CS2212 - Programming Challenge II

Vehicle Collision Warning System

from Dash Cam Video Stream

Final Report

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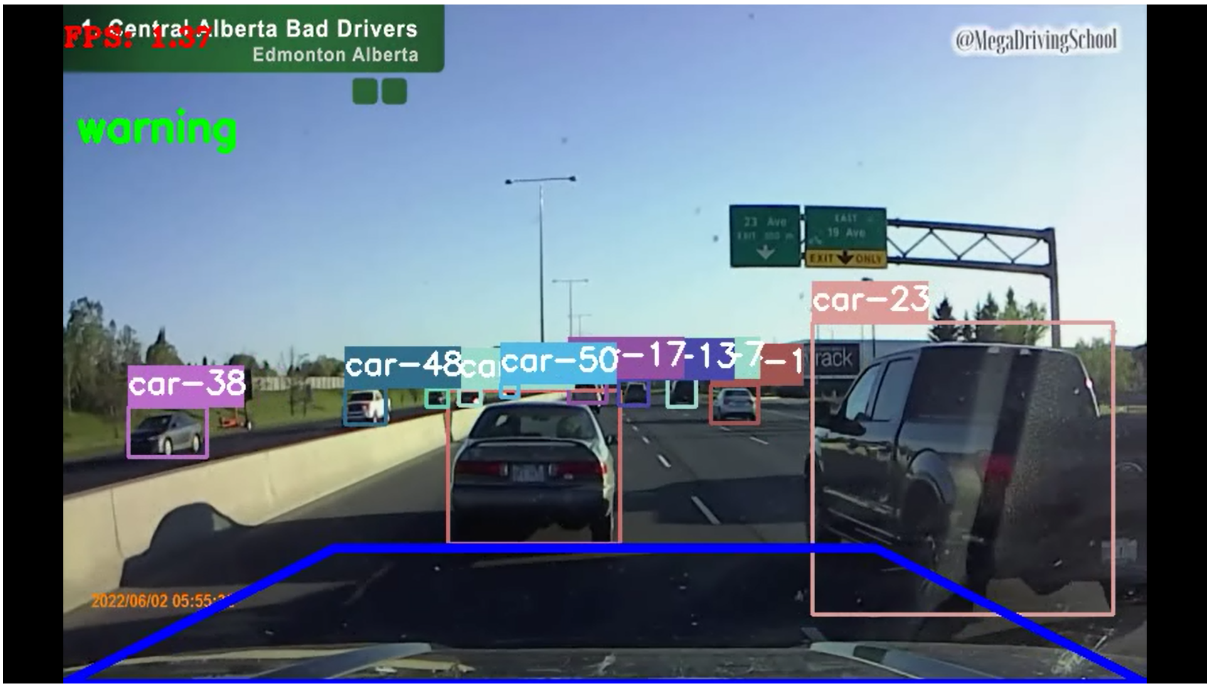
Introduction

Vehicle Collision Warning System is a safety system that is designed to assist drivers to **avoid collisions** with other vehicles and passengers through warnings and alerts. Its major role is to reduce road accidents, deaths and injuries caused by alerting the driver to the risks.

In this specific project we were asked to design and develop a **Vehicle Collision Warning System** that uses the **Vehicle Dash Cam Video Stream** to help drivers through producing warning signs. This particular system tracks the movements of the vehicles and predicts their movements for two seconds ahead. If the other vehicles are predicted to enter into the **Danger Area** marked by the user in the next two seconds then a **Warning Sign** is generated to alert the driver. Here already recorded **Dash Cam Videos** were taken as inputs to test the system.



Literature Review

Introduction

Advanced Driver Assistance Systems (**ADAS**) are the safety systems designed and developed in a way that they automate, adapt, and improve vehicle technology for people and vehicle safety and good driving. Their major role is to minimise human errors while driving by reducing road accidents, deaths and injuries caused. They use advanced electronic technologies and safe human-machine interfaces to help drivers while driving and parking and thereby increase car and road safety and performance of the drivers. There are several essential ADAS applications including Vehicle Detection, Pedestrian Detection, Traffic Sign Recognition, Automatic Emergency Braking, etc. that ensure safe distance and driving environment recognition. These existing automobile Driver Assistance Systems use various sensors such as **Cameras** (Optical Image Sensors), **RADAR**, **LiDAR**, **SONAR**, and **Thermal and Infrared Sensors** in order to detect nearby objects and obstacles and respond accordingly by alerting drivers. Each sensor has its own advantages and limitations while used in ADAS. They are given below.

Cameras Based Driver Assistance Systems

Cameras (Video Sensors) are Optical Image Sensors that can identify texture, recognize traffic signs, lanes, and obstacles around the vehicle. They are used for building and monitoring a three-dimensional (3D) model map of the area surrounding the vehicle and the driver, for obstacles, pedestrians, cyclists, and other vehicle detection, and for security purposes. In earlier days, these systems used only a backup camera aka "**Reverse Camera**". But today, these systems have multiple cameras, focusing on different directions around the vehicle.

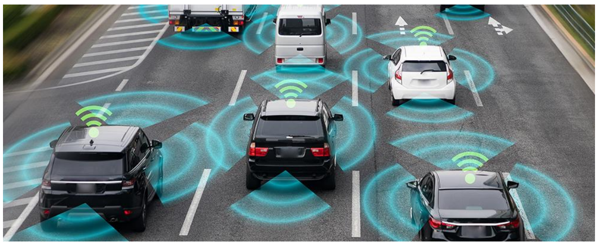
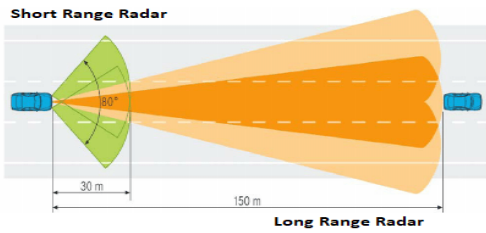
Camera-based Driver Assistance Systems can be classified depending on the placement of cameras as **Exterior Camera** and **Interior Camera**. In the Exterior Camera category, single or many cameras are fixed outside the vehicle for surround view, traffic sign recognition, parking assisting, and road vulnerability and obstacles detection. In the Interior Camera category, a single camera is placed inside the vehicle for monitoring the activities of the driver.

Advantages	**Limitations**
Cost is Low.	Short Range
Generate 3-Dimensional View	Low performance in Low Light and Poor Weather Conditions.
High Resolution, Detect RGB Information and Wilder Field of View	No Accurate Information about Distance and Position of other objects.

RADAR (Radio Detection And Ranging) Based Driver Assistance Systems

- Automotive radars detect the range and speed of objects nearby to the vehicle.

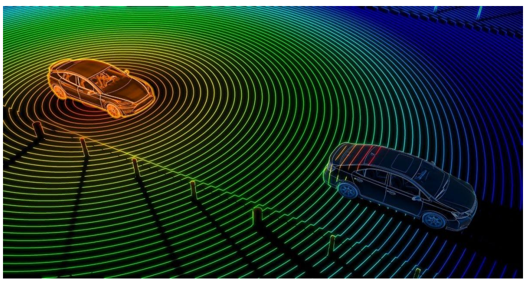
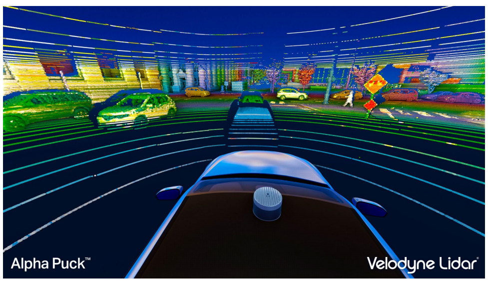
Advantages	Limitations
Unaffected by weather conditions	Takes more time to lock an object
Default sensor for emergency braking	It cannot track if an object is decelerating at more the 1mph/s
It is cheaper to compared to other system	Oversensitive , may lead to inaccurate data

LiDAR (Light Detection And Ranging) Based Driver Assistance Systems

- This technique creates a 3D picture of an environment using infrared light or lasers.
- LiDAR functions like a vehicle's eyes, allowing it to view in all directions at all times.

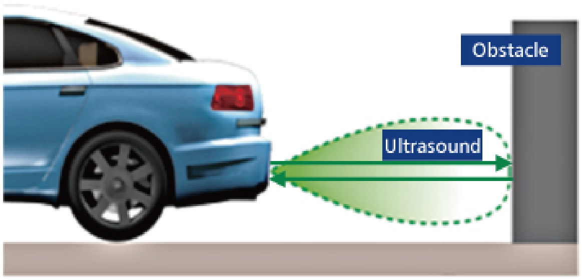
Advantages	Limitations
LiDAR can be seen as a more advanced version of RADAR	LiDAR sensors are significantly more expensive than cameras and radar systems
Like RADAR, LiDAR's efficiency is not affected by environmental conditions	Camera-based systems are more suitable with ADAS technology that improves with time
Can be used day and night It is not affected by light variations such as darkness and light.	Sensors can have difficulty differentiating between objects that are similar in size and shape, which means threats and non-threats can be confused with one another.

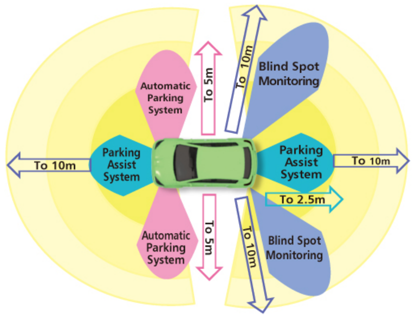



Ultrasonic Sensors Based Driver Assistance Systems

- These types of Driver Assistant Systems use reflected sound waves to calculate the distance between the obstacles and the vehicle.

- Since the effective operating range is low, it is highly useful in parking assistant systems (PAS). Blind-spot monitoring, auto parking, and parking assistance are some of its uses.





- **Advantages of ADAS using ultrasonic sensors**
  1. Cost-effective
  2. Robust
  3. Reliable

- **Limitations of ADAS using ultrasonic sensors**
  1. Not suitable for high-speed systems.
  2. Short-range RADAR is used as a replacement for ultrasonic sensors.

Thermal and IR Sensors Based Driver Assistance Systems

- ADAS using thermal sensors can detect people and animals in the dark, sun glare, fog at distances greater than the normal illumination distance of headlights of vehicles.

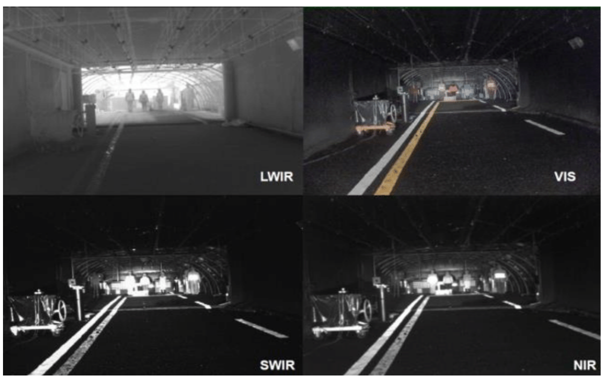
- LWIR (Long Wave Infra-Red), SWIR (Short Wave Infra-Red), NIR(Near Infra-Red) cameras are very helpful in thermal detection. But out of those LWIR cameras are most effective in penetrating the fog and identifying pedestrians in full darkness.

Advantages of ADAS using thermal sensors

1. Detection in full darkness

Limitations

1. Thermal cameras are highly expensive



Conclusion

ADAS is playing a major safety role in the world-leading autonomous industry. A perfect computer vision system probably will help to improve the ADAS, but that doesn’t exist for the time being. There are several techniques used by different autonomous companies to create a better ADAS. Tesla and Cadillac are leading companies in the field right now. Using RADAR or LiDAR or Single Camera or Multiple Camera or Ultrasonic or IR have an advantage over one another, therefore, most successful automakers use the combination of these sensors to overcome one’s downside. Cadillac’s Cadillac CT6 uses real-time multiple cameras, GPS, LiDAR, and a few other sensors, which overperforms every other existing market product including Tesla model Y. With the help of computer vision Tesla, Cadillac, and some other few automakers built the almost fully autonomous vehicles and the first step towards the achievement is lane change on demand.

Building the ADAS with multiple sensors has its own drawback too. There is a reason why these leading-edge autonomous vehicles are very expensive considering their working performance with manual vehicles. Building a very efficient system that gives the perfect computer vision is not the only concern when it comes to the industry. A balance between Cost and Perfection and Performance needs to be maintained to launch a successful market product.

Methodology

We used project TensorFlow which is the platform for machine learning and you only look once (YOLO) which is an object detection algorithm for real-time vehicle detection in our project for detecting the vehicles. By combining TensorFlow Yolo and other dependencies with python as a programming language, we have detected vehicles in real-time Specifically, by drawing bounding boxes around these detected vehicles, which allow us to locate where said vehicles are in a given scene. In our project, we have used the latest version of TensorFlow and version 3 of YOLO.

And we also have used then the Deep Sort algorithm in our project.Deep Sort Algorithm involves tracking of the objects using Kalman Filters.By using Kalman filters we are predicting the next position of the car and using deep sort and getting the Intersection over union (IOU)value of the bounding box area. We have set the predicted IOU value to 0.8, which means that if the calculated IOU value is greater or equal to 0.8 then both bounding boxes are for one vehicle otherwise they both are different vehicles.

And for the warning sign, we have drawn a red bounding box in front of the dashboard. And first, we tried to get the warning sign by predicting the next position of the bounding box of a vehicle. And the idea was if the next position touches the red bound box the system will generate a warning message. But when we tried that way the system was trying to predict the warning sign for an array of consecutive predictable bounding boxes and the system took a long time and did not work as we expected due to the amount of time which we had on our hand, we decided to use another method for the warning prediction.

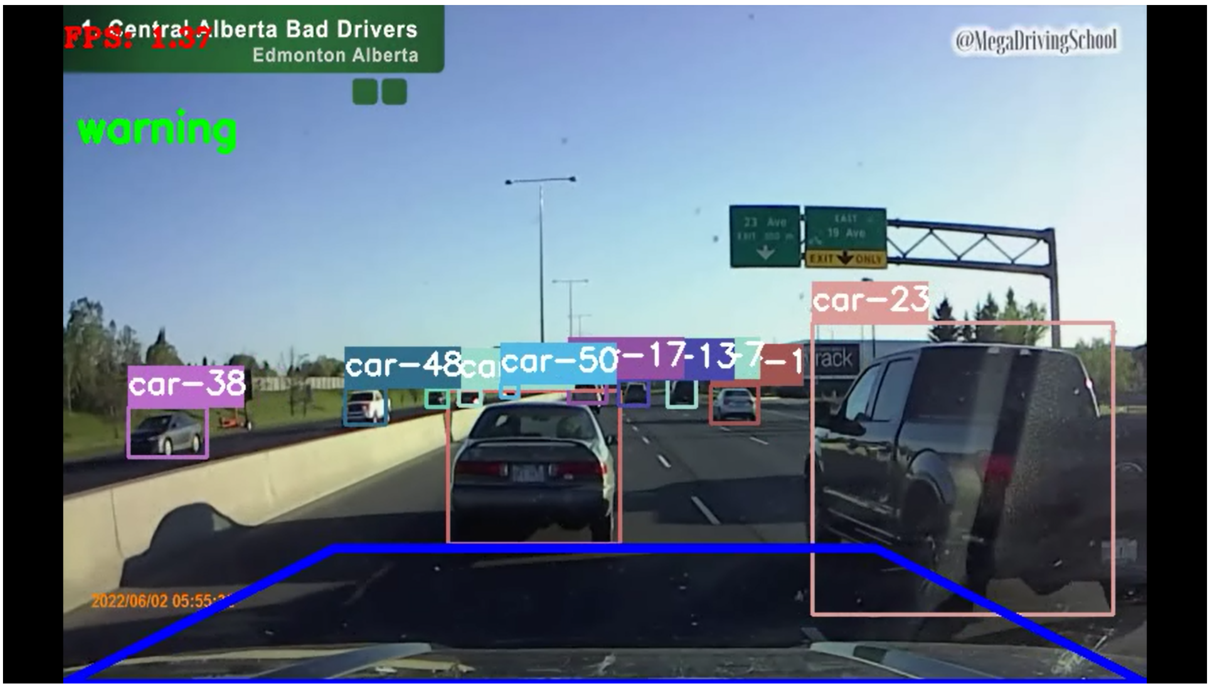
So what we did was without predicting the warning sign for the next predictable bounding box of a vehicle, we used the current bounding box of a vehicle for detecting the warning.

Experimental Evaluation

In this project, we tested our **Vehicle Collision Warning System** with various video inputs (**1 - 2 minutes**) that are taken from the **Dash Cam** at various locations at different time periods. We calculated the number of **Correct Warnings** (emergency situation and warning given), the number of **False Warnings** (warning given but no emergency situation) and the number of **Missed Warnings** (emergency situation but no warning given) for each result video of the input video. The table below shows the results we gained through testing.

Video	Correct Warnings	False Warnings	Missed Warnings
Test 1	7	0	0
Test 2	9	1	0
Test 3	18	0	1
Test 4	12	0	0
Test 5	16	0	0

Given below are some of the screenshots taken from the resulting video sets.




@MegaDrivingSchool
warning
car-230
N32° 43.933' W97° 21.682'
43MPH


@MegaDrivingSchool
warning
car-230
0:00:53
0:00:09
N32° 43.933' W97° 21.682'
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