Exploring Robotics

Unit C
Locomotion and Algorithm

Robot Locomotion

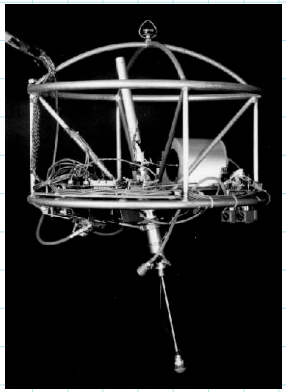
- Refers to the way a robot moves from place to place
- Moving requires significant “brain power”
  - Compare plants with the simplest moving animals
- Many effectors are used to move a robot
  - Legs (walking/crawling/climbing/jumping…)
  - Wheels (rolling)
  - Arms (swinging/crawling/climbing)
  - Wings (flying)
  - Flippers (swimming)

Robot Locomotion

- Legged locomotion is more difficult compared with wheeled locomotion
  - Larger number of degrees of freedom (DOF) – more difficult to control (how many DOFs for a wheel and a leg?)

    Wheel: 1 Leg: 6 (hip/3, knee/1, ankle/2)
  - Harder to stay stable on legs than on wheels
- Two kinds of stability:
  - Static stability: the robot can stand still without falling over when at rest. Control of the body not needed
  - Dynamic stability: the robot must actively balance or move to remain stable. Need to control the body

Robot Locomotion

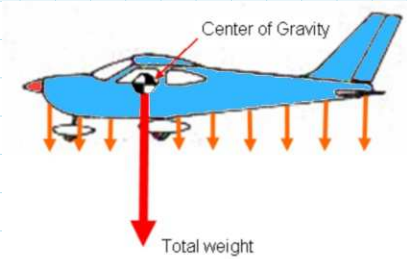


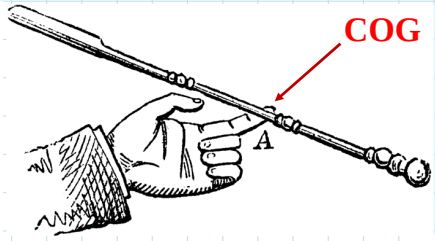
It can be static and stable

It must keep hopping

Static Stability

- Requires enough legs or wheels (how many?)
- Humans are not statically stable – need to actively control the body using the brain
- The *center of gravity (COG)* is the average location of the weight of an object





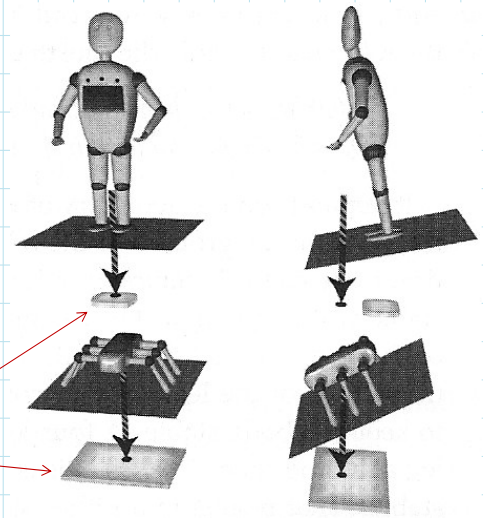
Static Stability

- The area covered by the ground points (legs or wheels) is called the *polygon of support*

- The COG of the body must be above the polygon of support to be statically stable

Static Stability

COG and polygons of support for a two-legged humanoid and a six-legged robot on a flat ground and on incline, which makes the humanoid unbalanced

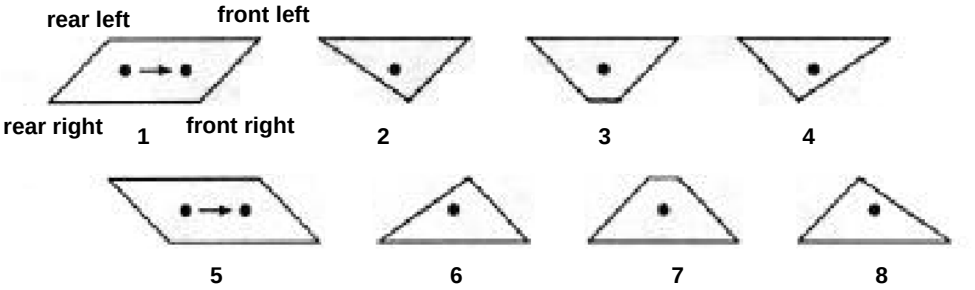


Dynamic Stability

- Needs brain control
- Has to keep moving
- E.g.
  - One-legged hopping robot (can't stop)
  - Two-legged running
- Dynamic stability vs. static stability:
  - Requires computation (more difficult)
  - Less stable
  - Much faster
  - More energy efficient

Stability of Walking

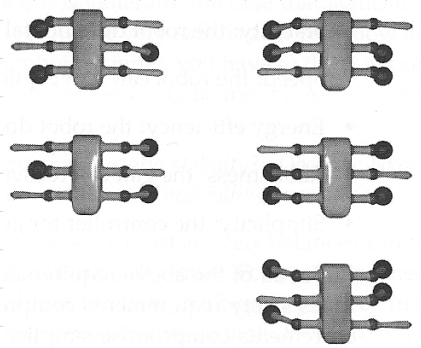
- Sequence of support patterns provided by the feet of a quadruped walking
- Body and legs move to keep the projection of COG within the polygon defined by the feet



Stability of Walking

- Six-legged walking is highly robust and therefore common in nature

Tripod gait



Ripple gait

Circles indicate feet touching the ground

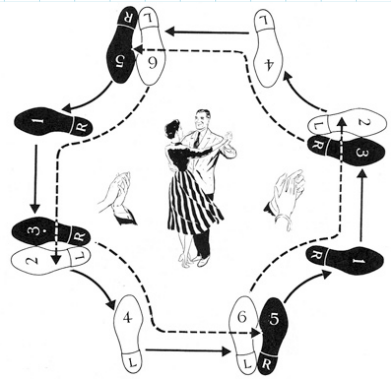
Wheels and Steering

- Wheels are more efficient and easier to control than legs
- Most wheeled robots are statically stable
- *Differential drive / differential steering* is the ability to drive / steer wheels separately and independently
- Most wheeled robots have differentially driven wheels – the VR robot has two differentially driven wheels – no need for a steering wheel – easier to turn around

Algorithm

- A step-by-step sequence of instructions for carrying out some task
- Examples of algorithms outside of computing:
  - Cooking recipes
  - Dance steps
  - Driving directions
  - Instructions for assembling a LEGO Robot

Algorithm



- Often, there is more than one way to solve a problem (more than one algorithm)

Algorithm

- In computing, algorithms are implemented as computer programs (written in computer languages), which are also algorithms
- *Steps in developing a program*
  - Understand the problem
  - Devise an algorithm
  - Translate it into a program
  - Fix the syntax errors
  - Execute the program
  - Debug the program (fix the logical errors)

Algorithm

- Features of algorithm
  1. Speed (number of steps)
  2. Memory (size of workspace)
  3. Complexity (Can others understand it?)
  4. Parallelism / Multitasking (Can the task be separated into two or more subtasks that can be executed simultaneously?)
     - E.g. To compute (130+50)×(333–27), we can first compute 130+50 and 333–27 simultaneously. Then we multiply the two partial results.

Algorithm

- Martial Arts Robots
  - A group of robots performing complex synchronized martial arts and dance routines together
  - Both statically and dynamically stable
  - Need to develop an algorithm
  - Robot will be multitasking

Multitasking

- In computing, multitasking is a method by which multiple tasks are run “simultaneously” by sharing common processing resources such as a CPU
- In the case of a computer with a single CPU, only one task is running at any point in time, meaning that the CPU is actively executing instructions for one task only
- Multitasking involves scheduling which task may be the one running at any given time, and when another waiting task gets a turn
- VEXCode VR does not support multitasking

Multitasking

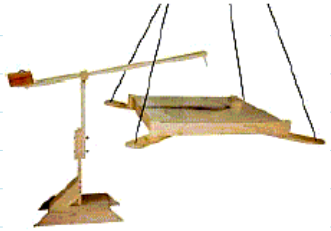
- When using Robolab to program the RCX, each program can have up to 10 tasks, from which one is the main task
- The execution of the program jumps from one active task to another in high frequency
- The act of reassigning the CPU from one task to another one is called a context switch
- When context switches occur frequently enough, the illusion of parallelism is achieved
- True parallelism (parallel programming or processing) requires multiple CPUs

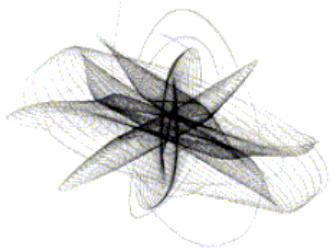
Robots and Art

- A variety of sub-types of art have been created either by robots or by using some form of robotic or automated technology

Machine Generated Art: Harmonographs

- A *harmonograph* is a mechanical apparatus that employs pendulums to create a geometric image
- Not robotic but could be considered the precursor to *machine generated art*
- Watch this harmonograph video





Robot Generated Art: Aaron the Painter

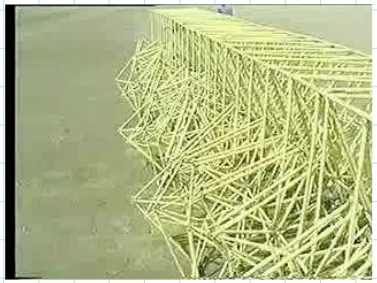
- *Aaron* is a robotic artist, created by Professor Harold Cohen (UCSD), a British abstract painter
- http://www.viewingspace.com/genetics_culture/pages_genetics_culture/gc_w05/cohen_h.htm

Robot Generated Art: Ai-Da Robot

- A painting by Ai-Da Robot, a humanoid robot powered using artificial intelligence (AI), sold for more than $1m

Kinetic Sculpture: Strandbeast

- *Kinetic sculpture* is art that contains moving parts or depends on motion for its effect. The moving parts are generally powered by wind, a motor or the observer
- Watch this Strandbeast video



Cybernetic Sculpture: Mediated Encounters

- *Cybernetic sculpture* is a sculpture that moves autonomously in response to the environment (the sound, the motion of the people around them, etc.), giving the impression of being alive
- Watch this Mediated Encounters video

Cybernetic Sculpture: Mediated Encounters

- Four fish tanks designed to allow Siamese fighting fish to determine the movement of two grapevine sculptures
- Six light break-beams connected to the computer activate motors that move the tanks in the direction the fish look to the outside world.

Robotic Drummer

- Robotic percussionist that can listen to live players, analyze their music in real-time, and use the product of this analysis to play back in an improvisational manner
- Watch this Robot Drummer video

Homework Assignment

- Read the article:

  "Artbots show talent"

  (Case Study, Unit C, Coursepack)