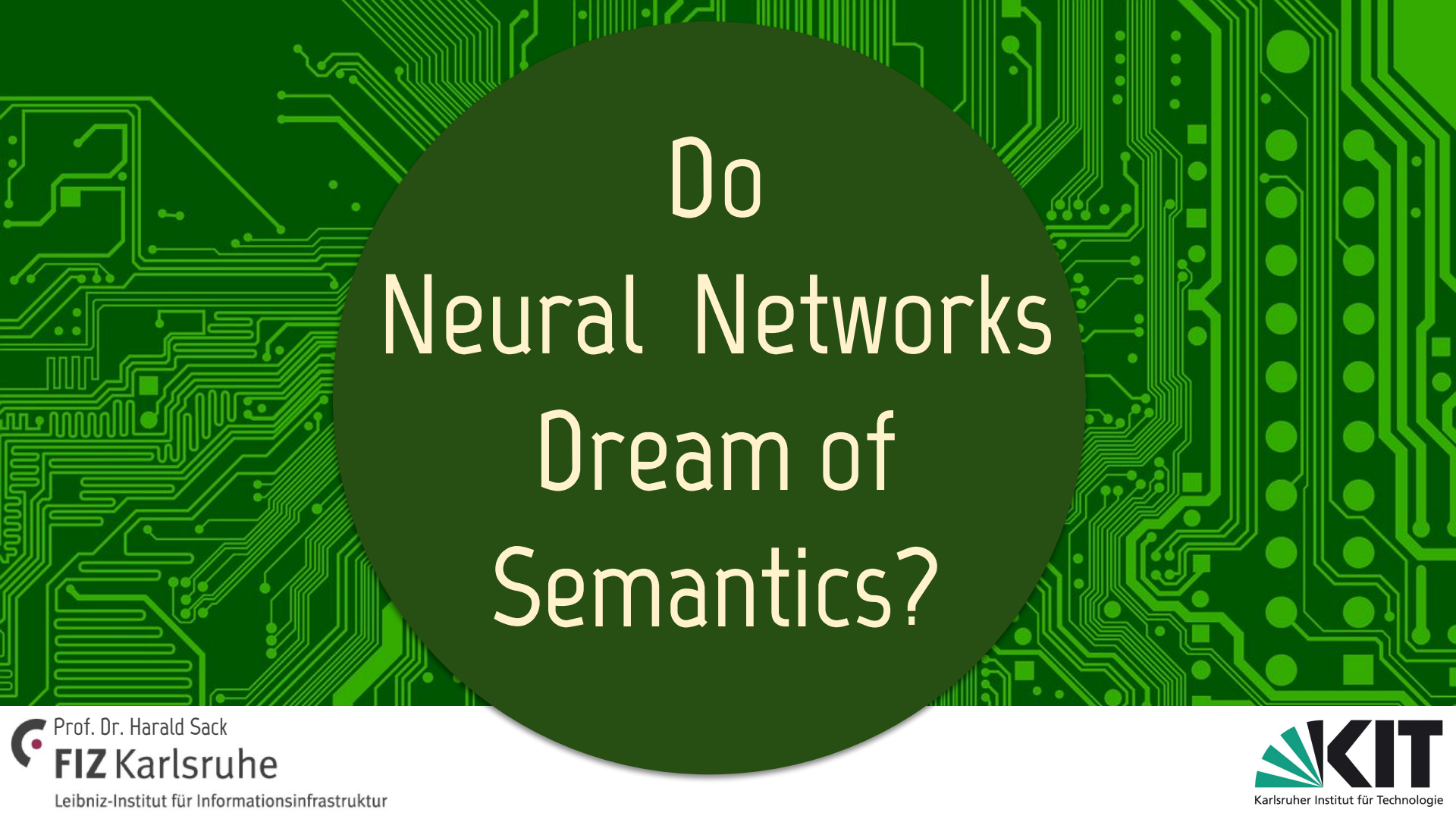

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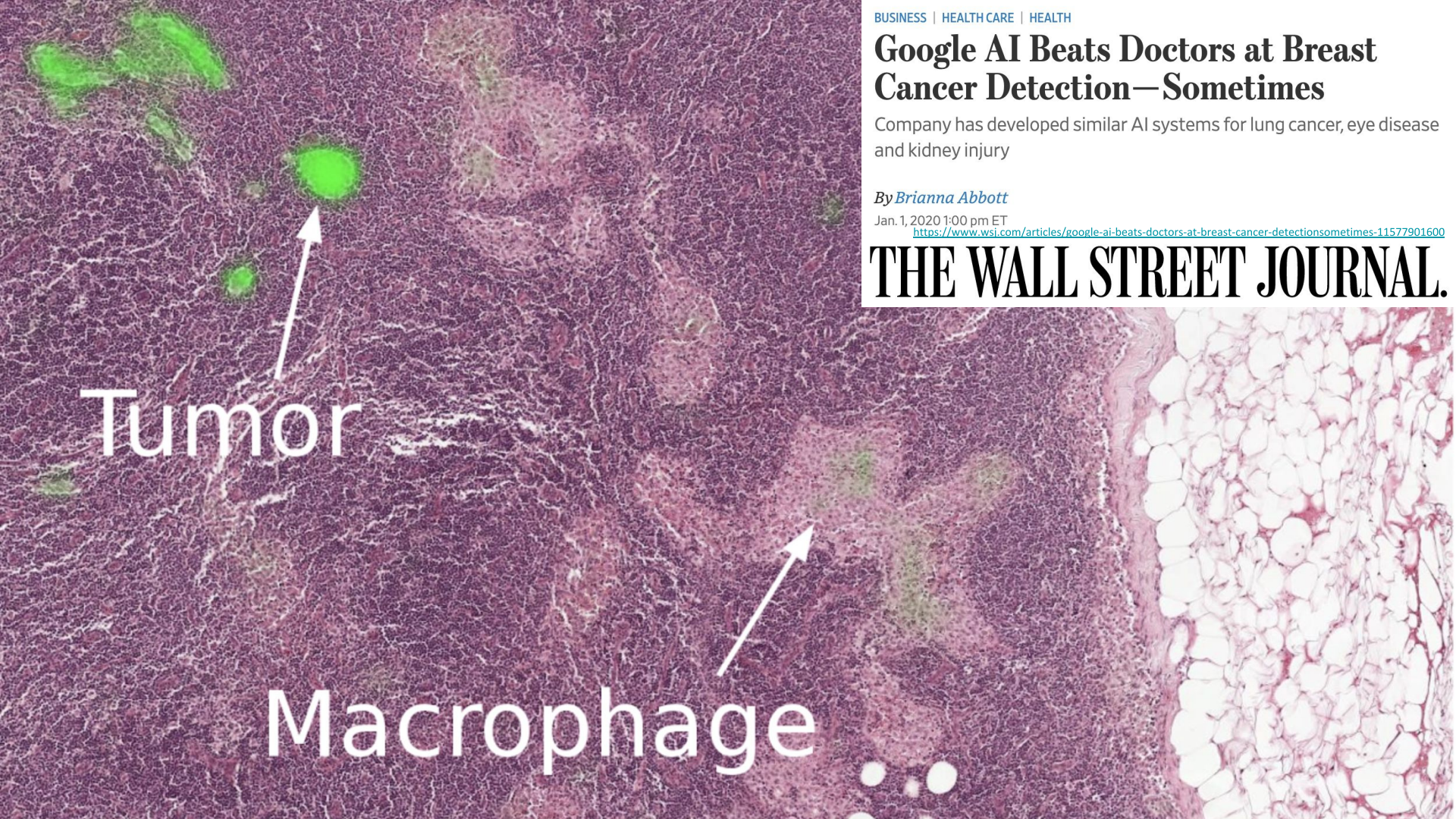
Karlsruher Institut für Technologie

Chapter I

"Any sufficiently advanced technology is indistinguishable from magic."

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

https://money.cnn.com/2017/03/03/technology/google-breast-cancer-ai/
Can you find the cancer?



BUSINESS | HEALTH CARE | HEALTH

Google AI Beats Doctors at Breast Cancer Detection—Sometimes

Company has developed similar AI systems for lung cancer, eye disease and kidney injury

By Brianna Abbott

Jan. 1, 2020 1:00 pm ET

https://www.wsj.com/articles/google-ai-beats-doctors-at-breast-cancer-detectionsometimes-11577901600

THE WALL STREET JOURNAL.

Science

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

AlphaGo

share

The Telegraph

17

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

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https://www.christies.com/features/A-collaboration-between-two-artists-one-human-one-a-machine-9332-1.aspx

Is artificial intelligence set to become art's next medium?

16 October 2018

PHOTOGRAPHS & PRINTS |

AI artwork sells for $432,500 — nearly 45 times its high estimate — as Christie's becomes the first auction house to offer

Humans and Technology

Machine learning has been used to automatically translate long-lost languages

Some languages that have never been deciphered could be the next ones to get the machine translation treatment.

https://www.technologyreview.com/s/613899/machine-learning-has-been-used-to-automatically-translate-long-lost-languages/

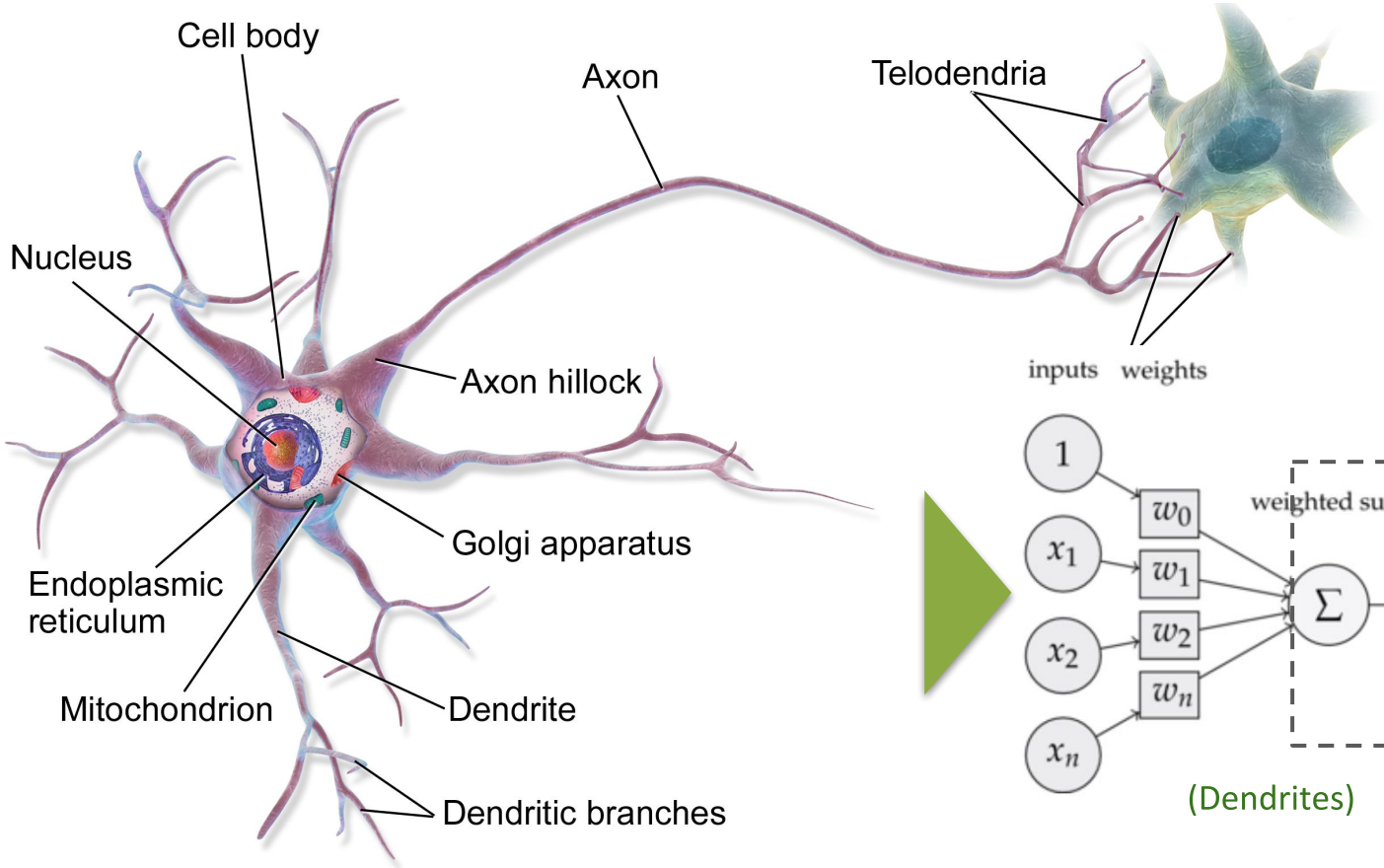
by **Emerging Technology from the arXiv** Jul 1, 2019

"...in from three to eight years we will have a machine with the general intelligence of an average human being", Marvin Minsky (1970)
Are we all doomed…?
...or do we simply have a tendency to overestimate technology?

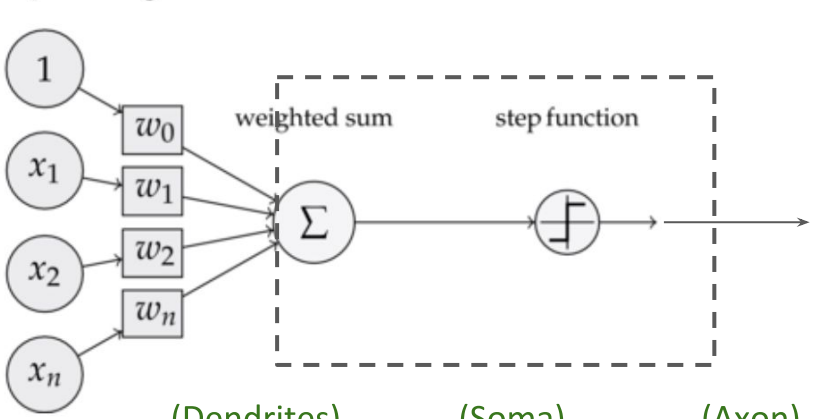
"Nothing succeeds like success."

Alexandre Dumas,
Ange Pitou, Vol. 1,
(1854)

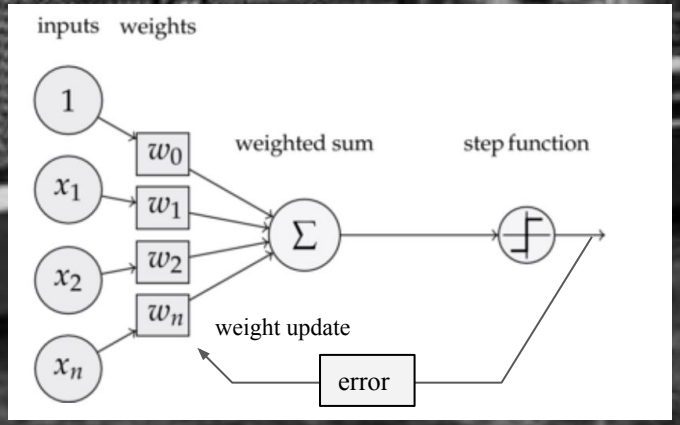
Transfering Biology into a Mathematical Model

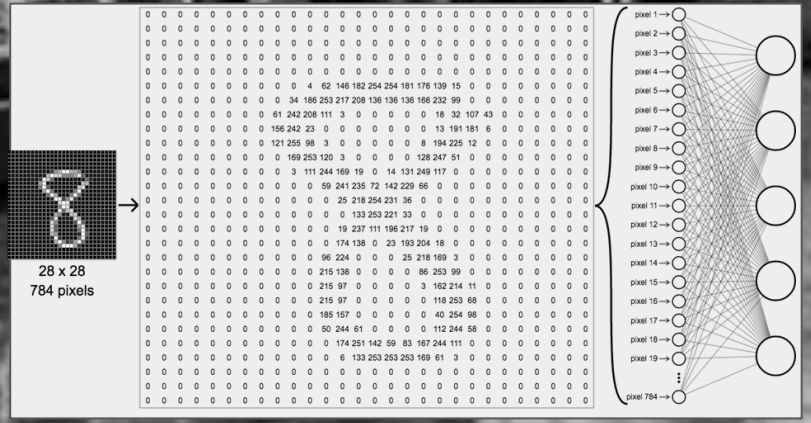


Donald Hebb (1940)
McCulloch & Pitts (1943)

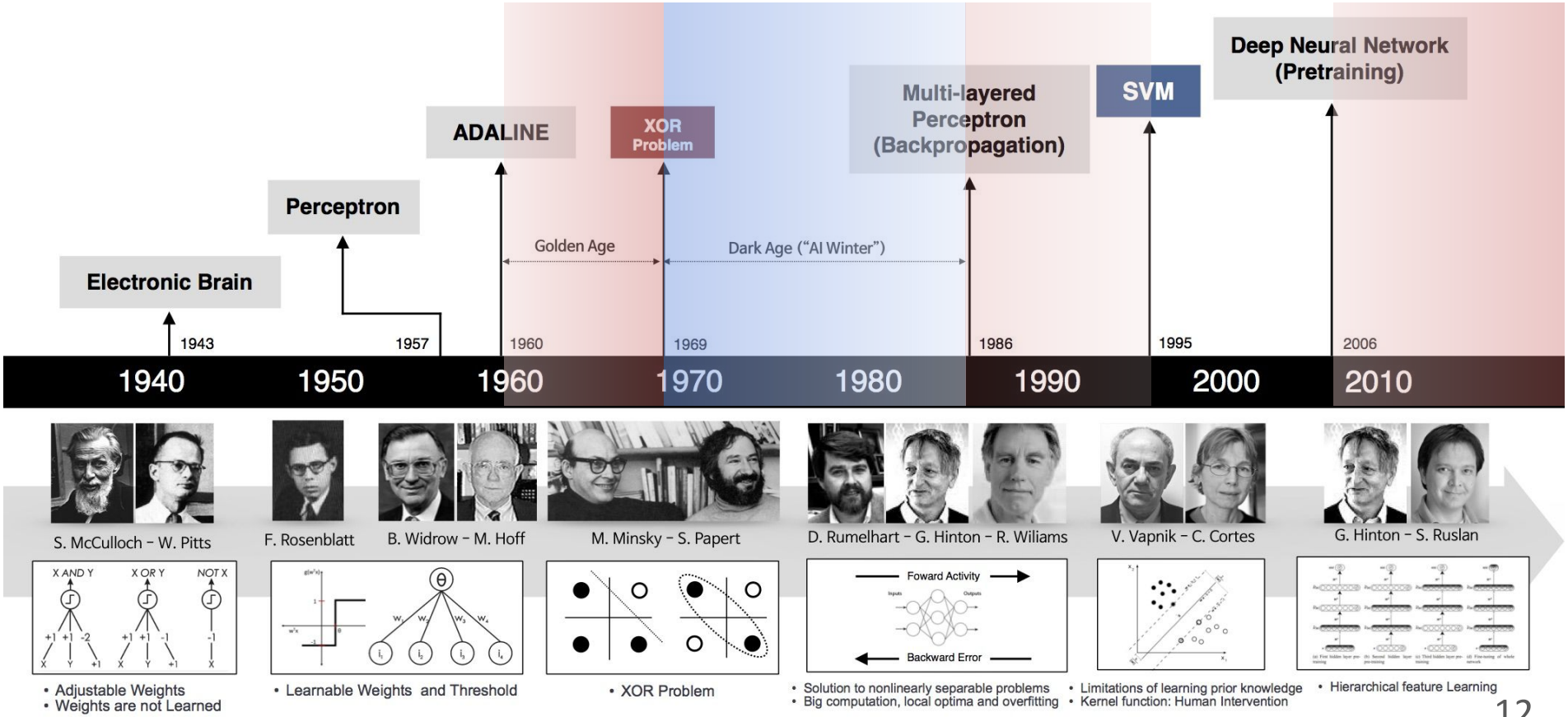


Cognitive Computing - The MARK 1 Perceptron (Rosenblatt, 1957)





The Triumph of the Connectionist Paradigm



Chapter 3

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

Terry Pratchett,
Night Watch (2002)

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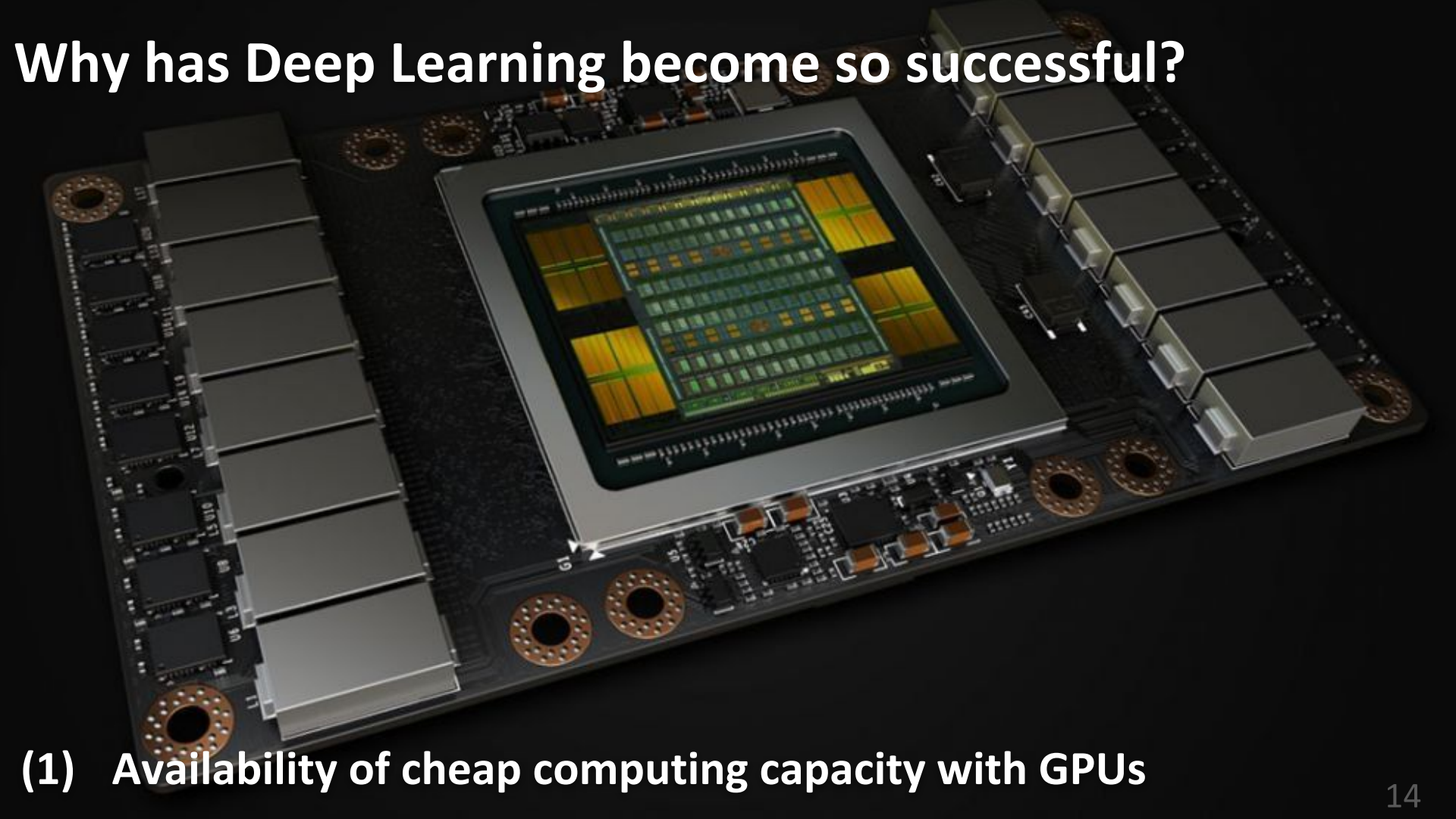
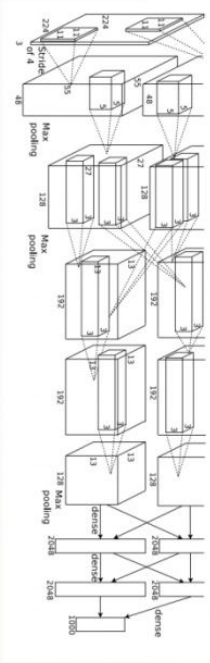
Why has Deep Learning become so successful?



(1) Availability of cheap computing capacity with GPUs

(2) Reusable Highly Trained Complex Models

“AlexNet”



[Krizhevsky et al. NIPS 2012]

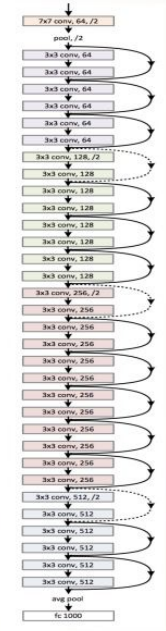
“GoogLeNet”

[Szegedy et al. CVPR 2015]

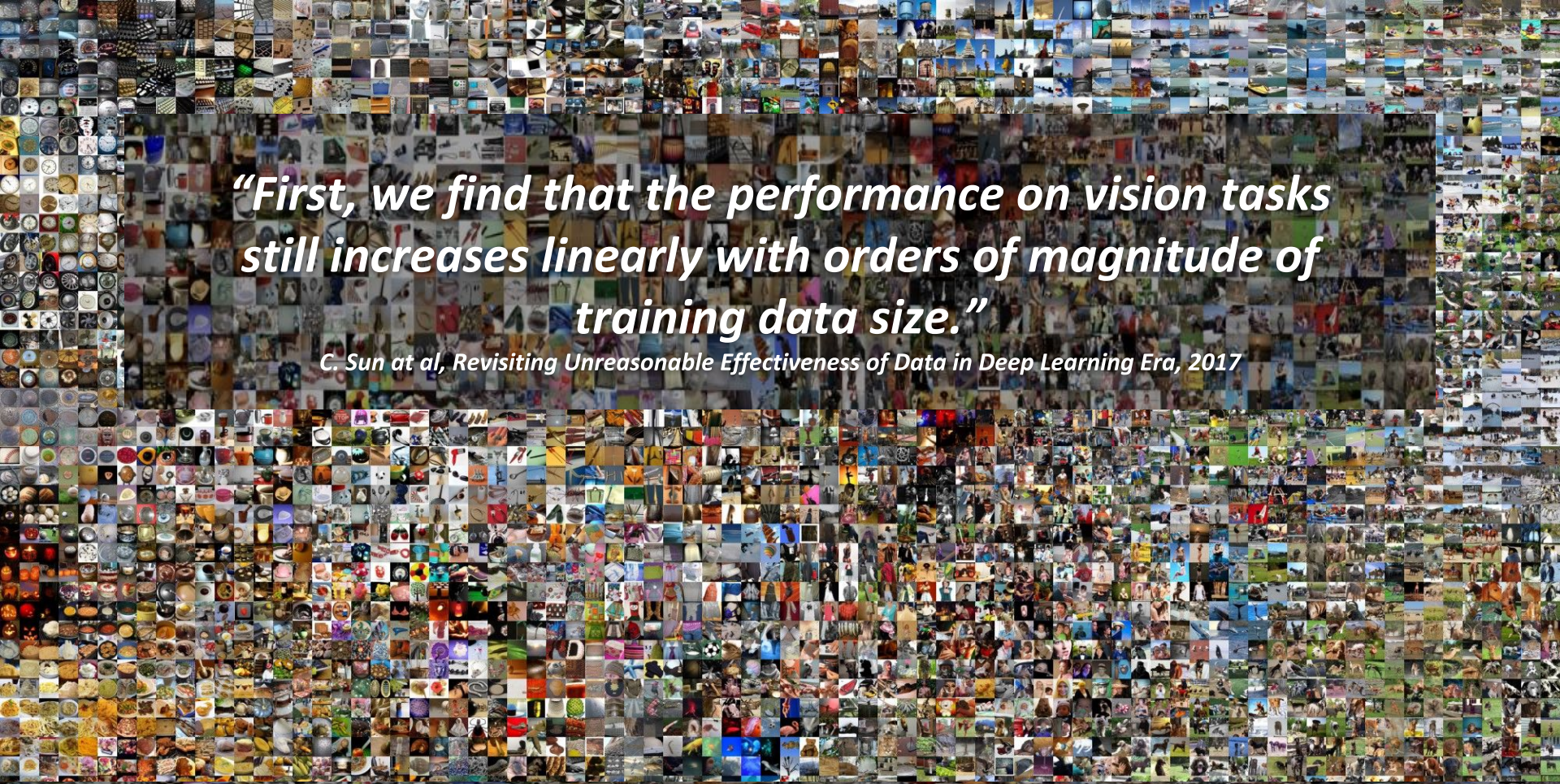
“VGG Net”

[Simonyan & Zisserman, ICLR 2015]

“ResNet”

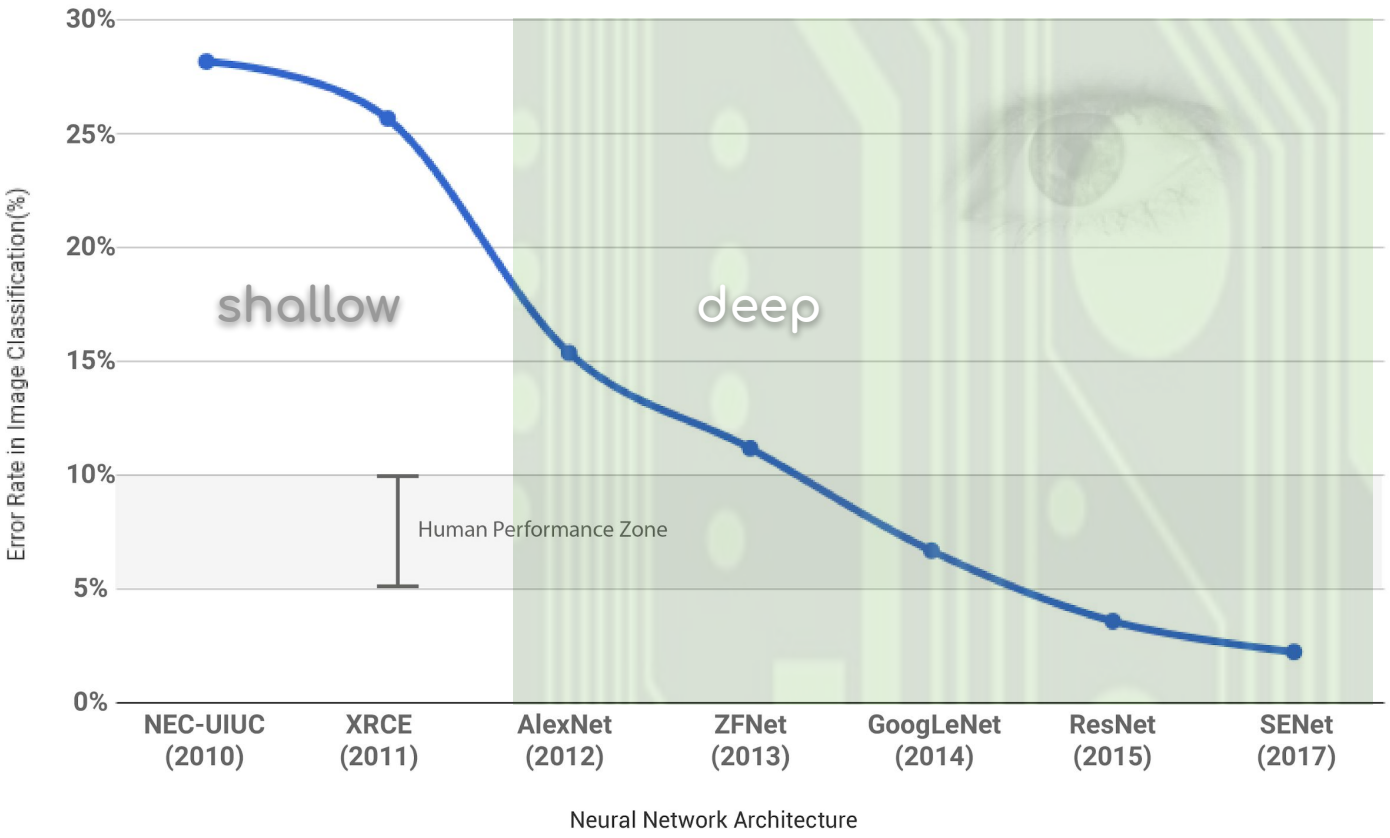


[He et al. CVPR 2016]



(3) Availability of Large Scale Labeled Data

Deep Learning for Visual Analysis



IMAGENET

Large Scale Visual Recognition Challenge (ILSVRC)

http://image-net.org/challenges/LSVRC/

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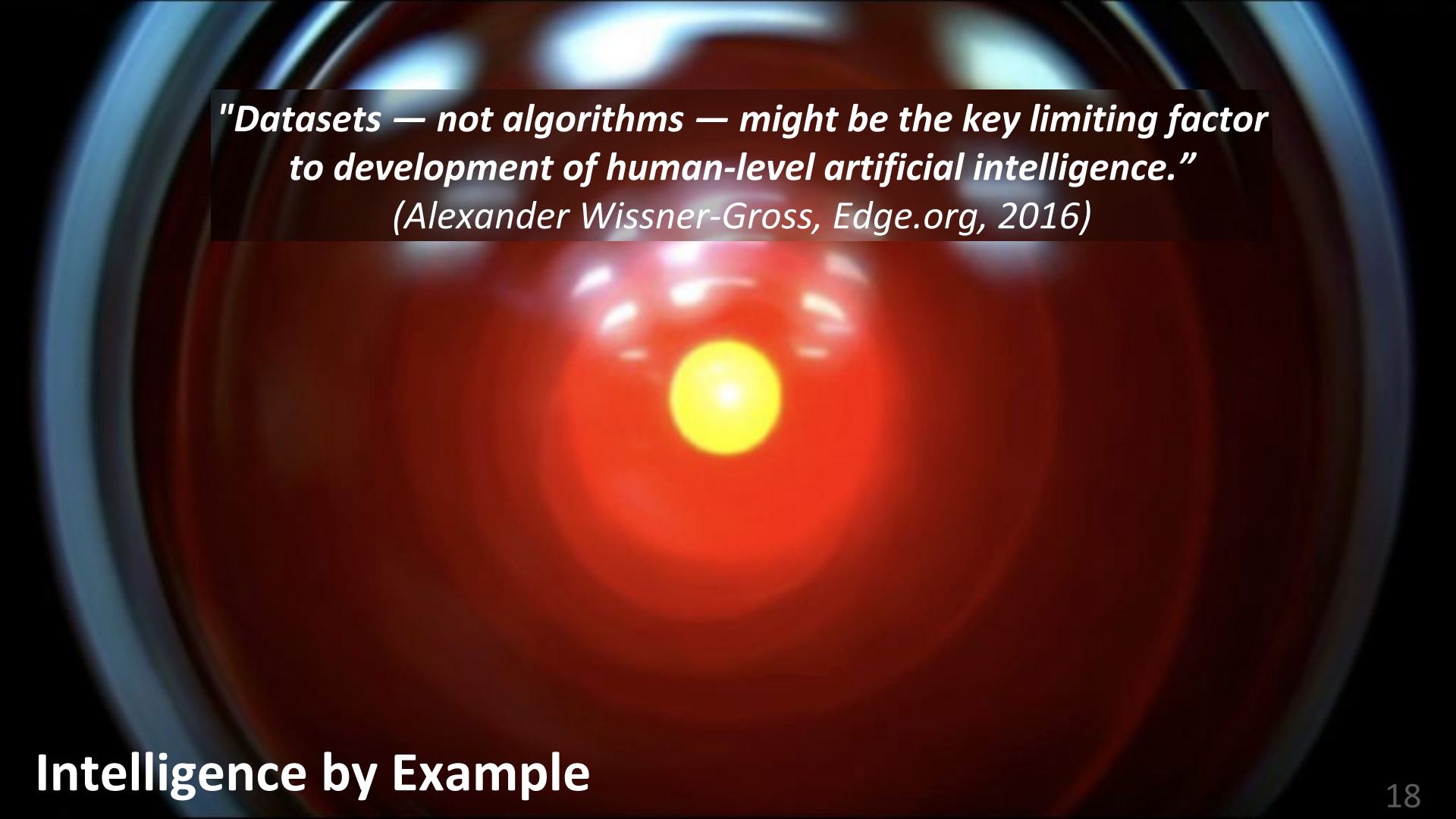

Intelligence by Example

Chapter 4

"Creation
is never complete.
It sarted once,
but it will never stop."

Immanuel Kant,
General Natural History
and Theory of Heaven (1755)

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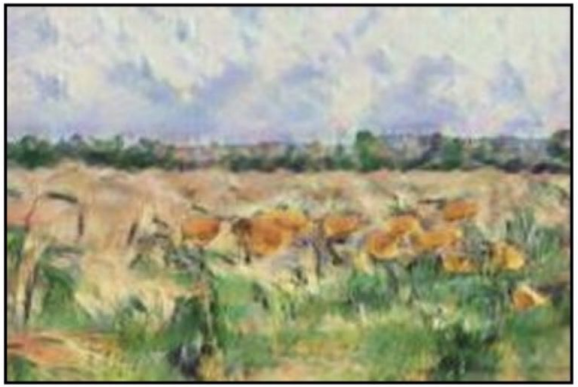
Karlsruher Institut für Technologie

Creation of New Content - Cross Domain Transfer

Photograph

Monet

Van Gogh



Cezanne

Ukiyo-e

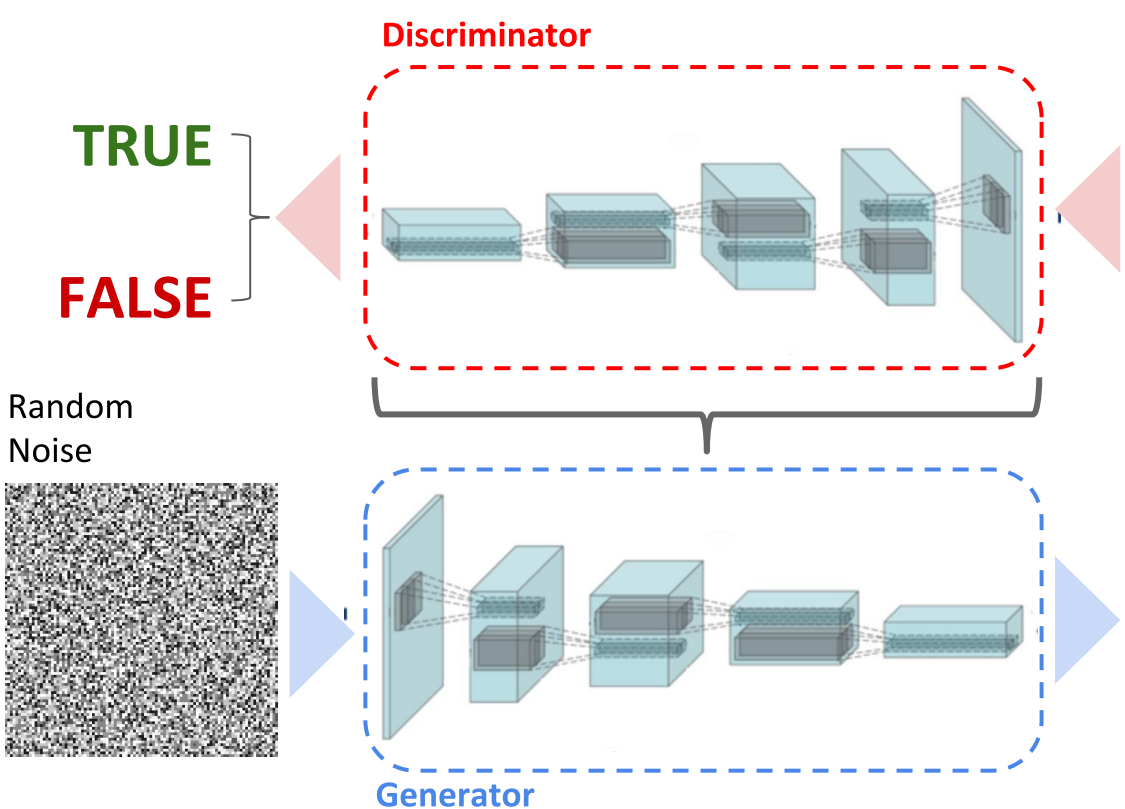
https://junyanz.github.io/CycleGAN/images/teaser_high_res.jpg

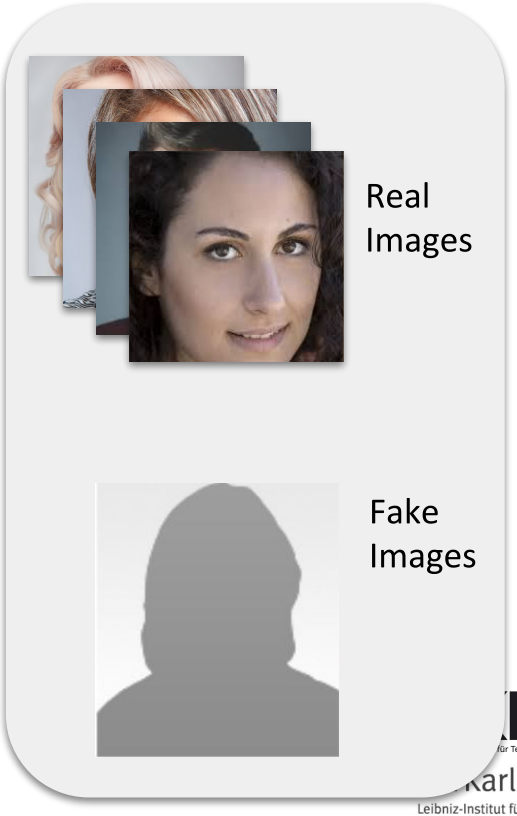
Creation of New Content - Cross Domain Transfer

Monet → Photograph

https://junyanz.github.io/CycleGAN/images/teaser_high_res.jpg

Comparative Learning - Generative Adversarial Networks





Schmidthuber, 1992
Niemitalo, 2010
Goodfellow, 2014

Creation of New Content - Cross Domain Transfer

https://junyanz.github.io/CycleGAN/

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https://github.com/jantic/DeOldify

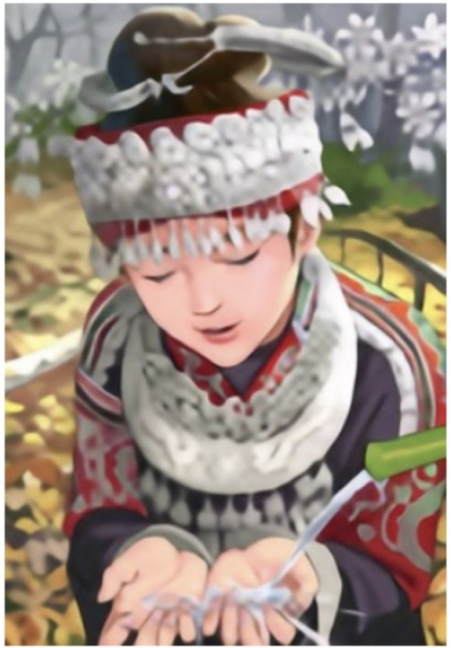
Generation of New Content - Colourization

Generation of New Content - Super Resolution

https://arxiv.org/pdf/1609.04802.pdf

bicubic
(21.59dB/0.6423)

SRResNet
(23.53dB/0.7832)



SRGAN
(21.15dB/0.6868)

original

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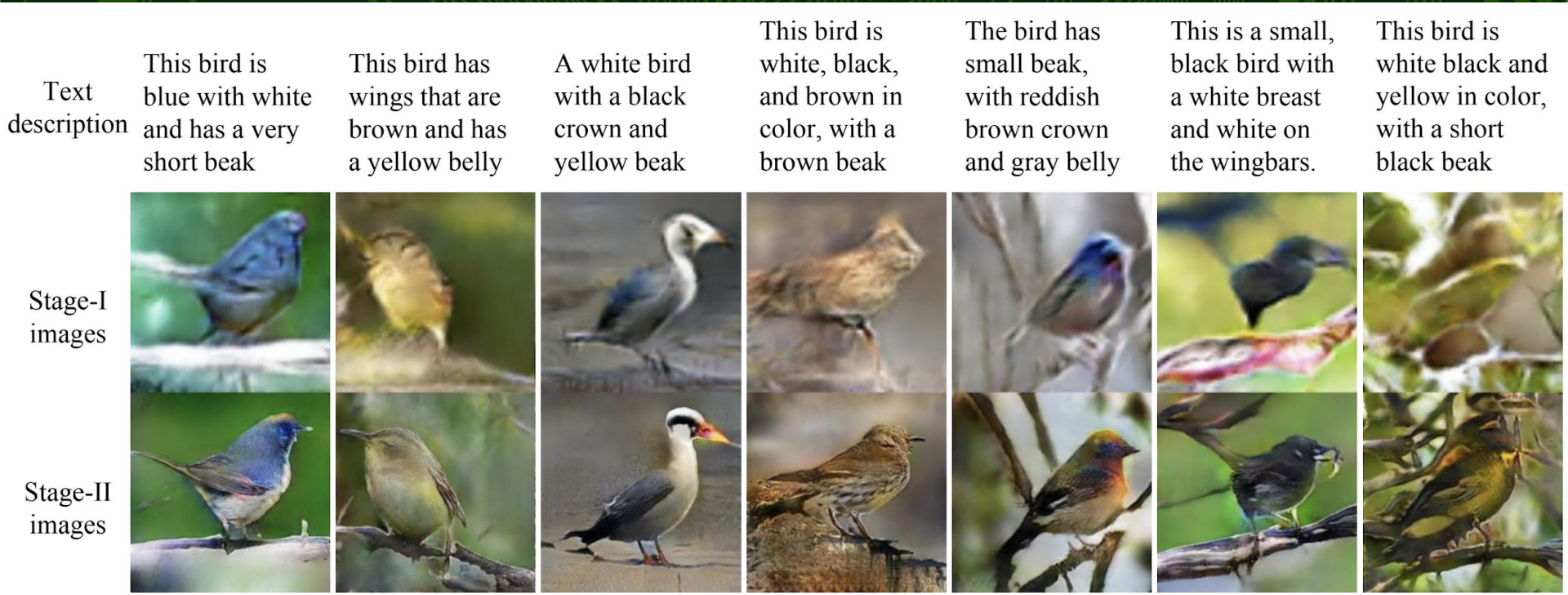
Generation of New Content - Text to Images



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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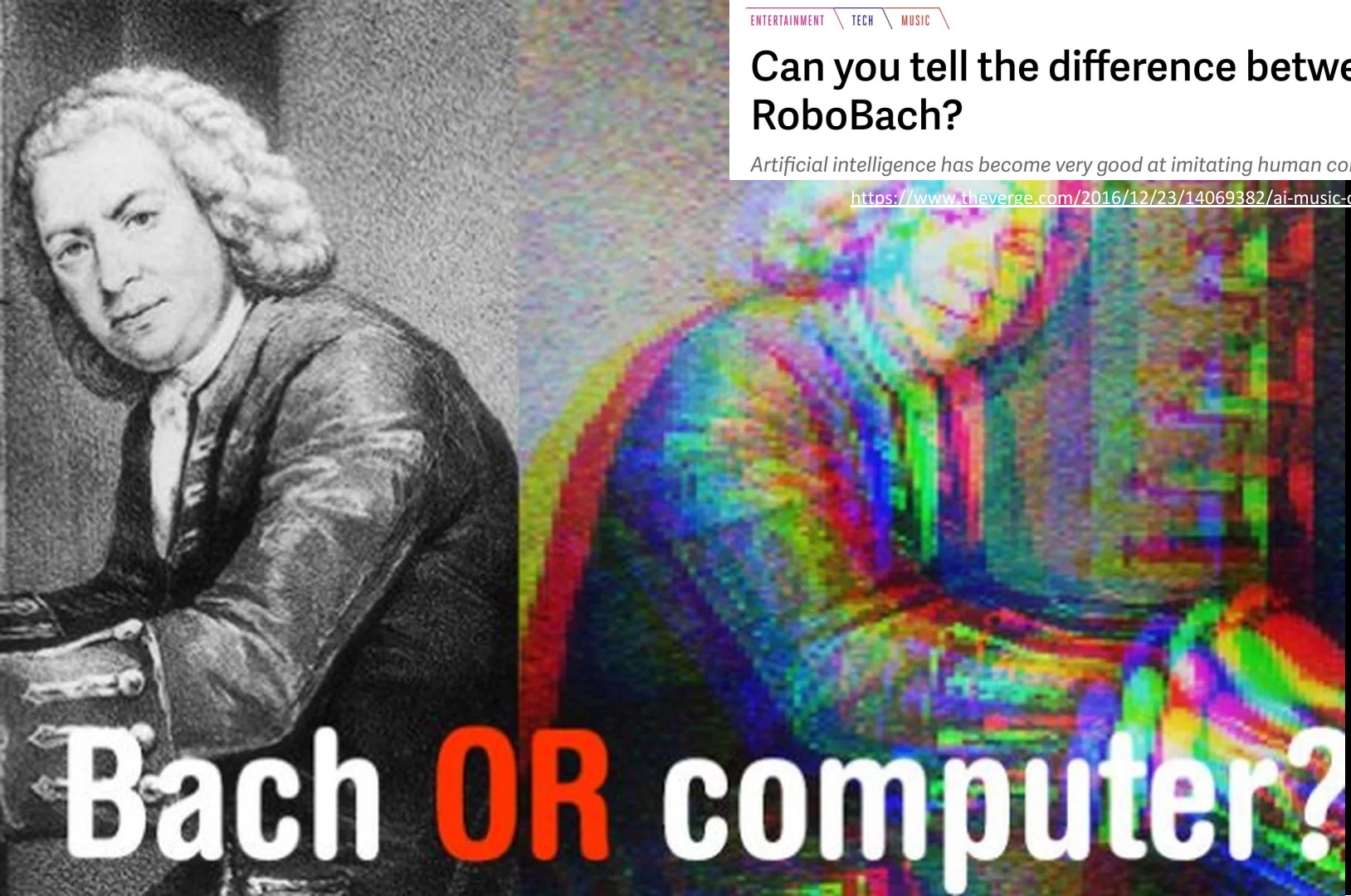


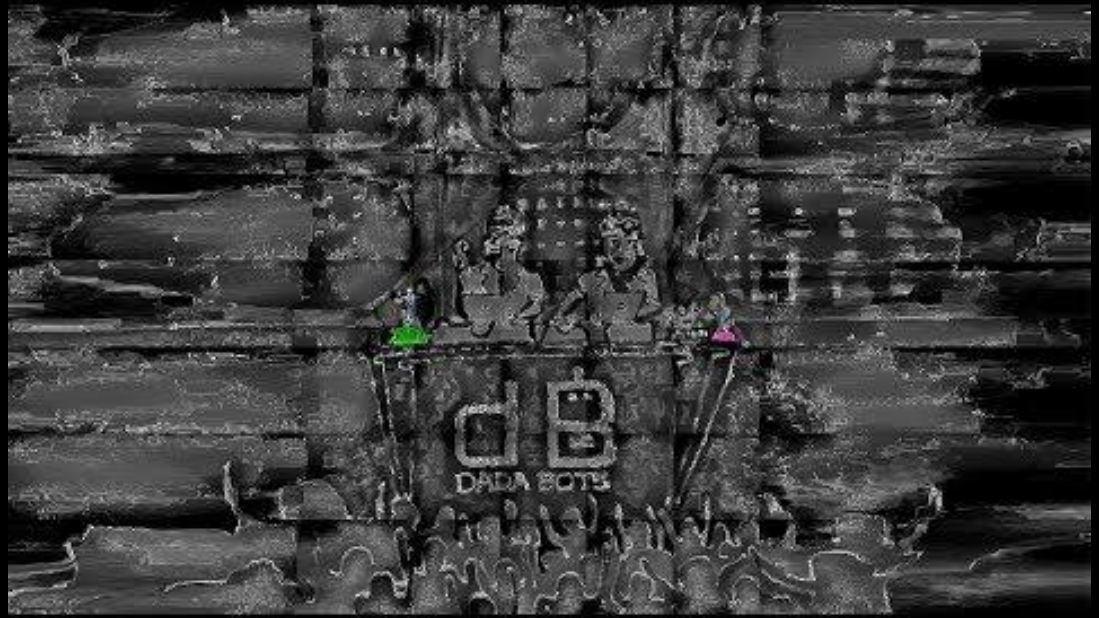
ENTERTAINMENT | TECH | MUSIC

Can you tell the difference between Bach and RoboBach?

Artificial intelligence has become very good at imitating human composers

https://www.theverge.com/2016/12/23/14069382/ai-music-creativity-bach-deepbach-csl

https://www.youtube.com/watch?v=CNNmBtNcccE



AI generates non-stop stream of death metal

by ENGADGET RSS FEED *on* APR 21, 2019

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** with speech interface
- Near-human level **autonomous driving**
- Superhuman Go playing

Chapter 5

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

Neil Gaiman,
The Invisible Labyrinth
(1990)

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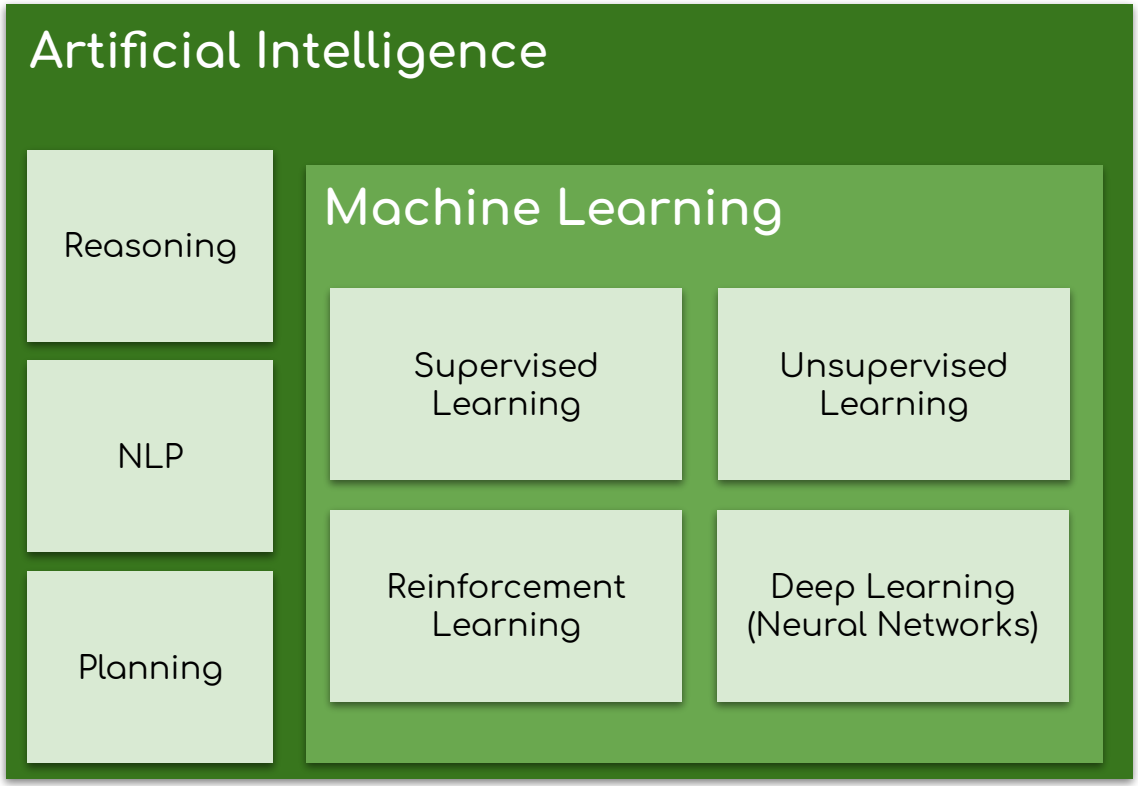
Artificial Intelligence and Machine Learning

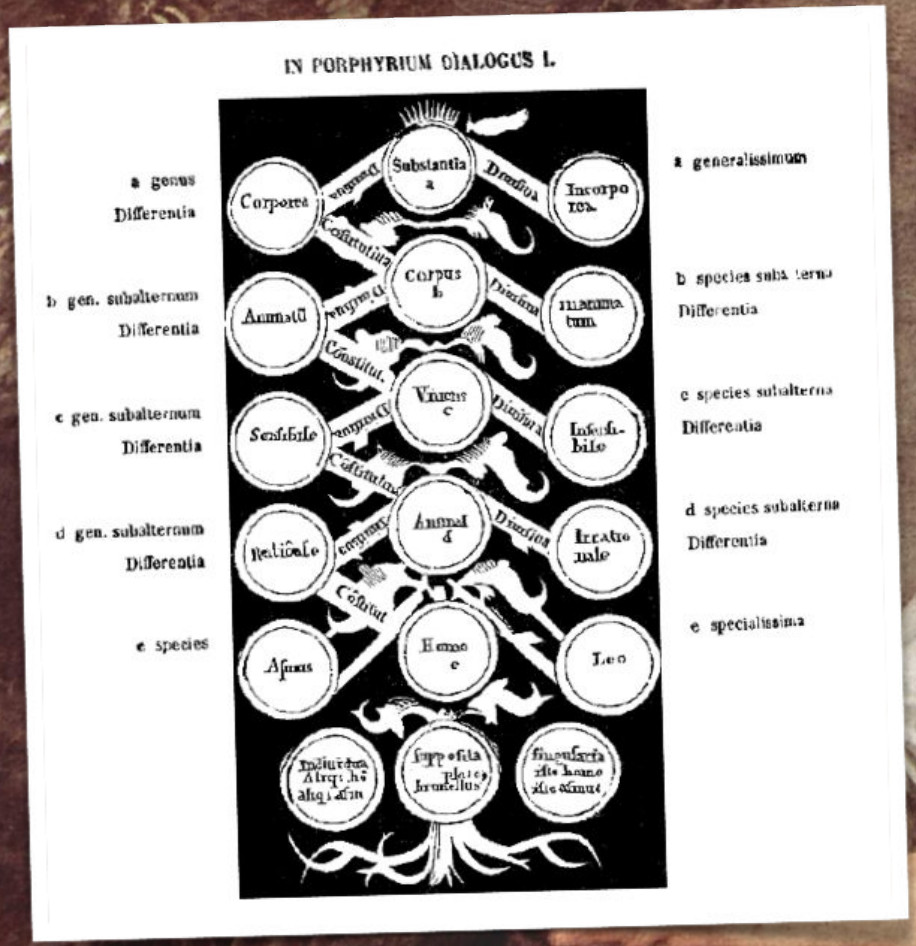


"The Goal of AI is to develop machines that behave as though they were intelligent."

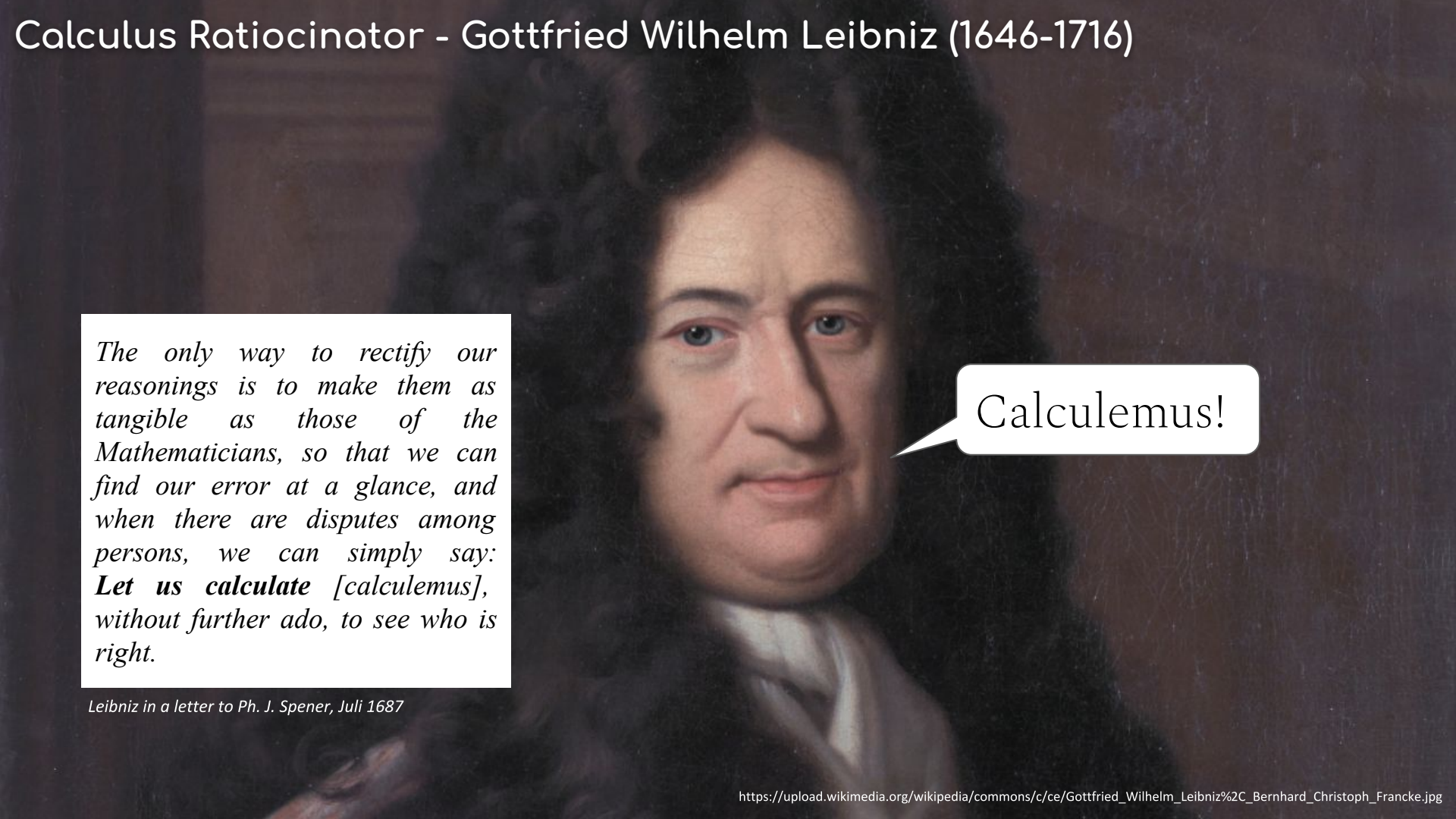
- John McCarthy (1955)

PARENTAL
ADVISORY
EXPLICIT SEMANTICS

The Universal Categories - Aristotle (384–322 BC)



Calculus Ratiocinator - Gottfried Wilhelm Leibniz (1646-1716)

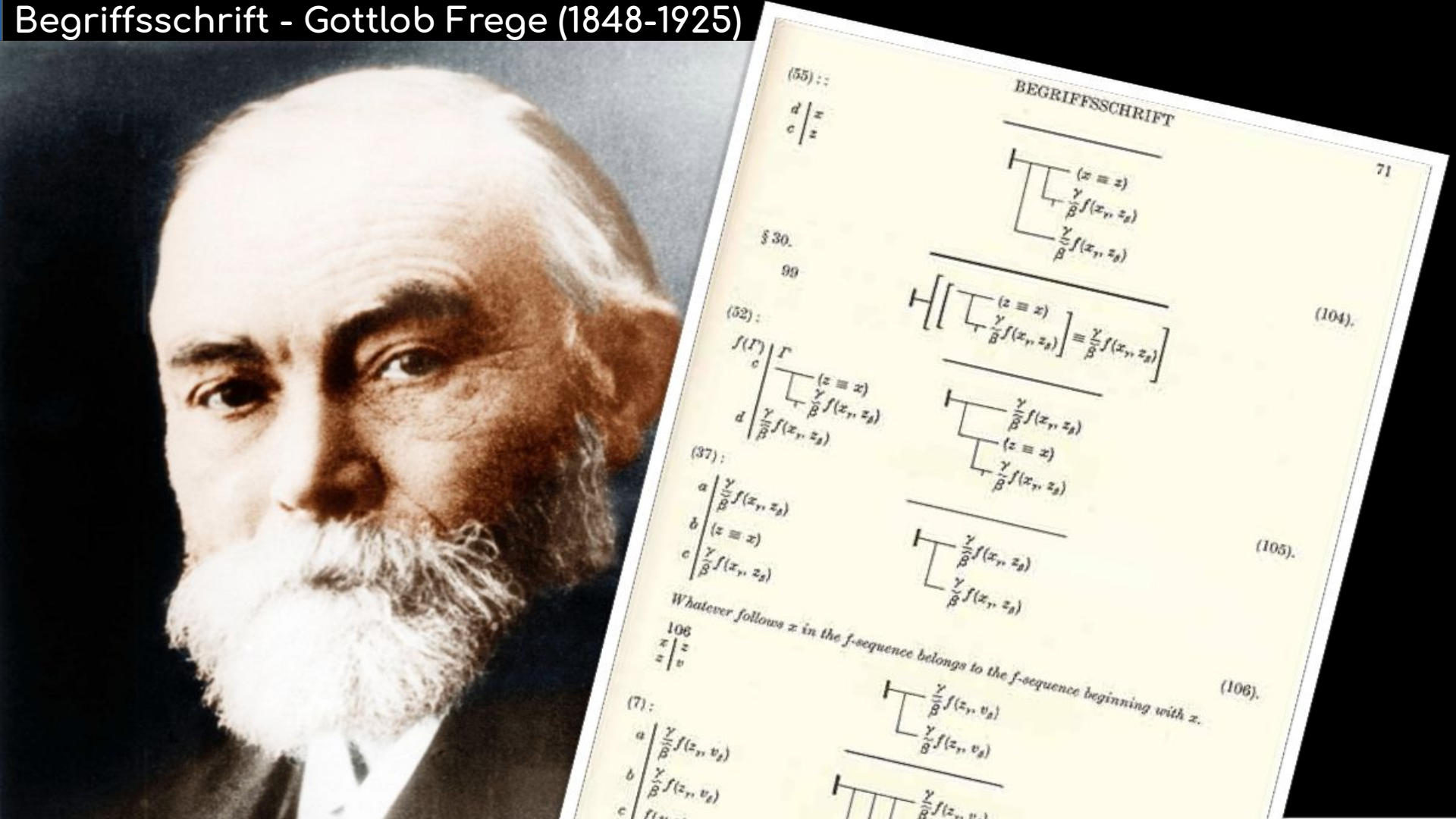


The only way to rectify our reasonings is to make them as tangible as those of the Mathematicians, so that we can find our error at a glance, and when there are disputes among persons, we can simply say: ***Let us calculate*** *[calculemus], without further ado, to see who is right.*

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

https://upload.wikimedia.org/wikipedia/commons/c/ce/Gottfried_Wilhelm_Leibniz%2C_Bernhard_Christoph_Francke.jpg

Begriffsschrift - Gottlob Frege (1848-1925)



BEGRIFFSSCHRIFT

71

§ 30.

99

(55) : :

$$\begin{array}{l|l} d & z \\ c & z \end{array}$$

$$\begin{array}{l} \\ \hline (x \equiv z) \\ \quad \frac{\gamma}{\beta} f(x_\gamma, z_\beta) \\ \frac{\gamma}{\beta} f(x_\gamma, z_\beta) \end{array}$$

(52) :

$$\begin{array}{l|l} f(\Gamma) & \Gamma \\ c & \quad (z \equiv x) \\ d & \frac{\gamma}{\beta} f(x_\gamma, z_\beta) \end{array}$$

$$\begin{array}{l} \\ \hline \left[\left[(z \equiv x) \right. \right. \\ \quad \left. \left. \frac{\gamma}{\beta} f(x_\gamma, z_\beta) \right] \equiv \frac{\gamma}{\beta} f(x_\gamma, z_\beta) \right] \end{array} \qquad (104).$$

$$\begin{array}{l} \\ \hline \frac{\gamma}{\beta} f(x_\gamma, z_\beta) \\ \quad (z \equiv x) \\ \quad \frac{\gamma}{\beta} f(x_\gamma, z_\beta) \end{array}$$

(37) :

$$\begin{array}{l|l} a & \frac{\gamma}{\beta} f(x_\gamma, z_\beta) \\ b & \quad (z \equiv x) \\ c & \frac{\gamma}{\beta} f(x_\gamma, z_\beta) \end{array}$$

$$\begin{array}{l} \\ \hline \frac{\gamma}{\beta} f(x_\gamma, z_\beta) \\ \frac{\gamma}{\beta} f(x_\gamma, z_\beta) \end{array} \qquad (105).$$

Whatever follows x in the f-sequence belongs to the f-sequence beginning with x. (106).

106

$$\begin{array}{l|l} x & z \\ z & v \end{array}$$

(7) :

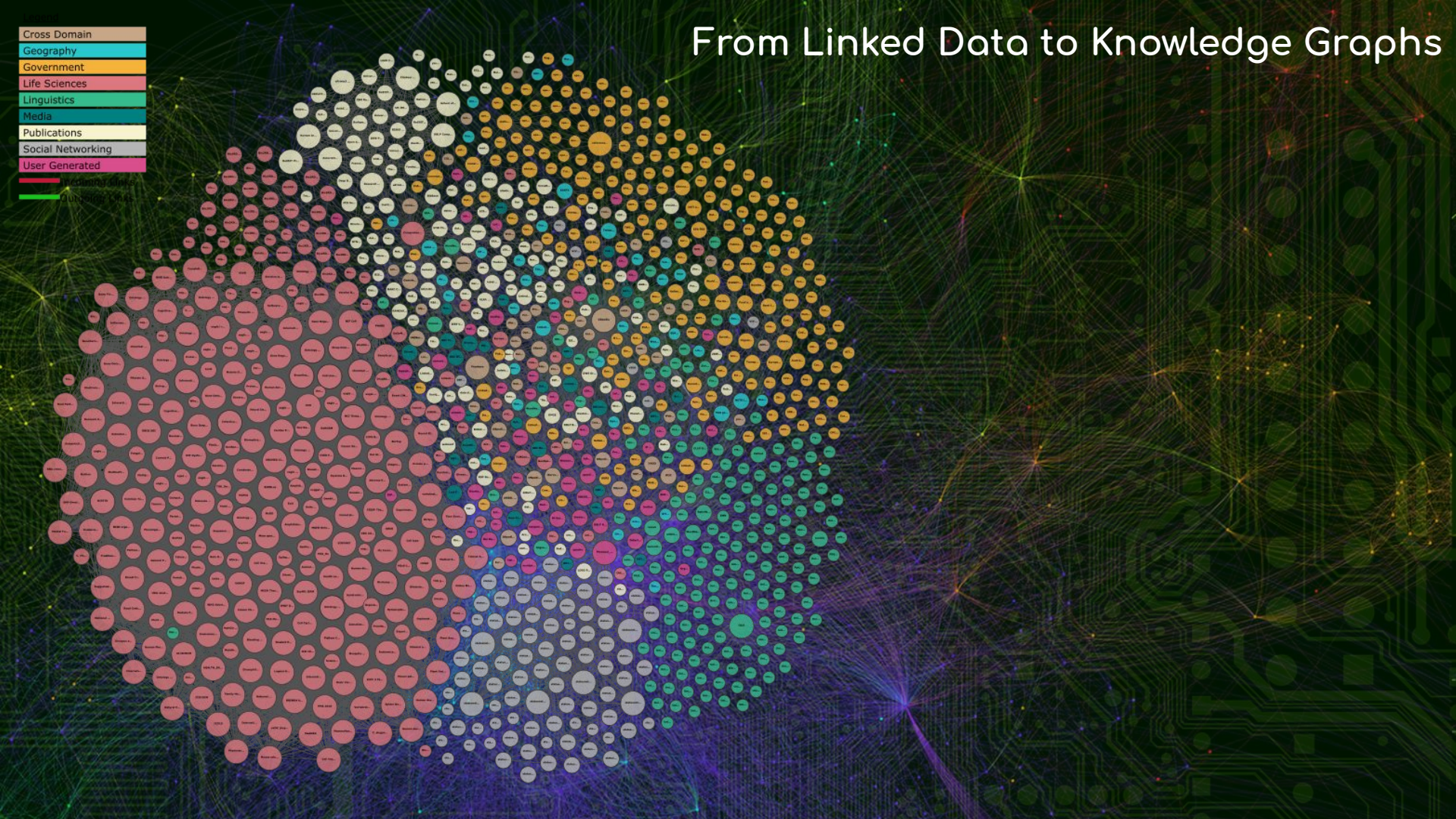
$$\begin{array}{l|l} a & \frac{\gamma}{\beta} f(z_\gamma, v_\beta) \\ b & \frac{\gamma}{\beta} f(z_\gamma, v_\beta) \\ c & f(z_\gamma, v_\beta) \end{array}$$

$$\begin{array}{l} \\ \hline \frac{\gamma}{\beta} f(z_\gamma, v_\beta) \\ \frac{\gamma}{\beta} f(z_\gamma, v_\beta) \end{array}$$

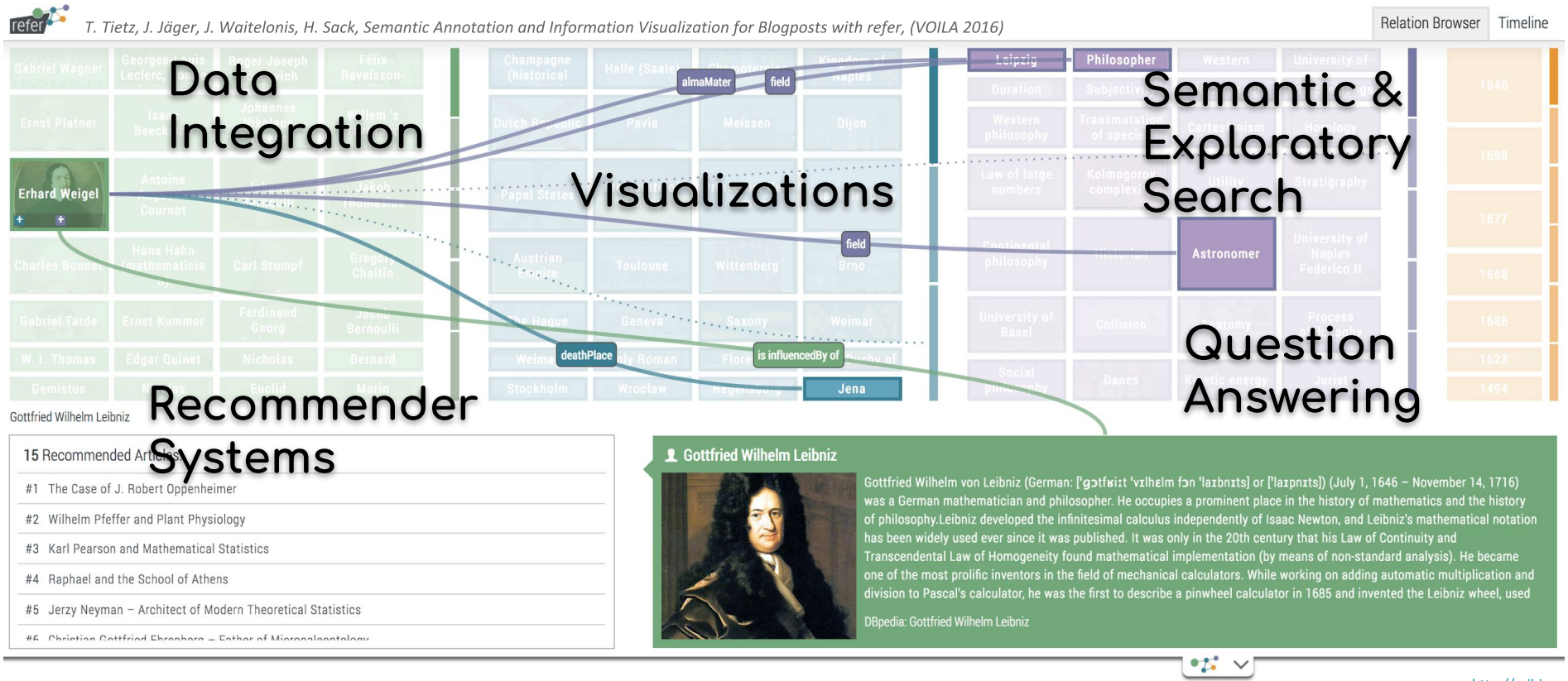
$$\begin{array}{l} \\ \hline \frac{\gamma}{\beta} f(z_\gamma, v_\beta) \\ \quad \frac{\gamma}{\beta} f(z_\gamma, v_\beta) \end{array}$$

Frame Logic for Knowledge Representation - Marvin Minsky (1974)

https://www.flickr.com/photos/x-ray_delta_one/


Legend
Cross Domain
Geography
Government
Life Sciences
Linguistics
Media
Publications
Social Networking
User Generated
From Linked Data to Knowledge Graphs

Knowledge Graph Applications



Chapter 6

"There ain't
no such thing
as a free lunch."

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

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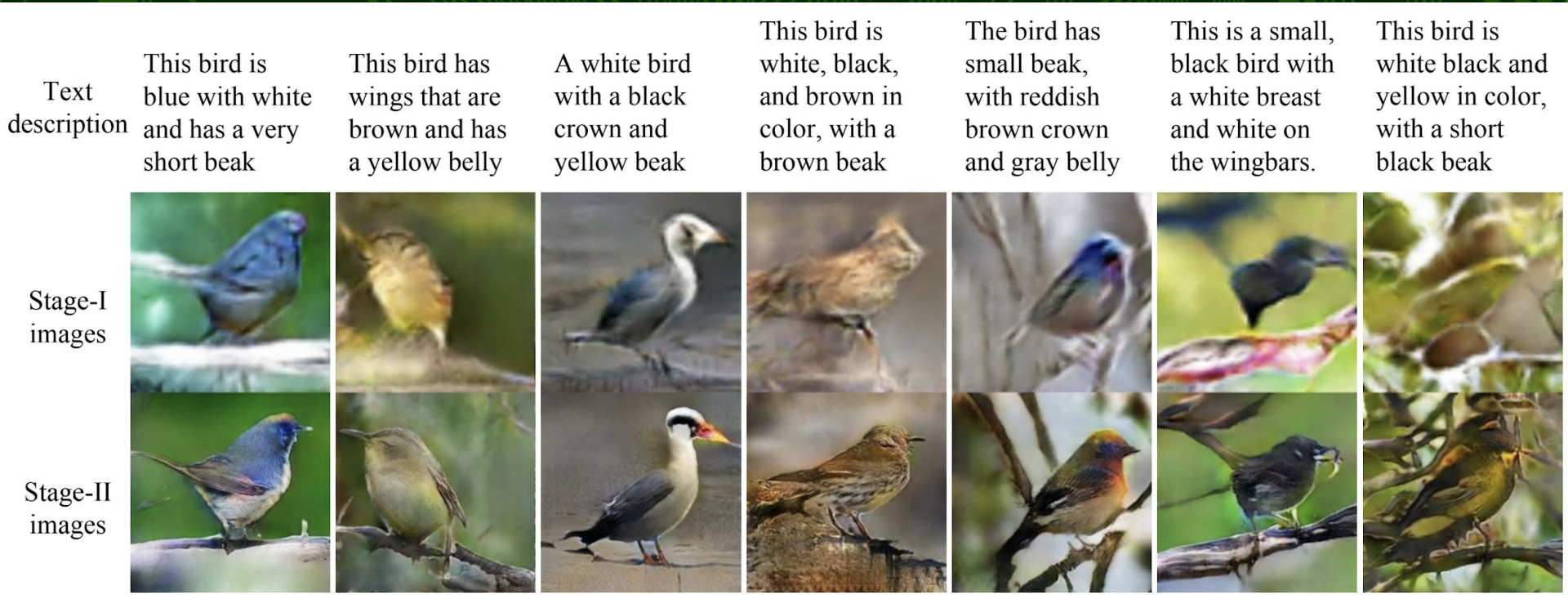
Karlsruher Institut für Technologie

The Clever Hans Effect

or Why we shouldn't always trust ML

https://commons.wikimedia.org/wiki/File:Osten_und_Hans.jpg

Generation of New Content - Text to Images



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CoRR abs/1710.10916 (2017)

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Generation of New Content - Text to Images

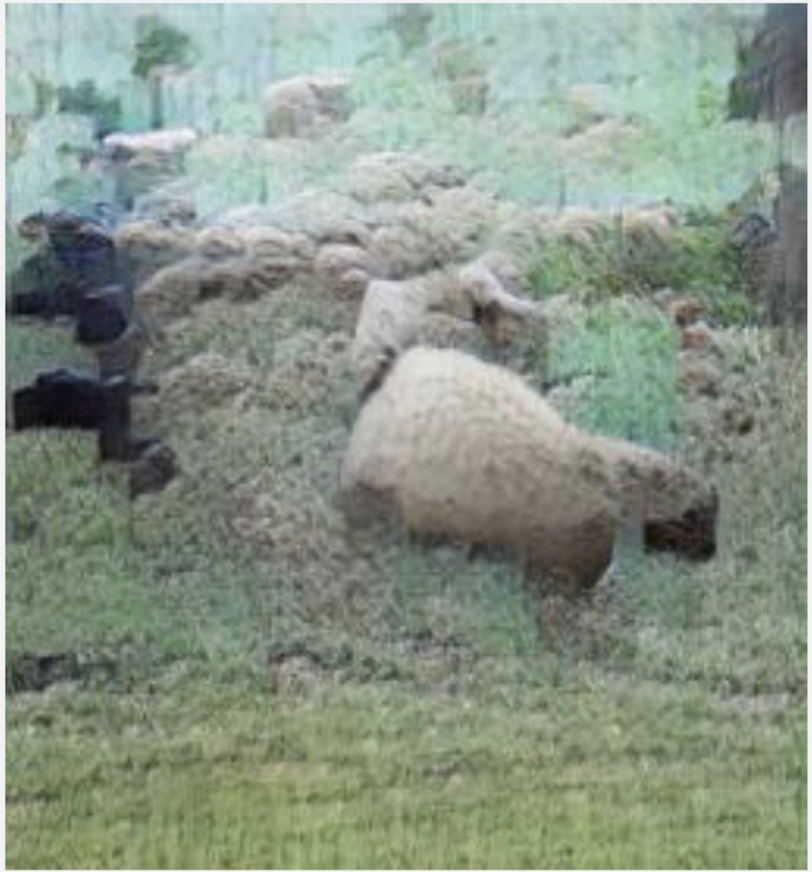
This is a small light gray bird with a small head and green crown nape and some green coloring on its wings

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)

Now let’s go for something more General ...

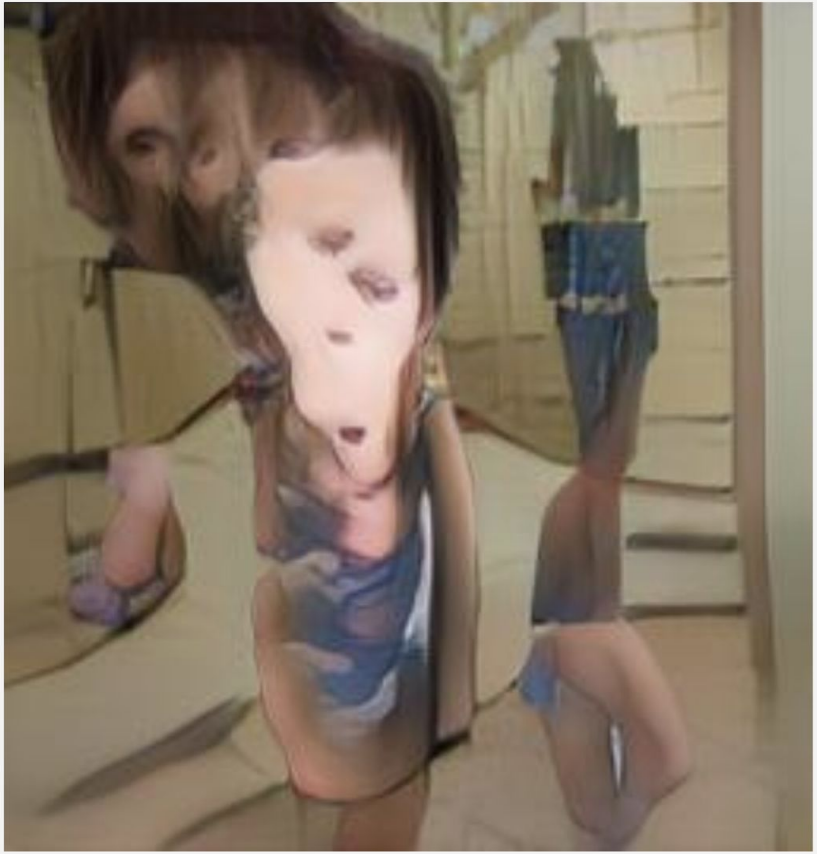
http://t2i.qvalenzuelan.com/

A flock of sheep on green meadows



http://t2i.cvalenzuelab.com/

a girl
watching tv

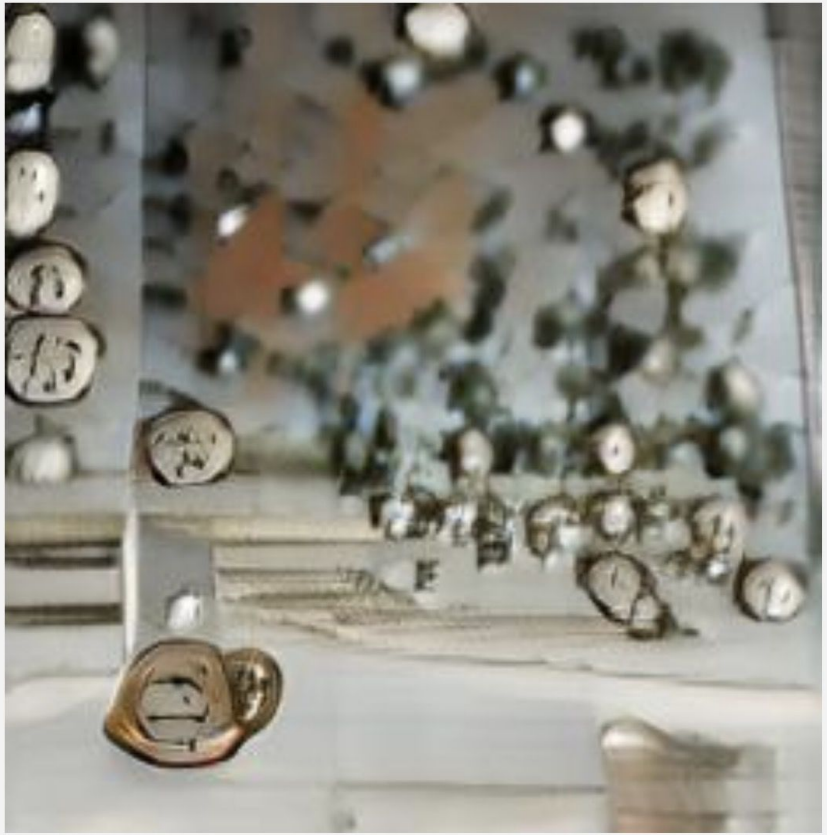


http://t2i.cvalenzuelab.com/

a girl with
two blue eyes,
one upturned
nose, and a
red mouth

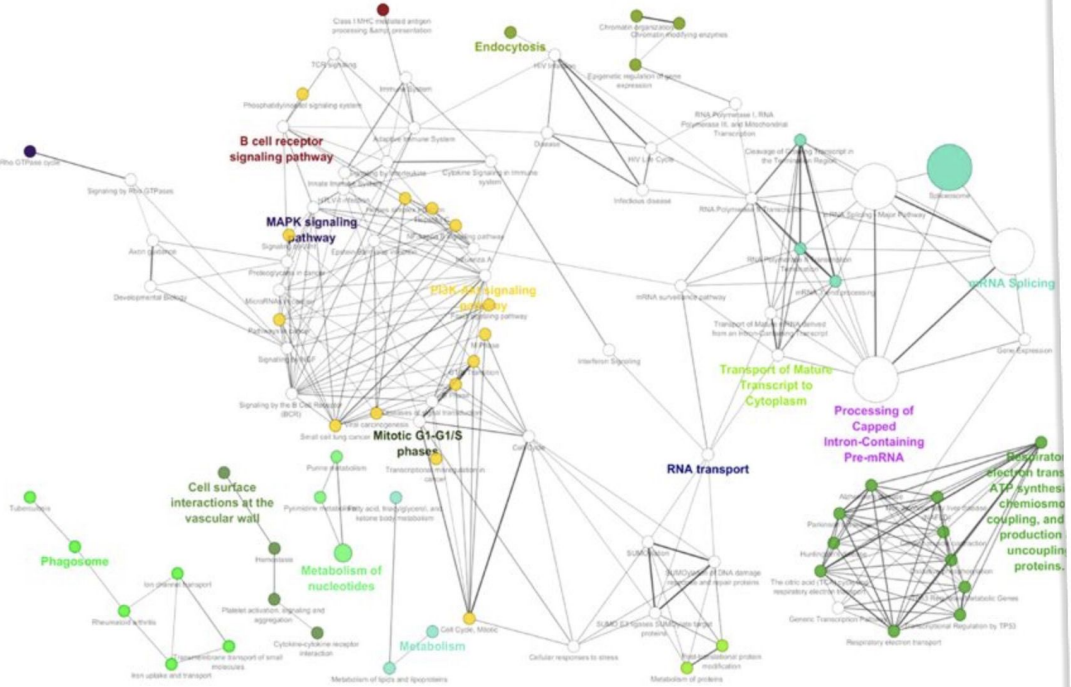
http://t2i.cvalenzuelab.com/

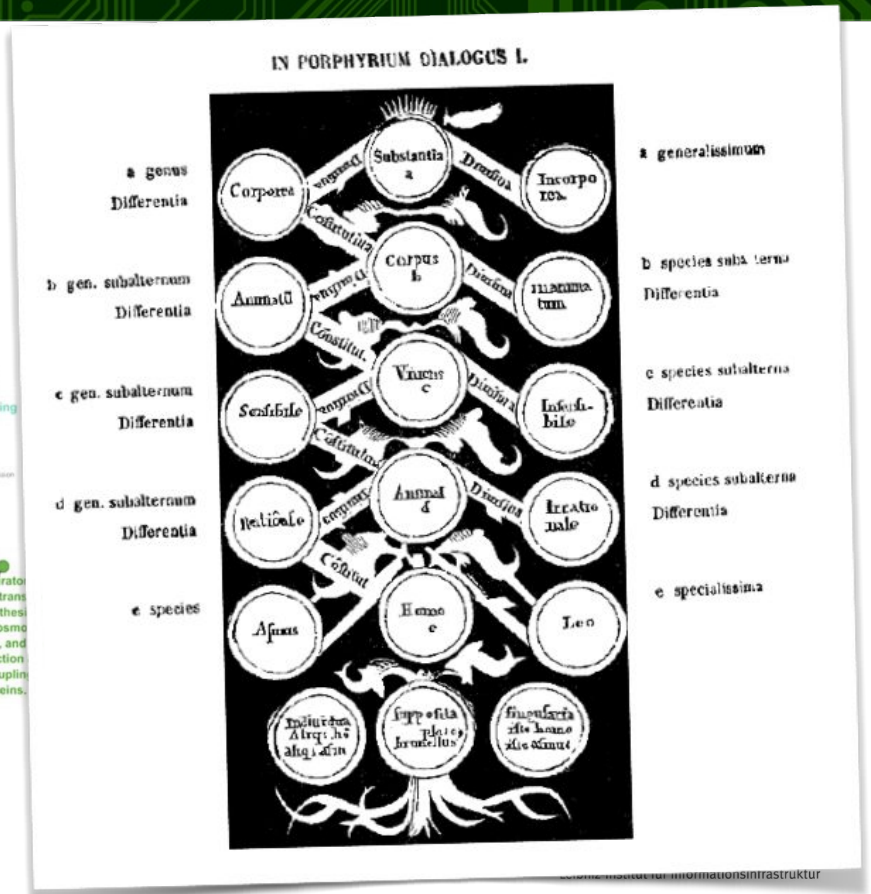
melting
clocks over
the dessert



http://t2i.cvalenzuelab.com/

Knowledge Graphs: Local Detail vs Global Coverage





Chapter 7

"All for one,
one for all,
that is our motto."

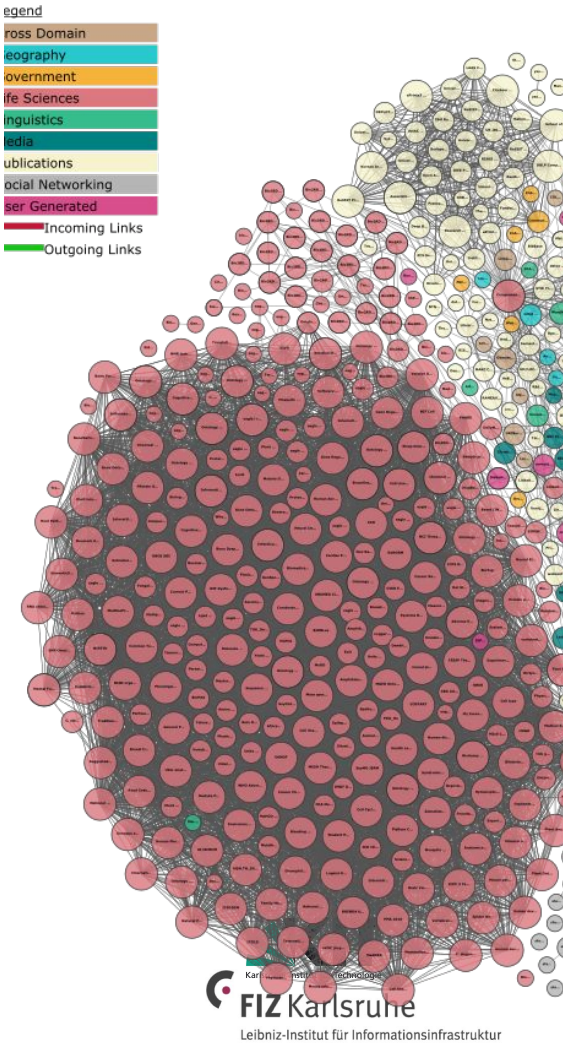
Alexandre Dumas,
The Three Musketeers,
(1844)

Prof. Dr. Harald Sack
FIZ Karlsruhe
Leibniz-Institut für Informationsinfrastruktur

Karlsruher Institut für Technologie

Deep Learning for Knowledge Graphs

- NLP and Knowledge Extraction via Deep Learning to **populate and extend Knowledge Graphs**
- NLP and Knowledge Extraction via Deep Learning for **Ontology Learning** to **extend and refine Knowledge Graphs**
- Graph Analysis and NLP with Deep Learning for **Ontology Alignment** and **Link Discovery** to **combine and integrate Knowledge Graphs**



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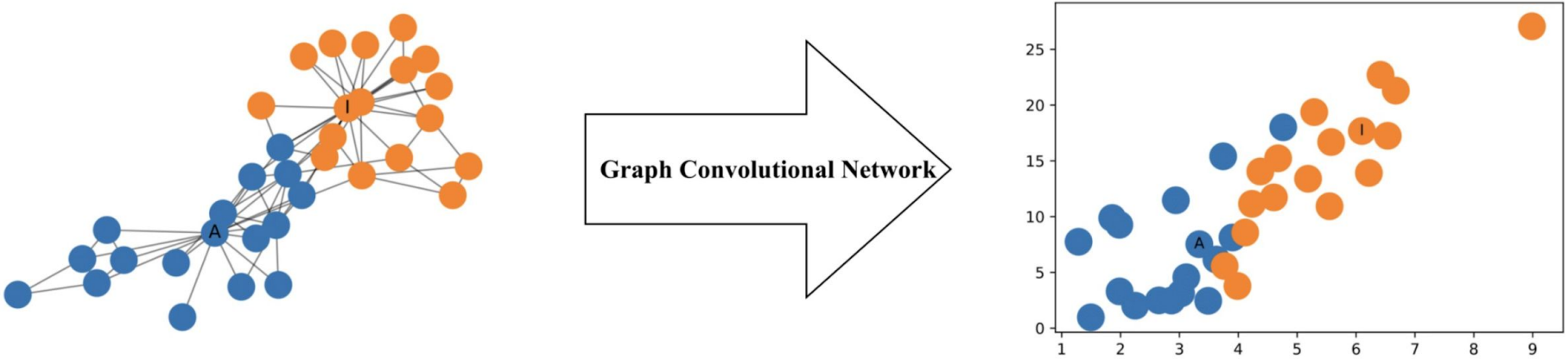
Knowledge Graphs for Deep Learning

- Use **Graph Embeddings** for a latent semantic representation of **Knowledge Graphs**
- Combining latent semantic representations of **different (symbolic) representations (Hybrid Embeddings)**
- **Graph Convolutional Neural Networks & Knowledge Graph Embeddings**



Indexing with Pretrained State-of-the-Art Models

(1) Image Captioning (resnet50, 5m iterations)

```
0) a collage of photos of a person holding a skateboard (p=0.000002)
1) a collage of photos with a bunch of different pictures (p=0.000002)
2) a collage of photos of a person holding a skateboard . (p=0.000001)
```

a collage of photos of a person holding a skateboard

(2) Visual Concept Detection (based on ImageNet 1K)

```
inception_v3: [[('n06596364', 'comic_book', 0.29700932), ('n07248320', 'book_jacket', 0.21479161)
vgg16       : [[('n03291819', 'envelope', 0.80103236), ('n07248320', 'book_jacket', 0.12616517),
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Mobilenet_V2: [[('n06596364', 'comic_book', 0.3172333), ('n03598930', 'jigsaw_puzzle', 0.16213572
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```

Abbot Hugo de Cluny, Margravine Mathilda of Tuscany and Henry IV, miniature from the manuscript Vita Mathildis (c 1115)

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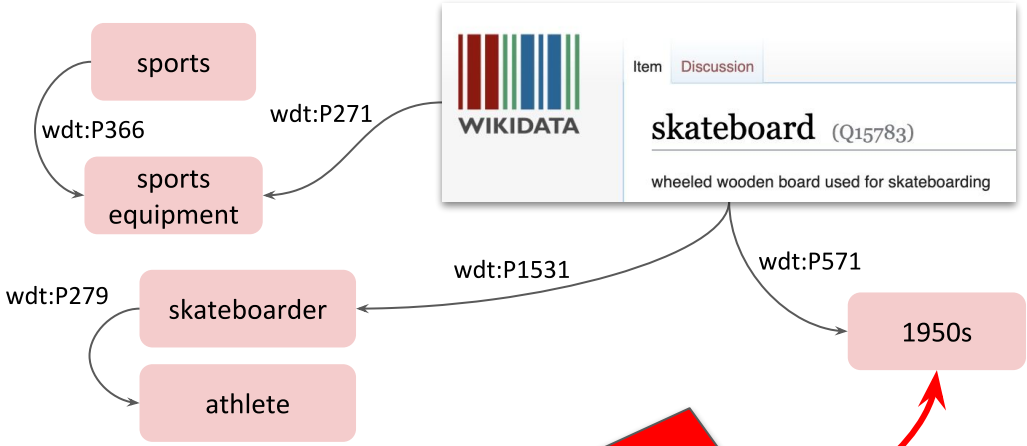
Combining Deep Learning and Semantics

Automated Image captioning:

a **person** holding a **skateboard**

Entity Linking



Metadata

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author:	Donizio
date:	**1115**
location:	Bibliotheca Apostolica Vaticana...

Knowledge Graph Based Exploration

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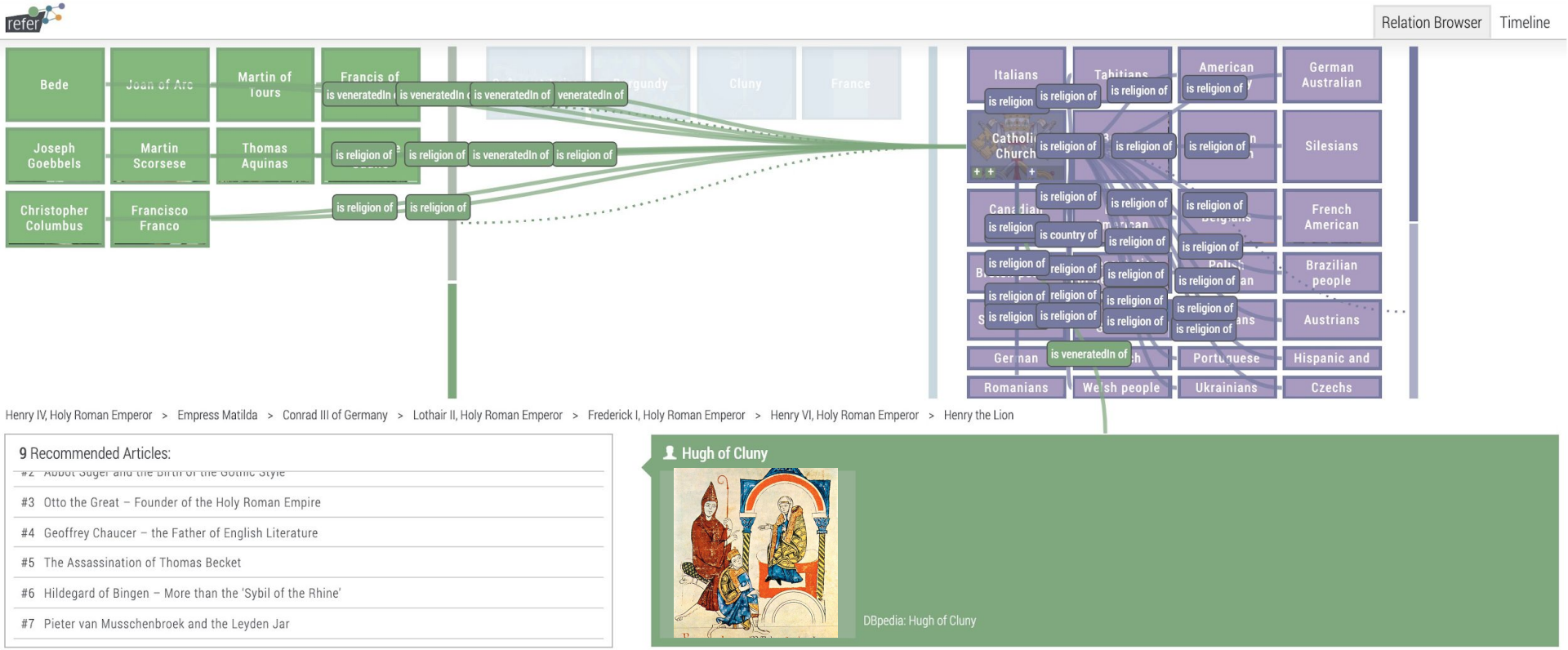

http://scihi.org/

Knowledge Graph Based Exploration

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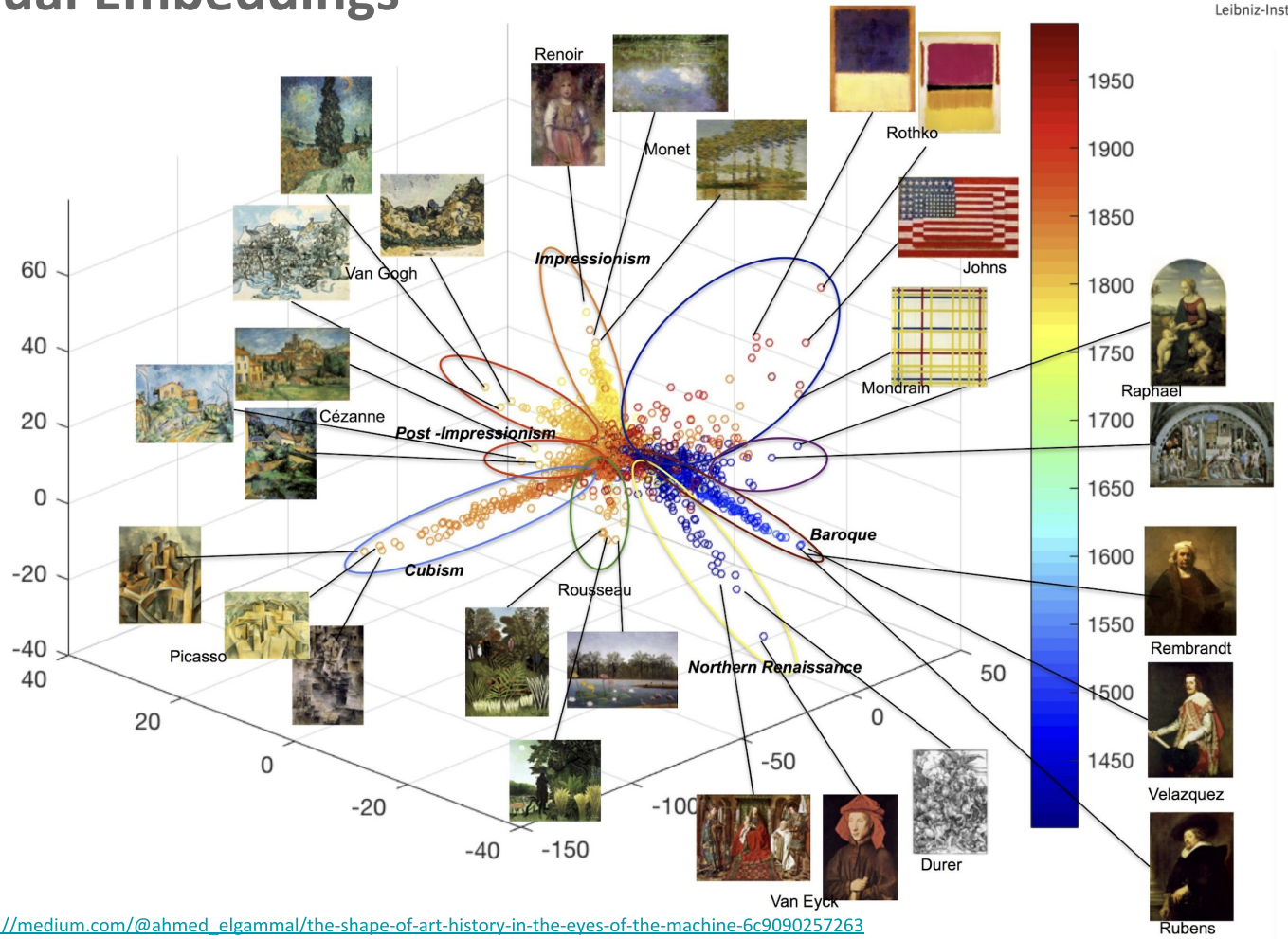
Q4060918
Q11398608
Yaroslav II of Kiev
Friedrich IV.
Kasimir I.
Richardis von Babenberg
Agnes von Österreich
Béla, Heir of Hungary
Q11801056
Heinrich
Heinrich II.
Judith de Lorraine
Q9140803
Boleslaw I.
Konrad III.
Mieszko I.
Stephan III.
Q933892
Beatrice of Auxonne
Ludmilla von Böhmen
Agnes of Bohemia
Adalbert III. von Böhmen
Jaroslaw
Konrad II. von Babenberg
Johann I.
Boleslaus, son of Dépolt
Balduin V.
Berta von Boll
Agnes von Babenberg
Dulcia II.
Gertrude von Babenberg
Friedrich
Sophie von Böhmen
Heinrich II.
Hedwig von Lothringen
Beatrice, Countess of Chalon
Konrad
Anna von Burgund, Gräfin von Savoyen
Ottone del Carretto, Marquis of Savona
Enrico II Del Carretto
Adalbert II.
Agnes von Waiblingen
Heinrich IV.
Leonor de Aragón
Ferdinando d'Aragona
Wilhelm von Montferrat
Vladimir Mstislavich
Richenza von Everstein
Heinrich V.
Beatrix
Beatrice del Monferrato
Azalaïs of Montferrat
Leopold
Sancha d'Aragona
Guigues VI of Viennois
Jutta von Babenberg
Mstislaw II.
Roman
Sancha von Kastilien
Beatrice Schwäbische
Otto von Freising
Ladislaus III.
Ferdinand of Castille
Peter II.
Konstanze von Aragón
Ambrogio Del Carretto
Bonifacio I
Konrad
Wsewolod Mstyslawytsch
Alfons II.
Rainer von Montferrat
Cunigunda of Lorraine
Heinrich IV.
Friedrich V. von Schwaben
Maria von Montferrat
Vsevolod Vsevolodovich
Bonifatius I.
Heinrich VI.
Vasylko Yaropolkpvych
Friedrich II.
https://w.wiki/CTJ

Visual Embeddings



https://medium.com/@ahmed_elgammal/the-shape-of-art-history-in-the-eyes-of-the-machine-6c9090257263

Similarity Based Search and Exploration

https://wikiview.net/

Take Home Messages:

- Deep Learning is a **game changer**
- The quality of your achieved results always depends on the **quality (and quantity)** of your **training data**
- (Out-of-the-box Deep Learning) models are **easy to use and work quite well** (however..not always)
- **Deep Learning benefits from exploiting explicit Semantics**
- **Semantics benefits from leveraging Deep Learning**

(Long Term) Goal

- Combine **Semantics** (a.k.a. Symbolic Reasoning) and **Machine Learning** into hybrid systems (**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.” (Ridley Scott, Bladerunner, 1982)

Prof. Dr. Harald Sack

Do Neural Networks Dream of Semantics?

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PLDN Knowledge Graphs & Linked Data Event 2020
Hilversum, 22. Jan. 2020

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