Internal

Hackathon 2020
Task Description

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Introduction of ZF

ZF Shapes the Future in Four Technology Domains

Internal

Car Chassis Technology Division: Digitalization Topics

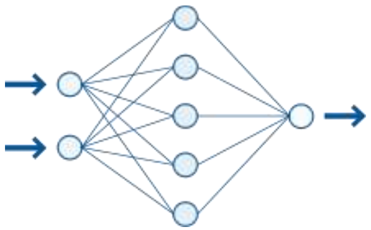
Internal

Chassis Systems

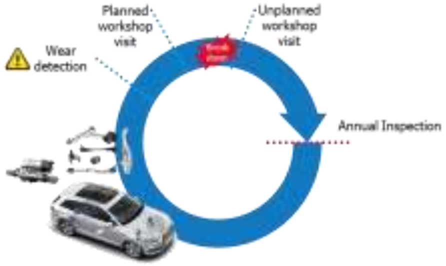
Chassis Components

Suspension Technology

Sensor Data



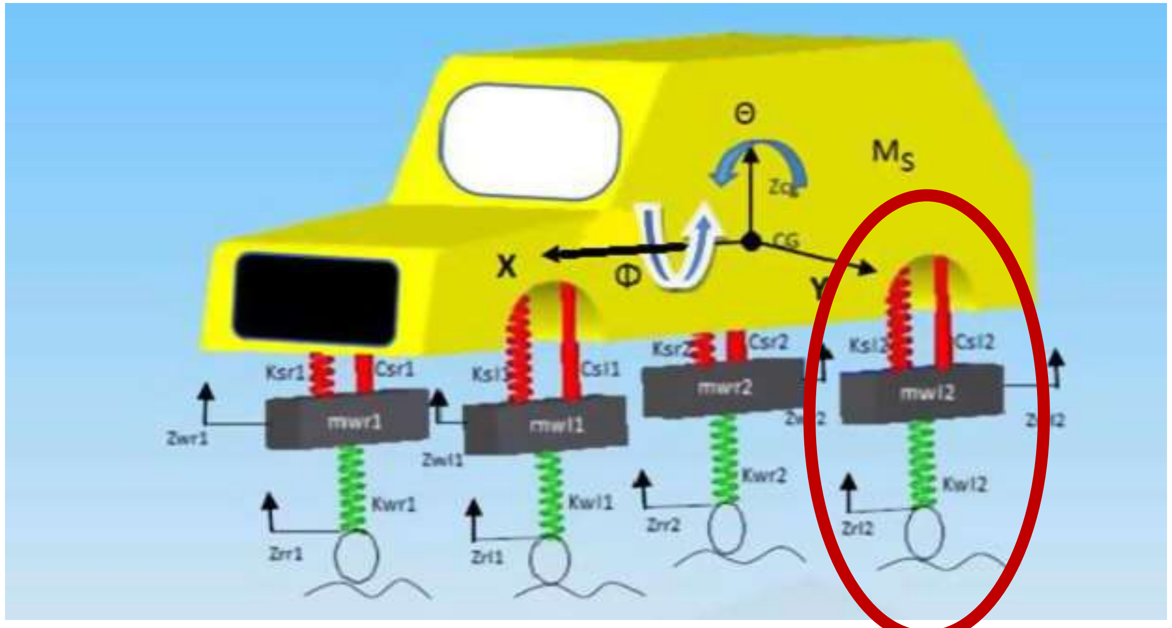
- Wear detection*
- Road Condition Monitoring*
- Vehicle motion control*
- Predictive Maintenance
- Driver condition monitoring



Task description

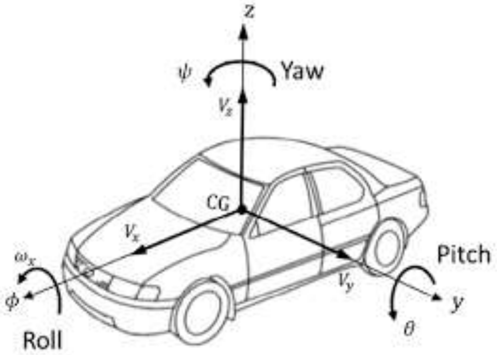
Optimize damper control depending on velocity and road surface profile ensuring optimal comfort and safety

Full Vehicle Model



A.E. Geweda et al.: Improvement of vehicle ride comfort using genetic algorithm optimization and PI controller, 2017

- Three (rotational) chassis degrees of freedom

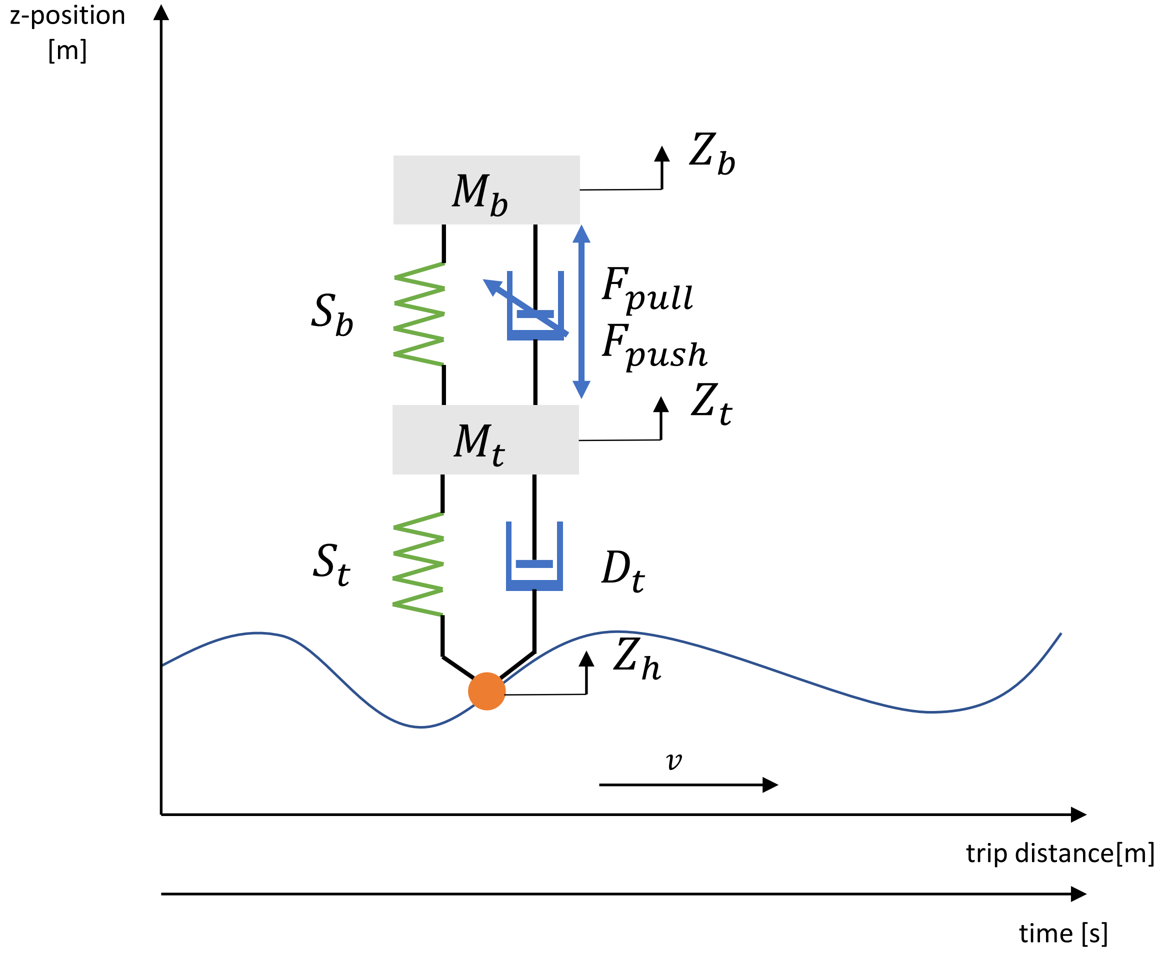


- Four (translational) degrees of freedom for each wheel in z direction

=> Seven degrees of freedom
=> Seven equations of motion

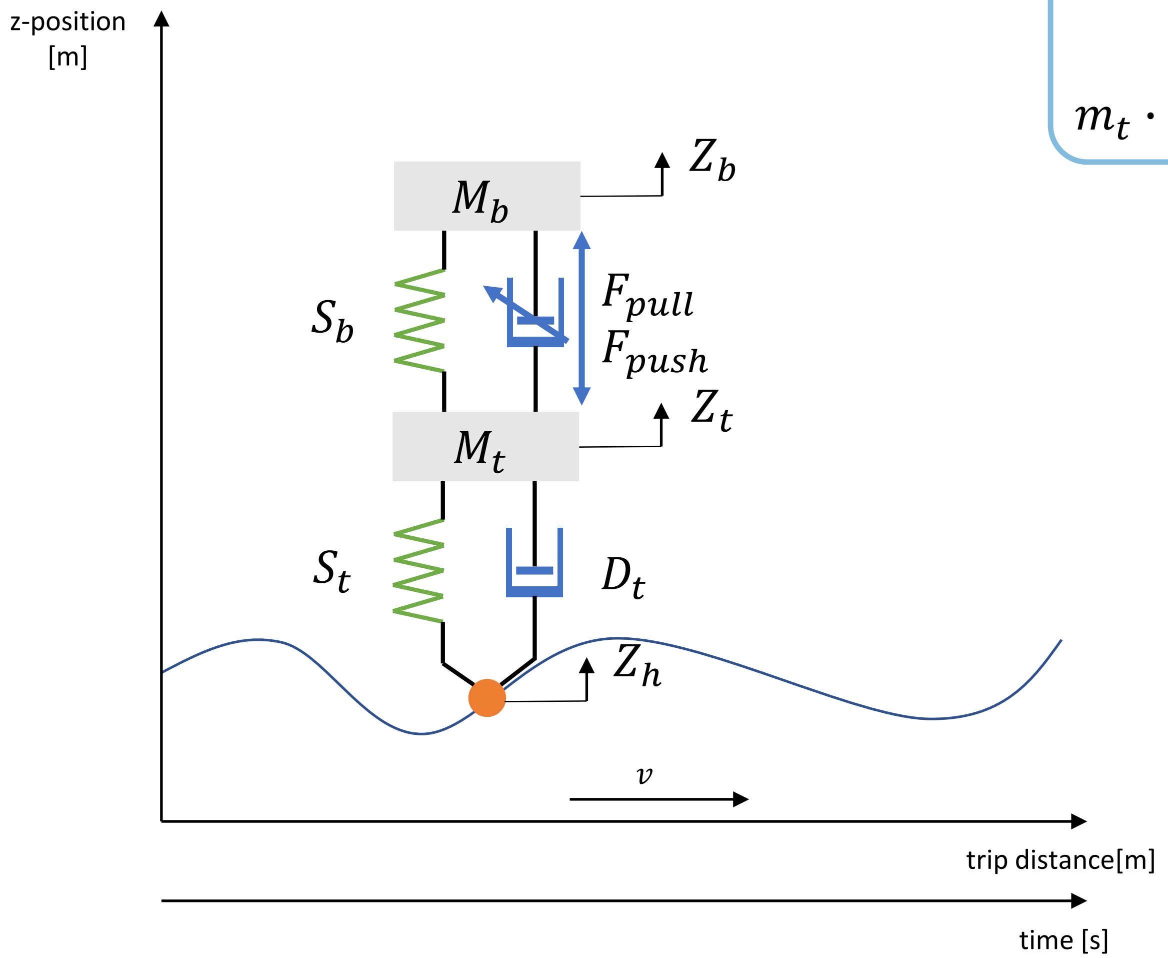
Quarter Car Model

Quarter Car Suspension Model



Z_b	z-position body [m]
Z_t	z-position tire [m]
Z_h	road profie [m]
F_{pull}	active damping force pull towards body
F_{push}	active damping force push towards tire
D_a	damping constant active suspension
D_{bound}	boundary damping constant active suspension
c	linear constant of active suspension
i	current of active suspension to generate damping force
D_t	damper tire constant
S_b	spring value tire to body
S_t	spring value tire to road
M_b	quarter body mass of vehicle
M_t	mass of tire incl. suspension system
v	driving speed of vehicle over trip distance

Quarter Car Suspension Model



$$M_b \cdot \ddot{Z}_b + S_b(Z_b - Z_t) + F_D = 0$$

$$m_t \cdot \ddot{Z}_t + S_t(Z_t - Z_h) + S_b(Z_b - Z_t) + D_t(\dot{Z}_t - \dot{Z}_h) - F_D = 0$$

$$F_D = \max\left(\mathrm{F_{push}}, \min\left(\mathrm{F_{bound}}, \mathrm{F_{pull}}\right)\right)$$

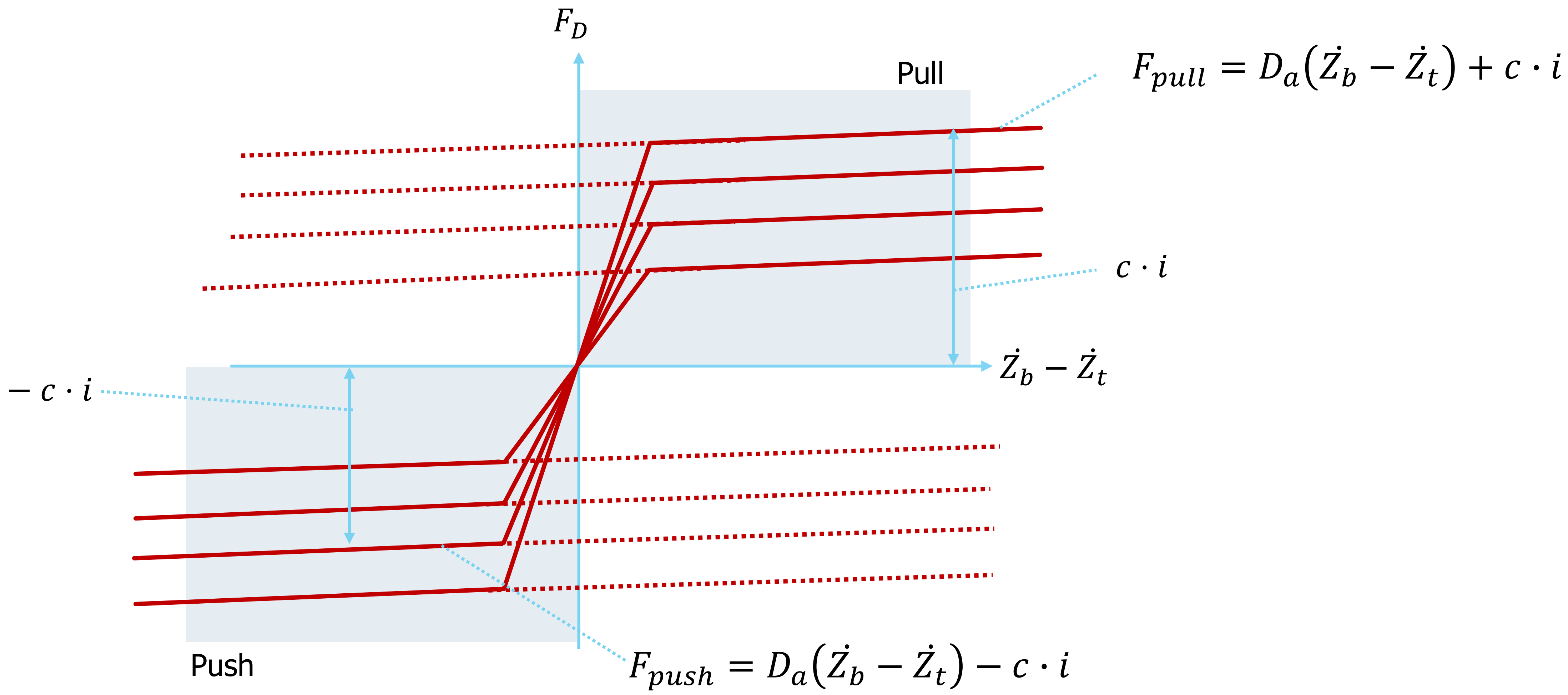
$$F_{push} = D_a(\dot{Z}_b - \dot{Z}_t) - \boxed{c \cdot i}$$

$$F_{bound} = D_{bound}(\dot{Z}_b - \dot{Z}_t)$$

$$F_{pull} = D_a(\dot{Z}_b - \dot{Z}_t) + \boxed{c \cdot i}$$

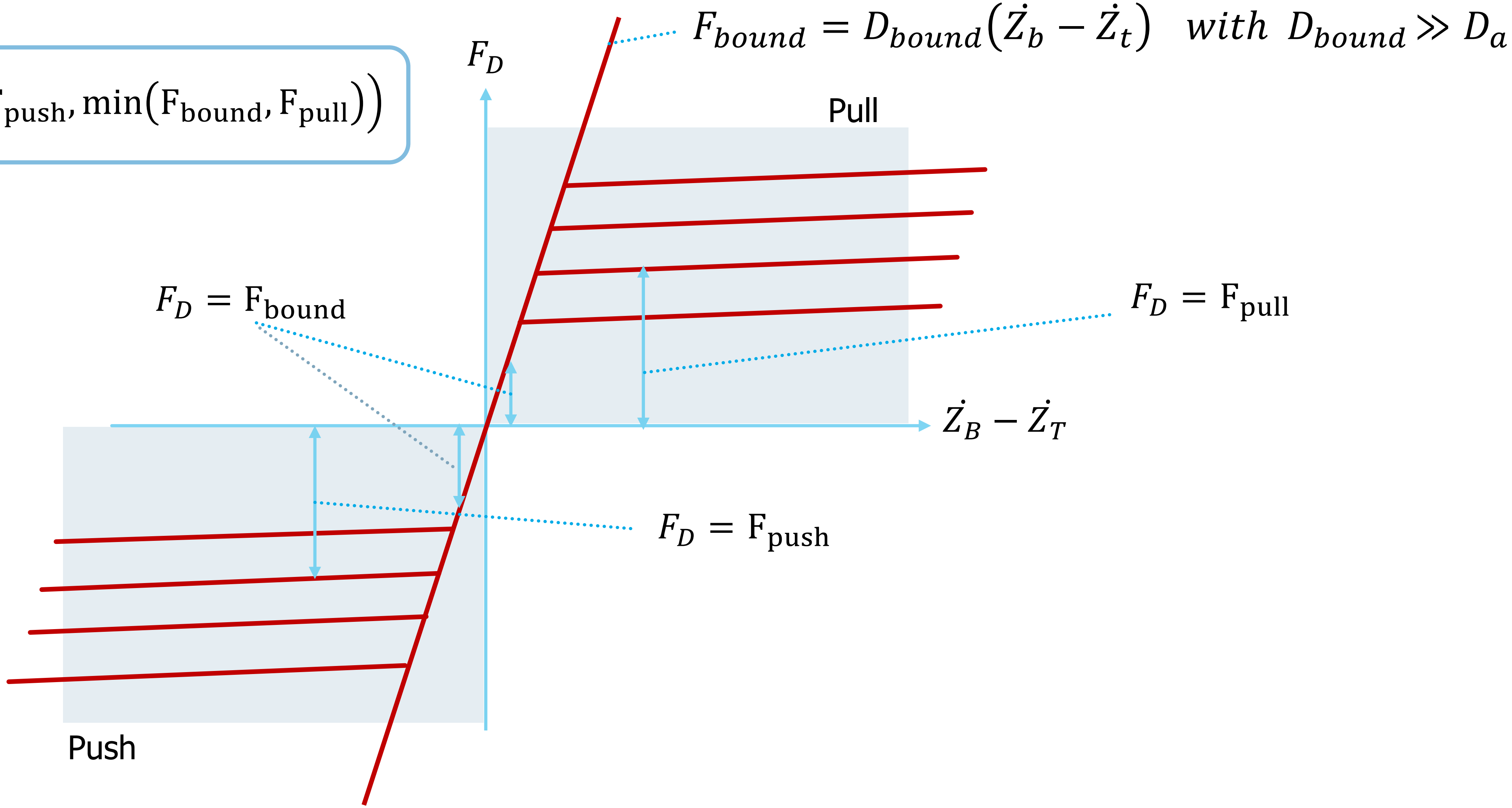
Tuning Parameter:
$i = [0 - 2A]$

Active Damping Force F_D



Damping Force Boundary F_{bound}

$$F_D = \max\left(\mathrm{F}_{\mathrm{push}}, \min\left(\mathrm{F}_{\mathrm{bound}}, \mathrm{F}_{\mathrm{pull}}\right)\right)$$



Optimization Target

minimize T_{Target} within the driving speed range $v = \left[5 - 30\,\frac{m}{s}\right]$

$$T_{target} = K \cdot \alpha_2 + \alpha_1$$

where $\alpha_1 = var\left(\ddot{Z}_{bf\,(0.4-3Hz)}\right)$ Bandpass 0.4 to 3Hz

$\alpha_2 = var\left(\ddot{Z}_{bf\,(10-30Hz)}\right)$ Bandpass 10 to 30Hz

$K = road\ specific\ weight\ factor\ for\ \alpha_2$ cf. data sets

bounding condition (tire always on the road)

$$\sigma(m_t \cdot \ddot{Z}_t) \leq \frac{F_{stat}}{3}$$

$$F_{stat} = (M_b + M_t) \cdot 9{,}81\ m/s^2$$

Constants

D_{a}	$10.02\ \frac{kg}{s}$
D_{bound}	$56.000\ \frac{kg}{s}$
c	$560\ \frac{N}{A}$
D_t	$10{,}02\ \frac{kg}{s}$
S_b	$35.000\ \frac{kg}{s^2}$
S_t	$280.000\ \frac{kg}{s^2}$
M_b	$500\ kg$
M_t	$50\ kg$

differentiate

Z	Way/Position
$\dot{Z}$	Velocity
$\ddot{Z}$	Acceleration

integrate

Thank You!