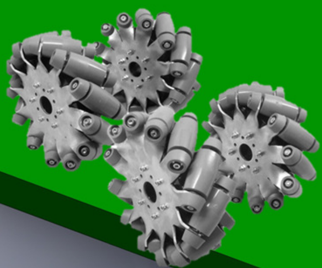
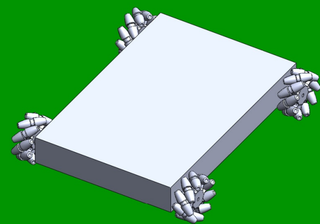
Mecanum-Wheeled Vehicle Base

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ETLS 789
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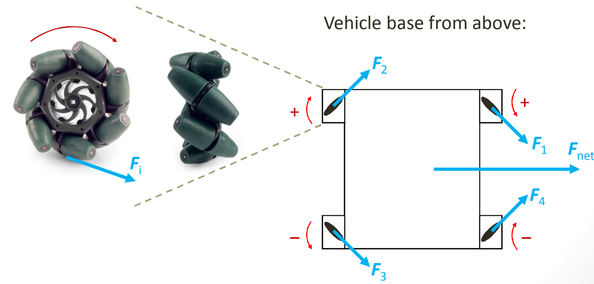
* wheel image from andymark.com

Mecanum Wheels

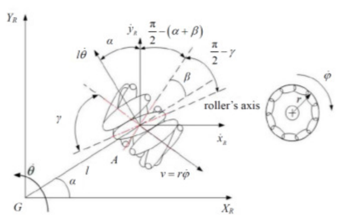
- Rollers provide a force vector at an angle relative to each wheel's plane of rotation
- Combinations of wheel rotations allow for translation in any direction (+ = c.w. rotation looking outward along the axle)

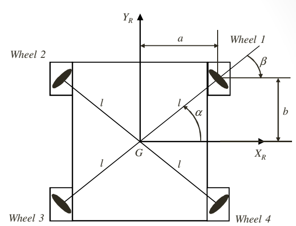
Vehicle base from above:



* wheel images from vexrobotics.com

Wheel Parameters





From Lin & Shih, *Modeling and Adaptive Control of an Omni-Mecanum-Wheeled Robot*
Intelligent Control and Automation, 2013, 4, 166-179

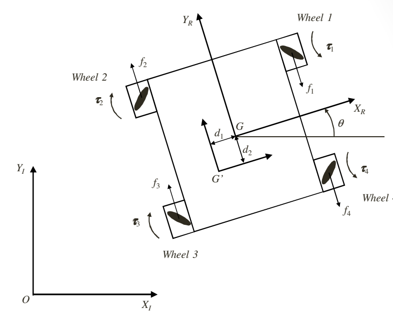
Wheels	α_i	β_i	γ_i*
1	$\tan^{-1}(b/a)$	$-\tan^{-1}(b/a)$	$-(\pi/2+\pi/4)$
2	$\pi-\tan^{-1}(b/a)$	$\tan^{-1}(b/a)$	$(\pi/2+\pi/4)$
3	$\pi+\tan^{-1}(b/a)$	$-\tan^{-1}(b/a)$	$-(\pi/2+\pi/4)$
4	$2\pi-\tan^{-1}(b/a)$	$\tan^{-1}(b/a)$	$(\pi/2+\pi/4)$

* γ_i values modified from Lin & Shih

System Definitions

G is the geometric center

G' is the center of mass



Input torques: $\boldsymbol{\tau} = [\tau_1 \quad \tau_2 \quad \tau_3 \quad \tau_4]^T$

Friction: $\boldsymbol{f} = [f_1 \quad f_2 \quad f_3 \quad f_4]^T$

Output state variables: $\boldsymbol{q} = [x_I \quad y_I \quad \theta]^T$

System Equations

(from Lin & Shih, modified)

$$\boldsymbol{\tau} = [\tau_1 \quad \tau_2 \quad \tau_3 \quad \tau_4\,]^{\mathrm{T}}$$

SYSTEM

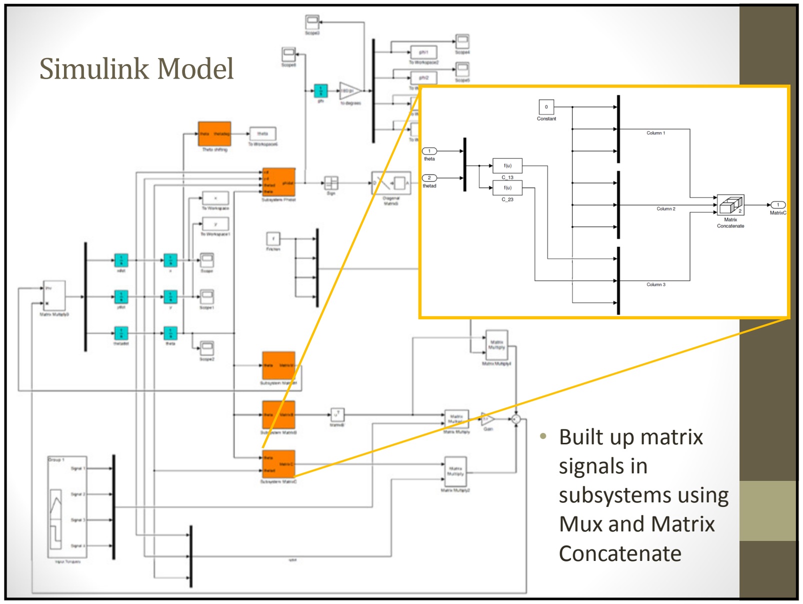
$$\boldsymbol{M}(\boldsymbol{q})\ddot{\boldsymbol{q}} + \boldsymbol{C}(\boldsymbol{q},\dot{\boldsymbol{q}})\dot{\boldsymbol{q}} + \boldsymbol{B}^{\mathrm{T}}\boldsymbol{S}\boldsymbol{f} = \frac{1}{r}\boldsymbol{B}^{\mathrm{T}}\boldsymbol{\tau}$$

$$\boldsymbol{q} = [x_I \quad y_I \quad \theta]^{\mathrm{T}}$$

Inverse Kinematic Equations (constraints for no slipping):

$$\begin{bmatrix} \dot\varphi_1 \\ \dot\varphi_2 \\ \dot\varphi_3 \\ \dot\varphi_4 \end{bmatrix} = -\left(\frac{\sqrt{2}}{r}\right) \begin{bmatrix} -\sqrt{2}/2 & \sqrt{2}/2 & l\sin(\pi/4+\alpha) \\ -\sqrt{2}/2 & -\sqrt{2}/2 & l\sin(\pi/4+\alpha) \\ \sqrt{2}/2 & -\sqrt{2}/2 & l\sin(\pi/4+\alpha) \\ \sqrt{2}/2 & \sqrt{2}/2 & l\sin(\pi/4+\alpha) \end{bmatrix} \begin{bmatrix} \cos\theta & \sin\theta & 0 \\ -\sin\theta & \cos\theta & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} \dot x_I \\ \dot y_I \\ \dot\theta \end{bmatrix}$$

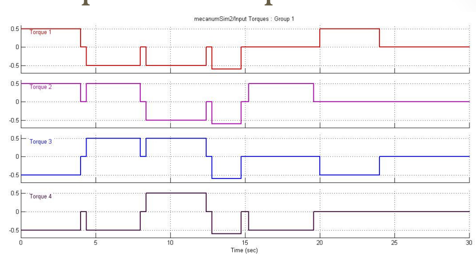
Simulink Model



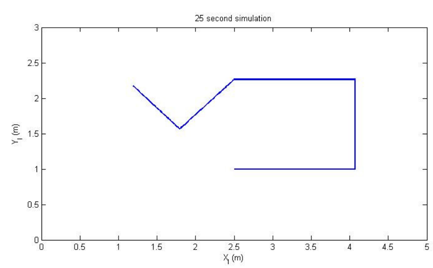
- Built up matrix signals in subsystems using Mux and Matrix Concatenate

Simulation Input and output

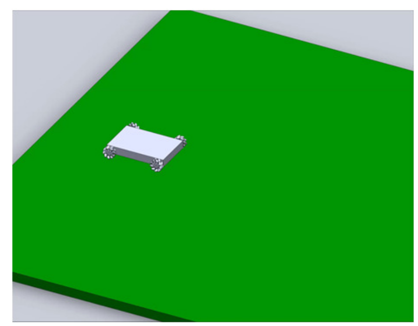
Input torques: (from Signal Builder block)



Output X_I, Y_I in inertial (lab) frame:



SolidWorks Animation



[Compare to physical example (YouTube)]

* wheel 3D CAD model by Scott Bruins, posted to grabcad.com