

AI's Past, Present, and Future

Professor Chad Jenkins

University of Michigan Robotics Institute

July 22, 2021 - TFAI Panel Presentation



Are you with the
football team?

No.

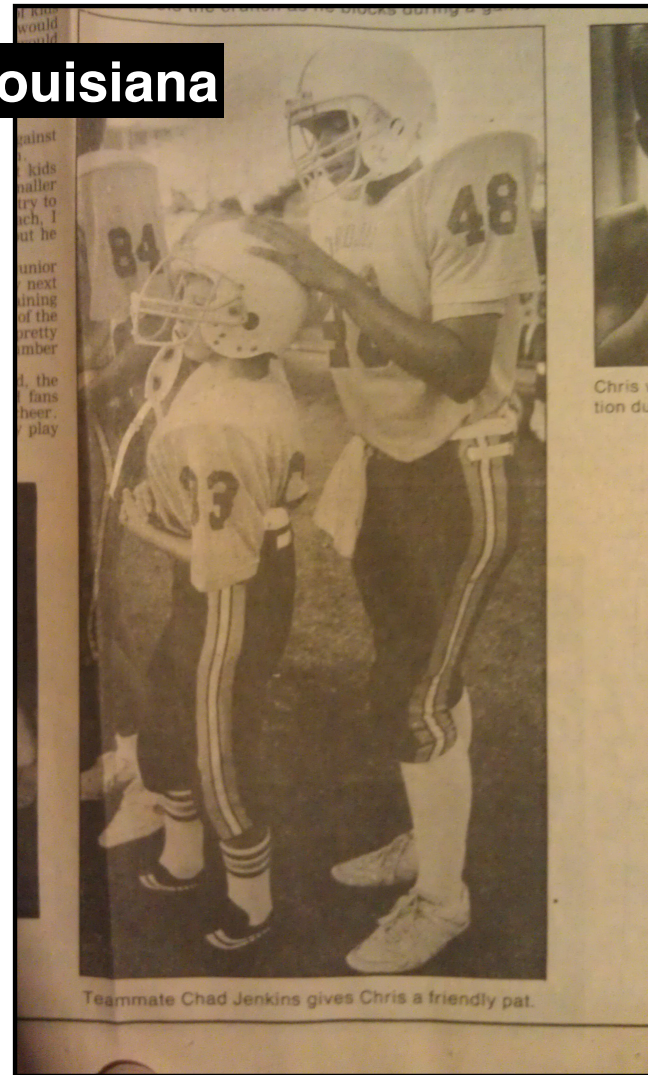


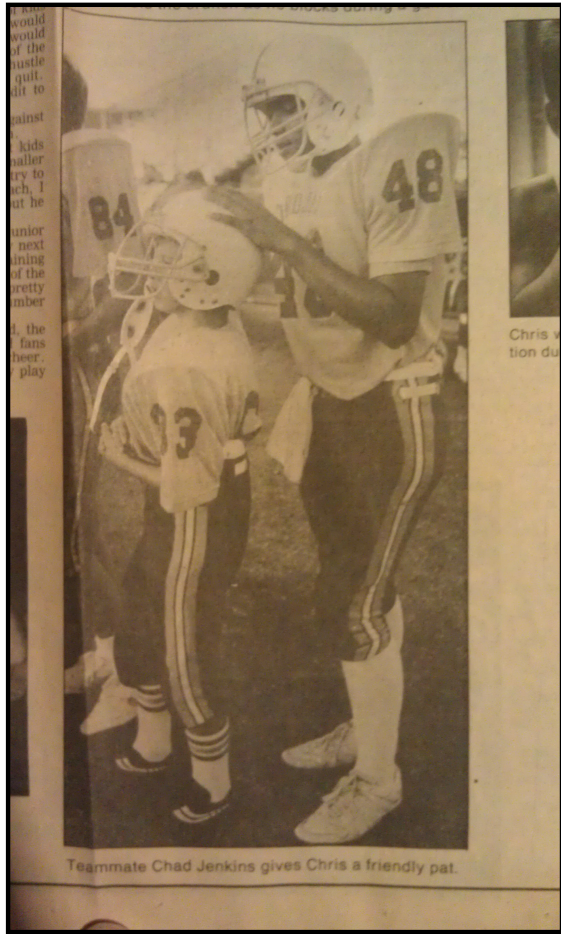
Alexandria, Louisiana

Are you with the
football team?

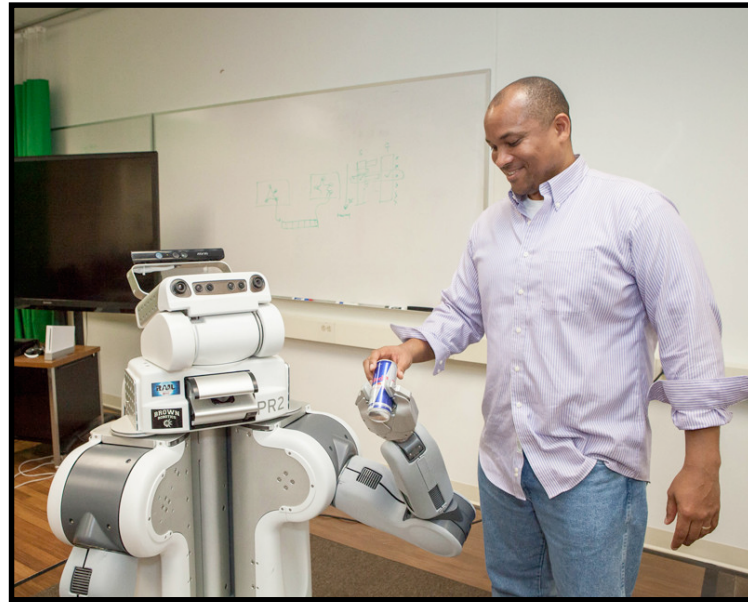
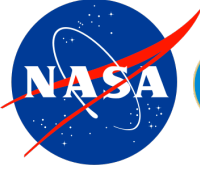
~~No.~~

Yes... in 1988





Teammate Chad Jenkins gives Chris a friendly pat.



1988

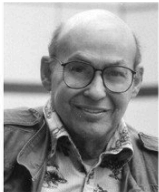
2013

Time

**1956 Dartmouth Conference:
The Founding Fathers of AI**



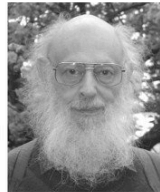
John McCarthy



Marvin Minsky



Claude Shannon



Ray Solomonoff



Alan Newell



Herbert Simon



Arthur Samuel



Oliver Selfridge



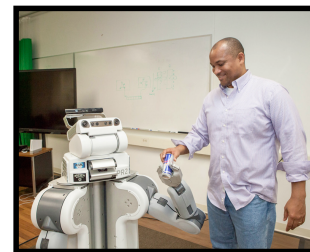
Nathaniel Rochester



Trenchard More

First wave AI: Model-based

“Think through the entire problem”



1956

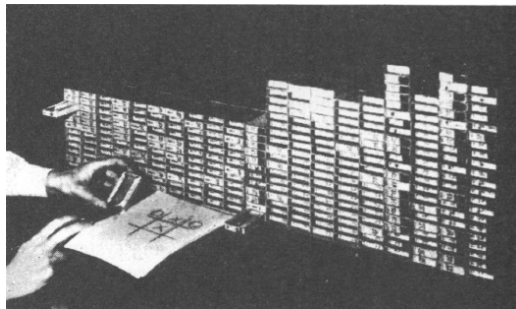
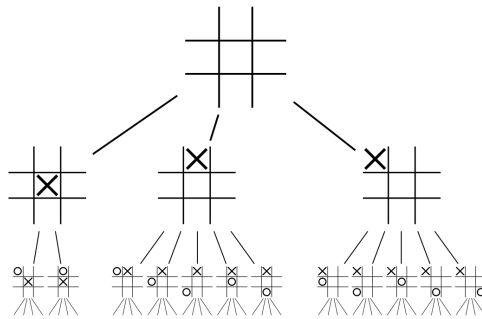
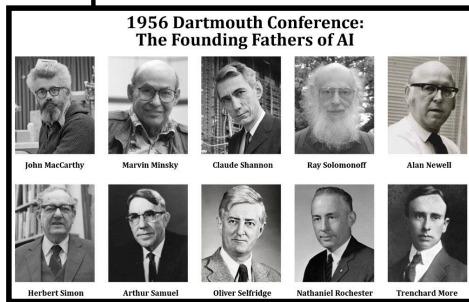
1988

2013

Time

First wave AI: Model-based

“Think through the entire problem”



MENACE: Matchbox Educable Noughts And Crosses Engine (1961)

1956

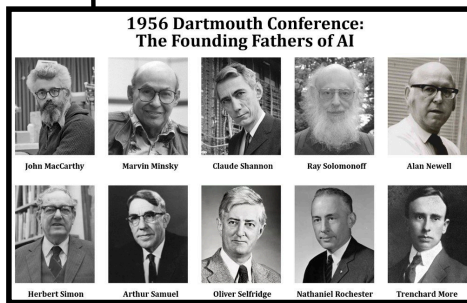
1960

1970

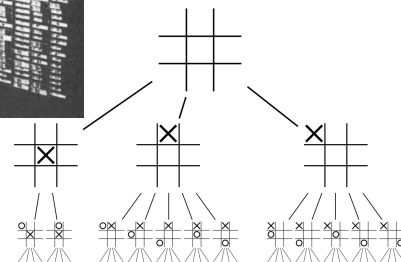
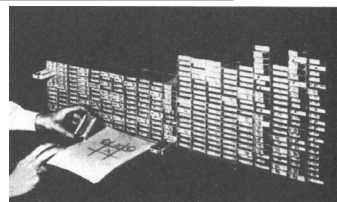
Time

First wave AI: Model-based

“Think through the entire problem”



IBM Deep Blue defeats chess grandmaster (1997)



1956

1960

1970

1980

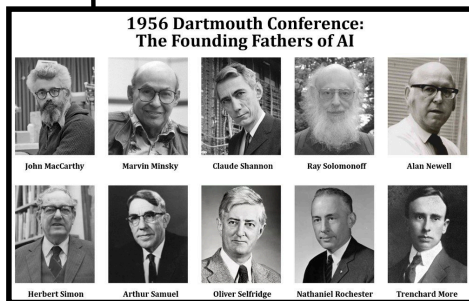
1990

2000

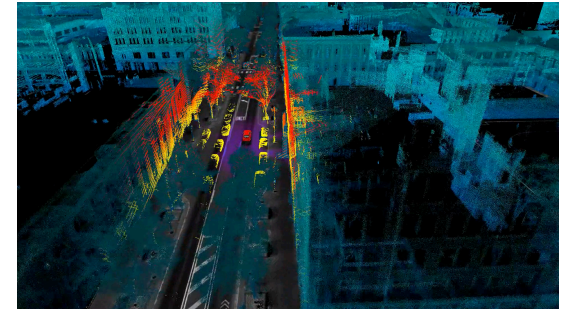
Time

First wave AI: Model-based

“Think through the entire problem”



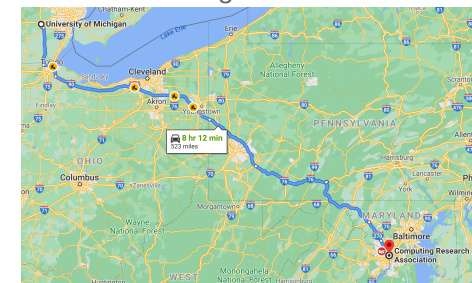
City-scale 3D mapping



Self-driving cars



Online route navigation



1956

1960

1970

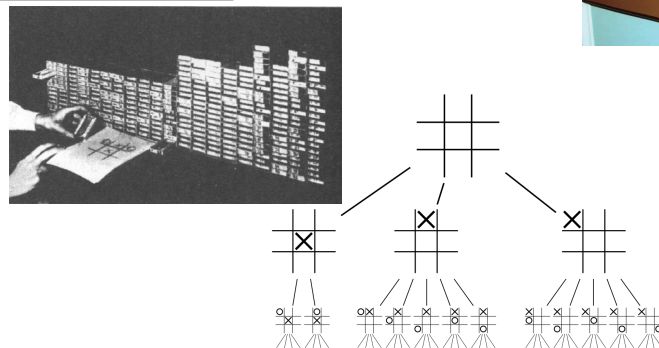
1980

1990

2000

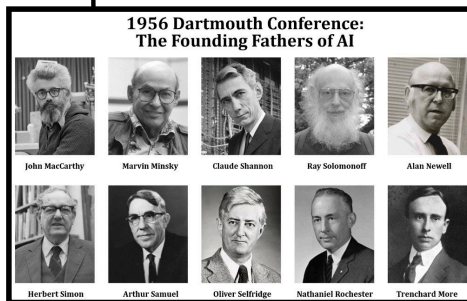
2010

Time



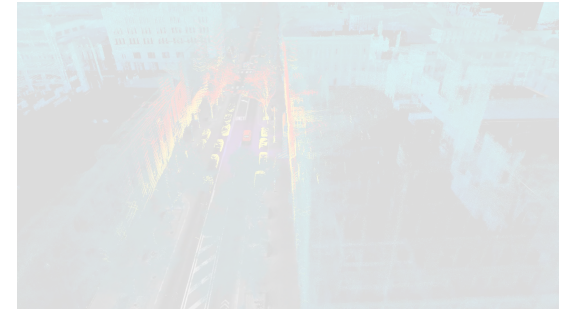
First wave AI: Model-based

“Think through the entire problem”



***Rational and Robust
but Sloooow***

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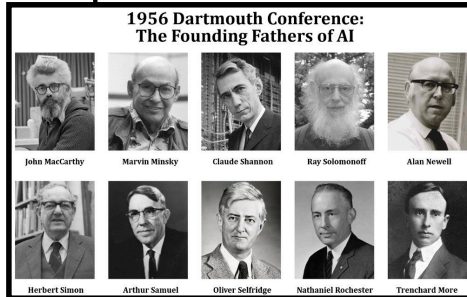
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Time

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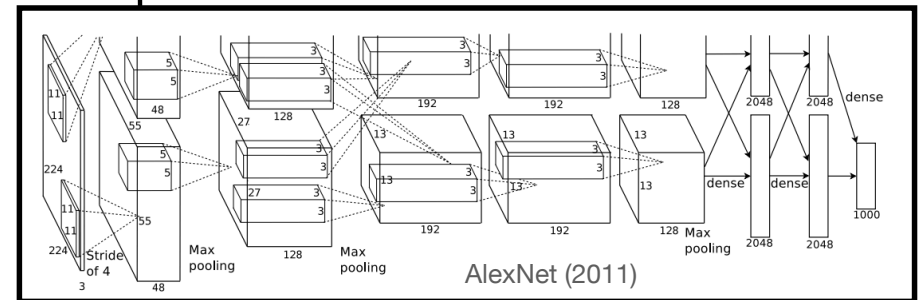
*Rational and Robust
but Sloooow*



Second wave AI: Data-driven

“Learn from lots of data”

Rise of “deep learning”



1956

2011

Time

First wave AI: Model-based

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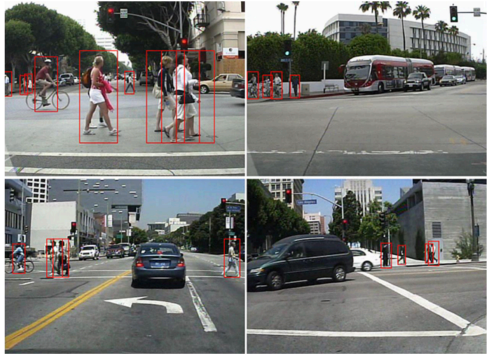
Cars That Think | Transportation | Advanced Cars

09 Feb 2016 | 17:00 GMT

Deep Learning Makes Driverless Cars Better at Spotting Pedestrians

Pedestrian detection systems for cars could become faster and more accurate with help from deep learning algorithms

By Jeremy Hsu



Images: Statistical Visual Computing Lab/UC San Diego

Second wave AI: Data-driven

“Learn from lots of data”



“deep learning”

1956

2011

Time

The AI of today needed decades of investment and research

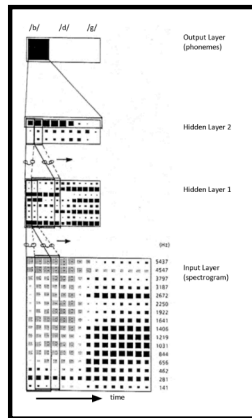


Rosenblatt's Perceptron

1958



Speech recognition by neural networks



Waibel et al.

1989

Second wave AI: Data-driven

“Learn from lots of data”



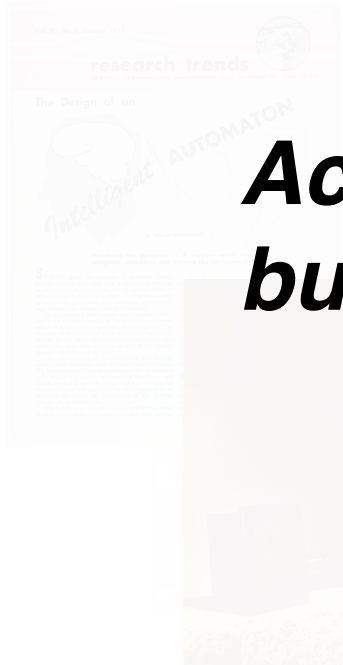
“deep learning”

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Accurate and Fast but Unpredictable



Rosenblatt's Perceptron

1958



Speech recognition by neural networks



Waibel et al.

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“deep learning”

Time

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Technology Quarterly | Jun 13th 2020 edition >

Automobiles

Driverless cars show the limits of today's AI

They, and many other such systems, still struggle to handle the unexpected

Tom Gauld

Second wave AI: Data-driven

“Learn from lots of data”

*Accurate and Fast
but Unpredictable*

FOOLING THE AI

Deep neural networks (DNNs) are brilliant at image recognition — but they can be easily hacked.

These stickers made an artificial-intelligence system read this stop sign as 'speed limit 45'.

©nature

1956

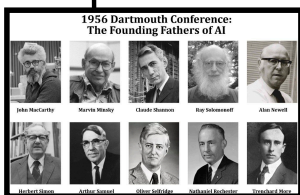
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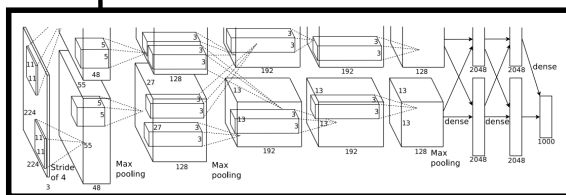


1956

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2011

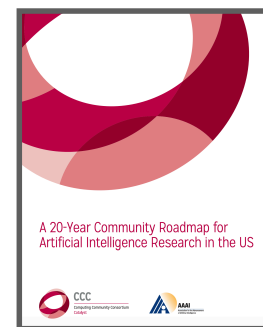
Third wave AI: Explainable

“Combine first and second wave
AI to generate explanations”

*Accurate and Fast and Accountable
and Ethical, Fair, Adaptable,
and Climate Sustainable*



20??



Time

YouTube Search

Models to drive decisions

Probable number of strokes: 1 - 4
 Each stroke: probable trajectory
 Each trajectory: probable shift in shape and location

Seed model

Generative model
 Generates explanations of how a test character might have been created

Training data

DARPA

14:54 / 16:11

A DARPA Perspective on Artificial Intelligence

241,472 views · Feb 15, 2017

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Third wave AI: Explainable

“Combine first and second wave AI to generate explanations”

*Accurate and Fast and Accountable
 and Ethical, Fair, Adaptable,
 and Climate Sustainable*



1956

2011

20??

Time

The Next Wave of AI

How to get ahead

- **Federal investment critical for success**
 - Was true before (since WWI), still true now
- **Global competition:** If we do not lead, others will
- **Education:** the classroom of today builds the AI leaders for tomorrow
- **Diversity:** the next breakthrough could come from anywhere



Next Wave Artificial Intelligence: Robust, Explainable, Adaptable, Ethical, and Accountable

A Computing Community Consortium (CCC) Quadrennial Paper

Odest Chadwicke Jenkins (University of Michigan), Daniel Lopresti (Lehigh University), and Melanie Mitchell (Portland State University and Santa Fe Institute)

We are now seeing the impact of decades of investment in artificial intelligence (AI) across our society. In recent years, AI systems have been deployed in a broad array of application areas, including healthcare, transportation, finance, design and manufacturing, education, scientific discovery, and national security, among others. Many of these applications have addressed important societal problems and directly improved peoples' lives. However, broad beneficial use of AI applications are often stymied by the limitations of today's state-of-the-art systems. In this brief overview, we describe the limitations of today's AI systems and make recommendations for focus areas that will enable the field to move to the next level in terms of robustness and trustworthiness.

The history of AI has included several "waves" of ideas. The first wave, from the mid-1950s to the 1980s, focused on logic and symbolic hand-encoded representations of knowledge, the foundations of so-called "expert systems". The second wave, starting in the 1990s, focused on statistics and machine learning, in which, instead of hand-programming rules for behavior, programmers constructed "statistical learning algorithms" that could be trained on large datasets. In the most recent wave, especially in the last decade, research in AI has largely focused on deep (i.e., many-layered) neural networks, which are loosely inspired by the brain and trained by "deep learning" methods. However, while deep neural networks have led to many successes and new capabilities in computer vision, speech recognition, language processing, game-playing, and robotics, their potential for broad application remains limited by several factors. Deep neural networks typically require "supervised" training on large datasets—that is on thousands to millions of examples that have been manually labeled; these labeling efforts often require prohibitive amounts of human labor. Moreover, the labels can contain errors as well as both overt and subtle biases. Deep learning methods also require large computing infrastructure, whose electricity use can have negative environmental impacts.