EXPLORE ROBOTICS – CISC 1003

CISC1003 – UNIT C LOCOMOTION

Locomotion

http://artimusmarching.com/locomotion/

Topics

- Modes of Locomotion
- Algorithm
- Multitasking

Locomotion

Locomotion

- Locomotion = locus (place) + motion
- Locomotion refers to the way a body moves
  - from place to place.
- A fundamental function of humans, animals
  - Acquired through training
  - Requiring significant “brain power”
- It’s generally the first challenge for a robot
- Many modes of locomotion exist

Locomotion

Modes of Locomotion

- Legs:
  - Walking, crawling, climbing, jumping, hopping etc.
- Wheels:
  - Rolling
- Arms:
  - Swinging, crawling, climbing, lifting
- Wings:
  - Flying
- Flippers:
  - Swimming

Modes of Locomotion

- Most common, legged vs. Wheeled
- Benefits and challenges:
  - Wheeled:
    - Most efficient use of power, low DOFs.
  - Legged:
    - Large DOFs, challenge of stability.

Stability

- “the property of a body that causes it when disturbed from a condition of equilibrium or steady motion to develop forces or moments that restore the original condition “
  - Webster dictionary
- Robots need to be stable
  - Not to fall over easily or wobble

Two Kinds of Stability

- **Static stability**: robots can stand still without falling over
  - maintain upright ***without*** constant active control
- Are humans statically stable?
  - We as humans are not statically stable!
    - Fall if fainting, etc.

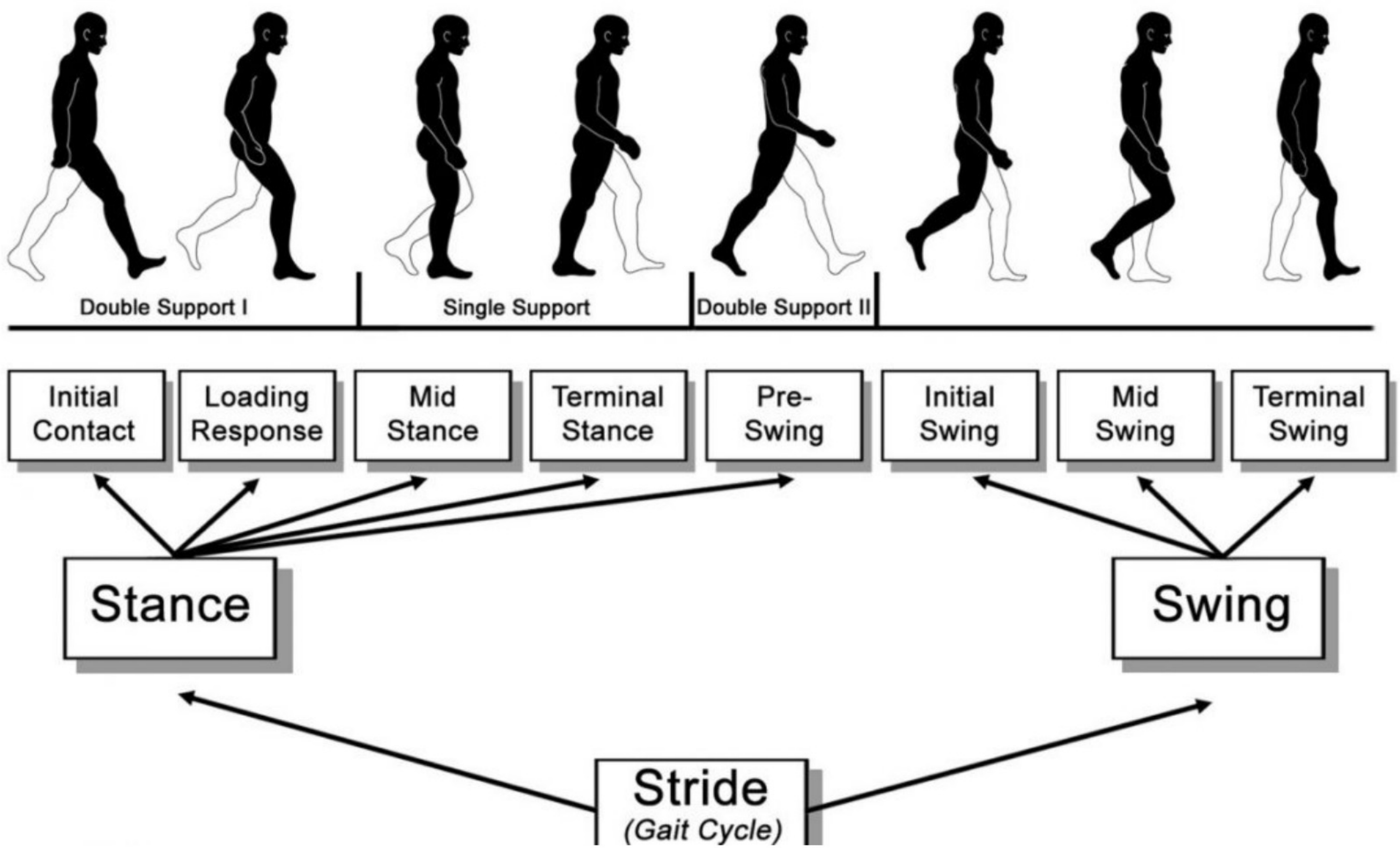
http://nursinglink.monster.com/benefits/articles/5019-top-10-qualities-of-a-great-nurse?page=3

Two Kinds of Stability

- **Static stability**: robots maintain upright without constant active control
  - Maintained when center of gravity (COG) is above a certain horizontal region
    - Region called **support polygon**
      - horizontal region over which the center of mass must lie to achieve static stability
  - Statically stable walking is slow, energy inefficient

Two Kinds of Stability

- **Dynamic stability**: robots must actively balance or move to maintain stability
  - Two legged walking
    - alternates between swing and stance phase



- https://www.protokinetics.com/2018/11/28/understanding-phases-of-the-gait-cycle/

Two Kinds of Stability

- A statically stable robot can use dynamically stable walking to better use energy
  - tradeoff between **stability/speed**.

Gaits

- The way a robot moves by using a particular pattern of footfall
- Depending on the number of legs and choice of gait

http://www.physiocapsule.com/2016/10/concept-of-gait-cycle-explained.html

Example of Robot Gaits

- 2 legged:
  - alternating swing and stance phases.
- 4 legged:
  - Diagonal walking: the feet on opposite sides move forward in sequence

Robot Gaits Examples

- 6 legged: alternating tripod gait vs. ripple gait.
  - Tripod gait: three legs move at a time
    - while the other three remain stationary
    - https://www.youtube.com/watch?v=nRtJu4qrqn0
  - Ripple gait: two legs from opposite sides shift each time
    - https://www.youtube.com/watch?v=3_Qk5svpUc0

Gaits

- Consideration for desirable robot gaits
  - Stability, speed, energy
  - Robustness, simplicity

Wheels and Steering

- Wheels are the choice of locomotion in robotics
  - Advantages of wheels:
    - Highly efficient
    - Simple to control
- Most wheeled robots are not holonomic

https://www.tirebuyer.com/wheels

Wheels and Steering

- ***Motion planning*** = following a specific trajectory
- ***Navigation*** = moving from one place to another
- Which is more complex?
  - Many times motion planning more complex
    - Need to follow more detailed plan

https://www.tirebuyer.com/wheels


QUESTIONS

ALGORITHMS

Go Beyond Locomotion - Dancing Automaton

- One or more robots come together
  - With music, dressed in costume
  - Moving in creative harmony.
- Need to develop an **algorithm**.
- Robot will be **multitasking**
  - allowing the program to perform more than one computer task at a time

https://www.youtube.com/watch?v=Fg0AGH_TaiQ

Algorithm

- A step-by-step sequence of instructions for carrying out some task.
- Examples of algorithms outside of computing:
  - Cooking recipes
  - Dance steps
  - Proofs (mathematical or logical)
  - Solutions to mathematical problems
- Often, there is more than one way to solve a problem.

https://www.computerhope.com/jargon/a/algorith.htm

Algorithms -Solving problems

- In computing, algorithms are synonymous with problem solving.
- *How To Solve It* [George Polya, 1945]
  - Understand the problem
  - Devise a plan
  - Carry out your plan
  - Examine the solution

Algorithms –Polya[1945]

- Understand the problem:
  - Understand all the words, goal
  - Create a picture or a diagram to help solve
  - Is there enough information to solve the problem?
- Devise a plan
  - Choose a strategy: guess and check, eliminate possibilities, etc.

Algorithms –Polya[1945]

- Carry out your plan
  - Write the program, run the system
- Examine the solution
  - Look back, did you solve the problem?

Algorithms - features

- Speed (number of steps)
- Memory (size of work space)
- Complexity (can others understand it?)
- Parallelism (can you do more than one step at once?)


QUESTIONS

CASE STUDY – *BOIDS* ALGORITHM BY CRAIG REYNOLDS

Algorithm - *Boids* by Craig Reynolds

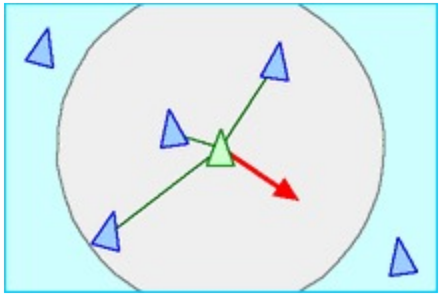
- Algorithmic for coordinated animal motion
  - Models steering behaviors
    - for animated flocking creatures.
  - Allowed individual elements to navigate their digital environments in a “life-like” manner
    - with strategies for different actions:
      - seeking, fleeing, wandering, arriving, pursuing, evading, path following, obstacle avoiding, etc.

Algorithm - *Boids* by Craig Reynolds (cont.)

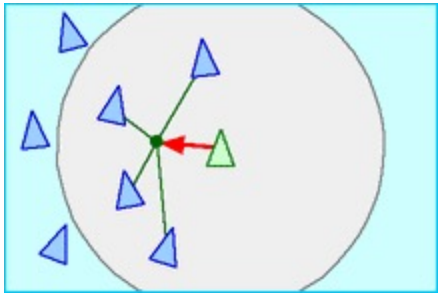
- System has multiple characters
  - each steering according to simple locally-based rules,
- Surprising levels of complexity emerge
  - the most famous example being Reynolds' "boids" model for "flocking"/"swarming" behavior.

Algorithm - *Boids* by Craig Reynolds (cont.)

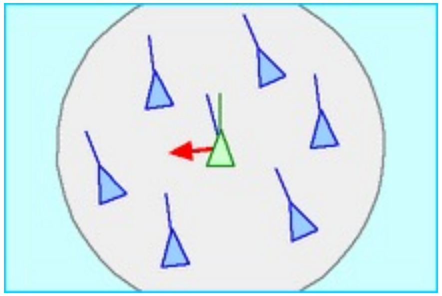
- Simple steering behaviors:
  - Separation:
    - avoid crowding neighbors



  - Alignment:
    - steer towards average heading of neighbors



  - Cohesion:
    - steer towards average position of neighbors



https://www.red3d.com/cwr/boids/

Algorithm - *Boids* by Craig Reynolds (cont.)

- An animated short featuring the boids model called **Stanley and Stella in: Breaking the Ice** was created
  - Boids video


QUESTIONS

LAB

- Let's start working with virtual robots!