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Adaptive Cruise Control using Model Predictive Controller

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Abstract:- Adaptive cruise control system that is used in modern vehicles are highly helpful and very similar to already existing cruise control system model.But the difference between both is that ACC has the capabilities to supervise the environment and take decisions based on the constraints.A vehicle equipped with adaptive cruise control system can monitor the exterior of the ego vehicle through an optical sensor and accelerate or decelerate accordingly.In case of absence of a preceding vehicle or an obstacle, the system guides the vehicle to move at a constant set velocity.When the preceding vehicle or the obstacle is inside the proximity range, then the system switches from speed control to spacing control.In spacing control, the acceleration and braking systems both are overridden from manual mode and when the proximity range has reached the threshold, the algorithm calculates the appropriate speed for the scenario and applies brakes in case it is necessary

I. INTRODUCTION

Adaptive cruise control is a feature that enables a vehicle to make decisions based on the environment that it's a part of. The system analyses the constraints and makes the most optimized decision. There are two modes at which the system works and are namely speed control and spacing control. These control types will be analysed and studied in further detail.

II. METHODOLOGY

The working methodology of an adaptive cruise control is based on the constraints that it deals with. The main two components used in the ACC system are front radar sensor and multi purpose camera. The radar sensor and multi purpose camera combination makes it possible to implement further assistance and safety functions, such as automatic emergency braking to prevent collision with vehicles ahead and protect pedestrians. If the driver doesn't react in the event of an impending rear-end collision and both sensor systems detect the critical object, the assistance function will automatically intervene and trigger a full emergency stop. Sensor data fusion can also significantly enhance comfort and convenience. For instance, thanks to the lateral measuring accuracy of the camera, the adaptive cruise control (ACC) can detect a vehicle entering the driver's own lane much earlier, enabling the system to respond more dynamically. With the help of the radar, the system can correctly identify the lane in which the cars ahead are driving, thus enhancing the capabilities of the ACC, particularly when cornering. Thanks to sensor data fusion, the radar sensor system can include speed limits identified by the camera into the driving strategy. This increases the safety and reliability of the driver assistance system.

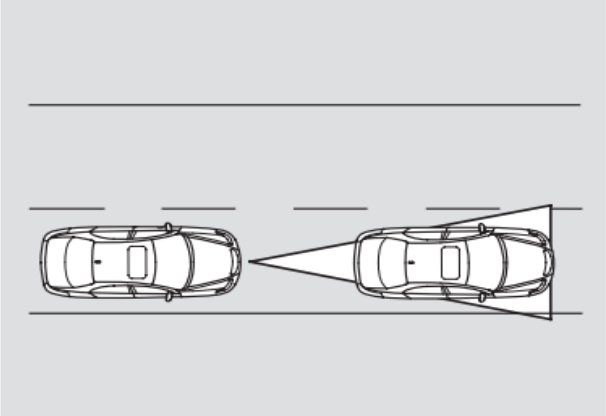

Fig 1.1 When a vehicle is in lead with ACC

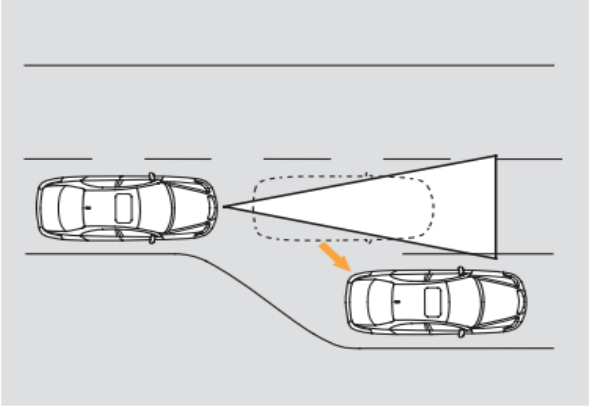

Fig 1.2 When vehicle change lane,ACC maintains set velocity.

Advantages of an ACC system

- As the driver is relaxed in the pilot seat, the ACC system will safely be able to transport the passengers as well as the driver with ease.
- Advanced technology such as an ACC system has no room for human error.
- It enables the user to have fuel efficient travel experience and provides economic feasibility
- ACC system drastically reduces the chances of rear end collisions and provides a smooth journey.
- It gives the driver some breathing space and helps him/her concentrate on the present traffic.
- During cross country trips and journeys, ACC system will be highly advantageous as the driver will also be able to have quality recreation time.

Disadvantages of ACC system

- ACC does not work below 25 mph (40 km/h). It cannot bring your vehicle to a complete stop.
- ACC may not recognize motorcycles or other small vehicles ahead of your vehicle.

III. COMPONENTS OF ACC SYSTEM

Adaptive Cruise Control (ACC) consists of a radar sensor in the front grille, the ACC buttons on the steering wheel, The radar sensor for ACC is shared with the braking mechanism and acceleration mechanics.

ACC Module: This is a primary processing unit for which the radar input is feeded into to determine if the forward vehicle is present.

Engine Control Module: The primary function of the Engine Control Module is to receive information from the ACC module and Instrument Cluster and control the vehicle's speed based on this information.

Brake Control Module: This module is used to determine if the braking is needed depending on the preceding vehicle. Instrument Cluster: The primary function of the Instrument Cluster is to process the Cruise Switches and send their information to the ACC and Engine Control Modules.

IV. SOFTWARE

Matlab:

Matlab is a proprietary multi-paradigm programming language and numerical computing environment developed by Matworks. The first Matlab was not a programming language, it was a simple interactive matrix calculated ,Matlab allows matrix manipulations ,plotting of functions and data, implementation of algorithms, creation of user interfaces, and interfacing with programs written in other languages. Although Matlab is intended primarily for numerical computing, an optional toolbox uses the MuPAD Symbolic engine allowing access to symbolic computing abilities.

V. PROGRAMMING

```
disp('--- Model Predictive Control of a Basic Adaptive Cruise Control ---');
disp('Choose one of the options below');
disp('1. Basic ACC');
disp('2. ACC MPC and ACC LQR Comparison');
disp('3. MPC of ACC with varying prediction horizon N');
disp('4. MPC of ACC with varying Q');
disp('5. MPC of ACC with varying R');
disp('6. MPC of ACC with varying distance between cars');
disp('7. Stability analysis');
disp('0. Exit');
pause(1);
choice = input('Please choose --> ');
switch choice
   case 1
      close all;
      figure(1);
      ACC_MPC_Final;
      disp('Do you want to run another simulation?');
  opt = input('Enter your option [Y/any other key] --> ','s');
      if opt == 'Y'
         main;
      else
         disp('Goodbye!');
      end
   case 2
      close all;
      figure(2);
      LQR_ACC;
      disp('Do you want to run another simulation?');
      opt = input('Enter your option [Y/any other key] --> ','s');
      if opt == 'Y'
         main;
      else
         disp('Goodbye!');
      end
   case 3
      close all;
      figure(3);
      ACC_MPC_varying_N;
      disp('Do you want to run another simulation?');
      opt = input('Enter your option [Y/any other key] --> ','s');
      if opt == 'Y'
         main;
      else
         disp('Goodbye!');
      end
   case 4
      close all;
```

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```
        figure(4);
        ACC_MPC_varying_Q;
        disp('Do you want to run another simulation?');
        opt = input('Enter your option [Y/any other key] -->
','s');
        if opt == 'Y'
           main;
        else
           disp('Goodbye!');
        end
    case 5
        close all;
        figure(5);
        ACC_MPC_varying_R;
        disp('Do you want to run another simulation?');
        opt = input('Enter your option [Y/any other key] -->
','s');
        if opt == 'Y'
           main;
        else
           disp('Goodbye!');
        end
    case 6
        close all;
        figure(6);
        ACC_MPC_init_dist;
        disp('Do you want to run another simulation?');
        opt = input('Enter your option [Y/any other key] -->
','s');
        if opt == 'Y'
           main;
        else
           disp('Goodbye!');
        end
    case 7
        close all;
        figure(7);
        stability_analysis;
        disp('Do you want to run a1nother simulation?');
        opt = input('Enter your option [Y/any other key] -->
','s');
        if opt == 'Y'
           main;
        else
           disp('Goodbye!');
        end
    case 0
        disp('Goodbye!');
    otherwise
        disp('Please input a valid number.');
        pause(2);
        main;
End
```

VI. CONCLUSION

Thus the Adaptive cruise control system using matlab has been simulated and a brief study about the mechanical components and mechatronics system design aspects have been looked into. Details related to adaptive cruise control system's feasibility and economic aspects in our modern day society have been studied in detail.

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