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

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

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:

$$\delta_{des} = 0.224314009055080 u_1 - 0.008867066788855 \tag{2}$$

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

$$k_{st} = 4.300730919846748 \tag{3}$$

4 Throttle Input

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

$$v_{des} = -10.445339156721717 u_0 - 3.584452482313747 \tag{4}$$

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

$$\begin{aligned} F_{rx} &= c_{m1} + c_{m2}\, u_0 + c_{m3}\, v_x + c_{m4}\, v_x\, u_0 + c_{m5}\, v_x^2 + c_{m6}\, u_0^2 + c_{m7}\, v_x\, u_0^2 + c_{m8}\omega^2 \\ &\text{where: } \omega = \dot{\psi} \end{aligned} \tag{5}$$

Const	Value	Unit
c_{m1}	-26.8598346219134	N
c_{m2}	-87.6546485543967	N
c_{m3}	3.14128477268640	$\frac{N\,s}{m}$
c_{m4}	35.5572000100370	$\frac{N\,s}{m}$
c_{m5}	0.7595495751754	$\frac{N\,s^2}{m^2}$
c_{m6}	-48.4489780846895	N
c_{m7}	15.3781821037200	$\frac{N\,s}{m}$
c_{m8}	-0.474095491113532	$\frac{rad^2}{s^2}$

4.3 Driving Force (braking)

For throttle inputs of $u_0 \geq 0.0$

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

Const	Value	Unit
c_{b1}	-4.16959507422809	N
c_{b2}	-15.1515686571814	$\frac{N\,s}{m}$
c_{b3}	5.21949175511601	$\frac{N\,s^2}{m^2}$

4.4 Driving Force (coasting)

This was fit with a throttle input of $-0.35 \geq u_0 > 0.0$

$$F_{rx} = c_{c1} + c_{c2} u_0 + c_{c3} v_x + c_{c4} v_x^2 \tag{7}$$

Const	Value	Unit
c_{c1}	-5.64256417783774	N
c_{c2}	-13.9194041124684	N
c_{c3}	-2.30808321006301	$\frac{N\,s}{m}$
c_{c4}	0.407655664039037	$\frac{N\,s^2}{m^2}$