Certificate I: Understanding AI and Machine Learning in Africa

Course AIMLO1: Artificial Intelligence – Past, Present, and Future

Module 1: What is AI, where did it come from, and where is it taking us?

Lecture 2: The Early Years of Al

Carnegie Mellon University Africa

# Learning Objectives

- 1. Identify the events that marked the beginning of AI
- 2. Compare Al's roots in cybernetics and in computationalism
- 3. Explain what is meant by connectionism and explain how it differs from computationalism
- 4. Explain the difference between strong AI and weak AI
- 5. Explain what is meant by an AI winter

Carnegie Mellon University Africa

# Lecture Contents

- 1. The birth of Al
- 2. Computationalism and GOFAI
- 3. Cybernetics and connectionism
- 4. Strong and weak Al
- 5. The AI winter(s)
- 6. Lecture summary

### 7. Recommended reading & references

Carnegie Mellon University Africa

The term Artificial Intelligence was coined by John McCarthy in 1955

- In proposal for a "Dartmouth Summer Research Project on Artificial Intelligence"
- Co-written by John McCarthy, Marvin Minsky, Nathaniel Rochester, and Claude Shannon





John McCarthy at Stanford's Artificial Intelligence Laboratory in 1974 Photo by Chuck Painter (https://www.bostonglobe.com/metro/obituaries/2011/10/27/john-mccarthy-pioneered-interactive-computing/CLFIfub8la9OylaHAX9ZzL/story.html)

Certificate I: Understanding AI and Machine Learning in Africa Course AIMLO1: Artificial Intelligence – Past, Present, and Future

#### Carnegie Mellon University Africa

"We propose that a 2 month, 10 man study of artificial intelligence be carried out during the summer of 1956 at Dartmouth College in Hanover, New Hampshire. The study is to proceed on the basis of the conjecture that every aspect of learning or any other feature of intelligence can in principle be so precisely described that a machine can be made to simulate it."



Page I of the Original Proposal. https://ojs.aaai.org/index.php/aimagazine/article/view/1904/1802

Certificate I: Understanding AI and Machine Learning in Africa Course AIMLO1: Artificial Intelligence – Past, Present, and Future Carnegie Mellon University Africa

Seven topics:

1. Automatic Computers

2. How Can a Computer be Programmed to Use a Language

3. Neuron Nets

This is sometimes forgotten: the workshop also targeted connectionism, not just abstract symbolic reasoning

4. Theory of the Size of a Calculation

5. Self-improvement

6. Abstractions

#### 7. Randomness and Creativity



Page 1 of the Original Proposal. https://ojs.aaai.org/index.php/aimagazine/article/view/1904/1802

Certificate I: Understanding AI and Machine Learning in Africa Course AIMLO1: Artificial Intelligence – Past, Present, and Future Carnegie Mellon University Africa

The term Artificial Intelligence was coined by John McCarthy in 1955

- It became known as the Dartmouth Workshop and is widely recognized as the founding event for this field of research
- It was held at Dartmouth College, New Hampshire, where John McCarthy was a professor, from June 17 to August 16, 1956



(Moor, 2006)

Certificate I: Understanding AI and Machine Learning in Africa Course AIMLO1: Artificial Intelligence – Past, Present, and Future

#### Carnegie Mellon University Africa

The participants included John McCarthy, Marvin Minsky, Allen Newell, Herbert Simon, Claude Shannon, Oliver Selfridge, and John Holland, among others

- These luminaries had a profound impact on the development of AI over the next 50 years
- We will hear more about them over the course of this program

Carnegie Mellon University Africa

The focus was on human-level intelligence:

"The high-level or cognitive capability of humans to reason and to think"

(Jordan, 2019)

Certificate I: Understanding AI and Machine Learning in Africa Course AIMLO1: Artificial Intelligence – Past, Present, and Future Carnegie Mellon University Africa

# Computationalism and GOFAI

Intelligence — both biological and artificial — is achieved by computations performed on internal symbolic knowledge representations

- An approach referred to as computationalism
- Grounded in cognitivist psychology
- Often referred to as GOFAI: good old-fashioned artificial intelligence
- Strong emphasis on logic
- We will see how this position is captured formally in Allen Newell's and Herbert Simon's Physical Symbol Systems Hypothesis

Certificate I: Understanding AI and Machine Learning in Africa Course AIMLO1: Artificial Intelligence – Past, Present, and Future Carnegie Mellon University Africa

Module 1: What is A!? Lecture 2: The Early Years of AI; Slide 10

Also known as the computational model of mind. It focusses on logical rules and symbolic computation, e.g., if a required condition exists then do something

Focusses on reasoning with internal symbolic models

However, AI has other roots in cybernetics

- Self-organization
- Regulation
- Control

championed by Norbert Wiener, W. Ross Ashby, Grey Walter, Claude Shannon, among others

Certificate I: Understanding AI and Machine Learning in Africa Course AIMLO1: Artificial Intelligence – Past, Present, and Future Carnegie Mellon University Africa

Norbert Wiener



https://www.nytimes.com/2013/05/21/science/mit-scholars-1949-essay-on-machine-age-is-found.html

N. Wiener. *Cybernetics: or the Control and Communication in the Animal and the Machine*, 1948.

(κυβερνητης or kybernetes: steersman)

Certificate I: Understanding AI and Machine Learning in Africa Course AIMLO1: Artificial Intelligence – Past, Present, and Future

#### Carnegie Mellon University Africa

"the scientific study of control and communication in the animal and the machine."



W. Ross Ashby



http://www.rossashby.info/index.html W. R. Ashby. Design for a Brain, first edition, 1952 ... 1956, 1960. Introduction to Cybernetics, 1956

Certificate I: Understanding AI and Machine Learning in Africa Course AIMLO1: Artificial Intelligence – Past, Present, and Future

#### Carnegie Mellon University Africa

W. Grey Walter's Tortoises (1950)

Neurophysiologist W. Grey Walter built two cybernetic tortoises to understand the functions of the brain

He nicknamed them

ELSIE (Electro-mechanical robot, Light-Sensitive with Internal and External stability) and

#### ELMER (ELectro-MEchanical Robot)



Meet the Roomba's Ancestor: The Cybernetic Tortoise, IEEE Spectrum, 2020 https://spectrum.ieee.org/tech-history/space-age/meet-roombas-ancestor-cybernetic-tortoise

Certificate I: Understanding AI and Machine Learning in Africa Course AIMLO1: Artificial Intelligence – Past, Present, and Future

#### Carnegie Mellon University Africa

Rotating photocell

### W. Grey Walter's Tortoises (1950)

- Roam around a room
- Find a charging station
- Recharge themselves.

"With just a photocell, a touch sensor, and two vacuum tubes, the robo-tortoise mimicked the way real animals move" (Marsh, 2020)



Meet the Roomba's Ancestor: The Cybernetic Tortoise, IEEE Spectrum, 2020 https://spectrum.ieee.org/tech-history/space-age/meet-roombas-ancestor-cybernetic-tortoise

#### Carnegie Mellon University Africa

Claude Shannon's Mouse (1950)

This was one of the world's first examples of machine learning: a robotic maze-solving mouse known as Theseus



https://www.technologyreview.com/2018/12/19/138508/mighty-mouse/

Certificate I: Understanding AI and Machine Learning in Africa Course AIMLO1: Artificial Intelligence – Past, Present, and Future Carnegie Mellon University Africa

Claude Shannon's Mouse

"These photos, published in Life magazine in 1952, show the path Theseus took while learning a maze pattern and the direct path taken on its second trip through the same maze"



Certificate I: Understanding AI and Machine Learning in Africa Course AIMLO1: Artificial Intelligence – Past, Present, and Future Carnegie Mellon University Africa



Walter McCulloch W. S. McCulloch and W. Pitts "A logical calculus of ideas immanent in nervous activity". Bulletin of Mathematical Biophysics 5:115–133, 1943

https://www.researchgate.net/publication/287293010\_Warren\_McCulloch\_and\_the\_British\_Cyberneticians/figures?lo=1

#### W. Ross Ashby, Warren McCulloch, William Grey Walter, Norbert Wiener at the 1951 Congress on Cybernetics, Paris

Certificate I: Understanding AI and Machine Learning in Africa Course AIMLO1: Artificial Intelligence – Past, Present, and Future

#### Carnegie Mellon University Africa

#### N. Wiener

Cybernetics: or the Control and Communication in the Animal and the Machine, **1948**.

#### (κυβερνητης or kybernetes: steersman)



W. S. McCulloch and W. Pitts "A logical calculus of ideas immanent in nervous activity". Bulletin of Mathematical Biophysics 5:115–133, **1943** 

Certificate I: Understanding AI and Machine Learning in Africa Course AIMLO1: Artificial Intelligence – Past, Present, and Future

#### **Carnegie Mellon University** Africa

W. Ross Ashby Design for a Brain, first edition, 1952 ... 1956, 1960. Introduction to Cybernetics, 1957

# Both Walter's and Shannon's robots built on behaviorist psychology

The link between two events is strengthened when they occur together or when they yield a reward

- using associative and reinforcement learning in relatively simple neural networks
- rather than focusing on internal models and symbolic computation



Meet the Roomba's Ancestor: The Cybernetic Tortoise, IEEE Spectrum, 2020 https://spectrum.ieee.org/tech-history/space-age/meet-roombas-ancestor-cybernetic-tortoise

Certificate I: Understanding AI and Machine Learning in Africa Course AIMLO1: Artificial Intelligence – Past, Present, and Future

#### Carnegie Mellon University Africa

Neural networks process information by

- propagating it through an interconnected layered network
- of relatively simple processing units: artificial neurons

These are very simplified versions of the neurons in biological brains



Credit: Adrian Rosebrock, Deep Learning for Computer Vision, PylmageSearch, 2017

Certificate I: Understanding AI and Machine Learning in Africa Course AIMLO1: Artificial Intelligence – Past, Present, and Future

#### Carnegie Mellon University Africa

Loosely speaking, these artificial neurons

- weight and aggregate the information received
- send a modified version of the result to other processing units

typically in the next layer



Credit: Adrian Rosebrock, Deep Learning for Computer Vision, PyImageSearch, 2017

Certificate I: Understanding AI and Machine Learning in Africa Course AIMLO1: Artificial Intelligence – Past, Present, and Future Carnegie Mellon University Africa

- Artificial neural networks that propagate results to the next layer are called feed-forward networks
- Networks that also propagate results back to previous layers are called recurrent neural networks



Credit: Adrian Rosebrock, Deep Learning for Computer Vision, PyImageSearch, 2017

Certificate I: Understanding AI and Machine Learning in Africa Course AIML01: Artificial Intelligence – Past, Present, and Future Carnegie Mellon University Africa



- The simple one-layer feed-forward networks ٠ developed in the 1960s are also called perceptrons
  - One perceptron can perform binary classification; — (provided their features can be separated by a straight line)
  - Several perceptrons can distinguish between several classes
- They are still in use today, in a modified form ٠

$O_{\mathcal{T}}$	
$\bigcirc$	
$\bigcirc$	
Layer 0	Layer 1

(Input layer)

#### **Carnegie Mellon University** Africa

- This approach is often referred to as connectionism
- It progressed in parallel with the computationalist approach over the next sixty years and more
- We'll say more about computationalist symbolic AI in Module 2, Lecture 1
- We'll say more about connectionist Al in Module, Lecture 2.



Credit: Adrian Rosebrock, Deep Learning for Computer Vision, PyImageSearch, 2017

Certificate I: Understanding AI and Machine Learning in Africa Course AIMLO1: Artificial Intelligence – Past, Present, and Future

#### Carnegie Mellon University Africa

# Strong and Weak Al

- From the outset, symbolic AI was concerned with producing intelligent artifacts that exhibited the versatility, flexibility, and robustness of humans in rational problem solving
- For this reason, it became known as strong Al
- Despite the early optimism, strong AI proved to be very difficult to achieve

Carnegie Mellon University Africa

# Strong and Weak Al

- Consequently, AI techniques began to be applied in more limited domains with stronger constraints and a narrower focus
- Targetting instead strong performance and robustness
- This approach became known as weak AI

Carnegie Mellon University Africa

# The AI Winter(s)

- Despite continual progress in both symbolic AI and connectionist AI in the 1970s and 1980s, performance on more challenging problems was disappointing
- The popularity of AI waned during a period known as the AI winter  $_{<}$
- Despite the lack of success in applications, research on statistical techniques and on neural networks continued
- We'll see the result of that research in the next lecture

As we will see in Module 2, Lecture 2, this was the second winter for connectionism. The first one happened in the early 1970s

Just as it had done in the connectionist AI winter in the 1970s

Carnegie Mellon University Africa

# Lecture Summary

- 1. John McCarthy coined the term Artificial Intelligence in a proposal for a summer project at Dartmouth College in 1956, attended by several pioneers in the field
- 2. This led to the birth of computational AI, focusing on symbolic representations and logic-based rational reasoning, emulating human intelligence. It is often referred to as GOFAI: good old-fashioned AI
- 3. The focus on human-level intelligence, exhibiting versatility, flexibility, robustness, is often referred to as Strong AI. It proved harder than anticipated.
- 4. Alternative approaches, often referred to as Weak AI, targeted more limited goals with greater success.

Carnegie Mellon University Africa

# Lecture Summary

- 5. All also has roots in an alternative approach based on cybernetics, championed by Norbert Wiener, W. Ross Ashby, and others.
- 6. Cybernetics focusses on self-organization, regulation, and control, rather than internal symbolic representations of the world in which the intelligence agent is situated.
- 7. This approach also targeted the use of neural networks and connectionist models of intelligent behavior
- 8. Lack of early success gave rise to a decrease in interest in AI during a period known as the AI winter. In fact, there were two AI winters, one in the early 1970s that mostly affected connectionist approaches, and one in the 1980s that impacted both symbolic and connectionist approaches

Carnegie Mellon University Africa

# **Recommended Reading**

Jordan, M. I. (2019). Artificial Intelligence — The Revolution Hasn't Happened Yet. Harvard Data Science Review, 1(1).

https://doi.org/10.1162/99608f92.f06c6e61

**Carnegie Mellon University** Africa

# References

McCarthy, J., Minsky, M. L., Rochester, N., & Shannon, C. E. (2006). A Proposal for the Dartmouth Summer Research Project on Artificial Intelligence, August 31, 1955. Al Magazine, 27(4), 12. https://doi.org/10.1609/aimag.v27i4.1904.

Moor, J.H. (2006). The Dartmouth College Artificial Intelligence Conference: The Next Fifty Years. Al Magazine, 27, 87-91.

https://ojs.aaai.org//index.php/aimagazine/article/view/1911

Marsh, A. (2020). Meet the Roomba's Ancestor: The Cybernetic Tortoise, IEEE Spectrum, February. https://spectrum.ieee.org/tech-history/space-age/meet-roombas-ancestor-cybernetic-tortoise

Carnegie Mellon University Africa