Day 15

Kinematics of Wheeled Robots

Wheeled Mobile Robots

- robot can have one or more wheels that can provide
 - steering (directional control)
 - power (exert a force against the ground)
- an ideal wheel is
 - perfectly round (perimeter $2\pi r$)
 - moves in the direction perpendicular to its axis

Wheel





Deviations from Ideal

This illustration gives a good sense of the steering and throttling you'll have to input to keep your car drifting. When snapping the car from its full drift angle in one direction to full drift in the opposite direction, be prepared for the rear end to come around with more force 1 then when initiating a drift from straight-ahead running. Give yourself plenty of space as you master your technique so you don't slap a curb or something equally immobile!

1 Steer hard into the turn to initiate a slide, then countersteer before the car loops out.

Continue countersteering to maintain the slide. It's a balancing act! ting up for the next turn. The goal is to drift all the way through without straightening out for more than a moment as the rear end swings around.

drift!

3 Now you're set-

to pin the throttle to keep the rear wheels slipping. Traction kills

3

2



Here's where it gets tricky. Keeping the rear end sliding through turns is relatively easy, but drifting down a straight is tough. As you lose momentum, the car will straighten out, but you'll be surprised how long you can hang it out.

Good luck!

http://worlddrifting.com/wp-content/uploads/2010/02/drifting-techniques.jpg 4

Instantaneous Center of Curvature

- for smooth rolling motion, all wheels in ground contact must
 - follow a circular path about a common axis of revolution
 - each wheel must be pointing in its correct direction
 - revolve with an angular velocity consistent with the motion of the robot
 - ▶ each wheel must revolve at its correct speed

Instantaneous Center of Curvature



Castor Wheels

provide support but not steering nor propulsion



Tangent Bug



Differential Drive

two independently driven wheels mounted on a common axis



Differential Drive

velocity constraint defines the wheel ground velocities

$$v_r = \omega(R + \frac{\ell}{2})$$
$$v_\ell = \omega(R - \frac{\ell}{2})$$

given the wheel ground velocities

$$R = \frac{\ell}{2} \frac{\left(v_r + v_\ell\right)}{\left(v_r - v_\ell\right)}$$
$$\omega = \frac{\left(v_r - v_\ell\right)}{\ell}$$

Forward Kinematics

• for a robot starting with pose $\begin{bmatrix} 0 & 0 & 0 \end{bmatrix}^T$ moving with velocity V(t) in a direction $\theta(t)$:

$$x(t) = \int_0^t V(t) \cos(\theta(t)) dt$$
$$y(t) = \int_0^t V(t) \sin(\theta(t)) dt$$
$$\theta(t) = \int_0^t \omega(t) dt$$

Forward Kinematics

for differential drive:

$$x(t) = \frac{1}{2} \int_0^t (v_r(t) + v_\ell(t)) \cos(\theta(t)) dt$$
$$y(t) = \frac{1}{2} \int_0^t (v_r(t) + v_\ell(t)) \sin(\theta(t)) dt$$
$$\theta(t) = \frac{1}{\ell} \int_0^t (v_r(t) - v_\ell(t)) dt$$

Sensitivity to Wheel Velocity

