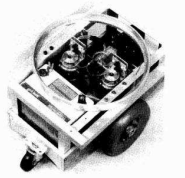
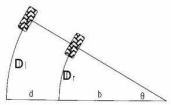
Robotic Locomotion

Design Tradeoffs with Mobility Configurations

- Maneuverability
- Controllability
- Traction
- Climbing ability
- Stability
- Efficiency
- Maintenance
- Environmental impact
- Navigational considerations

Differential Drive





$$D = \frac{D_l + D_r}{2}$$

$$\theta = \frac{D_l - D_r}{d}$$

Pictures from "Navigating Mobile Robots: Systems and Techniques" Borenstein, J.

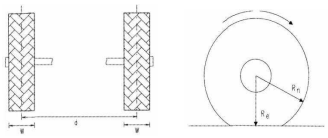
Where D represents the arc length of the center of the robot from start to finish of the movement.

Differential Drive (continued)

Advantages:
- Cheap to build
- Easy to implement
- Simple design

Disadvantages:
- Difficult straight line motion

Problem with Differential Drive: Knobbie Tires

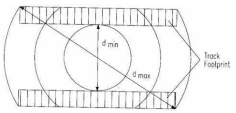


Pictures from "Navigating Mobile Robots: Systems and Techniques" Borenstein, J.

Changing diameter makes for uncertainty in dead-reckoning error

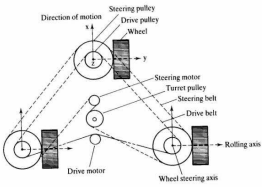
Skid Steering

Advantages:
•Simple drive system



Disadvantages:
•Slippage and poor odometry results
•Requires a large amount of power to turn

Synchro Drive



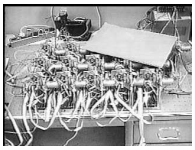
Advantages:
- Separate motors for translation and rotation makes control easier
- Straight-line motion is guaranteed mechanically

Disadvantages:
- Complex design and implementation

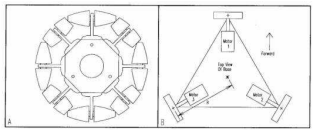
Pictures from "Navigating Mobile Robots: Systems and Techniques" Borenstein, J.

Distributed Actuator Arrays: Virtual Vehicle

- Modular Distributed Manipulator System
- Employs use of Omni Wheels



Omni Wheels

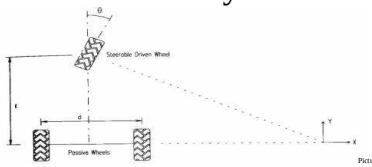


Pictures from "Navigating Mobile Robots: Systems and Techniques" Borenstein, J.

Advantages:
- Allows complicated motions

Disadvantages:
- No mechanical constraints to require straight-line motion
- Complicated implementation

Tricycle



Pictures from "Navigating Mobile Robots: Systems and Techniques" Borenstein, J.

Advantages:
- No sliding

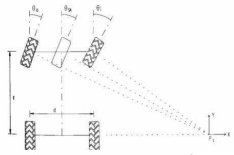
Disadvantages:
- Non-holonomic planning required

Ackerman Steering

$$\cot\theta_i - \cot\theta_o = \frac{d}{l}$$

where:

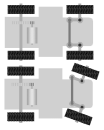
θ_i = relative steering angle of inner wheel
θ_o = relative steering angle of outer wheel
l = longitudinal wheel separation
d = lateral wheel separation.



$$\cot\theta_{ps} = \frac{d}{2l} + \cot\theta_i \quad \text{or alternatively:} \quad \cot\theta_{ps} = \cot\theta_o - \frac{d}{2l}$$

Pictures from "Navigating Mobile Robots: Systems and Techniques" Borenstein, J.

Advantages:
Simple to implement
- Simple 4 bar linkage controls front wheels



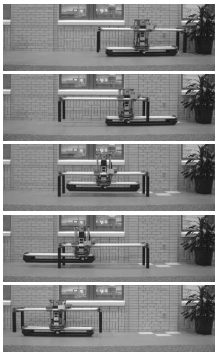
Disadvantages:
- Non-holonomic planning required

Articulated Drive: Nomad

Advantages:
- Simple to implement except for turning mechanism

Disadvantages:
- Non-holonomic planning is required

Framewalker: Jim2



Advantages:
- Separate actuation of translation and rotation
- Straight-line motion is guaranteed mechanically

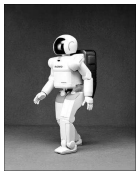
Disadvantages:
- Complex design and implementation
- Translation and rotation are excusive

Snake Robots

Advantages:
- Many applications
- Hyper-redundant

Disadvantages:
- Complex control and planning

Legged Robots



Advantages:
- Can traverse any terrain a human can

Disadvantages:
- Large number of degrees of freedom
- Maintaining stability is complicated

Are legs better than wheels?