

Rover Models

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1 Model

The input channels for the controller will be denoted $u_1 \in [-\pi, \pi]$ and $u_0 \in [-\pi, \pi]$ for steering and throttle, respectively

$$\begin{bmatrix} \dot{x} \\ \dot{y} \\ \dot{\psi} \\ \dot{v}_x \\ \dot{\delta} \end{bmatrix} = \begin{bmatrix} v_x(\cos \psi - \frac{l_r}{l} \sin \psi \tan \delta) \\ v_x(\sin \psi + \frac{l_r}{l} \cos \psi \tan \delta) \\ \frac{v_x}{l} \tan \delta \\ \frac{F_{rx} - m_o \frac{\tan \delta}{\cos^2 \delta} \dot{v}_x}{m + m_o \tan^2 \delta} \\ k_{st}(\delta_{des} - \delta) \end{bmatrix} \quad (1)$$

where:

$$\delta_{des} = f(u_1)$$

$$F_{rx} = f(u_0, v_x)$$

2 Vehicle Parameters

Param	Value	Unit
m	7.780	kg
m_o	2.972	kg
I_z	0.2120	$kg m^2$
l	0.3302	m
l_r	0.12	m

$$m_o = \frac{m l_r^2 + I_z}{l^2}$$

3 Steering Input

The map from wheel angle to input can be approximated by a line:

$$\delta_{des} = 0.224314009055080u_1 - 0.008867066788855 \quad (2)$$

The control gain on the wheel angle is modeled as proportional:

$$k_{st} = 4.300730919846748 \quad (3)$$

4 Throttle Input

4.1 Throttle Channel The channel inputs can be mapped to a velocity setpoints with the following approximation:

$$v_{des} = -10.445339156721717u_0 - 3.584452482313747 \quad (4)$$

This map seems to be a good fit for input values in the interval $u_0 \in [-0.525, -0.4] \mapsto v_{des} \in [1.899, 0.594]$ m/s. Note that it is not good for commands greater than -0.4. There is a dead-zone in the motor for the rover.

4.2 Driving Force (acceleration) This was fit with throttle inputs greater than -0.4 when the vehicle was driving in a straight line

$$F_{rx} = c_{m1} + c_{m2}u_0 + c_{m3}v_x + c_{m4}v_xu_0 + c_{m5}v_x^2 + c_{m6}u_0^2 + c_{m7}v_xu_0^2 \quad (5)$$

Const	Value	Unit
c_{m1}	-32.3444674451266	N
c_{m2}	-107.4936376966535	N
c_{m3}	5.4559263010323	$\frac{Ns}{m}$
c_{m4}	35.5572000100370	$\frac{Ns}{m}$
c_{m5}	0.7595495751754	$\frac{Ns^2}{m^2}$
c_{m6}	-48.4489780846895	N
c_{m7}	21.5881438769874	$\frac{Ns}{m}$

4.3 Driving Force (braking) This was fit with a throttle input of 3.0

$$F_{rx} = c_{b1} + c_{b2}v_x + c_{b3}v_x^2 \quad (6)$$

Const	Value	Unit
c_{b1}	-5.345435991947356	N
c_{b2}	-11.906846985500659	$\frac{Ns}{m}$
c_{b3}	3.564802758464205	$\frac{Ns^2}{m^2}$

4.4 Driving Force (coasting) This was fit with a throttle input of 0.0

$$F_{rx} = c_{c1} + c_{c2} v_x + c_{c3} v_x^2 \quad (7)$$

Const	Value	Unit
c_{c1}	-5.767811170782461	N
c_{c2}	0.378942271548532	$\frac{Ns}{m}$
c_{c3}	-0.346210024796956	$\frac{Ns^2}{m^2}$