National University
of Computer & Emerging Sciences

AI2002 Artificial Intelligence

Undergraduate Course

SPRING 2022

Instructor and AI Course Coordinator

Dr. Muhammad Farrukh Shahid

Computer Science Department NUCES-FAST Karachi

Welcome to the Course

My Research Area (Not Limited But Majors)

- AI techniques and Probabilistic Models for Anomalies detection in CR-IoT Network
- Deep Learning models for Autonomous Vehicles and UAVs
- Signal Processing techniques for 6G Mobile Networks

Course Description (Interesting Ingredient)

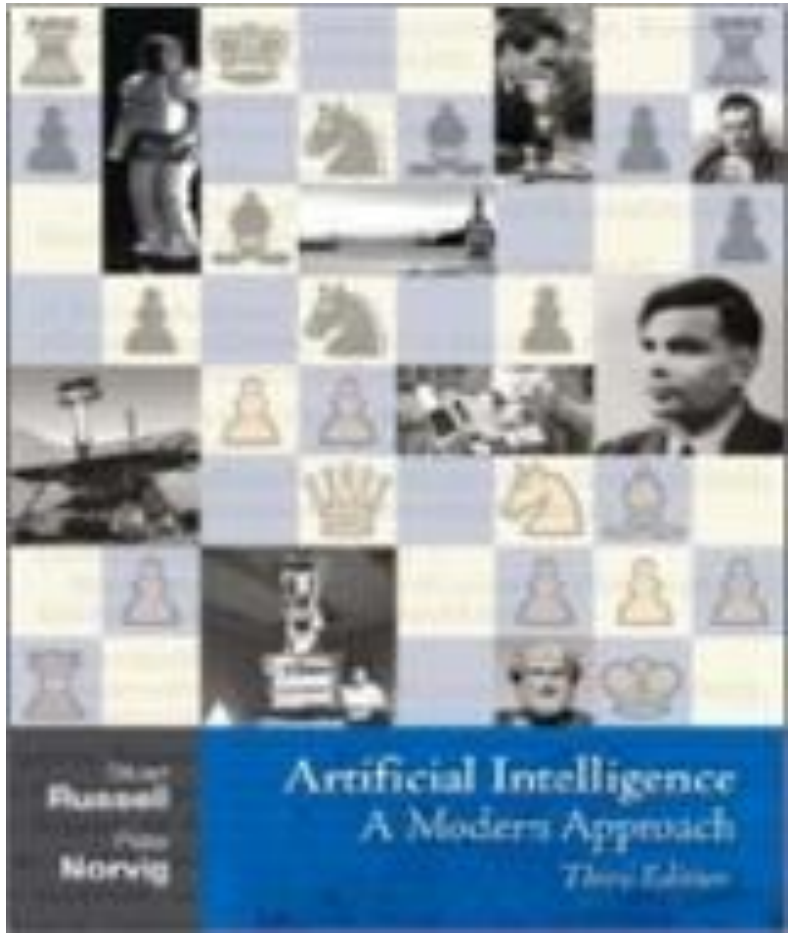
Marks Distribution

Assessment Item	Number	Weight (%)
Assignments	4	**10**
Midterm Exam	2	**15 each**
Project (Theory / Lab)	1	**10**
Final Exam	1	**50**

Teaching Material:

Textbook:

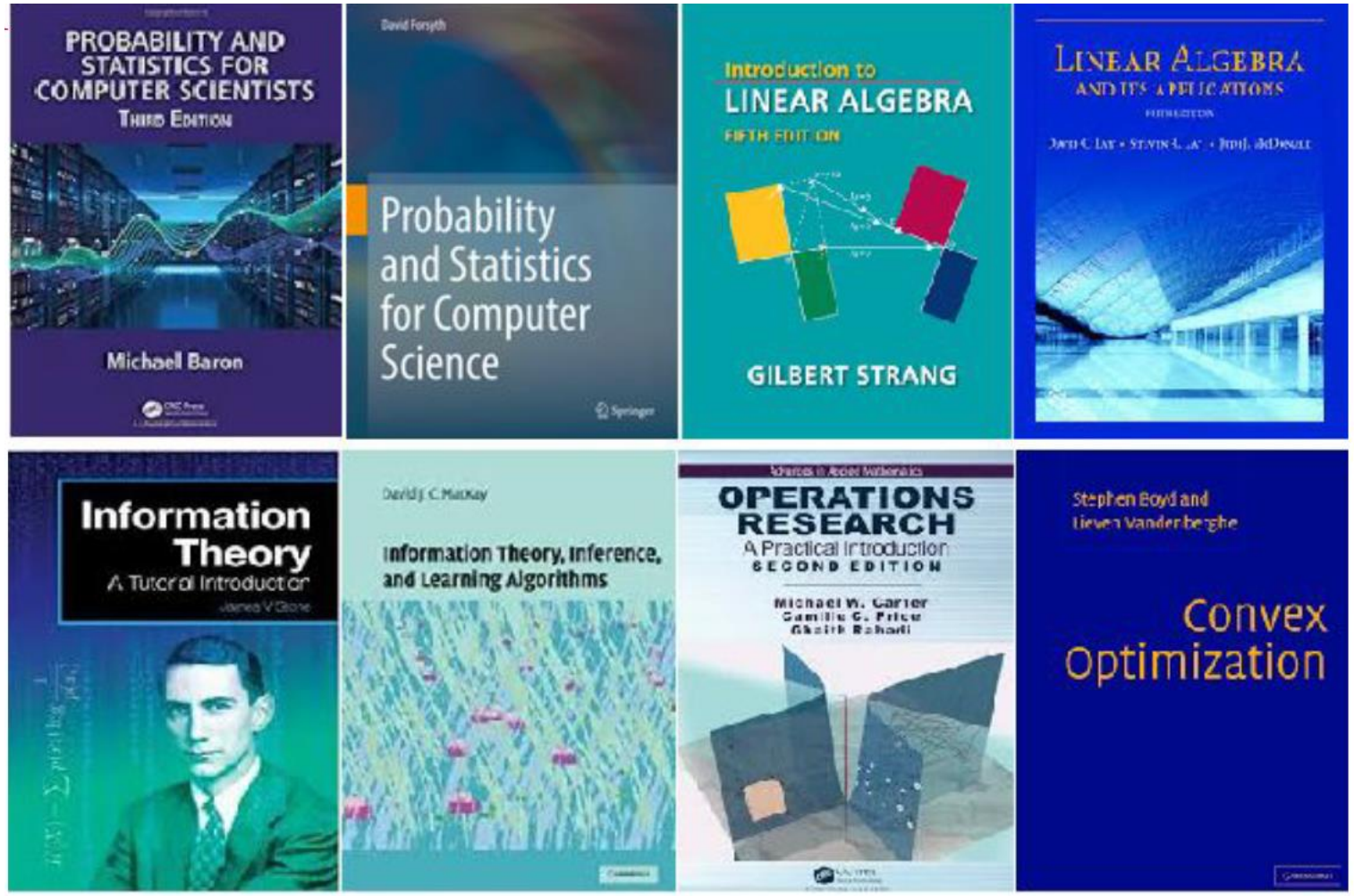
S. Russell and P. Norvig: ***Artificial Intelligence: A Modern Approach***. Pearson, 2010, *3rd Edition*



Additional Resources

http://aima.cs.berkeley.edu/

Books and Supporting Material

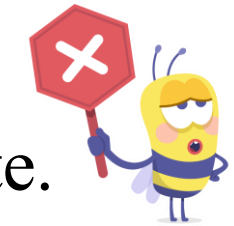


Reference Material / Books *(For your Future Need as well)*

1. Mathematics for Machine Learning, Marc Peter Deisenroth, A. Aldo Faisal, and Cheng Soon Ong, Cambridge University Press, 2020 ISBN-13: 978-1108455145
2. Probability and Statistics for Computer Scientists, Michael Baron, 3rd Edition (or 2nd Edition), CRC Press, 2019
3. Python for Probability, Statistics and Machine Learning, José Unpingco, Springer International, 2016
4. Probability and Statistics for Computer Science, David Forsyth, 1st Edition, Springer International, 2018
5. Basics of Linear Algebra for Machine Learning: Discover the Mathematical Language of Data in Python, Jason Brownlee, 2018
6. Introduction to Linear Algebra, Gilbert Strang, 5th Edition, Wellesley – Cambridge Press, 2016
7. Linear Algebra and its Applications, David C. Lay and Steven R. Lay, 5th Edition, Pearson Education, 2016
8. Information Theory, A tutorial Introduction, James V. Stone, 1st Edition, Sebtel Press, 2015
9. Information Theory, Inference, and Learning Algorithms, David J. C. MacKay, 4th Printing, Cambridge University Press, 2003
10. Convex Optimization, Boyd and Vandenberghe, Cambridge University Press, 2004

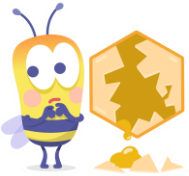
Tutorials, Handouts, and Scientific Research Papers

Class Room Policies – Pay attention



- Don’t come into the class if you are late.
- Don’t sit in my class for time passing or you have less interest.
- Attend the class with full motivation and passion.

Remember you are in the class to learn something new.



Class Room Policies

Activities such as Lecture recording and taking Photos of the board are not allowed

Course Policies – Pay attention

- Assignments must be submitted with in ***due dates***.
- Late submission will be subjected to the penalty which is as follow:

After ***2*** days of deadline ***30 %*** of marks deductions
After ***4*** days of deadline ***40 %*** of marks deductions
After ***5*** days of deadline ***100 %*** of marks deductions

- Student contact hours in my office are

Thursday 10:00 AM - 1:00 PM

Above all:

- Maintain Discipline in the class. Not even in class overall in your personality.
- May be lecture is not interesting for you. But for someone who wants to learn something so let him / her to learn.
- We have to grow as a **Nation** not individual.

Communication rules and Contact hours

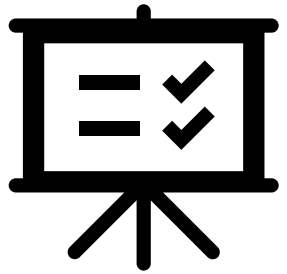
- For your queries related to the course, send an email to the following email address with clearly mention your Class and Student ID in the SUBJECT of an email.

mfarrukh.shahid@nu.edu.pk

Or you can visit the office (in contacting hours) **Academic Block 3 Room no 06**

Or discuss in the class (this is highly subjected to the time availability in a class)

*The **Course** objectives are follows,*



Course Objectives

- How AI has been changing the world ?
- From theory to the practical – Neuron -> UAVs, Robots etc.
- Insights of Model-driven and Data-Driven approaches.
- How to introduce intelligence into the devices of IoT network, 6G mobile networks ?
- Give you full insight to chose your Final Year Project.
- Developing International Collaboration
- Roadmap for Higher Education Abroad

Course Content

National Computing Education Accreditation Council
NCEAC

NCEAC.FORM.001-D

COURSE DESCRIPTION FORM: AI2002 / AL2002 Artificial Intelligence (AI)

COURSE DESCRIPTION FORM

INSTITUTION FAST School of Computing, National University of Computer and Emerging Sciences, Karachi

PROGRAM TO BE EVALUATED BS-CS– Spring 2022

Course Description

Course Code	AI2002 / AL2002
Course Title	Artificial Intelligence
Credit Hours	3+1
Prerequisites by Course(s) and Topics	-
Grading Policy	Absolute grading
Policy about missed assessment items in the course	Retake of missed assessment items (other than midterm/ final exam) will not be held. For a missed midterm/ final exam, an exam re-take/ pre-take application along with necessary evidence are required to be submitted to the department secretary. The examination assessment and retake committee will decide the exam re-take/ pre-take cases.
Course Plagiarism Policy	Plagiarism in project or midterm/ final exam may result in F grade in the course. Plagiarism in an assignment will result in zero marks in the **whole assignments** category.
Assessment Instruments with Weights (homework, quizzes, midterms, final, programming assignments, lab work, etc.)	***75% Theory 25% Practical*** Assessment Items

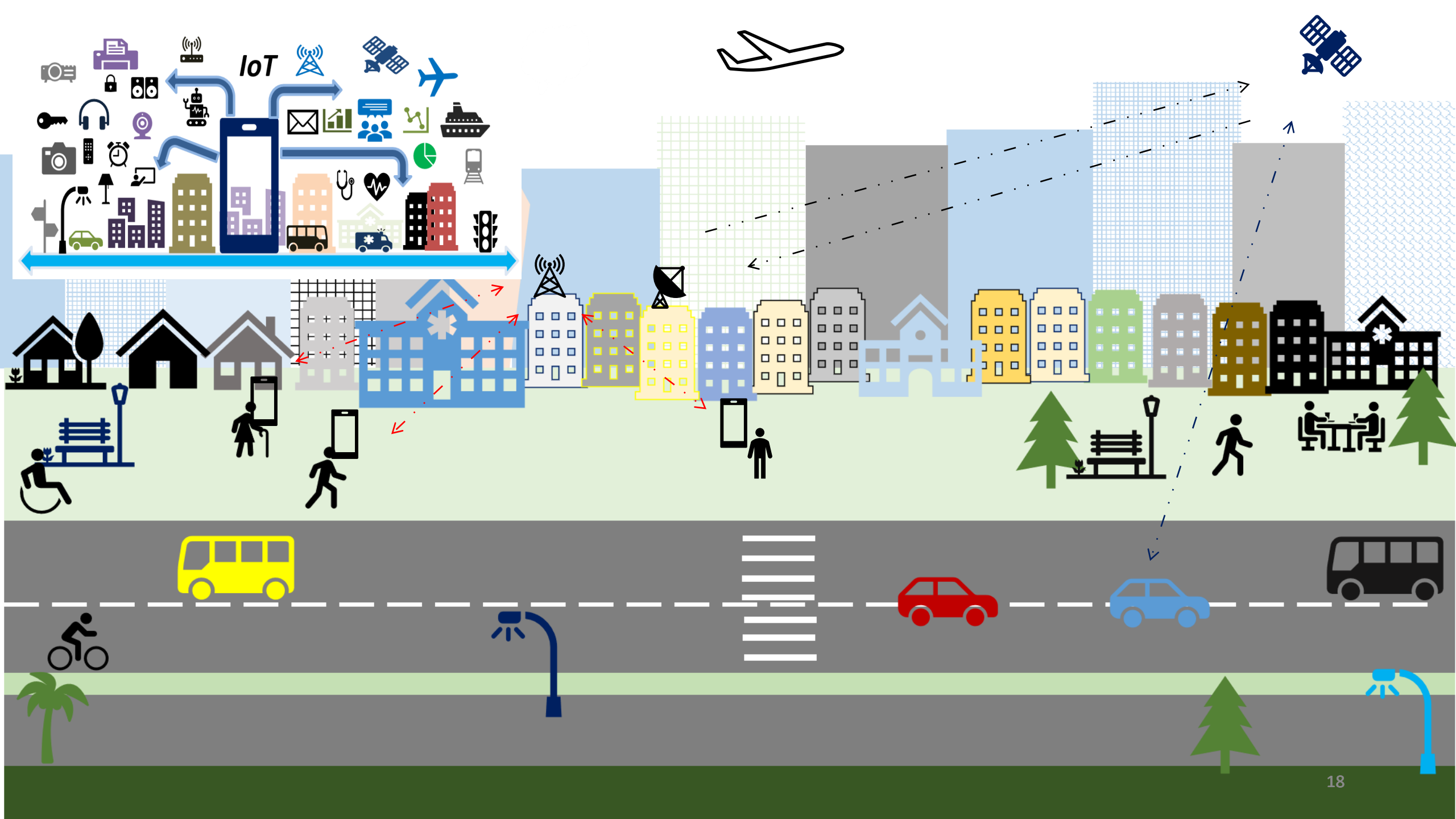
Assessment Item	Number	Weight (%)
Assignments	4	10
Midterm Exam	2	15 each
Project (Theory / Lab)	1	10
Final Exam	1	50

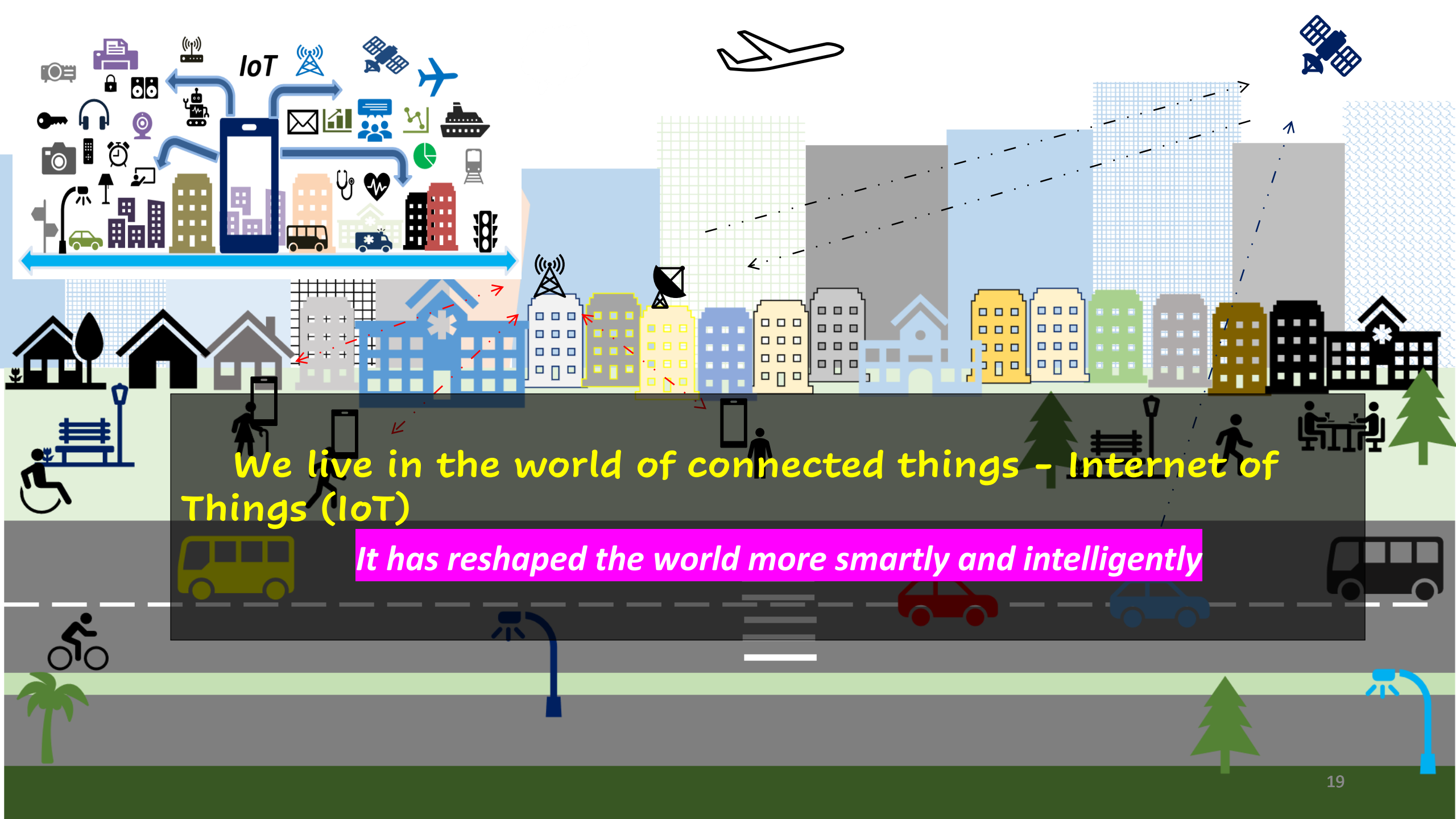
Course Instructors	
Lab Instructors (if any)	
Course Coordinator	Dr. Muhammad Farrukh Shahid
URL (if any)	
Current Catalog Description	This course introduces students to the basic knowledge representation, problem solving, and learning methods of artificial intelligence. Upon completion, students should be able to develop

1

NCEAC.FORM.001.D

Let’s explore 


IoT



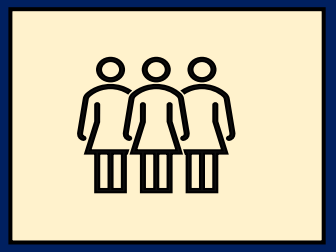
We live in the world of connected things - Internet of Things (IoT)

It has reshaped the world more smartly and intelligently


Objects everywhere

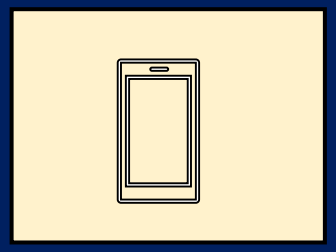
Digital around the world[1]

Total Population



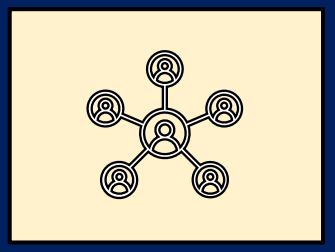
7.87
Billion
56.6 %
Urbanisation

Unique mobile phone users



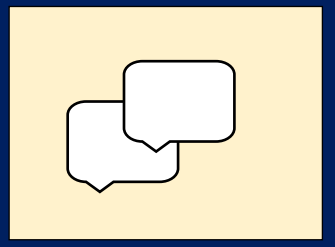
5.27
Billion
66.6 %
Population

Internet users



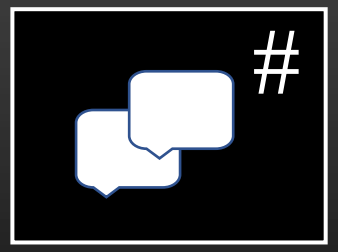
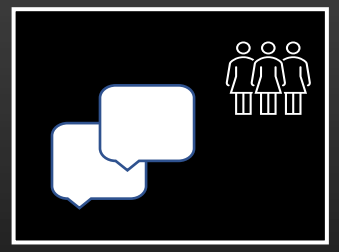
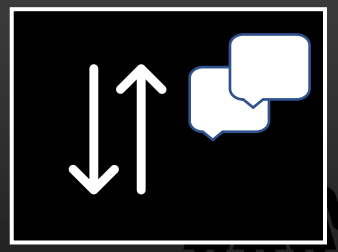
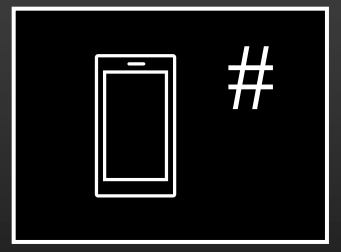
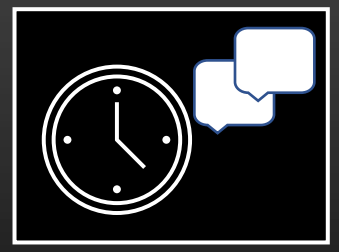
4.80
Billion
60.9 %
Population

Active Social media users



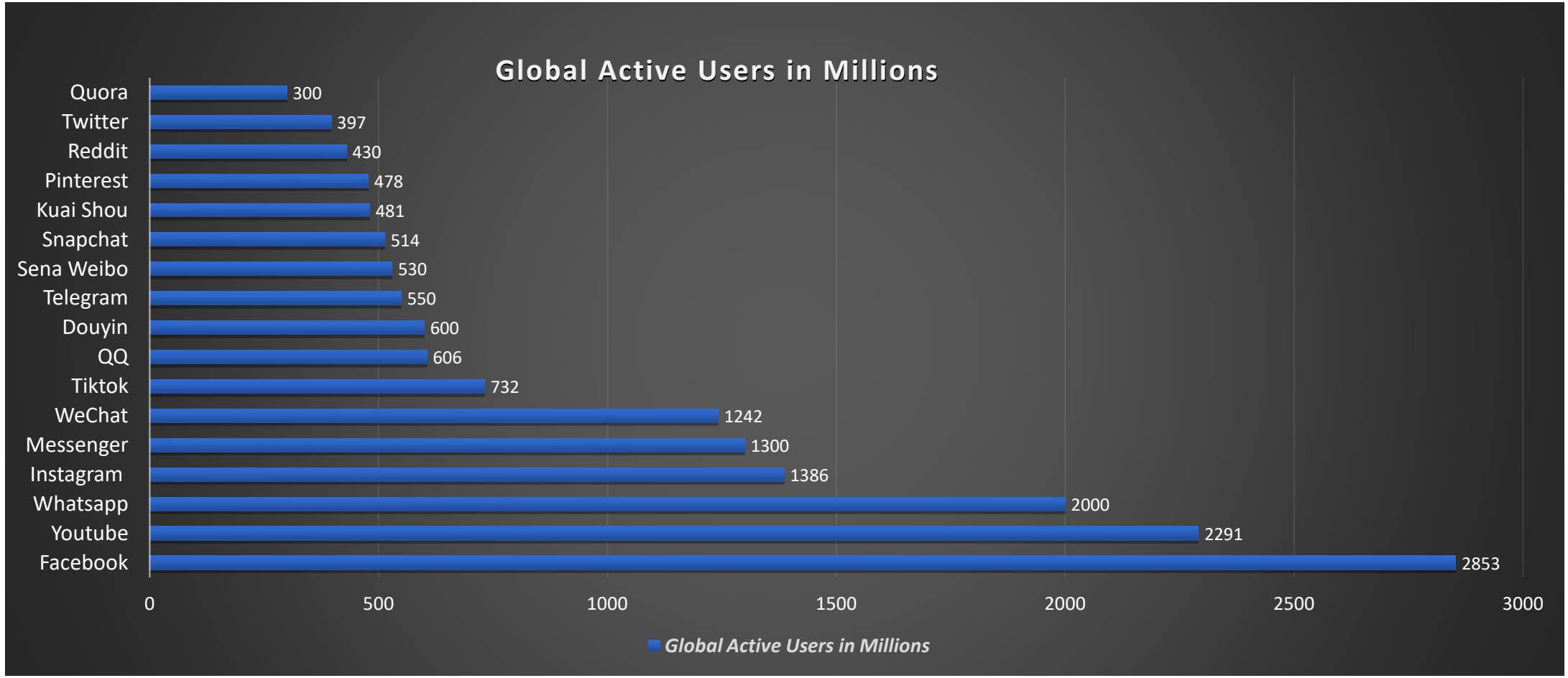
4.48
Billion
56.8 %
Population

Latest Statistics of Data generated by Social Media around the world [2]

Total number of active social media users	*Social media users as a % of the Global population*	*Annual change in the number of Global Social media users*	*Percentage of social media users accessing via mobile phones*	*Average amount of time per day spent using social media*
				
4.48 Billion	56.8 %	+13.1 % +520 Million	99.0 %	2H 24 M

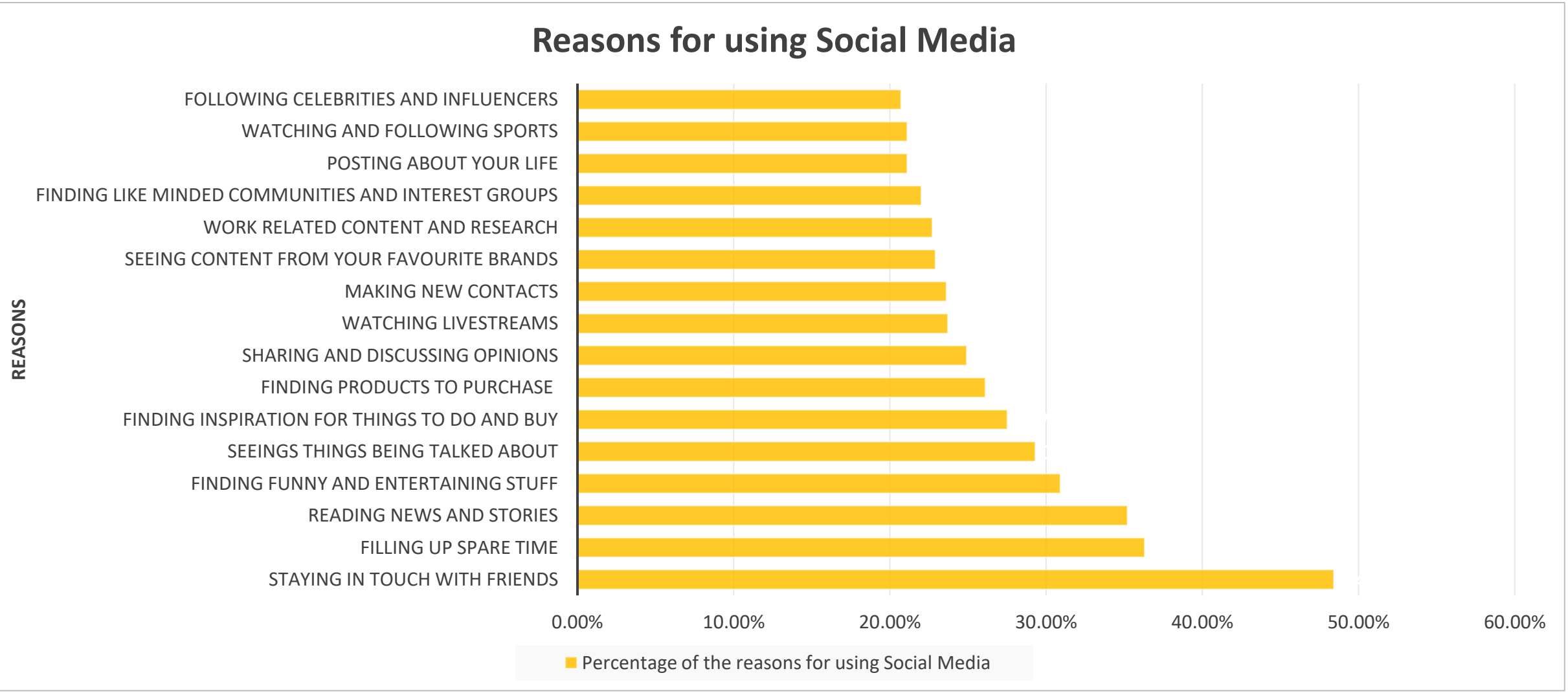
Digital adoptations around the world in 2021 [3]

Statistics insights !



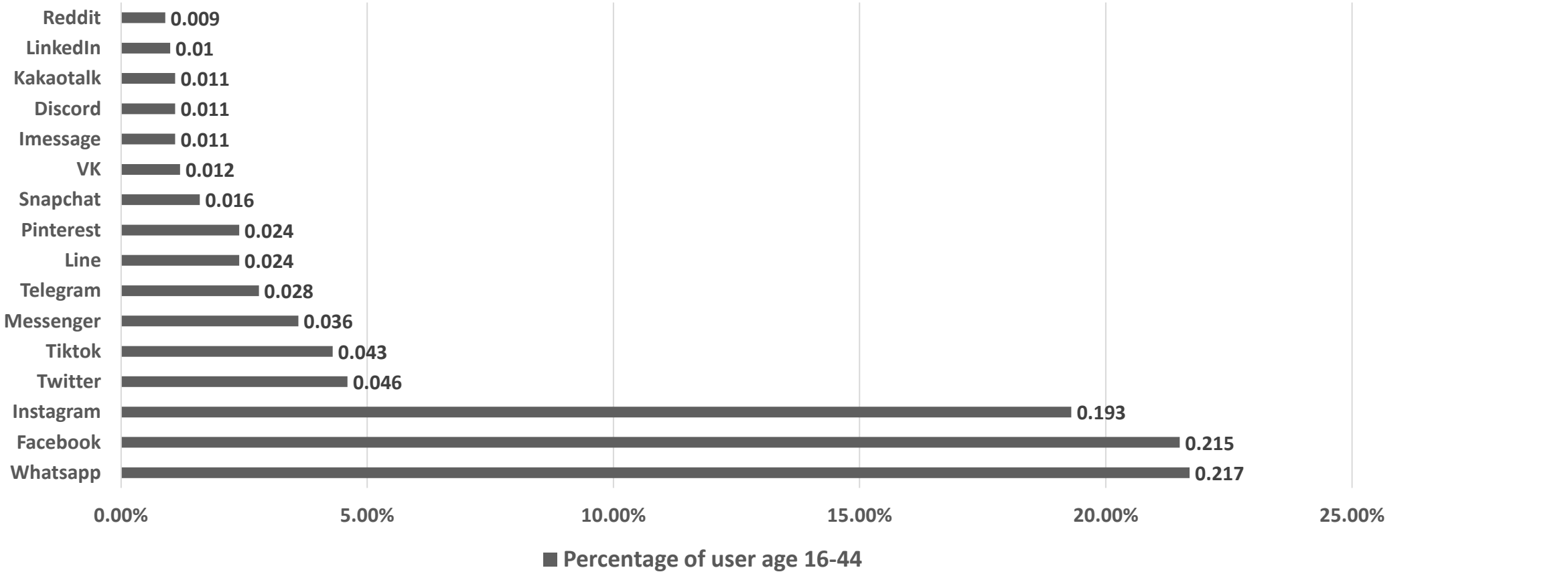
Digital adoptations around the world in 2021 [4]

Statistics insights !



Digital adoptations around the world in 2021[5]

Statistics insights !



[1,2,3,4,5] https://datareportal.com/social-media-users

Everyday we generate approximately the following amount of data

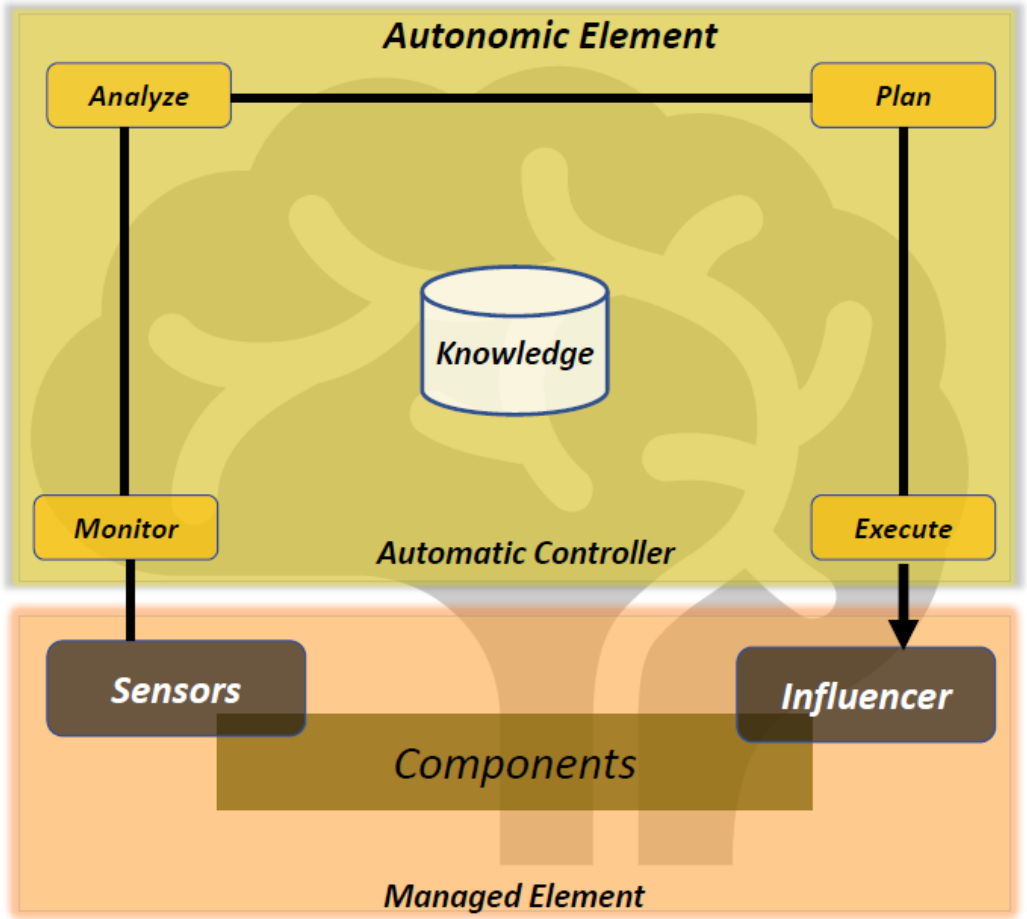
2.5 quintillion bytes a day
(175 trillion gigabytes of data)

How to introduce Intelligent attributes into an Objects ?

Autonomic Computing

- Autonomic Computing has been inspired by the biological nervous system and was introduced in 2001 [1] to represent self-managing systems.

- Autonomic computing systems (ACS) can manage themselves without any human interaction to meet the objectives.



The basic architecture of Autonomic System

[1] A. Ganek, \Autonomic computing: implementing the vision," in 2003 Autonomic Computing Workshop, 2003, pp. 1{1}

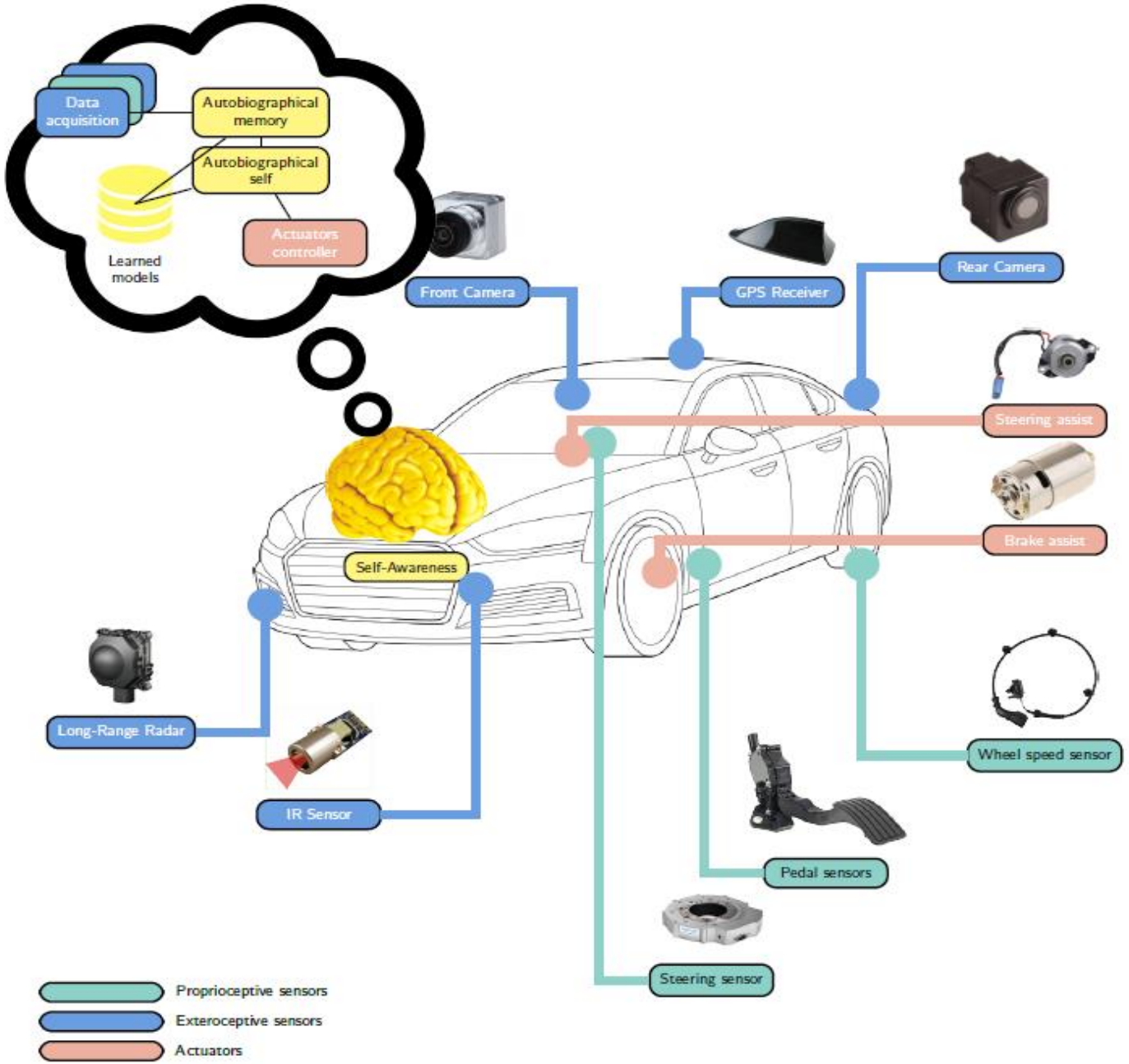
Self-Awareness (SA)

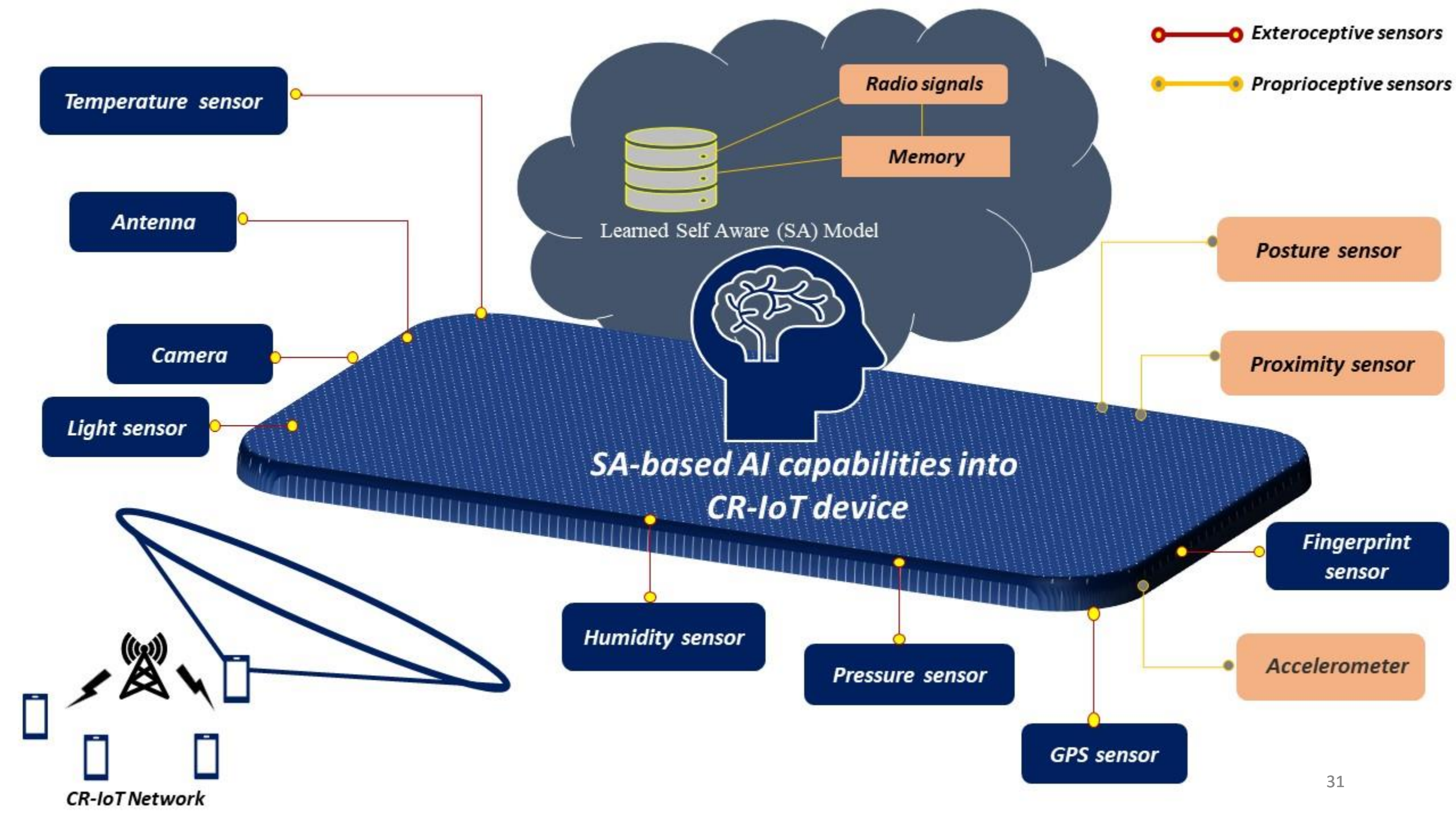
Self-awareness (SA) is a broad concept which describes a cognitive property of a biological—typical human—agent. Some definitions affirm that:

- The agent becomes a reflective observer, processing self-information [1].
- An agent becomes aware that it is *awake* and experiencing specific mental events [1].

How can SA be modeled?

[1] A. Morin, "Levels of consciousness and self-awareness: A comparison and integration of various neurocognitive views," Consciousness and Cognition, vol. 15, no. 2, pp. 358 – 371, 2006.


Data acquisition
Autobiographical memory
Autobiographical self
Actuators controller
Learned models
Front Camera
GPS Receiver
Rear Camera
Steering assist
Brake assist
Self-Awareness
Long-Range Radar
IR Sensor
Wheel speed sensor
Pedal sensors
Steering sensor
Proprioceptive sensors
Exteroceptive sensors
Actuators


Exteroceptive sensors
Proprioceptive sensors
Temperature sensor
Radio signals
Memory
Learned Self Aware (SA) Model
Antenna
Posture sensor
Camera
Proximity sensor
Light sensor
SA-based AI capabilities into CR-IoT device
Fingerprint sensor
Humidity sensor
Pressure sensor
Accelerometer
GPS sensor
CR-IoT Network

BIO-INSPIRED SELF-AWARENESS THEORIES

- Three fundamental bio-inspired theories that have studied SA from diverse viewpoints:

- **Damasio** [1]

- **Haykin** [2]

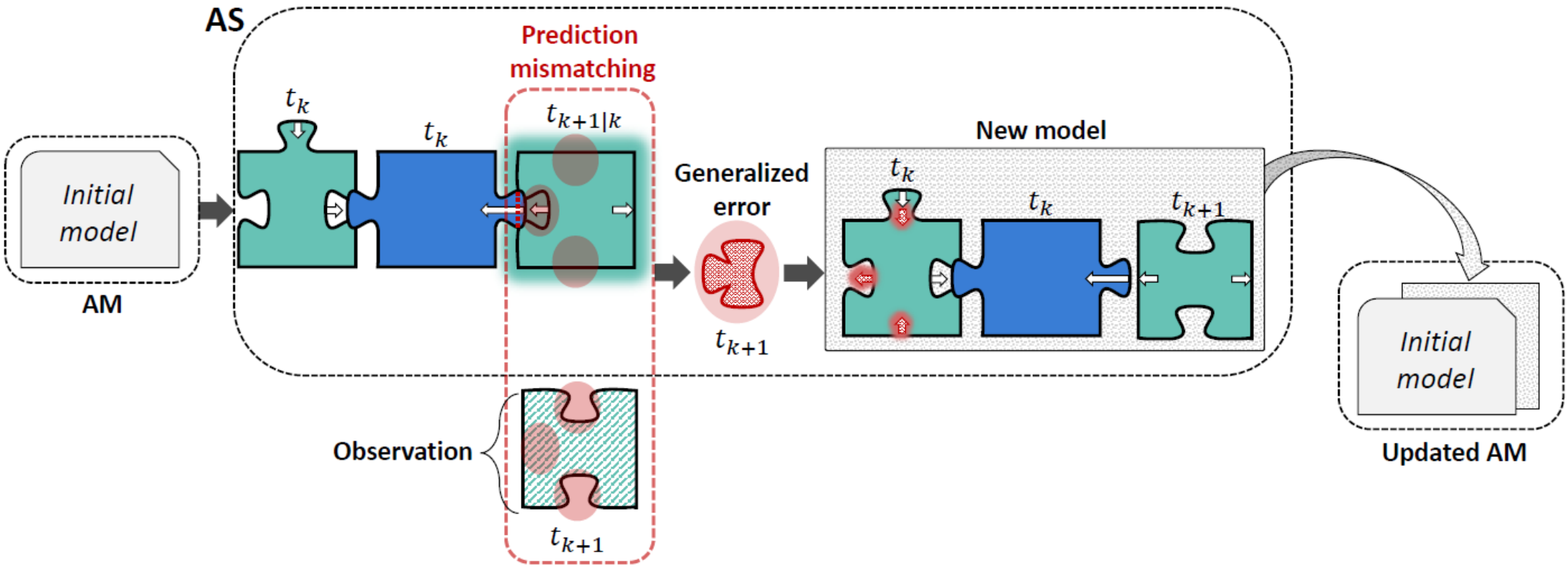
- **Friston** [3]

[1] A. R. Damasio, Looking for Spinoza: Joy, Sorrow, and the Feeling Brain, 1st ed. Orlando: Harcourt, 2003. [Online]. Available: http://lccn.loc.gov/2002011347

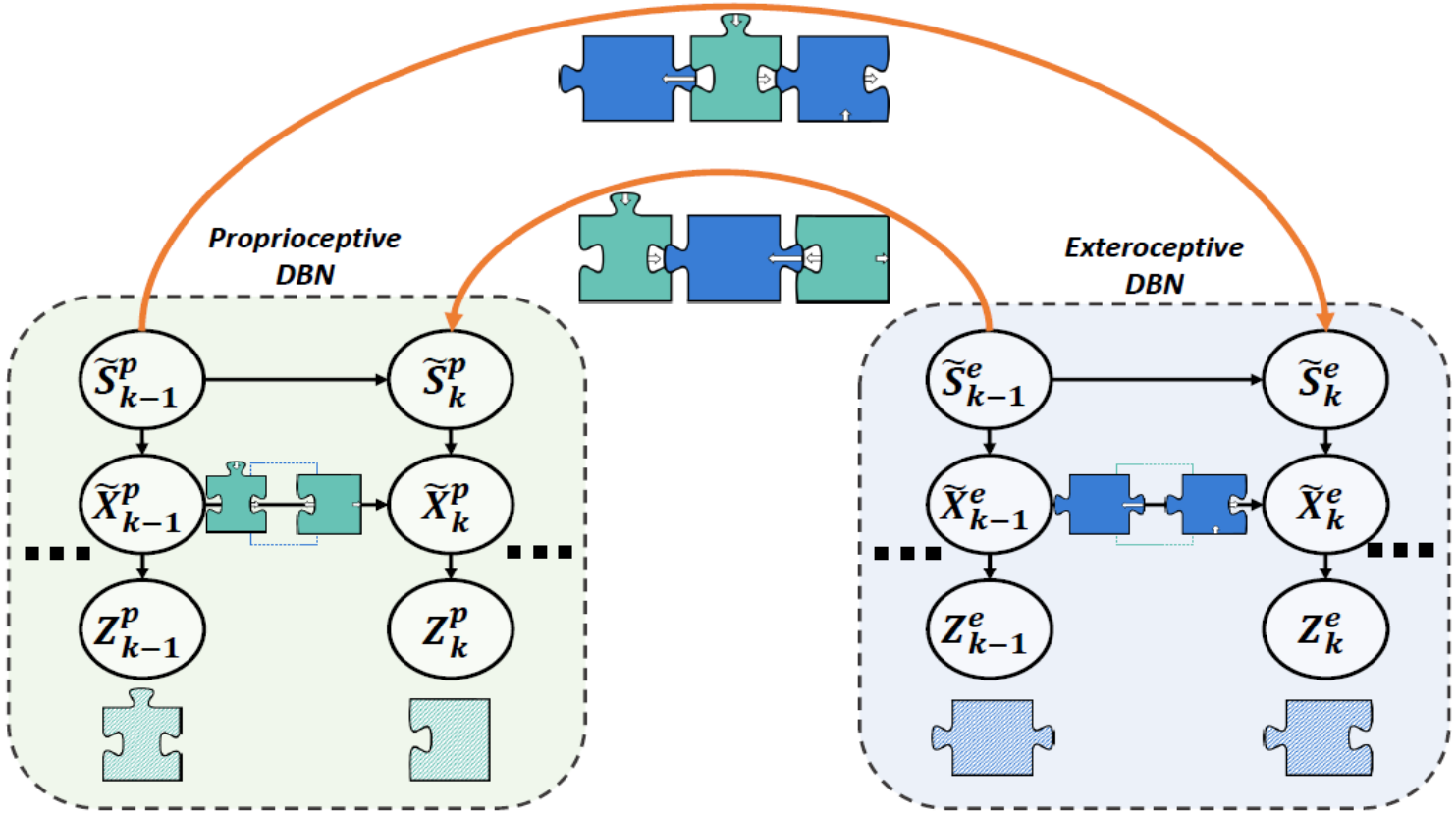
[2] S. Haykin, Cognitive Dynamic Systems: Perception-action Cycle, Radar and Radio, ser. Cognitive Dynamic Systems: Perception–action Cycle, Radar, and Radio. Cambridge University Press, 2012.

[3] K. J. Friston, B. Sengupta, and G. Auletta, "Cognitive dynamics: From attractors to active inference," Proceedings of the IEEE, vol. 102, no. 4, pp. 427–445, 2014. [Online]. Available: https://doi.org/10.1109/JPROC.2014.2306251

Friston's model (Initial Model)

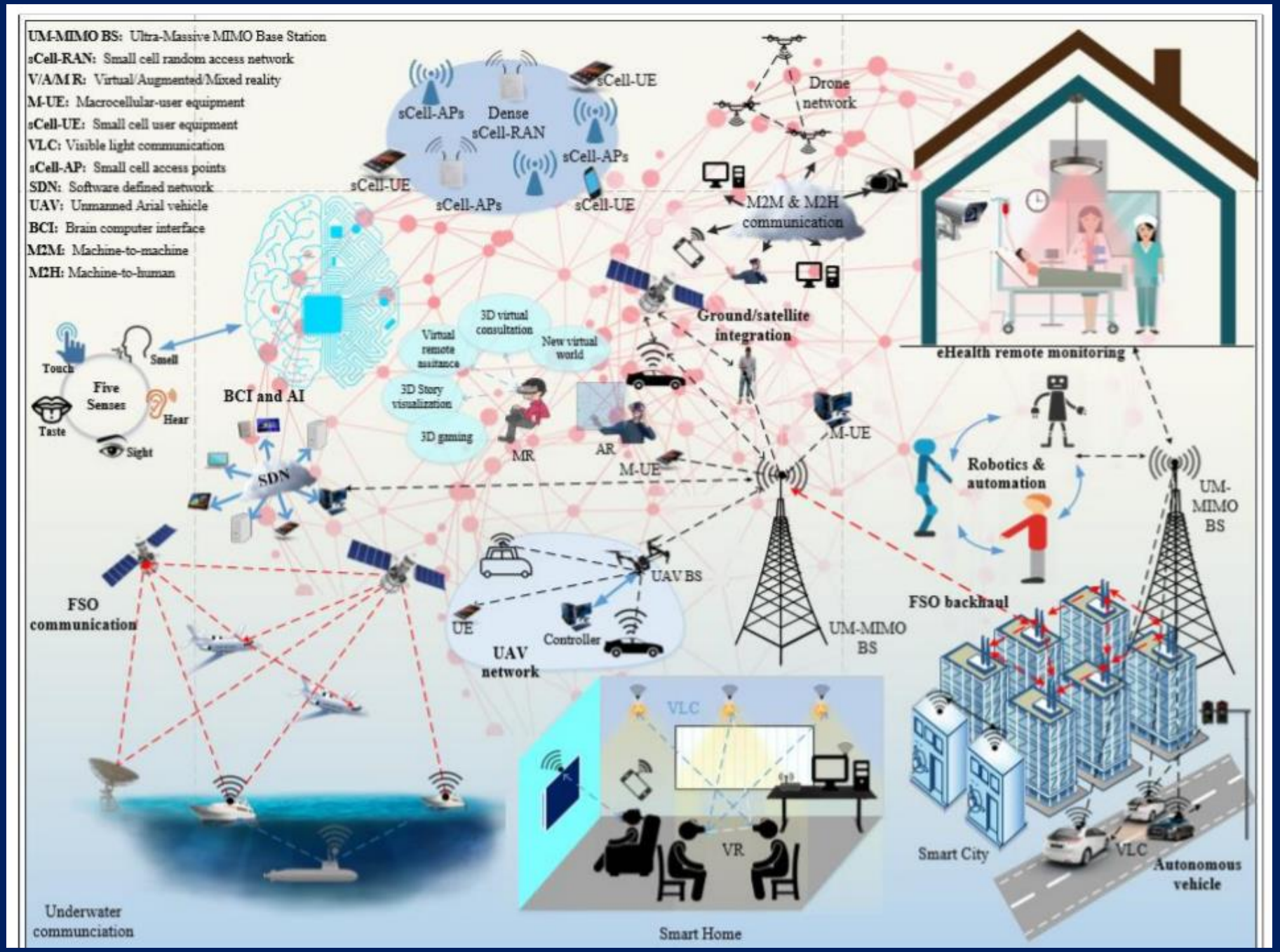


Friston's model (interactions)

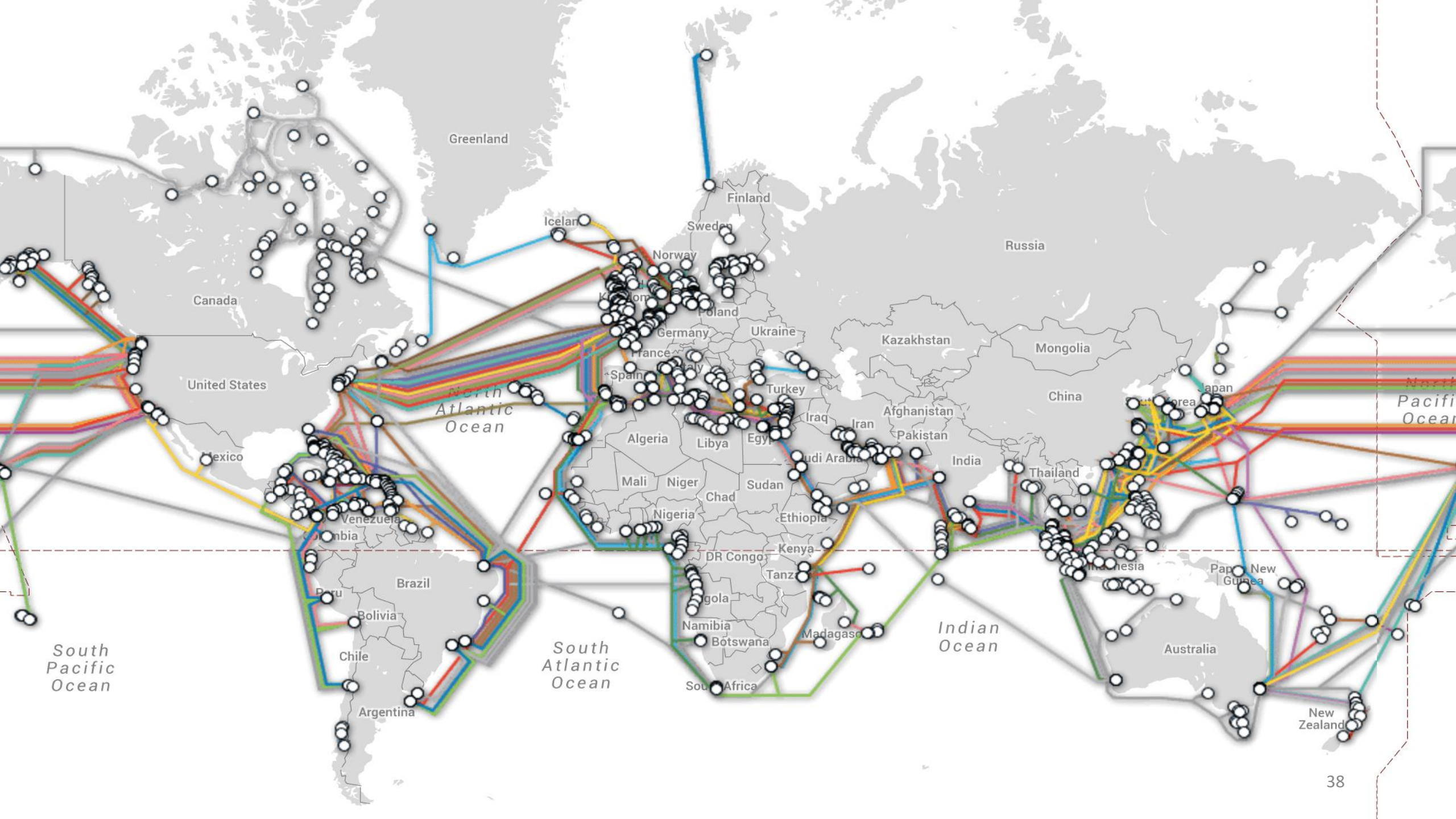


The AI – In Real World Systems

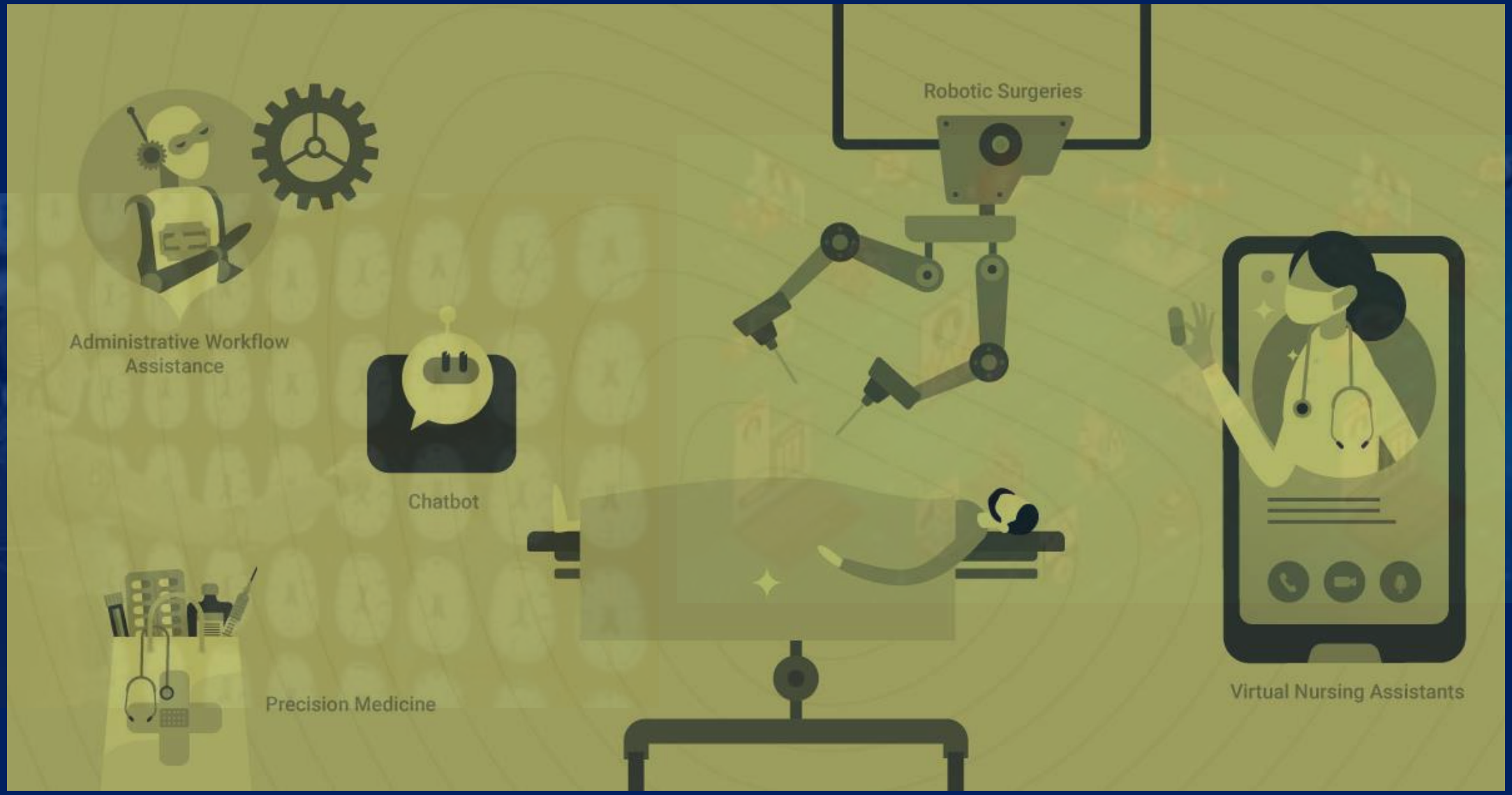
AI in 6G Mobile Network



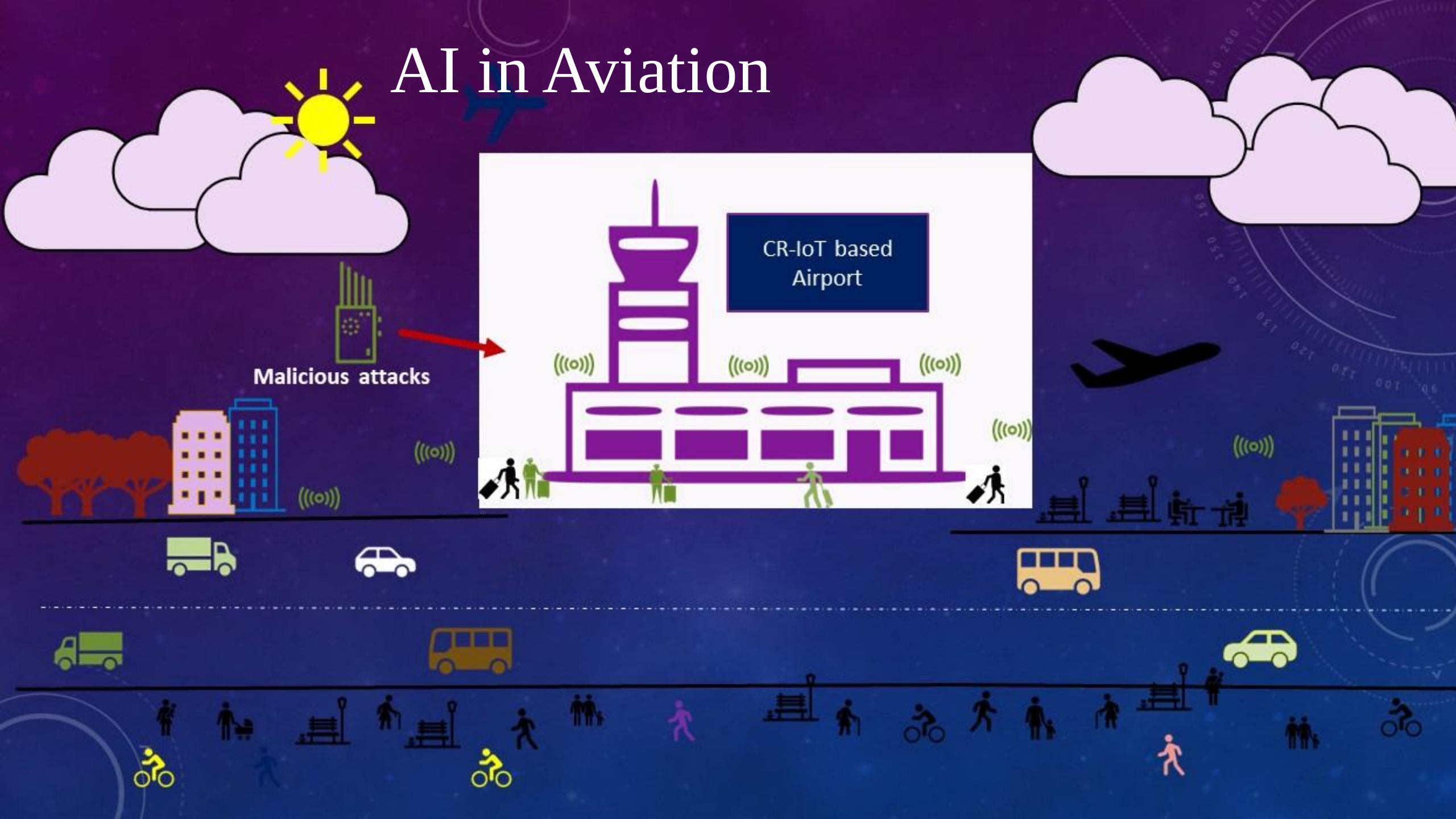
[4] https://arxiv.org/ftp/arxiv/papers/1909/1909.11315.pdf


Greenland
Canada
United States
Mexico
Venezuela
Brazil
Peru
Bolivia
Chile
Argentina
Finland
Sweden
Norway
Poland
Germany
France
Spain
Ukraine
Turkey
Algeria
Libya
Egypt
Mali
Niger
Nigeria
Chad
Sudan
Ethiopia
Kenya
DR Congo
Tanzania
Angola
Namibia
Botswana
Madagascar
South Africa
Russia
Kazakhstan
Mongolia
China
Afghanistan
Iran
Iraq
Pakistan
India
Thailand
Japan
Australia
New Zealand
North Atlantic Ocean
South Atlantic Ocean
South Pacific Ocean
Indian Ocean

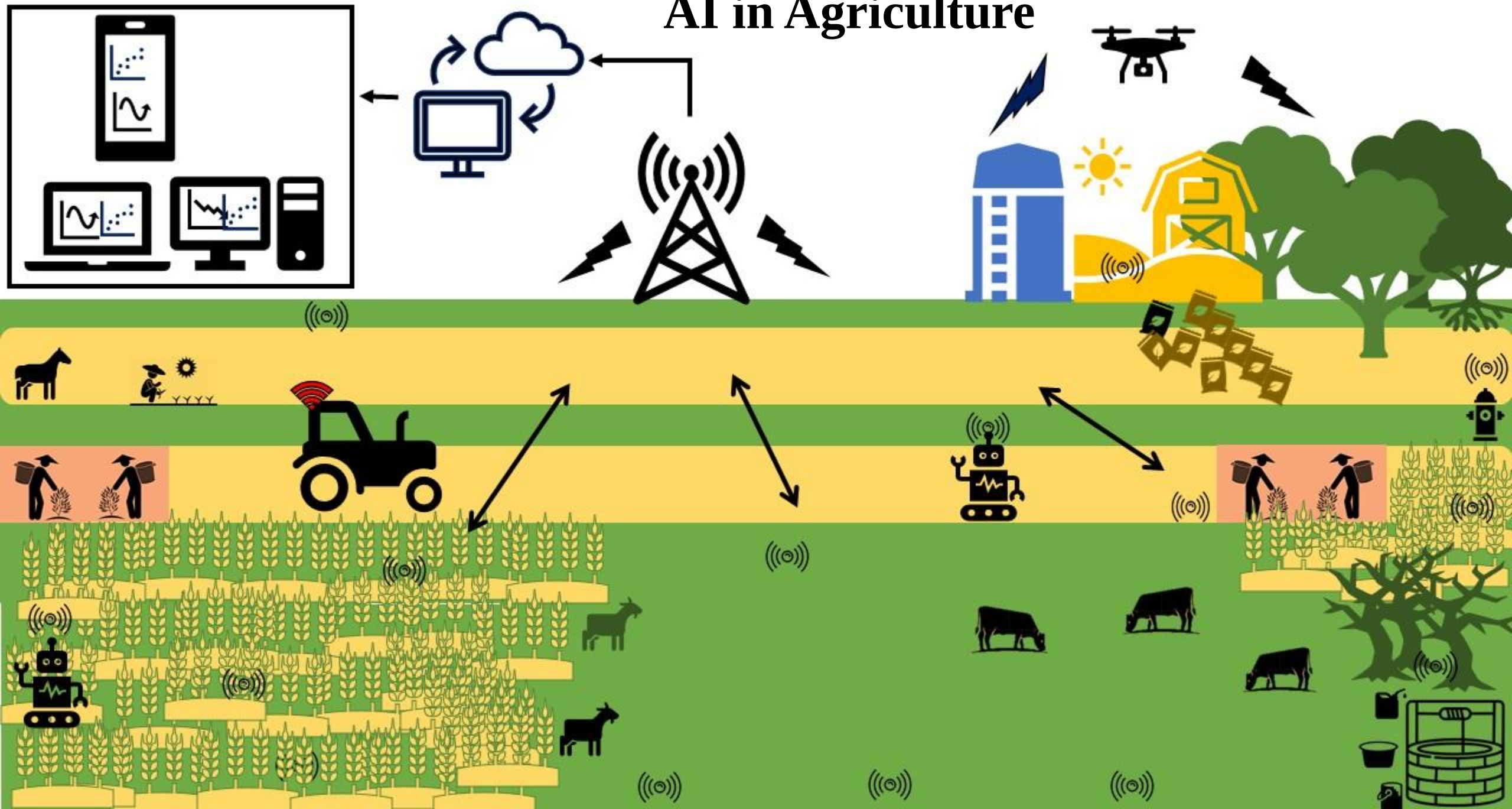
AI in Medical



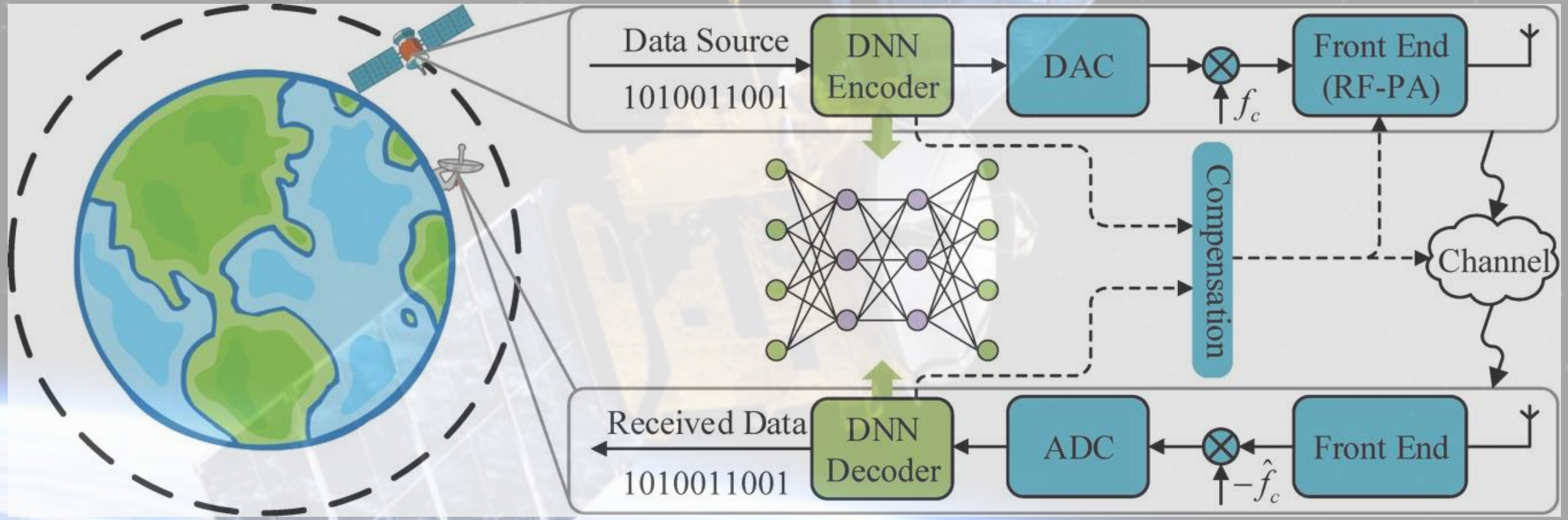
AI in Aviation



AI in Agriculture

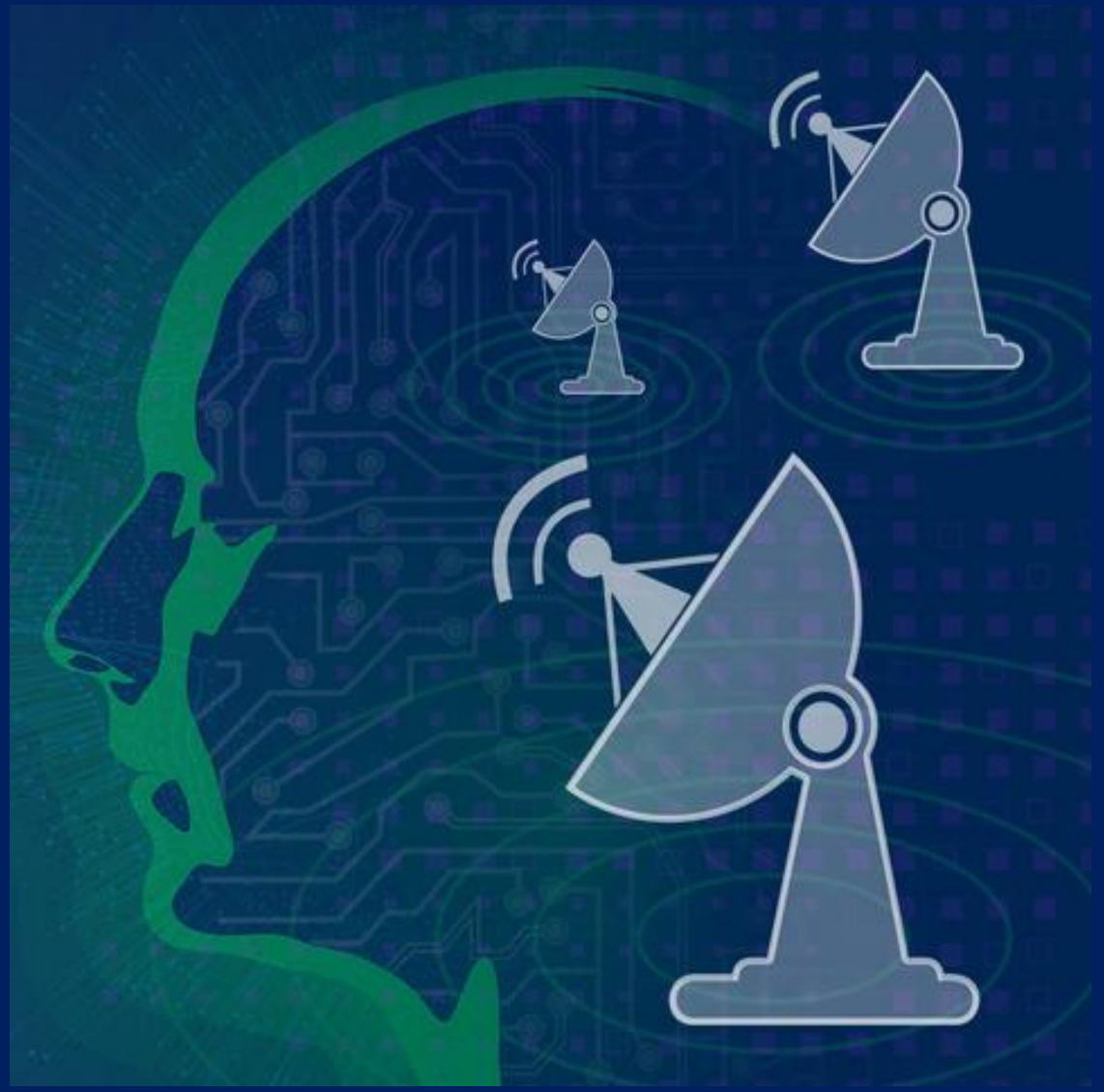


AI in Satellite Communication[5]

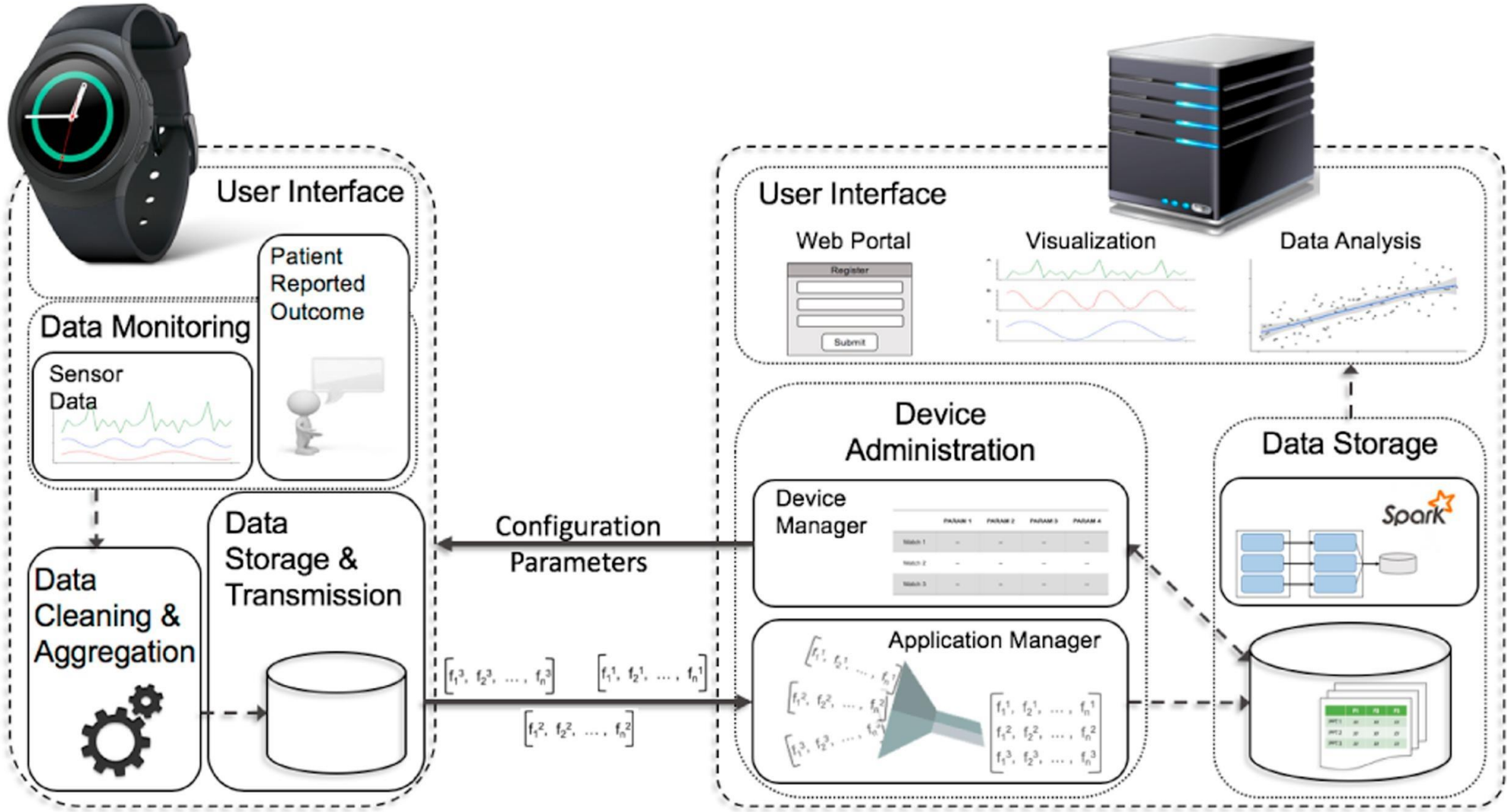


[5] https://www.ai.aau.dk/research/Deep+Learning+Based+Satellite+Communications/

AI in RADAR

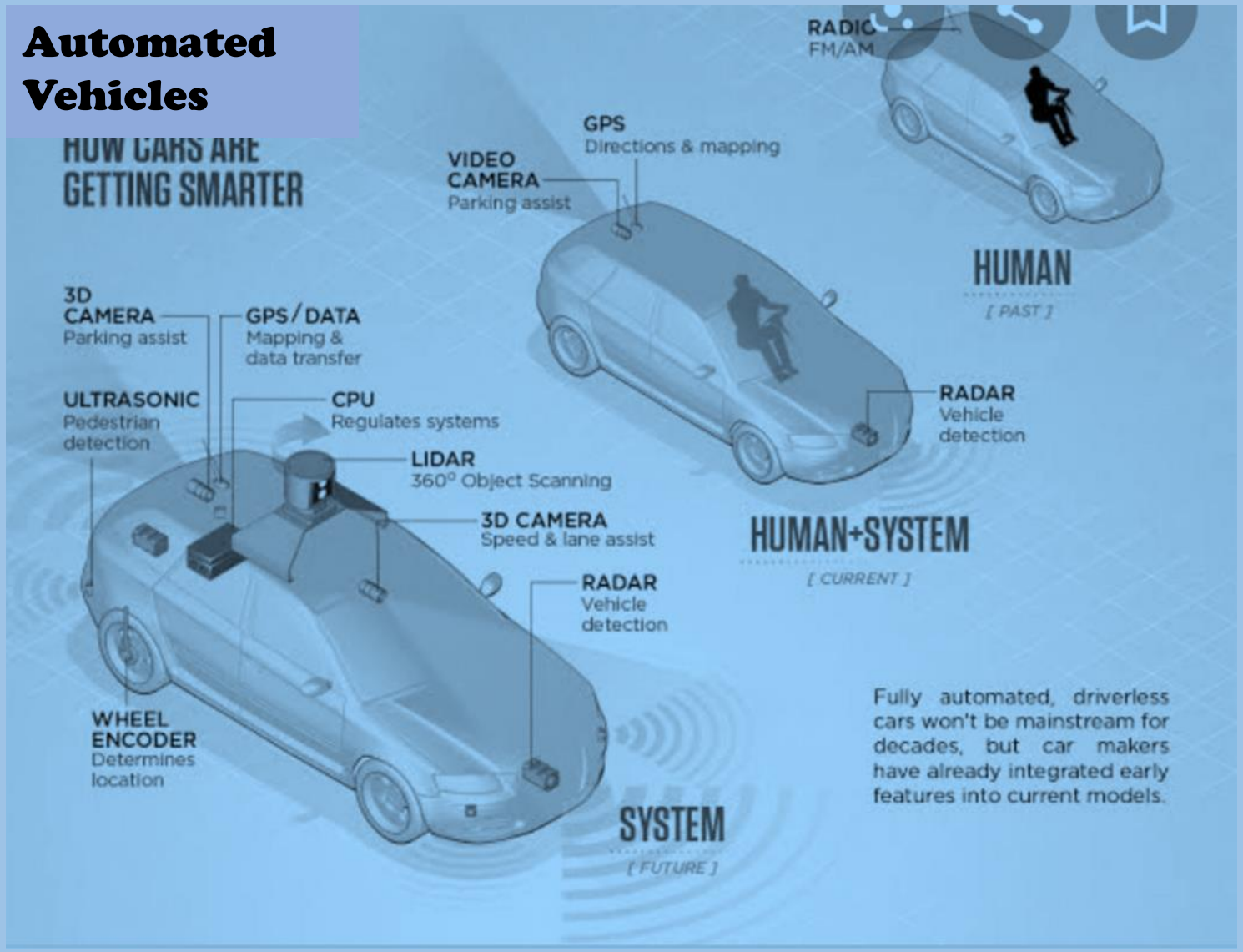


AI in smart watch [6]



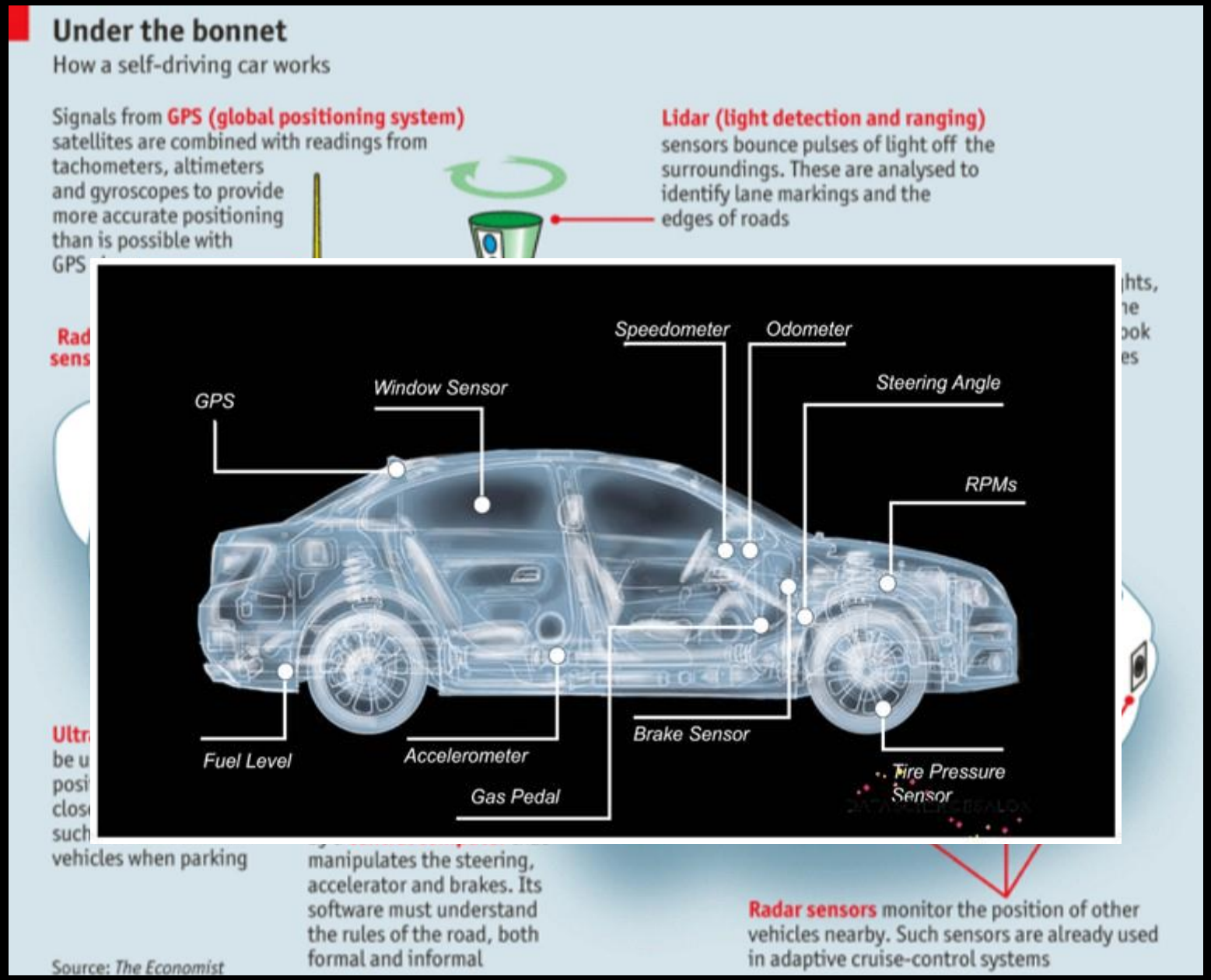
[6] https://www.sciencedirect.com/science/article/pii/S1532046418302120

AI in Smart Cars [7]



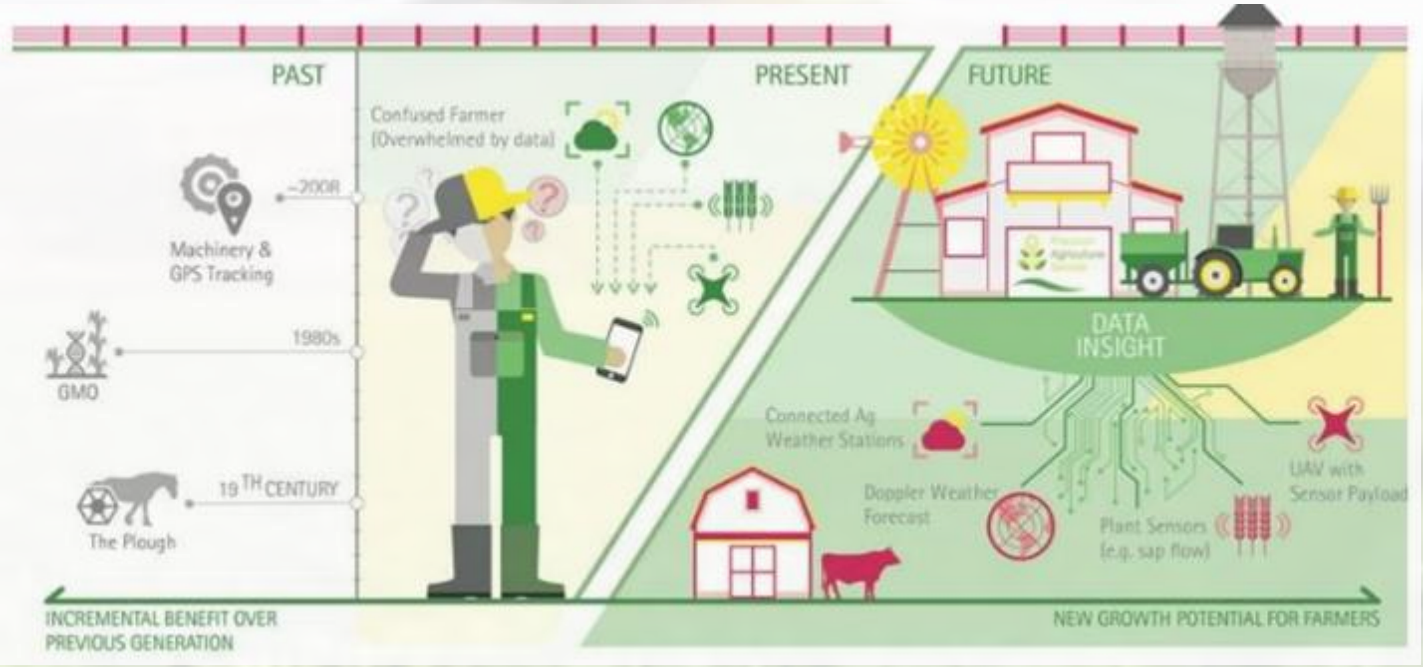
[7] https://medium.com/@jadesolaadedokun/use-case-for-data-science-in-self-driving-cars-9b0ca92f16e2

AI in smart cars

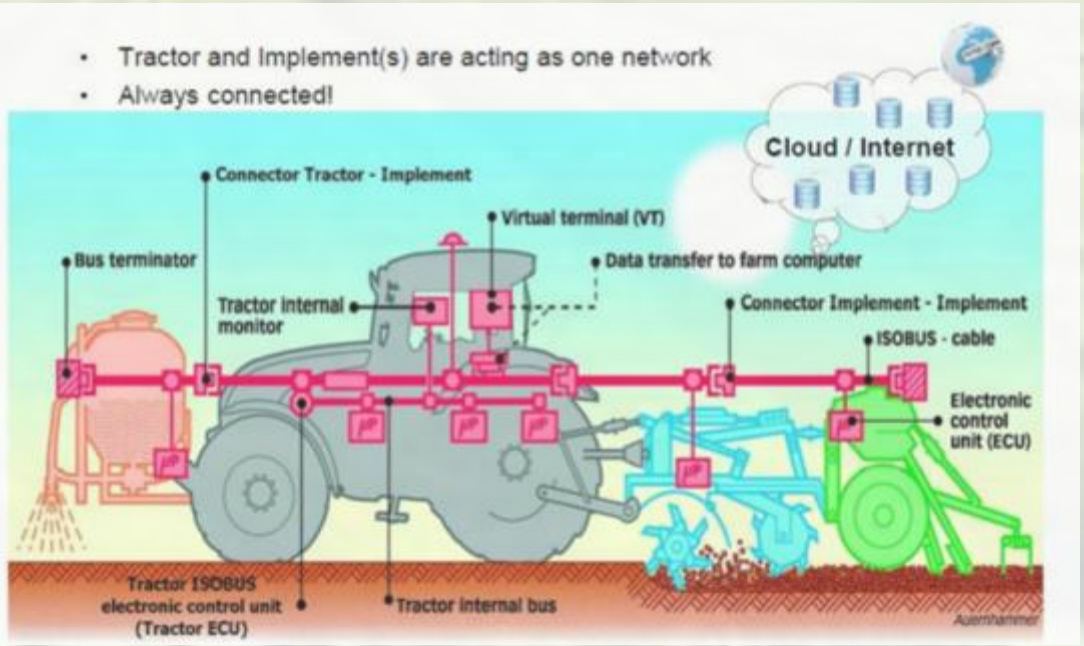


[8]https://medium.com/@jadesolaadedokun/use-case-for-data-science-in-self-driving-cars-9b0ca92f16e2

AI in Agriculture [9,10]



[9] https://possibility.teledyneimaging.com/progression-of-precision-agriculture/



[10] http://markoinsights.com/2015/08/25/precision-ag-cloud/

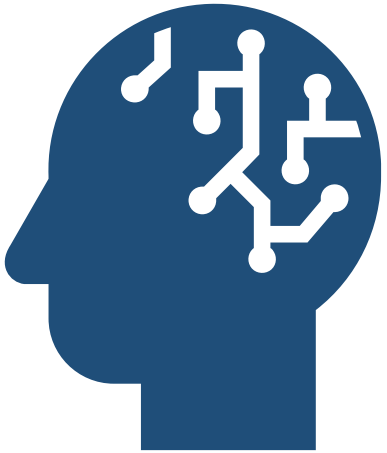
AI in Banking[11]

[11] https://techosaur.tech/business/artificial-intelligence-banking/

And Many more…

Disadvantages of AI

Intelligence



The capacity for:

Abstraction , logic, understanding, self-awareness, learning, emotional knowledge, reasoning, planning, creativity, critical thinking, and problem-solving.

More generally, it can be described as the ability to perceive or infer **information**, and to retain it as **knowledge** to be applied towards adaptive behaviors within an environment or context.

Intelligence is most often studied in **humans** but has also been observed in both **non-human** animals and in plants despite controversy as to whether some of these forms of life exhibit intelligence [1][2].
Intelligence in computers or other machines is called Artificial Intelligence.

[1] Goh, C. H.; Nam, H. G.; Park, Y. S. (2003). "Stress memory in plants: A negative regulation of stomatal response and transient induction of rd22 gene to light in abscisic acid-entrained Arabidopsis plants". *The Plant Journal*. **36** (2): 240–255.
[2] Volkov, A. G.; Carrell, H.; Baldwin, A.; Markin, V. S. (2009). "Electrical memory in Venus flytrap". *Bioelectrochemistry*. **75** (2): 142–147

From where Intelligence word is derived from ?

The word *intelligence* derives from the Latin nouns *intelligentia* or *intellēctus*, which in turn stem from the verb *intelligers*, to comprehend or perceive.

In the Middle Ages, the word *intellectus* became the scholarly technical term for understanding, and a translation for the Greek philosophical term *nous*. This term, however, was strongly linked to the metaphysical and cosmological theories of teleological scholasticism, including theories of the immortality of the soul, and the concept of the active intellect (also known as the active intelligence). This approach to the study of nature was strongly rejected by the early modern philosophers such as Francis Bacon, Thomas Hobbes, John Locke, and David Hume, all of whom preferred "understanding" (in place of "*intellectus*" or "intelligence") in their English philosophical works [3][4]. Hobbes for example, in his Latin *De Corpore*, used "*intellectus intelligit*", translated in the English version as "the understanding understandeth", as a typical example of a logical absurdity [5].

"Intelligence" has therefore become less common in English language philosophy, but it has later been taken up (with the scholastic theories which it now implies) in more contemporary psychology [6]

[3] Maich, Aloysius (1995). "A Hobbes Dictionary". Blackwell: 305
[4] *Nidditch, Peter. "Foreword". An Essay Concerning Human Understanding. Oxford University Press. p. xxii.*
[5] *Hobbes, Thomas; Molesworth, William (15 February 1839). "Opera philosophica quæ latine scripsit omnia, in unum corpus nunc primum collecta studio et labore Gulielmi Molesworth ." Londoni, apud Joannem Bohn. Archived from the original on 5 November 2013 – via Internet Archive.*
[6] This paragraph almost verbatim from *Goldstein, Sam; Princiotta, Dana; Naglieri, Jack A., Eds. (2015). Handbook of Intelligence: Evolutionary Theory, Historical Perspective, and Current Concepts. New York, Heidelberg, Dordrecht, London: Springer.*

More formal definition of Intelligence

A very general mental capability that, among other things, involves the ability to reason, plan, solve problems, think abstractly, comprehend complex ideas, learn quickly and learn from experience. It is not merely book learning, a narrow academic skill, or test-taking smarts. Rather, it reflects a broader and deeper capability for comprehending our surroundings—"catching on," "making sense" of things, or "figuring out" what to do [7][8][9].

[7] S. Legg; M. Hutter (2007). "A Collection of Definitions of Intelligence". Advances in Artificial General Intelligence: Concepts, Architectures and Algorithms. Vol. 157. pp. 17–24. ISBN 9781586037581
[8] Gottfredson & 1997777, pp. 17–20
[9] Gottfredson, Linda S. (1997). "Mainstream Science on Intelligence (editorial)" (PDF). *Intelligence*. **24**: 13–23. doi:10.1016/s0160-2896(97)90011-8. ISSN 0160-2896

More formal definition of Intelligence contd..

Researcher	Quotation
Alfred Binet	Judgment, Otherwise called “ good sense ‘’ , “Initiative ” the faculty of adapting oneself to circumstances……auto-critique.[11]
David Wechsler	The aggregate or global capacity of the individual act to purposefully, to think rationally and to deal effectively with his environment .[12]
Lloyd Humphreys	“The resultant of the process of acquiring , strong in memory , retrieving , combining, comparing , and using in new context information and conceptual skills”.[13]
Howard Gardner	To my mind a human intellectual competence must entail a set of skills of problem solving_ enabling the individual to resolve genuine problems of difficulties that he or she encounters and, when appropriate, to create an effective product_ and must also entail the potential for finding or creating problems_ and thereby lying the groundwork for the acquisition of new knowledge.[14]
Linda Gottfredson	The ability to deal with cognitive complexity [15]

[11] Binet, Alfred (1916) [1905]. "New methods for the diagnosis of the intellectual level of subnormals". The development of intelligence in children: The Binet-Simon Scale. E.S. Kite (Trans.). Baltimore: Williams & Wilkins. pp. 37–90
[12] *Wechsler, D (1944). The measurement of adult intelligence. Baltimore: Williams & Wilkins. ISBN 978-0-19-502296-4. OCLC 219871557.* ASIN = B000UG9J7E
[13] *Wechsler, D (1944). The measurement of adult intelligence. Baltimore: Williams & Wilkins. ISBN 978-0-19-502296-4. OCLC 219871557.* ASIN = B000UG9J7E
[14] *Frames of mind: The theory of multiple intelligences. New York: Basic Books. 1993. ISBN 978-0-465-02510-7. OCLC 221932479*
[15] Gottfredson, L. (1998). "The General Intelligence Factor" (PDF). Scientific American Presents. 9 (4): 24–29. Archived (PDF) from the original on 7 March 2008. Retrieved 18 March 2008.
[16] Sternberg RJ; Salter W (1982). *Handbook of human intelligence*. Cambridge, UK: Cambridge University Press. ISBN 978-0-521-29687-8. OCLC 11226466.
[17] Feuerstein, R., Feuerstein, S., Falik, L & Rand, Y. (1979; 2002). Dynamic assessments of cognitive modifiability. ICELP Press, Jerusalem: Israel; Feuerstein, R. (1990). The theory of structural modifiability. In B. Presseisen (Ed.), Learning and thinking styles: Classroom interaction. Washington, DC: National Education Associations.
[18] S. Legg; M. Hutter (2007). "Universal Intelligence: A Definition of Machine Intelligence". *Minds and Machines*. **17** (4): 391–444
[19] *"TED Speaker: Alex Wissner-Gross: A new equation for intelligence". TED.com. Archived from the original on 4 September 2016. Retrieved 7 September 2016*

More formal definition of Intelligence contd..

Researcher	Quotation
Robert Sternberg & William salter	Goal -directed Adaptive behavior.[16]
Reuven Feuerstein	The theory of structural cognitive modifiability describes intelligence as " the unique propensity of human being to change or modify the structure of their cognitive functioning to adapt to the changing demands of the life situations.[17]
Shane legg & Marcus Hutter	A synthesis of 70+ definitions from physiology , philosophy and AI researchers: " intelligence measure an agents ability to achieve goal in wide range of environment".[7] which has been mathematically formalized.[18]
Alexander wissner Gross	$F = T \nabla S_{\tau}$ [19] "Intelligence is a force ,F , that act to maximize future freedom of action . It act to maximize future freedom of action , or keep options open , with some strength T , with some diversity of possible accessible futures S, up to come future time horizon τ.

[11] Binet, Alfred (1916) [1905]. "New methods for the diagnosis of the intellectual level of subnormals". The development of intelligence in children: The Binet-Simon Scale. E.S. Kite (Trans.). Baltimore: Williams & Wilkins. pp. 37–90
[12] *Wechsler, D (1944). The measurement of adult intelligence. Baltimore: Williams & Wilkins. ISBN 978-0-19-502296-4. OCLC 219871557.* ASIN = B000UG9J7E
[13] *Wechsler, D (1944). The measurement of adult intelligence. Baltimore: Williams & Wilkins. ISBN 978-0-19-502296-4. OCLC 219871557.* ASIN = B000UG9J7E
[14] *Frames of mind: The theory of multiple intelligences. New York: Basic Books. 1993. ISBN 978-0-465-02510-7. OCLC 221932479*
[15] Gottfredson, L. (1998). "The General Intelligence Factor" (PDF). Scientific American Presents. 9 (4): 24–29. Archived (PDF) from the original on 7 March 2008. Retrieved 18 March 2008.
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[19] *"TED Speaker: Alex Wissner-Gross: A new equation for intelligence". TED.com. Archived from the original on 4 September 2016. Retrieved 7 September 2016*

Human and Non-human Intelligence

Human intelligence is the intellectual power of humans, which is marked by complex cognitive feats and high levels of motivation and self-awareness [20].

Intelligence enables humans to remember descriptions of things and use those descriptions in future behaviors. It is a cognitive process.

It gives humans the cognitive abilities to learn, form concepts, understand, and reason, including the capacities to recognize patterns, innovate, plan, solve problems, and employ language to communicate. Intelligence enables humans to experience and think [21].

[20] Tirri, Nokelainen (2011). Measuring Multiple Intelligences and Moral Sensitivities in Education. Moral Development and Citizenship Education. Springer. ISBN 978-94-6091-758-5. Archived from the original on 2 August 2017

[21] *Colom, Roberto (December 2010). "Human intelligence and brain networks". Dialogues Clin. Neurosci.* ***12*** *(4): 489–501. doi:10.31887/DCNS.2010.12.4/rcolom. PMC 3181994. PMID 21319494*

[22] Bouchard, Thomas J. (1982). "Review of The Intelligence Controversy". *The American Journal of Psychology*. **95** (2): 346–349. doi:10.2307/1422481. ISSN 0002-9556. JSTOR 1422481

[23] Salovey, Peter; Mayer, John D. (March 1990). "Emotional Intelligence". *Imagination, Cognition and Personality*. **9** (3): 185–211. doi:10.2190/DUGG-P24E-52WK-6CDG. ISSN 0276-2366. S2CID 219900460

[24] Salovey, Peter; Mayer, John D. (March 1990). "Emotional Intelligence". *Imagination, Cognition and Personality*. **9** (3): 185–211. doi:10.2190/DUGG-P24E-52WK-6CDG. ISSN 0276-2366. S2CID 219900460

Human and Non-human Intelligence (Contd..)

Emotional intelligence

Emotional intelligence is thought to be the ability to convey emotion to others in an understandable way as well as to read the emotions of others accurately [23].

Some theories imply that a heightened emotional intelligence could also lead to faster generating and processing of emotions in addition to the accuracy [24]. In addition, higher emotional intelligence is thought to help us manage emotions, which is beneficial for our problem-solving skills.

Emotional intelligence is important to our mental health and has ties into social intelligence [23].

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Human and Non-human Intelligence (Contd..)

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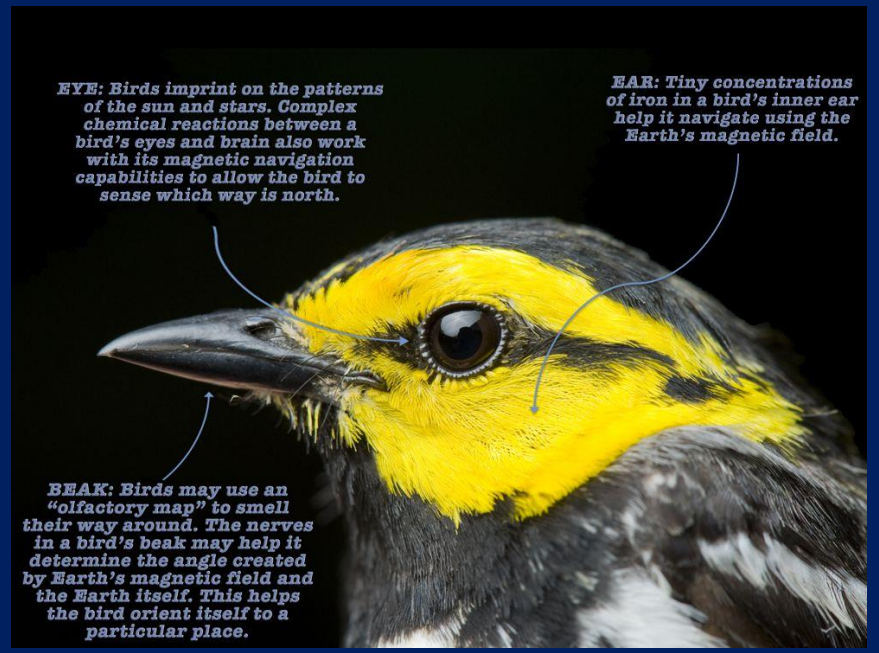
Non-Human Intelligence

Wolfgang Köhler's research on the intelligence of apes is an example of research in this area. Stanley Coren's book, The *Intelligence of Dogs* is a notable book on the topic of dog intelligence [27].

Non-human animals particularly noted and studied for their intelligence include chimpanzees, bonobos (notably the language-using Kanzi) and other dolphins, elephants and to some extent parrots, rats and ravens [28].

Explore Birds Intelligence



[27] Coren, Stanley (1995). The Intelligence of Dogs. Bantam Books. ISBN 978-0-553-37452-0. OCLC 30700778
[28] Childs, Casper. "WORDS WITH AN ASTRONAUT". *Valenti*. Codetipi. Retrieved 14 March 2021.
[29] Trewavas, Anthony (September 2005). "Green plants as intelligent organisms". *Trends in Plant Science*. **10** (9): 413–419

Non-Human Intelligence

Plant Intelligence

It has been argued that plants should also be classified as intelligent based on their ability to sense and model external and internal environments and adjust their morphology physiology phenotype to ensure self-preservation and reproduction.
A counter argument is that intelligence is commonly understood to involve the creation and use of persistent memories as opposed to computation that does not involve learning. If this is accepted as definitive of intelligence, then it includes the artificial intelligence of robots capable of "machine learning" but excludes the [illegible] responses that can be observed in many plants. Plants are not limited to automated sensory-motor responses; however, they can discriminate positive and negative experiences and of "learning" (registering memories) from their past experiences. They are also capable of communication, accurately computing their circumstances, using sophisticated cost–benefit analysis taking tightly controlled actions to mitigate and control the diverse environmental stressors [29].

Can we think on it ?

Intelligence v/s Wisdom ?

Intelligence v/s Wisdom [A]

Characteristics	Intelligence	Wisdom
Knowledge	Capable of easily obtaining and using knowledge	Knowledge has been obtaining through Experience that has occurred over a relatively long period of time
The mind	Lower-level Usage of the mind.	Complex , upper-level usage of the mind
Environmental Context	Understating the environmental context is the epitome of intelligence	Obtaining a deeper multifaceted understanding of ones environmental context is a sign od wisdom
Personality traits	An empirical and competitive person with a desire to learn	A grounded understanding and nurturing person.
Motivation	Understanding all knowledge and how it contributes to the meaning of our world.	Knowing how to apply learnt knowledge in real- life situations.

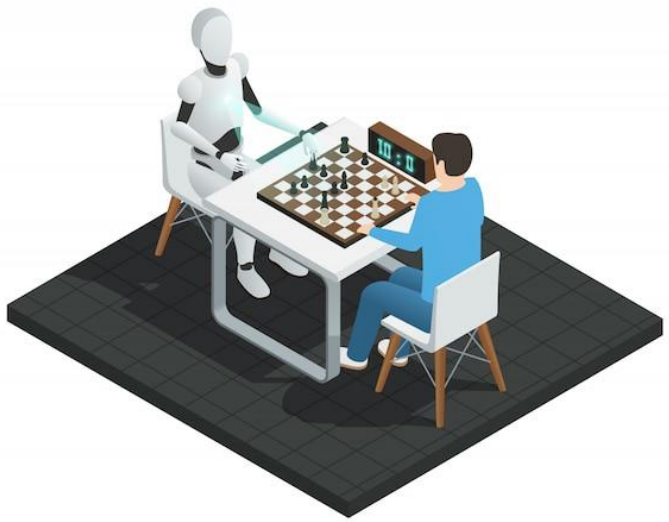
[A] Differences Between Intelligence and Wisdom | Difference Between

The Concept of Rationality

Rationality

A System is rational if it does the “Right Things”, given what it knows [B].

Examples:



[B] S. Russell and P. Norvig: ***Artificial Intelligence: A Modern Approach***. Pearson, 2010, *3rd Edition*

Artificial Intelligence

An intelligent agent can be defined as a system that perceives its environment and takes actions which maximize its chances of success [35].

Kaplan and Haenlein define artificial intelligence as "a system's ability to correctly interpret external data, to learn from such data, and to use those learnings to achieve specific goals and tasks through flexible adaptation“ [36].

Progress in artificial intelligence can be demonstrated in benchmarks ranging from games to practical tasks such as protein folding [37].

Existing AI lags humans in terms of general intelligence, which is sometimes defined as the "capacity to learn how to carry out a huge range of tasks“ [38].

[36] "Kaplan Andreas and Haelein Michael (2019) Siri, Siri, in my hand: Who's the fairest in the land? On the interpretations, illustrations, and implications of artificial intelligence, Business Horizons, 62(1)
[37] How did a company best known for playing games just crack one of science's toughest puzzles?". *Fortune*. 2020. Retrieved 21 February 2021
[38] *Heath, Nick (2018). "What is artificial general intelligence?". ZDNet. Retrieved 21 February 2021.*

Defining AI

Four schools of thoughts (Russel & Norvig) – From Scholars Point of View

Human Like V/s Rational

Thought V/s Behaviour

Thinking humanly	**Thinking rationally**
"The exciting new effort to make computers think... machines with minds, in the full and literal sense." *(Haugeland, 1985)*	"The study of mental faculties through the use of computational models." (Charniak & McDermott,1985)
Acting humanly	**Acting rationally**
"The study of how to make computers do things which, at the moment, people are better." *(Rich & Knight, 1991)*	"Computational Intelligence is the study of the design of intelligent agents." (Poole et al., 1998)

More Insights !

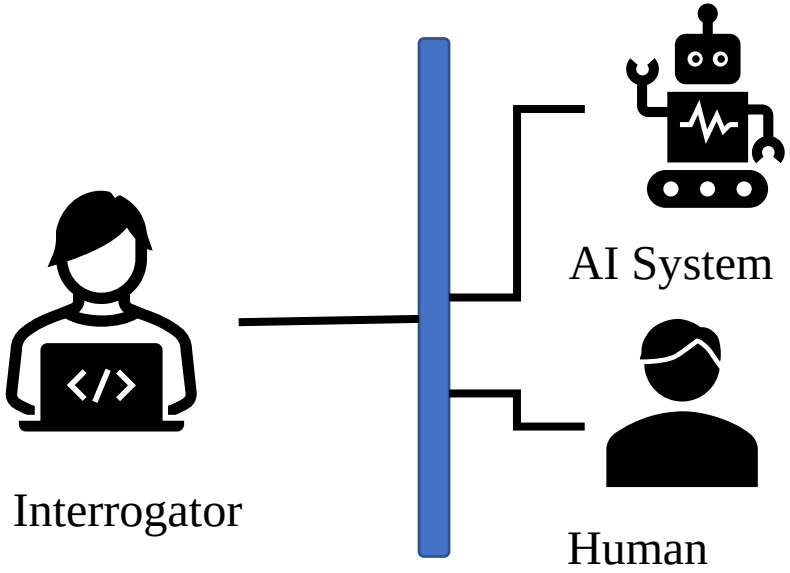
Human Like v/s Rational

Thought v/s Behaviour

Systems that think like Human	**Systems that think rationally**
Systems that act like human	Systems that act rationally

Acting Humanly: The Turing Approach

Turing test, by **Alan Turing 1950** to provide satisfactory operational definition of intelligence.



For more details The Turing Test (Stanford Encyclopedia of Philosophy)

Thinking Humanly: The cognitive modeling approach

How human thinks ?
Two approaches:

Introspection- Trying to catch out own thoughts as they go by.
Phycological experiments.

Cognitive Science: Brings together computer models from AI and experimental techniques from psychology to try to construct precise and testable theories of the working of human mind

Thinking rationally: The Laws of thought approach

If something is TRUE it is always true. Someone always thinks Right. Have full knowledge.

Right thinking.

Requires **100** % Knowledge.

Too many computations requires. (Even for taking small action)

Acting Rationally: The rational agent approach

An agent is just something that ACTS (agent comes from the Latin agree, to do).

However, computer agents are expected to have many attributes beside merely a simple programs
Such attributes are:

- Perceiving environment, Adaptivity, controlling, achieving targets, conscious, etc..

Rational Agent:

RA is one that acts so as to achieve the best outcome or, when there is uncertainty, the best expected outcome.

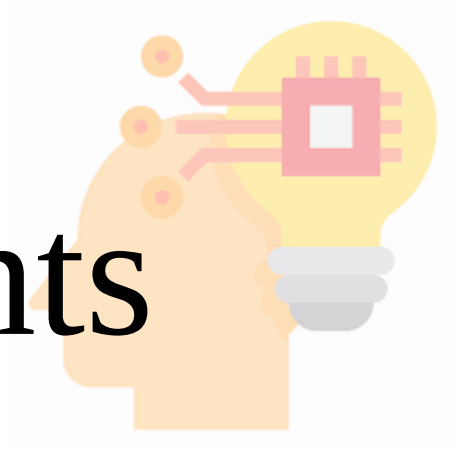
History of AI

Human Brain and AI

	Supercomputer	Personal Computer	Human Brain
Computational units	10^6 GPUs + CPUs	8 CPU cores	10^6 columns
	10^{15} transistors	10^{10} transistors	10^{11} neurons
Storage units	10^{16} bytes RAM	10^{10} bytes RAM	10^{11} neurons
	10^{17} bytes disk	10^{12} bytes disk	10^{14} synapses
Cycle time	10^{-9} sec	10^{-9} sec	10^{-3} sec
Operations/sec	10^{18}	10^{10}	10^{17}

A crude comparison of a leading supercomputer, Summit (Feldman, 2017); a typical personal computer of 2019; and the human brain. Human brain power has not changed much in thousands of years, whereas supercomputers have improved from megaFLOPs in the 1960s to gigaFLOPs in the 1980s, teraFLOPs in the 1990s, petaFLOPs in 2008, and exaFLOPs in 2018 (1 exaFLOP = 10^{18} floating point operations per second).

Intelligent Agents



Intelligent Agents

- Agent and Environment.
- Coupling between them.
- Rational agent.

- Some agents behave better than other – Hence, rational agent is one that behaves as good as possible.

- The behaviour of the agent depends on the nature of environment.

Agent

An agent is just something that acts

agent comes from the Latin agree, to do)

It is the capability beyond doing normal tasks such as sense the operating environment, take decision etc.

Rational Agent

A rational agent is one that acts so as to achieve the best outcome or when there is uncertainty, the best expected outcome.

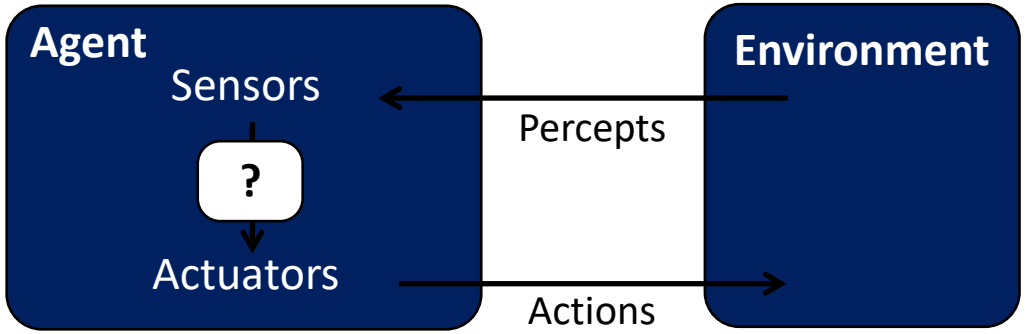
Or

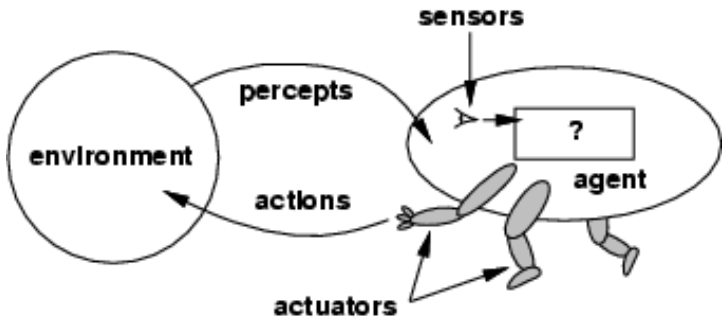
It is one that does the right thing.

Agents and Environments

An **agent** perceives the **environment** through **sensors** and acting upon that environment through **actuators**.

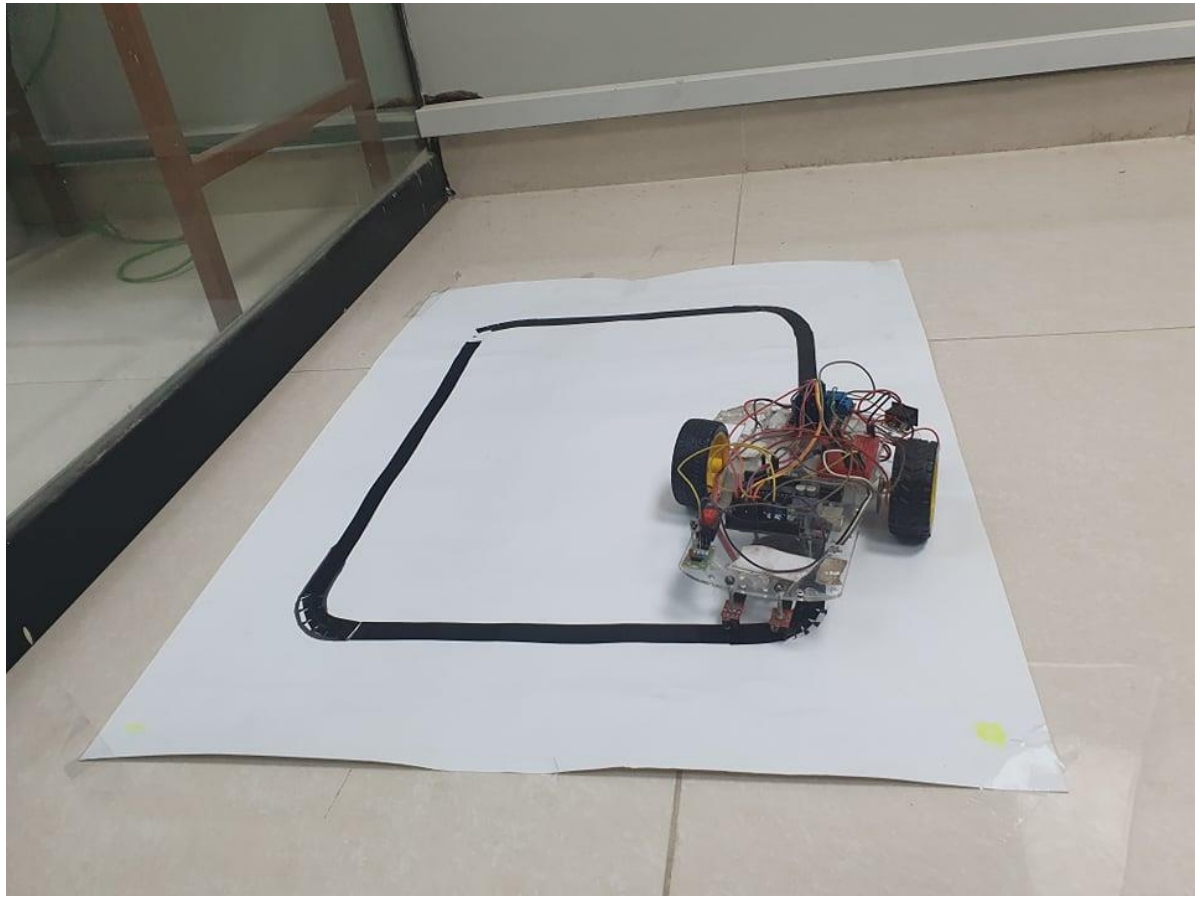
Environment could be everything

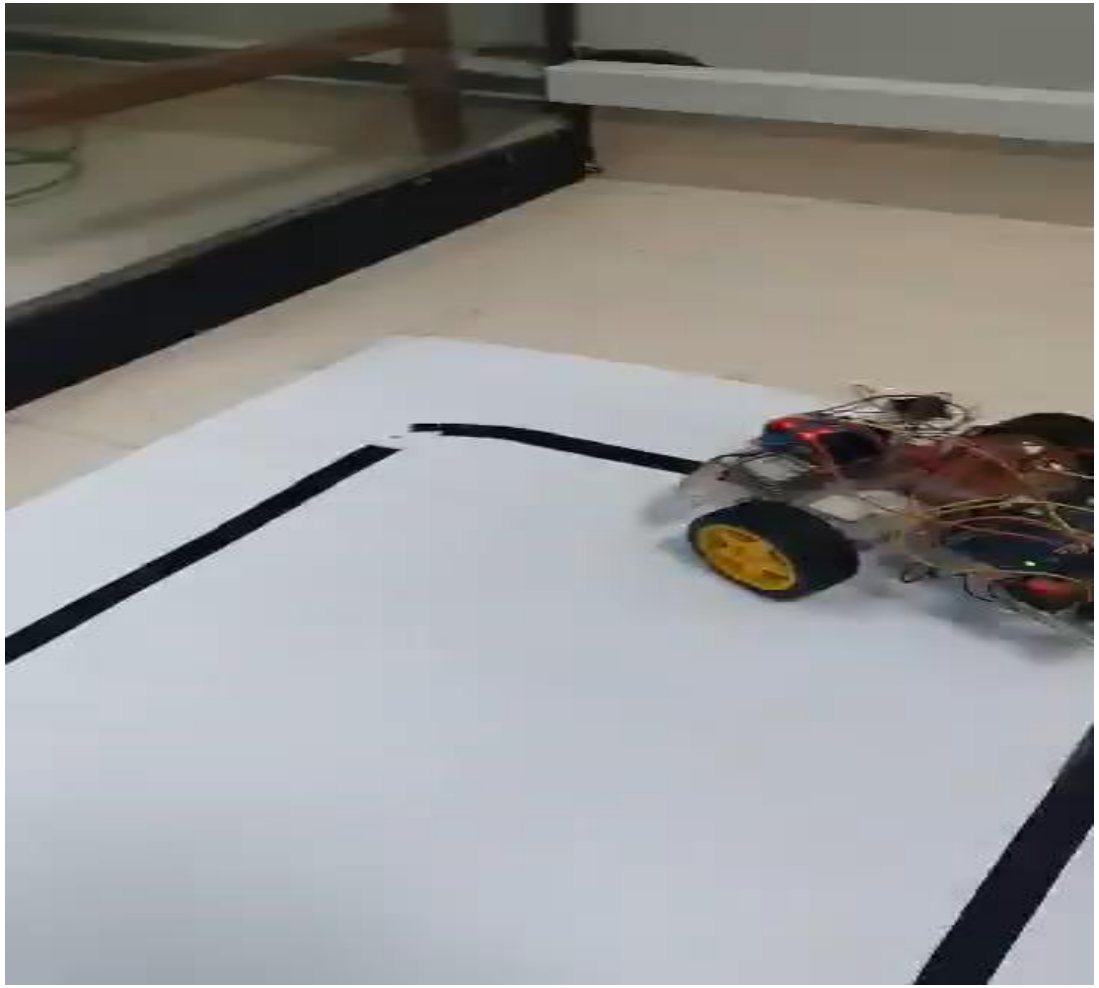




Agents interact with environments through sensors and actuators

Robot Example / Demonstration





Agents and Environments (contd..)

Examples:

Human Agent
Robotic Agent
Software Agent
.
.
.

Many more

Agents and Environments (contd..)

Percept – The content an agent's sensors are perceiving.

An agent **percept sequence** is the **complete history** of everything that agent has ever perceived.

An agent choice of actions at any given instant can depend on its **built-in knowledge** and on the entire **percept sequence** observed to date.

Agents and Environments (contd..)

Mathematically, agent behaviour is described by the **Agent Function:** that maps any given precept sequence to an action.

Agent Function *can be tabulated in a table form for any given agent placed in an experimental environment, constructing the table by tying all possible percept sequences and recording which actions the agent does in response.*

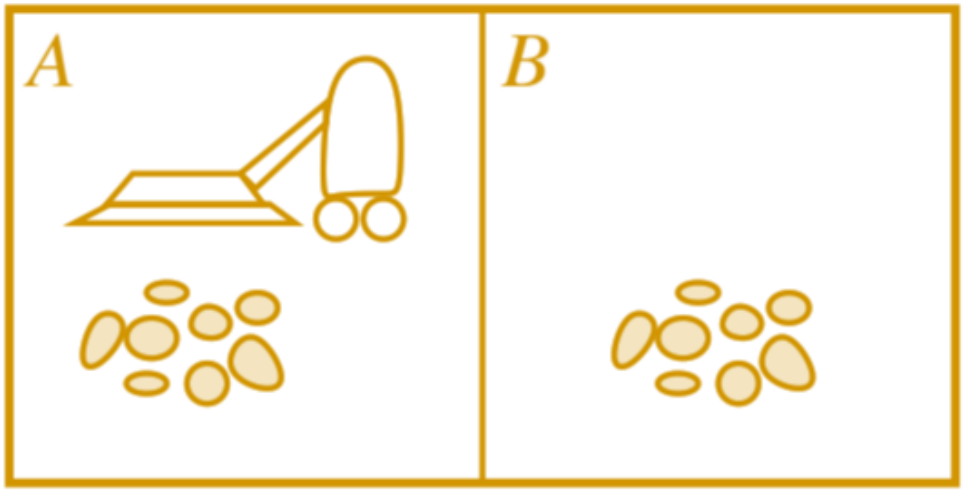
Agents and Environments (contd..)

Agent function is implemented by an agent program.

Agent Function is an abstract mathematical description.

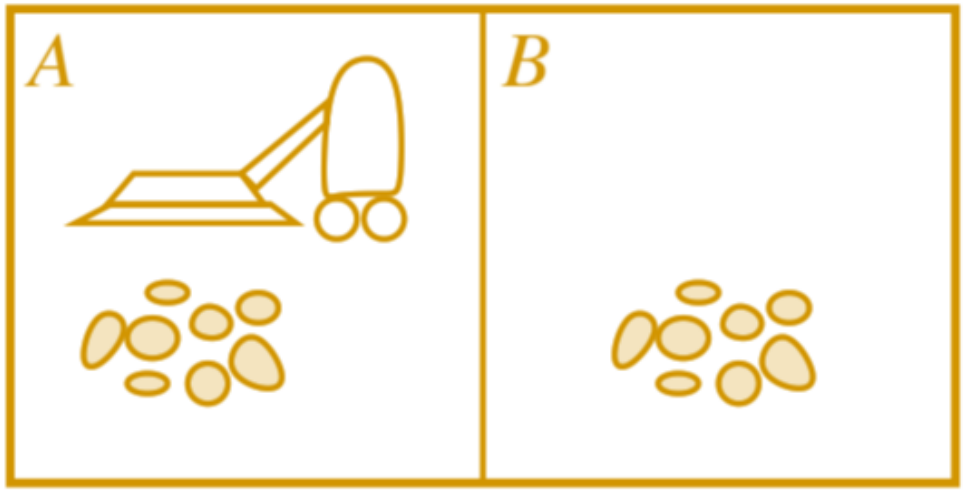
Agent Program is a concrete implementation, running within some physical system

Vacuum-Cleaner Agent



Percepts: location and contents, e.g., [A, Dirty]

Actions: Left, Right, Suck, Do Nothing



Tabulation of an agent function of the vacuum-cleaner

Percept sequence	Action
$[A, Clean]$	*Right*
$[A, Dirty]$	*Suck*
$[B, Clean]$	*Left*
$[B, Dirty]$	*Suck*
$[A, Clean], [A, Clean]$	*Right*
$[A, Clean], [A, Dirty]$	*Suck*
⋮	⋮
$[A, Clean], [A, Clean], [A, Clean]$	*Right*
$[A, Clean], [A, Clean], [A, Dirty]$	*Suck*
⋮	⋮

Good Behaviour: The Concept of Rationality

- Since we told earlier Rational Agent is one that does right things.
- What is the notion of Right things ?
- In AI we have the emerging notion Consequentialism.

Consequentialism – Evaluation of agent behaviour by its consequences.

Performance Measures

- When agent is launched in to the environment , it generates a sequence of actions according to the precepts it receives.

- This sequence of actions causes the environment to go through a **sequence of states**.

- If the **sequence of states** is desirable the agent has performed good job.

- This notion is characterized by a **Performance Measures** – that evaluates any given sequence of environment states.

Rationality Factors

1- The performance measure that defines the criterion of success.

2- The agent’s prior knowledge of the environment.

3- The actions that agent can perform.

4- The agent’s percept sequence to date.

More-Formal definition of Rational Agent.

For each possible percept sequence, a rational agent should select an action that is expected to maximize its performance measure, given the evidence provided by the percept sequence and whatever built-in knowledge the agent has.

Rational Agents (Contd..)

Rationality is distinct from **Omniscience**
(all- knowing with infinite knowledge).

An Omniscience agent knows the actual outcome of its actions and can act accordingly – Not realizable.

Agents can perform actions in order to modify future percepts so as to obtain useful information (**Information gathering, exploration**, **learn**).

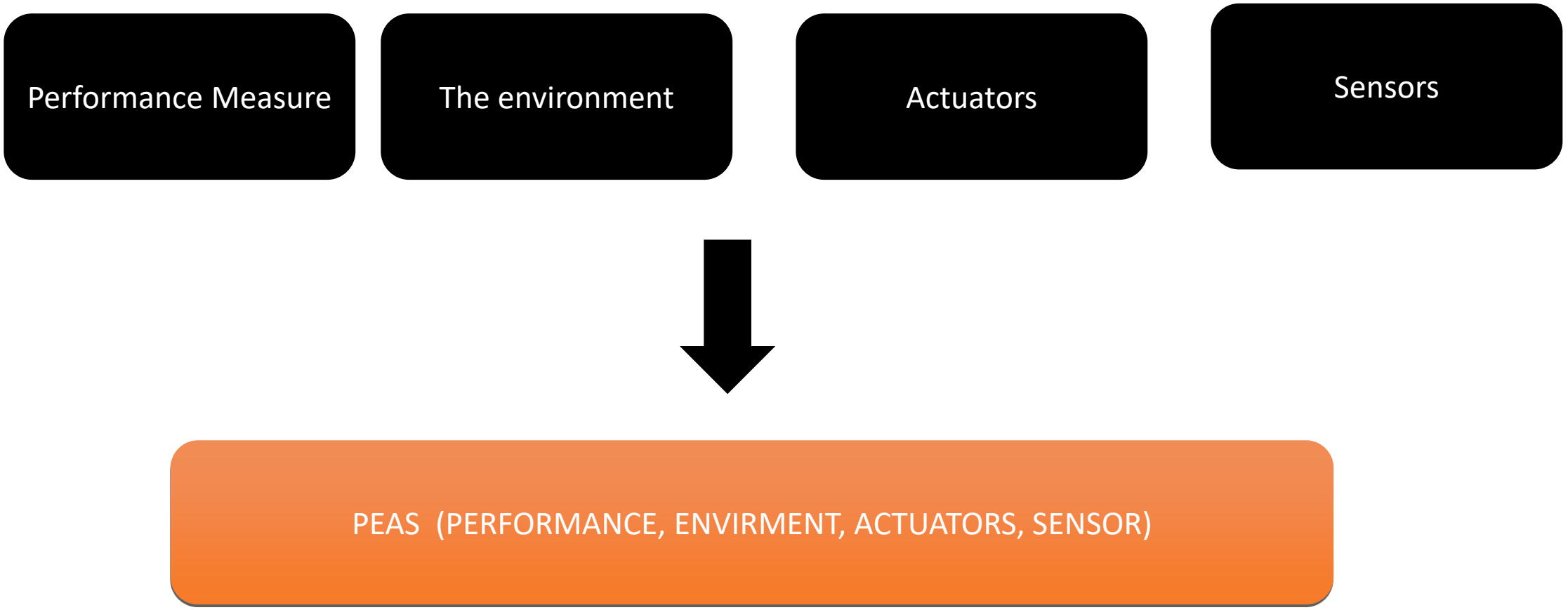
An agent is **autonomous** if its behavior is determined by its own experience
(with ability to learn and adapt).

The Nature of Environment

The Nature of Environment

Task Environment: which are essentially the **problems** to which Rational agents are the **solution**.

Specifying the Task Environment



PEAS description Of the task Environment for an Automated taxi

Agent Type	Performance Measure	Environment	Actuators	Sensors
Taxi driver	Safe, fast, legal, comfortable trip, maximize profits	Roads, other traffic, pedestrians, customer	Steering,accelerator, brake,signal,horn,display	Cameras,sonar,speedometer,GPS,odometer,accelerometer,engine sensors, keyboard

Examples of agent Types and their PEAS descriptions

Agent Type	Performance Measure	Environment	Actuators	Sensors
Medical diagnosis system	Healthy patient, minimize costs, lawsuits	Patient, hospital, staff	Display questions, tests, diagnoses, treatments, referrals	Keyboard entry of symptoms, findings, patient's answer
Satellite image analysis system	Correct image categorization	Downlink from orbiting satellite	Display categorization of scene	Color pixel arrays
Part-picking robot	Percentage of parts in correct bins	Conveyor belt with parts ;bins	Jointed arm and hand	Camera, joint angle sensors
Refinery controller	Maximize purity, yield, safety	Refinery ,operators	Valves, pumps,heaters,displays	Temperature, pressure, chemical sensors
Interactive English tutor	Maximize student’s score on test	Set of students, testing agency	Display exercises, suggestions, corrections	Keyboard entry

Properties of Task Environment

Properties of Task Environment

1. Fully Observable vs. Partially Observable
2. Deterministic vs. Stochastic
3. Episodic vs. Sequential
4. Discrete vs. continuous
5. Single vs. Multi Agent

Examples of task environments and their characteristics

Task Environment	Observable	Deterministic	Episodic	Static	Discrete	Agents
Crossword puzzle	Fully	Deterministic	Sequential	Static	Discrete	Single
Chess with a clock	Fully	Strategic	Sequential	Semi	Discrete	Multi
Poker	Partially	Strategic	Sequential	Static	Discrete	Multi
Backgammon	Fully	Stochastic	Sequential	Static	Discrete	Multi
Taxi driving	Partially	Stochastic	Sequential	Dynamic	Continuous	Multi
Medical diagnosis	Partially	Stochastic	Sequential	Dynamic	Continuous	Single
Image-analysis	Fully	Deterministic	Episodic	Semi	Continuous	Single
Part-picking robot	Partially	Stochastic	Episodic	Dynamic	Continuous	Single
Refinery controller	Partially	Stochastic	Sequential	Dynamic	Continuous	Single
Interactive English tutor	Partially	Stochastic	Sequential	Dynamic	Discrete	Multi

The Structure of Agents

$$Agent = Architecture + Program$$

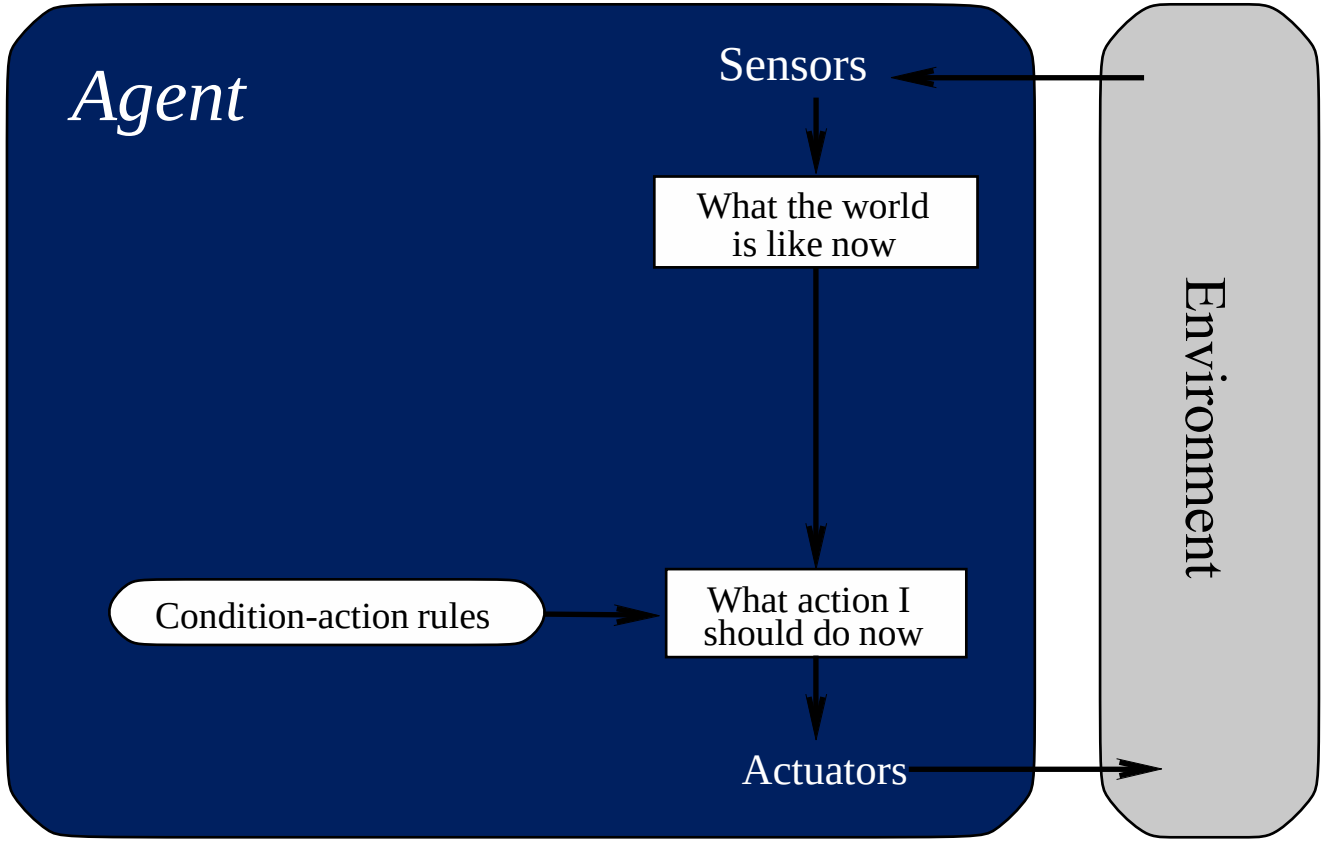
Agent Programs

- Simplex Reflex Agent.
- Model-Based Reflex Agent.
- Goal-Based Agents.
- Utility-Based Agents.
- Learning Agents

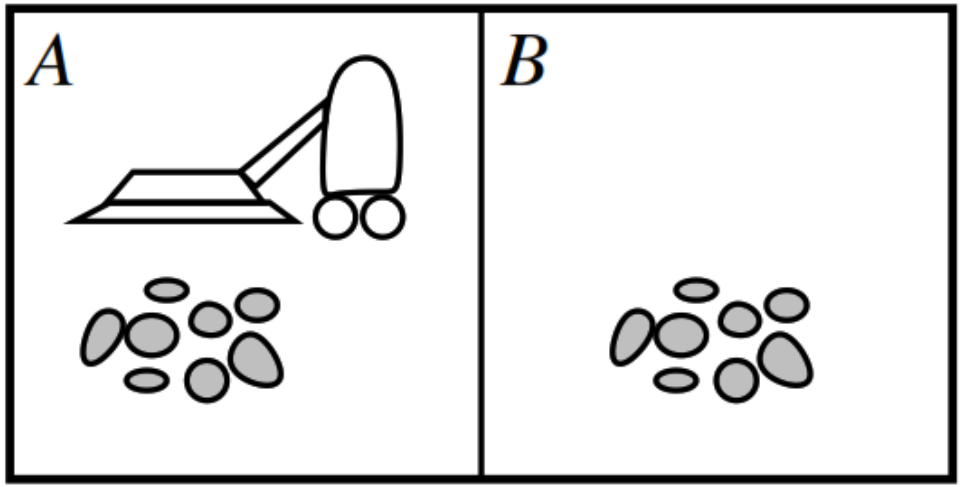
1. Simple reflex agents

The agent selects an action(s) based on the current precept and conditions, ignoring the rest of the precept history(previous state).

if x happens, do y



1. Simple reflex agents (Contd..)




```
function REFLEX-VACUUM-AGENT( [location,status]) returns an action
    if status = Dirty then return Suck
    else if location = A then return Right
    else if location = B then return Left
```

An Agent Program for a simple reflex agent in the two-location vacuum environment

1. Simple reflex agents (Contd..)

```
function SIMPLE-REFLEX-AGENT(percept) returns an action
  persistent: rules, a set of condition–action rules

  state ← INTERPRET-INPUT(percept)
  rule ← RULE-MATCH(state, rules)
  action ← rule.ACTION
  return action
```

Figure 2.10 A simple reflex agent. It acts according to a rule whose condition matches the current state, as defined by the percept.

if *car-in-front-is-braking* then *initiate-braking*.

1. Simple reflex agents (Contd..)

Play Music

Tell me a Joke about Classroom

2. Model-Based Reflex Agent.

States: Beyond Reflexes

- Recall the agent function that maps from percept histories to actions:

[*f*: P* □ A]

- An agent program can implement an agent function by maintaining an **internal state**.
- The internal state can contain information about the state of the external environment.
- The state depends on the history of percepts and on the history of actions taken:

[*f*: P*, A*□ S □A] where S is the set of states.

- If each internal state includes all information relevant to information making, the state space is **Markovian**.

2. Model-Based Reflex Agent (Contd...)

Handle partial observability *keep track of the part of the world it can’t see now.*

Agent should maintain internal state that depends on the percept history.

2. Model-Based Reflex Agent (Contd...)

The most effective way to hand partial observability is for the agent to keep
Track of the part of the world it can’t see now.

Agent should maintain some sort of internal state that depends on the percept history. And internal state also reflects some of the unobservable aspects of the current state.

Updating the agent internal state information requires **two kind of knowledge** as time evolves:

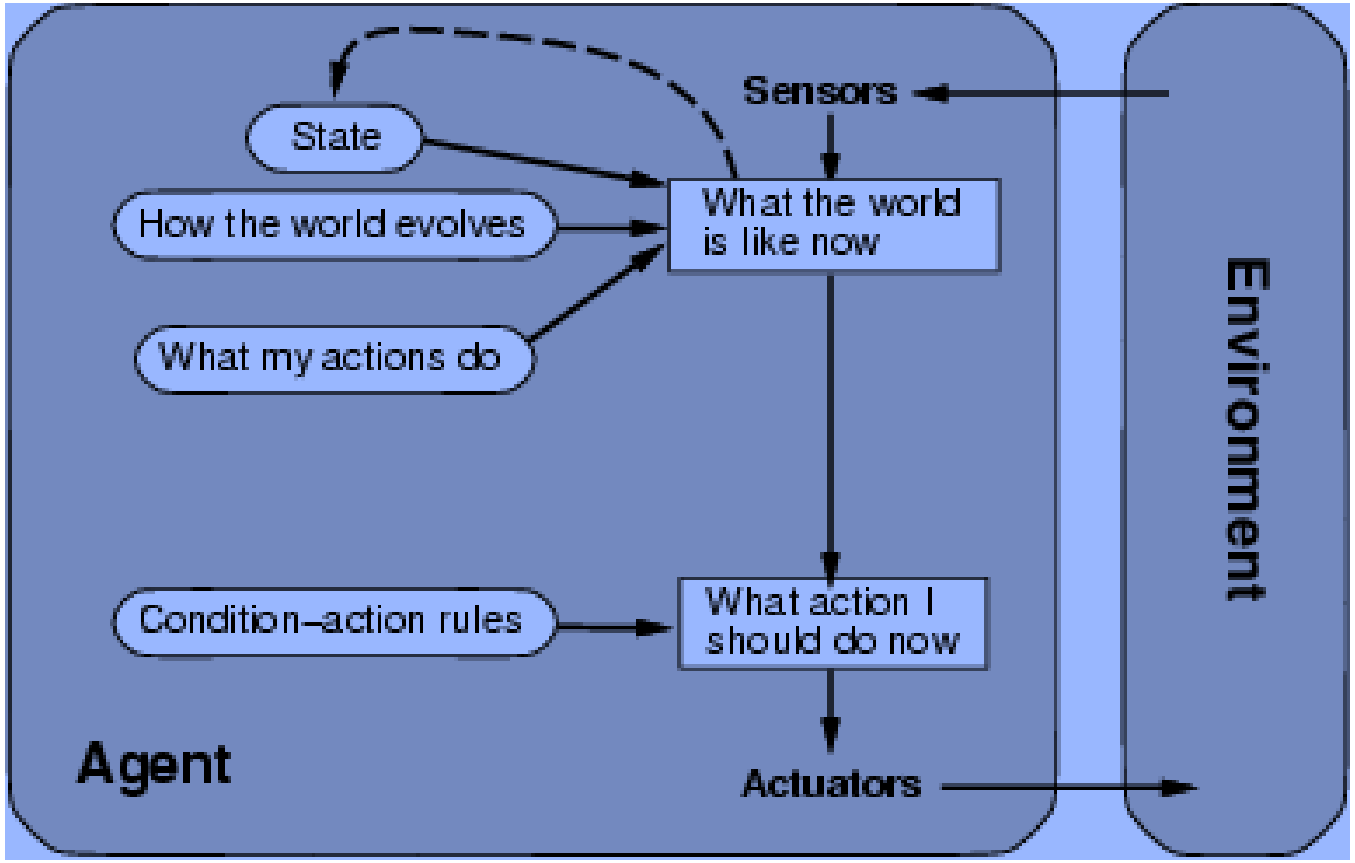
*First the information how world has been changing – **Transition Model***

*Second the information about how the state of the world is reflected in the agent’s precepts – **Sensor Model***

2. Model-Based Reflex Agent (Contd...)

Together Transition Model and Sensor Model allow an agent to keep track of the state of the world – Hence Model-Based Agent.

2. Model-Based Reflex Agent (Contd...)



- *Know how world evolves*
- *How agents' actions affect the world*
- *Model base agents update their state*

2. Model-Based Reflex Agent (Contd...)

```
function MODEL-BASED-REFLEX-AGENT(percept) returns an action
    persistent: state, the agent's current conception of the world state
                model, a description of how the next state depends on current state and action
                rules, a set of condition–action rules
                action, the most recent action, initially none

    state ← UPDATE-STATE(state, action, percept, model)
    rule ← RULE-MATCH(state, rules)
    action ← rule.ACTION
    return action
```

End of Lecture