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CSCI 101
Connecting with Computer Science
Lecture 4: Applications of CS III

Jetic Gū

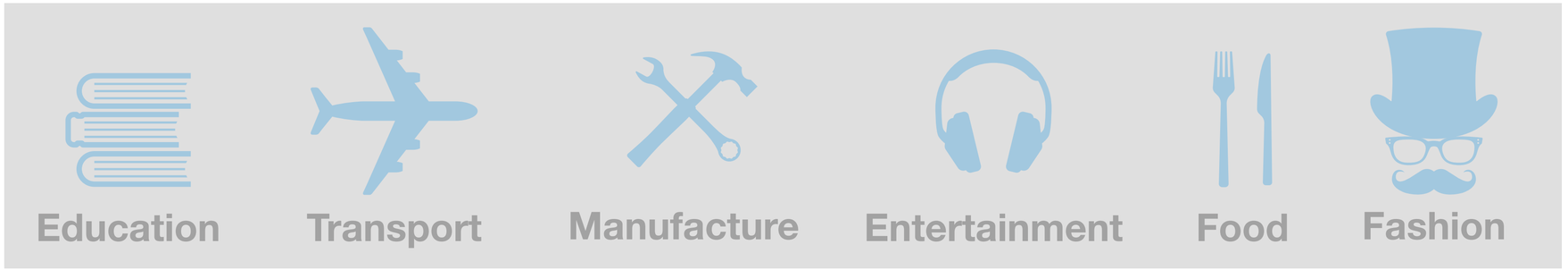
2023 Fall Semester (S3)

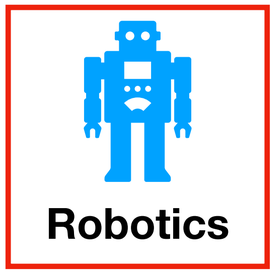
Overview

- Focus: Computing Science in Production
- Architecture: von Neumann
- Readings: 6, 7
- Core Ideas:
    1. Modern Robotics
    2. Challenges in Robotics

P0
Review

The Digital Revolution



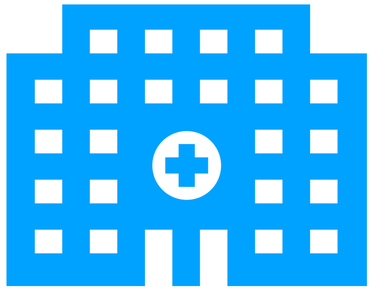


Review

P0
Review

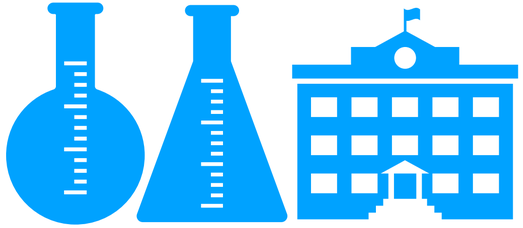
Bioinformatics

Medicine



Hospitals

Patient Oriented



Universities and Labs

Knowledge Oriented

- Digitisation of Patient Records database optimisation
- Computer analysis of Individual Examination Reports
- Quantitative Analysis including HGP
- Study biology, develop new treatments

Review

P0
Review

CS in Research

- Analyse large quantities of data in short periods of time
- Discover correlations between parameters and output
- Automate experimental procedures
- Physical simulations of Models

Review

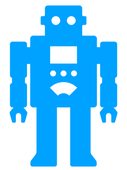
P1
Robotics

Modern Robotics

and why it matters

Summary

Important Aspects of Robotics



Robotics

- A machine programmable by a computer, capable of carrying out a complex series of actions automatically.
  - What kind of feedbacks (audio/visual/motor) can the robot provide? (Behaviour)
  - How much input does it expect the human to provide?
  - What kind of sensor does the robot have?

Concept

Robot: Vacuum Cleaning Robot

- Feedbacks
  Motor (for movement), Vacuum/Sweeper controls

- Human Input
  Schedule

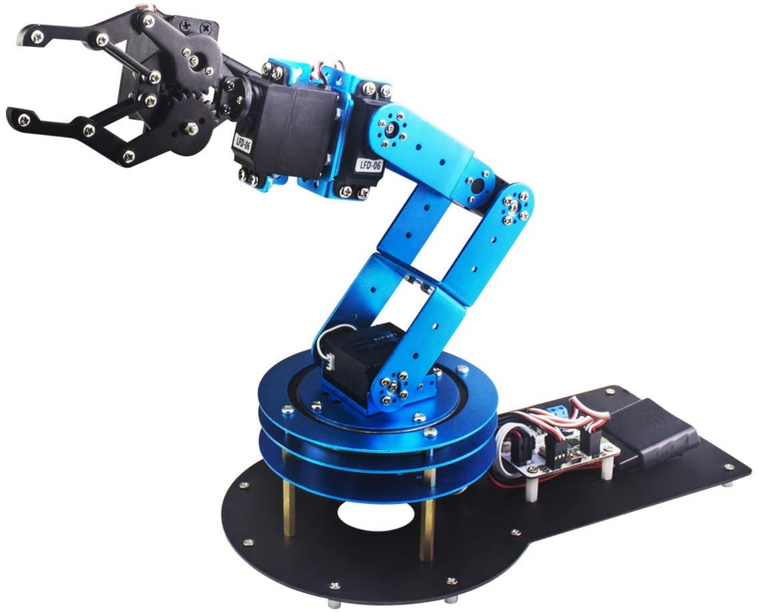
- Sensors
  Obstacle/Collision sensors, Optical Infrared camera

Examples

P1
Robotics

Robot: Assembling Robot

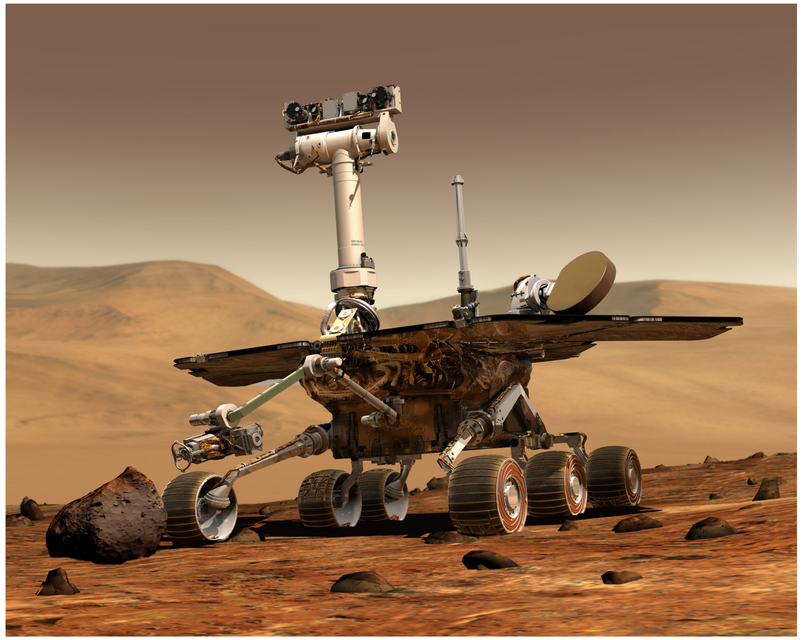
- Task
  Motor rotations
- Human Input
  Complete assembling programmes
- Sensors
  Pressure sensors or none



Examples

Robot: Research/Rescue Robot

- Task
  Motor rotations
- Human Input
  Remote controls
- Sensors
  Various



Examples

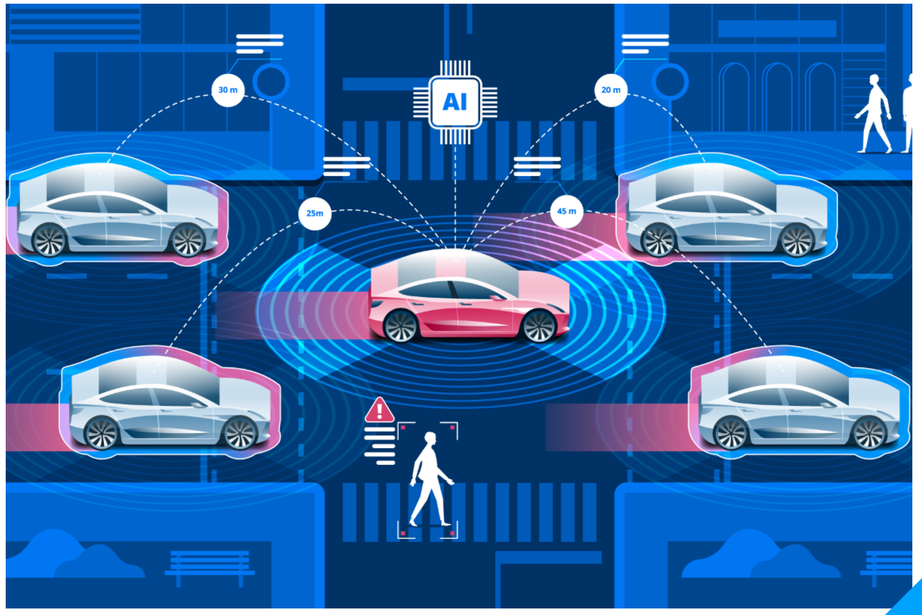
P1
Robotics

Robot: Autonomous Vehicles

- Task
  Motor rotations

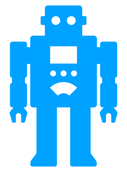
- Human Input
  Destination

- Sensors
  Optical sensors, Infrared sensors, Lidar sensor array, 5G antenna, etc.



Examples

Robotics Problems in CS



Robotics

- Degree of automation/intelligence
  - Hardware
    Mechanical engineers are responsible for all the motor functions and sensor design/installation, for computing scientists, the most important problem is control
  - Software
    CS people handles the algorithm for controlling the machine. Even remotely controlled machines such as drones have this problem!

Concept

Remote Controlled Drones

- Sensors
  - Proximity sensors
  - Optical sensors (daylight and infrared)
  - Pressure sensors
- Software
  - Automatic obstacle detection and evasion
  - Route planning
  - etc.

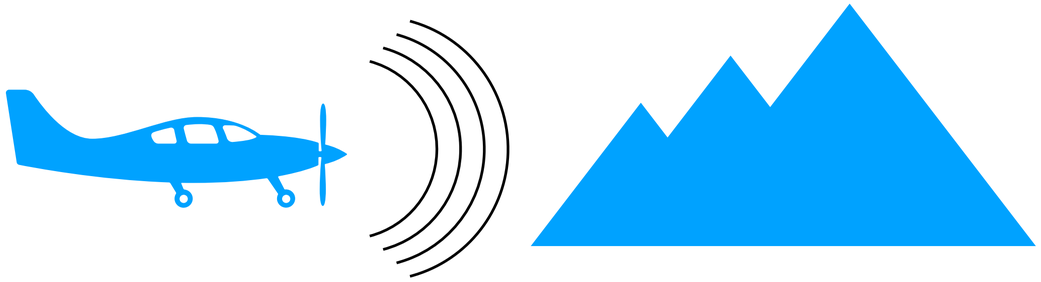



P1
Robotics

Remote Controlled Drones

Robotics

- Input
  - Sensors
  - Human command
- Output
  - Motor control / Resource management
  - Audio/Visual Feedback



Technical

Challenges in Robotics

Challenges in Robotics

- Hardware level
  - Power source
  - Material / Manufacturing Cost
  - Mechanics
  - Not this course’s concern
- Software level
  - Environmental Mapping
  - Artificial Intelligence
  - Brain-Computer Interface(*)
  - Swarm Intelligence

- **Ethics**

Concept

Challenges in Robotics

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- Software level
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  - Artificial Intelligence
  - Brain-Computer Interface(*)
  - Swarm Intelligence
- **Ethics**

Concept

P2
Challenges

Environmental Mapping & AI

- How to correctly interpret sensor input and establish the surrounding environment
  - 2D still image -> 3D scene
  - 2D still images -> 3D scene(s)
  - Motion picture -> 3D scene(s)
  - Lidar input -> 3D scene

Concept

P2
Challenges

Environmental Mapping & AI

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Concept

P2
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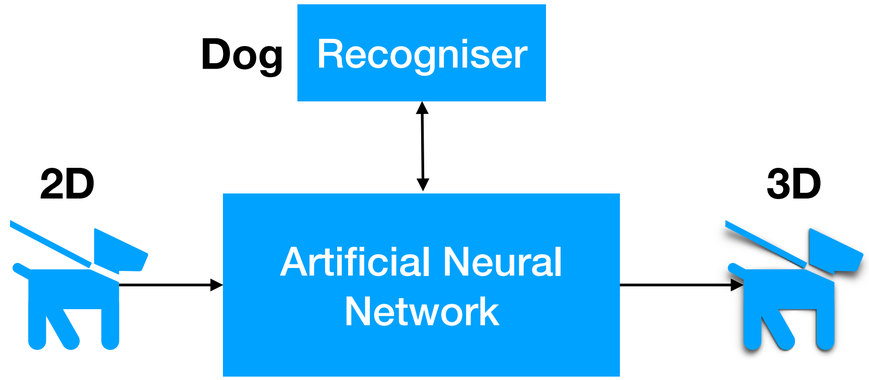

Concept

P2
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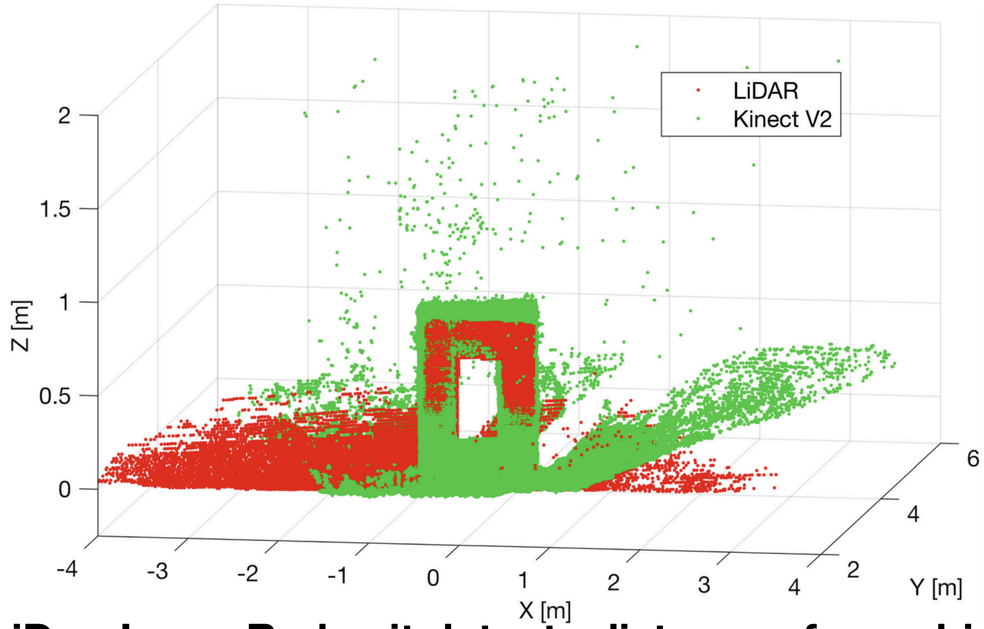


LiDar: Laser Radar, it detects distances from objects
LiDar: outputs are already 3D, all you need is object detection

Concept

Other AI Challenges

- Planning: Given objective, how do we achieve it?
  - E.g. path finding, navigation system
    - Input: map, current traffic conditions (including road blocks)
    - Output: route, lane changing information (for autonomous cars), traffic signal sensing and VRU[1] detection etc.
- How to react in unseen situations?
  - AI is trained on seen examples, and we assume it will generalise well in unseen
  - More in the following weeks

1. Vulnerable Road User

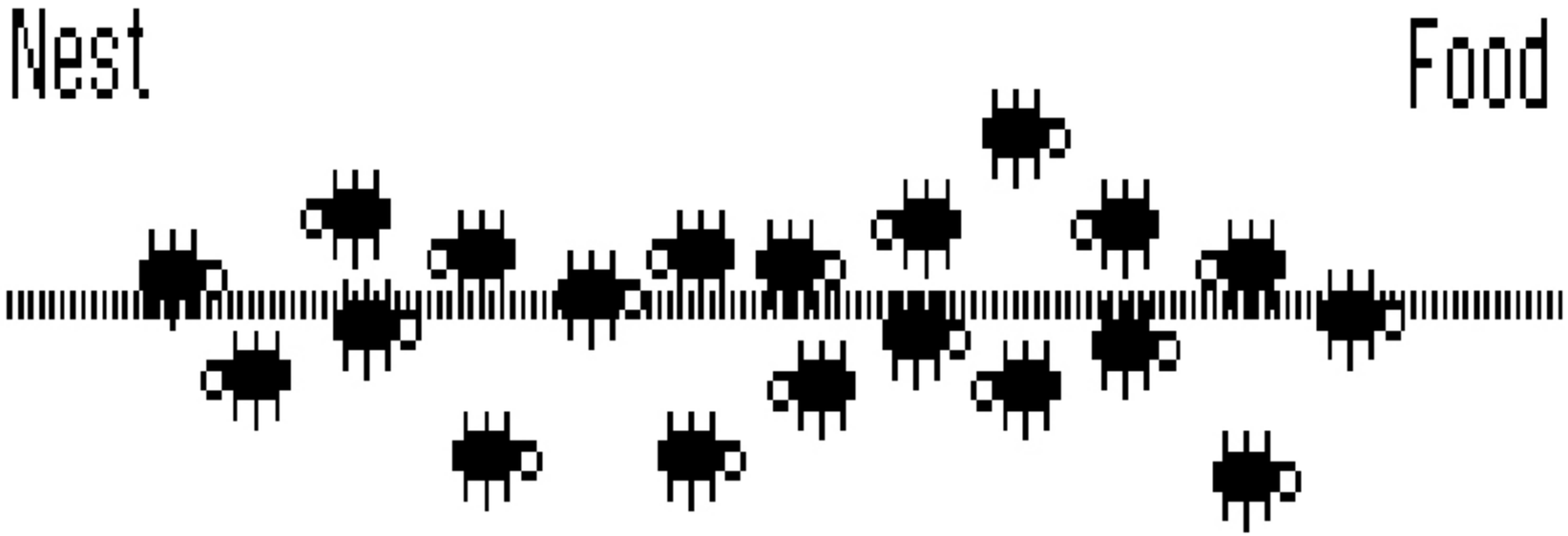
Swarm Intelligence

- Swarm: a group of autonomous robots
  - Inspired by animals such as bees
  - Cooperation
    Centralised management or independent
  - Efficiency via Specialisation
    division of labour
  - Communication
    to achieve collective objectives

Concept

P2
Challenges

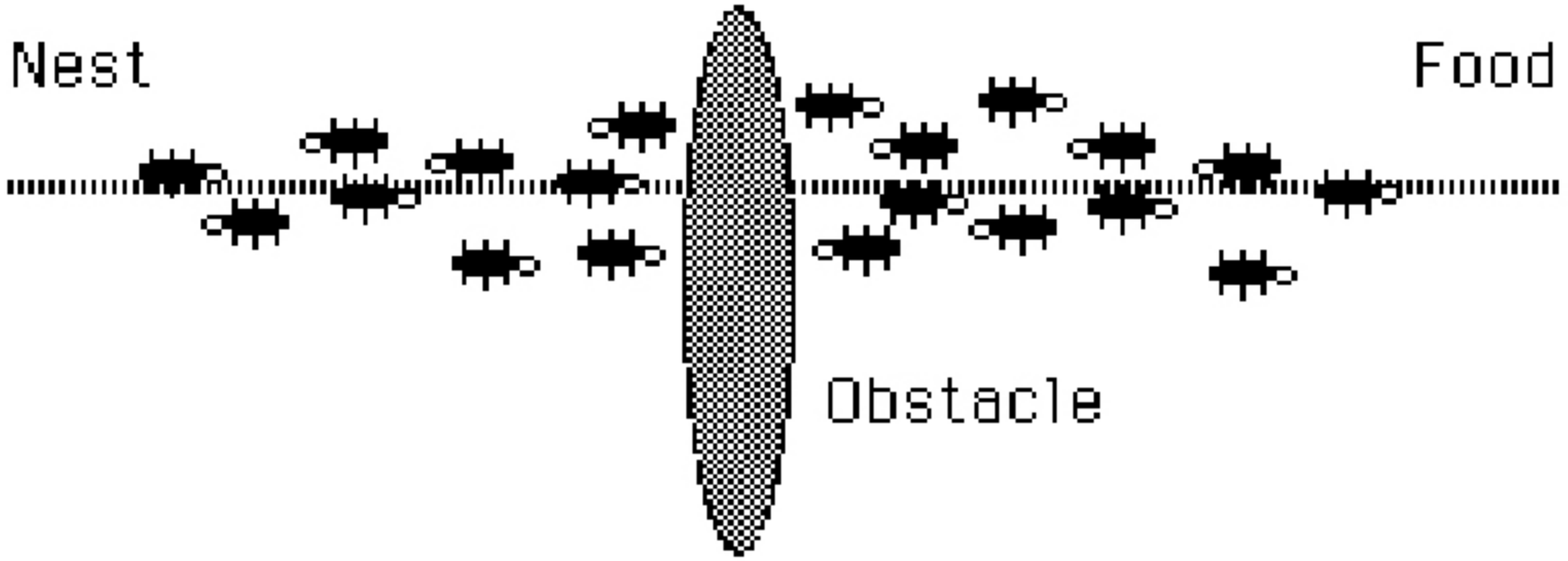
An In-depth Look at Real Ant Behaviour



Example

P2
Challenges

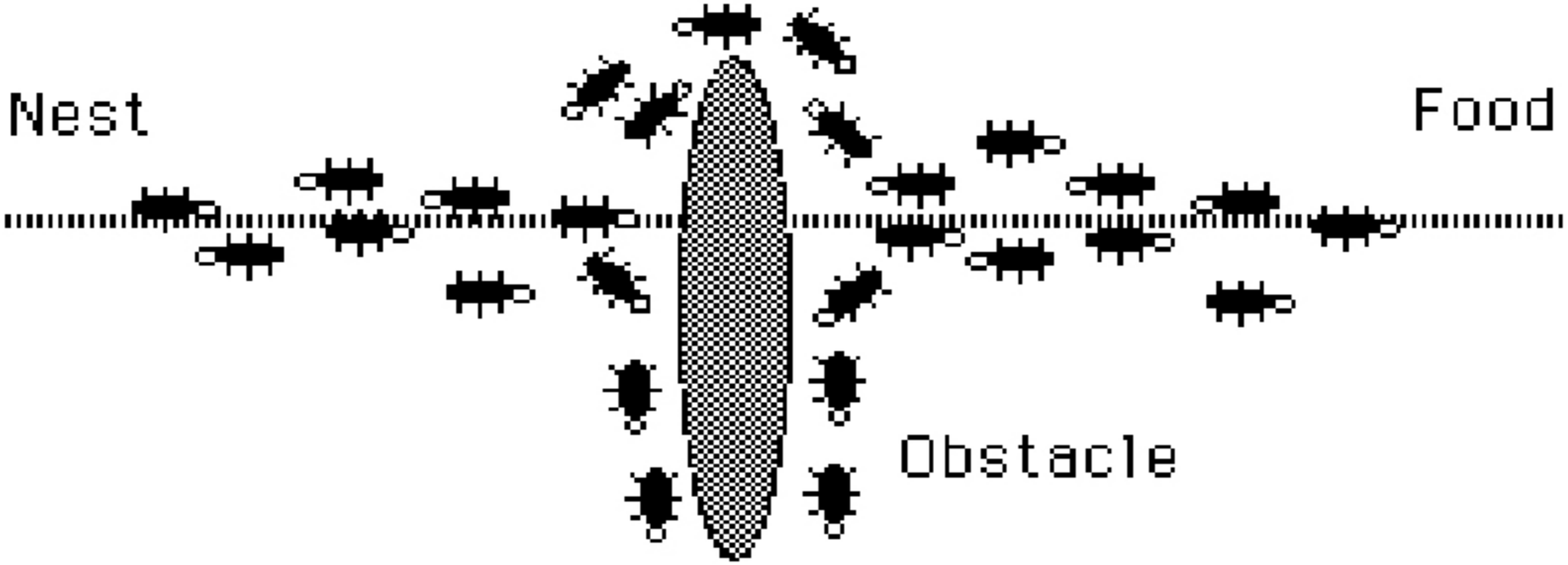
Interrupt The Flow



Example

P2
Challenges

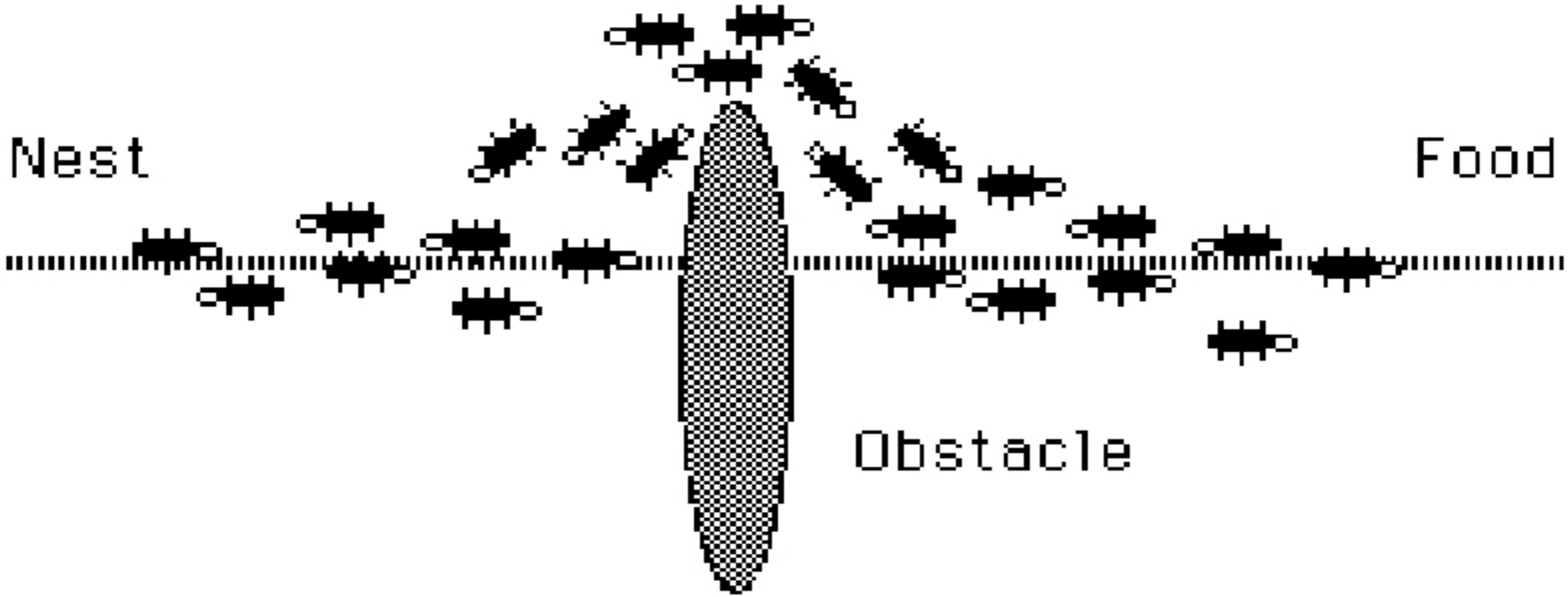
The Path Thickens!



Example

P2
Challenges

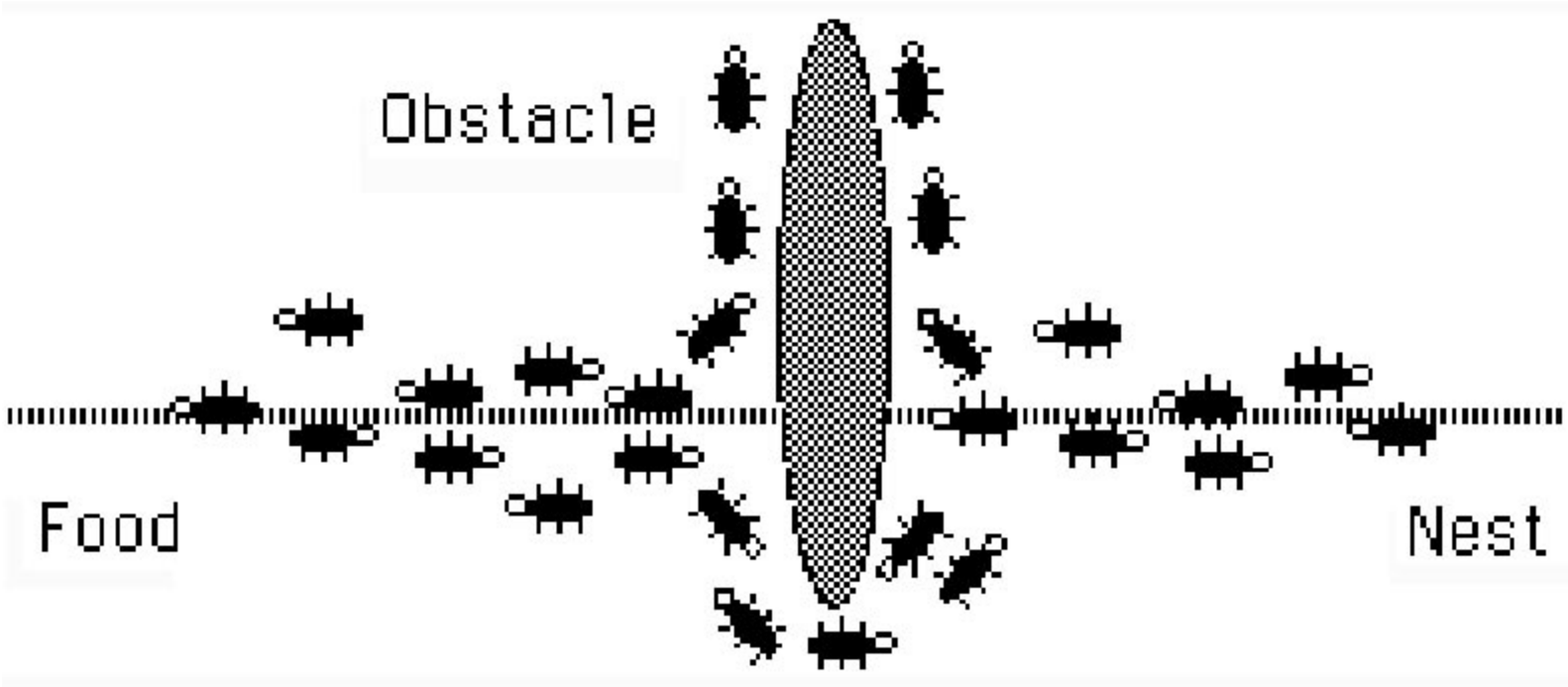
The New Shortest Path



Example

P2
Challenges

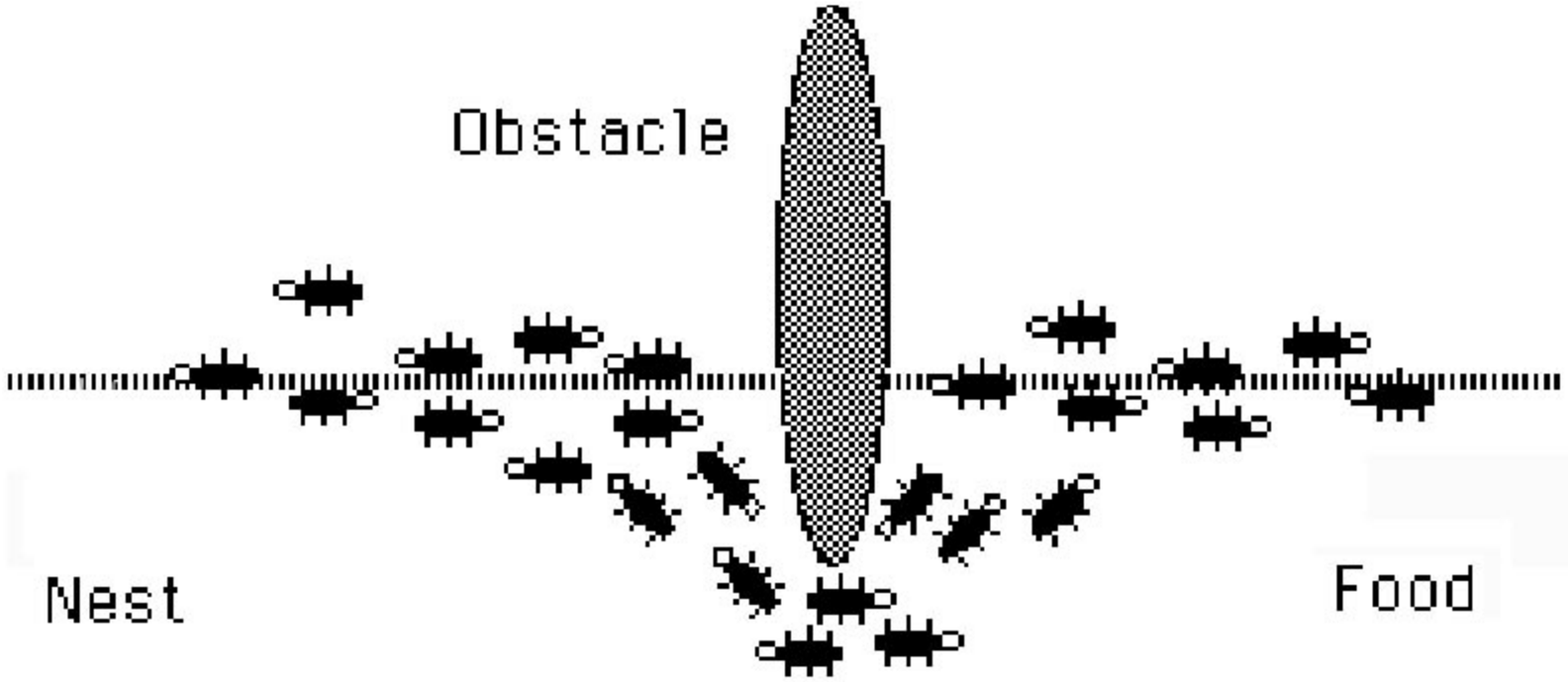
Adapting to Environment Changes



Example

P2
Challenges

Adapting to Environment Changes



Example

Possible Solutions to Create Swarm Intelligence Systems

- Create a catalog of the collective behaviours (impossible)
- Model how social insects collectively perform tasks
  - Use this model as a basis upon which artificial variations can be developed
  - Model parameters can be tuned within a biologically relevant range or by adding non-biological factors to the model
- **This is still a relatively new area of research!**

Concept

Questions to Think About

P3
Questions

How will robots change the human society?

- What are the robots you've encountered?
- Are robots going to take people's job?
- Are there problems with the 3 laws?
- What do you think is the ideal place for robots in human society?
  ref: *I, Robot*, *Her*
- What do you think can swarm technology do? What are the advantages?

1 A human-centered robot will not replace humans, only forms of human labor that are dangerous, repetitive, and exhausting.

2 A human-centered robot assists human beings, extends their capabilities, and promotes their quality of life.

3 To protect its own existence, a human-centered robot protects the existence of its human operator.

Discussion

P3
Questions

- A robot may not injure a human being or, through inaction, allow a human being to come to harm.
- A robot must obey the orders given it by human beings except where such orders would conflict with the First Law.
- A robot must protect its own existence as long as such protection does not conflict with the First or Second Laws.

Technical