Machine Learning Car Detection Applications for Road Cyclists

An insight into the advanced applications of the CST tool developed to benefit awareness of road bike users increasing safety and awareness

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ABSTRACT

This paper describes the specific development and uses of the creative support tool (CST) made to assist road bike users. The tool aims at giving a bike rider a heads-up display (HUD) to view specific dangers behind them. The tool uses a neural net developed through TensorFlow software to view and processes images to detect cars. The user is then notified by LED lights on the left and right handlebars specific to which side a car is approaching from. The application takes advantage of the Raspberry Pi 4 to have small yet powerful computing power to allow for the remote handling of the machine learning (ML) software.

This CST tool was developed with the user in mind. The user focus is bike users of all ages and sizes. The task is to help prevent road collisions and give the bike user a new sense of awareness and safety. Additionally, all rides are recorded and available for sharing helping to create a sense of community. The platform is a computer vision (CV) application that allows for image processing in real-time.

INTRODUCTION

Cycling has increased in Canada drastically over the past 20 years. In Victoria and the surrounding area bike users have doubled in population and the amount of bike users that use their bike as a regular method of travel has significantly increased (Assunçao-Denis & Tomalty, 2019). Building this tool was driven by helping the Victorian community with a focus on reducing bike & car related crashes.

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University of Victoria April 4, 2022, Victoria BC, Canada

Astonishingly, reported by a Belgium related study that 79% of all bike crashes were accounted for due to human error (Vanparijs et al., 2016). Many of these crashes were due to bike riders moving into traffic unaware of vehicles approaching them from the rear. With the increasing number of cyclists on the road year to year, evidently, there is an increase in crashes as well. E-Bike usage has also allowed for the maximum amount of speed a cyclist can take on to greatly increase. There is a large need for tools to be developed to assist the safety and experience of an everyday bike rider.

Advanced driver-assistance systems (ADASs) have become a salient feature for safety in modern vehicles. They are also a key underlying technology in emerging autonomous vehicles (Kukkala et al., 2018). The technology developed in driver assist cars has help to prevent human error car crashes by letting drivers know when cars are approaching them. This technology has been proven to work for cars, greatly decreasing the number of crashes and deaths related to human unawareness. Similarly, the ADAS uses ML technologies to increase the awareness of the operator. The transition of this technology to a bike user would evidently have the same effect.

Motivation

The CST bike tool has been developed with the idea in mind that the technology has already been developed for cars but hasn't been developed for bike users. E-bike have also increased the maximum speed of which a normal cyclist could produce. With this there is an even greater need to develop tools to assist cyclist, enhancing their safety and overall road experience.

RELATED WORKS

In this section we will look at related projects that have served as inspiration to the CST bike support tool. Projects that either helped develop technologies used in the CST or helped to understand the capabilities of the CST.

Tesla moving towards CV detection

At the 2021 Conference on Computer Vision and Pattern Recognition on Monday, Tesla's head of AI, Andrej Karpathy, revealed the company's new supercomputer that allows the automaker to ditch radar and lidar sensors on self-driving cars in favor of high-quality optical cameras. Musk has been advocating for a vision-only approach to autonomy for some time, in large part because cameras are faster than lidar and radar. As of May, Tesla Model Y and Model 3 vehicles in North America are being built without radar, relying on cameras and machine learning to support its advanced driver assistance system and autopilot (Bellan, 2021).

YoloV3 aerial car counting

Unmanned Aerial Vehicles are increasingly being used in surveillance and traffic monitoring thanks to their high mobility and ability to cover areas at different altitudes and locations. One of the major challenges is to use aerial images to accurately detect cars and count-them in real-time for traffic monitoring purposes. Several deep learning techniques were recently proposed based on convolution neural network (CNN) for real-time classification and recognition in computer vision (Benjdira et al., 2019).

TensorFlow data classification for deep learning

Deep learning is a subfield of machine learning which uses artificial neural networks that is inspired by the structure and function of the human brain. Despite being a very new approach, it has become very popular recently. Deep learning has achieved much higher success in many applications where machine learning has been successful at certain rates. It is preferred in the classification of big data sets because it can provide fast and efficient results. Tensorflow, one of the most popular deep learning libraries to classify MNIST dataset, which is frequently used in data analysis studies. Using Tensorflow, which is an open-source artificial intelligence library developed by Google, we have studied and compared the effects of multiple activation functions on classification results (Ertam & Aydin, 2017). This has a wide range application to CV car detection.

DESIGN FICTION

The design fiction is set to show the scalability and advanced techniques of the application for if and when fictional technologies do become available. Aimed to explore and critique possible futures.

Chapter 1: Skiing Application

The target focus is the CST principle of exploration. Given the assumption the skiing tool could be integrated similarly to that of the biking tool. How would safety be implemented? How can a user gain additional awareness of their surroundings?

John is going skiing. He recently purchased tickets to use the lift but it is a week before Christmas and the ski mountain is considerably more busy then usual. He has adopted new technology that allows for a buzz to go on the left or right ear depending on where ski users are coming from. John notices that it is a great tool for awareness and feels a lot more confident heading down hills as he has a sense of the activity going on behind him. Although john does feel much safer, he notices that when there is large groupings of people coming down right behind him there is a constant buzz in his ear which is annoying. He also notices that when he falls over and the camera becomes covered with snow, that the technology does not work. Similarly, on the hill near the top of the mountain, visibility is much less for John in the clouds. Due to this the buzz detection is much less useful.

Chapter 2: Clip Sharing

The target focus is the CST principle of supporting collaboration. Currently there is no specific community for sharing ML clips. How could this be beneficial to the user? What would a community surrounding the idea of clip sharing look like?

John has purchased a brand-new bike and is looking at going out and exploring all of the different roadways in Victoria. John takes his bike out when the weather is good and decides to try out the new CST biking tool.

Scenario 1: John takes his bike, and the weather is extremely beautiful. John captures many of the routes he takes to work with the biking support tool. When he gets home, he looks over the footage that he shot. Everything came out great and he wants to share it with his friends and family. He downloads the car detection model and uploads gif files to the open-source community of his bike ride. Other bike users see this and comment how great it is as well John receives messages from other Victorian bikers in that ride the same routes looking to join him next time.

Scenario 2: John takes his bike outside, and the weather looks to be fair at best. During his ride it starts to rain. Visibility is quite low and car detection is only handling when cars are extremely close. Although the video turns out great, the safety features of the application were quite limited for John.

Scenario 3: John takes his bike outside and decides to capture a new road that he wants to bike regularly. After his ride is completed, he noticed that his power supply to the camera has come loose, due to this his files are corrupted, and he is unable to share his ride.

Chapter 3: Steer Assist for biking

Current implantation cannot handle anything other than GPIO pin signals. If the bike could be aware of signals how could this be beneficial for users? Would safety increase or decrease?

John bikes his kids to school every day. John recently has gotten a new job and will be unable to bike his kids to school. His kids still want to bike to school but John is nervous about sending them on their own due to them having to cross major roadways. John downloads the new CST biking tool for his kids. His kids' bike to school and get notified when cars are approaching them on either side. One of John's kids accidently starts to rear towards traffic. The steer assist senses and guides the bike back into the bike lane avoiding a collision. The tool greatly increases safety and awareness when traveling on roadways at a steady speed.

PROTOTYPE DESIGN & IMPLEMENTATION

This is an overview on all the components, parts, and assembly of the project. Specifics will be discussed on how the system was built and implantation from a high level of the ML dataset.

Parts

- Bike Frame
- Raspberry Pi 4
- Raspberry Pi Camera 1080p
- Wireless Charging pack 13000mAh
- 3D-Printed housing for LED lights
- Housing for Pi Case
- LED lights x2
- Wires

The parts are housed together and attached on the bike frame as seen in Figure 1.

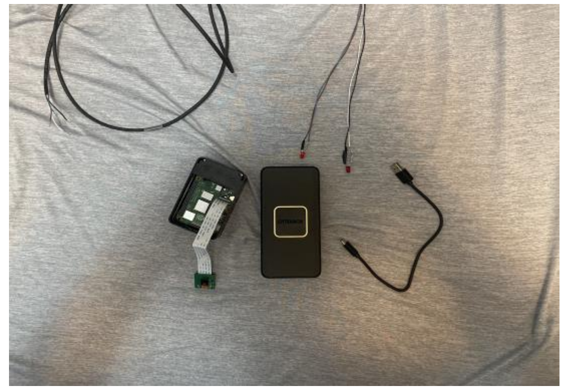

Figure 1: Image of all parts

Code

- Python 3.7
- TensorFlow Lite
- Dataset: Berkely Deep Drive (BBD100K)

Github:

https://github.com/cgriffs/car_detection_SENG480C

Design & Model

The TensorFlow dataset was developed through the BBD100K dataset. It was trained over 18 hours until localization loss was a minimum. The dataset used images of over 16000 cars to help train the model. Through ML the dataset was capable of handling most makes and models of vehicles.

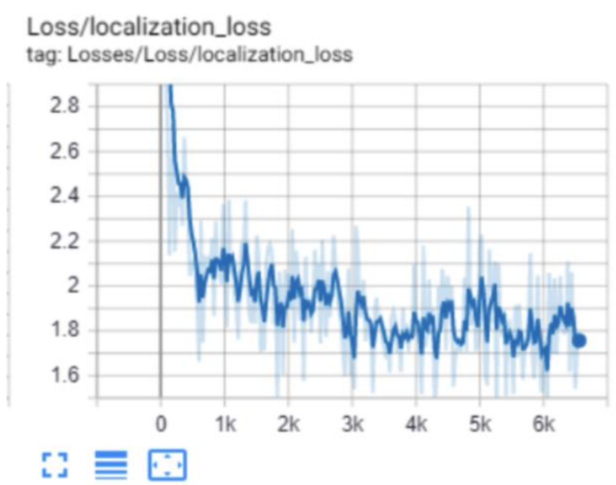

Figure 2: TensorFlow Modeled Dataset

Above in figure 2, we can see the drastic drop and stabilization of the ML car model.

How it Works

The project works by using the above TensorFlow dataset and CV to detect cars. As seen per figure 3, the detection works by drawing boxes around the vehicles and assigning a level of certainty. If the level of certainty is lower than 70% then the LED will not be triggered but the detection will still be handled.

Figure 3: Model of CV detection

From the CV detection above in figure 3. The handling of the model is split into two sections of the screen. If the upmost left pixel of the car falls in the left side of the screen, then left detection is triggered. Otherwise, the right detection will be triggered. The below figure 4 shows how the screen is split for detection.

Figure 4: Model of Left/Right Handling

From figure 4 above, we can see one of the inherent problems of the detection system as the cars are approaching the user from the left side, but detection handles for the right side. Eventually the car will move into the proper frame and detection will work as it should, but it is notable that there are flaws with the design.

Once the handling of the car detection has happened. The GPIO pin will trigger. Depending on which side the car was detected on the light will turn on with the corresponding side of detection.

Figure 5: Bike LED Lights On/Off

The user then views the lights on their handlebars and knows that if a light is on that a car is approaching them from that side. The detection also accounts for stationary cars and will notify the user regardless avoiding blind spot collision. Sensitivity is set fairly low due to enhancing safety over usability.

Additionally, housing was mocked up for potential usage. This is to hold the LED lights. Mock up can be seen in figure 6 below.

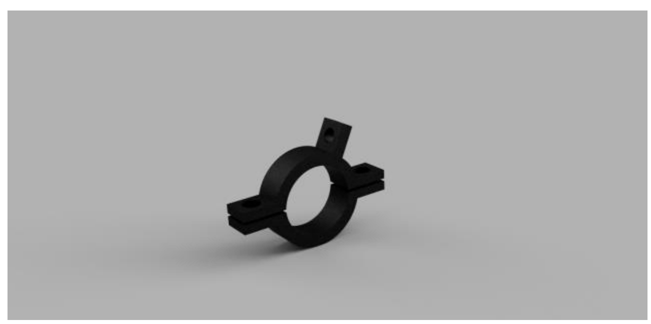

Figure 6: 3D printing model for LED housing

STRENGTHS & LIMITATIONS

The project was focusing on reducing bike collisions especially the ones resulting in deaths with vehicles. The project was an innovative and new way of doing something like this and is unique in nature. The project does adapt certain strengths from other projects such as Tesla's CV for car detection.

The strengths of the project are that bike users do increase safety as they are notified whenever it is dangerous to turn into traffic. The project also increases biker awareness. Having the ability to know where and when cars are approaching is a huge advantage to the bike user. The bike rider has more confidence on the roadways, and this leads to significantly less accidents.

The project does have many limitations. Some of the highlighted limitations is that depth not covered in the CV. For the model it recognizes when cars are in the frame and not, but it fails for depth to be handled. This can cause problems when biking by parked cars and other stationary vehicles. Another significant issue is that the framerate is low. The framerate is 2-4FPS which is very low and doesn't account for sudden movements. This is a limitation as it decreases the safety of the product. Lastly, detection isn't perfect. It is a small dataset to work with and there is limitations to the Pi's computing power. By increasing the model size, it will account for many more vehicle types and more precise modeling and measurements.

FUTURE WORK

For future work the plan is to take the current prototype implantation and turn it into a full functioning helmet system with augmented reality and smart functionality. Below are the specific features I am looking to develop, test and deploy.

1) Move the current system into a bike helmet. Power supply, computing, and wiring all within the helmet.
2) Develop a flip down glass display that projects AR visuals onto the glasses.
3) Change the LED display lights to small icons in the AR display.
4) Add map functionality for tracking specific routes as well display routes on the AR display.
5) Add bone condensing technology to play music within the helmet while keeping awareness of surroundings
6) Add incident reporting to better detect and prevent collisions.
7) Increase FPS coverage for better response time.
8) Add depth perception to better detect cars approaching and not just cars that are visible.

There are various applications beyond the scope of the project. The project could be developed into multifunctional detection and have various uses outside of just biking as well. These uses could be, skiing and detecting other skiers. Boating and detection of other boats.

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