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Sensing 1

Simple Sensors

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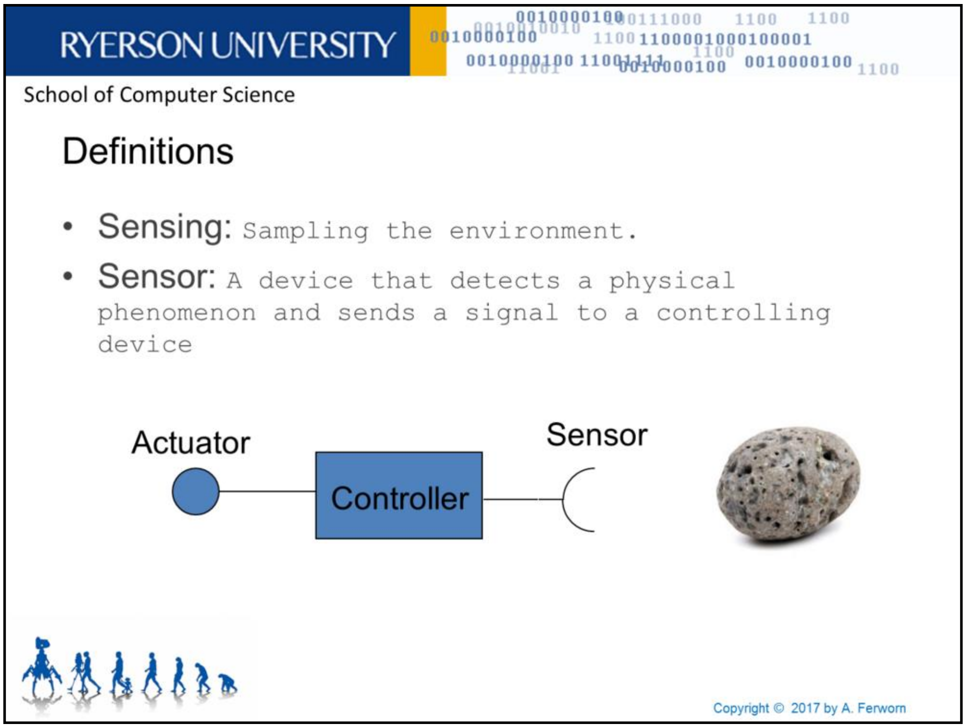
Topics

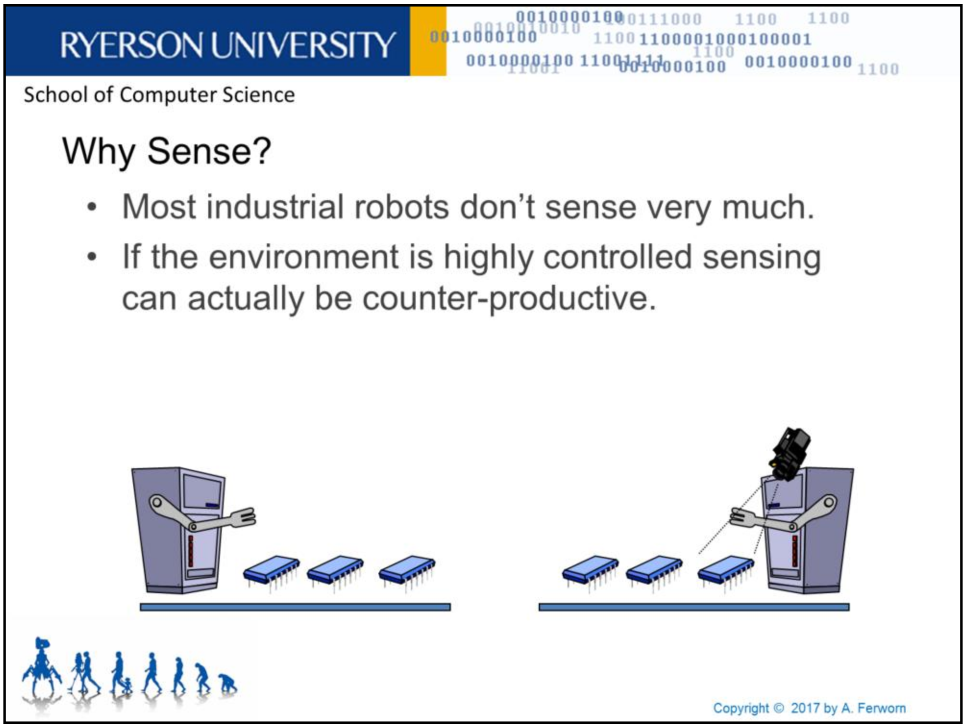
- What is a sensor?
- Why sense?
- What could a robot sense?
- The problems with sensing
- Sensing with Touch
- Sensing by active light
- Sensing by passive light
- Sensing by sound



•The diagram serves to illustrate the general case of sensing a specific phenomenon. In this case it is the presence or absence of light.

•The sensor in this case is a photo-resistor. When sufficient light strikes it, its internal resistance is reduced to several hundred Ohms. When no light strikes it its resistance is typically several million Ohms.

•A control circuit which specifically illustrates this case is shown below and might be drawn on a board.



•Industrial robots don't sense because they don't have to. An assembly line, for example, typically has many control points where parts are placed in exactly the right position for a robot arm to pick them up and manipulate them. The arm need not sense the part as it is guaranteed to arrive in exactly the same way as the last part.

•Assume for a moment that the arm actually did sense the parts coming down the line.

- •The controller is now burdened with the task of interpreting the sensor input. If this were a vision system, this would be a lot of data--possibly slowing the whole process down.
- •In addition, the sensor might fail, if this is the case the arm could not continue to function even though the sensing was, in fact, unnecessary.

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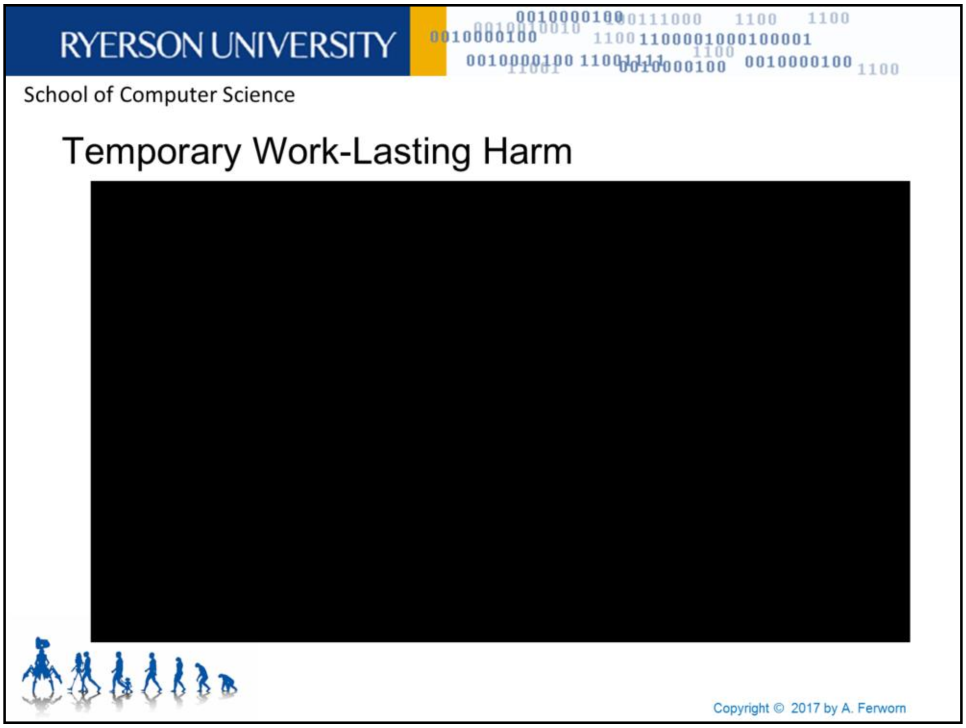
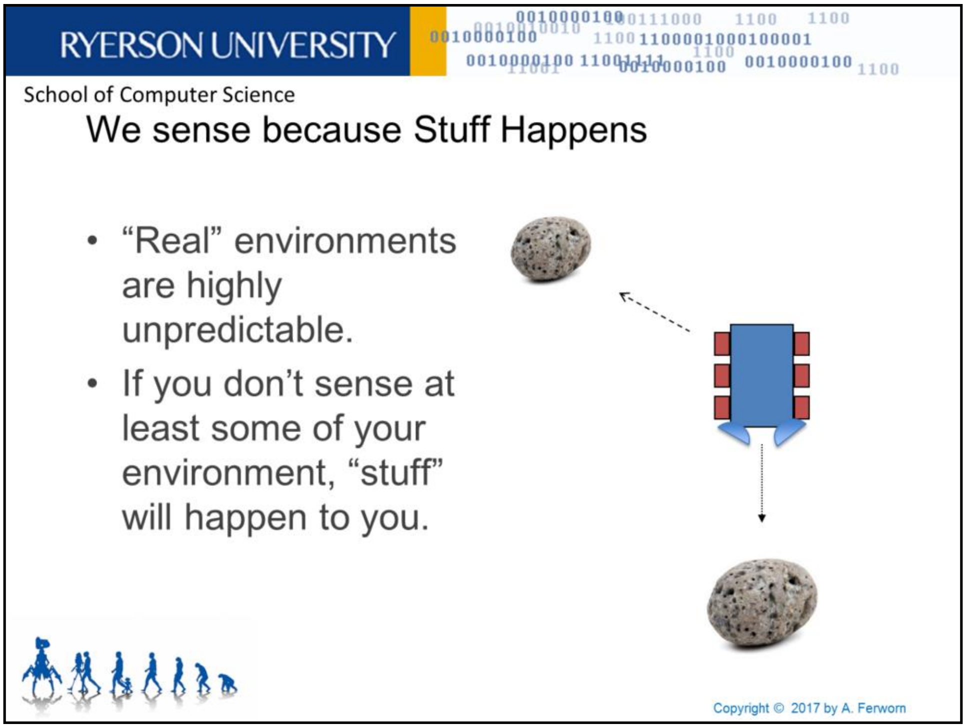
Altoids making robots in Chattanooga, Tn

Tennessee safety officials are investigating Chattanooga's Wrigley Manufacturing plant after the death of a 34-year-old woman. Mandie Chitwood died hours after she was seriously injured in an accident at the plant. Chitwood was a wife and mother who graduated from Ringgold High School in 1997. Details of the accident haven't been released, but the local plant has been cited twice in the past 10 years for safety violations.

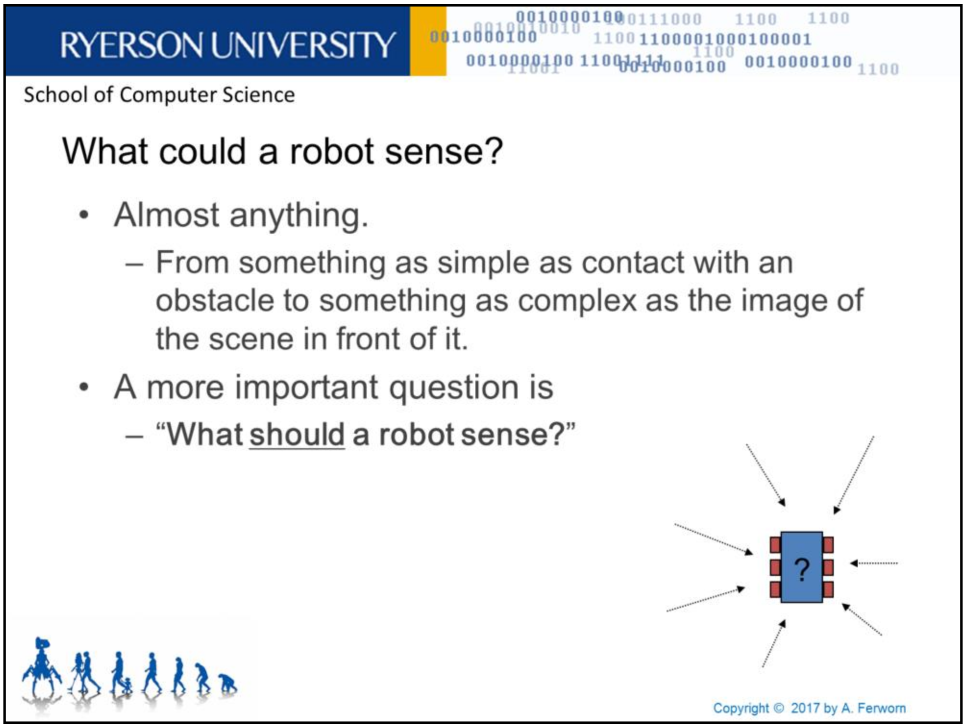


Ninety minutes into his first day on the first job of his life, Day Davis was called over to help at Palletizer No. 4 at the Bacardi bottling plant in Jacksonville, Fla. What happened next is an all-too-common story for temp workers working in blue-collar industries. Read the investigation: https://www.propublica.org/article/temporary-work-lasting-harm?utm_campaign=get-involved&utm_source=youtube&utm_medium=video&utm_term=temp-land



The vehicle moves forward and detects

- Industry pays a high price for highly controlled environments.
- Assembly lines are typically quite regidly designed and require a lot of resources to modify even slightly.
- Slight deviations in the expected path of a part can cause the entire system to fail. Many resources are plowed into ensuring this doesn't happen.
- The real world is a place where many things can happen.
    - Obstacles are in our way.
    - Things move all around us.
    - Taking our environment into account can cost time.
- If we cannot sense our environment our environment becomes a very problematic place.
- **EXERCISE**: A student volunteer should be blind folded and asked to walk a path which they have previously seen as quickly as possible. (this is the assembly line). Now the same student should be spun around three times and asked to walk the same path. If we are lucky it will take longer as the person will hesitate as sensed information will be lost and a lot more care taken.



•There are numerous examples of robotic systems sensing various physical phenomena such as;

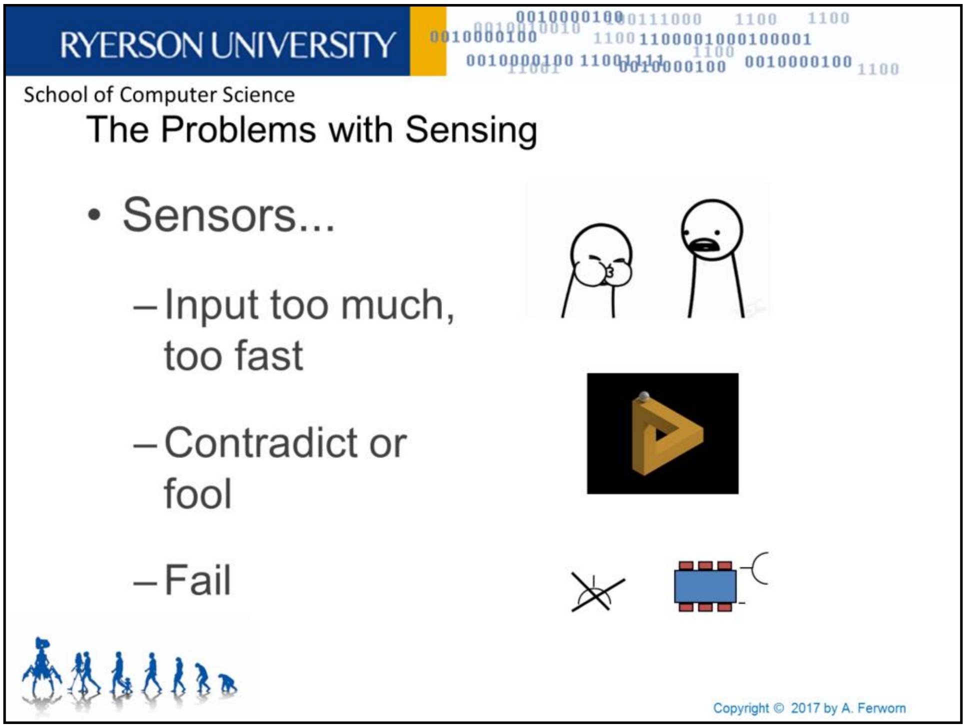
•heat (fire fighting robots), light (all kinds including laser, ultraviolet, infrared, visible images, etc.), sound (door bells, alarms, etc.), smell (drug detection, etc.), pressure (pipe cleaning robots), motion (security robots).

•While there is a lot to sense we should worry about what phenomena actually matter to the successful functioning of a robot.

EXAMPLE: When people first move near an airport they invariably look up at planes when which fly over-head. Eventually they become accustomed to the planes and don't even notice them. They do not play an important role in dealling with their environment therefore they are tuned out.

EXAMPLE: It was noticed that certain fighter pilots have crashed because they failled to listen to a warning that was being issued by some sensor on their plane because they were too busy dealling with other sensory input.

EXAMPLE: From 1973 to 1981, work was done at the Stanford University Artificial Intelligence Lab by Hans Moravec on developing a remote controlled TV equipped mobile robot. The Cart used stereo imaging to locate objects and to deduce its own motion. A TV link connected the Cart to a remote computer, which did all image processing. The camera on top of the Cart was mounted on rails and slid by remote control to nine different positions to get nine pictures of the view before it. The system was reliable for short runs, but was slow. The motion was in lurches of one meter every 10 to 15 minutes. After rolling a meter it stopped, took some pictures and thought about them for a long time. Then it planned a new path, executed a little of it and paused again.



•**<u>Speed:</u>** Imaging understanding typically requires the processing of extremely large data sets.

> **<u>Example</u>**: Video input from a 8mm camera. Assume a 1024 x 1024 image at 30 frames a second (animation speed for example) = 31,457,280 bits of information per second.

•**<u>Contradiction:</u>** How do you resolve it? Which sensor is right or are they all correct and the controller must interpret what it means.

> **<u>Example</u>**: This scenario could be shown on the board. A robot attemps to go through a passage. One set of sensors indicate the way is clear and another set indicate the way is blocked. Such a situation might arise if the vehicle were attempting to negotiate a arrow passage where forward sensors indicate clear and side sensors indicate contact.

•**<u>Fail:</u>** Sensors can become damaged, missing or "Flakey" in that they lose calibration or enter an environment in which they produce erroneous results.

> **<u>Example:</u>** The air speed of an F15 and similar aircraft is determined through the use of air flow sensors. The sensors rely on a filament which is heated with a predetermined amount of energy. When the plane flys the speed is determined by the amount of heat which is lost through air moving over the filament. An early problem with the sensors was reported when the plane was motionless as it would be on a run way. The filament would burn out and the air speed would register as Mach 10.

•**<u>$$$$:</u>** They often don't come cheap. A vision system can cost several million dollars.

Example: The U of T has a vision system which can track a ball moving in a scene. The processing is done with 3 SGI “super computers” worth several hundred thousand dollars each.

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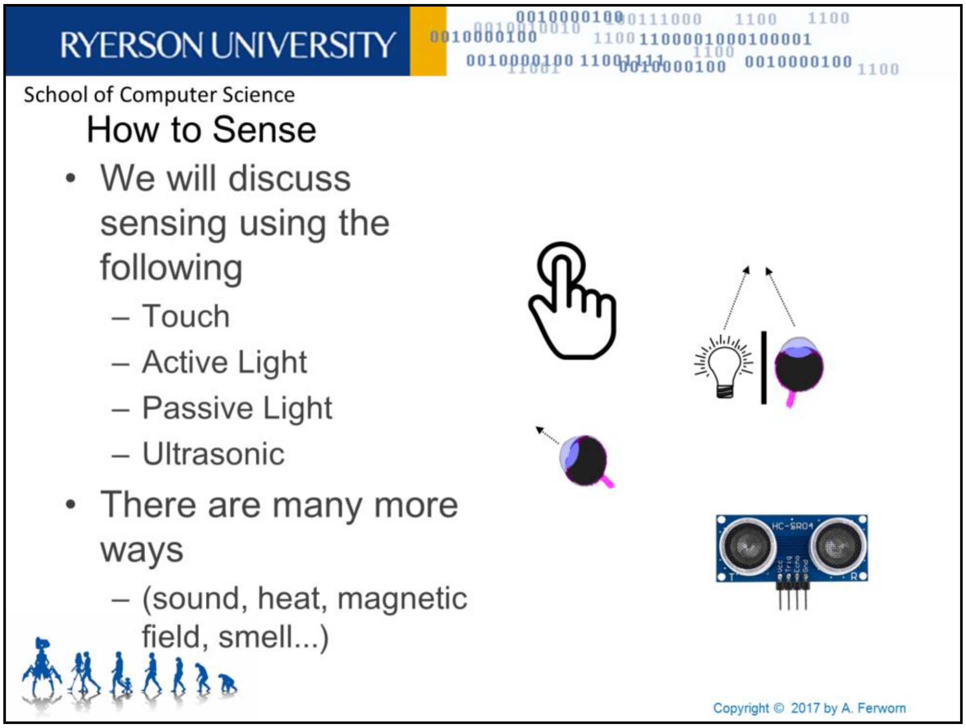
Fooling Sensors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How to Sense
• We will discuss sensing using the following
– Touch
– Active Light
– Passive Light
– Ultrasonic
• There are many more ways
– (sound, heat, magnetic field, smell...)
HC-SR04
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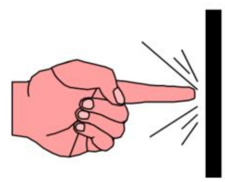
Sensing with touch

- Normally done to avoid collisions
  - Avoiding is a lot better than Detecting
- There are basically 3 forms
  - Bumper Switch
  - Whisker
  - Pressure Pad



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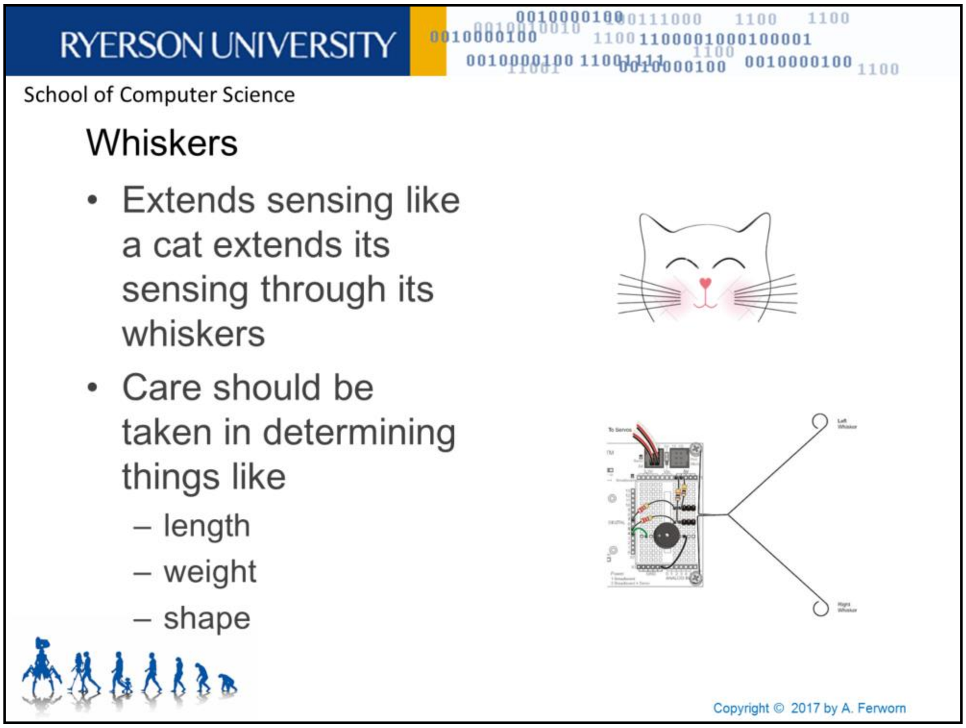
Bumper Switch

- Mounted on the chasis of the robot
- When plunger depressed collision is about to occur
- Characteristics
  - small surface area
  - low cost = low sensitivity

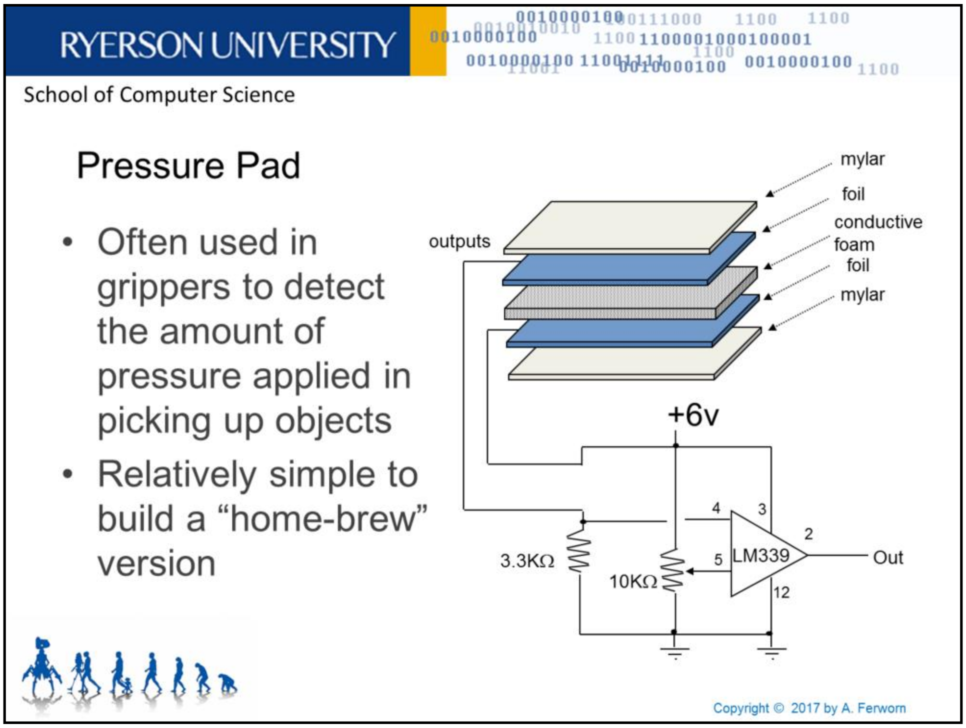


•Cat whiskers measure space. If a whisker touches the cat knows that it will not be able to go through an opening as the whiskers define the sizeof entrance it is capable of moving through.

•Things like suspended ceilling wire, coffee sticks or tooth picks can all act as whiskers. They should no interfere with the actual sensing element.

MIT Mechanical Engineering 2015

Inspired by the ability of seals to detect flow features and other underwater information through their whiskers, Dr. Heather Beem (PhD ’15) has designed a sensor that could be used by underwater robots to collect data on hydrothermal events or marine life.



LM339 is a quad comparator circuit. Output will be +6V

Or could use an ohm meter to detect the resistance change which would be proportional to amount of pressure applied.

British firm Shadow Robot has designed a prosthetic hand that can analyse the shape of an object and how best to pick it up. It is called the Dexterous Hand, and it includes finger-tip mounted pressure sensors so it can judge how much force is needed when touching something. The developers claim it is a real leap forward in artificial intelligence. Rich Walker, Shadow Robot's Managing Director, explained: "What we've tried to do is put intelligence into the robot hand, and that means sensing. So we're adding sensors on the fingertips that can understand how the robot is touching the world and interacting with it. And we're adding 3D cameras so the robot can see things around it and be able to work out how to grasp and manipulate them." The 3D depth-sensing cameras let the Dexterous Hand examine an object. The internal software then arranges the fingers for optimal grip, while touch sensors monitor its stability. The software is open source. Rich Walker says it has been well received: "What we've found really exciting is we have customers who are using this hand to develop next-generation prosthetics by looking at, for example, what does a brain-computer interface look like to control a robot hand? How do you get that to work? We're exploring applications of the hand in areas where you'd really like to put a person but can't. And that might be a search and rescue scenario where you send a robot in somewhere and now you want to lift something up, move something out of the way."

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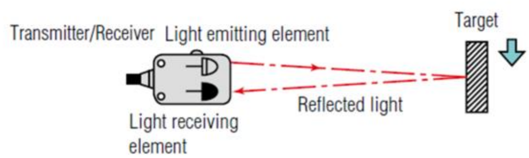
Active Light Sensing

- The agent illuminates what is being sensed and uses the reflected light
- Can be used for a number of tasks
  - collision avoidance/proximity detection
  - following (mail delivery)
- We will discuss
  - line following



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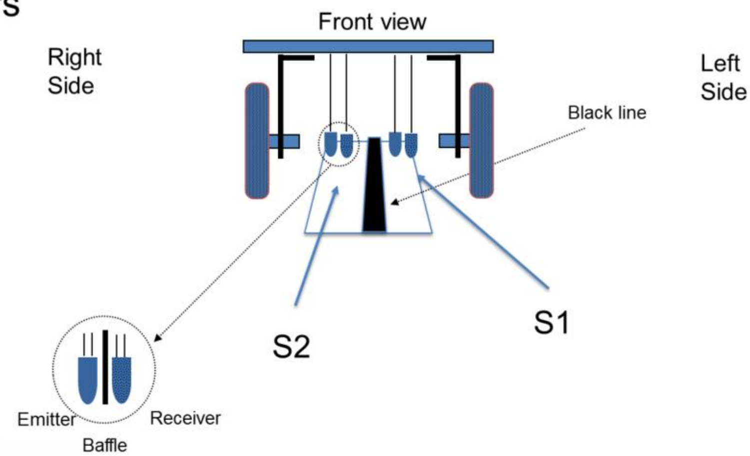
Line Detecting and Following using 2 sensor pairs



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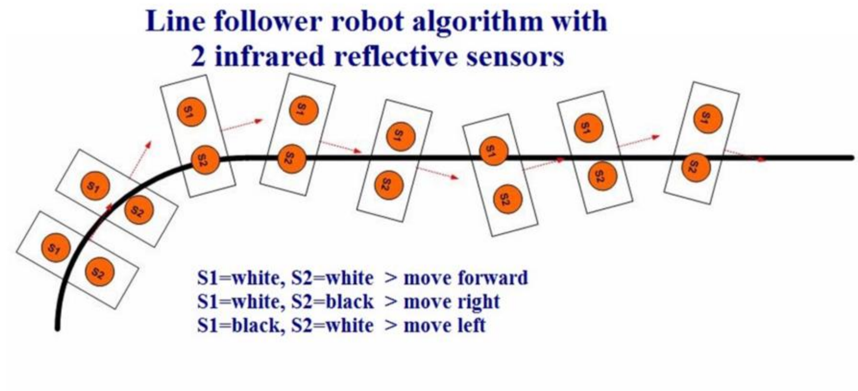
Line Following Algorithm 1: Line balancer



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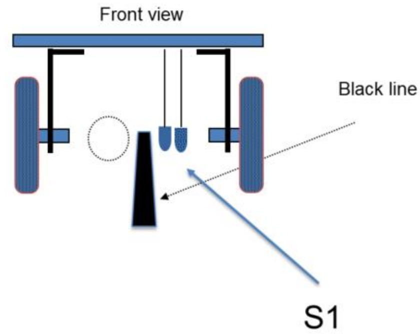
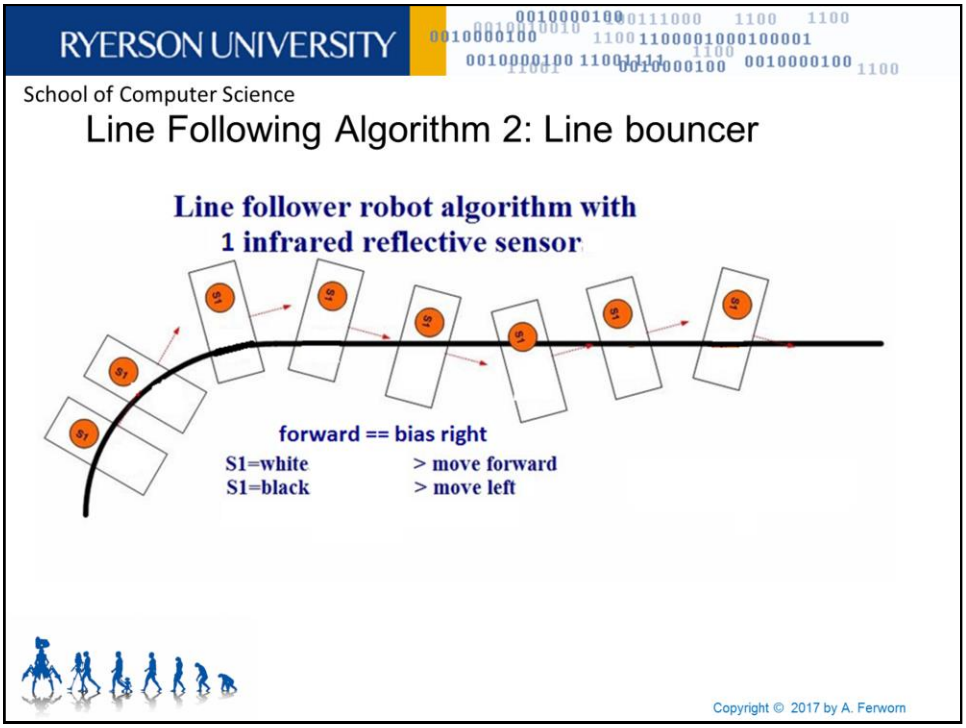
Line Detecting and Following using 1 sensor pair

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Line Following Algorithm 2: Line bouncer
Line follower robot algorithm with
1 infrared reflective sensor
forward == bias right
S1=white > move forward
S1=black > move left
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Passive Light Sensing

- Light is received from the environment directly
- Used to,
  - locate,
  - move towards, or
  - avoid
- We will discuss
  - a single cell eye

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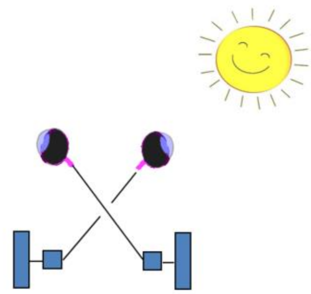
The Cyclops Circuit

- Cross connected single eyes
- Single Photo-resistor per side
- Controls a differentially steered vehicle



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Light Follower

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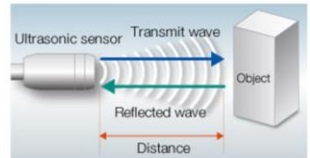
Ultrasonic Sensors



- Sensor has 2 parts
  - Emitter: transmits sound, (tiny speaker)
  - Receiver: listens for sound (tiny microphone)
- Sensor emits a high-frequency sound pulse and then times how long it takes for the echo of the sound to reflect back to the receiver
- Converts this into distance to object
  - **Distance = 1/2 × T × C**

Useful Characteristics of Ultrasonics

- **Transparent object detectable**
  - Since ultrasonic waves can reflect off a glass or liquid surface and return to the sensor, even transparent targets can be detected.
- **Resistant to mist and dirt**
  - Detection is not affected by accumulation of dust or dirt.
- **Complex shaped objects detectable**
  - Presence detection is stable even for targets such as mesh trays, springs and other sparse structures.

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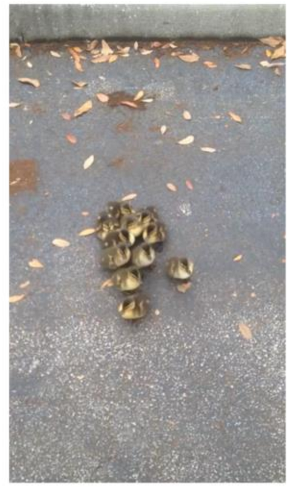
Duckling behaviour

- When ducks hatch, the chicks tend to follow the first thing they see.
- This behaviour can be duplicated



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Subsumptive Ultrasonic Duckling Robot

- no object
  - turns scanner right
- object
  - turns scanner left
- scanner left?
  - turn robot left.
- scanner right?
  - turns robot right.

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Beware Failure Modes