V-Assist Implementation of ADAS features

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Abstract— **As the world is progressing towards the electric car revolutions, car safety has become a greater concern for automobile industry. With number of cars increasing daily, accidents are becoming more common. It is found that more than 50% of accidents happen on highways which comprises of 5% of total road network. Thanks to rapid growth of science and technology, automobiles today have many advance safety systems. These safety systems are classified into passive safety system and active safety system. The active safety system is still under development phase and is being tested on real world scenarios. This paper describes an algorithm for active safety system that can be used in ADAS equipped automobiles to reduce the rates of accidents on highways. Although there are several different implementations of safety systems with different operation conditions, the development of an active safety system inventory becomes a useful tool for experts to have a feel for the generic system, project the functionality of such a system onto available data collected, and, most relevantly, assess if somehow the system completely meets the needs of drivers.**

Keywords—ADAS, V-Assist, Automotive

I. INTRODUCTION

For the past decades, automobile manufacturers have made significant efforts to improve the passive safety as well as active safety of the cars [1]. However, current road safety studies suggest that preventative (prevention of accidents) and active safety measures must be addressed currently [2]. Fig. 1 shows the V-Assist features in a vehicular network.

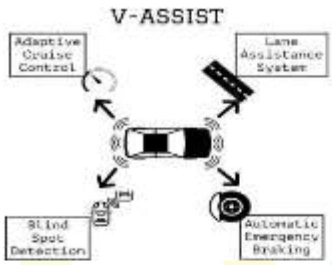

Fig. 1. V-ASSIST Features

V-ASSIST is implemented as a part of active safety systems with the aim to provide four key features Adaptive Cruise Control [3], Lane Assistance System [4], Emergency Braking System [5] and Blind Spot Detection [6]. These features are sufficient to provide enhanced safety on highways where majority of accidents occur. The project is designed on Highway Models.

A. *Adaptive Cruise Control (ACC)*

With constant research cruise control has evolved to modern technology commonly named as Adaptive Cruise Control. [2] This feature helps drivers reduce strain during long trips on highways by keeping constant distance with the front vehicle on free roads.

Adaptive Cruise Control = Velocity + Speed Control

Cruise Control = Velocity control

The cruise control works on two modes [7-8]:

- Constant Distance Mode: In this mode, the vehicle keeps constant distance control with the preceding vehicle and follows that vehicle until the driver manually changes the lane.
- Constant-Distance-Speed-mode: When the vehicle at the front goes at a speed greater than cruise speed that is set by the driver, the system switches between velocity and distance control causing instability control of the vehicle. Hence when the vehicle is following another vehicle it must also consider relative velocity as a factor and must not exit vehicle follow mode.

Operation of the two modes in different scenarios is shown in Fig. 2.

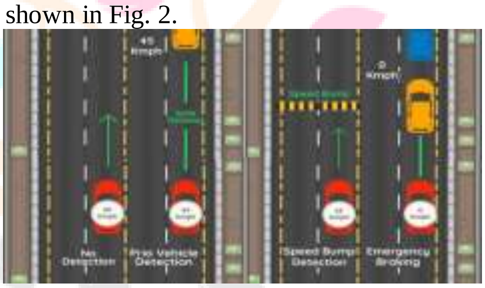

Fig. 2. Adaptive Cruise Control

B . *Lane Assistance System (LAS)*

Under this the system has

- Lane detection and Tracking using Image and sensors: In [9] authors proposed to have developed and implemented a visual based lane assistance system. The current position of the vehicle is first determined, which acts as an input for maintaining the vehicle in the desired lane. The steps followed by this system are inverse perspective mapping, detection of lane scope features and reconstruction of the lane markings. The major disadvantage of this system is a reduction in efficiency in low light conditions like a tunnel.
- Predictive Controller Lane Detection and Tracking (PBL Approach): In [10] authors proposed a LKAS consisting of two modes of assistance, namely, LDP (lane departure prevention) mode and LK Co-pilot (lane keeping co-pilot) mode. The former one gives a better consistency in performance. The LDP will be triggered only when the vehicle path does not match the lateral position which is parallel to the lane edges. The co-pilot mode can be activated by the driver when he no longer wishes to change lanes. It will decide the best route based on the steering input of the driver. False lane

detection can prove to be a disadvantage when proper thresholds are not established.

- Robust Lane Detection and Tracking (Model Based Approach): In [11] authors proposed to have developed a tracking algorithm for multi lane detection which determines the best route for roads with poor markings, guardrails and other obstacles. This algorithm even works when road images are unclear as it is able to define the strong features of the lane using adaptive threshold. To forestall deceptive lane detection the algorithm will draw out the incorrect lane features using the RANSAC algorithm. This system has an advantage that it works even when the lanes are new or unknown.

B. *Emergency Braking System (EBD)*

For Emergency Braking Conditions for Electrified Vehicles, Dynamically Coordinated Control for Generator and Anti-Lock Shock Absorbers. The system may encounter braking situations ranging from low-intensity slowing to sudden braking during the two phases of motor braking

- Low-intensity braking
- Anti-lock brakes with emergency braking

The fuzzy PID approach can be used to simplify the complex nonlinear ABS controller system.

C. *Blind Spot Detection (BSD)*

As the public's interest in driver safety and convenience develops, so does demand for intelligent car functions. BSD (Blind Spot Detection) is a type of ADAS (Advanced Driver Assistance System) capabilities that helps the driver change lanes safely.

At night, the car black box was used for BSD, which is a rear-view camera. The system used a mix of video footage filmed on a simple roadway and in a city setting with a complicated backdrop. [12-15] By tracking the car in the blind spot, the system can successfully produce an alarm signal.

D. *Active Safety System (ASS)*

It is an intelligent real-time system capable of monitoring vehicle environment and actively helps the driver to reduce the impact of an emergency situation. The system has main features as listed below:

- Adaptive Cruise Control (ACC)
- Emergency Braking System (EBS)
- Lane Assistance System (LAS)
- Blind Spot Detection (BSD)

II. Methodology

To implement V-Assist the implementation was divided into two phases

- Implementation/developing the V-Assist model (Model Preparation)
- Incorporating the features of V-Assist into the model prepared (Feature Implementation)

A. *Model Preparation*

The model preparation has three layers incorporated in it

- The Bottom Layer: It consists of motor controller, motors and IR sensors. As shown in the figure 10, the motor controller is used to control the speed using PWM pins ENA and ENB and directions IN1, IN2, IN3, IN4 of all four motors. This is represented in Fig. 3 below.

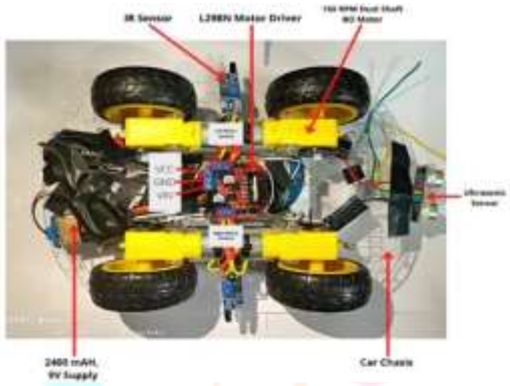

Fig. 3. Bottom Layer of V-Assist Model

- The Middle Layer: It consists of microcontroller – Arduino Mega Board which controls the motor speed and direction, takes input from IR sensor and Ultrasonic sensor and takes command from Raspberry Pi. This layer also has two 9 V, 1200 mAH battery each connected in parallel, used to provide load power to motors. The switch is used to turn ON/OFF the motor system. This is represented in Fig. 4.

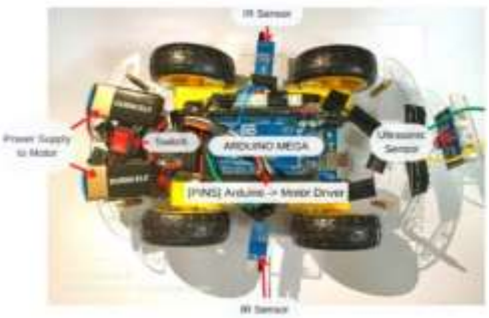

Fig. 4. Middle Layer of V-Assist Model

- The Top Layer: In the top layer, Raspberry Pi model 4b is placed which is the referred as the brain of the safety system. Main function of system is to read the camera input – Pi Camera, process the image and send commands to Arduino for controlling motors. Top layer also has rechargeable battery which supplies 5V to the Arduino. This is represented in Fig. 5.

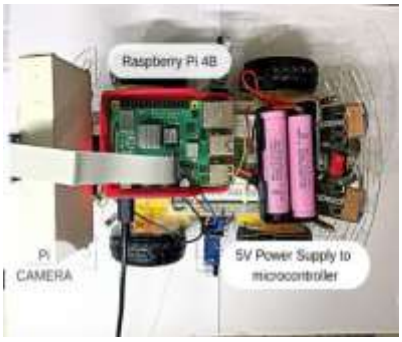

Fig. 5. Top Layer

B. *Feature Implementation*

The core part of the project is to create a real time system by implementing algorithms of different features in a single system. The algorithm is initialized with two global parameters – "spd" and "turn".

- spd: This variable is mapped between -1 to +1. This variable indicates speed of the vehicle.
- turn: This variable is mapped between -1 to +1. This variable indicates the steering angle of the vehicle.

These two global variables are used as input to function "vassist.mov (spd, turn, delay)" which is used to control the movement of the vehicle.

- Feature 1 - Adaptive Cruise Control (ACC): Vehicles with ACC are considered Level 1 Autonomous Car. This feature can be enabled when vehicle is required to run on certain constant speed (> 40 kmph) on highway. Once enabled the vehicle starts monitoring the environment in a loop. The flowchart representing methodology of implementation of ACC is given in Fig. 6 below.

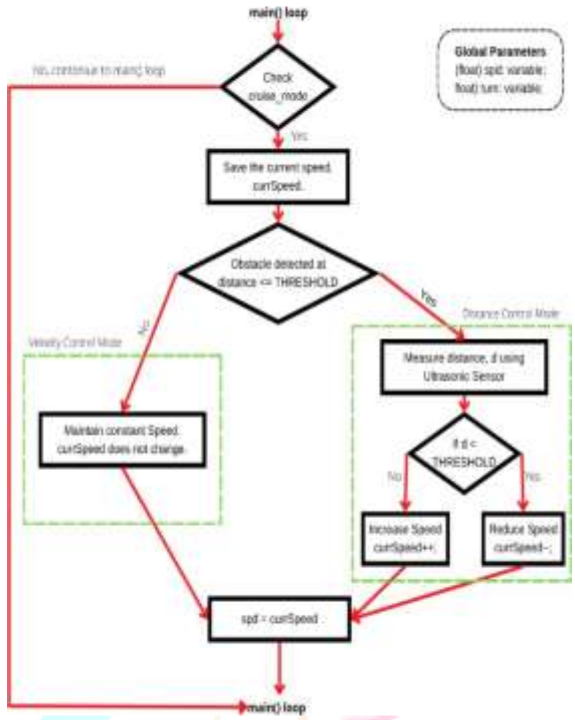

Fig. 6. Flow diagram for ACC algorithm

- Feature 2 - Emergency Braking System (EBS): Majority of accidents occur due to unconsciousness of driver in emergency situation. The vehicle monitors the environment continuously and can avoid or reduce the impact of accident better than drivers. The methodology for implementation of EBS is given in Fig. 7.

Fig. 7. Flow diagram for EBS algorithm

- Feature 3 - Lane Assistance System (LAS): Cruise control with lane assist comes under Level 2 Autonomous driving. The camera system detects the lane and assist the driver to smoothly control car on lanes. The methodology to implement LAS is given in the flowchart given in Fig. 8.

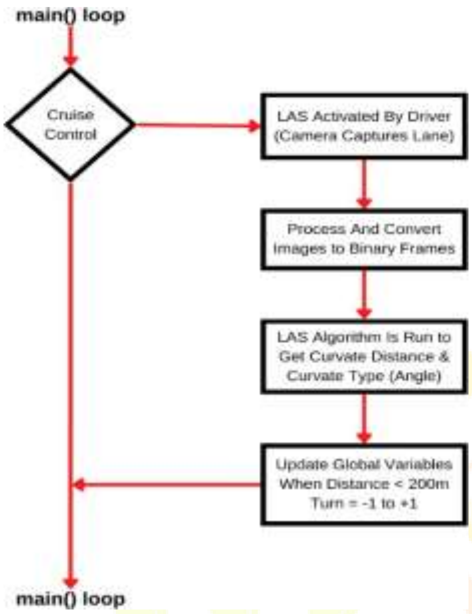

Fig. 8. Flow diagram of LAS algorithm

- Feature 4: Blind Spot Detection (BSD): It is a part of LAS but when driver opts to turn the vehicle to another lane, one part of lane approaches vehicle rapidly. Such case will be used for BSD. Fig. 9 gives the methodology used for implementation of BSD.

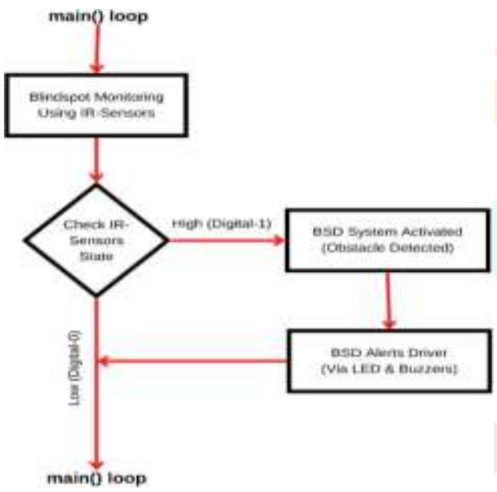

Fig. 9. Flow diagram of BSD Algorithm

III. Results and Discussions

The V-Assist model is built using Raspberry Pi-4 and is shown in Fig. 10 below. The model uses Pi Camera for capturing the frames of the lane and using these frames will be processed to indentify the lane departure; which will be used as an input for controlling the vehicle position of the lane. The model is tested on a simulated highway environment, where the vehicle is cruising at constant speed.

Fig. 10. V-ASSIST model

Figure 16: V-ASSIST model

Fig. 11 shows the V-Assist model under left turn condition. Fig. 12 shows the results of the image captured and processed for lane departure and warning, along with the cruise control to keep the V-Assist model on the lane.

Fig. 11. V-ASSIST model under left turn condition

Fig. 12. V-Assist model captures the frame and processes the image to identify left turn

Similar condition for right turn is also observed. Fig. 13 shows the frame captured by the V-Assist model during the right turn condition. The image/frame captured is and identification is made by the model detecting the right turn condition.

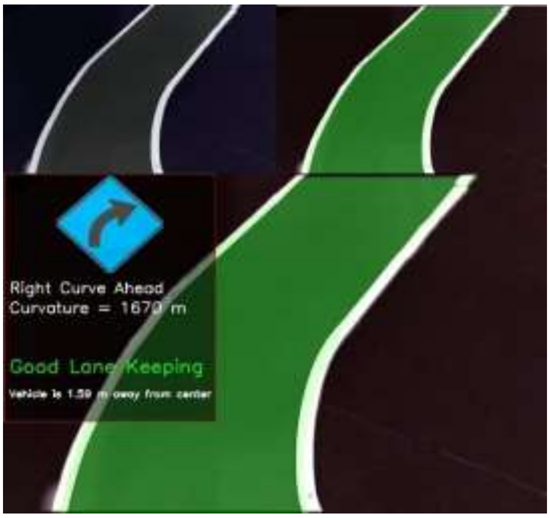

Fig. 13. -Assist model captures the frame and processes the image to identify right turn

IV. CONCLUSION

Using the Raspberry-Pi4 to implement the V-Assist model incorporating ACC, LAS, EBD, BSD and ASS was achieved. The model was able to maintain the lane discipline under different conditions, such as curvature identification and taking a right or left turn or maintain straight lane. The V-Assist can find its usefulness in different situation such as saving energy, saving fuel and so on. The work incorporated is our first step towards autonomous vehicle implementation.

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REFERENCES

[1] S. Hamsini and M. Kathiresh, "Automotive Safety Systems | SpringerLink," Automotive Safety Systems | SpringerLink, Apr. 25, 2021.

[2] Bifulco, Gennaro Nicola & Pariota, Luigi & Simonelli, Fulvio & Di Pace, Roberta. "Development and testing of a fully Adaptive Cruise Control system," Transportation Research Part C-emerging Technologies - TRANSPORT RES C-EMERG TECHNOL, 2013. 10.1016/j.trc.2011.07.001.

[3] A. Abdullahi and S. Akkaya, "Adaptive Cruise Control: A Model Reference Adaptive Control Approach," 2020 24th International Conference on System Theory, Control and Computing (ICSTCC), 2020, pp. 904-908, doi: 10.1109/ICSTCC50638.2020.9259641.

[4] P. C. Gagan Machaiah and G. Pavithra, "A review article on lane sensing and tracing algorithms for Advanced Driver Assistance Systems," 2022 7th International Conference on Communication and Electronics Systems (ICCES), 2022, pp. 1508-1514, doi: 10.1109/ICCES54183.2022.9835999.

[5] J. Gao, W. Li, W. Zhou, H. Chen and M. Qiao, "Research on Simulation Test Method of Advanced Emergency Braking System of Commercial Vehicles," 2022 11th International Conference of Information and Communication Technology (ICTech)), 2022, pp. 133-137, doi: 10.1109/ICTech55460.2022.00034.

[6] M. R. W. Pratama, M. Abdurohman and A. G. Putrada, "Vehicle Blind Spot Area Detection Using Bluetooth Low Energy and Multilateration," 2021 9th International Conference on Information and Communication Technology (ICoICT), 2021, pp. 165-169, doi: 10.1109/ICoICT52021.2021.9527516.

[7] Y. Liu, C. Fu, X. Tang, C. Guo and M. Hu, "A Comparison of Mode Switching Strategies for Adaptive Cruise Control," 2020 4th CAA International Conference on Vehicular Control and Intelligence (CVCI), 2020, pp. 465-470, doi: 10.1109/CVCI51460.2020.9338575.

[8] Sang-Jin Ko, Ju-Jang Lee, "Fuzzy logic based adaptive cruise control with guaranteed string stability," 2007 International Conference on Control, Automation and Systems, 2007, pp. 15-20, doi: 10.1109/ICCAS.2007.4406871.

C. Y. Kuo, Y. R. Lu, S. M. Yang, "On the Image Sensor Processing for Lane Detection and Control in Vehicle Lane Keeping Systems," Sensors, vol. 19, no. 7, p. 1665, Apr. 2019. [Online]. Available:http://dx.doi.org/10.3390/s19071665.

[9] Y. Bian, J. Ding, M. Hu, Q. Xu, J. Wang, K. Li, "An Advanced Lane-Keeping Assistance System with Switchable Assistance Modes," in IEEE Transactions on Intelligent Transportation Systems, vol. 21, no. 1, pp. 385-396, Jan. 2020, doi: 10.1109/TITS.2019.2892533.

[10] Son, Y., Lee, E.S, Kum, D, "Robust multi-lane detection and tracking using adaptive threshold and lane classification," Machine Vision and Applications 30, 2019, 111–124,. https://doi.org/10.1007/s00138-018-0977-0.

[11] K. Jung, K. Yi, "Determination of moving direction by the pose transition of vehicle in blind spot area," 2015 International Symposium on Consumer Electronics (ISCE), 2015, pp. 1-2, doi: 10.1109/ISCE.2015.7.

[12] Tigadi, A.S., Changappa, N., Singhal, S., Kulkarni, S, "Autonomous Vehicles: Present Technological Traits and Scope for Future Innovation. In: Automotive Embedded Systems,". EAI/Springer Innovations in Communication and Computing. Springer, Cham. https://doi.org/10.1007/978-3-030-59897-6_7

[13] B. Chougula, A. Tigadi, P. Manage, S. Kulkarni, "Road segmentation for autonomous vehicle: A review," 2020 3rd International Conference on Intelligent Sustainable Systems (ICISS), 2020, pp. 362-365, doi: 10.1109/ICISS49785.2020.9316090.

[14] B. Chougula, "Automatic Smart Parking and Reservation System Using IOT," Bioscience Biotechnology Research Communications, vol. 13, no. 13. Society for Science and Nature, pp. 107–113, Dec. 25, 2020. doi: 10.21786/bbrc/13.13/15.

[15] G. Rudrappa, A. Tigadi, S. B. Kulkarni, S. Jadhav and B. Chougula, "CANoe Tool usage for Communication Between Automotive Grade Processors," 2022 3rd International Conference for Emerging Technology (INCET), 2022, pp. 1-5, doi: 10.1109/INCET54531.2022.9824832.