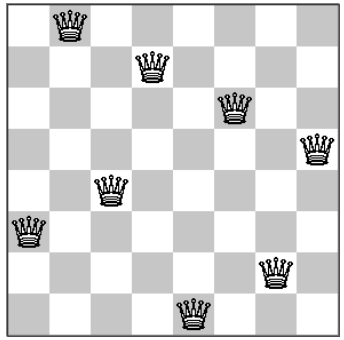
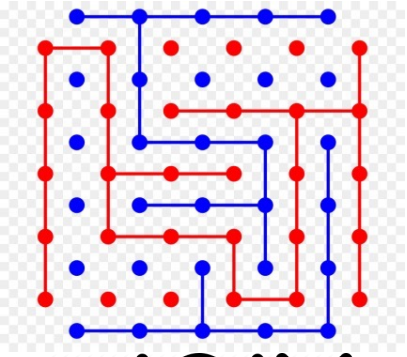
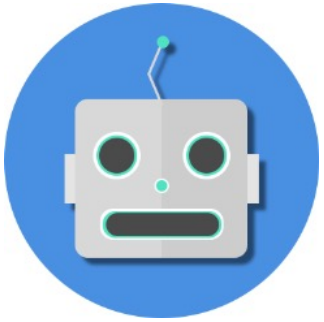
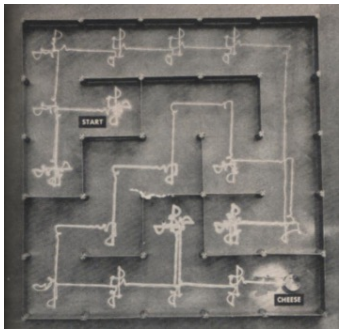
Artificial Intelligence:

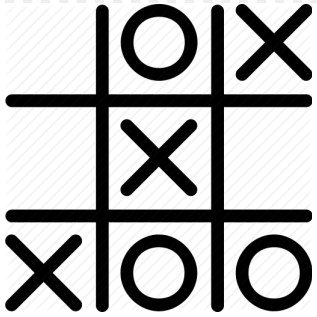
Past, Present and Future











Chee Wei Tan

Challenges of Artificial Intelligence

AI Birth: When, Where, Why?

1956 Dartmouth Conference: The Founding Fathers of AI


John MacCarthy


Marvin Minsky


Claude Shannon


Ray Solomonoff


Alan Newell


Herbert Simon

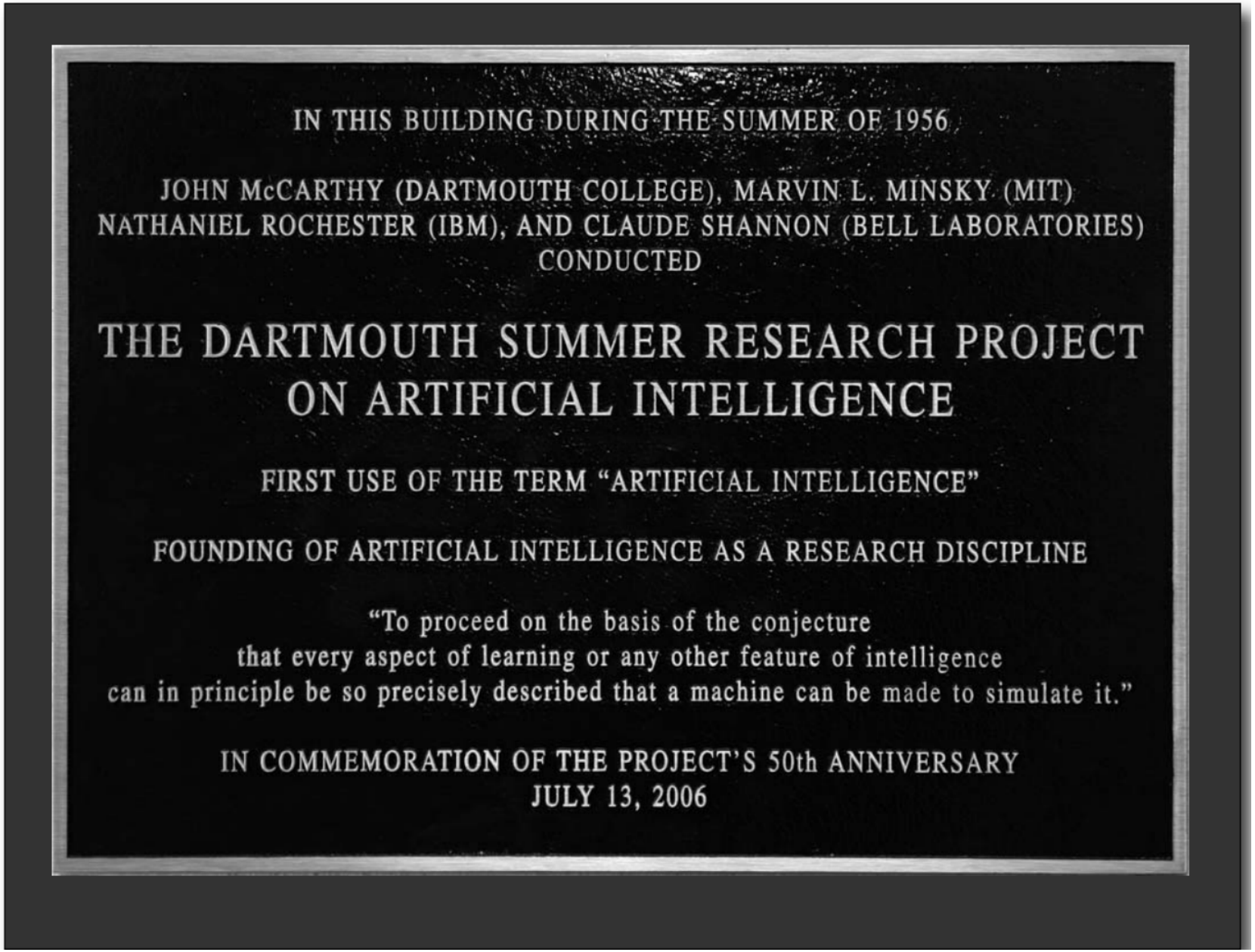

Arthur Samuel


Oliver Selfridge


Nathaniel Rochester


Trenchard More

Challenges of Artificial Intelligence



AI@50: The Next Fifty Years

Five of the attendees of the 1956 Dartmouth Summer Research Project on Artificial Intelligence reunited at the July AI@50 conference. From left: Trenchard More, John McCarthy, Marvin Minsky, Oliver Selfridge, and Ray Solomonoff. (Photo by Joseph Mehling '69)

https://www.dartmouth.edu/~ai50/homepage.html

Challenges of Artificial Intelligence

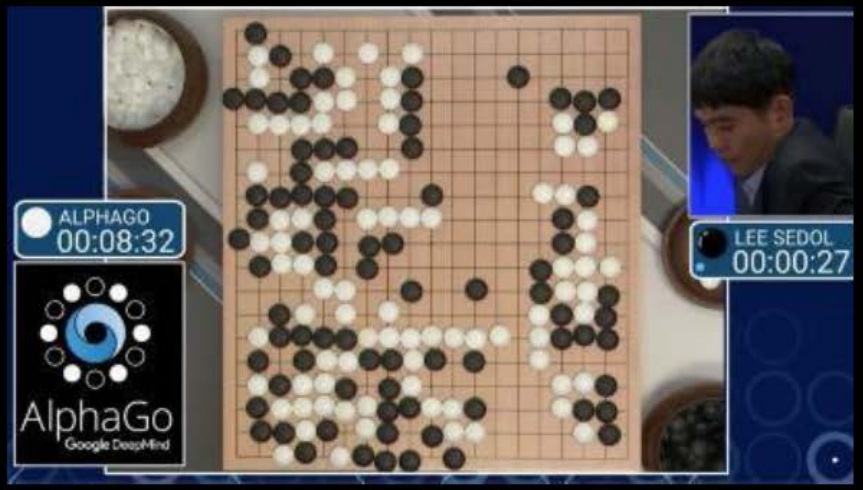
"Field of study that gives computers the ability to learn without being explicitly programmed"

Arthur Samuel, 1959

1952 – 1962 Beat CT Champ

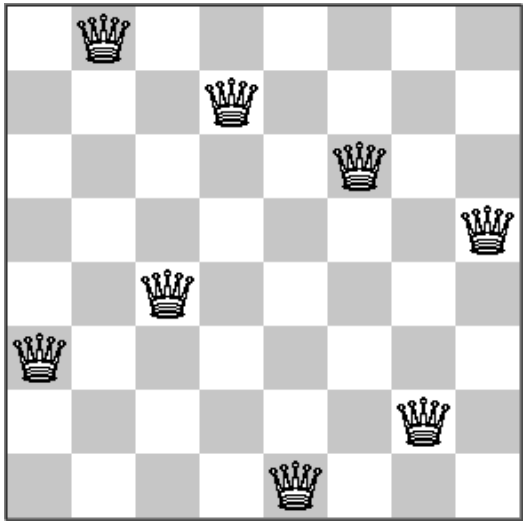
May 11, 1997. Game 6

Feb 2011. Final Jeopardy Watson



Mar 2016. DeepMind vs. Go Champ

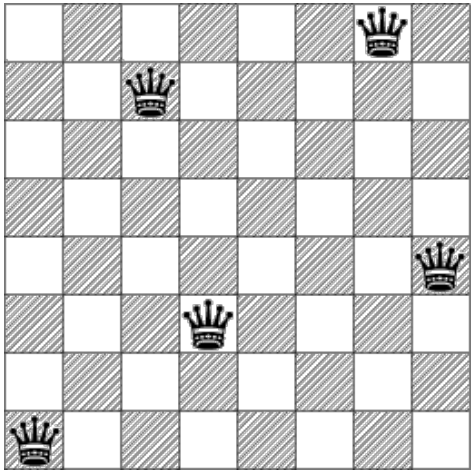
Eight Queens Problem



The problem is to place eight queens on a chessboard, such that no two queens are attacking each other along the same row, column, or diagonal.
Max Bezzel, a German chess composer (1848)

How many possible solutions can you find altogether?

Can you complete the solution for the problem instance below?



Hilbert's Problems: What is Computation

Twenty-three problems in mathematics published by German mathematician **David Hilbert** in 1900. The problems were all unsolved at the time, and several of them were very influential for 20th-century mathematics. Hilbert's tenth problem asks for the *construction of an **algorithm***, whose answer in the negative by a talented group of mathematicians contradicted Hilbert's philosophy of mathematics.
https://en.wikipedia.org/wiki/Hilbert%27s_problems

Hilbert's *Entscheidungsproblem* (1928)

The problem asks for an **algorithm** that takes as input a statement of a first-order logic (possibly with a finite number of axioms beyond the usual axioms of first-order logic) and answers "Yes" or "No" according to whether the statement is universally valid.

Alan Turing published in January 1937 with the title "*On Computable Numbers, with an Application to the Entscheidungsproblem*" that some decision problems are "undecidable": there is no single algorithm that infallibly gives a correct "yes" or "no" answer to each instance of the problem.

https://www.maa.org/sites/default/files/pdf/news_old/Thiele.pdf

Gödel's Incompleteness Theorem

As part of his Incompleteness Theorem, Gödel translated the paradoxical statement:

"This statement cannot be proved"

into the pure mathematical statement:

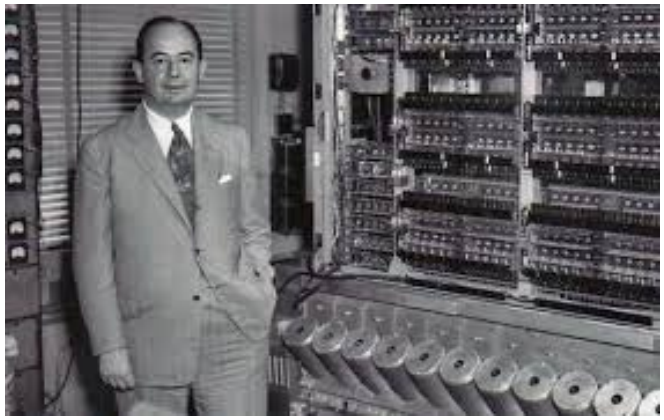
~(3r:3s: (P(r,s) V (s=g(sub (f_2(y)))))))

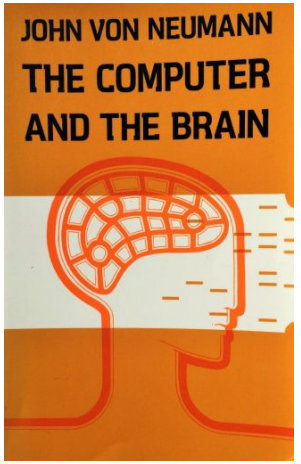
and used this to show there there are some mathematical statements which are true but which nevertheless cannot be proved.

Gödel's incompleteness theorems (1931) demonstrate the inherent limitations of every formal axiomatic system capable of modelling basic arithmetic. His theorems imply that not all mathematical questions are even computable, and that it is impossible, even in principle, to create a machine or computer that will be able to do all that a human mind can do. Since then, much of the debate centers on whether the human mind is equivalent to a Turing machine, or by the Church–Turing thesis, any finite machine at all. If it is, and if the machine is consistent, then Gödel's incompleteness theorems would apply to it.

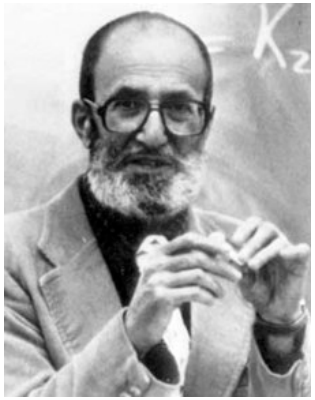
https://www.storyofmathematics.com/20th_godel.html

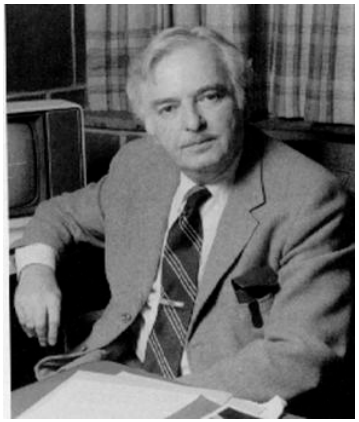
The Martians and Computing





This *unfinished book* discusses how the human brain can be viewed as a computing machine





A group of prominent Hungarian scientists (mostly, but not exclusively, physicists and mathematicians) who emigrated to the United States in the early half of the 20th century. A major part of their work laid the foundations of computer science in the second half.

https://en.wikipedia.org/wiki/The_Martians_(scientists)

John von Neumman Documentary, 1966 The Mathematical Association of America
https://www.youtube.com/watch?v=Y2jiQXI6nrE

From motion of stars to moon-landing to seeing better: Gauss's Least Squares


DELLA SCOPERTA

DEL NUOVO PIANETA

CERERE FERDINANDEA

OTTAVO TRA I PRIMARJ DEL NOSTRO SISTEMA SOLARE.

PALERMO

1802

NELLA STAMPERIA REALE.

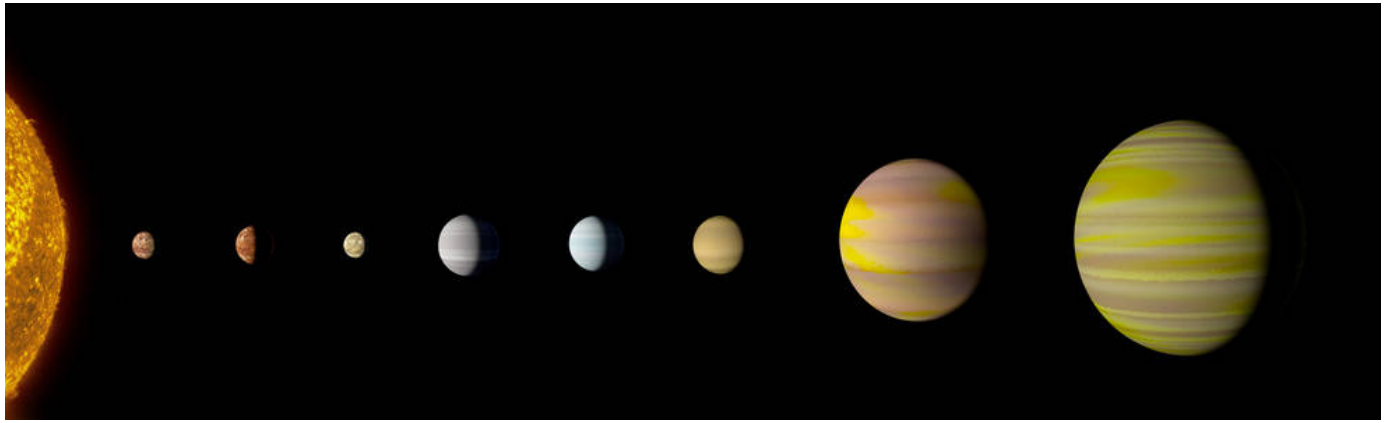
An influential treatment of the method of least squares, a procedure used in all sciences to this day to minimize the impact of measurement error – now an indispensable tool in machine learning and statistics

Schmidt-Kalman filter

https://en.wikipedia.org/wiki/Carl_Friedrich_Gauss

https://www.nasa.gov/feature/ames/math-invented-for-moon-landing-helps-your-flight-arrive-on-time

AI, NASA data discovers new planet



Shallue, a senior software engineer with Google's research team Google AI, came up with the idea to apply a neural network to Kepler data. He became interested in exoplanet discovery after learning that astronomy, like other branches of science, is rapidly being inundated with data as the technology for data collection from space advances.

"In my spare time, I started googling for 'finding exoplanets with large data sets' and found out about the Kepler mission and the huge data set available," said Shallue. "Machine learning really shines in situations where there is so much data that humans can't search it for themselves."

Artificial Intelligence, NASA Data Used to Discover Eighth Planet Circling Distant Star (December 2017)
https://www.nasa.gov/press-release/artificial-intelligence-nasa-data-used-to-discover-eighth-planet-circling-distant-star

DARPA Grand Challenge: Igniting self-driving cars and pushing AI frontiers

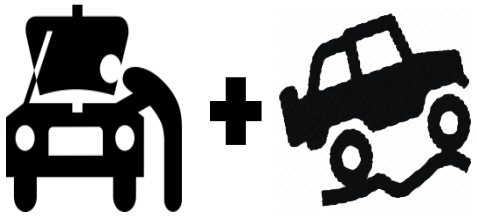
- "Software is eating the world," Marc Andreessen (2011)
  - Computing affects technological and economical shift and disrupts old economies

    http://www.wsj.com/articles/SB10001424053111903480904576512250915629460
  - Barrier is low: Anyone (i.e., you!) can learn programming to carry out "computation" on a computer

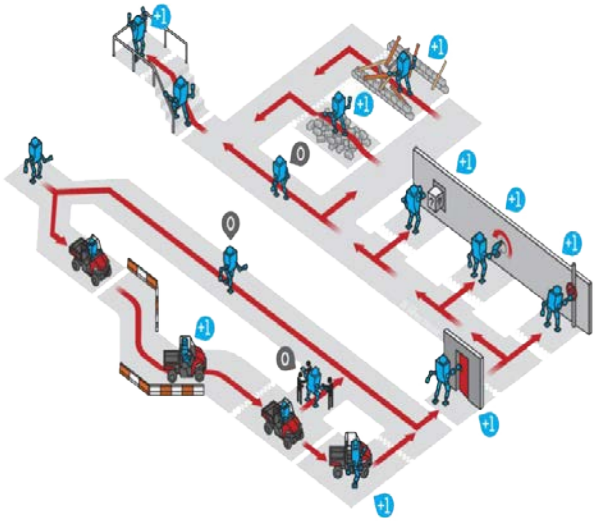
- AI, as a subfield of computer science, is about the *future*
- What are *deserving problems* that AI technologies and computer science can solve?

What is DARPA Grand Challenge?

1. A $1 million prize competition for autonomous vehicles, funded by the Defense Advanced Research Projects Agency (DARPA)



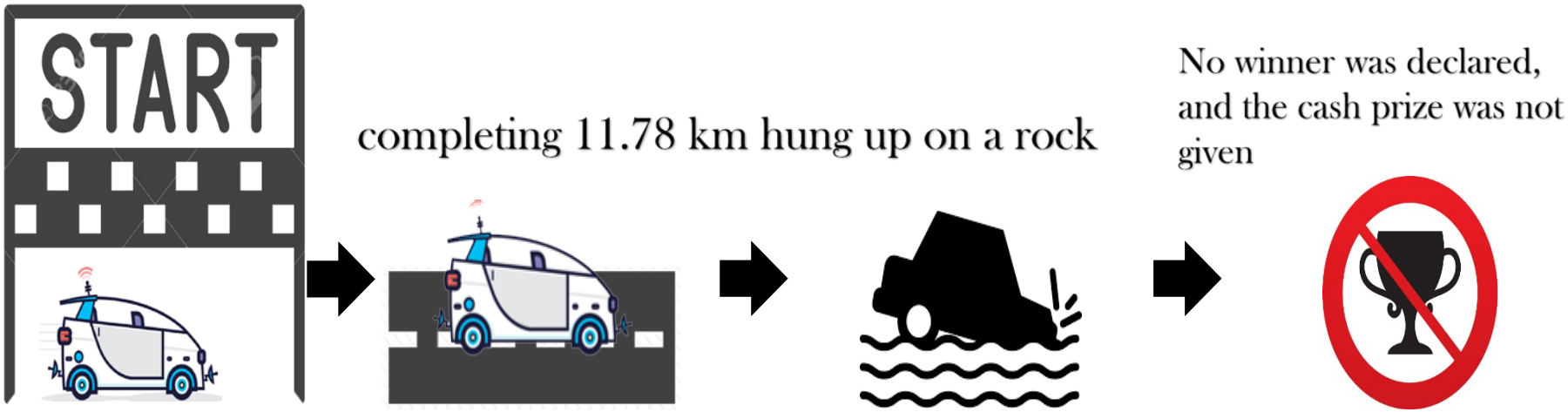
2. The initial DARPA Grand Challenge was created to spur the development of technologies needed to create the first fully autonomous ground vehicles capable of completing a substantial off-road course within a limited time



3. The most recent challenges are the 2012 DARPA Robotics Challenge and 2019 DARPA Subterranean Challenge focusing on autonomous robots in mazes

DARPA Grand Challenge 2004

The first competition of the DARPA Grand Challenge was held on March 13, 2004 in the Mojave Desert region of the United States, along a 150-mile (240 km) route that follows along the path of Interstate 15 from just before Barstow, California to just past the California–Nevada border. None of the robot vehicles finished the route. Carnegie Mellon University's car (a converted Humvee) traveled the farthest distance, completing 11.78 km (7.32 miles) of the course before getting hung up on a rock. No winner was declared, and the cash prize was not given.

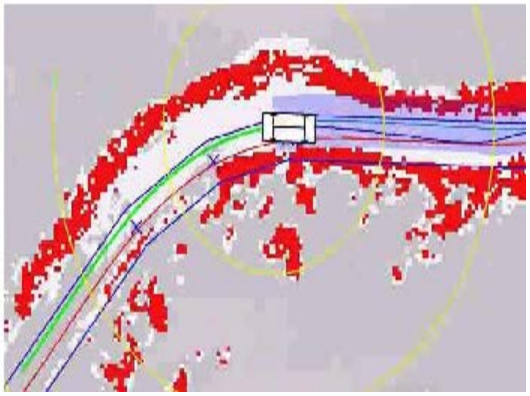


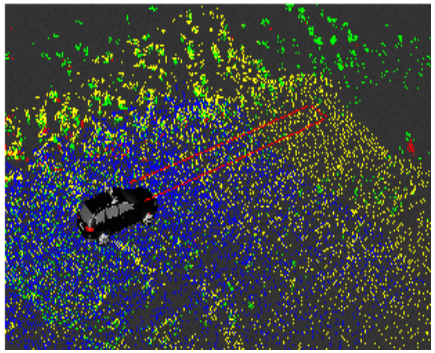
https://en.wikipedia.org/wiki/DARPA_Grand_Challenge_(2004)

DARPA Grand Challenge 2005

In the second competition of the DARPA Grand Challenge, all but one of the 23 finalists in the 2005 race surpassed the 11.78 km (7.32 miles) distance completed by the best vehicle in the 2004 race. Five vehicles successfully completed the course of length 212 km (132 miles)!

The champion team (Stanford University AI Lab) used machine learning to obstacle detection. Data from the LIDARs was fused with images from the vision system to perform more distant look-ahead. If a path of drivable terrain could not be detected for at least 40 meters in front of the vehicle, speed was decreased and the LIDARs were used to locate a safe passage.



https://en.wikipedia.org/wiki/DARPA_Grand_Challenge_(2005)

DARPA Robotics Challenge 2012

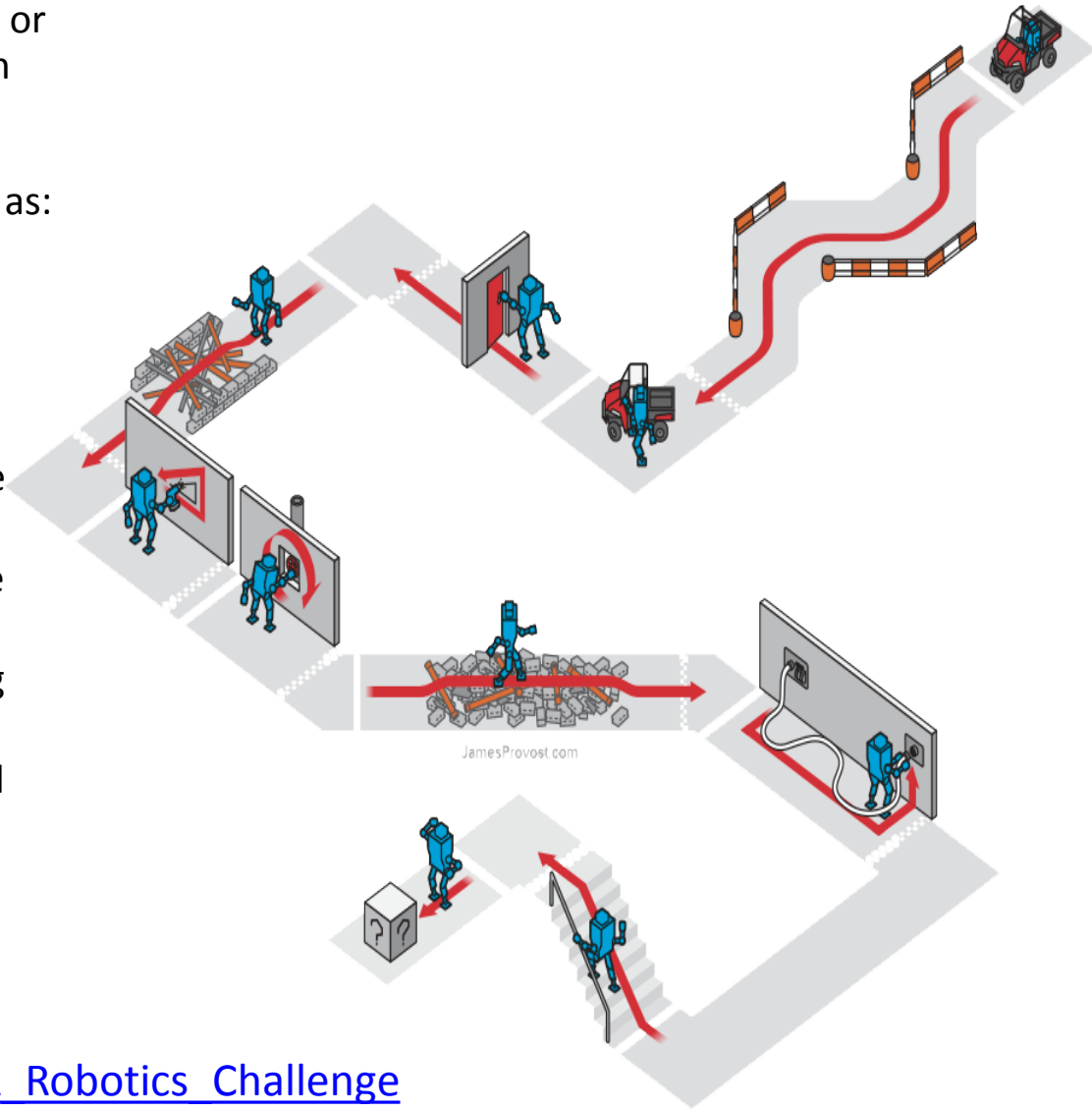
- The DARPA Robotics Challenge is a competition focusing on humanoid robotics. The primary goal is to develop ground robotic capabilities to execute complex tasks in
  - dangerous
  - degraded
  - human-engineered environments
- Unlike prior Challenges, the construction of "vehicles" are not within the scope of the Robotics Challenge.

- What are *deserving problems* that can be solved by AI and robotics?

DARPA Robotics Challenge 2012

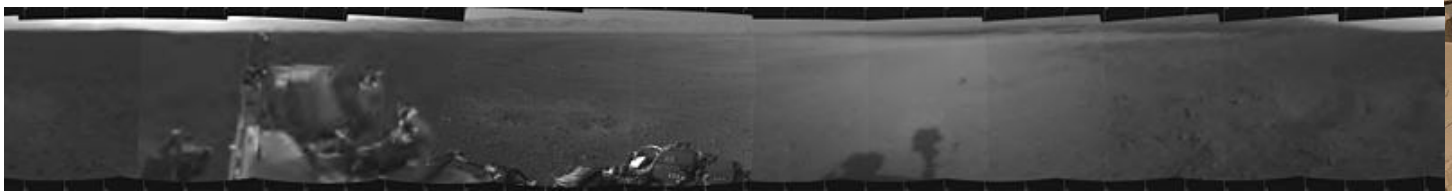
The Robotics Challenge focus on disaster or emergency-response scenarios. Although the requirements may change as the contest progresses, the initial task requirements for robot entries are listed as:

1. Drive a utility vehicle at the site.
2. Travel dismounted across rubble.
3. Remove debris blocking an entryway.
4. Open a door and enter a building.
5. Climb an industrial ladder and traverse an industrial walkway.
6. Use a tool to break through a concrete panel.
7. Locate and close a valve near a leaking pipe.
8. Connect a fire hose to a standpipe and turn on a valve.



https://en.wikipedia.org/wiki/DARPA_Robotics_Challenge

NASA Curiosity Rover



- NASA Curiosity is a car-sized rover designed to explore the crater Gale on Mars as part of NASA's Mars Science Laboratory mission. The main scientific goals of the MSL mission are to help determine whether Mars could ever have supported life, as well as determining the role of water, and to study the climate and geology of Mars.
- Curiosity landed on Mars in August 2012 and measured the radiation exposure in the interior of the spacecraft as it traveled to Mars.
- Curiosity has covered a distance of 21.09 km (13.10 miles) as of 30 July 2019 and perform scientific measurements such as the nature and inventory of organic carbon compounds, and investigate the chemical, isotopic, and mineralogical composition of the Martian surface and near-surface geological materials. The software is designed to allow the robot to autonomously select appropriate rock and soil targets for analysis. All these data would be important for a **future crewed mission**.

Curiosity rover gets a boost from artificial intelligence, Nature (2017)
https://www.nature.com/articles/d41586-017-00626-6

Curiosity has landed, NASA JPL, August 2012
https://www.youtube.com/watch?v=N9hXqzkH7YA