

Exploring Robotics

Unit B Intelligence and Construction



Intelligent Robots

A robot is intelligent in the following ways:

- Autonomous
 - Making decisions on its own
- Problem solving
 - Can figure out how to complete a task
- Modeling the environment
 - Able to store and represent the environmental knowledge
- Control architectures
 - Provide strategies for solving problems

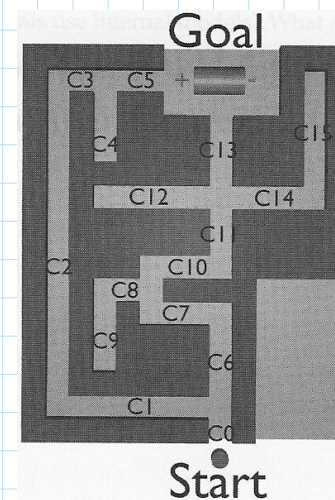
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Modeling the Robot's Environment

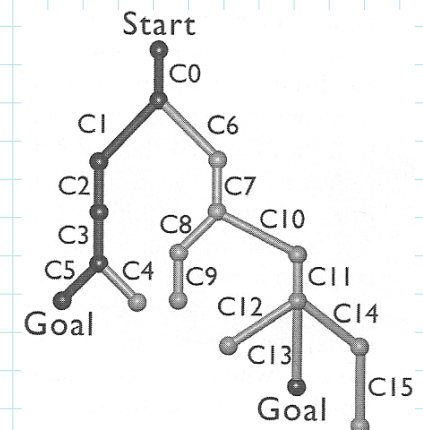
- Information about the environment is stored internally: *internal representation*
- Knowledge of the environment is represented using some **math models**: e.g. graphs
 - E.g. maze: robot stores a **map** of the maze in its "head"; GPS has a **map** of roads, streets, highways, etc. in its memory
 - The maps are stored as computer representations of graphs (**matrix, tables, linked list ...**), not **images**
- The knowledge can be built-in or acquired through learning or experience
 - Sensors are used to obtain the information

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Modeling the Robot's Environment



A close-up of a maze



A graph of the maze

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Robot Environment

- **Accessible vs. Inaccessible**
 - Robot has access to all required information to make an informed decision about what to do next
- **Deterministic vs. Nondeterministic**
 - Any action that a robot undertakes has only one possible outcome
- **Static vs. Dynamic**
 - The world changes by itself, not only due to actions effected by the robot
- It is much more challenging to design a robot in an inaccessible, nondeterministic and dynamic environment

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Robot Control Architectures

- Provides strategy for the control system to solve problems
- Refers to the way in which the sensing and action of a robot are coordinated
- Provides a set of guiding principles and constraints for organizing a robot's control system (its brain, a component of a robot)

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Classes of Robot Control Architectures

- **Deliberative**
 - Look-ahead; think, plan, then act – slow
- **Reactive**
 - Don't think, don't look ahead, just react – quick
- **Hybrid**
 - Think but still act quickly; Think and act separately, in parallel – difficult to implement
- **Behavior-based**
 - Distribute thinking over “behaviors” or control modules – an alternative to hybrid

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Gears

- what are gears? **a rotating machine part with teeth**
 - gears use small teeth that mesh with the teeth of another gear to transmit motion
 - most gears look just like a wheel with tiny teeth along the outside
 - gears are used in everything from automobiles to small toys
 - we will use spur gears (see pictures). Spur gears are generally identified by the number of teeth they have. **straight cut gears**
 - common sizes for LEGO spur gears are 8, 16, 24, and 40 tooth.



24-tooth gear



8-tooth gear

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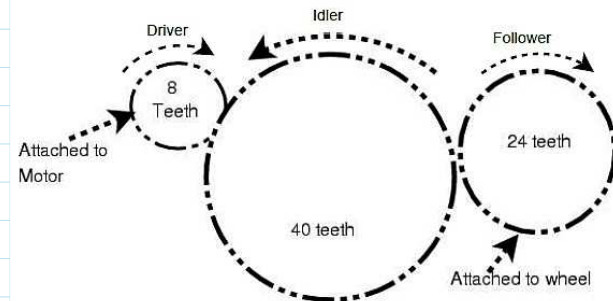
Function of Gears

- What can gears do?
 - Transfer motion
 - Change planes of rotation
 - Change direction
 - Increase/decrease **Speed** (i.e. gearing up/down)
 - Increase/decrease **Torque** (e.g. driving up/down hill)

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Driver, Follower and Idler Gears

- Driver gear is turned by a power source (attached to motor)
- Follower gear is turned by the driver (attached to wheel)
- Idler gear
 - Placed between driver and follower gears
 - Only changes direction, does not affect the gear ratio (speed)



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Gear Ratios

- Gear ratios
 - Gear ratio = $\frac{\text{\# of teeth of follower gear}}{\text{\# of teeth of driver gear}}$
 - If driver has 8 teeth and follower has 24 teeth, the gear ratio is 3:1. Remember the idler gear does not affect the gear ratio (speed)
 - Gear ratio (3:1) can be interpreted as:
 - Every time the driver gear turns 3 rotations, the follower gear will turn 1 rotation

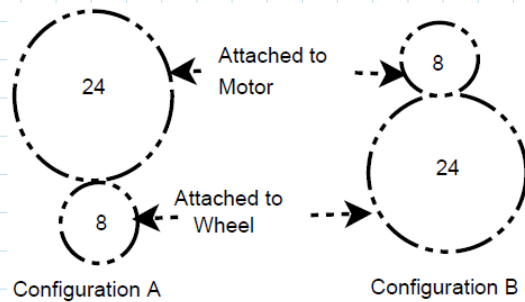
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Controlling Robot's Speed

- Using gears to make the robot go slower is called **gearing down**, where small gear is the driver and large gear is the follower.
- Using gears to make the robot go faster is called **gearing up**, where large gear is the driver and small gear is the follower.

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Controlling Robot's Speed



Questions:

- 1) What is the gear ratio for configuration A & B ?
- 2) Which configuration is gearing up / down ?
- 3) If driver gear rotates at 900 rpm, what is the speed of the follower gear for configuration A & B?

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Controlling Robot's Speed

- Program control: drivetrain velocity
 - You can also control the robot's speed from your VEXcode VR program by adjusting the drivetrain's velocity.
 - The accepted velocity range is from 0% to 100%. The default velocity is 50%.
 - The following will set robot's speed to 10% before it moves forward.



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Torque

Torque

- It is a measure of force that **tends** to cause an object to rotate while mere force causes an object to move linearly
- It must overcome friction to move the wheels of a vehicle (gravity too if it is on incline)
- If the torque is not big enough, the wheels will not move
- It is defined as the force multiplied by the radius

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Measuring Torque

Torque is the product of force and distance.

$$\tau = F \times d$$

There is 2lb-ft of torque being applied to the two bolts below.

The force and distance can change, as long as the torque does not change.

There is no torque on the bolt below, because the path of force is passing through the bolt's centre.

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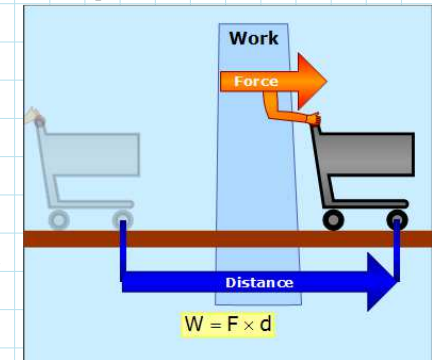
Gear Configuration and Torque

- Gearing down configuration gives less speed but more torque and is used when the robot is going uphill
- Gearing up configuration gives your robot more speed but less torque and is used when the robot is moving in a flat and smooth ground
- Why?

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What Is Work?

- Work is defined as the transfer of energy from one system to another
- Force is required to do work
- Mathematically it is the product of force and distance
- Unit: lb-ft (same as torque)

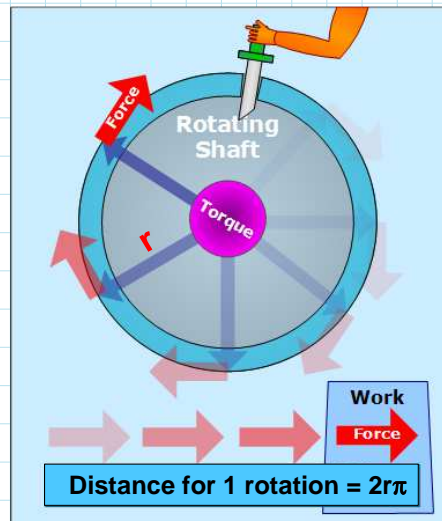
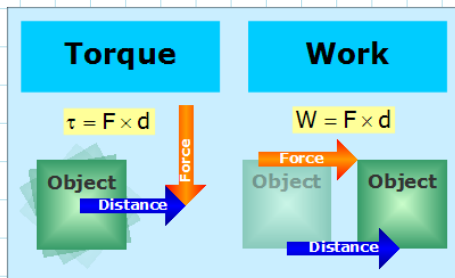


Work is done on the object by applying a force along a distance

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Difference between Torque and Work

- Torque may not cause an object to move along a distance while work must be done by moving an object along a distance



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Calculation of Torque and Work

- A spanner that is used to tighten a nut is 2 feet long. The force exerted on the end of a spanner is 10 pound.
 - 1) What is the torque exerted on the nut?
 - 2) What is the work done when the nut turns 5 rotations?

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Calculation of Torque and Work



■ Solution

- 1) $\tau = F \times d = 10 \times 2 = 20 \text{ (lb-ft)}$
- 2) $W = F \times d = 10 \times 5 \times \text{circumference}$
 $= 10 \times 5 \times 2 \times 2 \times \pi = 628 \text{ (lb-ft)}$

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Homework Assignment

- Read all articles about:
-
- **“Darpa Grand Challenge Preview”**
 - Update #1 ~ #5
-
- **(Case Study, Unit B, Coursepack)**

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Homework Assignment

Read all articles about Darpa Grand Challenge (Case Study, Unit B, Coursepack) and answer the following questions:

1. The Blue Team from The University of California at Berkeley chose to use a motorcycle rather than a four (or more) wheeled vehicle which the other teams used.
 - 1.1. What advantages are there to using a motorcycle?
 - 1.2. What disadvantages are there in using a motorcycle?
2. During the 2004 Challenge the Blue Team neglected to turn on the unit responsible for maintaining balance. Consequently, the robot fell over immediately and was unable to right itself. What changes might be made to the system to prevent this sort of blunder?
3. Team DAD used a Toyota truck with a system of spinning lasers as it's “visual” system. What advantages and/or disadvantages does such a system have compared to camera-based systems?

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Homework Assignment

4. The team from Virginia Tech entered two vehicles. They are nearly identical mechanically but have widely different control strategies. One remembers every object it detects (Rocky) while the other reacts to what it sees but then forgets everything it saw when it scans its field of view again (Cliff). You might say Rocky used a more deliberative strategy while Cliff used a more reactive strategy. What advantages and ~~or~~ disadvantages would there be to **each** approach to the race?
5. The team from Stanford University (which **won** the 2005 challenge) used redundancy extensively in their entry, Stanley. Most crucial systems are duplicated within Stanley. In addition, their “visual” system consists of radar, stereo video, lasers, more redundancy.
 - 5.1. What are the advantages of such a design strategy?
 - 5.2. What are the disadvantages?

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