AVOIDING HUMAN INTERVENTION DURING ACTIVE VEHICLE SYSTEM OPERATIONS

ABSTRACT

As you drive many forces act upon your vehicles, you probably feel some of them in everyday driving. Like you lean towards the side in a corner when you turn the steering wheel that is because your car does not just move to one side, it rotates about a vertical axis. Under the same conditions the car might rotate too much or not enough like when you serve to avoid an obstacle or to take a curve too fast or encounter a slippery road. Therefore, most of the hybrid cars and the electrical cars are equipped with internal subsystems which are also known as vehicle subsystems.

These cars have a network of sensors working together which continuously monitor how the car is performing and measure the Dynamics of the car. These systems mainly monitor how well the car is carrying out the driver's orders.

For example, an ESC subsystem (Electronic Stability Controller) compares the driver steering input and the speed of all four wheels individually along with the car's rotation and within fraction of seconds it can sense if the car is not following the driver's intended course. The system is programmed to perform certain manure or corrective steps to get the vehicles back to the intended course.

But in most of the cases when the system is following or actuating the corrective steps, humans may intervene. It is obvious that humans are always emotional driven and many drivers with moderate driving skills may panic and may not take corrective steps, but the system is being programmed and it follows only the steps that are to be followed. In this project we address this problem of human intervention when a vehicle subsystem is actively performing certain corrective steps, It also provides a possible solution to this problem by designing a controller which will reduce the effect of human control while the subsystem is actively correcting vehicle’s course.

INTRODUCTION

As there are many subsystems simultaneously working in a vehicle, for better understanding of the project insights and flow, let us narrow our application on Traction Control System (TCS), which is the second function of an Electronic Stability Controller.

Traction control System

When a vehicle is accelerated on a slippery road, the resulting wheel slip, it reduces the traction force and increases the instability of the vehicle. Traction control system TCS is used to maximize the longitudinal friction coefficient by maintaining an appropriate slip ratio.

The slip ratio is defined as

$$\frac{(R\omega - V)}{R\omega}$$

, Where ω is the wheel speed and V is the vehicle velocity.

Generally, TCS consists of one, or a combination of throttle valve intervention, injection cut out, brake intervention, and limited slip differential control. For many possibilities, a quick throttle valve intervention is enough for the TCS of front-wheel-driven passenger vehicles. While the system is executing these tasks to get the vehicle back on course, driver's panic actions may cause the system to deviate from its target trajectory.
By using TCS as an example we can understand how the designed controller will be reducing the effects of human intervention while TCS is actively taking corrective measures to get the vehicle back on course.

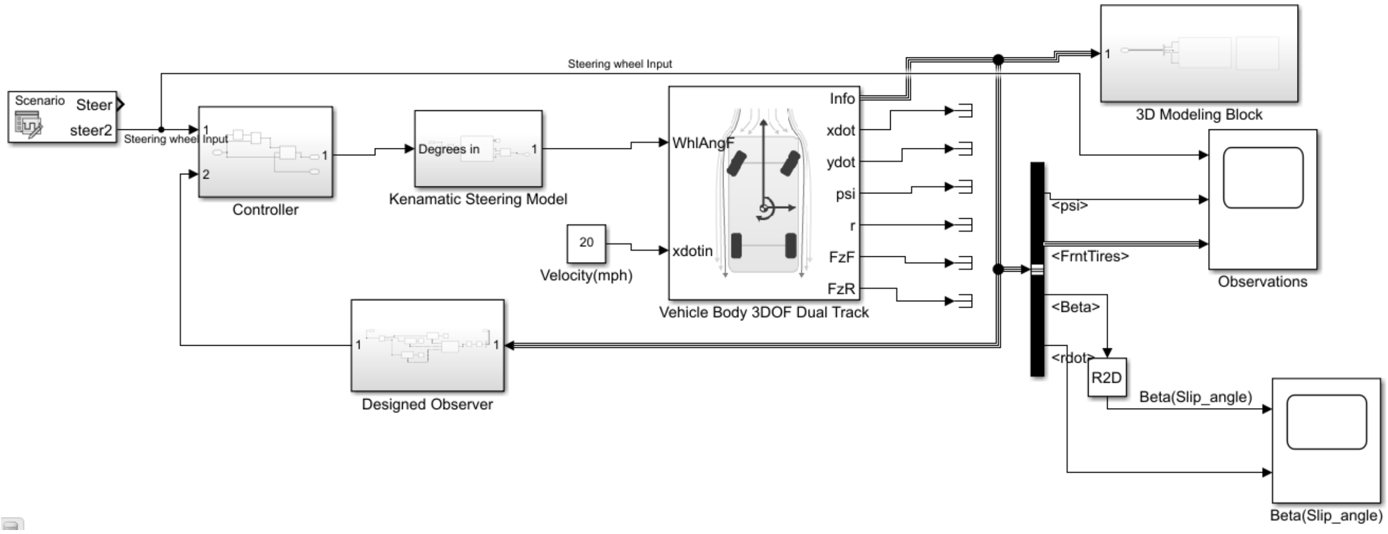
Simulated Vehicle Scenario:

We can take a scenario off a car traveling at higher speed on an icy road here if the car is sliding or fishtailing then the ECS sub system comes into action, and it applies individual brakes on the wheels meanwhile if the driver panics and jams his leg on the brakes then this sudden braking triggers slides and makes the existing slide worse. Moreover, driver may also give steer input in the wrong direction worsening the situation and the system may reach a state where it cannot further take any corrective measures.

Simulated Vehicle in a virtual 3D environment

Using Vehicle Dynamic Block set in Simulink we will simulate a same scenario where a car is fishtailing or sliding and meanwhile, we also observe how our designed controller is reducing the effect of input parameters so that the subsystems actions are not intervened by human's panic actions, At the end we compare what would be the results with and without the designed controller.

SIMULINK MODEL



The Simulink model consist of

- 3DOF Dual Track Vehicle Body
- Kinematic Steering Model
- 3D Modeling Bock
- Designed Observer Block
- Controller Block

The 3dof dual track vehicle body is a prebuilt application model of Vehicle Dynamic Block set that takes in inputs like steering angle, body mass, aerodynamic drag, vehicle velocity, external forces, and the weight distribution between the axles due to acceleration and steering. then determines various parameters like longitudinal, lateral, and yaw motion of the vehicle.

In real world there are plethora of parameters that are observed by TCS to predict if the car is sliding. However, limiting to the Scope of the project and ease of understanding we will be observing only the slip angles. Slip angle also called as side slip angle, is the angle between the direction in which the wheel is pointing and the direction in which it is traveling, speaking in technical terms it is an angle between the forward velocity vector and the vector sum of wheel forward velocity and lateral velocity.

Slip angle α is defined as:

$$\alpha \triangleq -\arctan\left(\frac{v_y}{|v_x|}\right)$$

Where, Vx and Vy are wheel forward velocity and wheel lateral velocity, respectively.

Control Law

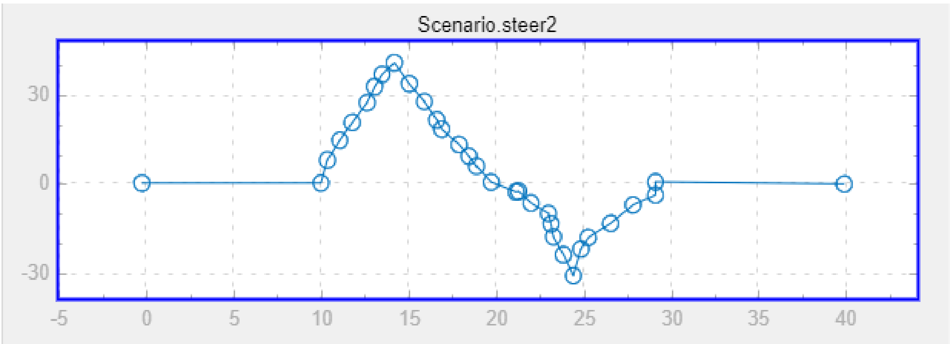
While TCS is taking corrective measures to get the vehicle back on intended course. The deigned observer continuously monitors the slip angle and if the slip angle exceeds the threshold value, then its triggers the controller to reduce the effect of the steering and brake input got from the driver. The driver's input is passed through differentiators so that its effect on the vehicle may reduce.

DETAIL OF EACH BLOCK

Steering Scenario

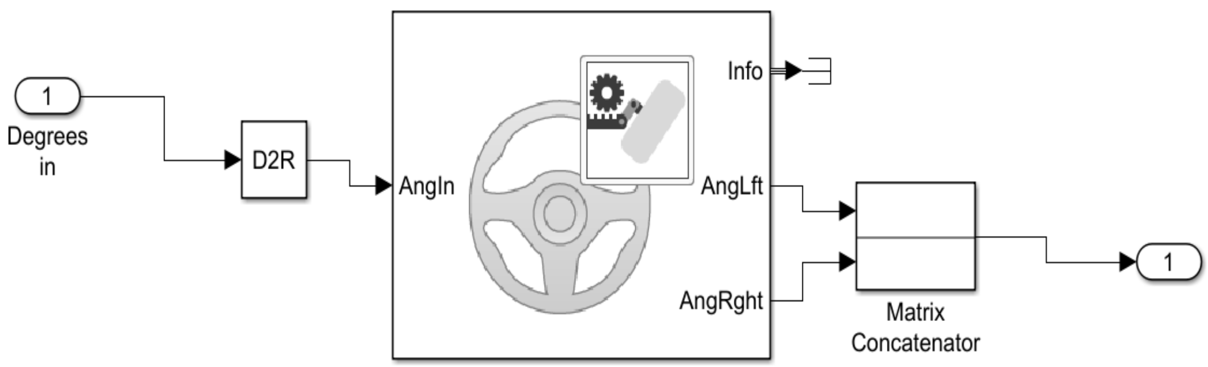
The steering input here is got from the signal builder block and to simulate a fishtailing scene, we generate a custom steering signal and evaluate the working of the whole model.

Steering Input: (Signal Builder Block)



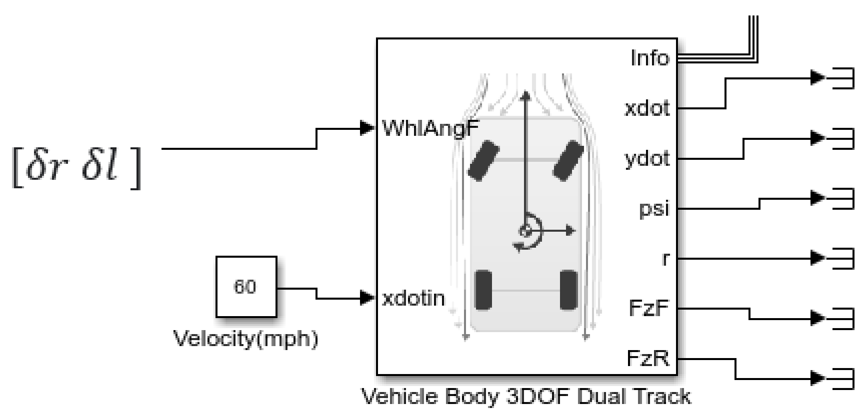
This is a custom designed steering input to simulate the fishtailing scenario, here the steering input value are varied from 0 to 40 and again from 0 to -30, from this the car will initially turn left and then from time t=14sec it starts turning in the opposite direction.

kinematic steering block



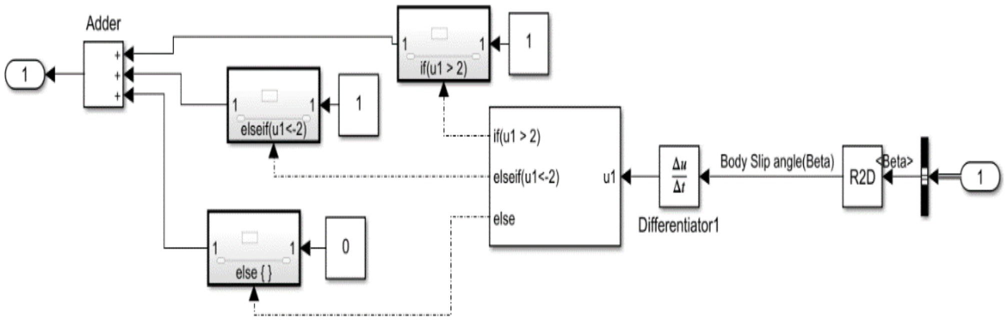
Kinematic steering block takes the steering input (unit: radian) and calculate the front wheel angles according to the rack and pinion steering mechanism, these individual wheel angles are the concatenated together in the matrix concatenator block (i.e. [δr δl]).

3dof dual track vehicle body



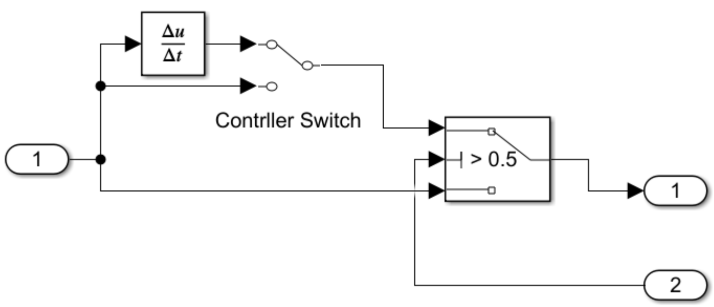
With wheel angle matrix and velocity as input, the vehicle body block calculates the vehicle parameters. The info bus contains all the parameters values which are further used by the observer and the 3D virtual simulation engine block.

Designed Observer



As mentioned earlier the designed observer block takes calculated slip angle α from the information bus and compare it with the threshold value, here the threshold value may vary based on the vehicle size and mass, for demonstration let us assume threshold = 2 Degrees.
While TCS is actively operating the controller, s triggered only if the driver intervenes by giving steering input.

Controller



Once the controller is triggered the steering input is made to pass through a differentiator whose output is proportional to the rate of change in the input, by this we are not completely reducing the drivers control over the vehicle instead we are just avoiding sudden changes in the input parameters.

OBSERVATIONS

In order compare how our designed controller is reducing the effect of driver inputs to the vehicle while the subsystems are active, we first look at parameter without using the controller in figure.1. later in the figure.2 we see how much effect our designed controller has on the system parameters.

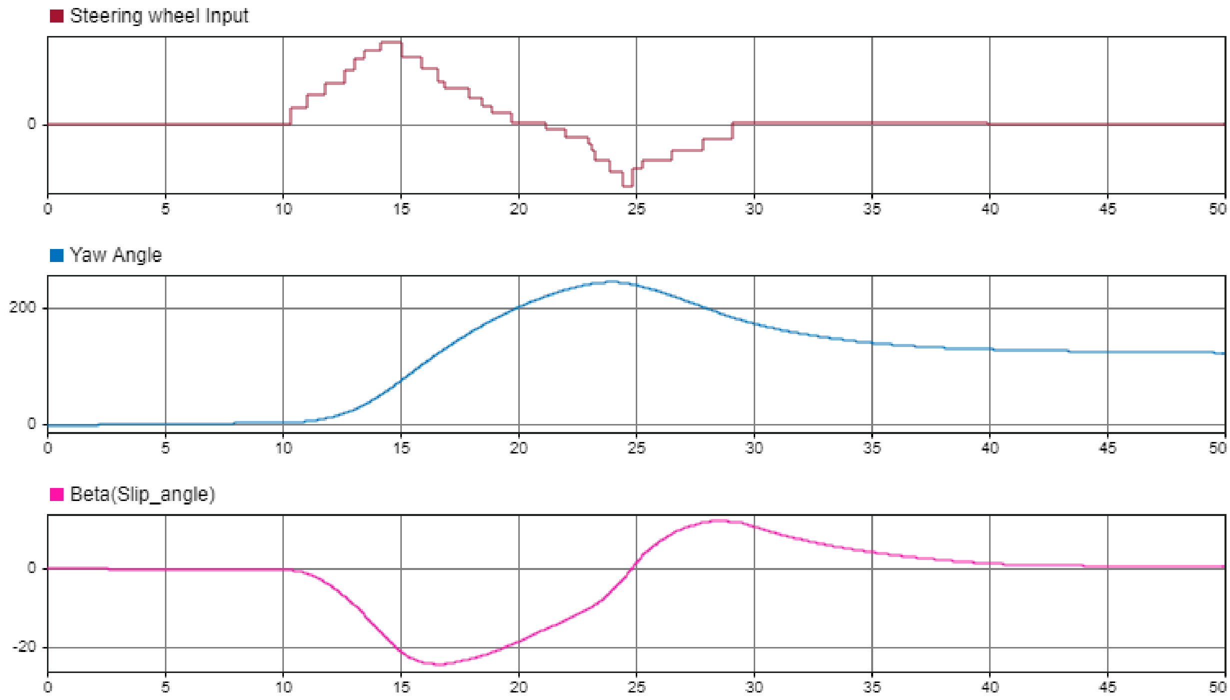


Fig1.Values without controller

Here we can observe that as the steering input increases gradually the vehicle rotates i.e., its yaw angle also changes positively, since the vehicle is changing direction, this induces a slip angle.
On time t= 15 the steering input is suddenly reverse and starts decreasing, the slip angle also changed rapidly with higher magnitude. And the same behavior is observed on time t=25 when the steering input is again reversed,
Overall, here we are observing how the due to sudden changes in the steering input the driver can worsen a slide.

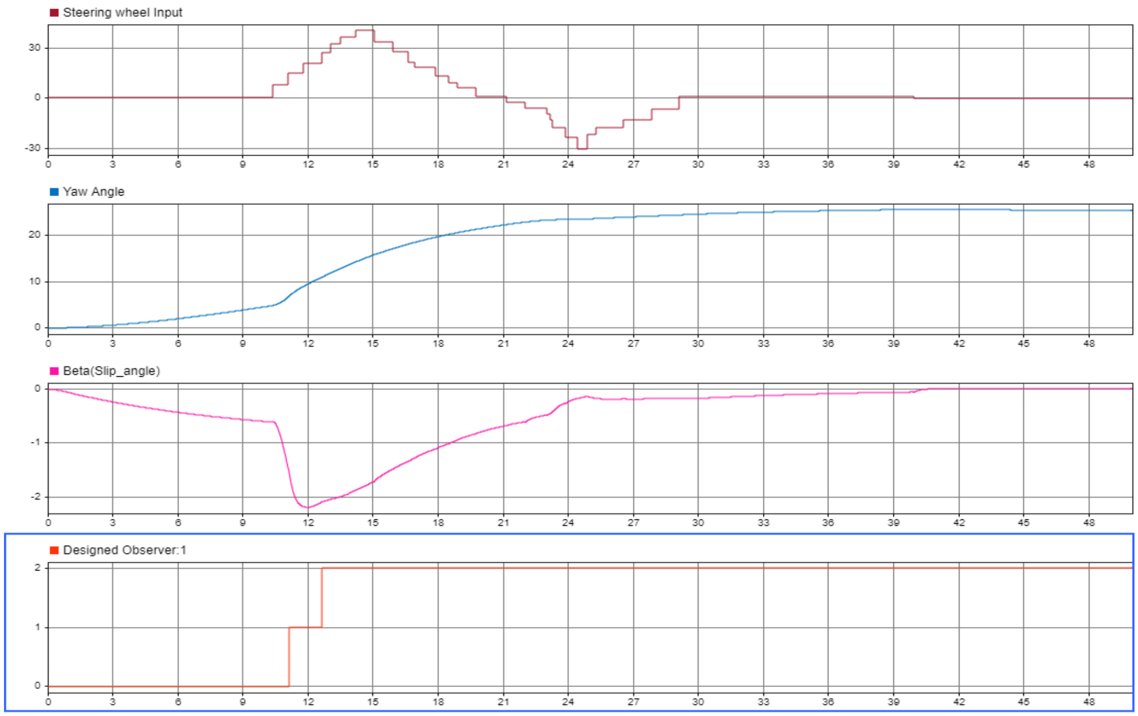


Fig2.Values with controller

When the designed controller is triggered (controller signal >1), the steering input is passed through a differentiator so that there are no sudden changes made by the driver. At time t~ 12 secs we see that the controller is triggered, and the steering input is passed through differentiator, now since the differentiated output has no sudden changes this is result in reduces slip angle, which means vehicle has less traction losses.

Overall, with the same steering input the slip angle now is ranging from approximately -3 to 1 unlike in the case without the controller where it ranged from approximately -20 to 15

CONCLUSION

While the vehicle subsystems are taking corrective steps to get the car on intended course, drivers panic actions like steering input or sudden braking may cause interruption to the subsystem operations. but by using the designed controller we reduce the input from the driver so that the subsystem exhibits improvements in performance by eliminating human intervention. simulation results show that the controller can effectively reduce the inputs from the driver while subsystems are actively operating.

REFERENCES

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4. Journal: Wheel Slip Control in Traction Control System for Vehicle Stability by Jong Hyeon park 1 and Chan young Kim.

Git Hub Repository

https://github.com/Bharat-kudachi/Control-System