehicle detected in the image it goes back to capturing image or video.

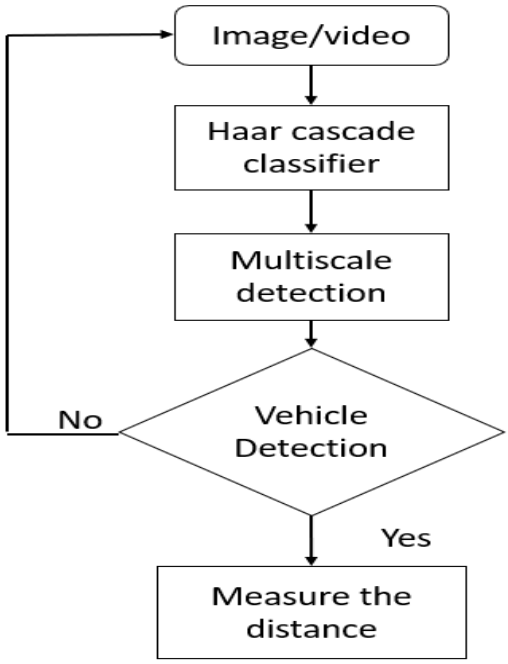

Figure 3.6: Flowchart

Chapter 4

Results

In this chapter we have provided the results obtained from our methodology and discussed the results.

4.1 Detection of vehicle

Figure 4.1 and Figure 4.2 represent the detection of the image from the captured image, after detection, it is passed through the distance estimation to find the distance.

Figure 4.1: Detection of the vehicle in the captured image

Figure 4.2: Detection of the vehicle from a pre-recorded video

4.2 Distance estimation

This section shows the estimated distance from the ego vehicle to the front vehicle detected in the image.

4.2.1 Distance in Real-time

Figure 4.3 shows the distance estimation of the detected image obtained through the camera.

Figure 4.3: Distance calculation of detected image

4.2.2 Distance in Video File

Figure 4.4 shows the distance estimation of the detected image from a pre-recorded video file.

Figure 4.4: Distance calculation of a pre-recorded video

Chapter 5

Conclusion and Future Scope

5.1 Conclusion

Forward collision avoidance using the monocular camera is an effective way to reduce the risk of a collision. It can detect potential hazards and alert the driver in time for them to make an appropriate response. It is an affordable and reliable technology that can be easily integrated into existing vehicles. While it may not be able to detect every potential hazard, it can help to reduce the risk of a collision and save lives.

5.2 Future Scope

As we have seen from our report, our methodology is able to detect the object and estimate the distance from the ego vehicle to the detected vehicle, our accuracy was not up to the mark as we had hoped, so In order to improve and get accurate distance estimation To achieve better outcomes, we can consider utilizing multiple cameras.

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