EEE 187 Robotics
ROBOT LOCOMOTION

- Allows the robot to move in its environment.
  - • legged locomotion
  - • wheeled locomotion
  - • crawling
  - • sliding
  - • flying

- Some of these locomotion mechanisms are inspired by biological systems
  - But wheeled locomotion mechanisms are pure human invention
  - Most robots use legged or wheeled locomotion

- Stability main attributes
  - Number of contact points with the ground
  - Geometry of the contact pints
  - Robot center of gravity
  - Inclination of the terrain

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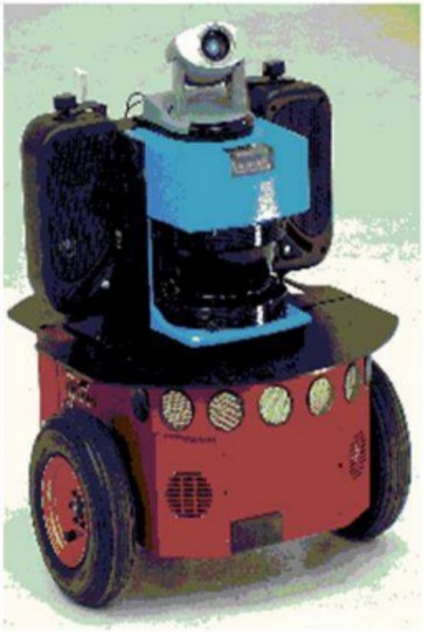
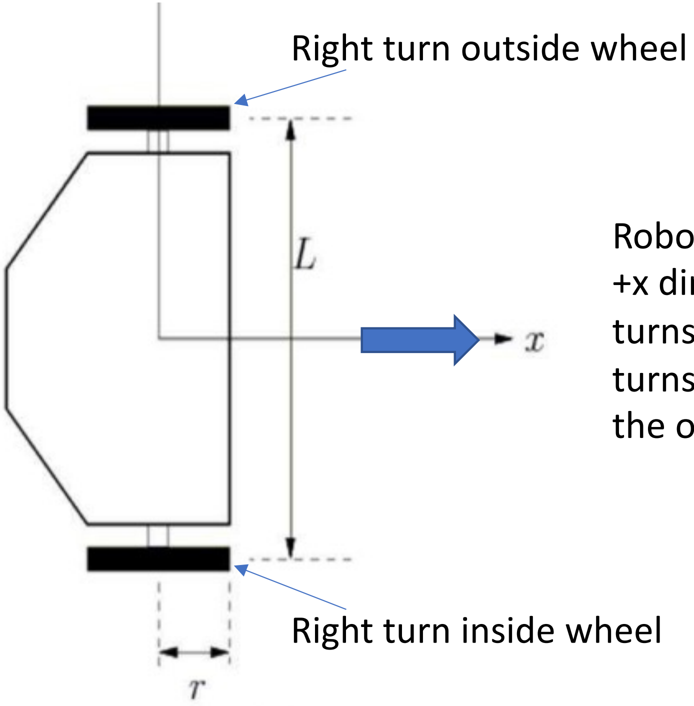
POPULAR CONFIGURATIONS FOR WHEELED ROBOTS

Differential drive: Differential drive has two motorized wheels (steerable) driven independently and one passive wheel (not shown).





Robot moves in the +x direction. During turns the inside wheel turns more slowly than the outside wheel

NOPE!!!!


YOU COULD GO AT ANY TIME NOW.
HA! I DID IT! I LIVED MY WHOLE LIFE WITHOUT EVER ONCE USING ALGEBRA!!
Glenn McCoy

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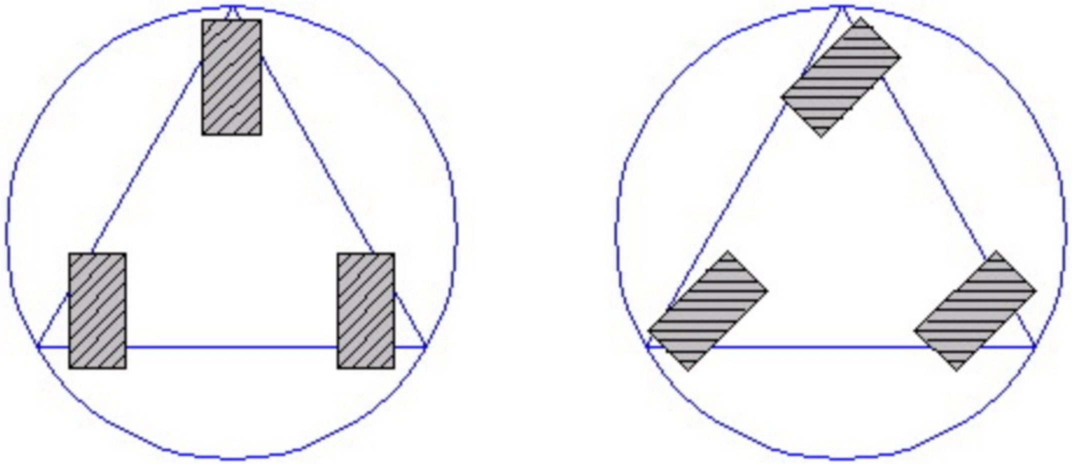
- Synchro drive: The wheels are mechanically coupled. **All wheels rotate at the same speed and orientation.** The synchro drive robot has two motors: a drive motor and a steering motor. The drive motor sets the speed for all three wheels and the steering motor spins all three wheels together. All three wheels point at the same direction and turn at the same rate.



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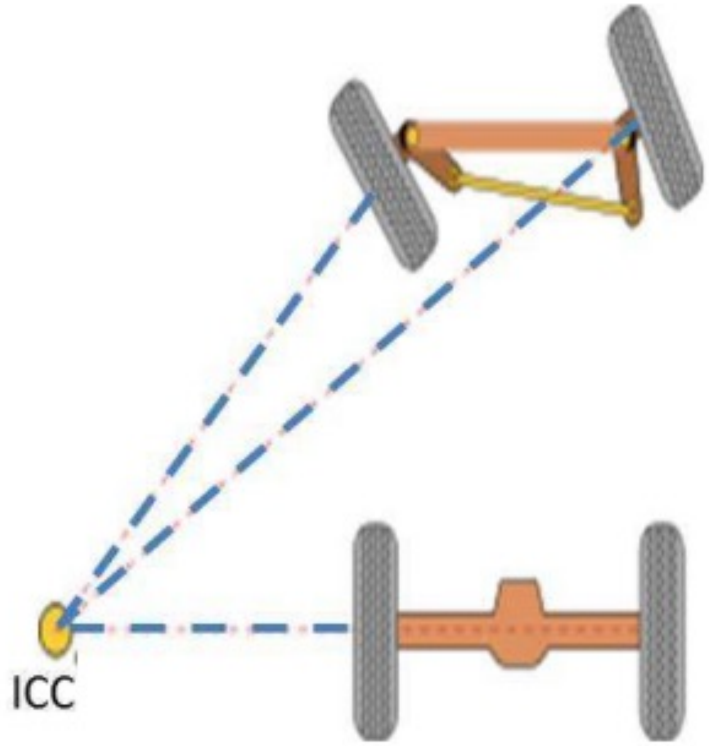

Ackermann drive:
When turning, the wheels rotate at different velocities.

- Ackerman Drive: Two steerable wheels in the front + two non-steerable wheels in the back + at least two wheels connected by an axle are motorized. Ackermann steering should not be confused with "turntable" steering where the front wheels are fixed on an axis with central pivot point. Instead, each wheel has its own pivot point and the system is constrained in such a way that all wheels of the car drive on circles with a common center point, avoiding skid.

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Differential Drive ICC (Instantaneous center of curvature)

$v_r = \omega(R + L/2)$

$v_l = \omega(R - L/2)$

$v_r = u_r r$

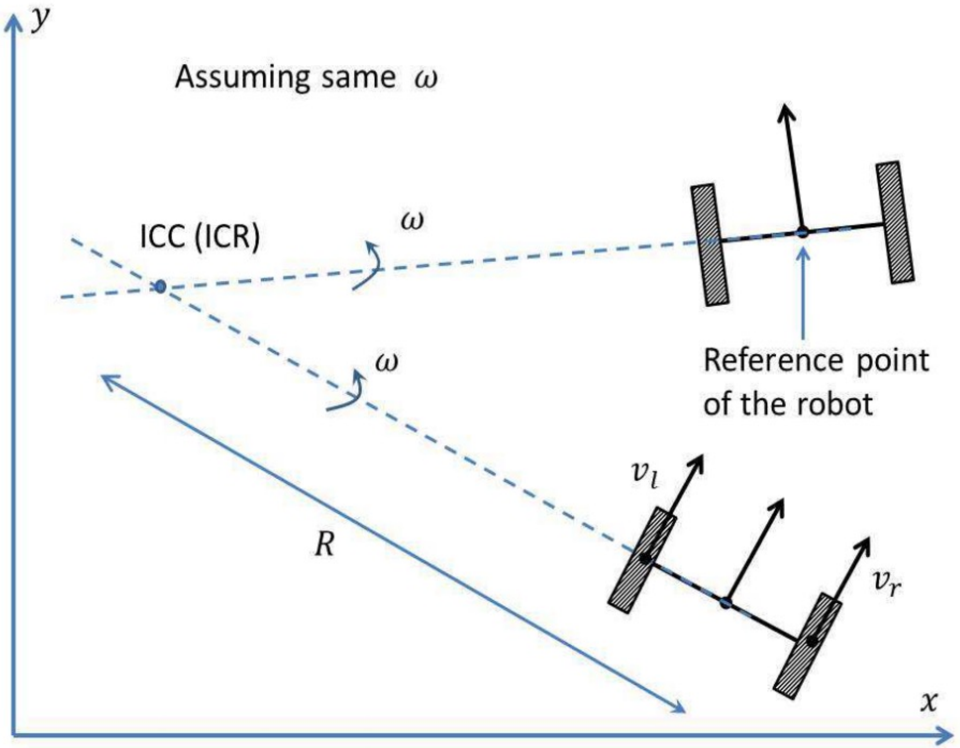
$v_l = u_l r$

where v_r and v_l are right wheel and left wheel speeds. You can derive

$R = (L/2)(v_r + v_l)/(v_r - v_l)$

$\omega = (v_r - v_l)/L$

$v = r\omega$



A Differential Drive robot's equations of motion are

- $dx/dt = (r/2)(u_l + u_r)\cos\theta = (r/2)(u_l + u_r)\cos(\omega t)$
- $dy/dt = (r/2)(u_l + u_r)\sin\theta = (r/2)(u_l + u_r)\sin(\omega t)$
- $d\theta/dt = \omega = (r/L)(u_l - u_r)$
- u_r : is the angular velocity of the right wheel in radian/second
- u_l : is the angular velocity of the left wheel in radian/second
- r : is the radius of the wheels
- L : is the distance between the wheels
- Θ is the angle between the velocity vector and the X direction
- Speed $= v = (r/2)(u_l + u_r)$
- Note that:

When $\omega = 0$ both wheels spin at the same speed.

When $u_l = u_r$: The robot moves forward in a straight line

When $u_l = -u_r$: The robot rotates about its reference point.

When $u_\ell = 0; u_r \neq 0$ or $u_\ell \neq 0; u_r = 0$:

The robot rotates around the left wheel or the right wheel.

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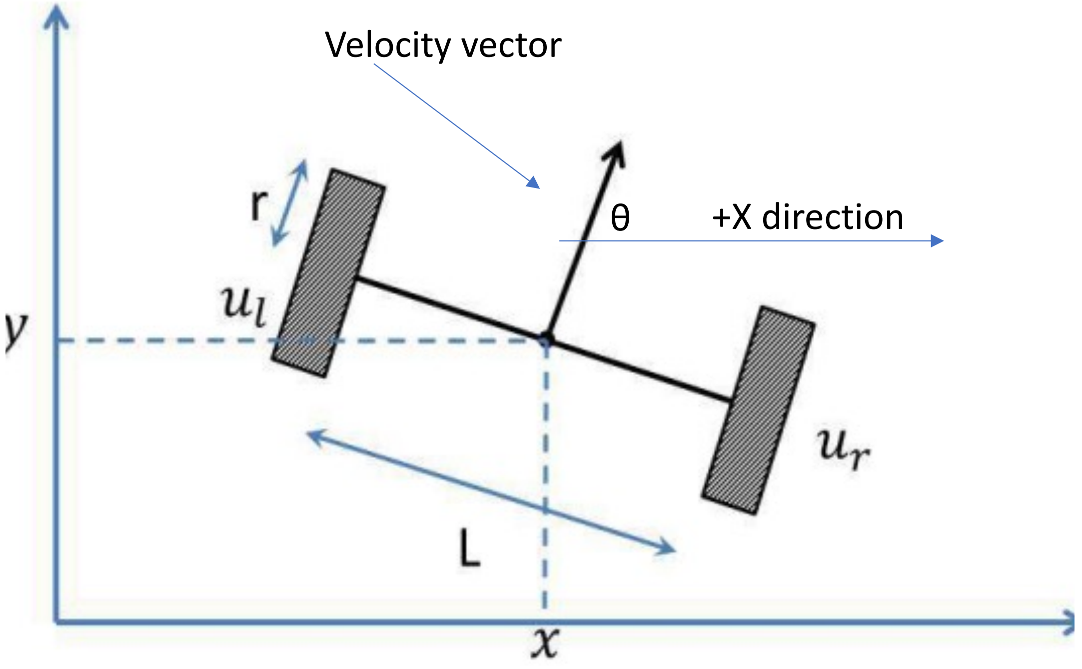
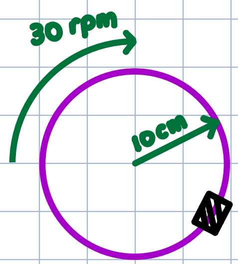


Example:



Solve for velocity.

30 RPM = 0.5 RPS = π rad/s

V (cm/s) = $(\pi)(10)$

= 10π cm/s

Axle = Ave of the velocity of right and left wheel

ω = 2π / time the car 1 lap

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Comparison between the different drives

- **Differential drive:**
  - Advantages: Simple and cheap. Omnidirectional.
  - Disadvantages: Difficult to achieve straight line motion
- **Synchro drive:**
  - Advantages: Easy to control. Omnidirectional
  - Disadvantages: Complex design and implementation
- **Ackermann drive:**
  - Advantages: Simple to implement and control
  - Disadvantages: Non-holonomic constraint

•Holonomic motion: is where a vehicle can go in all X and Y directions and is not constrained.
•Non-holonomic motion: is where a vehicle is constrained to only certain motions. An example is a car that is not capable to drive sideways (with its Ackerman steering).