$\mu_{T/B} = 0$ ← Brake Torque Request [-1,1]

$\vec{X}_o = \{\beta, \delta_{sw}, \dot{x}, \dot{\psi}\}$ ← Yaw Velocity

Body Slip | Steering Wheel Angle | Long speed

$\vec{f}_A = f(\dot{x}, \beta, \theta, \phi, z_r, \dot{\psi})$

① $\dot{y} = \dot{x} \tan(\beta)$ (By Defn of β) ← (Powertrain .. Brake Init)

② $(\dot{x}, \dot{y}, \dot{\psi}) \xrightarrow{\text{Two Point Theorem}} \vec{\alpha}$ $\vec{v}_c$ (4x2) ↑ 4 tires $r_{x,y}$

$\vec{k} = 0$ (Slip Ratio)

$\vec{\alpha} = f(\vec{v}_{c_{\alpha}}, \delta(\delta_{sw}, \theta, \phi, z_r, \ldots))$

③ Iteration — Highest order is a multibody model... ish

(3a) Assume Static Tire Loading $\vec{F}_{T,z} = \vec{F}_{T,z0}$ / Assume no pitch/roll $\ddot{x}, \ddot{\psi}$

(3b) Evaluate Tires $\vec{F}_T = f(\alpha, k, F_z, \sigma, \mu_i)$ / Eval Aero Loads $\vec{F}_A$

(3c) Evaluate Chassis Response "Sprung Mass" $[\ddot{x}, \ddot{y}, \ddot{\psi}, \ddot{\theta}, \ddot{\phi}] = f(\vec{F}_T, \vec{F}_A, \dot{x}, \dot{y}, \dot{\psi})$

(3d) Evaluate WT

Create a nonlinear algebraic system of (3b)–(3d) init. by (3a)

$a_y = \ddot{y} + \dot{x}\dot{\psi}$ vs. $\ddot{\psi}$ $(a_y, \dot{\psi})|_{\dot{x}, \ddot{x}}(\delta, \beta)$

Main

- Operating space sampling (Cndgrid)
- 1-Liner ($\ddot{y}$) ①
- Compute slips ②
  - Compute Tire Center Velocity (2-Lines)
  - Compute α (Slip Angle) (1-Line)
  - Compute k (Later)
- Nonlinear Solver
- Nonlinear System Formation (Objective Function)

② $a_{y,trim}(\dot{x}, \dot{\psi}, \ddot{x})$

$a_{y,limit}(\dot{x}, \dot{\psi}, \ddot{x})$

$s_{y,limit}(\dot{x}, \dot{\psi}, \ddot{x})$

[2-pt Thm] $\frac{\partial \ddot{\psi}}{\partial \delta_{sw}}\Big|_{\beta=0}(\dot{x}, \dot{\psi}, \ddot{x})$ ← linear stability

Suspension kinematics

$\delta = \delta(\delta_r \mid z_r, \theta, \phi \mid \vec{F})$

- δ_r: Rack Displacement
- z_r, θ, ϕ: Kinematic
- $\vec{F}$: compliance (load)

$\gamma = \gamma(\;\;)$ ← Inclination

$F = ma$

$F - ma = 0$

~~Solver~~

= Tiref

Aerof

Classisf/WTf

Brakef

Powertrainf

System Compilation / Residual

$F(u) = 0$

Solver