CORC 3303 Exploring Robotics

Lecture C
Locomotion

- **Topics:**
  1) Modes of Locomotion
  2) Algorithm
  3) Multitasking

Locomotion = locus (place) + motion

- Locomotion refers to the way a body moves from place to place.
- It is a fundamental function of humans and animals, and it's acquired through training, requiring significant "brain power"
- It's generally the first challenge for a robot
- Many modes of locomotion exist

Modes of Locomotion

- Legs: walking, crawling, climbing, jumping, hopping etc
- Wheels: rolling
- Arms: swinging, crawling, climbing
- Wings: flying
- Flippers: swimming
- Most common, legged vs. Wheeled
  - Wheeled: most efficient use of power, low DOFs.
  - Legged: large DOFs, challenge of stability.

Two Kinds of Stability

- **Static stability**: robots maintain upright without constant active control
  - We as humans are not statically stable!
  - Maintained when the center of gravity (COG) is above the polygon of support
  - Statically stable walking is slow, energy inefficient
- **Dynamic stability**: robots must actively balance or move to maintain stability
  - The *inverse pendulum* model for one legged balance
  - Two legged walking alternates between swing and stance phase between the two legs.
- 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
  - 2 legged: alternating swing and stance phases.
  - 4 legged: lateral walking vs. diagonal walking
  - 6 legged: alternating tripod gait vs. ripple gait.
- Consideration for desirable robot gaits
  - Stability, speed, energy
  - robustness, simplicity

Wheels and Steering

- Wheels are the choice of locomotion in robotics because they are
  - Highly efficient
  - Simple to control
- Most wheeled robots are not holonomic
  - Following a specific trajectory (motion planning) is more difficult than simply moving from one place to another (navigation).
- Differential drive(steering): wheels are driven independently by separate motors -> easier control.

Go Beyond Locomotion - Dancing Automaton

- One or more robots come together with music, dressed in costume and moving in creative harmony.
- Need to develop an **algorithm**.
- Robot will be **multitasking**.

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.

Algorithm
Solving problems

- In computing, algorithms are synonymous with problem solving.
- *How To Solve It*, by George Polya
  1. Understand the problem
  2. Devise a plan
  3. Carry out your plan
  4. Examine the solution

Algorithm
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?)

Algorithm

Boids by Craig Reynolds

- Algorithmic steering behaviors for animated characters.
- These behaviors allowed individual elements to navigate their digital environments in a “life-like” manner with strategies for seeking, fleeing, wandering, arriving, pursuing, evading, path following, obstacle avoiding, etc.
- By building a system of 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.

  Simple Rules:
  - Separation: avoid crowding neighbors
  - Alignment: steer towards average heading of neighbors
  - Cohesion: steer towards average position of neighbors

Multitasking

- In computing, multitasking is a method by which multiple tasks, also known as processes, share common processing resources such as a CPU.
- In the case of a computer with a single CPU, only one task is said to be running at any point in time, meaning that the CPU is actively executing instructions for that task.
- Multitasking involves scheduling which task may be the one running at any given time, and when another waiting task gets a turn.

Multitasking

The RCX using RoboLab

- Each program can have up to 10 tasks, from which one is the main task.
- The execution of the program jumps from one active task to another.
- The act of reassigning a CPU from one task to another one is called a **context switch**. When context switches occur frequently enough the illusion of parallelism is achieved.