

Artificial Intelligence: A Natural Pursuit

Shivaram Kalyanakrishnan

`shivaram@cse.iitb.ac.in`

Department of Computer Science and Engineering
Indian Institute of Technology Bombay

January 2019

What is AI?

What recently happened to AI?

Topics in AI

- Machine Learning (Supervised, Unsupervised, Reinforcement)
- Neural Networks and Deep Learning
- Computer Vision and Robotics
- Speech and Natural Language Processing
- Multiagent Systems: Game Theory and Mechanism Design
- Crowdsourcing
- Planning and Scheduling

What is AI?

What recently happened to AI?

Topics in AI

- Machine Learning (Supervised, Unsupervised, Reinforcement)
- Neural Networks and Deep Learning
- Computer Vision and Robotics
- Speech and Natural Language Processing
- Multiagent Systems: Game Theory and Mechanism Design
- Crowdsourcing
- Planning and Scheduling

Imagination and Reality



From the Mahabharata^[1]

[1] <http://www.holy-bhagavad-gita.org/public/images/bg/1.jpg>

Imagination and Reality



From the Mahabharata^[1]



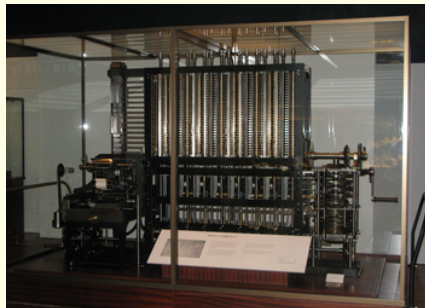
Modern-day videoconferencing^[2]

[1] <http://www.holy-bhagavad-gita.org/public/images/bg/1.jpg>

The Urge to Replicate Human Behaviour and Thought



Automaton, Swiss CIMA Museum^[1]



Babbage's Difference Engine (1830s)^[2]

[1] https://upload.wikimedia.org/wikipedia/commons/thumb/6/6e/CIMA_mg_8332.jpg/220px-CIMA_mg_8332.jpg

[2] https://upload.wikimedia.org/wikipedia/commons/8/8b/Babbage_Difference_Engine.jpg

AI: Definitions

“It may even be proposed, as a rule of thumb, that any activity computers are able to perform and people once performed should be counted as an instance of intelligence.”

Artificial Intelligence and Life in 2030, Peter Stone, Rodney Brooks, Erik Brynjolfsson, Ryan Calo, Oren Etzioni, Greg Hager, Julia Hirschberg, Shivaram Kalyanakrishnan, Ece Kamar, Sarit Kraus, Kevin Leyton-Brown, David Parkes, William Press, AnnaLee Saxenian, Julie Shah, Milind Tambe, and Astro Teller. One Hundred Year Study on Artificial Intelligence: Report of the 2015-2016 Study Panel, Stanford University, Stanford, CA, September 2016.

AI: Definitions

“It may even be proposed, as a rule of thumb, that any activity computers are able to perform and people once performed should be counted as an instance of intelligence.”

Artificial Intelligence and Life in 2030, Peter Stone, Rodney Brooks, Erik Brynjolfsson, Ryan Calo, Oren Etzioni, Greg Hager, Julia Hirschberg, Shivaram Kalyanakrishnan, Ece Kamar, Sarit Kraus, Kevin Leyton-Brown, David Parkes, William Press, AnnaLee Saxenian, Julie Shah, Milind Tambe, and Astro Teller. One Hundred Year Study on Artificial Intelligence: Report of the 2015-2016 Study Panel, Stanford University, Stanford, CA, September 2016.

“Artificial intelligence is that activity devoted to making machines intelligent, and intelligence is that quality that enables an entity to function appropriately and with foresight in its environment.”

The Quest for Artificial Intelligence: A History of Ideas and Achievements, Nils J. Nilsson, Cambridge University Press, 2010.

AI: Definitions

"It may even be proposed, as a rule of thumb, that any activity computers are able to perform and people once performed should be counted as an instance of intelligence."

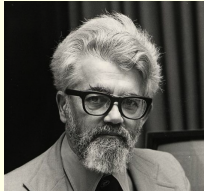
Artificial Intelligence and Life in 2030, Peter Stone, Rodney Brooks, Erik Brynjolfsson, Ryan Calo, Oren Etzioni, Greg Hager, Julia Hirschberg, Shivaram Kalyanakrishnan, Ece Kamar, Sarit Kraus, Kevin Leyton-Brown, David Parkes, William Press, AnnaLee Saxenian, Julie Shah, Milind Tambe, and Astro Teller. One Hundred Year Study on Artificial Intelligence: Report of the 2015-2016 Study Panel, Stanford University, Stanford, CA, September 2016.

"Artificial intelligence is that activity devoted to making machines intelligent, and intelligence is that quality that enables an entity to function appropriately and with foresight in its environment."

The Quest for Artificial Intelligence: A History of Ideas and Achievements, Nils J. Nilsson, Cambridge University Press, 2010.

AI Paradox: Once we understand how X works, X is no longer AI!

Dartmouth Summer Research Project on Artificial Intelligence (1956)



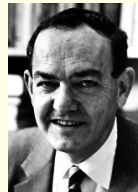
John McCarthy (1927–2011)^[1]



Marvin Minsky (1927–2016)^[2]



Allen Newell (1927–1992)^[3]



Herbert Simon (1916–2001)^[4]

[1] <https://www.wired.com/wp-content/uploads/blogs/wiredenterprise/wp-content/uploads/2011/10/john-mccarthy.png>

[2] https://pi.tedcdn.com/r/pe.tedcdn.com/images/ted/55211_254x191.jpg?

[3] http://amturing.acm.org/images/lg_aw/3167755.jpg

[4] http://www.nobelprize.org/nobel_prizes/economic-sciences/laureates/1978/simon.jpg

1950's–1980's

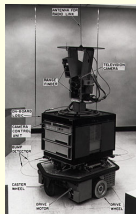
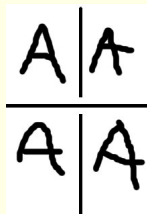
Theorem proving: **Logic Theorist** (Newell and Simon).

Mobile robotics: **Shakey** (Rosen).

Pattern recognition: **Pandemonium** (Selfridge).

Speech processing: **Spoken language systems** (Reddy).

Expert systems: **Dendral** (Feigenbaum).

Shakey^[1]OCR^[2]

[1] https://upload.wikimedia.org/wikipedia/commons/thumb/0/0c/SRI_Shakey_with_callouts.jpg/250px-SRI_Shakey_with_callouts.jpg

[2] https://upload.wikimedia.org/wikipedia/commons/7/79/More_A's.jpg

1950's–1980's

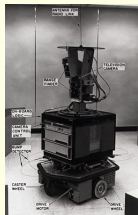
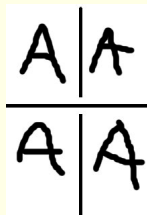
Theorem proving: **Logic Theorist** (Newell and Simon).

Mobile robotics: **Shakey** (Rosen).

Pattern recognition: **Pandemonium** (Selfridge).

Speech processing: **Spoken language systems** (Reddy).

Expert systems: **Dendral** (Feigenbaum).

Shakey^[1]OCR^[2]

1980's: AI Winter!

[1] https://upload.wikimedia.org/wikipedia/commons/thumb/0/0c/SRI_Shakey_with_callouts.jpg/250px-SRI_Shakey_with_callouts.jpg

[2] https://upload.wikimedia.org/wikipedia/commons/7/79/More_A's.jpg

What is AI?

What recently happened to AI?

Topics in AI

- Machine Learning (Supervised, Unsupervised, Reinforcement)
- Neural Networks and Deep Learning
- Computer Vision and Robotics
- Speech and Natural Language Processing
- Multiagent Systems: Game Theory and Mechanism Design
- Crowdsourcing
- Planning and Scheduling

AI in Life Today



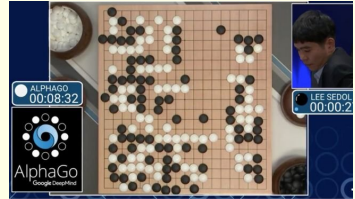
[1]



[2]



[3]



[4]

[1] <https://fortunedotcom.files.wordpress.com/2016/04/gettyimages-152435606-1.jpg>

[2] <http://www.extremetech.com/wp-content/uploads/2012/08/Google500KmilesLexus.jpg>

[3] <http://www.in.techradar.com/photo/52119657/news/This-STAR-robot-is-better-at-soft-tissue-surgery-than-a-human.jpg>

[4] <https://media.licdn.com/mpr/mpr/AAEAAQAAAAAAAAARQAAAAJGZmMGZhYWxLTE0NDQ1Ni1iNWE3LTJlNWVhYWFhMmJjNg.jpg>

Internet

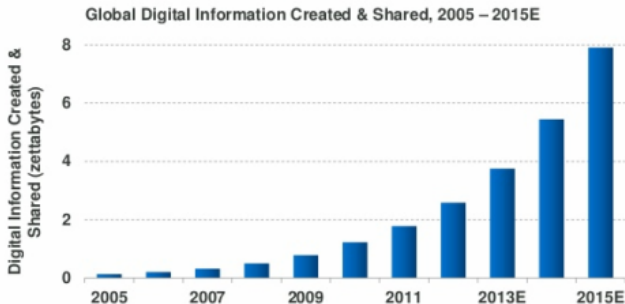


[1]

[1] <http://images.financialexpress.com/2015/09/Internet-connectivity.jpg>

World's Content is Increasingly Findable + Shared + Tagged - Digital Info Created + Shared up 9x in Five Years

*Amount of global digital information created & shared
– from documents to pictures to tweets –
grew 9x in five years to nearly 2 zettabytes* in 2011, per IDC.*

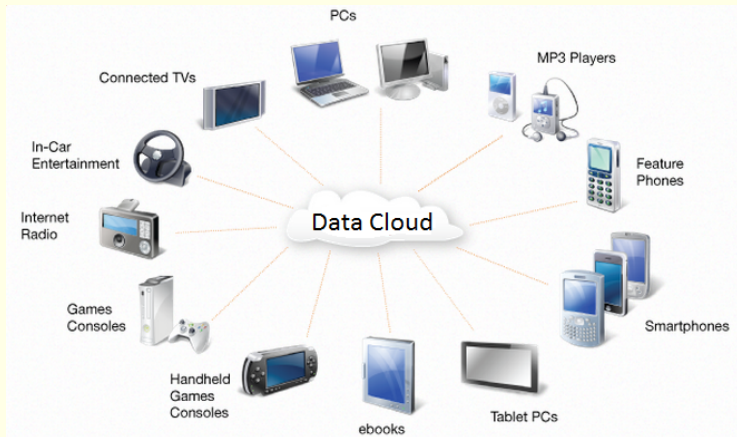


KPCB

Note: * 1 zettabyte = 1 trillion gigabytes. Source: IDC report "Extracting Value from Chaos" 6/11. 11

[1]

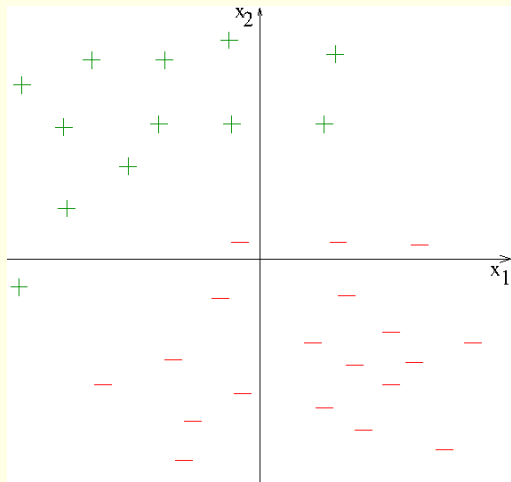
Cheaper Hardware and Sensors



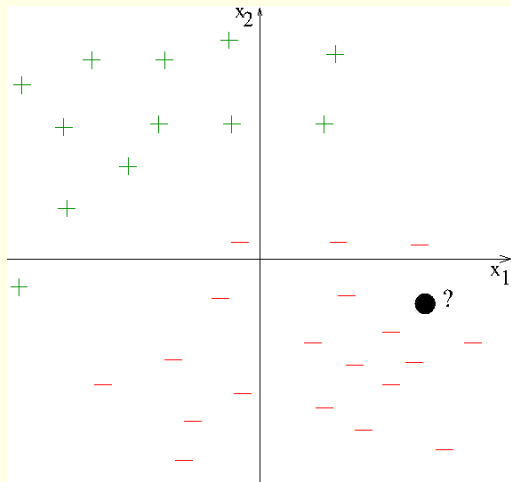
[1]

[1] <https://smist08.files.wordpress.com/2012/09/clouddevices.png>

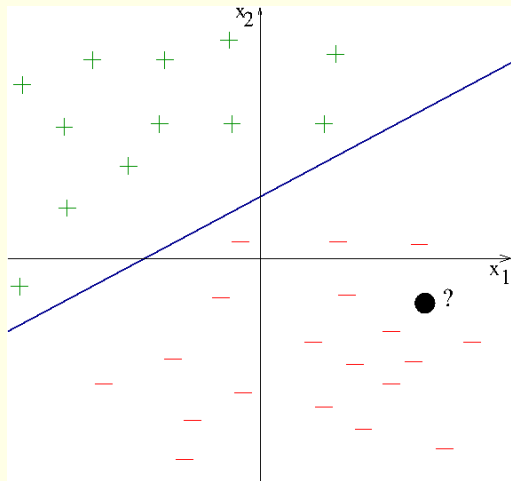
Machine Learning



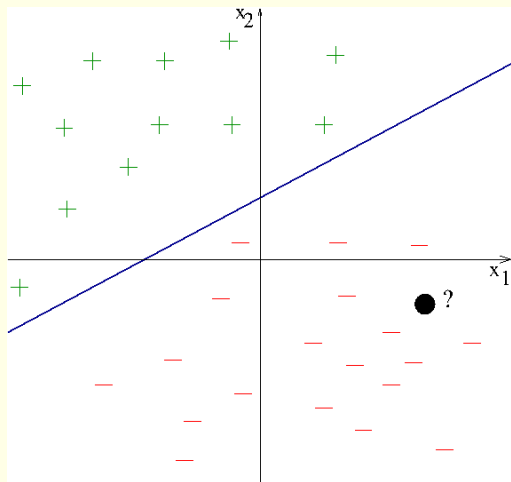
Machine Learning



Machine Learning



Machine Learning

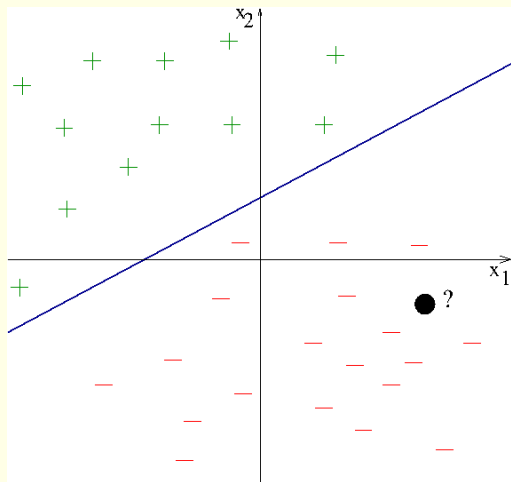


x_1	x_2	Label
12	1	-
-4	20	+
-15	-2	+
-4	-4	-
15	-6	-

Learn a model

16	-7	?
----	----	---

Machine Learning



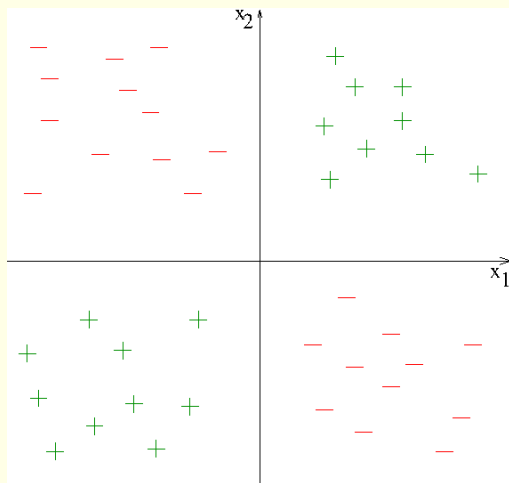
x_1	x_2	Label
12	1	-
-4	20	+
-15	-2	+
-4	-4	-
15	-6	-

Learn a model

16	-7	?
----	----	---

Face recognition, Credit-card fraud discovery, Sentiment analysis, . . .

Machine Learning



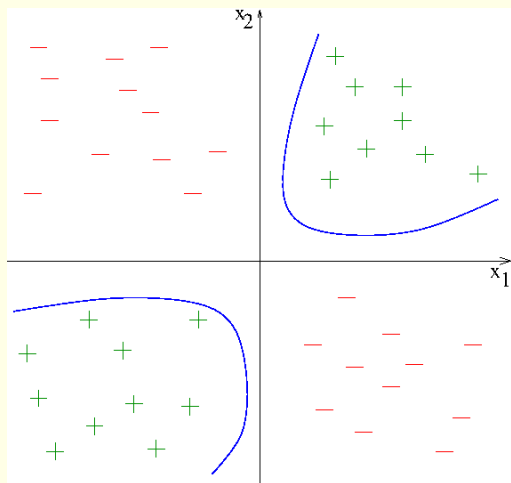
x_1	x_2	Label
12	1	-
-4	20	+
-15	-2	+
-4	-4	-
15	-6	-

Learn a model

16	-7	?
----	----	---

Face recognition, Credit-card fraud discovery, Sentiment analysis,

Machine Learning



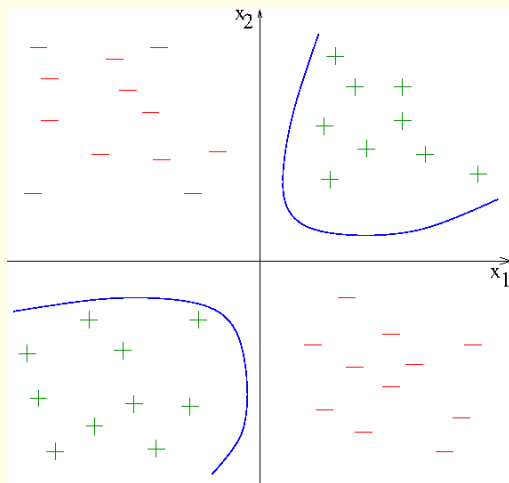
x_1	x_2	Label
12	1	-
-4	20	+
-15	-2	+
-4	-4	-
15	-6	-

Learn a model

16	-7	?
----	----	---

Face recognition, Credit-card fraud discovery, Sentiment analysis,

Machine Learning



x_1	x_2	Label
12	1	-
-4	20	+
-15	-2	+
-4	-4	-
15	-6	-

Learn a model

16	-7	?
----	----	---

Face recognition, Credit-card fraud discovery, Sentiment analysis,

Deep learning can find highly non-linear patterns in visual, audio data.

What is AI?

What recently happened to AI?

Topics in AI

- Machine Learning (Supervised, Unsupervised, Reinforcement)
- Neural Networks and Deep Learning
- Computer Vision and Robotics
- Speech and Natural Language Processing
- Multiagent Systems: Game Theory and Mechanism Design
- Crowdsourcing
- Planning and Scheduling

Machine Learning: Supervised Learning

Given labeled data, produce model to predict labels for unseen data.

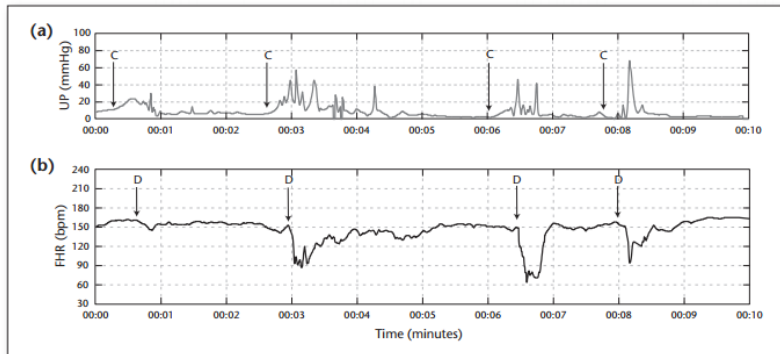


Figure 2. CTG Signal over 10 Minutes, Including Four Contraction-Deceleration Pairs.

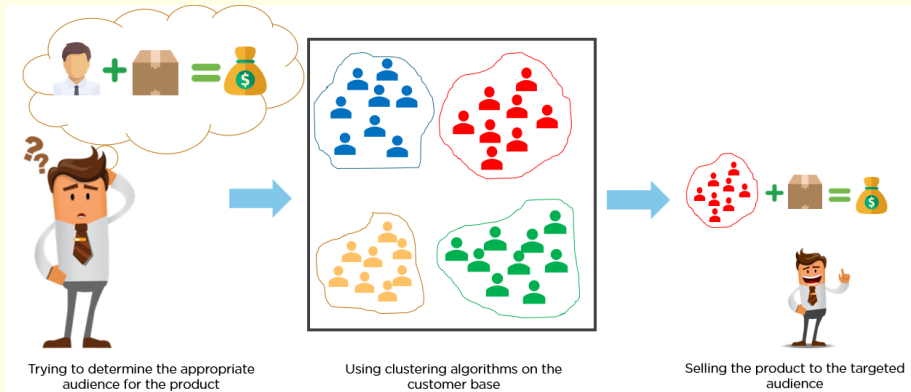
Top: UP signal with contraction onsets (C) indicated. Bottom: FHR signal with deceleration onsets (D) indicated.

[1]

1. A Machine Learning Approach to the Detection of Fetal Hypoxia during Labor and Delivery, Philip A. Warrick, Emily F. Hamilton, Robert E. Kearney, Doina Precup, *AI Magazine*, 33(2):79–90, AAAI Press, 2012.

Machine Learning: Unsupervised Learning (Clustering)

Given unlabeled data, produce model to assign to clusters.

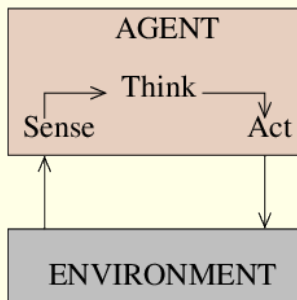


[1] <https://qph.ec.quoracdn.net/main-qimg-3bed74bc6559f62e6bbc2cdeea74f1dc>

Machine Learning: Reinforcement Learning

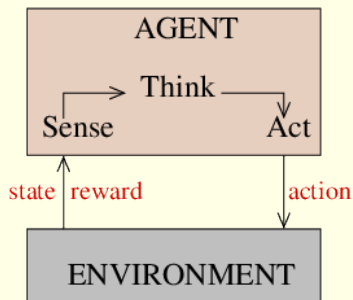
Answer: Reinforcement Learning (RL).

Machine Learning: Reinforcement Learning



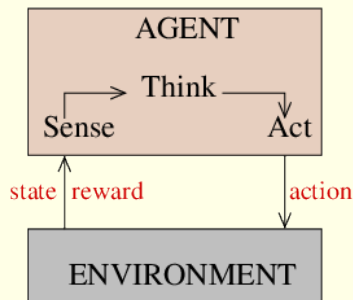
Answer: Reinforcement Learning (RL).

Machine Learning: Reinforcement Learning



Answer: Reinforcement Learning (RL).

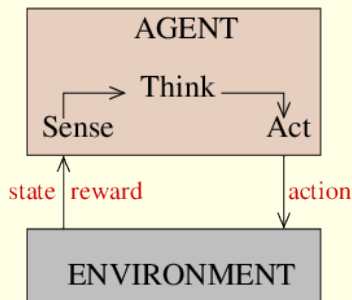
Machine Learning: Reinforcement Learning



Question: How must an agent in an *unknown* environment act so as to maximise its long-term reward?

Answer: Reinforcement Learning (RL).

Machine Learning: Reinforcement Learning



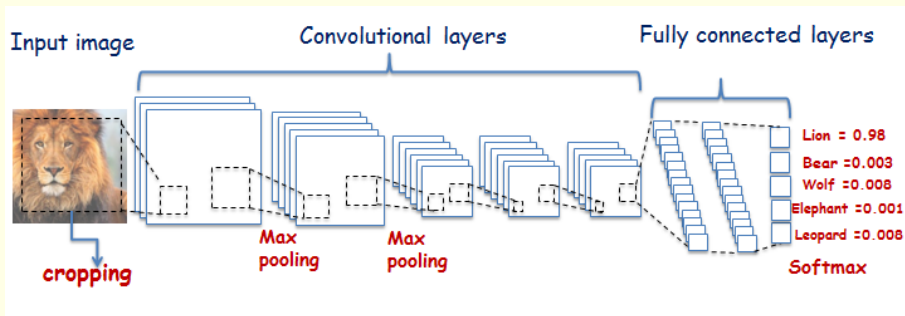
Question: How must an agent in an *unknown* environment act so as to maximise its long-term reward?

Answer: Reinforcement Learning (RL).

Learning to play breakout [Video¹]

[1] <https://www.youtube.com/watch?v=TmPfTpjtdgg>

Neural Networks and Deep Learning



[1]

[1] <https://www.rug.nl/research/alice/autonomus-perceptive-systems/plaatjes-pdf/modified-alexnet.png>

Computer Vision and Robotics

Objective: Integrate **Sensing**, **Thinking**, and **Acting** to perform task.

[Video of task 1]

1. <https://www.youtube.com/watch?v=-mOS5FknyLo>

Computer Vision and Robotics

Objective: Integrate **Sensing**, **Thinking**, and **Acting** to perform task.

[Video of task 1]

[Video of task 2]

1. <https://www.youtube.com/watch?v=-mOS5FknyLo>
2. <https://www.youtube.com/watch?v=LdQw8PSV2P8>

Computer Vision and Robotics

Objective: Integrate **Sensing**, **Thinking**, and **Acting** to perform task.

[Video of task 1]

[Video of task 2]

[Video of task 3]

1. <https://www.youtube.com/watch?v=-mOS5FknyLo>
2. <https://www.youtube.com/watch?v=LdQw8PSV2P8>
3. <https://www.youtube.com/watch?v=0d8qwrGHPR8>

Speech and Natural Language Processing



[1]

Topics: Text summarisation, Sentiment analysis, Machine translation, etc.

[1] <http://previews.123rf.com/images/reddees/reddees0712/reddees071200067/>

2262365-View-of-Indian-10-Ruppee-Bank-Note-on-white-showing-value-in-14-indian-languages-Stock-Photo.jpg

Multiagent Systems: Game Theory and Mechanism Design

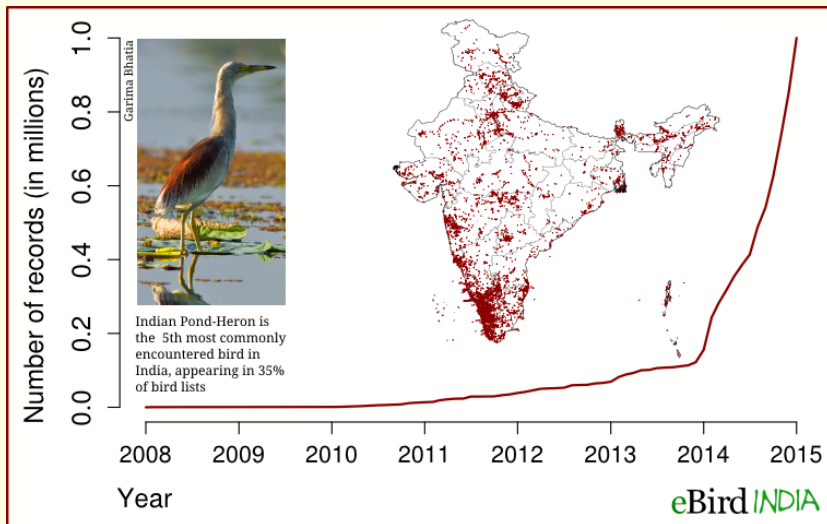


[1]

Security and game theory: algorithms, deployed systems, lessons learned,
Milind Tambe, Cambridge University Press, 2012.

[1] <http://static.seattletimes.com/wp-content/uploads/2016/03/113a962a-f152-11e5-97c9-1641d1868cca-1020x599.jpg>

Crowdsourcing



[1]

[1] <http://www.birdcount.in/wp-content/uploads/2015/02/eBird-growth.png>

Planning and Scheduling



[1]

[1] https://ak.jogurucdn.com/media/image/p15/media_gallery-2015-12-16-7-fotor_delhi_3dd7a445519e5fc50a3459bc558a24f3.jpg