



RYERSON UNIVERSITY

School of Computer Science

Understanding Animal Behaviour



Using Animal Behavior as a Model
for Robot Behavior




Copyright © 2017 by A. Ferworm

RYERSON UNIVERSITY

School of Computer Science

Topics

- Reflexes
- Some Assumptions
- Some Biology
- Observing Animal Behavior
- Ethology, Behavioral Psychology and Physiology
 - Top down vs. Bottom up
- The wasp (instinct) and the dog (learning)




Copyright © 2017 by A. Ferworm

RYERSON UNIVERSITY

School of Computer Science

What is a reflex?

- General Definition
 - An action that is performed as a response to a stimulus and without conscious thought.
- In humans
 - made possible by neural pathways called reflex arcs
 - act on an impulse before that impulse reaches the brain.
- automatic response to a stimulus that does not receive or need conscious thought.



Copyright © 2017 by A. Ferworm



RYERSON UNIVERSITY

School of Computer Science

The Reflex Arc

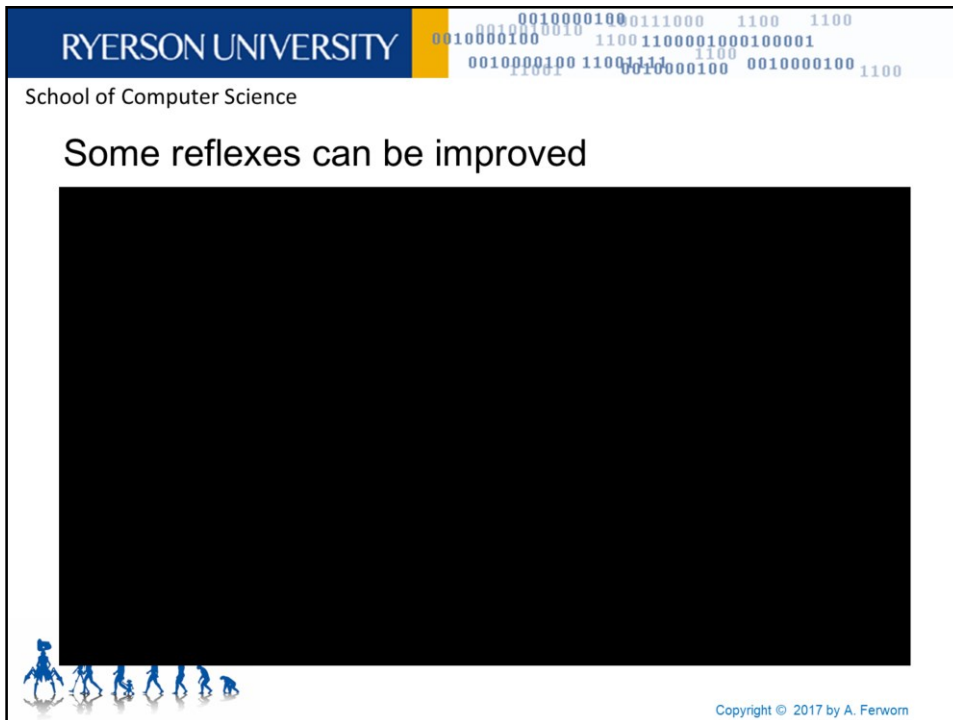
edukite
Let the mind fly!

Pain == Wrong!

Copyright © 2017 by A. Ferworm

A reflex arc is a neural pathway that controls a reflex. In vertebrates, most sensory neurons do not pass directly into the brain, but synapse in the spinal cord. This allows for faster reflex actions to occur by activating spinal motor neurons without the delay of routing signals through the brain. However, the brain will receive the sensory input while the reflex is being carried out and the analysis of the signal takes place after the reflex action.

There are two types: autonomic reflex arc (affecting inner organs) and somatic reflex arc (affecting muscles). However, autonomic reflexes sometimes involve the spinal cord and some somatic reflexes are mediated more by the brain than the spinal cord.



As has been pointed out here, a reflex doesn't involve the brain. Stimulus sends a signal to the spinal cord which sends back a signal for the proper response. No thinking needed, it is very fast. In order for a boxer to dodge a punch, he has to know the punch is coming. That information comes from the eyes and must be processed by the brain.

There is something else that looks and feels a lot like reflex that can be developed through repetition, practice, training, etc. People here are calling it muscle memory, but that's a misleading term as it implies the memory resides in the muscles. It happens when a response or activity becomes so familiar that it is stored in a part of the unconscious brain. Many of the daily tasks we do are executed in this way: tying your shoes, driving home from work, typing on your keyboard. You're barely aware of doing them and you would be hard pressed to explain exactly how you do them.

It would be impossible to hit a fastball if you had to think about it; it would be in the catcher's mitt before you formulated any thought or initiated any action. But practice trying to hit a ball 1000 times, or 10,000 times, and then you're ready to bypass, not the brain, but the

Autonomous Mobile Robotics

conscious thought process. And, if you're good, you will be able to hit that fastball one time out of every three or four. But it's not a reflex, the information needed to do it is still in your brain, but in a part of your brain that works much faster than conscious thought.

Sources: Thinking, Fast and Slow: Daniel Kahneman, The Stuff of Thought: Language As a Window Into Human Nature: Steven Pinker.

RYERSON UNIVERSITY

School of Computer Science

Taking Advantage of Reflexes in Robots



Copyright © 2017 by A. Ferworm

Researchers from MIT's Department of Mechanical Engineering have designed an interface that takes advantage of a human's split-second reflexes allowing a humanoid to maintain its balance and complete tasks.


RYERSON UNIVERSITY

00100001000111000 1100 1100
0010000100 1100 1100001000100001
0010000100 1100 1100 0010000100 1100
1100 0010000100 1100

School of Computer Science

Behavioural Robotic Assumption

- In order for a robot to act autonomously over a wide range of tasks and environments, it must be capable of exhibiting a variety of different behaviors.
- Behaviour-based robotics examines behavioral patterns that exist when limited to constructing such behavior from computational devices which contain no internal state.
 - No memory
- Each primitive behavior models a simple form of reflex behavior.



Copyright © 2017 by A. Ferworm

From: Anderson, T. L., & Donath, M. (1990, July). Autonomous robots and emergent behavior: A set of primitive behaviors for mobile robot control. In Intelligent Robots and Systems' 90.'Towards a New Frontier of Applications', Proceedings. IROS'90. IEEE International Workshop on (pp. 723-730). IEEE.


RYERSON UNIVERSITY

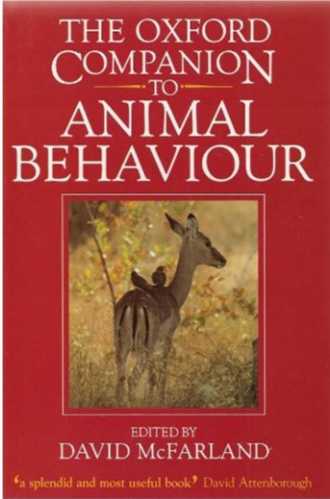
0010000100 0111000 1100 1100
0010000100 1100 1100001000100001
0010000100 1100 1100 0010000100 1100

School of Computer Science

Biological Evidence

- Behavioural robotics ideas are often supported by ethological observation on the behavior of animals
 - D. McFarland (ed) The Oxford Companion to Animal Behavior
- Differ from traditional approaches to robot control which have concentrated on the development of a single behavior.
 - Useful for thinking about the final exercise in this course





EDITED BY
DAVID McFARLAND
“a splendid and most useful book” David Attenborough

Copyright © 2017 by A. Ferworm

Animal Behavior

- Nature has often been used as a source for the design of man made artifacts. In robotic design (recall biomimicry),
 - grasping,
 - manipulation, and
 - locomotion
- These biological examples have provided us with a basis for the design of robot hands, flexible and rigid manipulators and various walking machines.



What is Animal Behavior?

- The study of how and why animals interact with each other (both within and among species) and their environment.
- Immediate questions – how?
 - mechanisms responsible for interactions
- Ultimate questions – why?
 - how these interactions influence a species' survival and reproductive success



Observing Animal Behavior

- Nature provides many examples of different types of behavior
 - We've been observing for thousands of years
- allow both vertebrates and invertebrates to successfully interact with their environment.
- Successful interaction is essential to their survival.
- Examples include
 - attack and escape behaviors,
 - mating,
 - feeding, and
 - nest building behaviors.





Approaches in the Study of Animal Behavior

- Two basic approaches have been used in the study of animal behaviour.
 - Top down strategy
 - attempts to explain the behavior of the animal without complete knowledge of the underlying physical mechanisms.
 - Bottom up strategy
 - taken by physiologists
 - » based on the analytical decomposition of the organism into its various physical subcomponents.
 - Shared by ethologists and behavioral psychologists.




RYERSON UNIVERSITY

00100001000111000 1100 1100
0010000100 1100 1100001000100001
0010000100 1100 1100 0010000100 1100
1100 0010000100 1100

School of Computer Science

Top Down Approach: Ethology

- Study the behavior of animals under natural settings
 - in addition to the cause of the behavior, they are interested in determining what function it provides the animal and its evolutionary consequences.
- Bottom line belief: Survival of a given species depends not only upon their physical structures but also upon possessing the necessary behavioral characteristics.



Copyright © 2017 by A. Ferworm

belief that behavior is largely a result of the animal's innate response to certain environmental stimuli.

It is their belief that types of behavior are specific to certain species. Related species will exhibit similar behaviors while unrelated species will exhibit dissimilar behaviors.


RYERSON UNIVERSITY

School of Computer Science

0010000100 0111000 1100 1100
0010000100 1100 1100001000100001
0010000100 1100 1100 0010000100 1100

Top Down approach: Behavioural Psychology

- study the behavior of animals in a controlled laboratory environment.
- largely ignore the natural habitat in which the animal exists.
- Bottom line belief: They desire to formulate general laws of learning.



Copyright © 2017 by A. Ferworm

They believe that the response exhibited by an animal to certain stimuli is not an innate response but instead is primarily a learned response.


Their aim is to uncover general principles which describe the behavior of an animal in terms of its ability to learn to respond to certain stimuli.

RYERSON UNIVERSITY

School of Computer Science

Bottom Up Approach: Physiology

- attempt to explain animal behavior in terms of the interactions between the physical components of the animal.
- approach animal behavior from analytical perspective
- Bottom line belief: primarily concerned with the functioning of the animal at the neural level.



Copyright © 2017 by A. Ferworm

decomposing the animal into physiological subcomponents, and then focus upon understanding the underlying mechanisms of each the subcomponents.



A Lack of Framework

- Describing the behavior of an animal presents a serious problem to the observer.
 - no common unit of measurement.
 - like voltage, current, and force,
 - the description of behavior depends upon the behavior being investigated
 - is subjective at best.
- What is happening here?



RYERSON UNIVERSITY

00100001000111000 1100 1100
0010000100 1100 1100001000100001
0010000100 1100 1100 0010000100 1100
1100 0010000100 1100

School of Computer Science

What is happening here?

- When you talk about a thing or animal as if it were human, you're *anthropomorphizing* it.
 - The Easter Bunny is an anthropomorphized rabbit.





Copyright © 2017 by A. Ferworm

RYERSON UNIVERSITY

School of Computer Science

00100001000111000 1100 1100
0010000100 1100 11000
0010000100 1100 11000
11001 0010000

A Theory of Animal Behavior

- The ethological approach to the study of animal behavior began in the late 1930s
- mainly through the early work of
 - Konrad Lorenz, and
 - Niko Tinbergen.
- It was Lorenz who introduced a model to explain the predictable behavior of certain animals when exposed to specific stimuli.

Copyright © 2017 by A. Ferworm

Konrad Lorenz (1903-1989)

- examined genetically programmed behaviors in young and “imprinting”.
 - Young geese form an image of “parent” just after hatching.
 - If the hatchlings first encounter a human, they will imprint on him and follow him around as if he were their mother.




RYERSON UNIVERSITY

School of Computer Science

The Lorenz Model

- Consists of an internal centre based in the central nervous system, receiving sensory information from the environment.
 - Called the “innate releasing mechanism”
 - causes a specific response from the animal when certain situations in the environment detected
- Stimulus when invoked the response was called a “releaser”
- Pattern of behavior exhibited was called a “fixed action pattern”
- Surprisingly similar to the way we look at behavior-based robotics




Copyright © 2017 by A. Ferworm

RYERSON UNIVERSITY

School of Computer Science

On Instinct and Learning

- How is it that an animal
 - possesses the ability to feed themselves,
 - produce and raise offspring,
 - build nests, and
 - avoid predators?
- The answer is believed to be due to a combination of
 - inherited responses to certain situations (instinct), and
 - the ability to adapt to situations for which no response is available (learning).



Copyright © 2017 by A. Ferworm



RYERSON UNIVERSITY

00100001000111000 1100 1100
0010000100 1100 1100001000100001
0010000100 1100 1100 0010000100 1100
1100 0010000100

School of Computer Science

Digger Wasp behaviour algorithm

- Mate
- Dig a hole
- Hunt and paralyze insect
- Bring insect to hole
- Drag insect into hole
- Lay egg(s) on insect
- Fill in hole




Copyright © 2017 by A. Ferworm


RYERSON UNIVERSITY

School of Computer Science

Digger Wasp-Instincts



- A female digger-wasp emerges from her underground pupa in spring
 - Her parents died the previous summer.
- She has to mate with a male wasp and then perform a whole series of complex patterns connected with
 - digging out a nest hole,
 - constructing cells within it,
 - hunting and killing prey such as caterpillars,
 - provisioning the cells with the prey,
 - laying eggs and
 - finally sealing up the cells.
- All of this must be completed with a few weeks, after which the wasp dies.”



Copyright © 2017 by A. Ferworm

A. Manning, An Introduction to Animal Behavior, 3rd ed., 1979, pg 22

Lorenz Explains food storing behaviour

- This behavior is an aggregation of a series of sequential behaviors.
 - result of one behavior triggers the next.
- In this example, the releaser would be the presence of hole which would evoke an inspection behavior, the result of which would evoke a dragging behavior, and so on.
- Note that under this hypothesis, if the digger wasp's triggers are disturbed, the results of behaviours become unreliable.
 - This has been experimentally verified.



RYERSON UNIVERSITY

School of Computer Science

Screwing with a digger wasp?



Copyright © 2017 by A. Ferworm

Genetically Programmed Behaviour

- This is an example of an innate behavior which has been genetically passed on from previous generations.
- The wasp is not trying to accomplish a “goal” but acts as it does because that is the way its ancestors acted.
- These wasps survive because,
 - Each wasp is physically suited to its environment
 - Its behaviour is suited to the environment
- This is the main idea behind “ethology”





Learning and Dogs


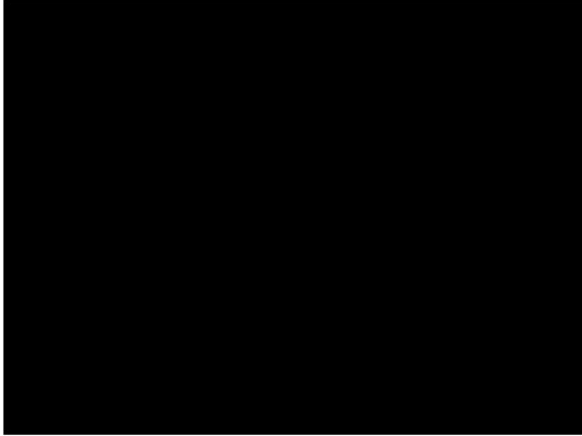
- Learning: The acquisition of knowledge or skills through experience, study, or by being taught.
- Some biological systems use instinctive behaviour as a starting place for learning to build on top of.
 - Like Dogs



RYERSON UNIVERSITY

School of Computer Science

Urban Search and Rescue (USAR) or Disaster Dogs




Copyright © 2017 by A. Ferworm


RYERSON UNIVERSITY

School of Computer Science

Bark Barrel Training



www.PonderosaKennels.com



Copyright © 2017 by A. Ferworm

RYERSON UNIVERSITY

School of Computer Science

USAR Dog Learning in Action




Copyright © 2017 by A. Ferworm

RYERSON UNIVERSITY

School of Computer Science

More on Instinct and Learning

- Adaptation, or learning, has the obvious benefit of allowing the animal to react to new situations.
- Innate responses have the benefit of immediacy, since no time is required in order to develop a learned behavior.
- Many creatures use both.



Copyright © 2017 by A. Ferworm

Revisiting the Wasp and the Dog

- digger wasp learns to identify the location of its nest by local land marks.
 - experiments consisted of surrounding the nest by a ring of pine cones.
 - When the wasp first emerged from the nest, it exhibited a behavior in which it circled the nest repeatedly before leaving to capture prey.
 - During this period, the pine cones were moved a distance away from the nest, but eh pinecones' arrangement was maintained.
 - Upon its return, the wasp was observed to orient itself towards the pinecones, not the nest.
- Dogs learn because they have innate drives (play, food, etc). They/we take advantage of those drives so that dogs learn what we want them to.

