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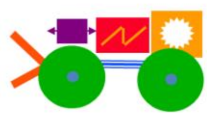
The Tutebot 1

Creating a Simple Autonomous Robot Vehicle



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Topics

- What is a tutebot?
- Definitions
- Parts of the Physical Plant
- Examples
- Tools and supplies you will need

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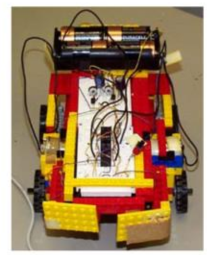
What is a tutebot

- A tutebot is a tutorial robot. We will discuss the parts of such a robot in this class
  - Lab 1's robot is a version of a tutebot
- There is an old adage (possibly Chinese)
  - I hear, I forget.
    I see, I remember.
    I do, I understand.



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Definitions

- Physical Plant: The mechanisms of an AMR which allow it to act and be acted upon by its environment
- Behavior: Action in response to stimulation
- Environment: That which is acted on by the robot and is acted on by it

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Purpose of lab 1

- A quick start in getting something working
- Get your group working together
- Introduction to the parts of a mobile robot
  - Physical Plant (this lesson)
  - Control Mechanism (next lesson)
  - Behavior (the rest of the course)

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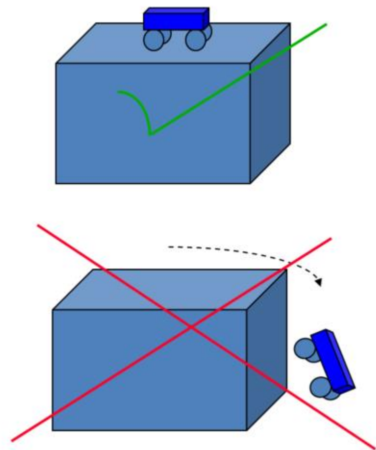
Lab 1: Make an edge detecting robot

- You are to create a ‘first order autonomous’ vehicle whose environment is a flat surface.
- The robot must survive in its environment for a brief period of time.



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Mechanisms of the physical plant

- Sensing
- Mobility
- Steering
- Energy
- Propulsion
- Suspension/Chasis
- Integrity (In)

Not discussed yet!

Suspension/Chasis

- The chasis is what holds the non-contact parts of the robot together
- Suspension provides the means of keeping the non-contact parts off the surface
- Design based on the vehicle’s purpose
  - rigid/flexible
  - shock absorption
  - protection
  - Permeability

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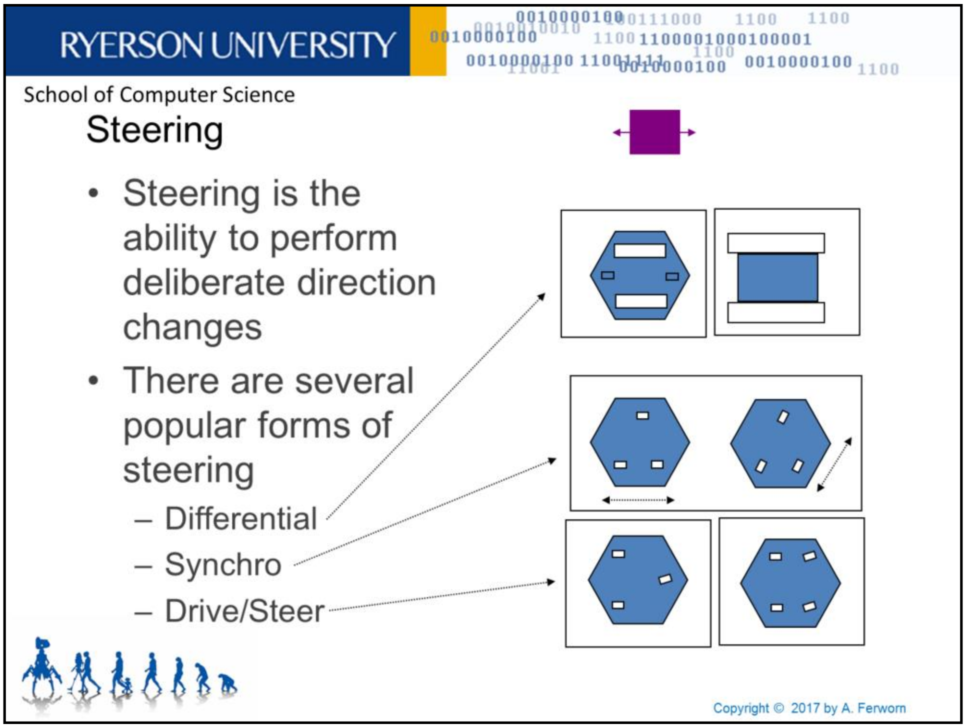
Hints on Making the Chasis and Suspension

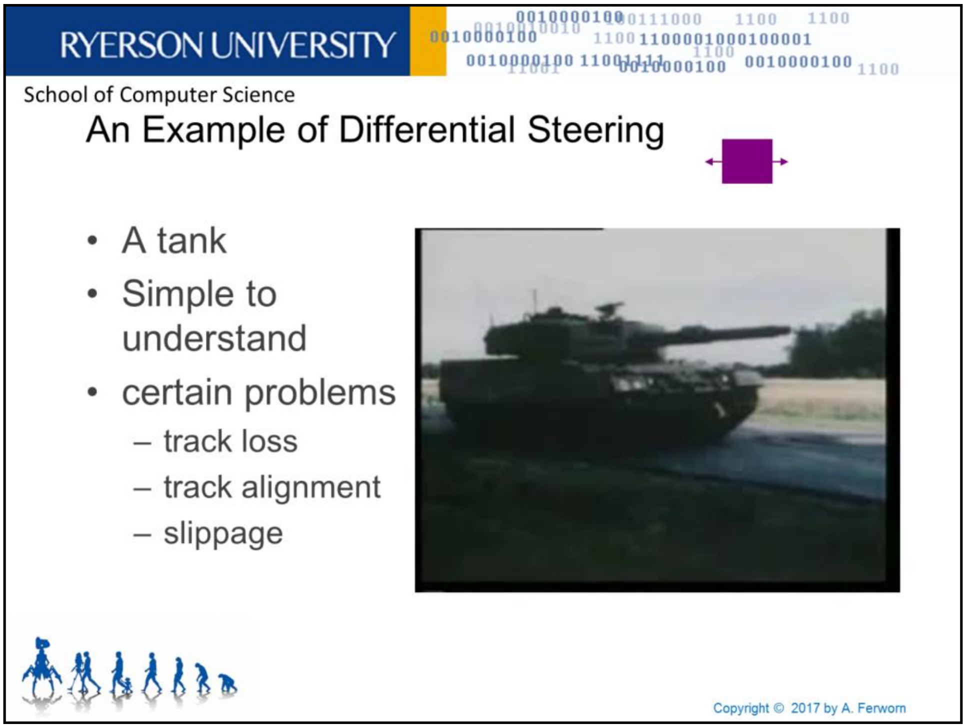
- A remote control car chasis is fine
- Round makes sensor logic easier to figure out
- Rectangular usually makes it easier to drive
- Should be the strongest part of the vehicle
- Suspension usually doesn't make much difference if the robot it relatively small



Differential drive might employ at least two propelling surfaces. By stopping one and keeping the other moving, or differing their speeds or reversing their direction you can achieve steering. There are two types shown here 1) Wheeled differential employing unpowered castor wheels and 2) Tracked differential employing two powered tracks. Differential steering is relatively simple to implement and is very robust in the size robots we will build. As the structure of robots gets bigger differential steering looses some of its advantages, particularly with tracks as they tend to be rather complex and heavy. Wheels stay pretty good.

Synchro drive is used primarily in tight spaces or where it is critical that the robot body stay oriented in a certain direction. While it is conceptually not very hard to understand it is rather difficult to achieve in practice as a hobby robotisist as parts tend to need close fitting tolerances to work very well.

Drive/Steer is how your family car works. One steering wheel (tricycle) is easier to achieve. Actually rotating the wheels usually involves some form of servo mechanism turning them. They tend not to be as strong as differntially steered robot in the smaller sizes.



Development of the Leopard 2 main battle tank began in 1970. In those days a clash between NATO and the Warsaw Pact was possible and the German Army needed a well protected MBT, which was superior to the models introduced in the Eastern Block. The first prototypes of the Leopard 2 were completed in 1972. In 1977 Bundeswehr initially ordered 1 800 of these main battle tanks to replace the Leopard 1. First production batch of 30 tanks was completed in 1979 and the Leopard 2 was adopted by the German Army the same year. At the time of its introduction the Leopard 2 was a very advanced and successful design. By 1993 German Army operated a total of 2 155 of these MBTs. This vehicle was also exported worldwide. Export operators are Netherlands (445 tanks), Poland, Switzerland (380 tanks, known as the Pz.87), Sweden (160), Spain (650), Turkey, and some other countries.

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Hints on Steering

- As a first go it is probably good advice to try two wheeled differential steering
- You will need two different drive geared motors
  - one for each wheel
- The drive mechanisms of the wheels should be firmly attached to one another or the body of the vehicle.

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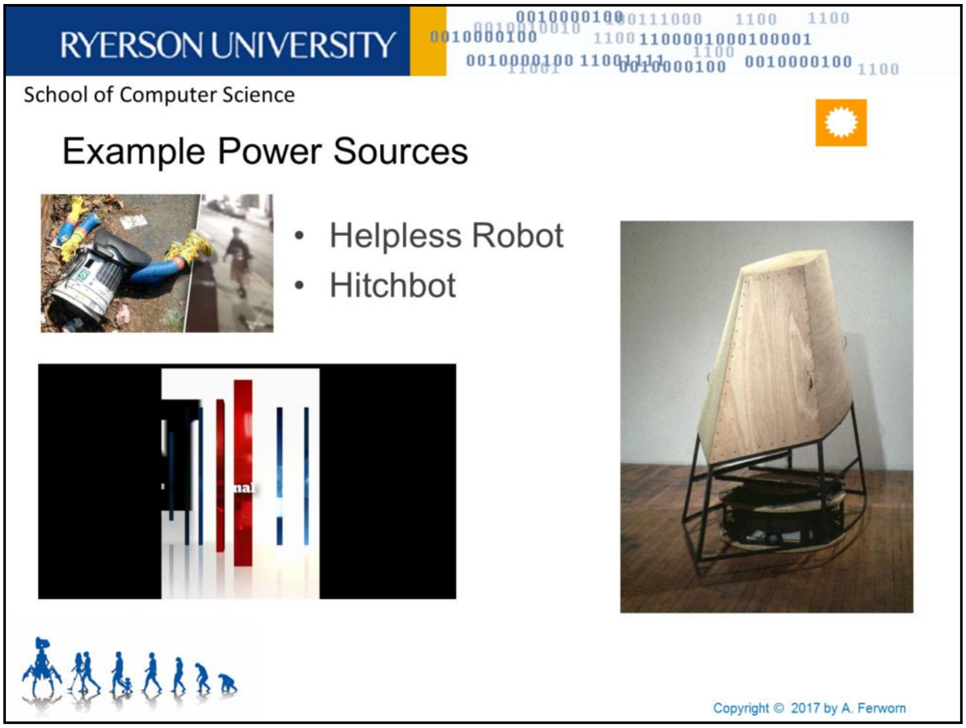
Power/Propulsion

- Power is what propels the robot
- Power must be generated and channeled
- For our purposes we will assume a power source based on a small on-board electric motor.
- This need not be the case...



The Helpless Robot

Norman White (born 1938, San Antonio Texas) Canadian New Media artist considered to be a pioneer in the use of electronic technology and robotics in art.

In "The Helpless Robot" (1987–96), an electronically synthesized voice asks for the physical assistance of passers-by with a persuasive tone. Over time, the voice slowly changes to a more forceful, commanding tone, complaining when the interaction is not being completed properly.

Hitchbot

The robot had a cylindrical body composed mainly from a plastic bucket, with two flexible "arms" and two flexible "legs" attached to the torso. The top section of the cylindrical body was transparent, containing a screen which displayed eyes and a mouth, making the robot approximately humanoid in external appearance, but gender-neutral.

The robot was able to carry on basic conversation and talk about facts, and was designed to be a robotic travelling companion while in the vehicle of the driver who picked it up. It had a GPS device and a 3G connection, which allowed researchers to track its location. It was equipped with a camera, which took photographs periodically to document its journeys. It was powered either by solar power or by cigarette lighter sockets in cars. The robot was not able to walk – it completed its "hitchhiking" journeys by "asking" to be carried by those who picked it up. It was created as a social experiment.

During the summer of 2014, hitchBOT hitchhiked across Canada from Halifax, Nova Scotia to Victoria, British Columbia. In just 26 days it hitched a total of 19 rides and travelled over 10,000 kilometres. hitchBOT’s adventure continued in 2015 as it visited Germany to explore cities like Munich, Cologne, Berlin, and Hamburg. hitchBOT also took a vacation in the Netherlands to see some of Twente’s most notable arts and culture locations.

In 2015, a new hitchBOT was created by the team for an American adventure. hitchBOT’s journey started on July 17 in Salem, Massachusetts and it had hoped to make it to San Francisco, California. During the two weeks that hitchBOT was on the road, it managed to cross two items from its hitchhiking bucket list with the help of friendly strangers. hitchBOT’s journey ended abruptly on August 1, 2015 in Philadelphia when it was destroyed by vandals.

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Hints on Choosing Propulsion

- If the motor will be used in the drive train it should be matched to any other motors
- Getting motors is not very hard
- Getting means of transmitting power is hard
  - look for gear boxes (toy cars) or pulley systems (old tape recorders)
- Motors are usually too fast and need to be geared down
  - you might try car window motors

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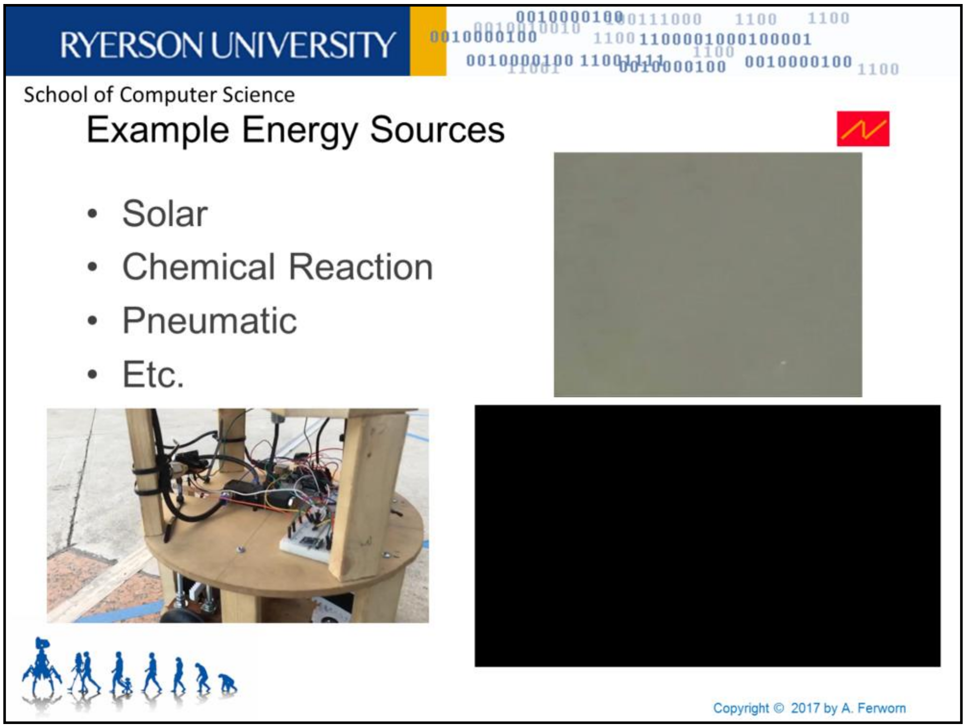
Energy

- Energy must either be
  - stored, or
  - provided continuously from the environment
- It is used by the physical plant as well as the control mechanisms of the vehicle.
- For our purposes we will assume an electrical source of stored energy (batteries)
- This need not be the case...



<u>Solar: Lawnmower (2014)</u>

In this post we present a robotic lawn mower, powered with solar energy and able to operate just with the clean energy from the sun; this one is a great difference from the commercial projects having a robot in need of a charging station connected to the electrical grid. When designing a lawn mower powered by solar energy, it is essential that most of the energy comes from the sun, and of course the ultimate result would be obtained if solar energy were enough to completely power up the robot: this one is however an objective that will be very difficult to obtain, given the low efficiency of existing solar panels. In our project the whole surface of the robot is destined to solar panels, acting also as a cover: only the sides have been left free, and anyway they wouldn't play a decisive role in supplying energy. Obviously, this choice poses a serious constraint to the rest of the project, since in this way we already defined the maximum power available. See: http://www.open-electronics.org/a-robotic-lawn-mowers-powered-by-solar-energy-with-an-arduino-heart/

<u>Chemical Reaction: Ocotobot (2016)</u>

A team of Harvard University researchers with expertise in 3-D printing, mechanical engineering, and microfluidics has demonstrated the first autonomous, untethered, entirely soft robot. This small, 3-D-printed robot — nicknamed the "octobot" — could pave the way for a new generation of such machines. Soft robotics could help revolutionize how humans interact with machines. But researchers have struggled to build entirely compliant robots. Electric power and control systems — such as batteries and circuit boards — are rigid, and until now soft-bodied robots have been either tethered to an off-board system or rigged with hard components. Robert Wood, the Charles River Professor of Engineering and Applied Sciences, and Jennifer A. Lewis, the Hansjorg Wyss Professor of Biologically Inspired Engineering at the Harvard John A. Paulson School of Engineering and Applied Sciences (SEAS), led the research. Lewis and Wood are also core faculty members of the Wyss Institute for Biologically Inspired Engineering at Harvard University. “One longstanding vision for the field of soft robotics has been to create robots that are entirely soft, but the struggle has always been in replacing rigid components like batteries and electronic controls with analogous soft systems and then putting it all together,” said Wood. “This research demonstrates that we can easily manufacture the key components of a simple, entirely soft robot, which lays the foundation for more complex designs.”

Octopuses are notorious escape artists, able to squeeze and squish themselves into and around nearly any obstacle they encounter. In an ode to these crafty cephalopods, researchers have created **the first completely soft-bodied robot**, dubbed the “octobot.” The palm-sized machine’s exterior is made of silicone. And whereas other soft robots have had at least a few hard parts, such as batteries or wires, the octobot uses a small reservoir of hydrogen peroxide as fuel. When the hydrogen peroxide washes over flecks of platinum embedded within the octobot, the resulting chemical reaction produces gas that inflates and flexes the robot’s arms. As described online today in *Nature*, the gas flows through a series of 3D-printed pneumatic chambers that link the octobot’s eight arms; their flexing propels it through water. Over the course of their project, the team created hundreds of trial octobots, meticulously tweaking the pneumatics until the timing was just right. Right now, the octobot’s fuel lasts between 4 and 8 minutes, and it can’t steer in any particular direction. The researchers are now working to add sensors to the robot, which would allow it to detect objects in its environment and navigate toward or away from them. The basic design can be scaled up or down, increasing or decreasing fuel capacity depending on the robot’s job. As the field of soft robotics advances, the scientists envision these robots being used for marine search and rescue, oceanic temperature sensing, and military surveillance.

Pneumatic: Tire-powered robot (2017)

The air in the tire is what drives this thing forward and an Arduino is programmed to vary the speed of the piston firing and to control the steering. Both the steering and propulsion systems are rack and pinion.

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Energy Density

- Energy density is the amount of energy that can be stored in a given mass of a substance or system.
- The higher the energy density of a system or material, the greater the amount of energy stored in its mass.
- Energy can be stored in many different types of substances and systems.

- Storage Devices (batteries)
  - large energy density == less weight while containing the same amount of energy as something heavier.
  - An energy storage device can be used either as the energy supply for a system or as a unit to store energy from a generator.

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Hints on Choosing an Energy source

- 6 to 12 volts DC will usually be sufficient
- Usually the higher the amps the better
- Alkaline batteries are more powerful than regular rechargeable (NiCad, etc.) batteries but can’t be recharged (and may explode if you try)
- bunnies not withstanding, Duracell coppertop batteries are the best

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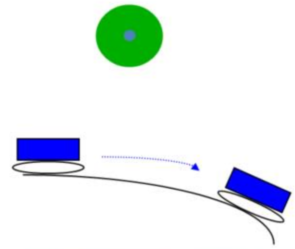
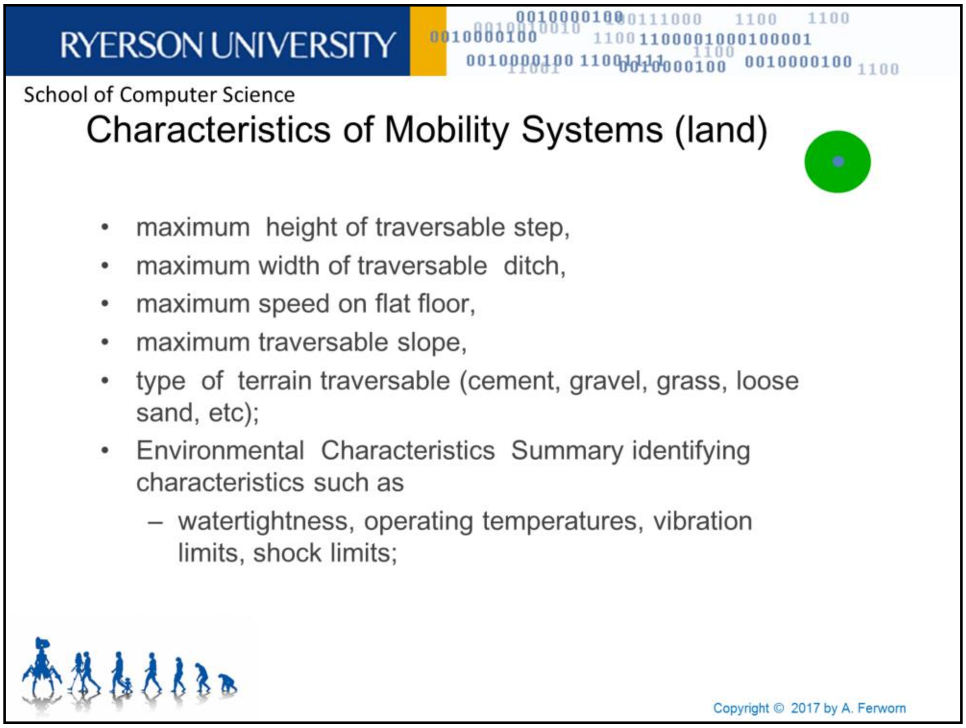
Mobility

- Mobility is a robot's ability to change location
- Most easily implemented form is wheeled
- Different mobility systems have different characteristics





DARPA characteristics

MOBILE ROBOT PLATFORMS (SS 97-28) DUE 072397 POC

Dr. Eric Krotkov, DARPA/TTO, Fax: (703) 696-2204 WEB: http://www.darpa.mil, http://www.darpa.mil. BACKGROUND: DARPA, along with other Government agencies, is contemplating a future research program to enable teams of tens to hundreds of robots to perform tactical operations. In this context, DARPA is evaluating the costs and benefits of producing multiple mobile robot platforms that could serve as Government Furnished Equipment (GFE) for researchers.

(2016) DARPA's Ground X-Vehicle Technology (GXV-T) program seeks to develop groundbreaking technologies that would make future armored fighting vehicles significantly more mobile, effective, safe and affordable. The program recently awarded Phase 1 contracts to eight organizations. See: https://www.darpa.mil/news-events/2016-04-26

DARPA Robot mobility fails courtesy of Russian TV

Russian T14 Super Tank fail on Red Square courtesy of mobility gremlins

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Hints on Choosing a Mobility System

- Buy-and-modify is a good solution
- Lego or Mechano provide good starts
- Big tires are better than small
- Firm is better than flimsy

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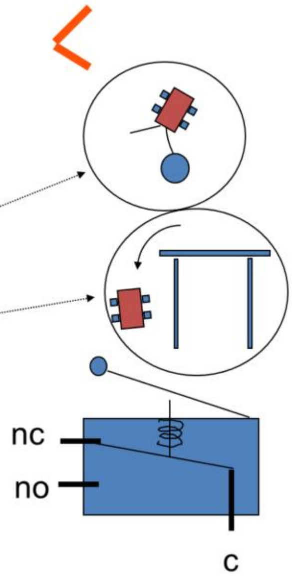
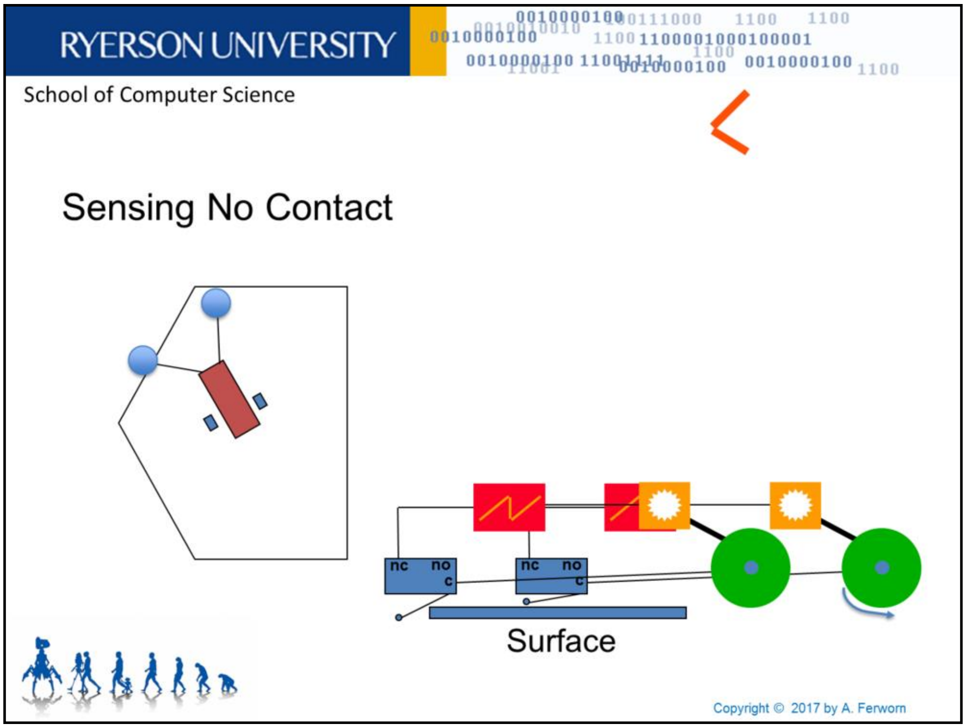
Sensing

- Sensing is sampling the environment with a sensor
- Simplest sensor is
  - Contact
  - No Contact
- Example Technique
  - Momentary Contact Switch

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Sensing No Contact
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Surface
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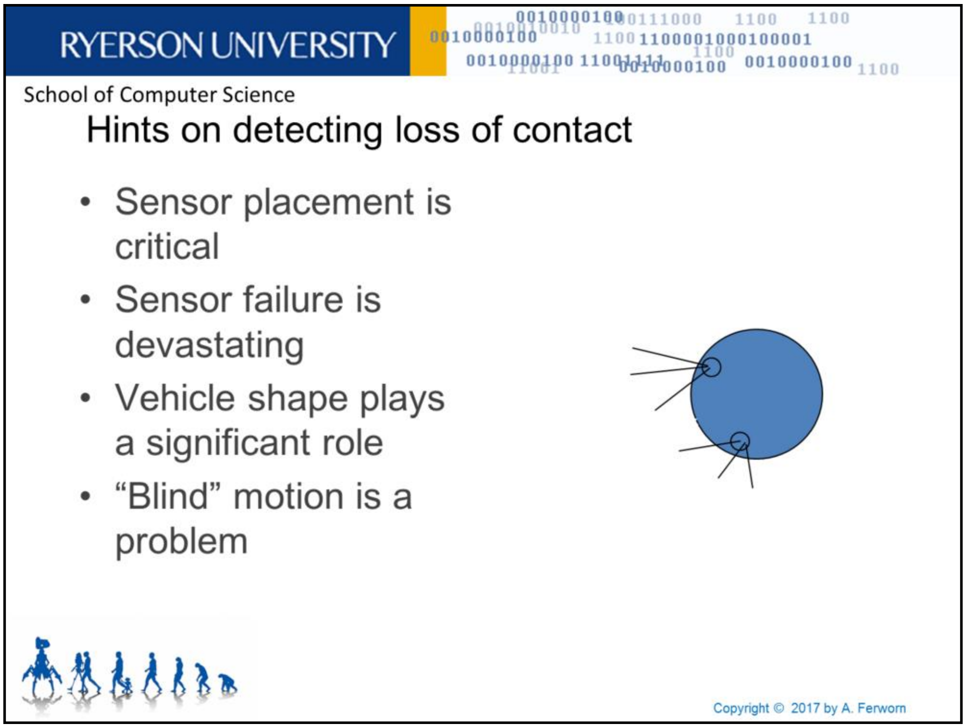

•**Sensor placement is critical**: Any vehicle motion must be covered by sensor feedback. For example, if the vehicle detects an edge and moves backward and there is another undetected edge to its rear, the result will be catastrophic system failure.

•**Sensor failure is devastating**: No sensor = no detection, this can be caused by physical failure or erroneous input. If there are dips or irregular surfaces, the sensor could detect features which are not really present--an edge mirage. This mirage effect is a nuissance which might cause the entire system to fail as it is pushed to the edge.

•**Vehicle shape plays a significant role**: Protrusions, etc in the vehicle body alter its balance characteristics and must be accounted for by appropriate sensing. The more irregular the shape the greater the need for sensing.

•"**Blind" motion is a problem**: We have a buttocks. When we back up we bump into things because we do not sense them...the buttocks provides padding for our mistake. AMRs do not have buttocks!

•Wire cutters: Best type is electrically insulated side cutting variety.

•Pliers: Needle nose is the most useful but you may wish to acquire several types as they are excellent for persuading material to do what you want

•Assorted Screw Drivers: Assorted sizes are essential. Flat and Star types are the most common.

•Skinning Knife: A sharp Jack-Knife will do. Avoid exacto-type knives as they are too flimsy. Shouldn't be too big this makes them difficult to manipulate.

•Hot Glue Gun with Glue: 1/4 inch with trigger (avoid the kind you push with your thumb unless you want to get burned.

•Soldering iron with solder: Tin solder. Point type soldering iron. You should get a sponge to go with it and some fine sand paper for cleaning the thing.

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Building Materials You Will Find Useful and Useless

- Old toys
- Old printers
- Lego
- Mechano
- Dollar store craft items

- Old Computers
- Household Appliances