Project 2: Module 2

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Trim Approach:

Utilizing Newton's method iterative method to drive state derivatives to zero.

- Numerically compute partial derivatives using central difference and construct Jacobian matrix

$$\text{Central Difference: } \partial\dot{X} = \frac{\dot{f}(x+h) + \dot{f}(x-h)}{2 * h}$$

$$\text{Jacobian: } \begin{Bmatrix} \frac{\partial \dot{v}}{\partial u_{acc}} & \frac{\partial \dot{v}}{\partial \omega_f} & \frac{\partial \dot{v}}{\partial \omega_r} & \frac{\partial \dot{v}}{\partial T} \\ \frac{\partial \dot{\omega}_f}{\partial u_{acc}} & \frac{\partial \dot{\omega}_f}{\partial \omega_f} & \frac{\partial \dot{\omega}_f}{\partial \omega_r} & \frac{\partial \dot{\omega}_f}{\partial T} \\ \frac{\partial \dot{\omega}_r}{\partial u_{acc}} & \frac{\partial \dot{\omega}_r}{\partial \omega_f} & \frac{\partial \dot{\omega}_r}{\partial \omega_r} & \frac{\partial \dot{\omega}_r}{\partial T} \\ \frac{\partial \dot{T}}{\partial u_{acc}} & \frac{\partial \dot{T}}{\partial \omega_f} & \frac{\partial \dot{T}}{\partial \omega_r} & \frac{\partial \dot{T}}{\partial T} \end{Bmatrix}$$

The Newton algorithm: $next = current - J^{-1}[e_x^{(k)}; e_y^{(k)}]$

Where $[e_x^{(k)}; e_y^{(k)}]$ is the state derivatives since all needs to be zero for trimmed case except x(position)

The general approach is to create a while loop that checks if the magnitude of the state derives (excluding position) is less than tolerance (e-6). If not, use the Newton method to compute the next guess and compute the new state derivative using the VehicleDynamicsModel from previous module.

Result:

For the trim cases, majority of the case are spot on or have an error less than 10e-6, it is unclear if the result is caused by machine error or computation error since the error magnitudes are inconsistent to indicate computation error.

Linearization:

For the Linearization case, I used the methods provided to construct matrix A, B, C, D. However, the linearization result did not match the validation values provided.

Simulink:

Following the instruction provided, I created the simulink model integrating X-dot numerically provided the input given by trim function. The expected result is that vehicle state remains fairly steady state. However, there may be error in the Vehicle Dynamic model from previous module that causes unexpected behavior.