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THE ANALYTICAL USE OF PID AND FUZZY LOGIC CONTROLLERS IN COLLISION AVOIDANCE

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ABSTRACT

This thesis presents collision avoidance integrated with PID and FUZZY LOGIC CONTROLLERS for a car. Collision avoidance is the ability to avoid obstacles that are in the vehicle's path, without causing damage to the obstacle or car. There are three types of collision avoidance controllers, passive, active, and semi-active. This thesis is designed using active collision avoidance controllers. There are two controllers developed for collision avoidance in this thesis. They are PID controller and a fuzzy controller. The PID controller is design and Tuning was made. The fuzzy controller makes decisions based on the system rules. A simulation environment was created to compare these two controllers as viable solutions for collision avoidance. The environment uses MATLAB/Simulink for simulation of the vehicle as well as fuzzy controllers. The simulation incorporates system blocks of the kinematics of a car, navigation, states, control law, and velocity controller. Once the controllers are fully developed and tested in the simulation environment, they are implemented and tested on the platform vehicle. This verifies the real world performance of the controllers.

I INTRODUCTION

Collision avoidance systems for cars are designed to reduce the number of accidents and fatalities on the roadways and highways. Safety systems are designed to helped safe lives like the seat belt when worn properly and the air bag. In the United States in 2003, there were 42,643 people killed from motor vehicle accidents and 2,889,000 people injured in motor vehicle accidents. With any of the vehicle, accidents if there were a passive system to avoid an obstacle; it would have greatly decreased the number of fatalities and injuries. Driving is not a right but a privilege, we should treat driving seriously. The reason for researching collision avoidance is so the fraction of a second where a driver is not paying attention, a passive system could be implemented to keep the driver, passengers, and others safe. [9] Currently, the marketplace is starting to see technology to help avoid motor vehicle collisions. There are three different types of collision avoidance systems: passive, active, and semi-active. Passive collision avoidance systems are typically audio or visual alarms indicating the potential for a collision. Active collision avoidance systems take control of the vehicle by controlling the throttle, braking, and steering to avoid or minimize a collision. Semi-active collision avoidance systems minimize the impact the collision has on the driver. These systems are starting to be available in the market today and the near future.

Passive collision avoidance systems that are either on the market or soon to be on the market Delphi has developed: lane change warning alarm, a vision system that detects roadway markers and warns of unintended lane changes. [16] Roadway Departure warning system that mimics the sound of rumble strips. The sound comes from the side toward which the car veers. [18] Blind Spot collision avoidance system, which is a combination of radar and vision systems to help a driver better sense his crash envelope. [16] Active collision avoidance systems that are either on the market or soon to be on the market Delphi has developed: Forewarn Collision Avoidance Systems uses sensors strategically located around the vehicle to collect data and recognize hazards within their detection zone. Forewarn can then not only communicate when driver intervention is necessary, but take automatic action when appropriate. Smart Cruise Control detects traffic ahead, and using throttle control and limited braking, maintains a driver-selectable gap. [17] Another example is Jaguar's adaptive cruise control system. Jaguar's description of this system is: "Radar-based Adaptive Cruise Control (ACC) constantly maintains a comfortable gap to the car ahead, taking 40 individual measurements during each horizontal scan. ACC also offers Forward Alert, which provides a timely audible warning if traffic ahead starts to slow down. Adaptive Cruise Control is available on all models with automatic transmission." [4] Semi-active collision avoidance systems that are either on the market or soon to be on the market Ford has developed: A video monitor embedded in the dashboard of a Ford Explorer concept vehicle shows a vehicle ahead of it, with a green box around it. As the concept vehicle gets too close for safety, the box turns to red, which senses that a crash may be imminent. This makes the seat belts tighten automatically and a computerized voice beckons, "Warning."

II METHODOLOGY

2.1 Dynamic System of the Car Model and State Equations

The car turns until theta and theta1±Turn_Alpha are approximately equal; it is ± because it depends on whether the car is turning left or right. The car repeats the curve executed at the beginning of the lane change manoeuvre except in the opposite direction to align the car with the white line. In addition, the lane_change.m file updates the lane_we_are_in. The reason for the delays (1/Z) is to retain the previous values of the lane_we_are_in, In_Lane_Change, theta1, lane_change_direction_latched. Since there are multiple cars, the delays remember the previous values for each car separately. This way the same functions can be used for each car. The obstacle detection system models ultrasonic or range finder distance sensors, and when there is an obstacle in the region the sensor detects it. The region for each sensor is defined by 360 degrees divided by the number of sensors. The obstacle_sensor_function uses the current x,y, and theta and returns an array with the distance the closest obstacle is away from each sensor. If there is no obstacle closer than max_dist the obstacle_sensor_function outputs max_dist. There is an array static_obstacles, which includes obstacles that do not move, and the cars' positions. It is a 2 dimensional array which has a row for each obstacle, in each row there is a column for x-position, yposition, and obstacle radius. The Obstacle Avoidance subsystem shown in Appendix A, takes in x, y, and theta which goes to the obstacle sensor function which simulates the distance sensors, using the MATLAB function obstacle_sensor_function.m The discrete derivative is used to calculate the velocity of the obstacles. Impulse_to_zero function eliminates the impulse that occurs when a sensor rotates and detects a nearby object. The obstacle_avoidance_cost_function_control_law.m has twenty-one different states, each distance sensor, velocity from each distance sensor, lane we are in (1=outer 3=inner), car velocity V1, car heading theta, System

Mode, and x location. The outputs for the cost function are u1 (car linear velocity), turn left or right, and System Mode. The cost function calculates using optimal control, the optimal control outputs. For the fuzzy obstacle avoidance controller the function fuzzy_law.missubstituted for obstacle_avoidance_cost_function_control_law.

III RESULT ANALYSIS AND DISCUSSION

3.1 Simulation Results

After all the work deriving the change trajectory, the simulation was a lot easier to complete. The simulation car avoids non-moving obstacles as well as moving obstacles coming from behind it. When the simulated car avoids obstacles it takes the PID control. The simulated ultrasonic sensor behaves as the actual sensor does. The simulation was run under various conditions of obstacles and various speeds of the cars. Updating the vehicle position on the screen every 20ms makes a great improvement on the speed of the simulation over the simulation time interval of 0.4 ms. Running the simulation with a fixed step time in Simulink approximated the actual program of the real car, which calculates its parameters at the same fixed time interval of 0.4 ms. The simulation was run with the vehicle in all lanes and thoroughly tested obstacles and pursuing vehicles in various lanes, and everything worked as was expected. The fuzzy controller works as well as the PID control, but it is significant slower than the control model. There are many advantages of fuzzy control over PID control. The fuzzy control gives you a clearer understanding of the inputs and outputs. The rules are easier to understand than the numericalformulas of PID control. Expanding the rules to include other collision avoidancebehaviours are much easier using fuzzy control. The tools that are available in MATLAB to optimize the behaviourof the controller are easier to use. There are notools for the PID control; you have to createyour own tools. It is easier to see the different shapes and graphs because they are built into the fuzzy logic toolbox that you would otherwise have to create yourself for the PID control. The disadvantages of fuzzy control over PID control are; theprogram runs much slower, at times there seems to be too many options to have the PID solution, they are not as precise, and the decisions points are less clear.

3.2Model Car Results

With values of M=1000 , b=100 , Kp=40, Ki=50, Kd=10 and U1=3, U2=1, and U3=2

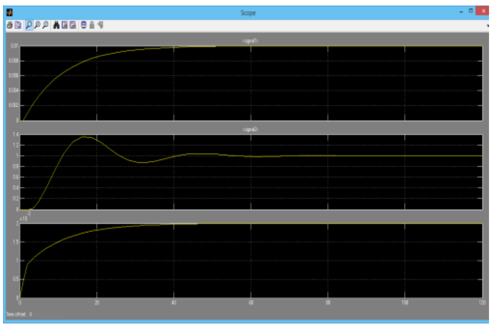

Fig 3.0: comparison of the two Controllers with different step input With M=100, b=1000, and Unit Ramp inputs the result is:

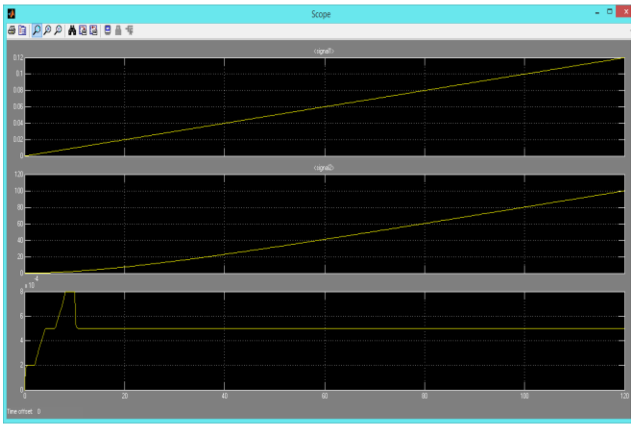

Fig 3.1: comparison with Ramp Input With twoUnits step Input and One unit Ramp input

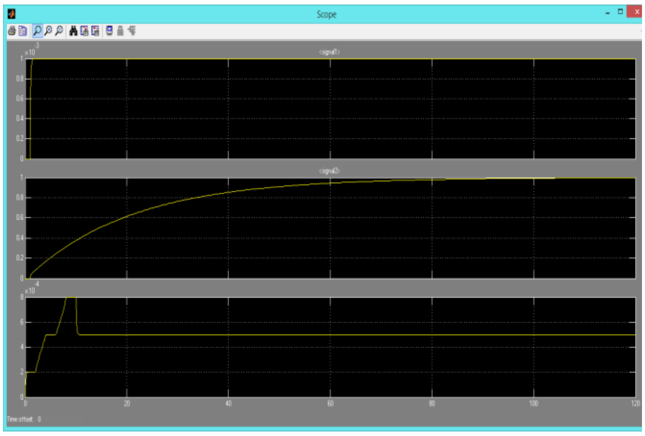

Fig: 3.2comparisons with two unit step input and one Ramp Input

3.3 Discussion of Results

With regard to my results simulated I found that fuzzy logic controller is more reliable than PID controller. In PID tuning from above I found that I can easily change the overshoot, settling time, and steady state error. Using unit step input to both of the controllers I found that the fuzzy logic controller is more reliable and more efficient to get the reasonable output.

For comparison of the results between two controllers

S/N	**Fuzzy logic controller**	**PID controller**
1	Very simple to understand	Difficuly to understand
2	Not tunable	Tunable
3	Usd language as resule	Mathematical modelling

4	Used Ramp input	Only step input
5	App;icable to very few systems	Applicable to many systems

IV CONCLUSION

The PID controller was designed and tested first. As more functions were added to the PID controller, it became more difficult to come up with the formulas to have the car behave correctly. When deciding to turn or not to turn the distances could be set exactly. The next controller that was worked on was the Fuzzy controller. Fuzzy programming was easier to use and manipulate and to describe the rules needed for obstacle avoidance. With the Fuzzy controller, it was easy to add more rules and functions. Although setting exactly when to turn or not turn was difficult, because of the fuzzy nature of the controller. Also, it is so flexible, and has so many adjustments that it takes time to setup optimally. The curvature estimation formula included from , made the vehicle perform poorly when it was used in both the simulation and the model car. The reason was because of the discrete nature of the sensors which cause the term Error! Objects cannot be created from editing field codes. to generate noisy data. The car and the simulation .The PID controller was designed and tested first. As more functions were added to the PID controller, it became more difficult to come up with the formulas to have the car behave correctly. When deciding to turn or not to turn the distances could be set exactly. The next controller that was worked on was the Fuzzy controller. Fuzzy programming was easier to use and manipulate and to describe the rules needed for obstacle avoidance. With the Fuzzy controller, it was easy to add more rules and functions. Although setting exactly when to turn or not turn was difficult, because of the fuzzy nature of the controller. Also, it is so flexible, and has so many adjustments that it takes time to setup optimally, We are now at the forefront of designing Smarter/Safer vehicles, when it comes to avoiding obstacles. We have hybrid-powered cars now, maybe one day soon hybrid (Human/Computer) controlled steering vehicles will be on the roads, behaved significantly better with a higher gain and the curvature output going to the controller set to zero except when doing the lane change maneuvererWe are now at the forefront of designing Smarter/Safer vehicles, when it comes to avoiding obstacles. We have hybrid-powered cars now, maybe one day soon hybrid (Human/Computer) controlled steering vehicles will be on the roads.

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