

Do Neural Networks Dream of Semantics?



Prof. Dr. Harald Sack

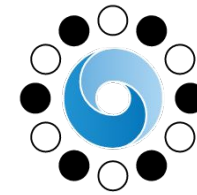
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Karlsruher Institut für Technologie

AlphaGo Zero: Google DeepMind supercomputer learns 3,000 years of human knowledge in 40 days



AlphaGo



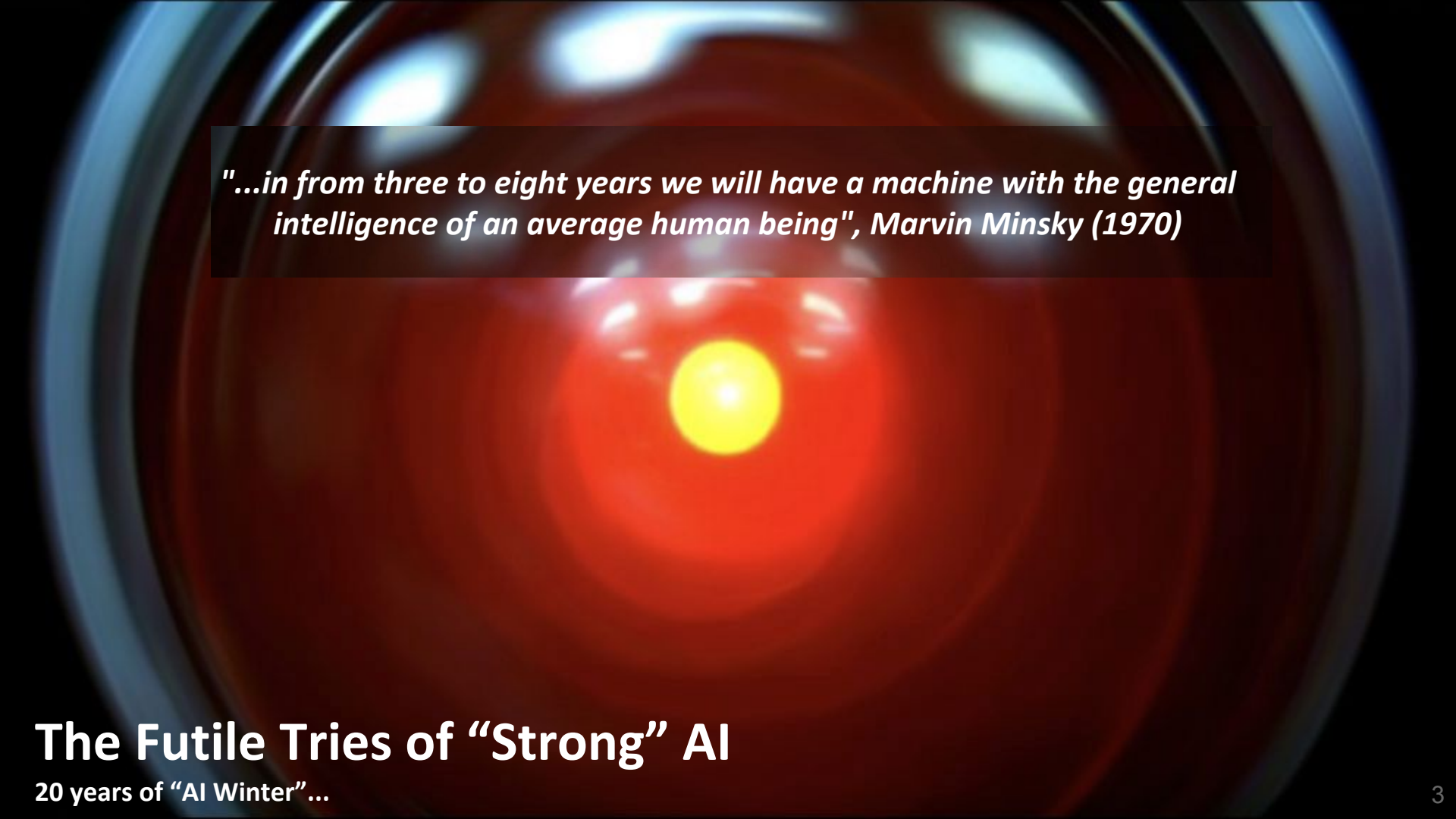
17



<http://www.telegraph.co.uk/science/2017/10/18/alphago-zero-google-deepmind-supercomputer-learns-3000-years/>



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"...in from three to eight years we will have a machine with the general intelligence of an average human being", Marvin Minsky (1970)

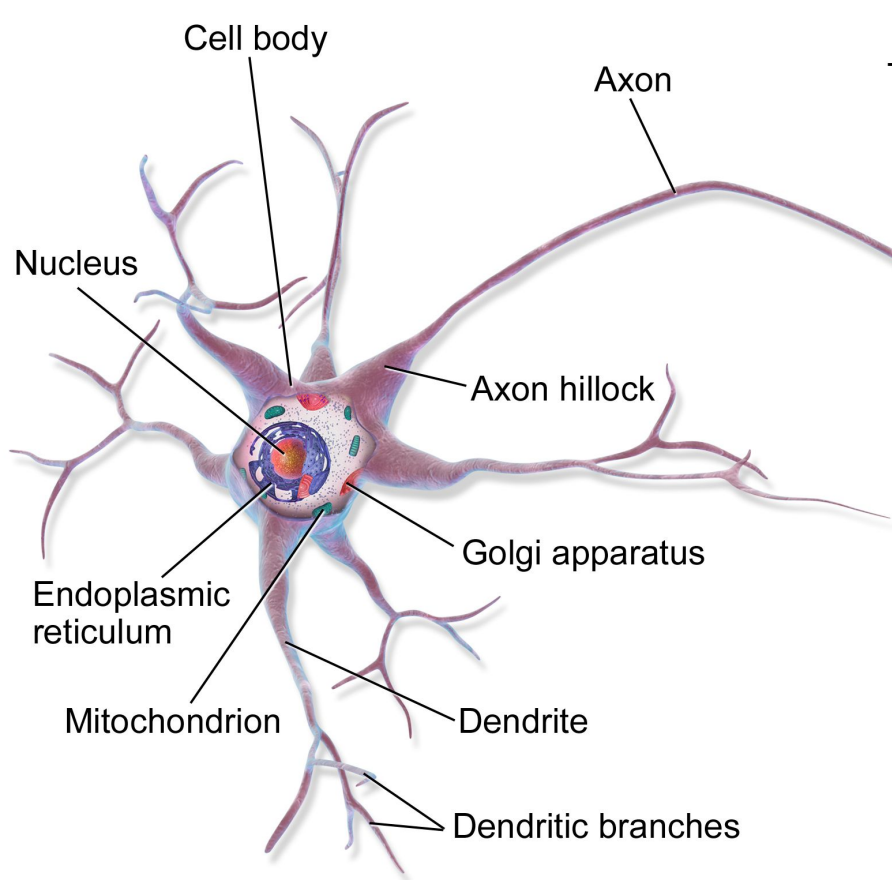
The Futile Tries of “Strong” AI

20 years of “AI Winter”...

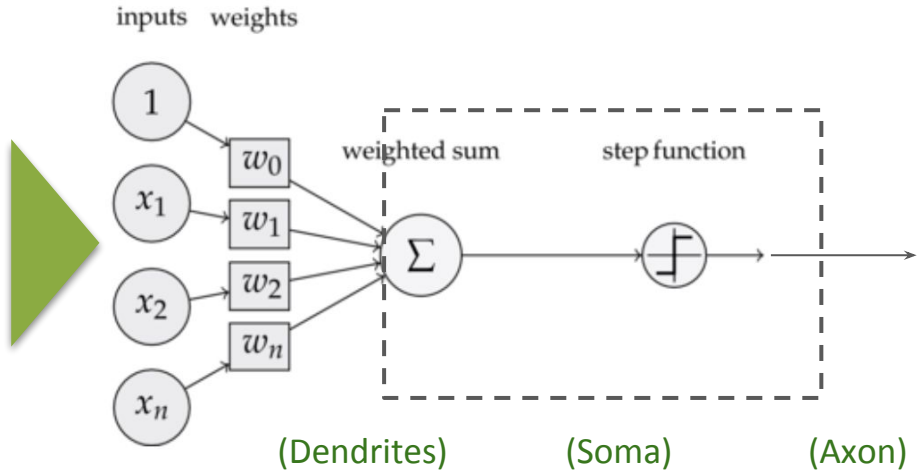


Where
did
the Magic
come
from...?

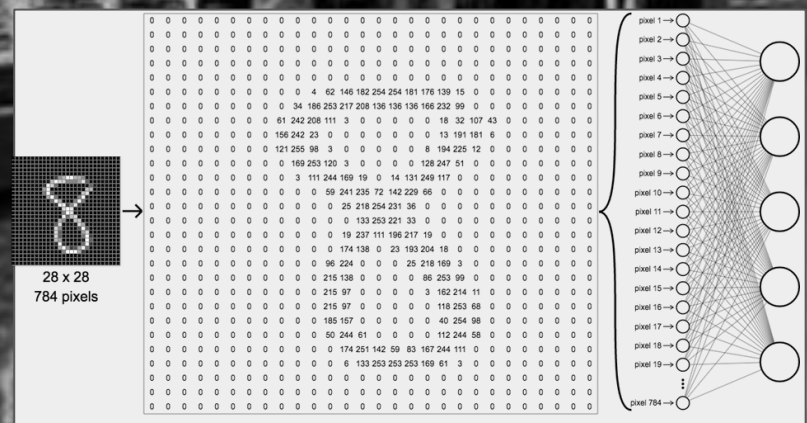
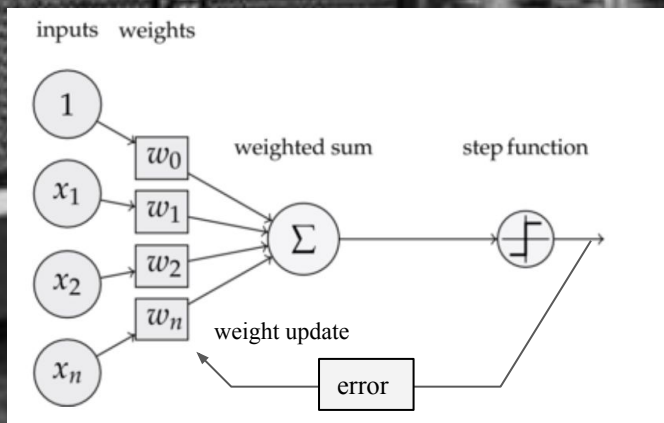
Transferring Biology into a Mathematical Model



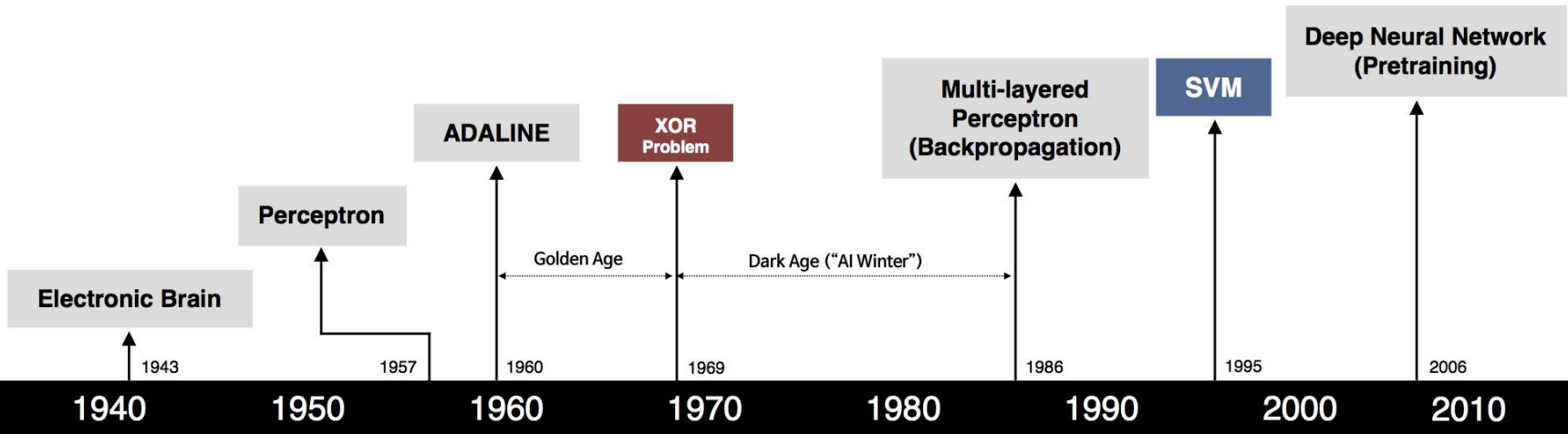
Donald Hebb (1940)
McCulloch & Pitts (1943)



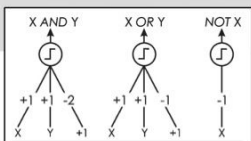
Cognitive Computing - The MARK 1 Perceptron (Rosenblatt, 1957)



The Triumphant Progress of Neural Network



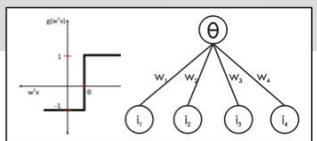
S. McCulloch – W. Pitts



- Adjustable Weights
- Weights are not Learned



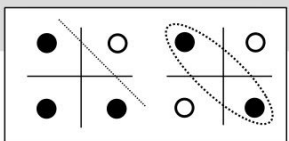
F. Rosenblatt B. Widrow – M. Hoff



- Learnable Weights and Threshold



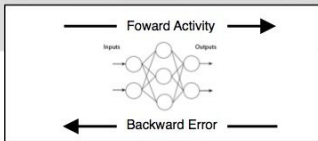
M. Minsky – S. Papert



- XOR Problem



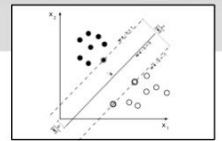
D. Rumelhart – G. Hinton – R. Williams



- Solution to nonlinearly separable problems
- Big computation, local optima and overfitting



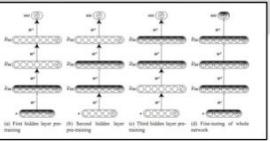
V. Vapnik – C. Cortes



- Limitations of learning prior knowledge
- Kernel function: Human Intervention

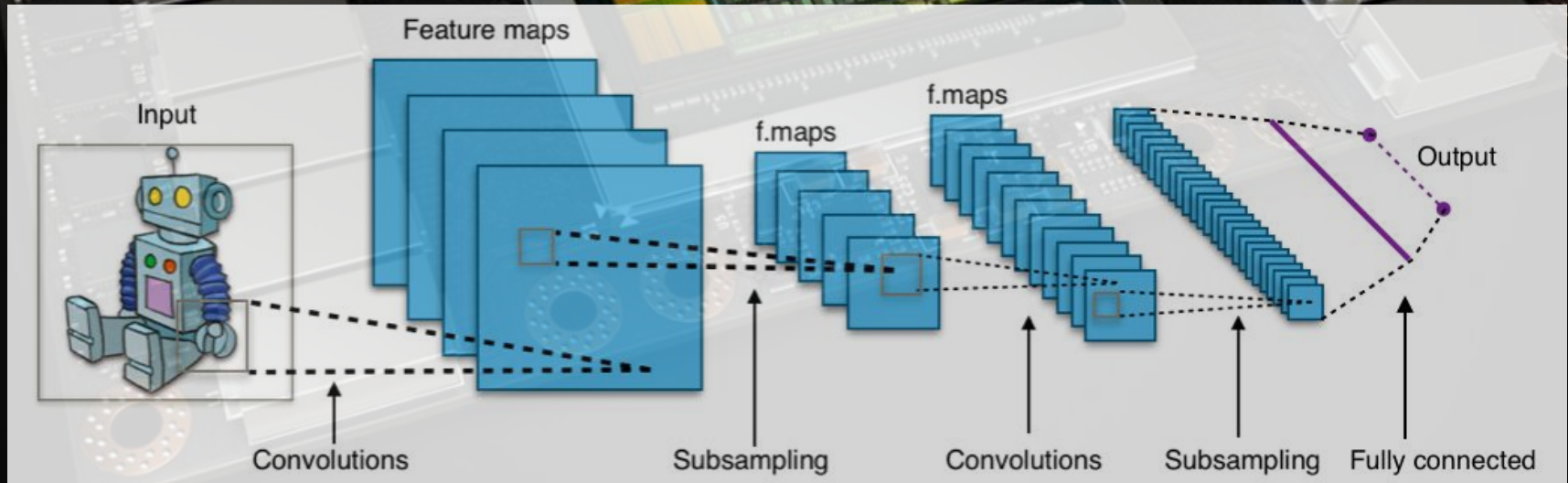



G. Hinton – S. Ruslan



- Hierarchical feature Learning

Deep Convolutional Neural Networks on GPU Supercomputers

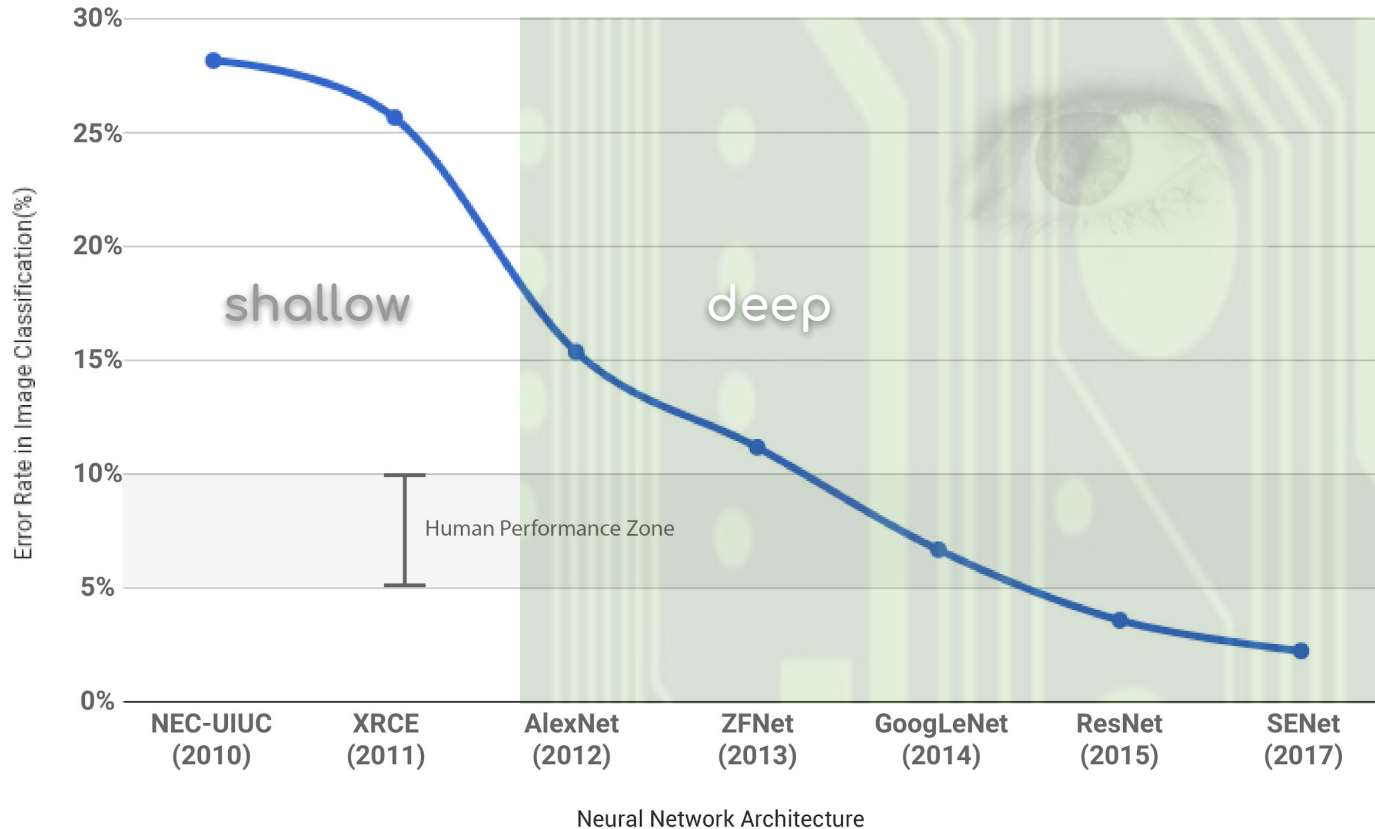


The background is a vibrant green color with a complex, glowing circuit board pattern. The pattern consists of numerous thin, light green lines that form various geometric shapes, including rectangles, circles, and zig-zags, resembling a printed circuit board (PCB). In the center of the image, there is a large, dark green circle. Inside this circle, the text "Any sufficiently advanced technology is indistinguishable from magic." is written in a clean, white, sans-serif font. The text is arranged in five lines, centered within the circle.

Any
sufficiently
advanced
technology is
indistinguishable
from magic.

Arthur C. Clarke,
Profiles of the Future (1973)

Neural Network in Visual Analysis



Combining Visual Analysis and Linguistics

Rose Hork

Corcanitol Orange

Suffer

Snowbonk

Golder Craam

Sindis Poop

Navel Tan

Burf Pink

Stargoan

Clear Paste

Burple Simp

Horble Gray

Turdly

Stanky Bean

Dry Custard

Clardic Fug

Burnt Bit Curry

Dondarf

Sink

Grass Bat

Snader Brown

Sudden Pine

Very Barrel

Sane Green

Homestar Brown

Testing

Colona


Dorkwood

Burfream

Violet Ook

What Deep Learning has achieved so far

- Near-human to superhuman level **image classification**
- Near-human level **speech recognition**
- Near-human level **handwriting transcription**
- Improved **machine translation**
- Improved **text-to-speech conversion**
- **Digital assistants** such as Google Now or Amazon Alexa
- Near-human level **autonomous driving**
- Superhuman Go playing



First
rule of magic:
Don't let
anyone know
your real
name.

Neil Gaiman,
The Invisible Labyrinth (1990)

Artificial Intelligence and Machine Learning

Artificial Intelligence

Reasoning

NLP

Planning

Machine Learning

Supervised Learning

Unsupervised Learning

Reinforcement Learning

Deep Learning
(Neural Networks)

“The Goal of AI is to develop machines that behave as though they were intelligent.”

- John McCarthy (1955)

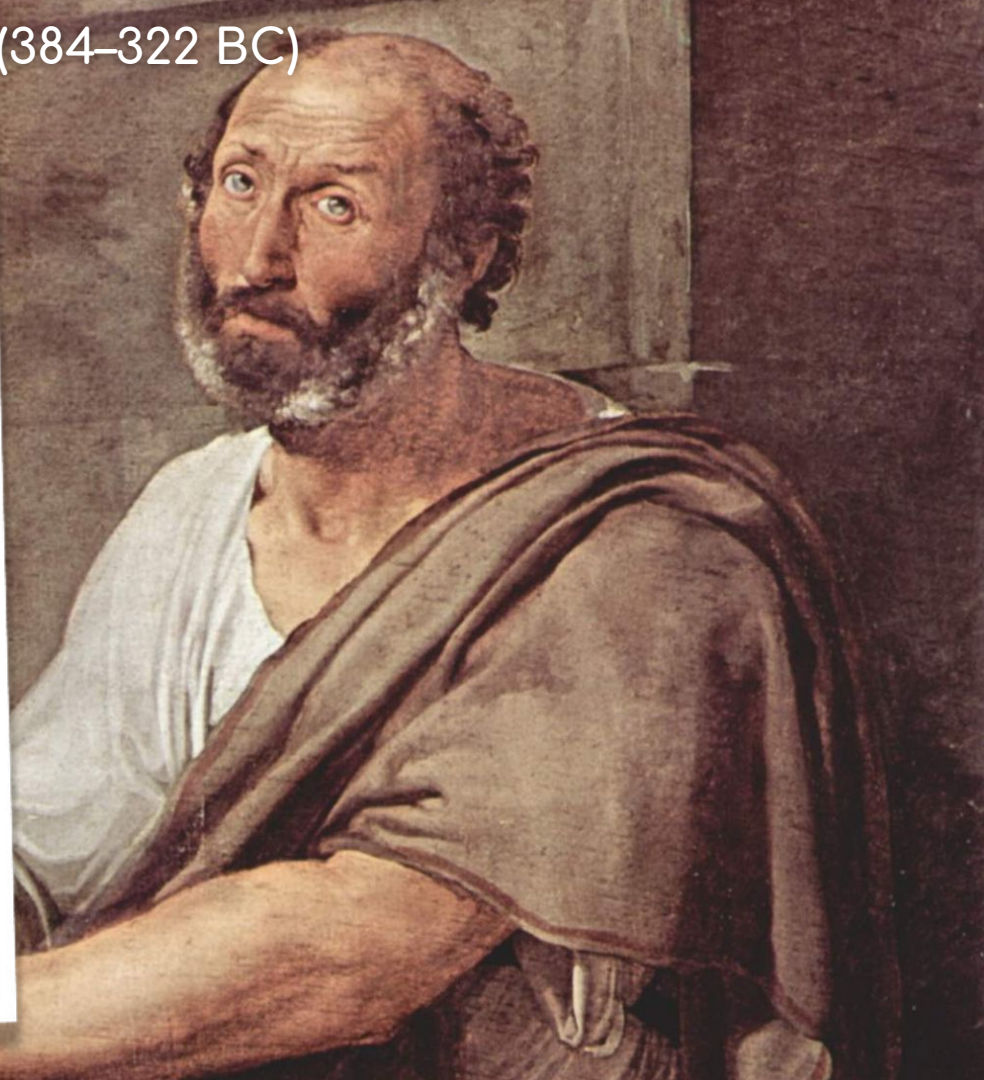
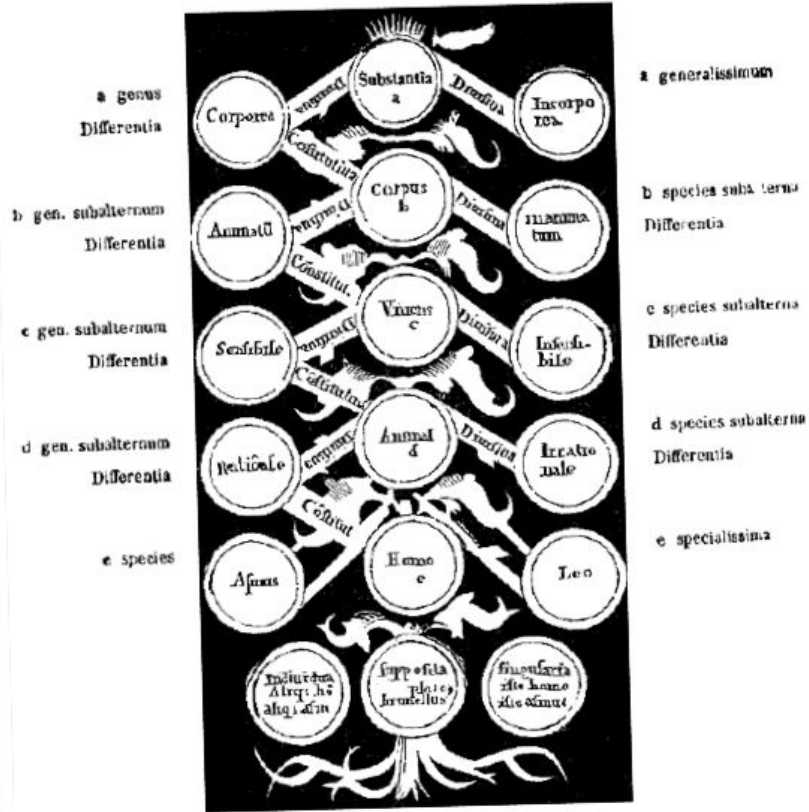
P A R E N T A L

ADVISORY

EXPLICIT SEMANTICS

The Universal Categories - Aristotle (384–322 BC)

IN PORPHYRIUM DIALOGUS I.



Calculus Ratiocinator - Gottfried Wilhelm Leibniz (1646-1716)

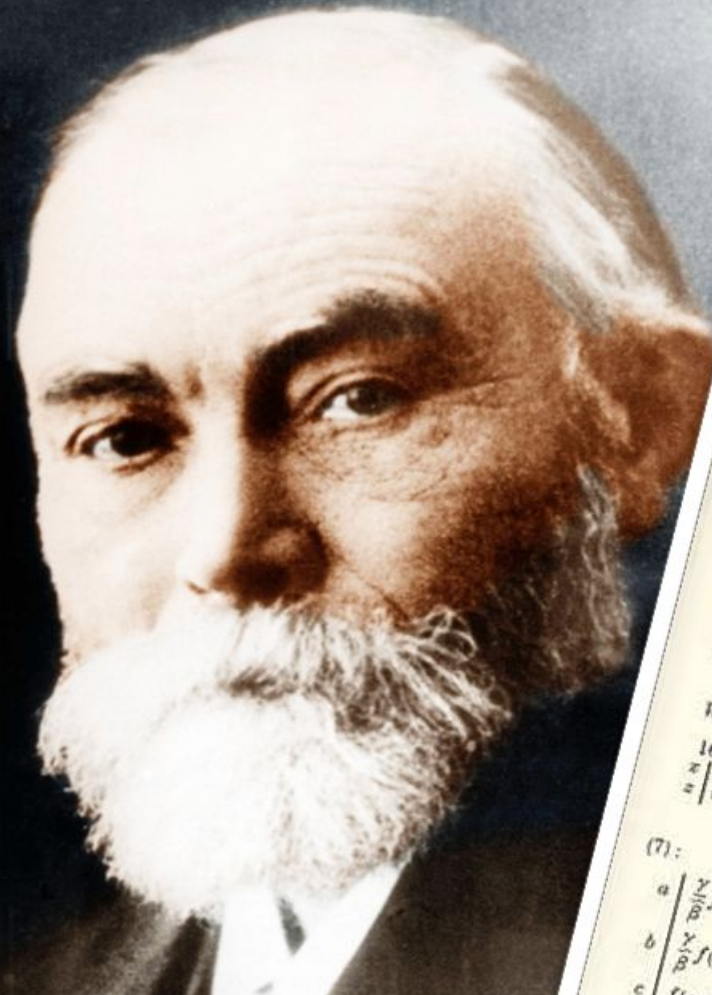
*The only way to rectify our reasonings is to make them as tangible as those of the Mathematicians, so that we can find our error at a glance, and when there are disputes among persons, we can simply say: **Let us calculate** [calculemus], without further ado, to see who is right.*

Leibniz in a letter to Ph. J. Spener, Juli 1687

A portrait of Gottfried Wilhelm Leibniz, a German philosopher, mathematician, and scientist. He is shown from the chest up, wearing a dark coat and a white cravat. A white speech bubble with a black outline is positioned to the right of his face, containing the text "Calculemus!".

Calculemus!

Begriffsschrift - Gottlob Frege (1848-1925)



71

BEGRIFFSSCHRIFT

(55) ::

$$\begin{array}{l} d \mid x \\ c \mid z \end{array}$$

$$\begin{array}{l} \vdash \\ \quad \vdash (x = z) \\ \quad \quad \vdash \frac{\gamma}{\beta} f(x, z) \\ \quad \quad \quad \vdash \frac{\gamma}{\beta} f(x, z) \end{array}$$

§ 30. 99

(52):

$$\begin{array}{l} f(I) \mid \Gamma \\ c \mid \end{array} \begin{array}{l} \vdash \\ \quad \vdash (z = x) \\ \quad \quad \vdash \frac{\gamma}{\beta} f(x, z) \\ \quad \quad \quad \vdash \frac{\gamma}{\beta} f(x, z) \end{array}$$

$$\left[\begin{array}{l} \vdash \\ \quad \vdash (z = x) \\ \quad \quad \vdash \frac{\gamma}{\beta} f(x, z) \end{array} \right] \equiv \frac{\gamma}{\beta} f(x, z)$$

(37):

$$\begin{array}{l} a \mid \frac{\gamma}{\beta} f(x, z) \\ b \mid (z = x) \\ c \mid \frac{\gamma}{\beta} f(x, z) \end{array}$$

$$\begin{array}{l} \vdash \\ \quad \vdash \frac{\gamma}{\beta} f(x, z) \\ \quad \quad \vdash (z = x) \\ \quad \quad \quad \vdash \frac{\gamma}{\beta} f(x, z) \end{array}$$

(104).

$$\begin{array}{l} \vdash \\ \quad \vdash \frac{\gamma}{\beta} f(x, z) \\ \quad \quad \vdash \frac{\gamma}{\beta} f(x, z) \end{array}$$

(105).

Whatever follows x in the f -sequence belongs to the f -sequence beginning with x .

$$\begin{array}{l} 106 \\ x \mid z \\ z \mid v \end{array}$$

$$\begin{array}{l} \vdash \\ \quad \vdash \frac{\gamma}{\beta} f(z, v) \\ \quad \quad \vdash \frac{\gamma}{\beta} f(z, v) \end{array}$$

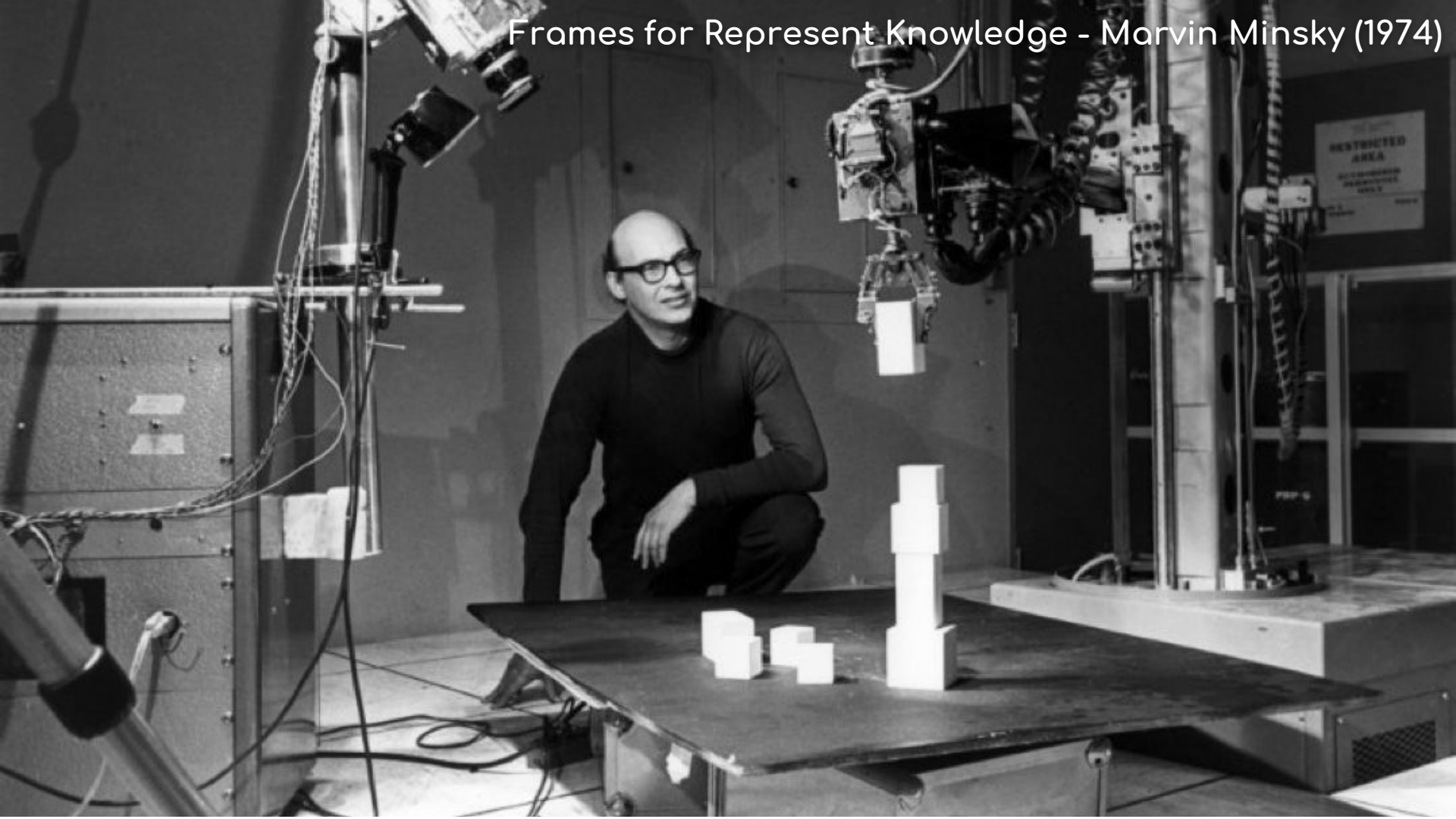
(7):

$$\begin{array}{l} a \mid \frac{\gamma}{\beta} f(z, v) \\ b \mid \frac{\gamma}{\beta} f(z, v) \\ c \mid f(z, v) \end{array}$$

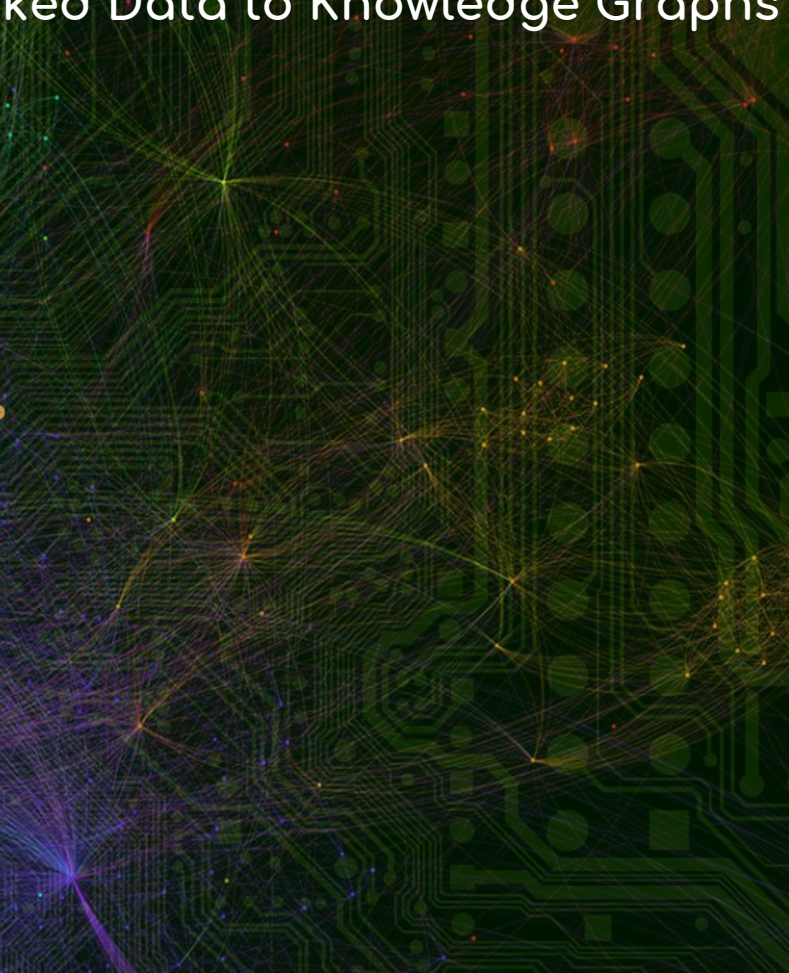
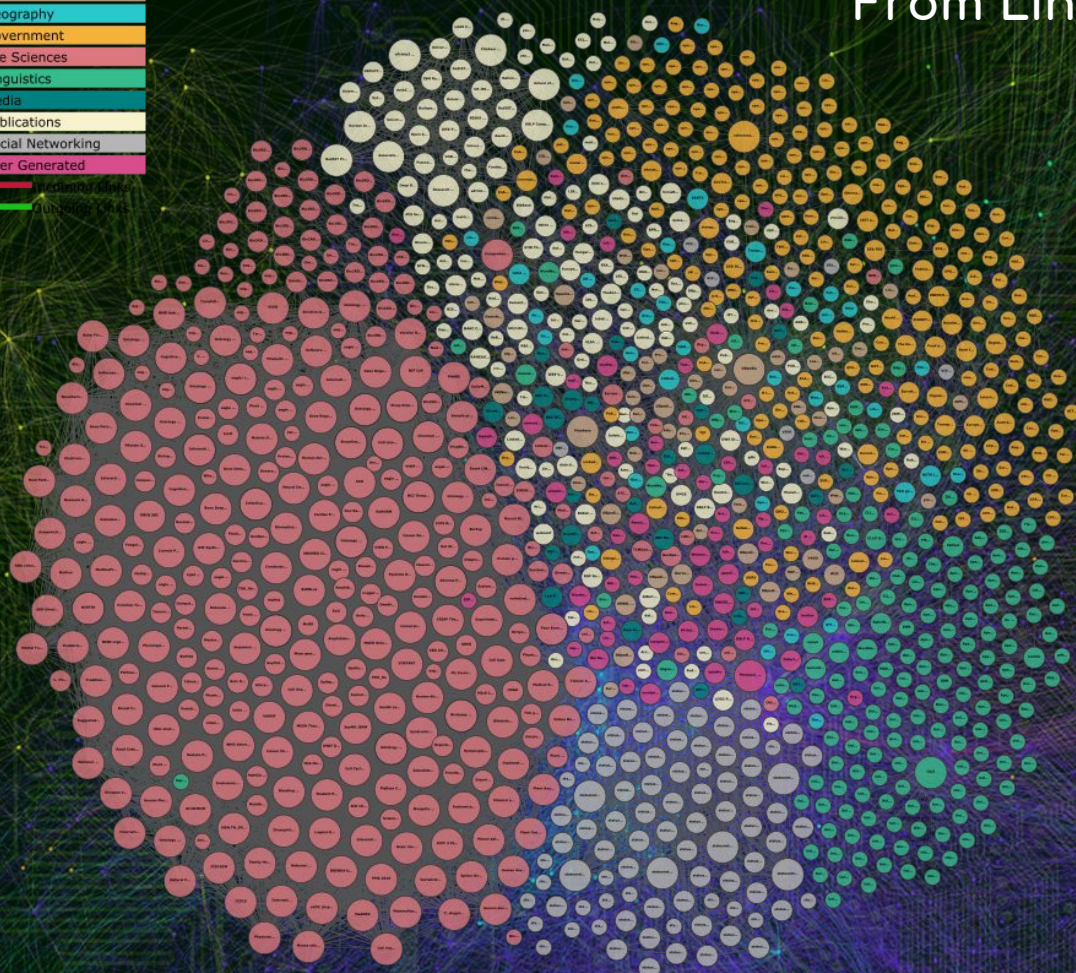
$$\begin{array}{l} \vdash \\ \quad \vdash \frac{\gamma}{\beta} f(z, v) \end{array}$$

(106).

Frames for Represent Knowledge - Marvin Minsky (1974)



From Linked Data to Knowledge Graphs



Knowledge Graph Applications



T. Tietz, J. Jäger, J. Waitelonis, H. Sack, Semantic Annotation and Information Visualization for Blogposts with refer, (VOILA 2016)

Relation Browser Timeline

Data Integration

Visualizations

Semantic & Exploratory Search

Question Answering

Recommender Systems

Entities shown include: Erhard Weigel, Gottfried Wilhelm Leibniz, Erhard Weigel, Antoine Cournot, Hans Hahn, Carl Stumpf, Gregory Chaitin, Gabriel Tarde, Ernst Kummer, Ferdinand Georg, Jakob Bernoulli, W. I. Thomas, Edger Quinet, Nicholas, Bernard, Gemistus, Euclid, Marin, Champagne (historical), Halle (Saale), Pavia, Meissen, Dijon, Dutch Republic, Papal States, Austrian Empire, Toulouse, Wittenberg, Brno, Weimar, Saxony, Florence, Jena, Leipzig, Philosopher, Western, University of, Duration, Subjectivity, Cartesianism, Homology, Transmutation of species, Kolmogorov complexity, Utility, Stratigraphy, Continental philosophy, Astronomer, University of Naples Federico II, Collision, Cosmology, Process, University of Basel, Social philosophy, Danes, Kinetic energy, Jurist, 1646, 1698, 1677, 1668, 1686, 1623, 1494.


- 15 Recommended Articles
- #1 The Case of J. Robert Oppenheimer
 - #2 Wilhelm Pfeffer and Plant Physiology
 - #3 Karl Pearson and Mathematical Statistics
 - #4 Raphael and the School of Athens
 - #5 Jerzy Neyman – Architect of Modern Theoretical Statistics
 - #6 Christian Gottfried Ehrenberg – Father of Microzoology

Gottfried Wilhelm Leibniz

Gottfried Wilhelm von Leibniz (German: [ˈɡɔʦfʁiːt ˈvɪlhɛlm fɔn ˈlaɪbnɪtʃ] or [ˈlaɪpnɪtʃ]) (July 1, 1646 – November 14, 1716) was a German mathematician and philosopher. He occupies a prominent place in the history of mathematics and the history of philosophy. Leibniz developed the infinitesimal calculus independently of Isaac Newton, and Leibniz's mathematical notation has been widely used ever since it was published. It was only in the 20th century that his Law of Continuity and Transcendental Law of Homogeneity found mathematical implementation (by means of non-standard analysis). He became one of the most prolific inventors in the field of mechanical calculators. While working on adding automatic multiplication and division to Pascal's calculator, he was the first to describe a pinwheel calculator in 1685 and invented the Leibniz wheel, used

DBpedia: Gottfried Wilhelm Leibniz





“There ain’t no
such thing as
a free Lunch.”

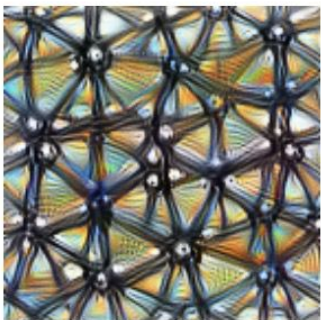
Robert A. Heinlein,
The Moon is a Harsh Mistress (1966)

What do Neural Networks (really) see?



Neuron

$\text{layer}_n[x, y, z]$



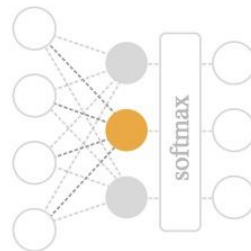
Channel

$\text{layer}_n[:, :, z]$



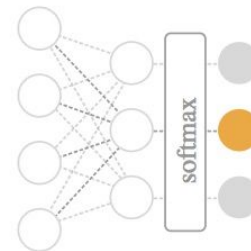
Layer/DeepDream

$\text{layer}_n[:, :, :]^2$



Class Logits

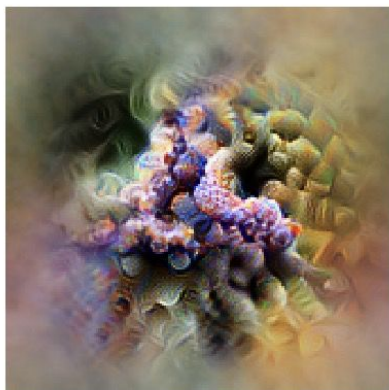
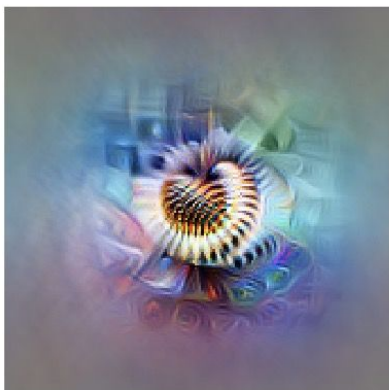
$\text{pre_softmax}[k]$



Class Probability

$\text{softmax}[k]$

What do Neural Networks (really) see?




Baseball—or stripes?

Animal faces—or snouts?

Clouds—or fluffiness?

Buildings—or sky?



90%
of most
Magic merely
consists of
knowing one
extra fact.

Terry Pratchett, *Night Watch* (2002)

Generative Adversarial Networks Example

Text description

This bird is blue with white and has a very short beak

This bird has wings that are brown and has a yellow belly

A white bird with a black crown and yellow beak

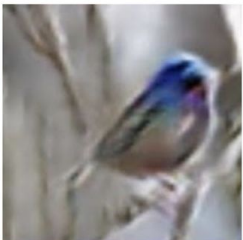
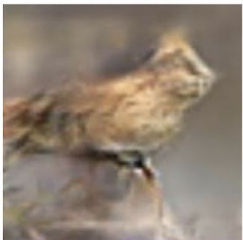
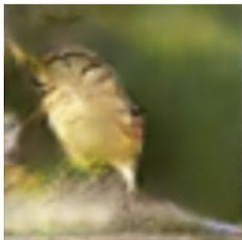
This bird is white, black, and brown in color, with a brown beak

The bird has small beak, with reddish brown crown and gray belly

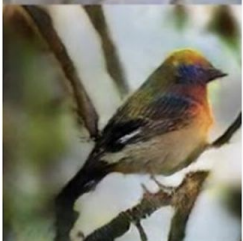
This is a small, black bird with a white breast and white on the wingbars.

This bird is white black and yellow in color, with a short black beak

Stage-I images



Stage-II images



Han Zhang, Tao Xu, Hongsheng Li, Shaoting Zhang, Xiaogang Wang, Xiaolei Huang, Dimitris N. Metaxas:

[StackGAN++: Realistic Image Synthesis with Stacked Generative Adversarial Networks.](#)

CoRR abs/1710.10916 (2017)

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Generative Adversarial Networks Example

This is a small light gray bird with a small head and green crown nape and some green coloring on its wings



Now let's go for Something More General...



A flock of sheep on green meadows



<http://t2i.cvalenzuelab.com/>

a girl watching tv |



<http://t2i.cvalenzuelab.com/>

A girl wearing a red
skirt



<http://t2i.cvalenzuelab.com/>

It's a kind of Magic, Semantic and AI, Semantic Meetup Vienna, 11 Sep. 2018, Harald Sack, CC BY-NC-SA 3.0

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A girl with two eyes one
mouth and one nose



<http://t2i.cvalenzuelab.com/>

It's a kind of Magic, Semantic and AI, Semantic Meetup Vienna, 11 Sep. 2018, Harald Sack, CC BY-NC-SA 3.0

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A man with white hair, a white beard and a white shirt, wearing glasses



<http://t2i.cvalenzuelab.com/>

melting clocks flying over a large dessert



<http://t2i.cvalenzuelab.com/>

(Long Term) Goals

- Combining **Semantics** (a.k.a. Symbolic Reasoning) and **Machine Learning** (**Neuro-Symbolic Integration**)

(Short Term) Goals

- **Knowledge Graphs:**
Don't try to make Everything Explicit
- **Deep Learning:**
Try to make the Implicit Explicit
otherwise....

Otherwise...

“All those moments will be lost in time,
like tears in the rain.” (Bladerunner, 1982)