EUROPEAN ALARA NETWORK

26 - 28 November 2019 - Athens
19th EAN WORKSHOP "INNOVATIVE ALARA TOOLS"

Artificial intelligence in interventional techniques

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The author declares no conflict of interest

Artificial intelligence (AI)

- The term AI is applied when a device mimics cognitive functions, such as learning and problem solving.

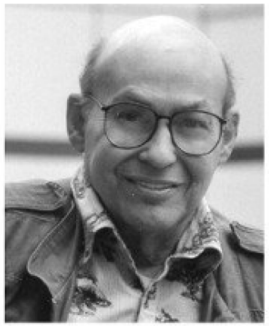
- AI refers to a field of computer science dedicated to the creation of systems performing tasks that usually require human intelligence, branching off into different techniques.

Presapane et al. 2018. AI in medical imaging. Threat or opportunity? Radiologists again at the forefront of innovation in medicine.

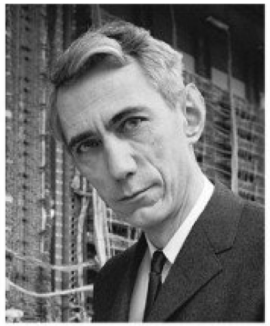
History of AI

History of AI – 1956 Dartmouth College, New Hampshire

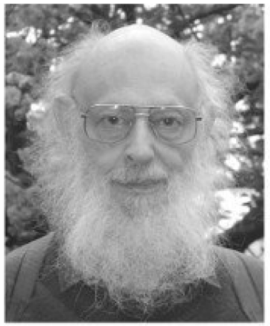
John MacCarthy



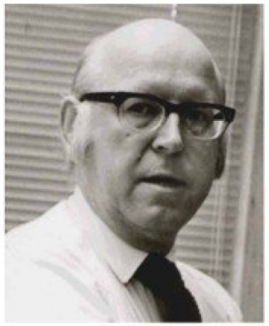
Marvin Minsky



Claude Shannon



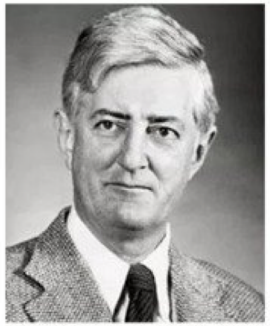
Ray Solomonoff



Alan Newell

Herbert Simon

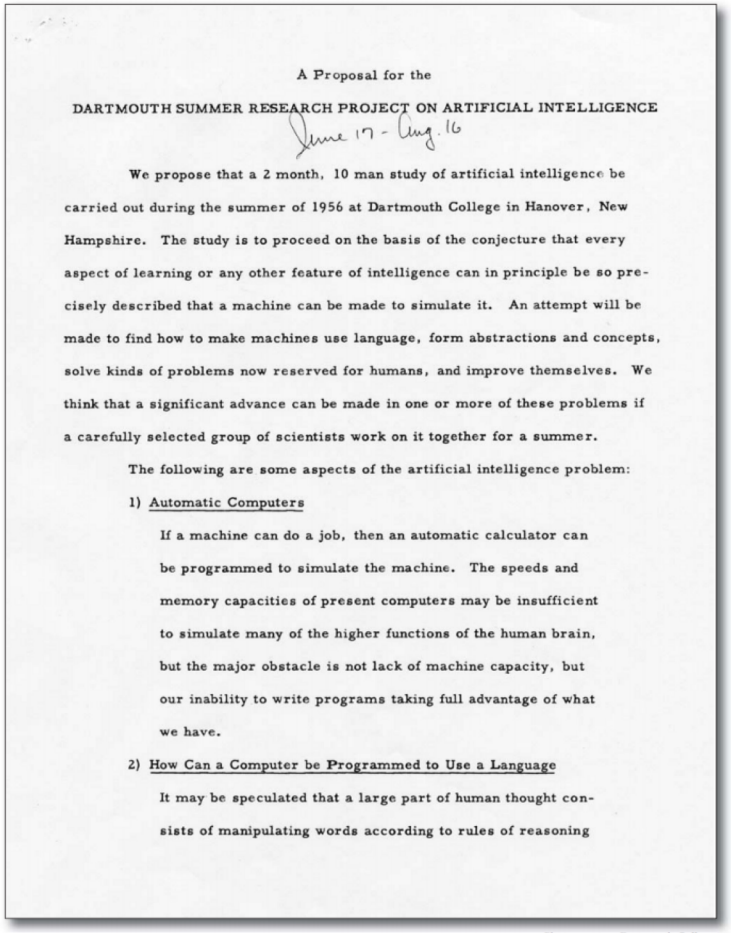
Arthur Samuel



Oliver Selfridge

Nathaniel Rochester

Trenchard More



A Proposal for the

DARTMOUTH SUMMER RESEARCH PROJECT ON ARTIFICIAL INTELLIGENCE

June 17 - Aug. 16

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. An attempt will be made to find how to make machines use language, form abstractions and concepts, solve kinds of problems now reserved for humans, and improve themselves. We think that a significant advance can be made in one or more of these problems if a carefully selected group of scientists work on it together for a summer.

The following are some aspects of the artificial intelligence problem:

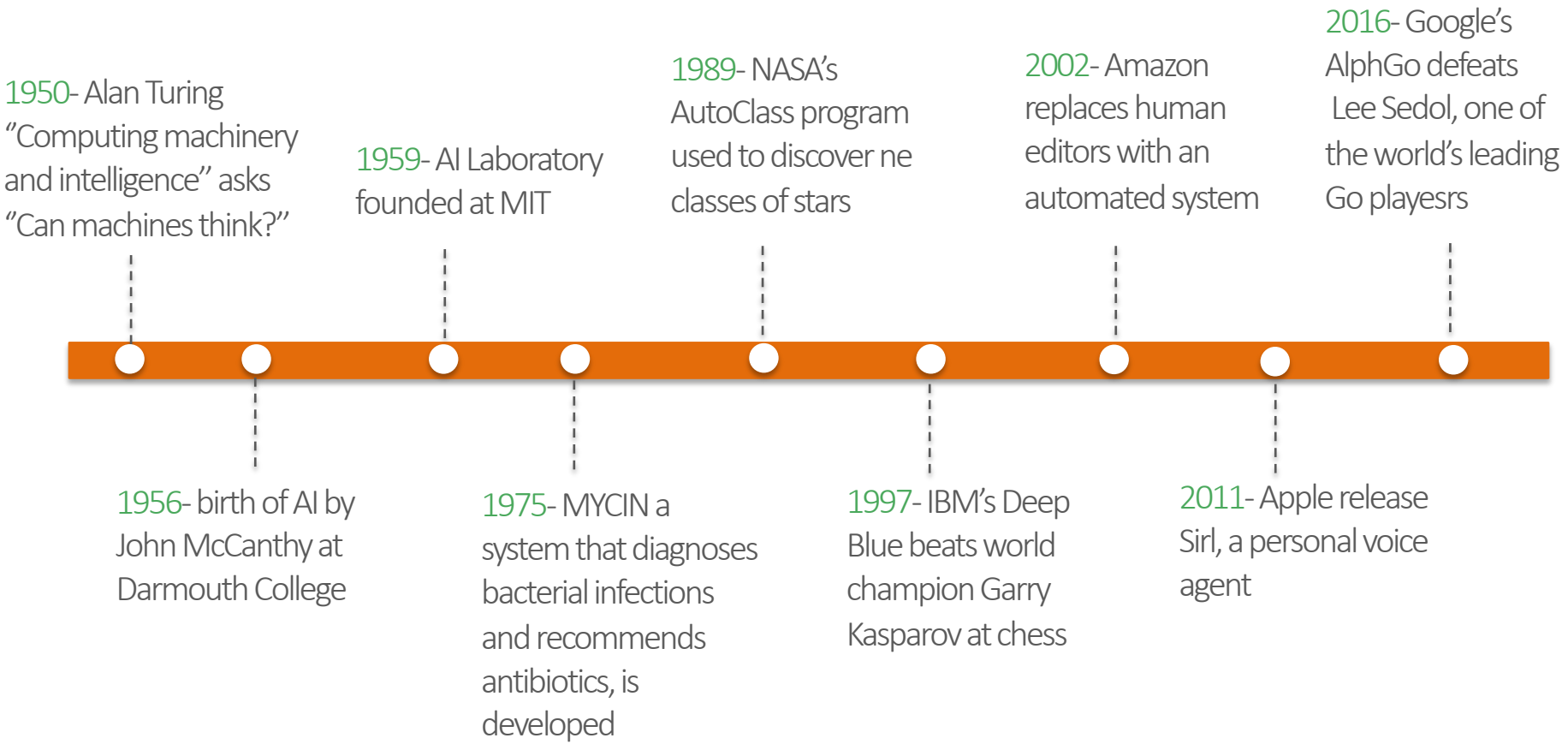
1) Automatic Computers

If a machine can do a job, then an automatic calculator can be programmed to simulate the machine. The speeds and memory capacities of present computers may be insufficient to simulate many of the higher functions of the human brain, but the major obstacle is not lack of machine capacity, but our inability to write programs taking full advantage of what we have.

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

It may be speculated that a large part of human thought consists of manipulating words according to rules of reasoning

"We propose that a two-month, ten-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. An attempt will be made to find how to make machines use language, form abstractions and concepts, solve kinds of problems now reserved for humans, and improve themselves…"


1950- Alan Turing "Computing machinery and intelligence" asks "Can machines think?"
1956- birth of AI by John McCanthy at Darmouth College
1959- AI Laboratory founded at MIT
1975- MYCIN a system that diagnoses bacterial infections and recommends antibiotics, is developed
1989- NASA's AutoClass program used to discover ne classes of stars
1997- IBM's Deep Blue beats world champion Garry Kasparov at chess
2002- Amazon replaces human editors with an automated system
2011- Apple release Sirl, a personal voice agent
2016- Google's AlphGo defeats Lee Sedol, one of the world's leading Go playesrs

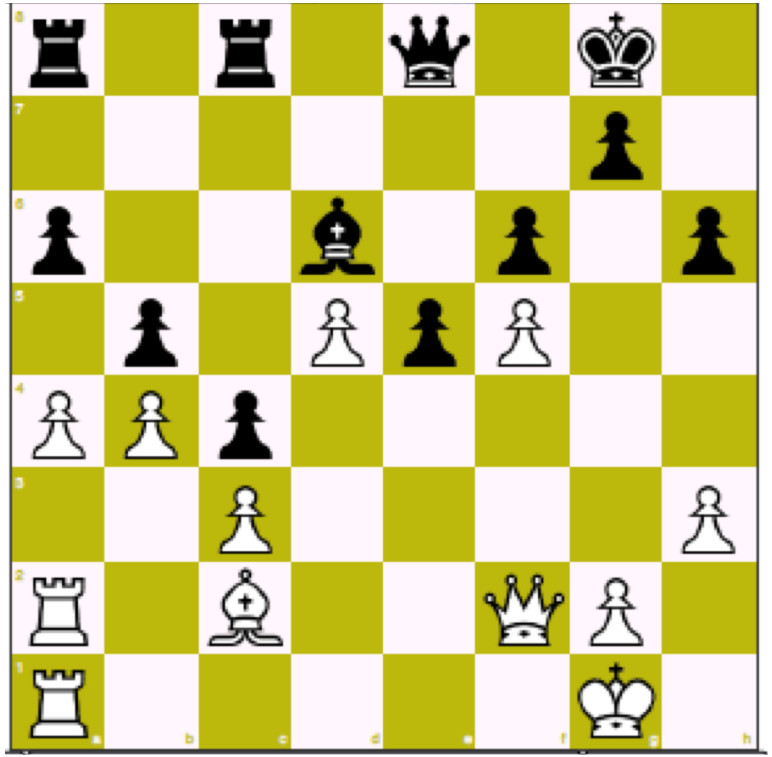
Chess

Chess – Man vs. Machine

D. Bronstein vs. M20 (1963)

R. Fischer vs. Greenblatt (1977)

Gary Kasparov vs. Deep Blue 1997



1.e4 e5 2.♘f3 ♘c6 3.♗b5 a6 4.♗a4 ♘f6 5.O-O ♗e7 6.♖e1 b5 7.♗b3 d6 8.c3 O-O 9.h3 h6 10.d4 ♖e8 11.♘bd2 ♗f8 12.♘f1 ♗d7 13.♘g3 ♘a5 14.♗c2 c5 15.b3 ♘c6 16.d5 ♘e7 17.♗e3 ♘g6 18.♕d2 ♘h7 19.a4 ♘h4 20.♘xh4 ♕xh4 21.♕e2 ♕d8 22.b4 ♕c7 23.♖ec1 c4 24.♖a3 ♖ec8 25.♖ca1 ♕d8 26.f4 ♘f6 27.fxe5 dxe5 28.♕f1 ♘e8 29.♕f2 ♘d6 30.♗b6 ♕e8 31.♖3a2 ♗e7 32.♗c5 ♗f8 33.♘f5 ♗xf5 34.exf5 f6 35.♗xd6 ♗xd6 36.axb5 axb5 37.♗e4 ♖xa2 38.♕xa2 ♕d7 39.♕a7 ♖c7 40.♕b6 ♖b7 41.♖a8+ ♔f7 42.♕a6 ♕c7 43.♕c6 ♕b6+ 44.♔f1 ♖b8 45.♖a6 1-0

«I have been cheated»

- The champion's reaction after the end of the game was furious.
- He claimed that he was cheated and that it was a "dirty game".
- He characterized the computer's move not to take the pawn as "human", with imagination and creativity.

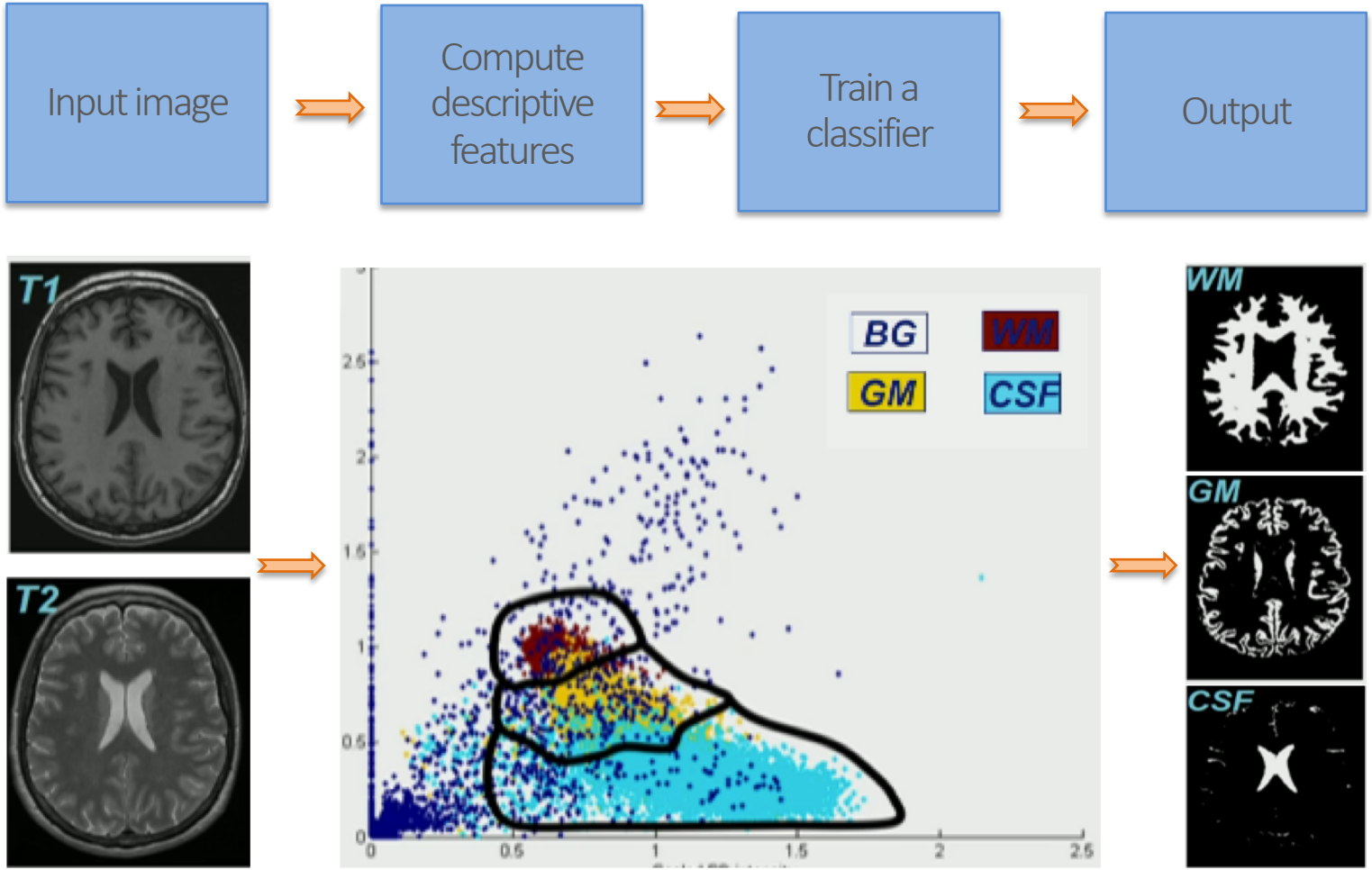

Garry Kasparov
The Bright Future of
Human *Plus* Machine
Microsoft Summit
Transform. Innovate. Grow.

Examples of AI in daily life

Machine Learning (ML)

- ML describes a subfield of AI that includes all those approaches that allow computers to learn from data, to make and improve predictions (for example cancer) without being explicitly programmed.

- Example: Patients can be stratified into categories by ML clustering methods that find similarities between individuals, without the ML system being instructed on specific characteristics *(Letzen et al. 2019. The role of AI in Interventional Oncology: A Primer)*

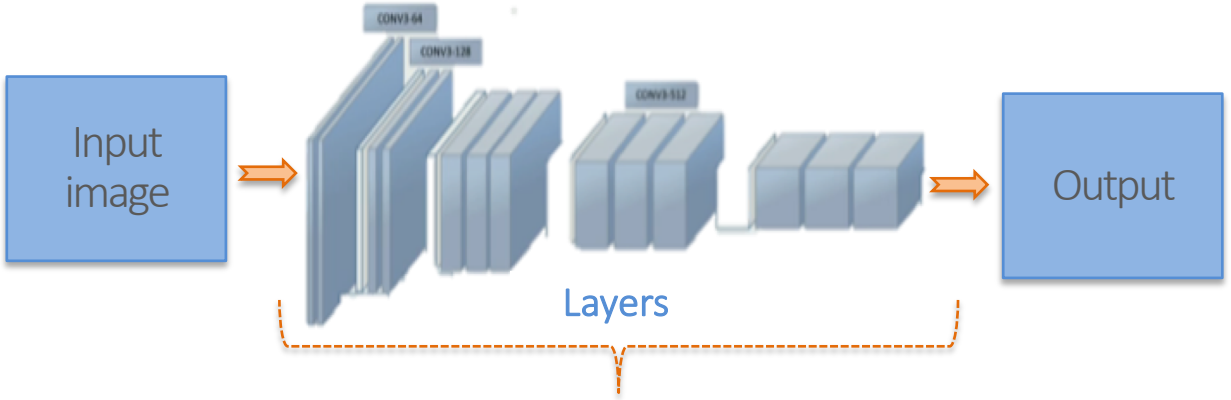


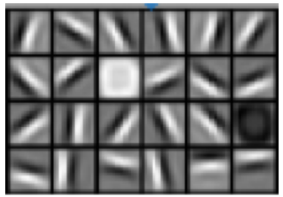
Machine and Deep Learning in Radiology, M. De Bruijne, https://www.maiesr.org/recorded-lectures/

Deep Learning (DL)

- Deep learning is a subset of ML where artificial neural networks, algorithms inspired by the human brain, learn from large amounts of data.

- Similarly to how we learn from experience, the deep learning algorithm would perform a task repeatedly, each time tweaking it a little to improve the outcome.





1st layer
Recognizes edges and shapes

2nd layer
Identifies more complex shapes and features such as nose and ears

3rd layer
Final prediction

J Vasc Interv Radiol. 2018 Jun;29(6):850-857.e1. doi: 10.1016/j.jvir.2018.01.769. Epub 2018 Mar 14.

Predicting Treatment Response to Intra-arterial Therapies for Hepatocellular Carcinoma with the Use of Supervised Machine Learning-An Artificial Intelligence Concept.

Abajian A[1], Murali N[1], Savic LJ[2], Laage-Gaupp FM[1], Nezami N[1], Duncan JS[3], Schlachter T[1], Lin M[4], Geschwind JF[5], Chapiro J[6].

- 36 patients with hepatocellular carcinoma (HCC) treated with transarterial chemoembolization
- MRI was obtained before and 1 month after transarterial chemoembolization.
- Clinical information, baseline imaging, and therapeutic features were used to train logistic regression (LR) and random forest (RF) models to predict patients as treatment responders or nonresponders.
- Both LR and RF models predicted transarterial chemoembolization treatment response with an overall **accuracy of 78%**.
- Transarterial chemoembolization outcomes in patients with HCC may be predicted pre-procedurally by combining clinical patient data and baseline MR imaging with the use of AI and ML techniques.

J Neurointerv Surg. 2019 Aug;11(8):847-851. doi: 10.1136/neurintsurg-2018-014381. Epub 2019 Feb 2.

Using machine learning to optimize selection of elderly patients for endovascular thrombectomy.

Alawieh A[1,2], Zaraket F[3], Alawieh MB[4], Chatterjee AR[5], Spiotta A[2].

- The study used a retrospectively identified cohort of 110 patients undergoing endovascular thrombectomy for acute ischemic stroke treatment to train a regression tree model that can predict 90-day modified Rankin Scale (mRS) scores.
- The identified algorithm, termed SPOT, was compared with other decision trees and regression models, and then validated using a prospective cohort of 36 patients.
- Performance of SPOT was significantly better than results obtained using National Institutes of Health Stroke Scale score, Alberta Stroke Program Early CT score, or patients' baseline deficits.
- SPOT is a useful tool to determine which patients to exclude from endovascular thrombectomy.

J Am Heart Assoc. 2019 Feb 19;8(4):e011685. doi: 10.1161/JAHA.118.011685.

Angiography-Based Machine Learning for Predicting Fractional Flow Reserve in Intermediate Coronary Artery Lesions.

Cho H[1], Lee JG[2], Kang SJ[1], Kim WJ[3], Choi SY[4], Ko J[2], Min HS[1], Choi GH[1], Kang DY[1], Lee PH[1], Ahn JM[1], Park DW[1], Lee SW[1], Kim YH[1], Lee CW[1], Park SW[1], Park SJ[1].

- Supervised machine learning model separated the lesions with fractional flow reserve ≤0.80 versus >0.80 with overall accuracy of 82% in the test set.

- The angiography-based ML model shows good diagnostic performance for identifying ischemia-producing lesions and may reduce future need for pressure wires and risk of procedural complications.

Utilization of deep learning techniques to assist clinicians in diagnostic and interventional radiology: development of a virtual radiology assistant

K. Seals, B. Dubin, L. Leonards, E. Lee, J. McWilliams, S. Kee, R. Suh; David Geffen School of Medicine at UCLA, Los Angeles, CA

- Creation of a "chatbot" interventional radiologist that can automatically communicate (via text message) with referring clinicians and quickly provide evidence-based answers to frequently asked questions .
- The "chatbot" allows the referring physician to provide real-time information to the patient about the next phase of treatment, or basic information about an interventional radiology treatment.
- The researchers used a technology called Natural Language Processing, implemented using IBM's Watson artificial intelligence computer

https://www.sirweb.org/advocacy-and-outreach/media/news-release-archive/news-release-artificial_intelligence/

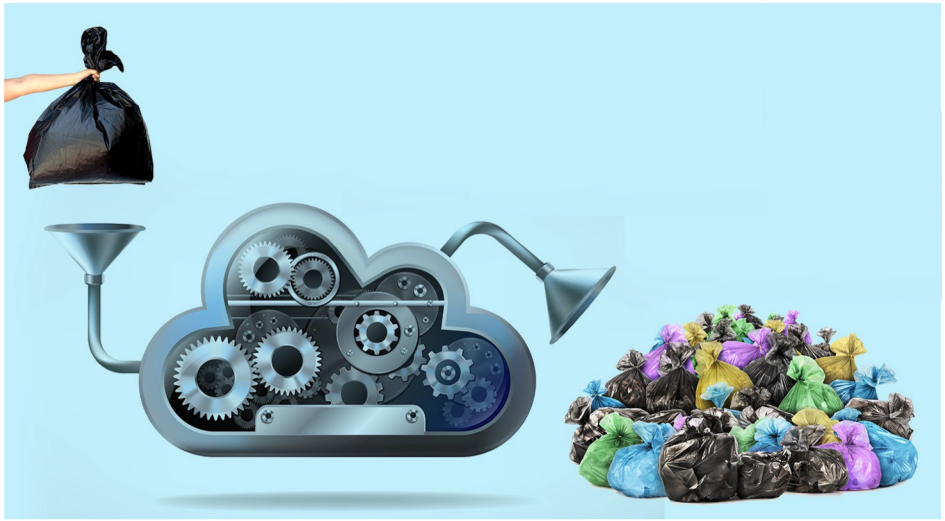
The impact of AI in Interventional Radiology

- Prediction of therapeutic outcome
- Optimization of patient selection
- Improvement of IR procedures: new catheter navigation assistance systems
- Education and training: development of simulation tools for training

- Letzen et al. 2019. The role of AI in Interventional Oncology: A Primer
- Meek et al. 2019. Machine learning for the Interventional Radiologist

Open issues: Training data

- How much data is needed?
- What type of data do I need?
- What about the quality of data?



Open issues: Data control

Open issues: Data ownership-privacy

Monkey steals a camera from a photographer to snap himself a selfie. Gets uploaded to Wikipedia. Photographer sues Wikipedia to remove it. Wikipedia refuses to delete photo as "monkey owns it".

Open issues: Who is responsible for the prediction (diagnosis)?

Man or Machine?!

- The Radiologist?
- The Hospital?
- The software developers?
- The company which developed the AI system?

Thank you for your attention!