

Deep Learning Representations for All

(a.k.a. the AI hype)



Xavier Giro-i-Nieto



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DE CATALUNYA
BARCELONATECH



Barcelona
Supercomputing
Center
Centro Nacional de Supercomputación



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UNIVERSITAT POLITÈCNICA DE CATALUNYA
BARCELONATECH

Department of Signal Theory
and Communications
Image Processing Group



IDEAI Center for
Intelligent Data Science
& Artificial Intelligence



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Image Processing Group
Signal Theory and Communications Department
Universitat Politècnica de Catalunya. BARCELONATECH

- 11 faculty members
- 12 Phd students

<https://imatge.upc.edu/>



IDEAI (Intelligent Data Science and Artificial Intelligence)

- Center funded in 2017
- 60 researchers

<https://ideai.upc.edu/>

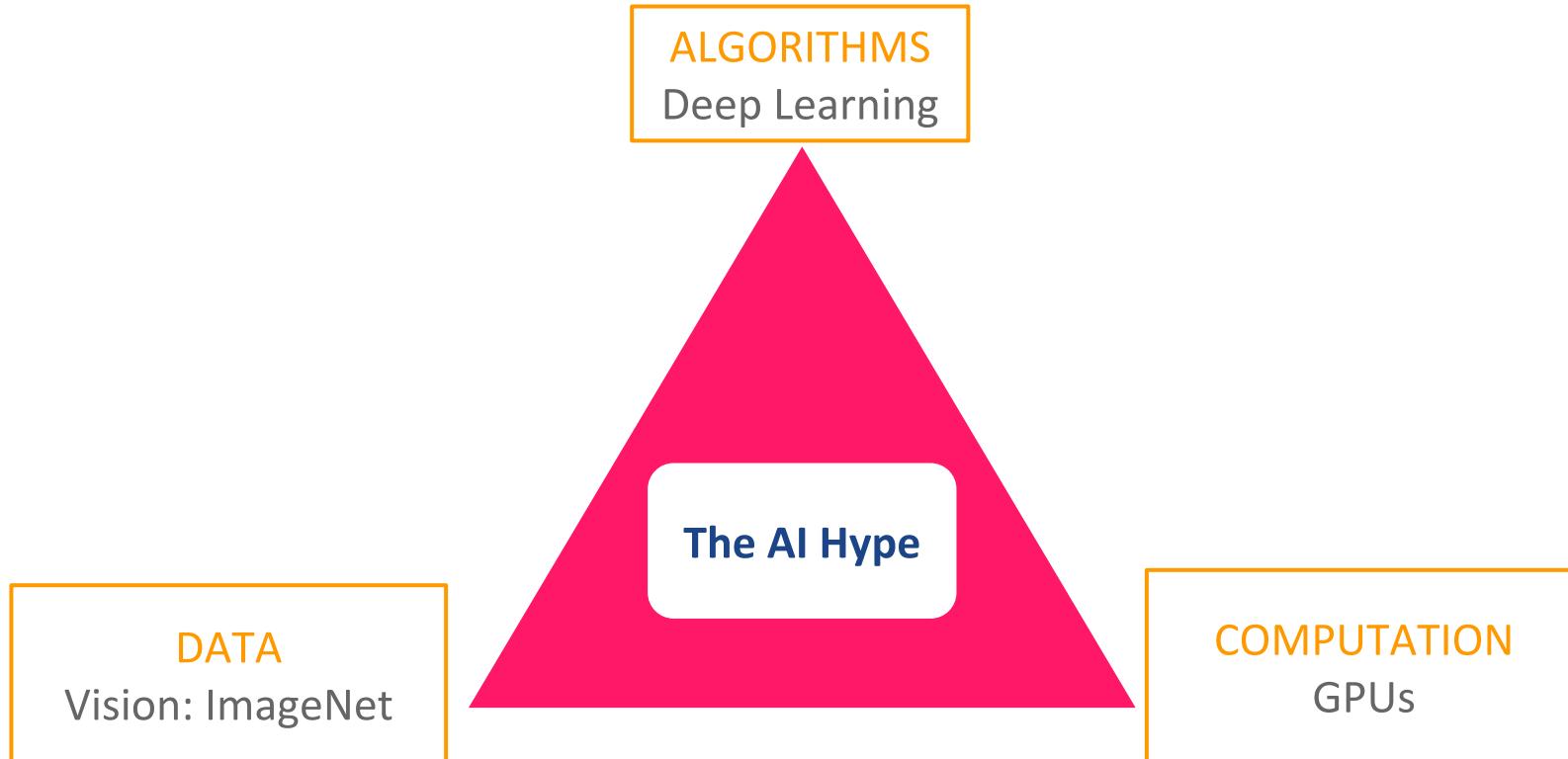


Barcelona Supercomputing Center
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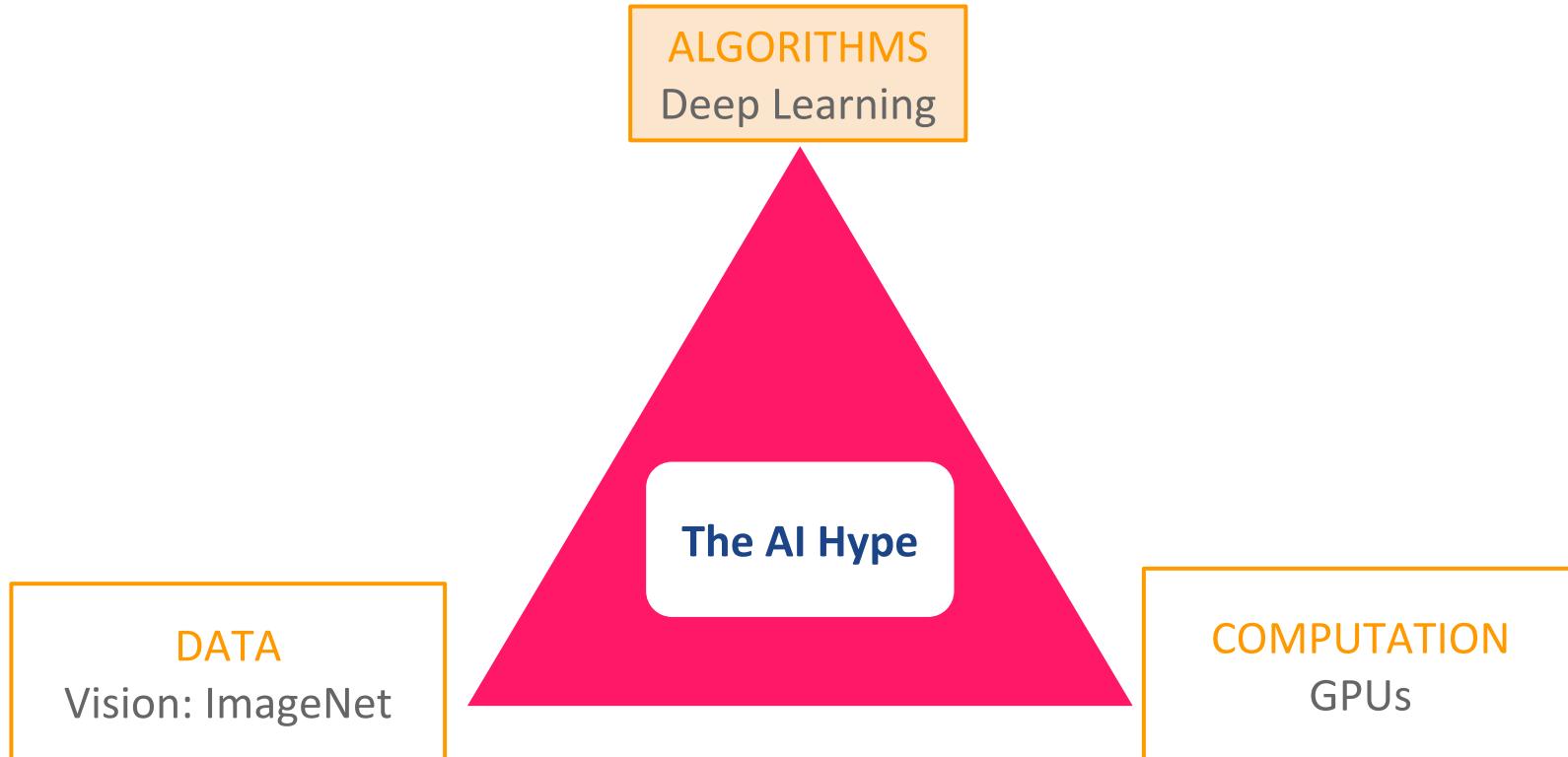
- National computation center #1
- Supercomputer MareNostrum
- [Emerging Technologies for Artificial Intelligence Group](#), directed by [Prof. Jordi Torres](#).

<https://www.bsc.es/>

Why am I here ?



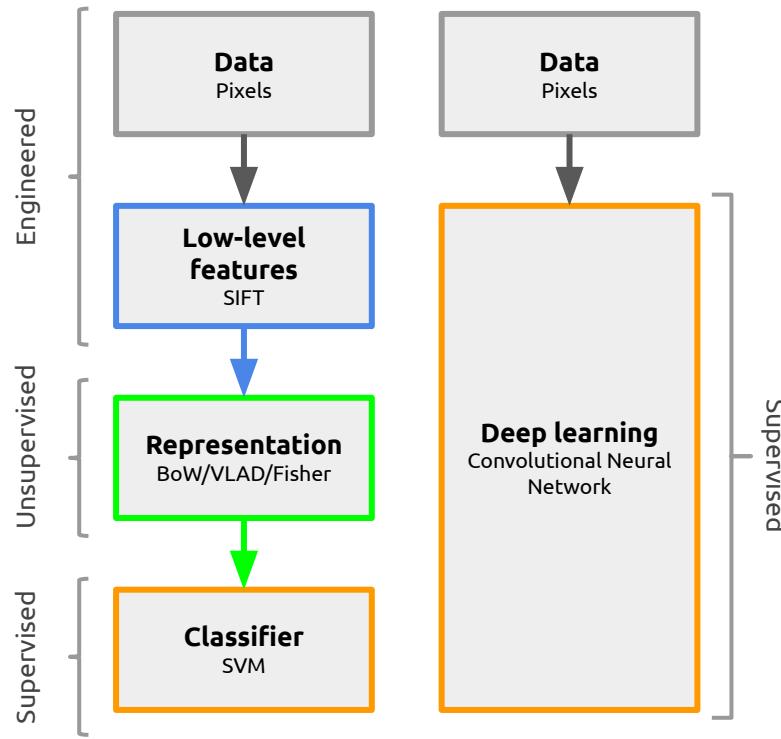
Why am I here ?



Why am I here ?



- Old style machine learning:
 - Engineer features (by some unspecified method)
 - Create a representation (descriptor)
 - Train shallow classifier on representation
- Example:
 - SIFT features (engineered)
 - BoW representation (engineered + unsupervised learning)
 - SVM classifier (convex optimization)
- Deep learning
 - Learn layers of features, representation, and classifier in one go based on the data alone
 - Primary methodology: deep neural networks (non-convex)

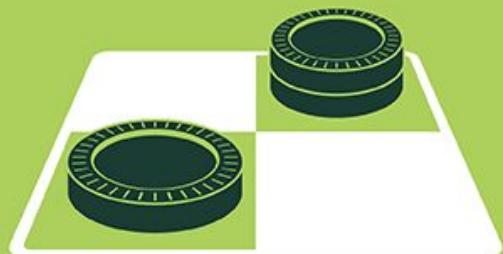


When you move on to deep learning



ARTIFICIAL INTELLIGENCE

Early artificial intelligence
stirs excitement.



MACHINE LEARNING

Machine learning begins
to flourish.



DEEP LEARNING

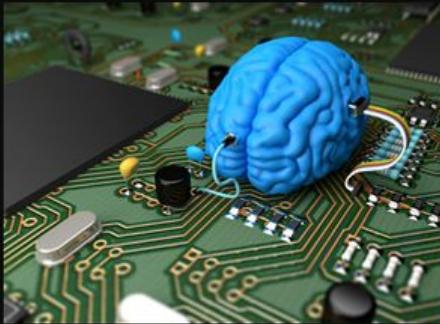
Deep learning breakthroughs
drive AI boom.



Deep Learning



What society thinks I do



What my friends think I do



What other computer
scientists think I do



What mathematicians think I do



What I think I do

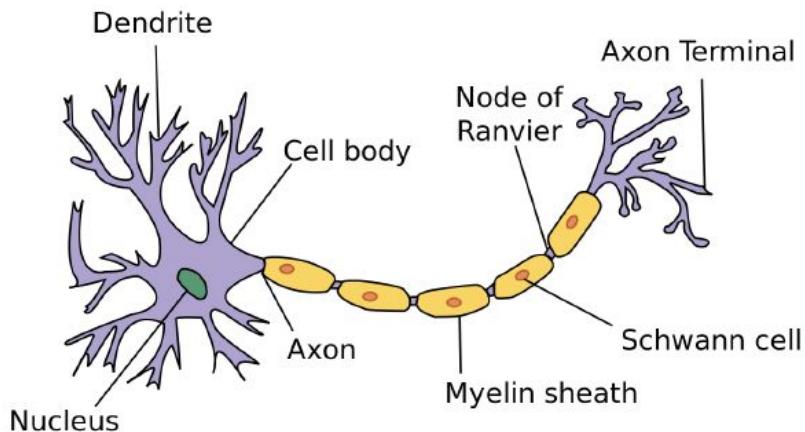
```
from theano import *
```

What I actually do

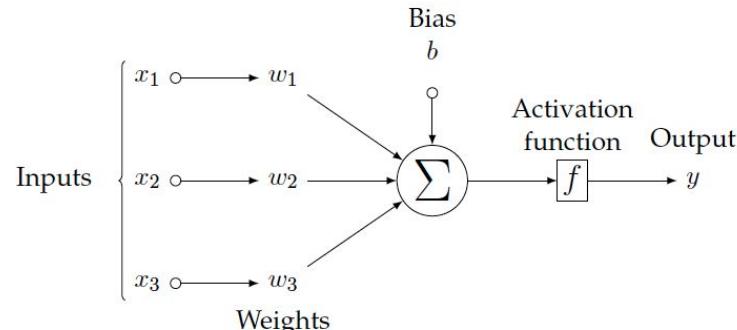
DL basic unit: The Perceptron



The Perceptron is seen as an analogy to a biological neuron, because it fire an impulse once the sum of all inputs is over a threshold.



Rosenblatt's Perceptron (1958)

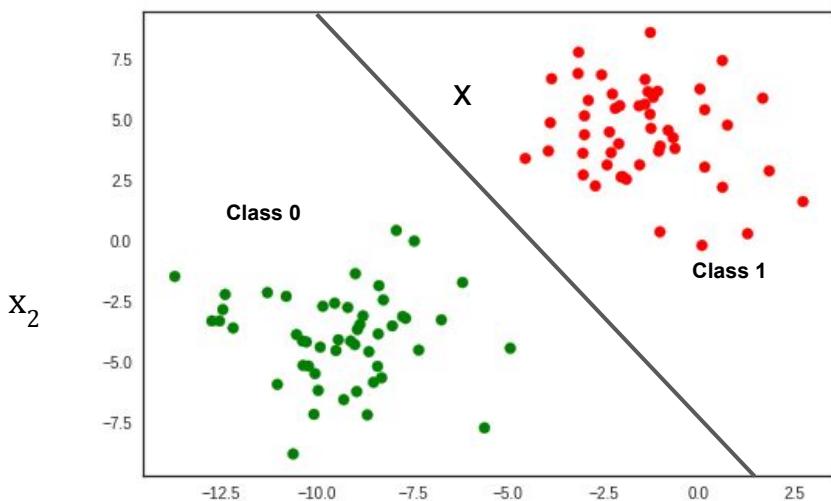


DL basic unit: The Perceptron



A single perceptron can only define linear decision boundaries.

2D input space data



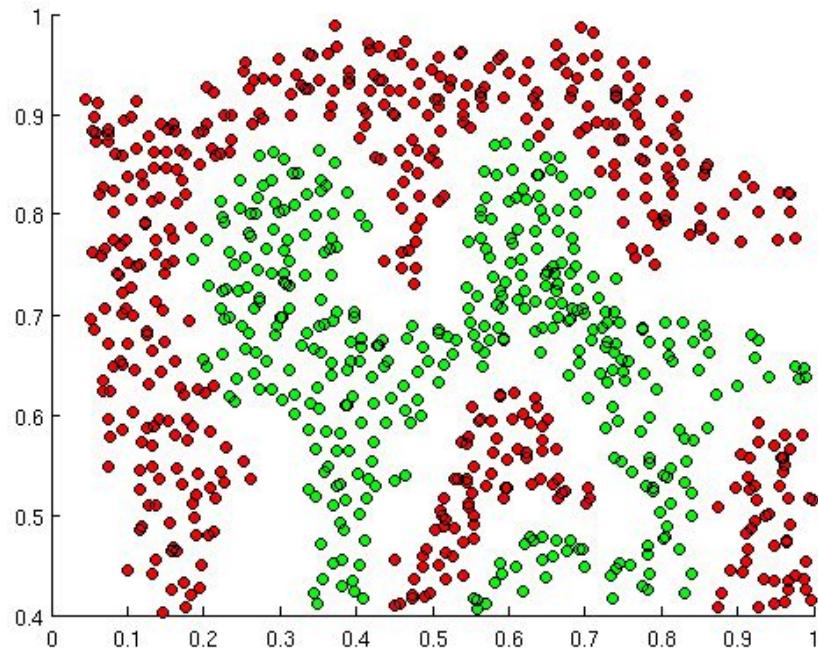
$$f(x) = \begin{cases} 1 & \text{if } w \cdot x + b > 0 \\ 0 & \text{otherwise} \end{cases}$$

Non-linear decision boundaries



Real world data often needs a non-linear decision boundary

- Images
- Audio
- Text





Neural Networks

Volume 2, Issue 5, 1989, Pages 359-366



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Original contribution

Multilayer feedforward networks are universal approximators

Kurt Hornik, Maxwell Stinchcombe, Halbert White ¹

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[https://doi.org/10.1016/0893-6080\(89\)90020-8](https://doi.org/10.1016/0893-6080(89)90020-8)

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Abstract

This paper rigorously establishes that standard multilayer feedforward networks with as few as one hidden layer using arbitrary squashing functions are capable of approximating any Borel measurable function from one finite dimensional space to another to any desired degree of accuracy, provided sufficiently many hidden units are available. In this sense, multilayer feedforward networks are a class of universal approximators.



Neural Networks
Volume 2, Issue 5, 1989, Pages 359-366



Original contribution

Multilayer feedforward networks are universal approximators

Kurt Hornik, Maxwell Stinchcombe, Halbert White^{2,1}

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Abstract

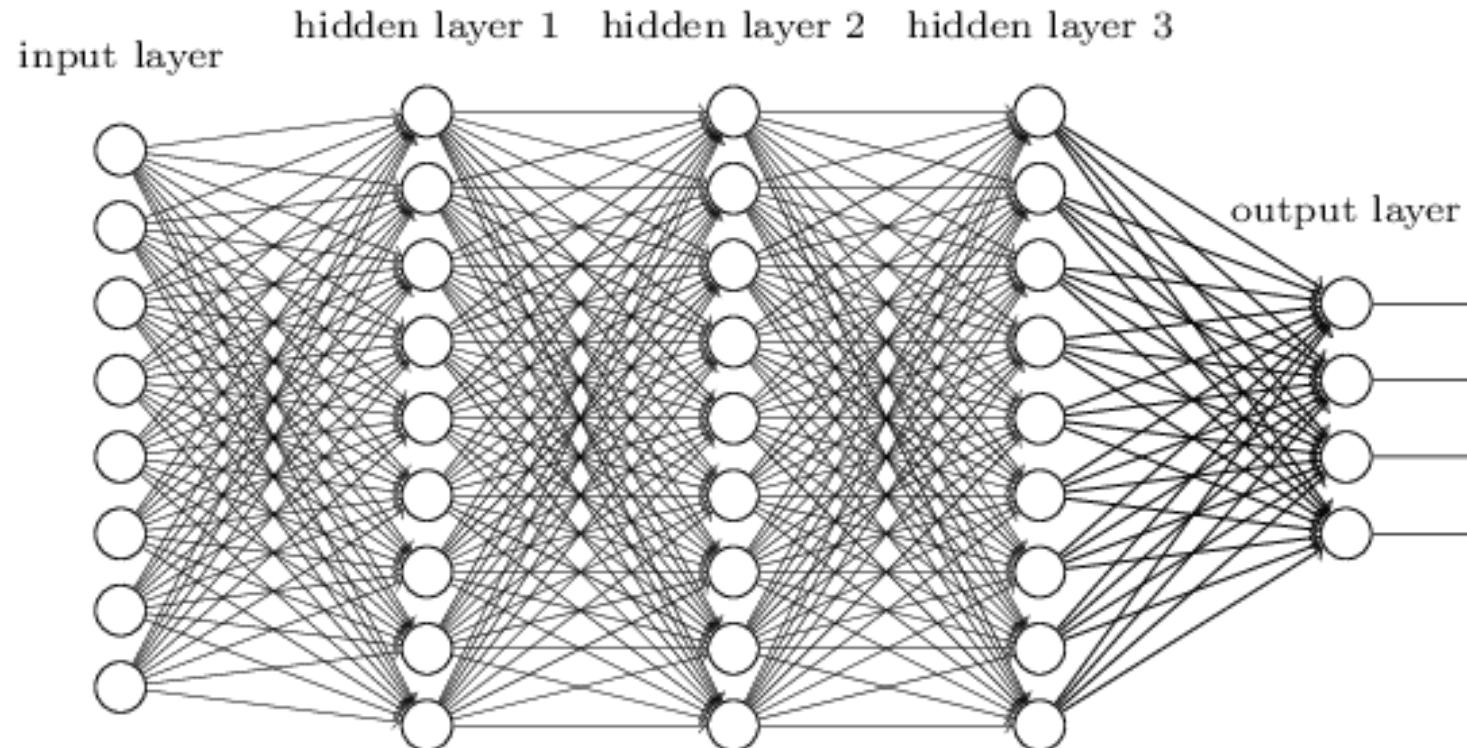
This paper rigorously establishes that standard multilayer feedforward networks with as few as one hidden layer using arbitrary squashing functions are capable of approximating any Borel measurable function from one finite dimensional space to another to any desired degree of accuracy, provided sufficiently many hidden units are available. In this sense, multilayer feedforward networks are a class of universal approximators.

- Needs a “finite number of hidden neurons”: finite may be extremely large
- How to find the parameters (weights, biases) of these neurons ?

Multilayer Perceptron (MLP)



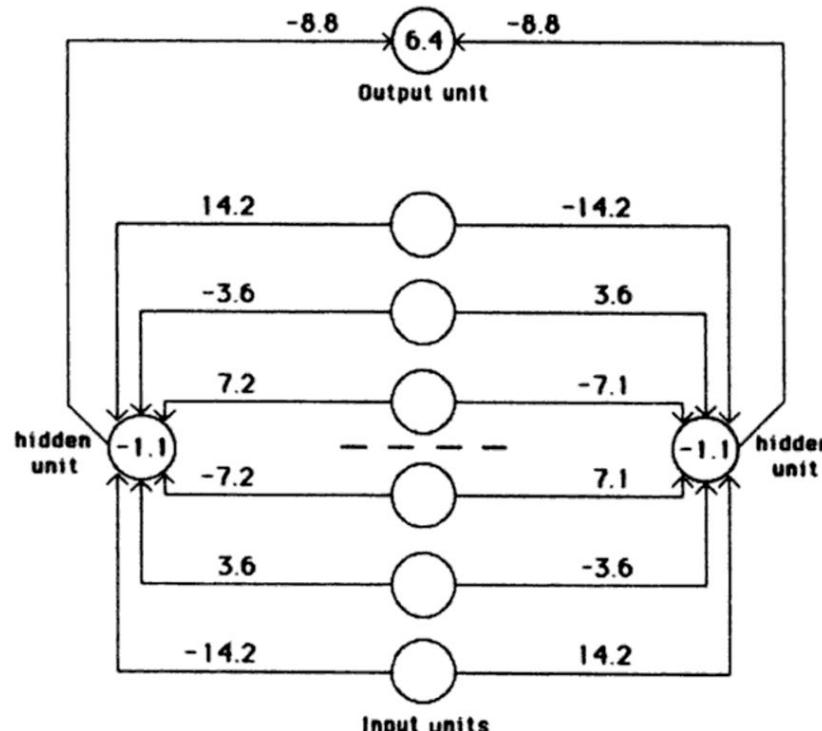
In practice, **deep neural networks** nets can usually represent more complex functions with less total neurons (and therefore, less parameters)



How to find the parameters ?

Training a neural network with the back-propagation algorithm.

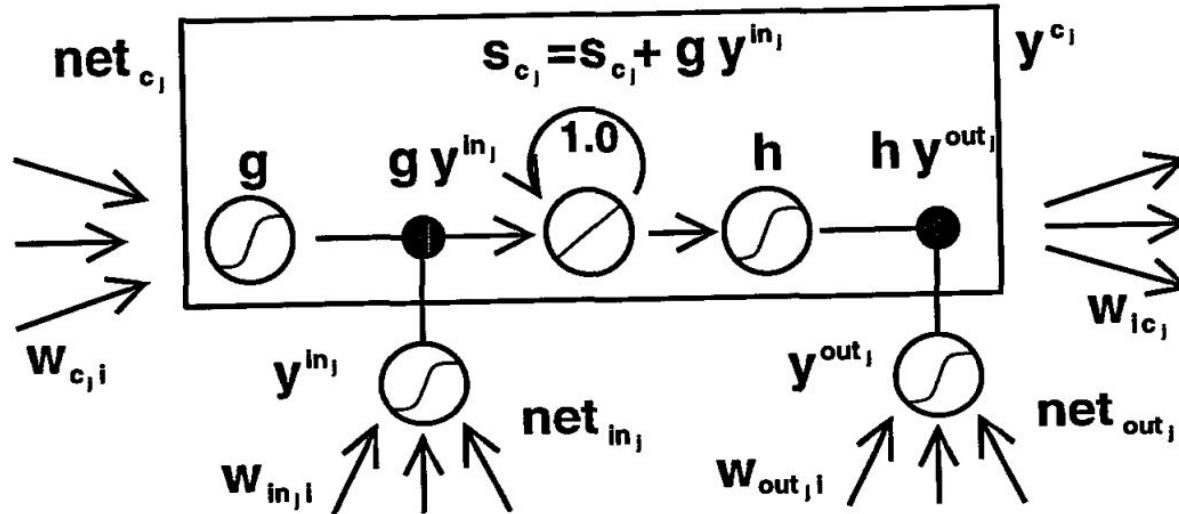
Geoff Hinton after writing the paper on backprop in 1986



How to learn a memory unit ?

1744

Sepp Hochreiter and Jürgen Schmidhuber

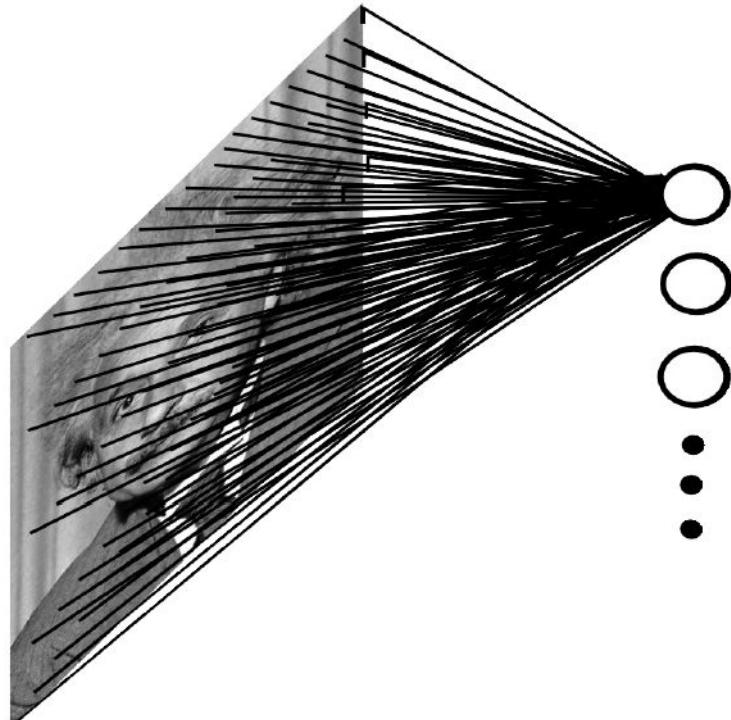


How to reuse neurons ?

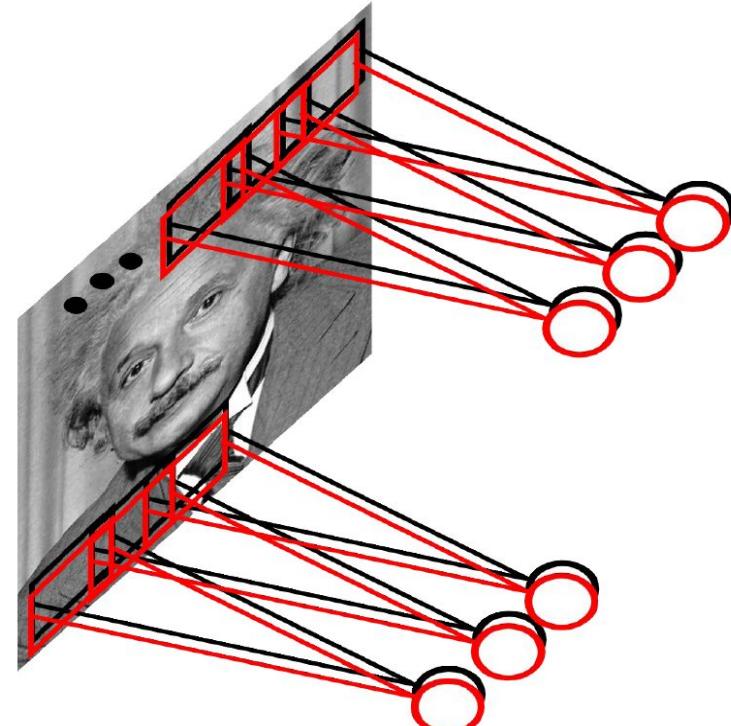
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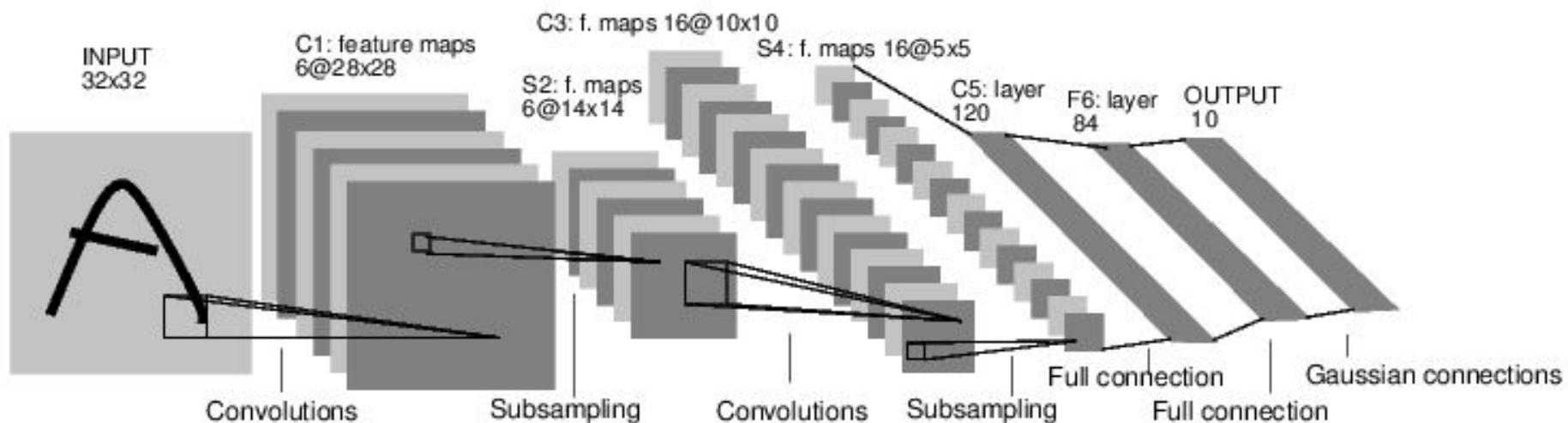
Fully Connected layer (FC)



Convolutional layer (Conv)



Convolutional Neural Network (CNN)





Yoshua Bengio, Geoffrey Hinton and Yann LeCun, the fathers of #DeepLearning, receive the 2018 #ACMTuringAward for conceptual and engineering breakthroughs that have made deep neural networks a critical component of computing today.

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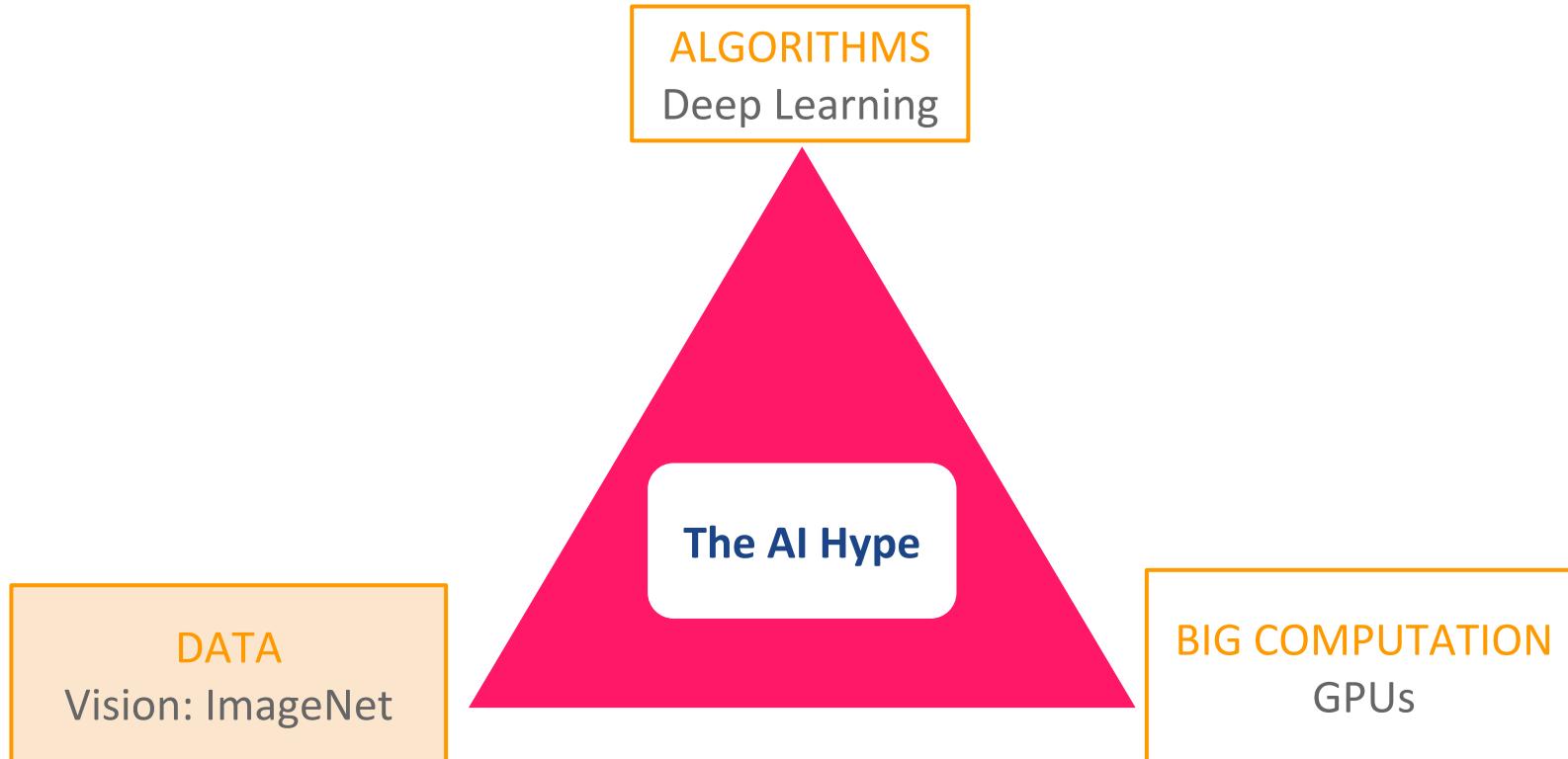
Tradueix el tuit



Many other researchers have also contributed to the field as, for example, those pointed out by LSTM author Jürgen Schmidhuber in ["Deep Learning Conspiracy"](#).



Why am I here ?



Big data for Vision: ImageNet

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- 1,000 object classes (categories).
- Images:
 - 1.2 M train
 - 100k test.



Data Challenge: Social Biases

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Baseline-FT



UpWeight



Equalizer w/o ACL



Equalizer



A man walking a dog on a leash.

A man and a dog are in the snow.

A man riding a snowboard down a snow covered slope.

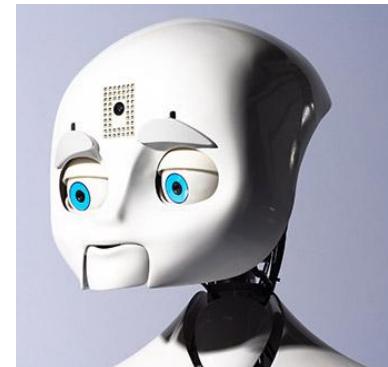
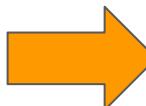
A person walking a dog or a leash.

Data Challenge: Data access

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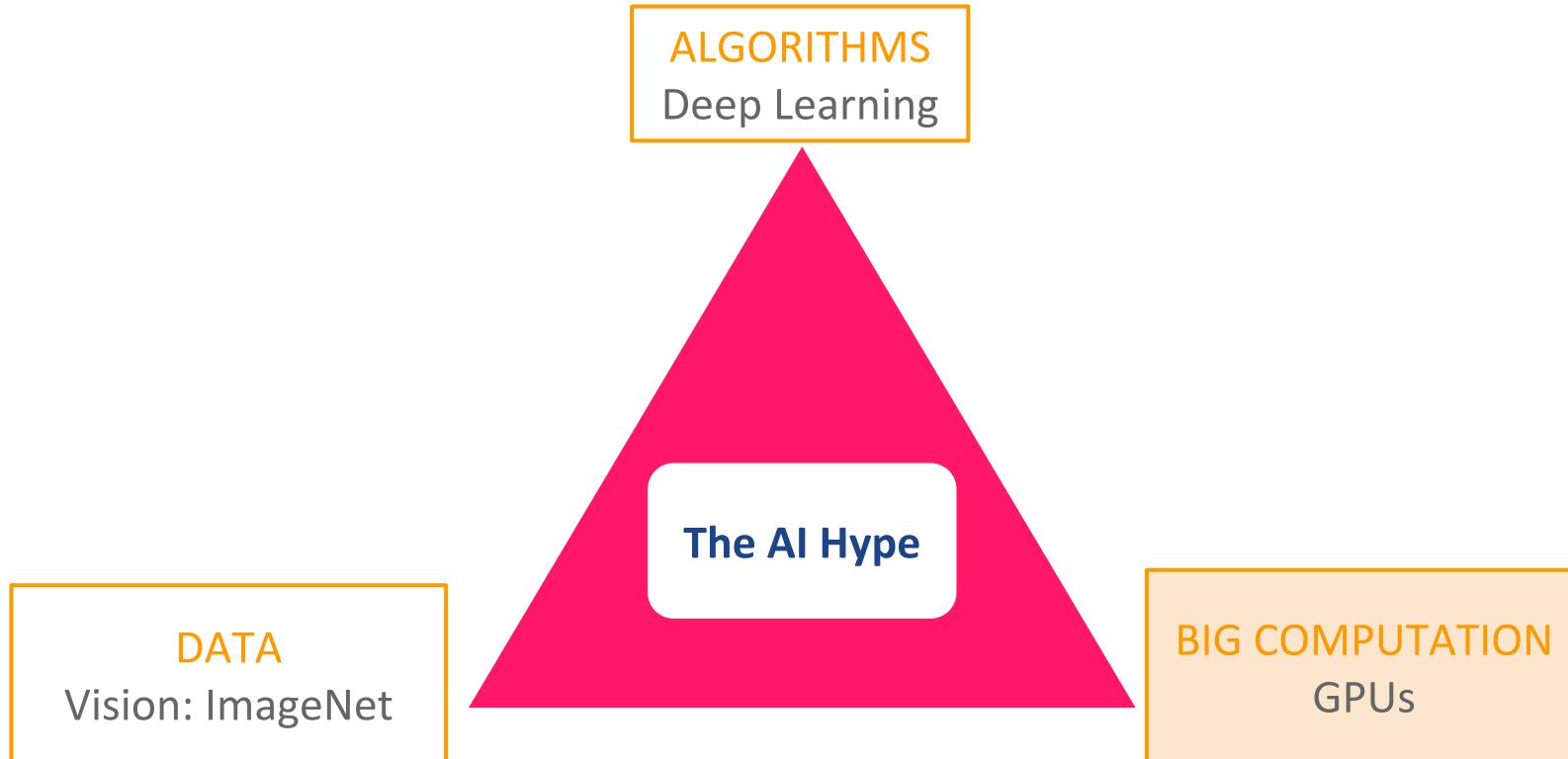
Personal data



Internet of things - IoT

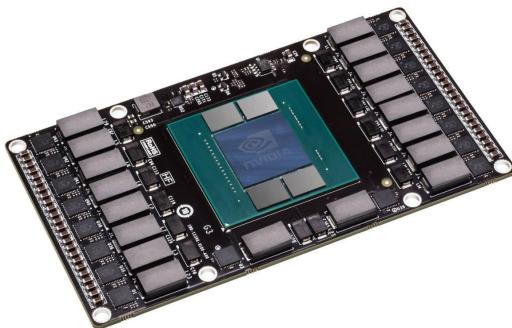
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Computation

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NVIDIA Corporation
NASDAQ: NVDA

+ Follow

166.17 USD +1.94 (1.18%) ↑

Closed: Jul 1, 16:39 EDT · Disclaimer
After hours 166.20 +0.030 (0.018%)

1 day 5 days 1 month 6 months YTD 1 year 5 years Max



Computation

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IMAGENET



Google Cloud Platform



Deng, Jia, Wei Dong, Richard Socher, Li-Jia Li, Kai Li, and Li Fei-Fei. "[Imagenet: A large-scale hierarchical image database.](#)" CVPR 2009.

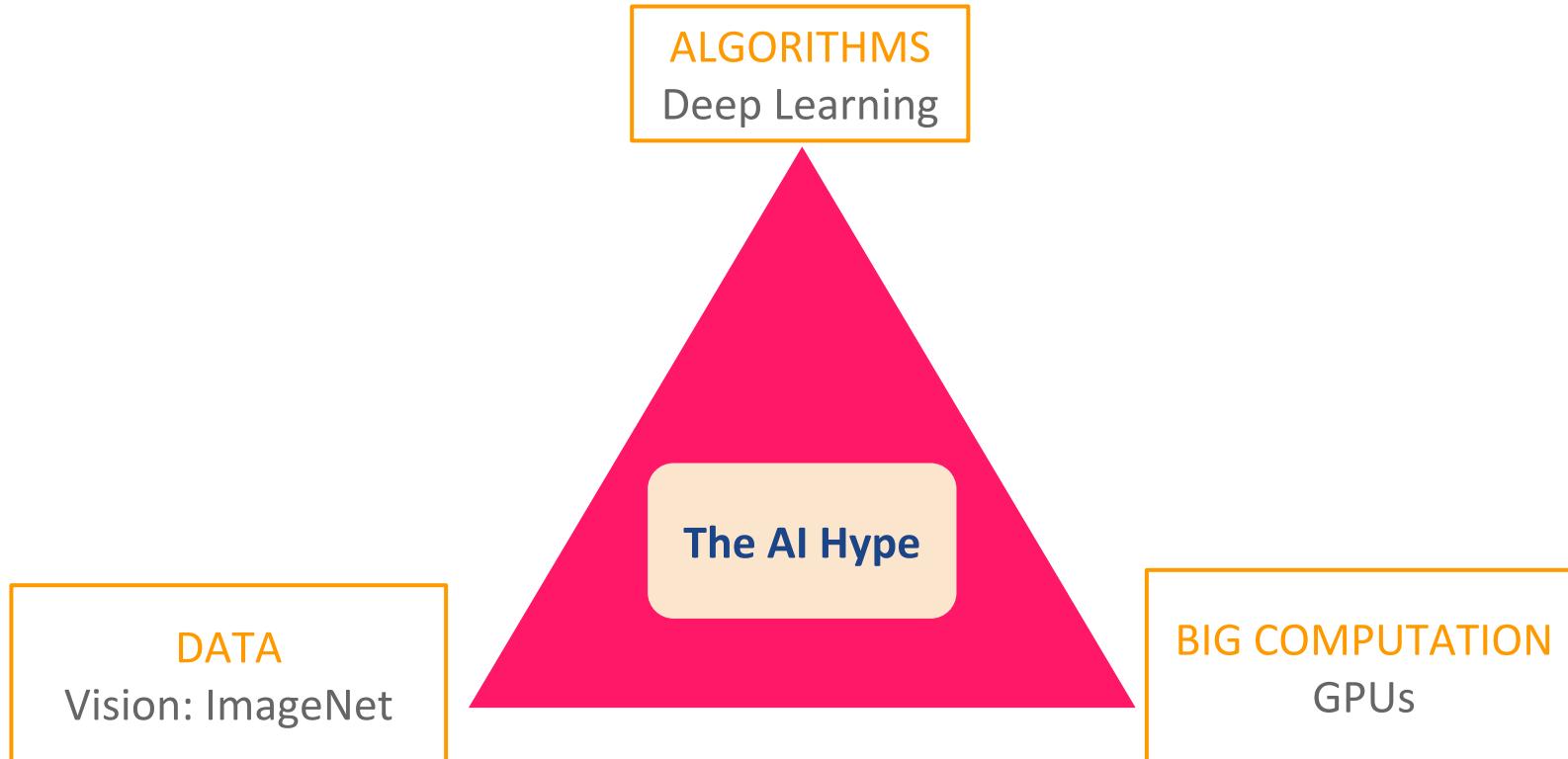
Computation challenge

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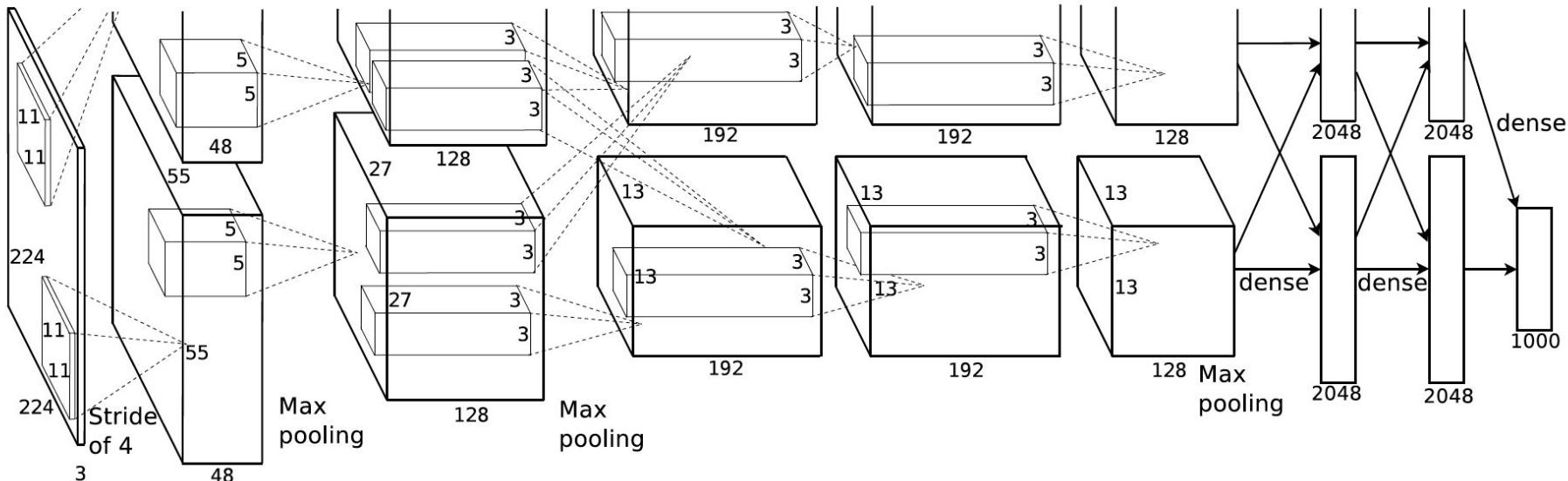
Deng, Jia, Wei Dong, Richard Socher, Li-Jia Li, Kai Li, and Li Fei-Fei. "[Imagenet: A large-scale hierarchical image database.](#)" CVPR 2009.

Why am I here ?



the BIG BANG

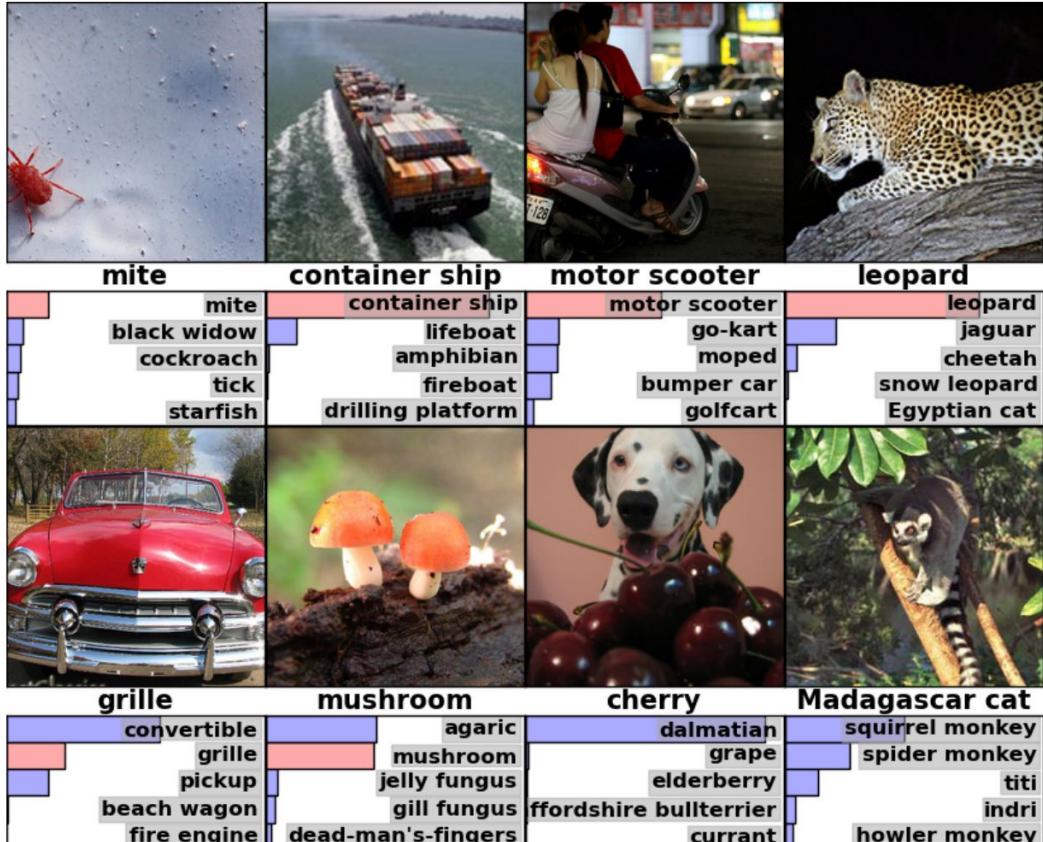
12,573 citations (June 2017)
28,366 (Sep 2018)
42,077 (Jun 2019)



ImageNet Challenge



- 1,000 object classes (categories).
- Images:
 - 1.2 M train
 - 100k test.

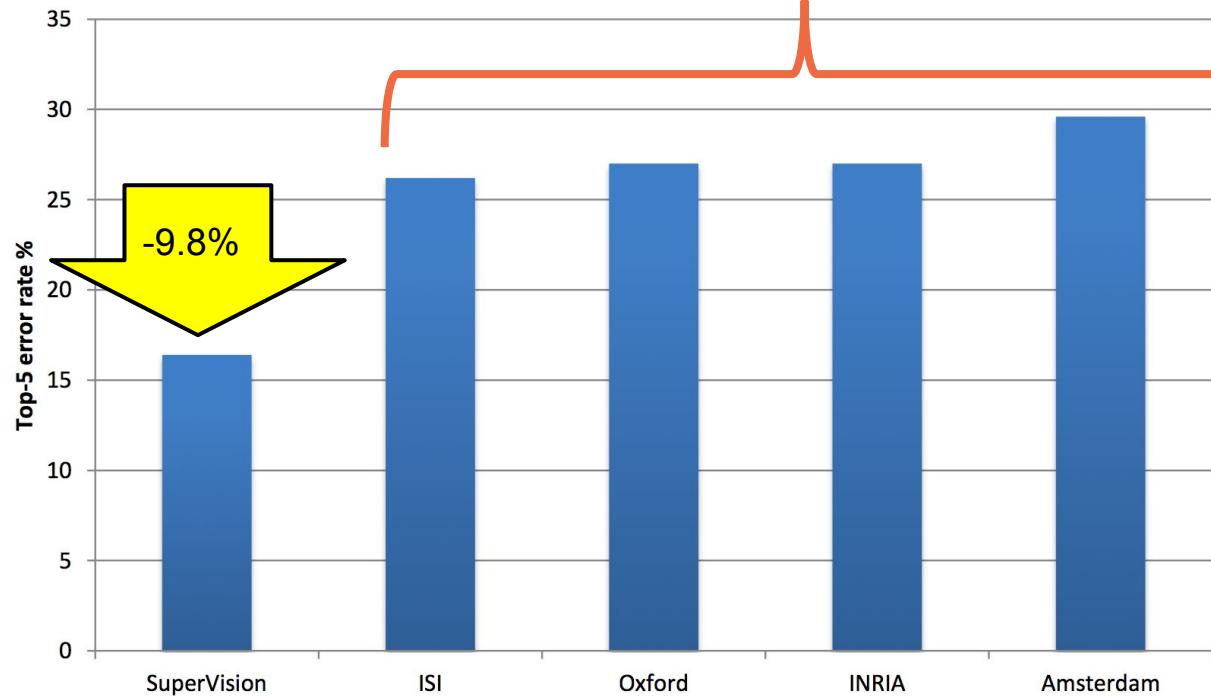


ImageNet Challenge

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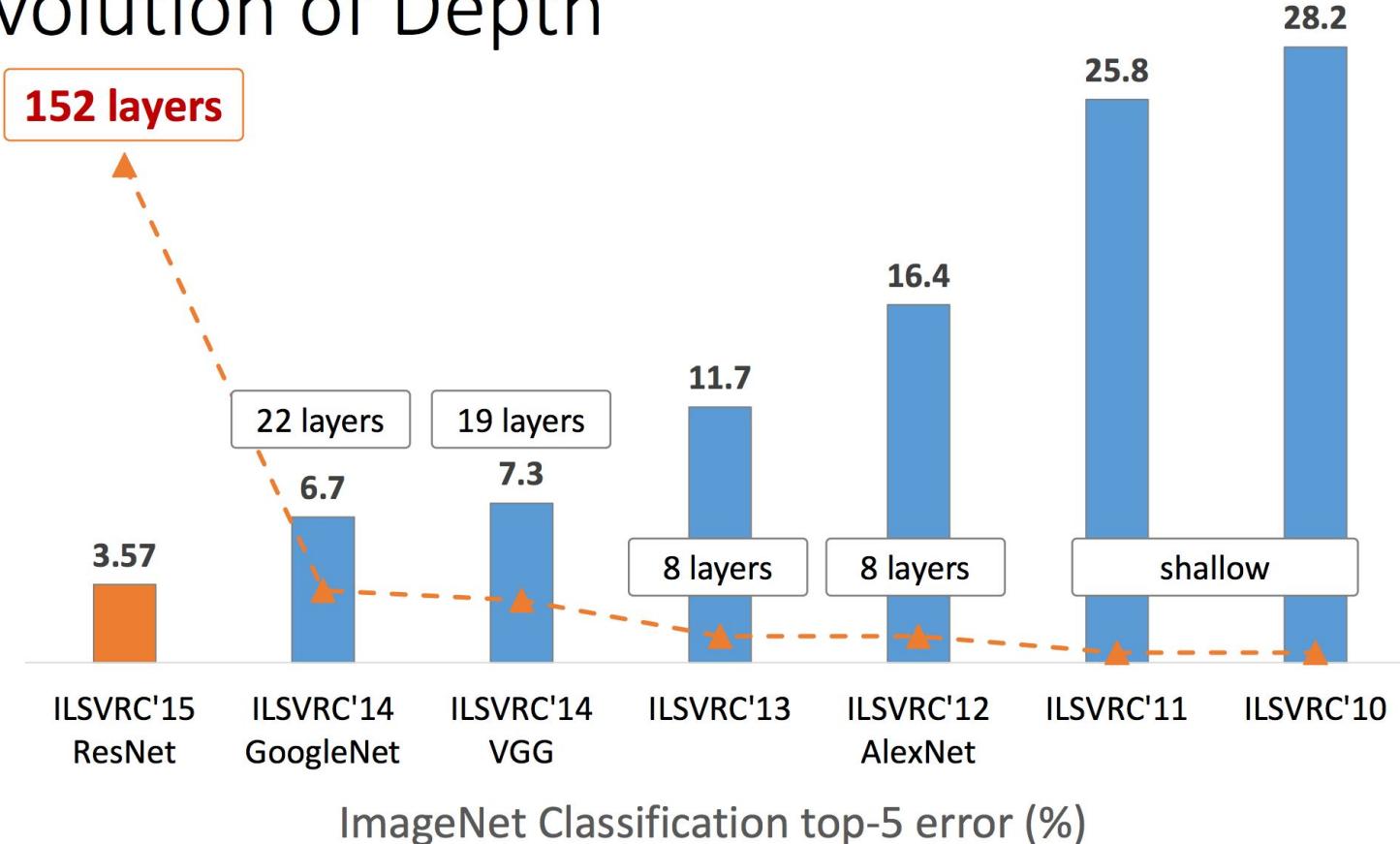
Slide credit:
[Rob Fergus](#) (NYU)

Based on SIFT + Fisher Vectors



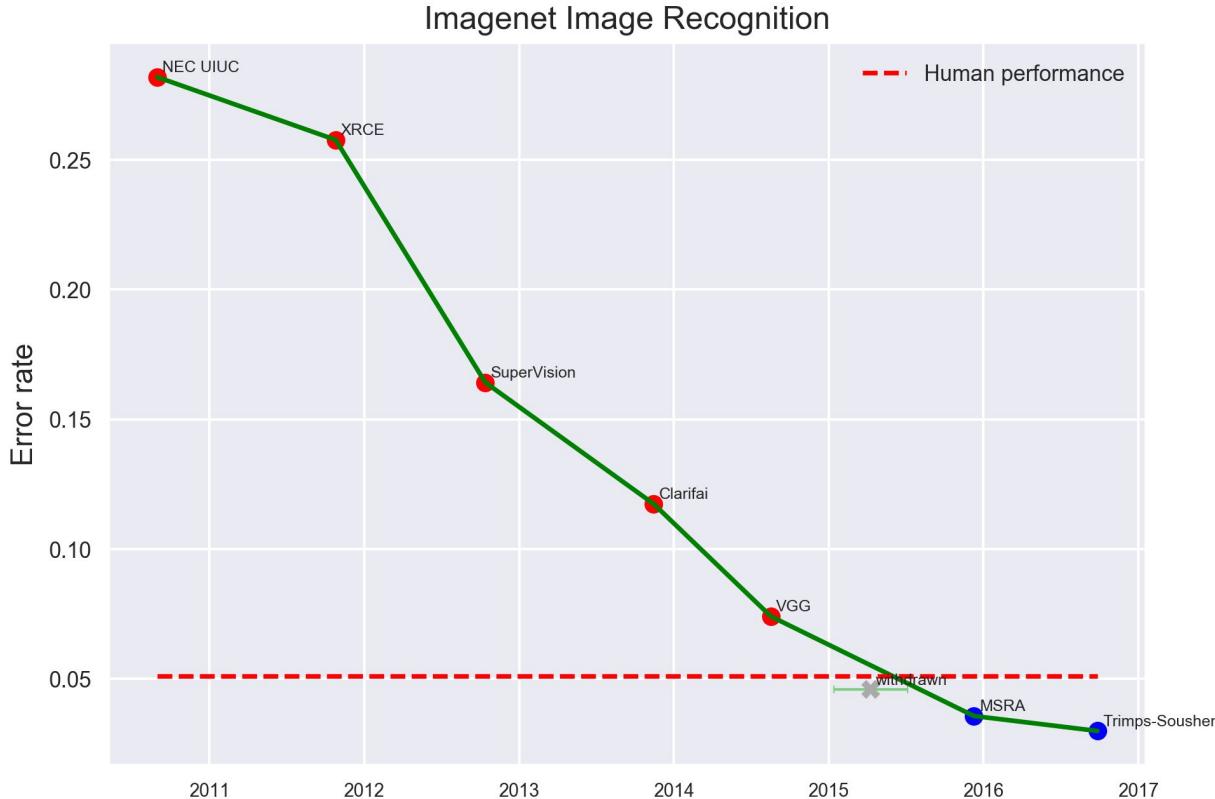
Deeper Networks

Revolution of Depth

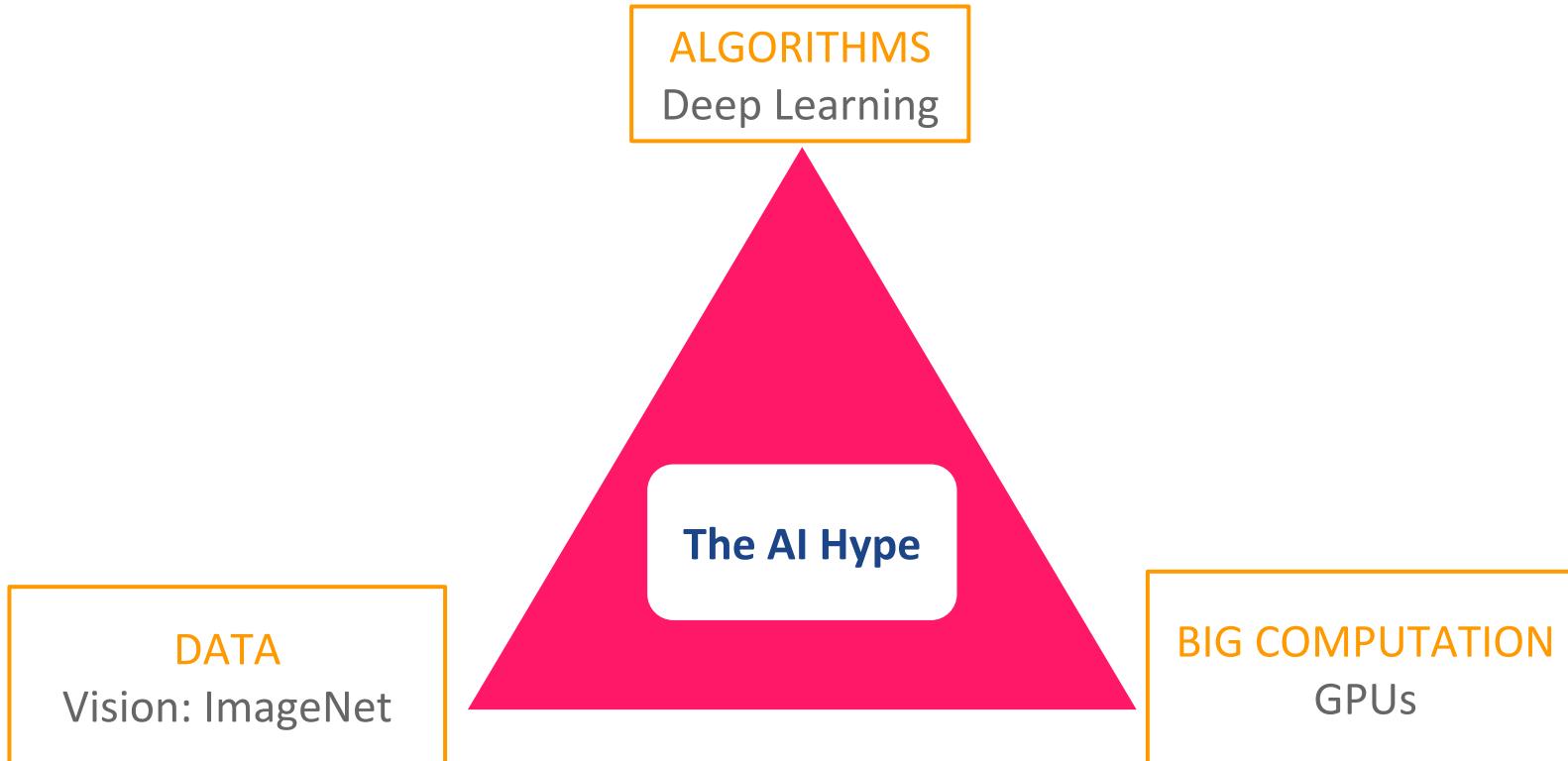


ImageNet Image Recognition

PROBLEM
SOLVED



Learning Representations





Vision



Speech

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Text



Audio

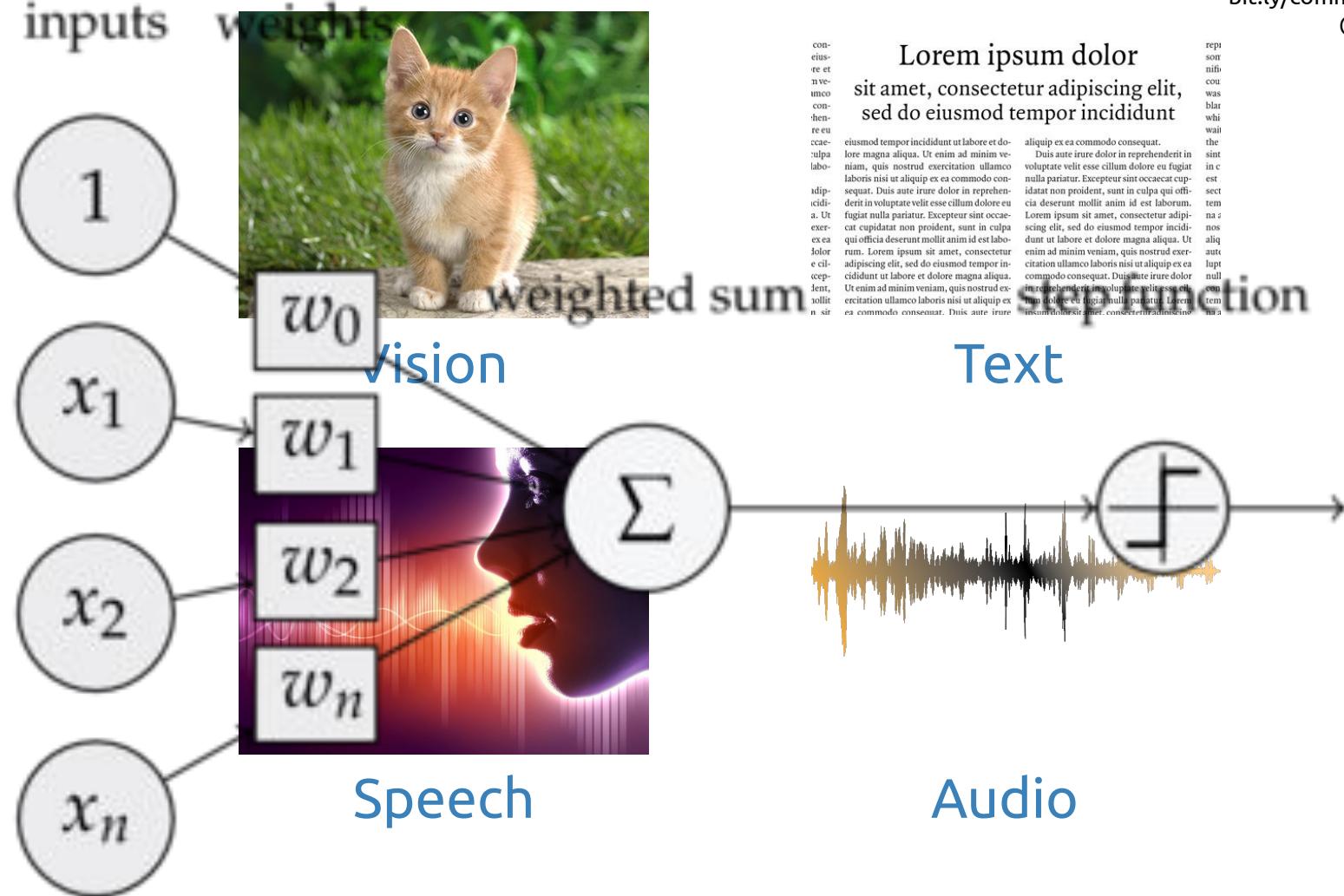


Audio

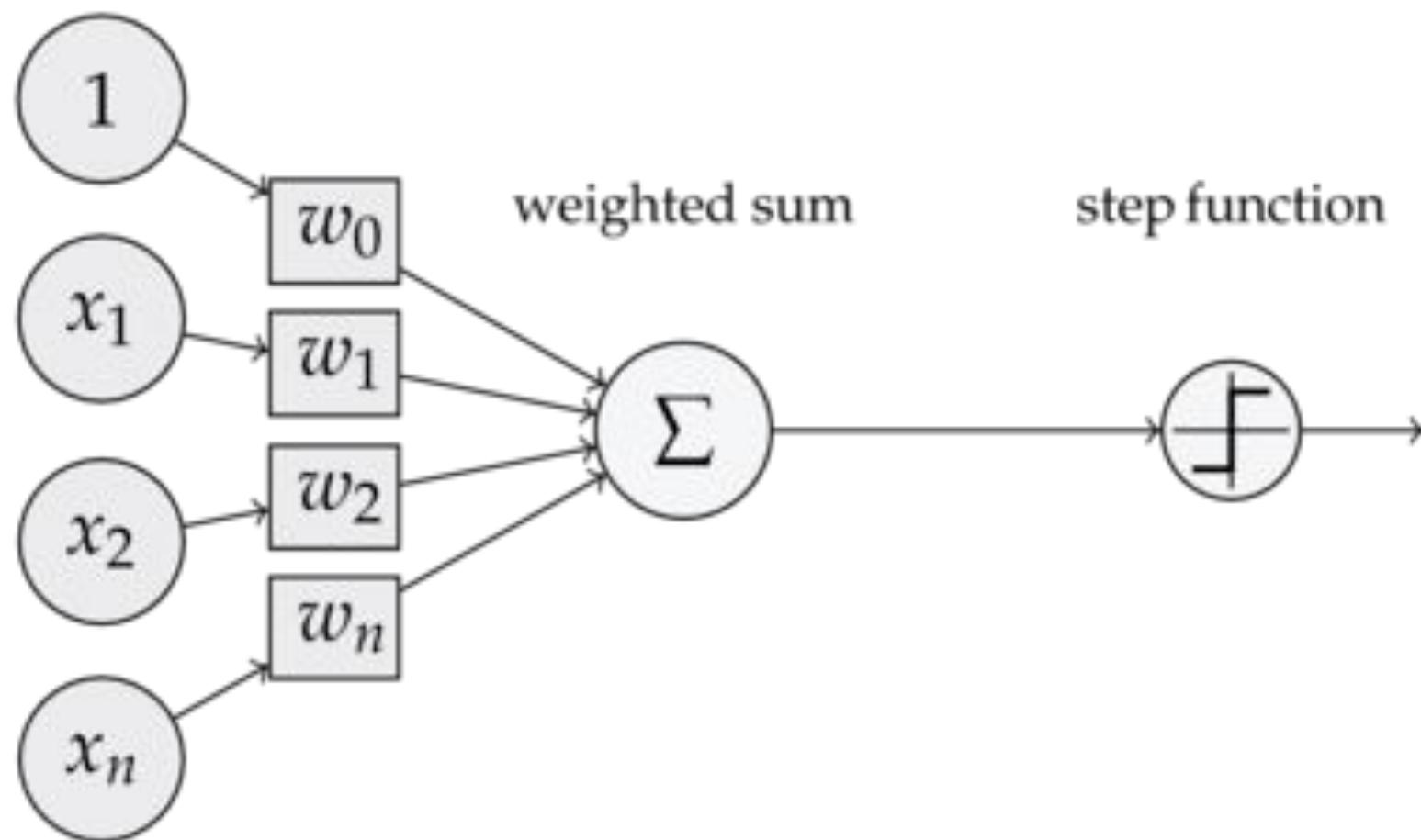
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inputs weights



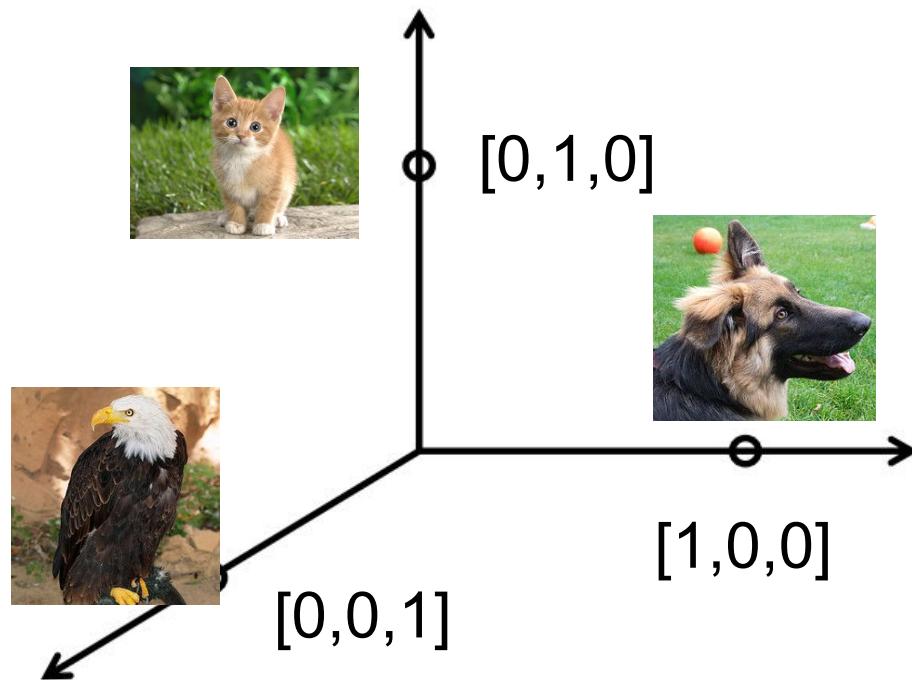


Encoder

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→ Cat

One-hot Representation





Encoder

Representation



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Encoder

Representation



Cat

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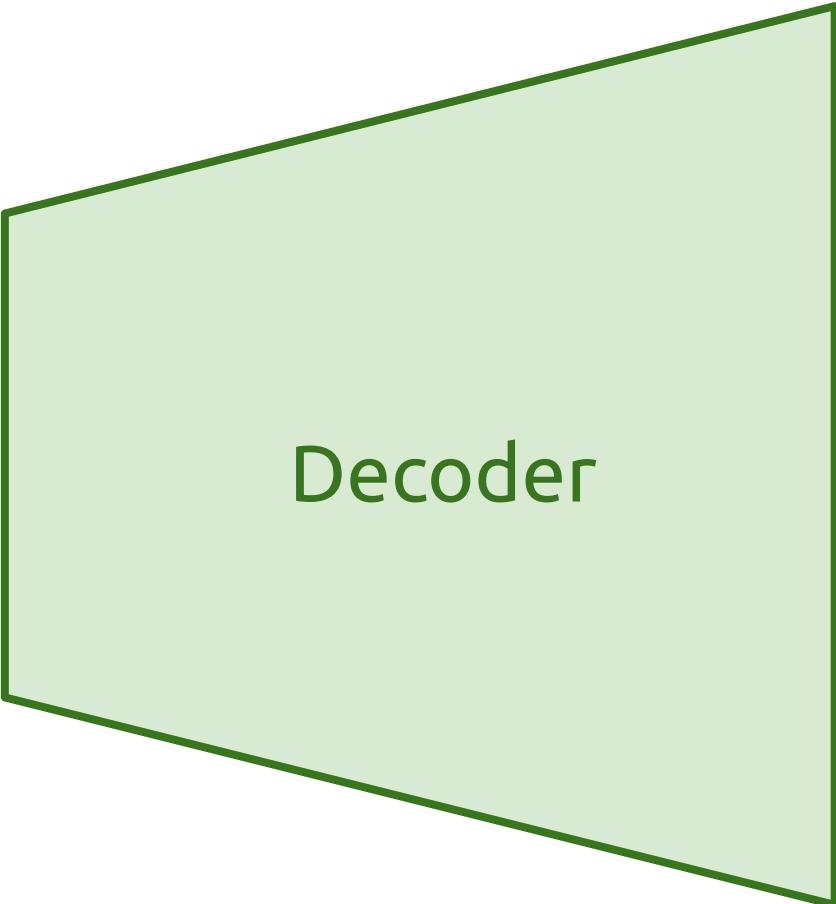
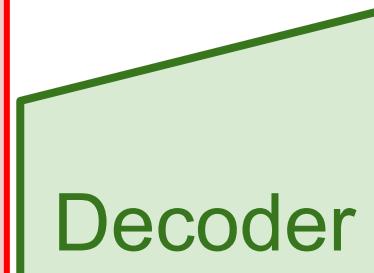
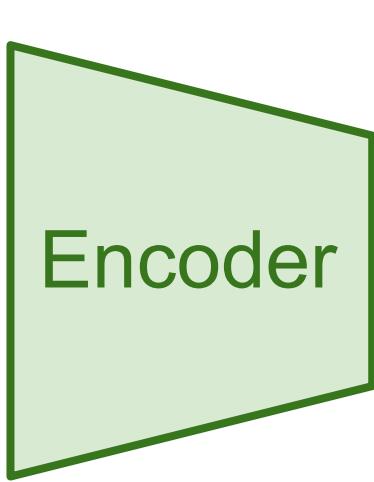
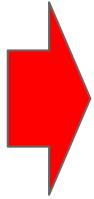


Fig: [Xudong Mao](#) #DCGAN

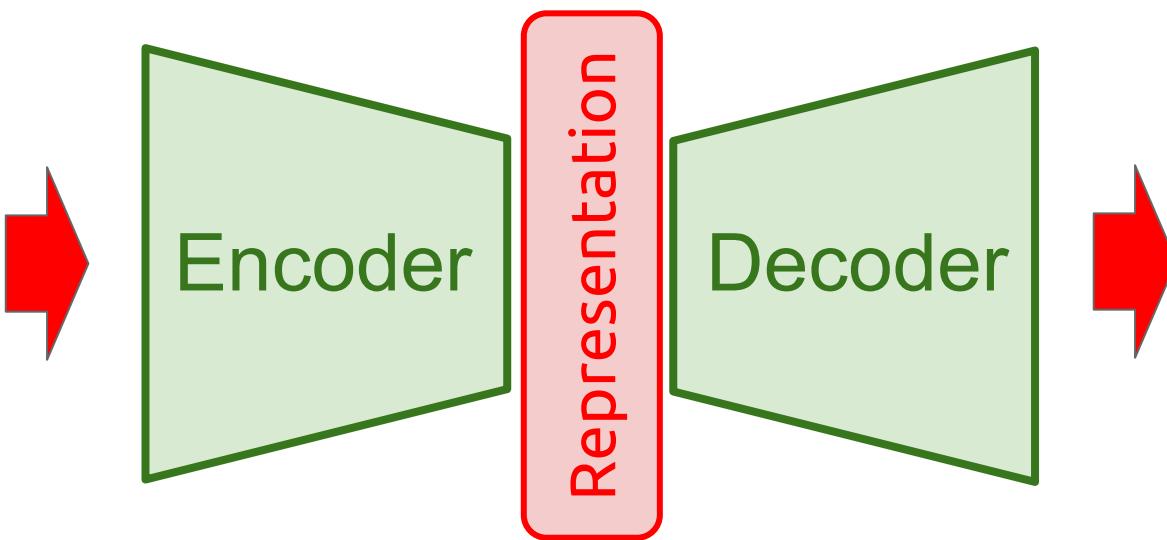


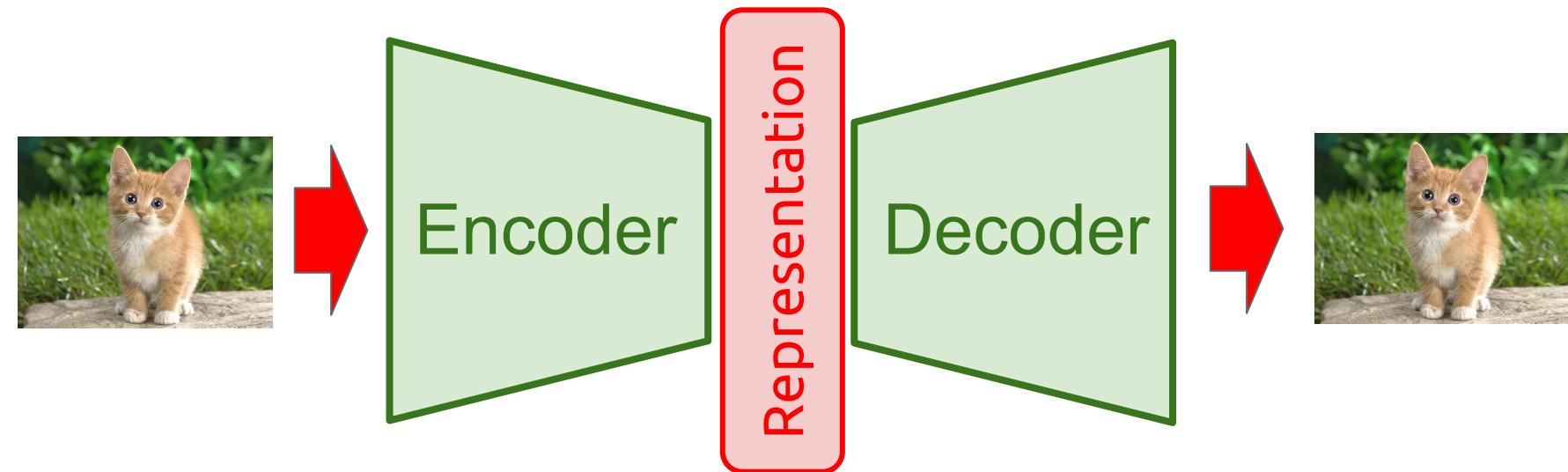
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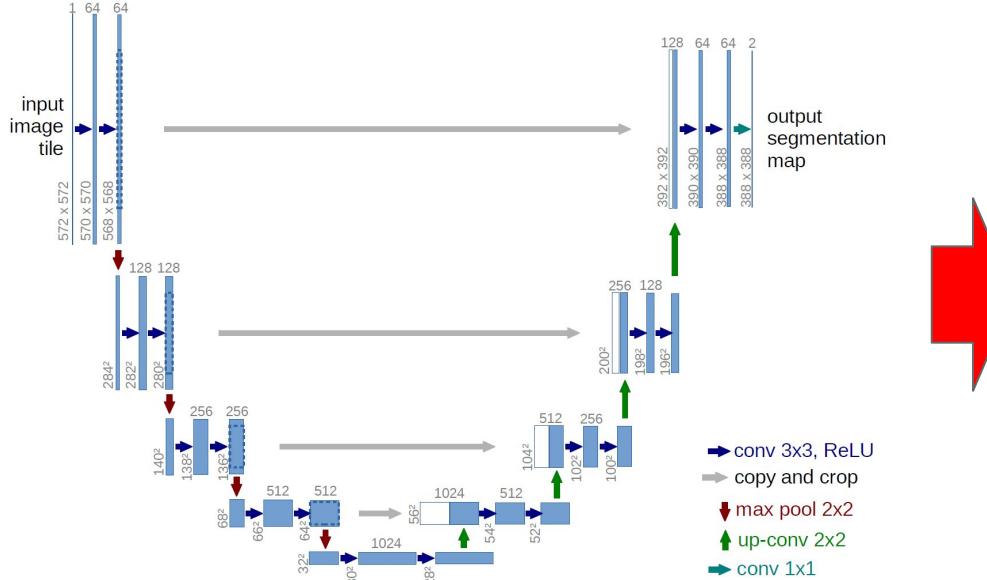
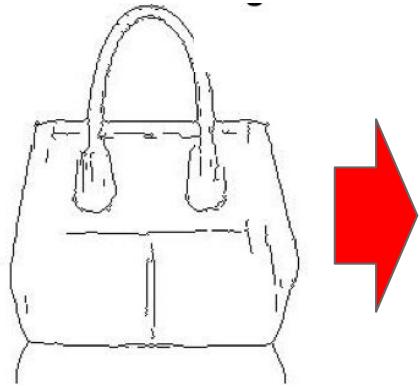


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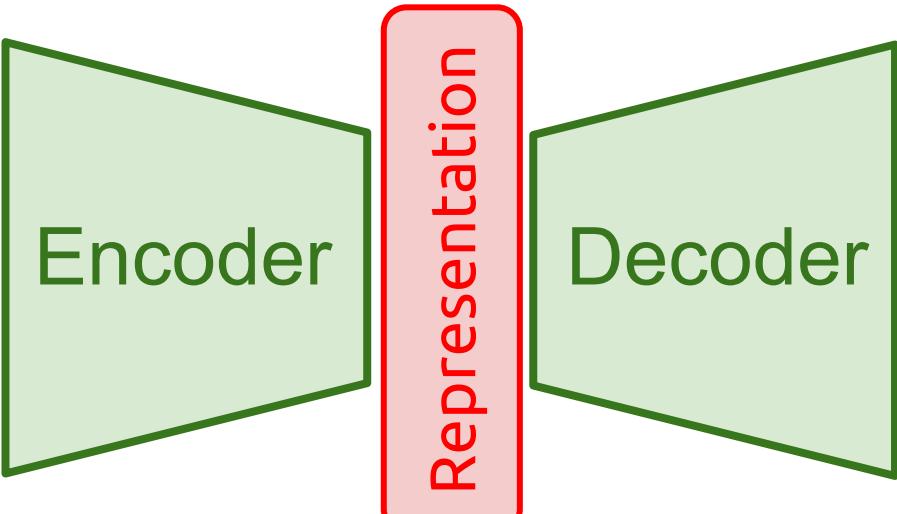
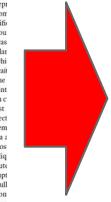






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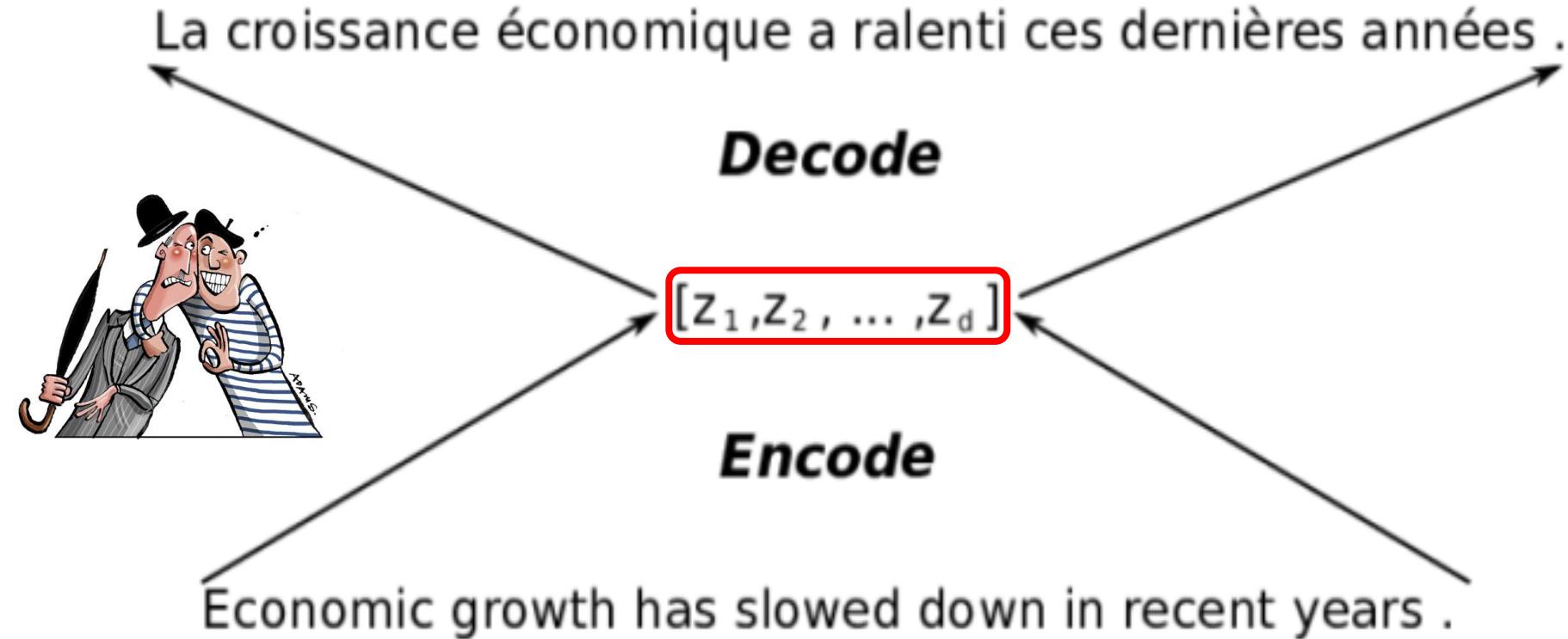
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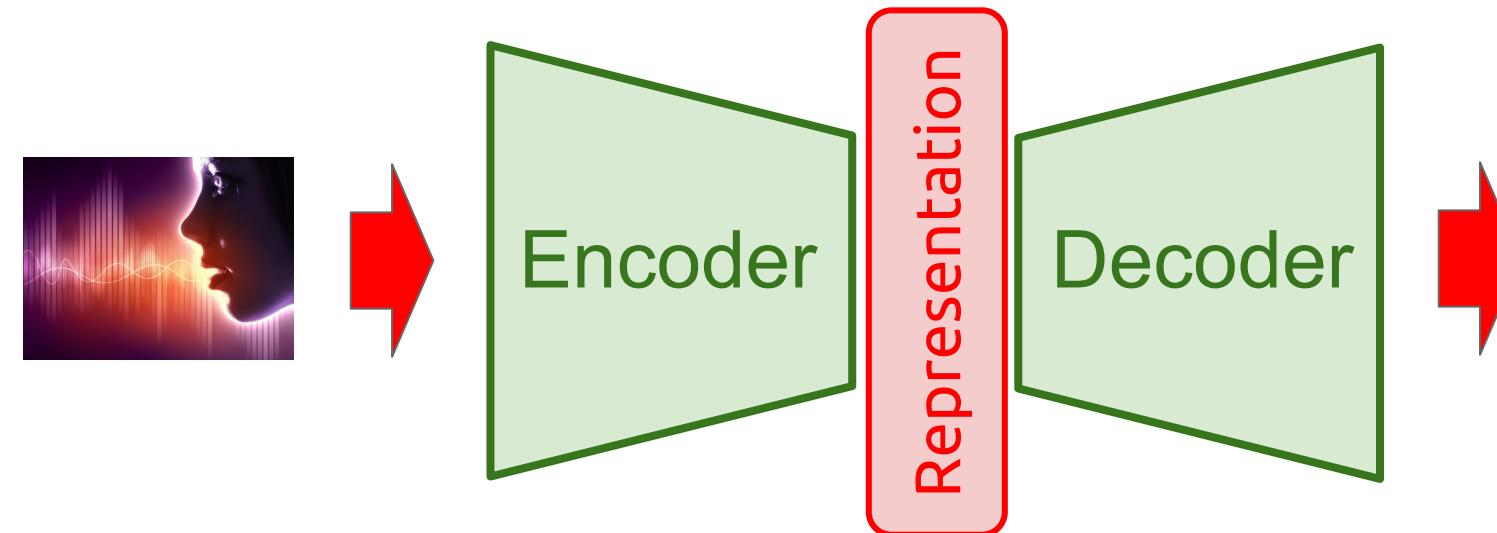


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Neural Machine Translation (NMT)





Encoder
Decoder
Representation

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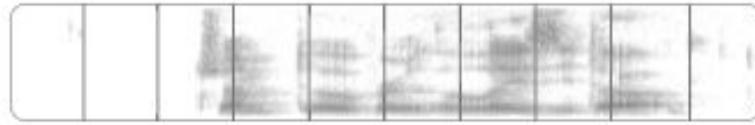
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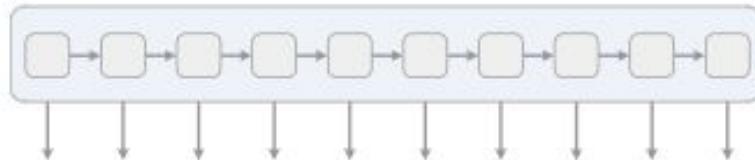
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Automatic Speech Recognition (ASR)



We start with an input sequence,
like a spectrogram of audio.



The input is fed into an RNN,
for example.

h	h	h	h	h	h	h	h	h	h
e	e	e	e	e	e	e	e	e	e
l	l	l	l	l	l	l	l	l	l
o	o	o	o	o	o	o	o	o	o
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The network gives $p_t(\alpha | X)$,
a distribution over the outputs
 $\{h, e, l, o, \epsilon\}$ for each input step.



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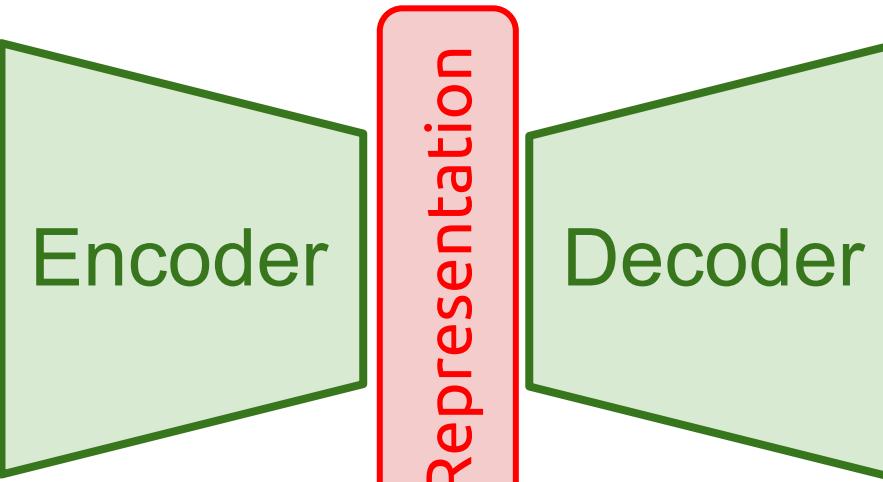
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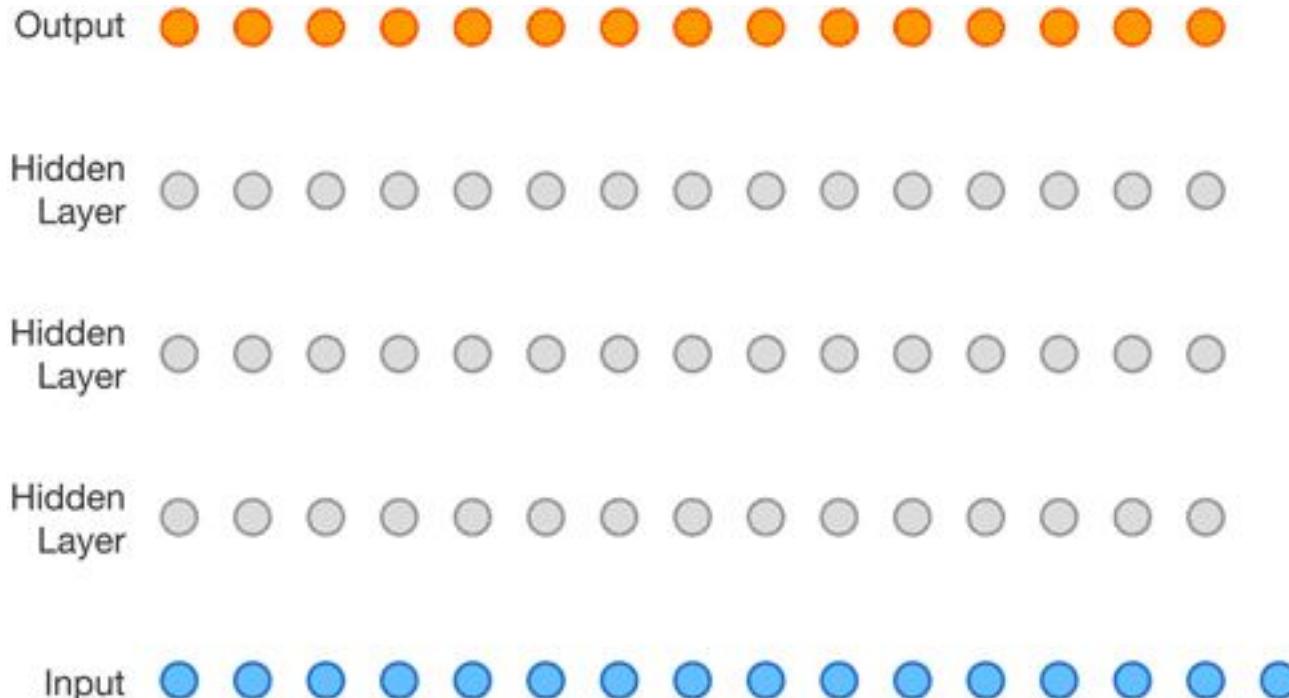
Decoder

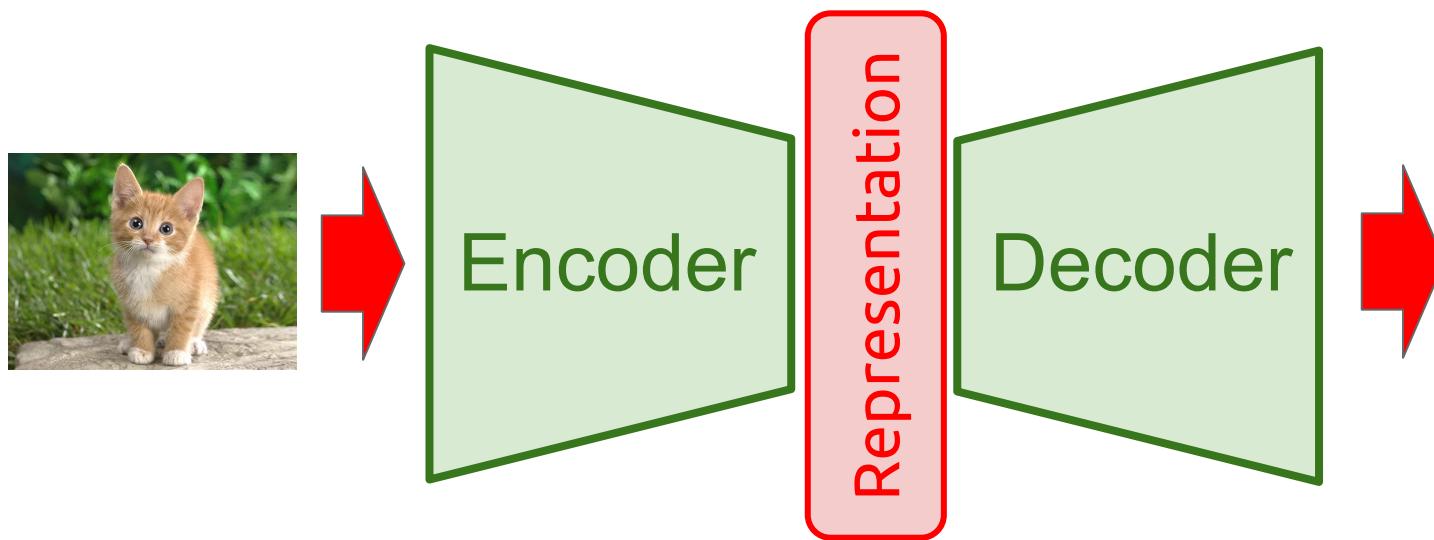
Representation





Speech Synthesis





Encoder
Decoder
Representation

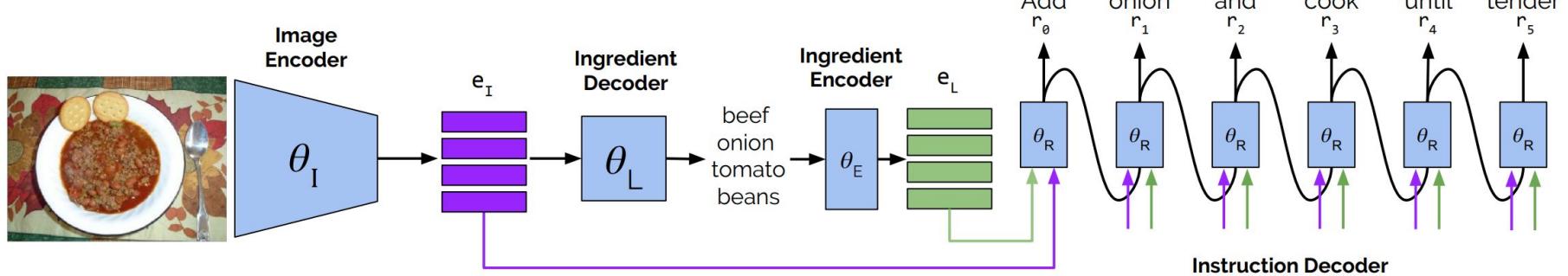
Representation

Decoder

Encoder
Decoder
Representation

Salvador, Amaia, Michal Drozdzal, Xavier Giro-i-Nieto, and Adriana Romero. "[Inverse Cooking: Recipe Generation from Food Images.](#)" CVPR 2019.

Image-to-Text



Salvador, Amaia, Michal Drozdzal, Xavier Giro-i-Nieto, and Adriana Romero. "[Inverse Cooking: Recipe Generation from Food Images.](#)" CVPR 2019.



Chung, Joon Son, Andrew Senior, Oriol Vinyals, and Andrew Zisserman. Lip reading sentences in the wild."
CVPR 2017

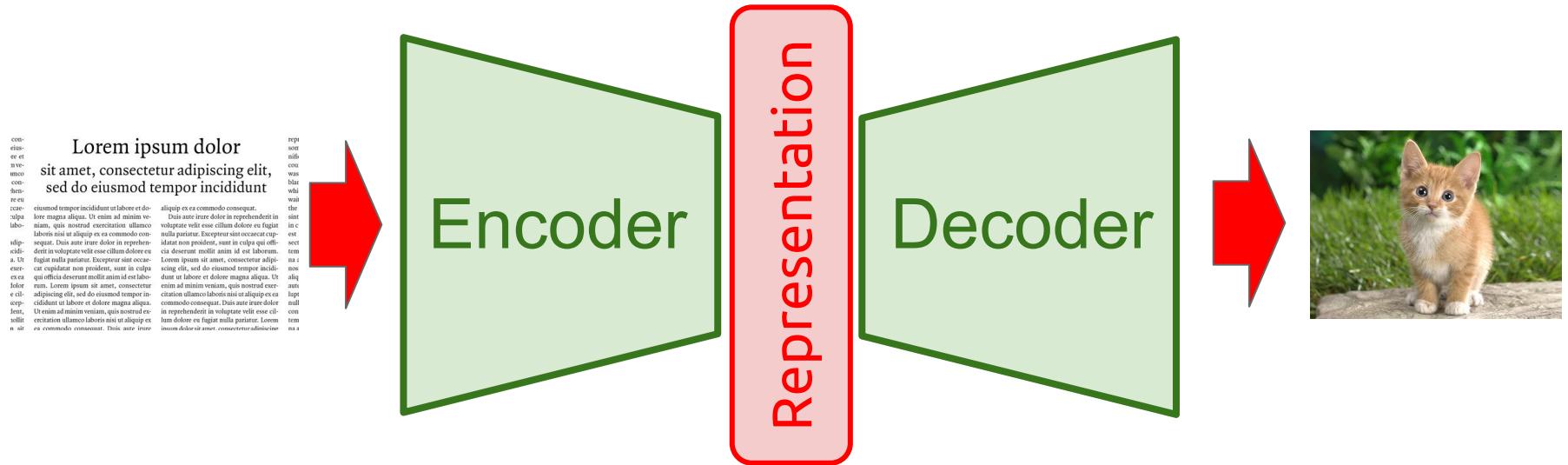
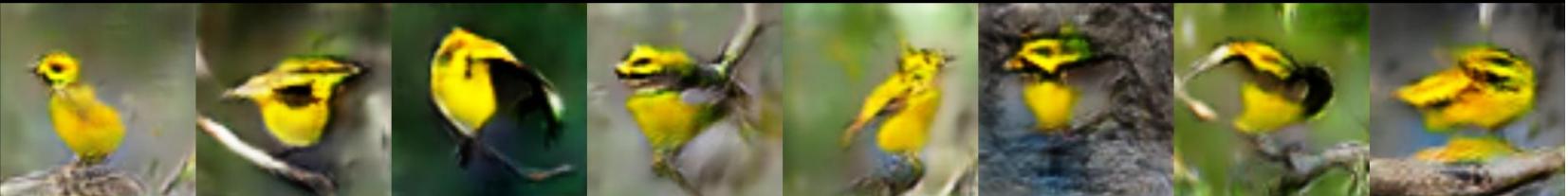


Image Synthesis

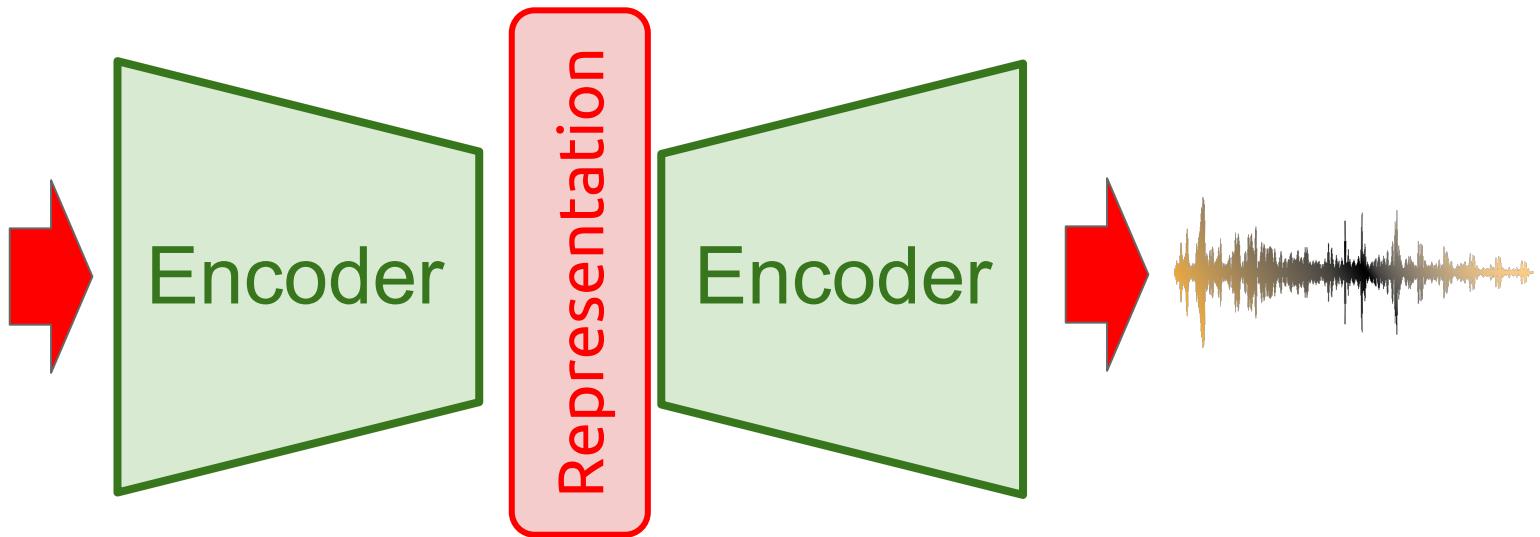
A small yellow bird with a black crown and a short black pointed beak

Stage-I



Stage-II







Visually Indicated Sounds

Andrew Owens

Phillip Isola

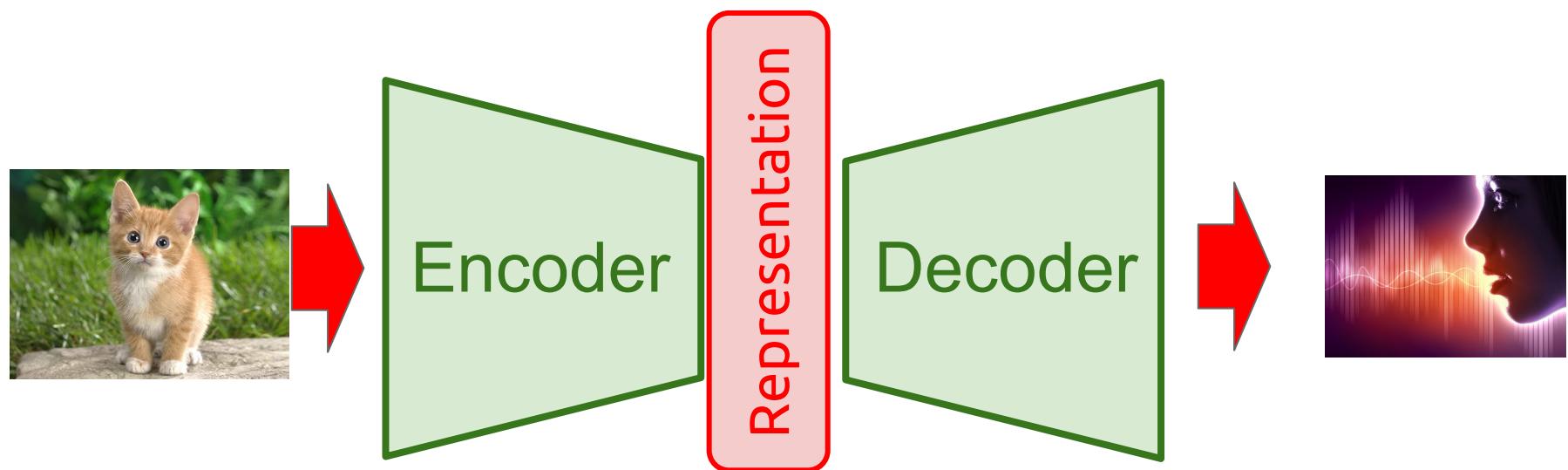
Josh McDermott

Antonio Torralba

Edward Adelson

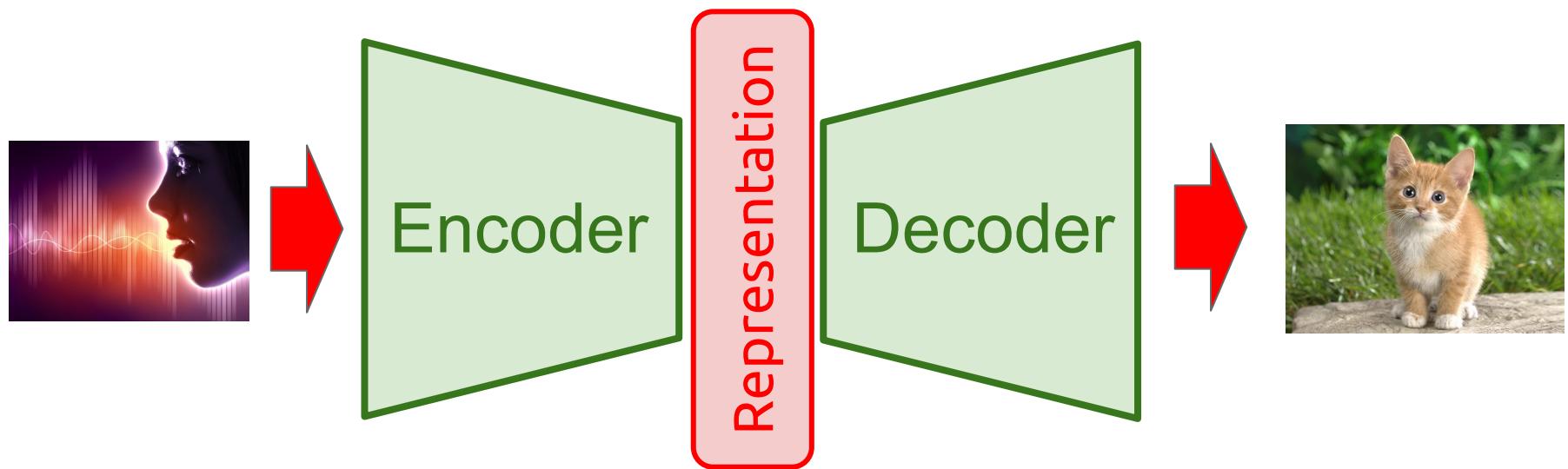
William Freeman

Owens, Andrew, Phillip Isola, Josh McDermott, Antonio Torralba, Edward H. Adelson, and William T. Freeman. "Visually indicated sounds." CVPR 2016.

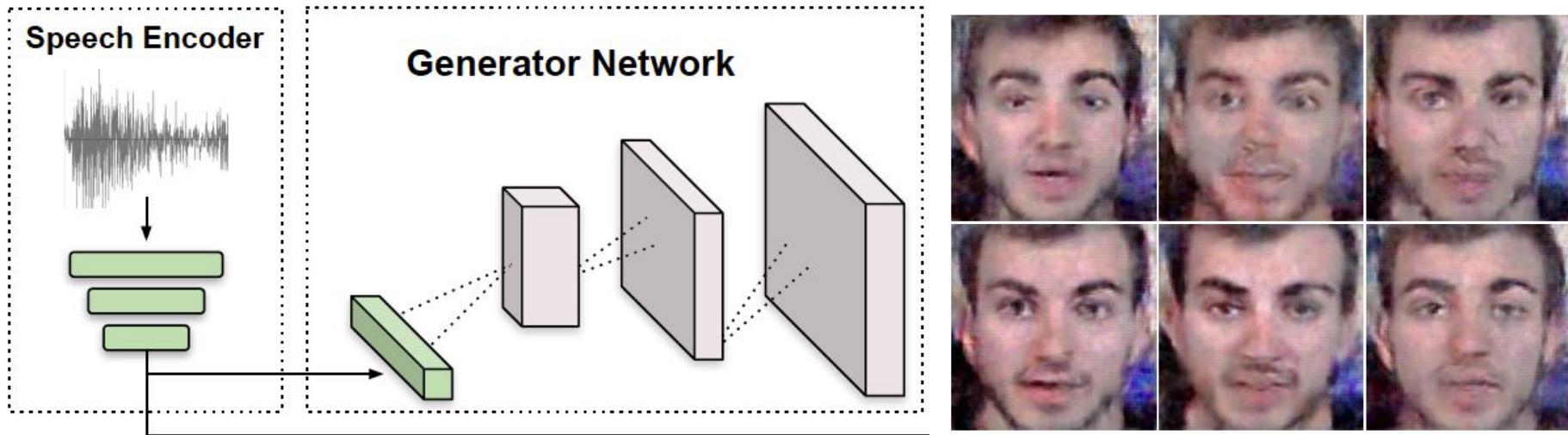


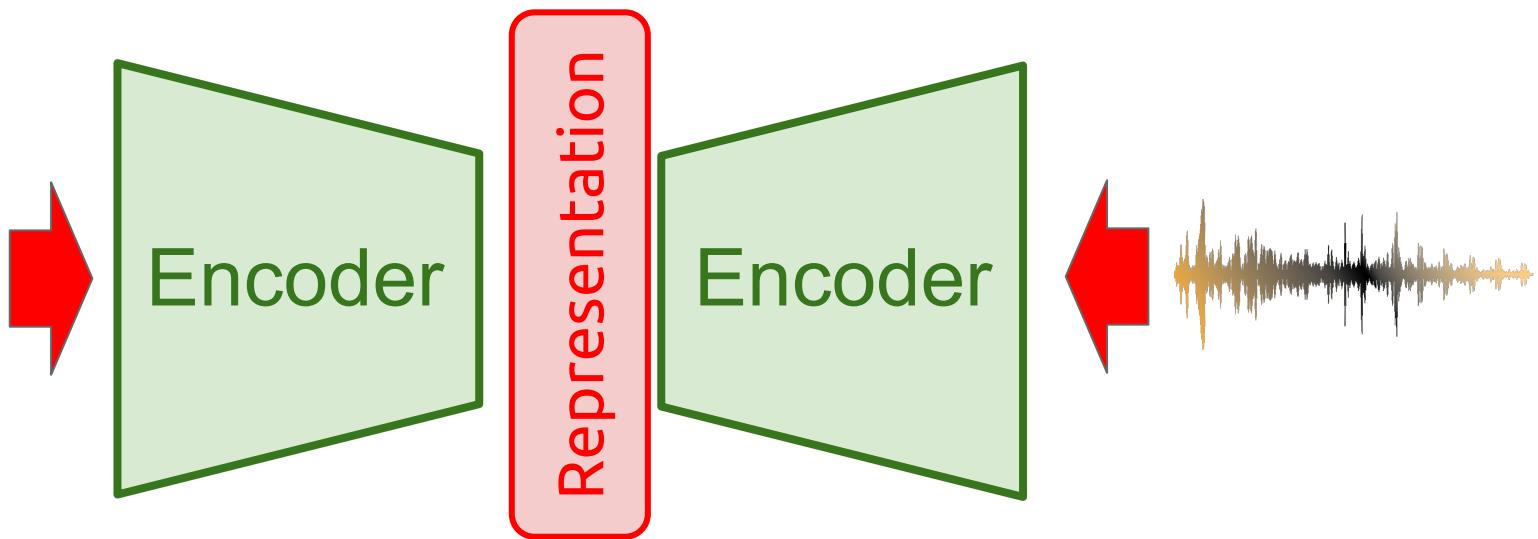


Ephrat, Ariel, Tavi Halperin, and Shmuel Peleg. "Improved speech reconstruction from silent video." In ICCV Workshop on Computer Vision for Audio-Visual Media. 2017.



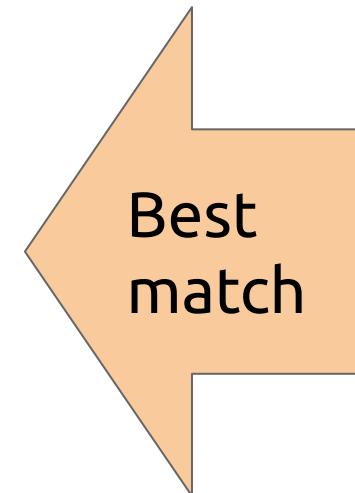
Speech to Pixels



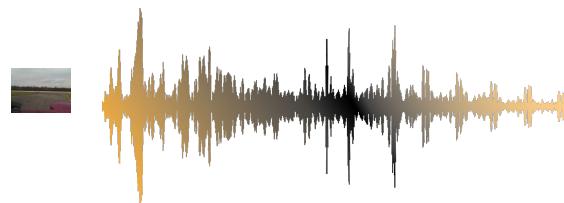


Multimodal Retrieval

bit.ly/mmm-docxavi
@DocXavi



Audio feature



Multimodal Retrieval

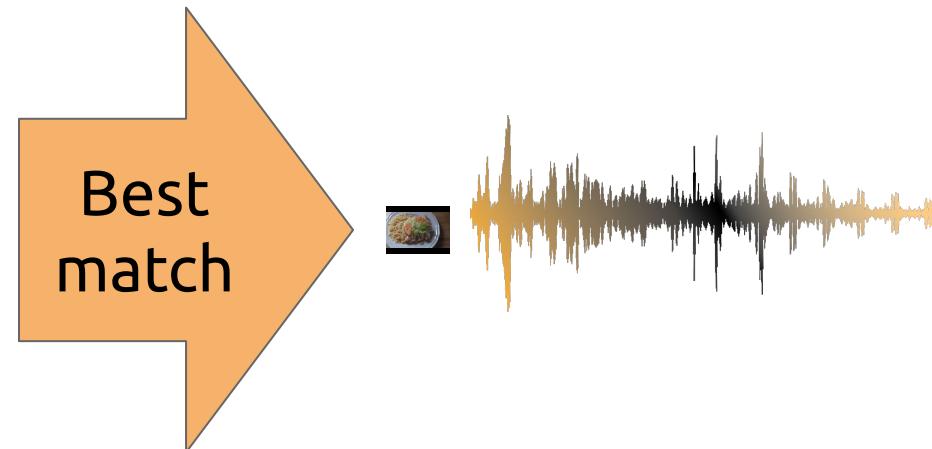
bit.ly/mmm-docxavi
@DocXavi

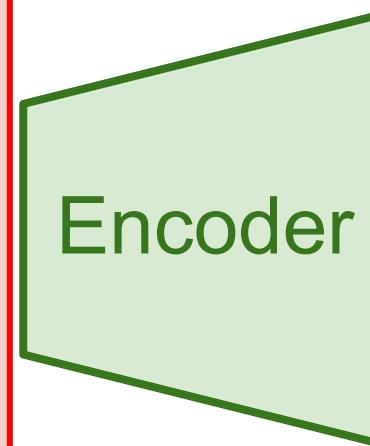
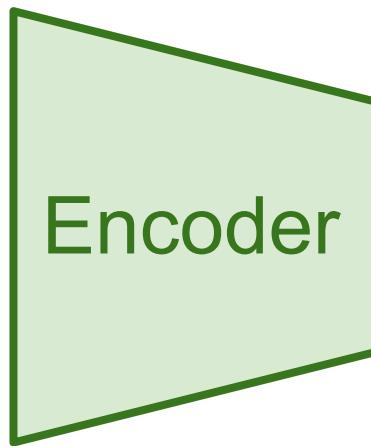


Visual feature



Audio feature





Jointly Discovering Visual Objects and Spoken Words from Raw Sensory Input

David Harwath, Adrià Recasens, Dídac Surís, Galen Chuang, Antonio Torralba, and James Glass

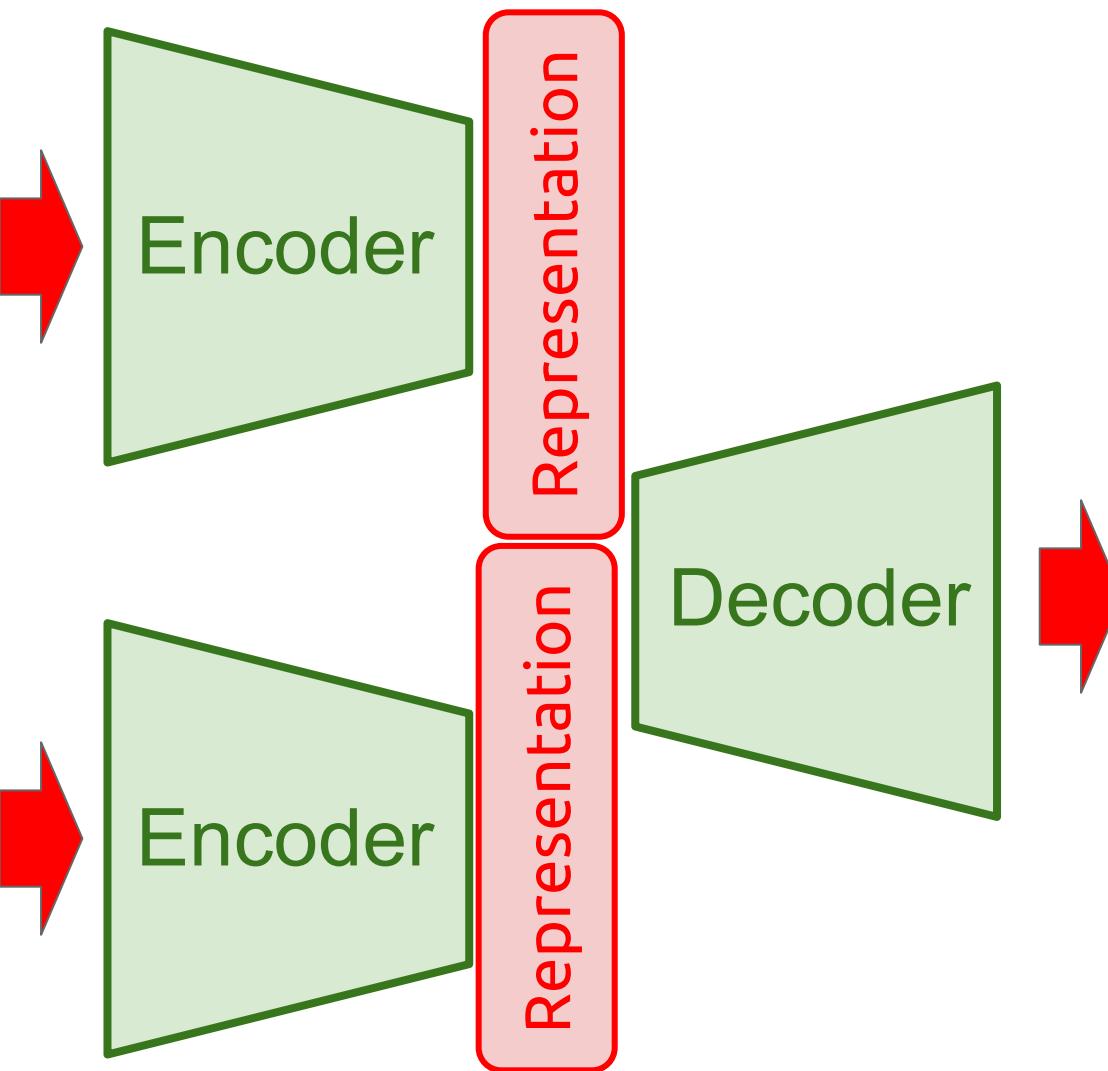


MIT Computer Science and Artificial Intelligence Lab

Cambridge, Massachusetts, USA

September 11, 2018





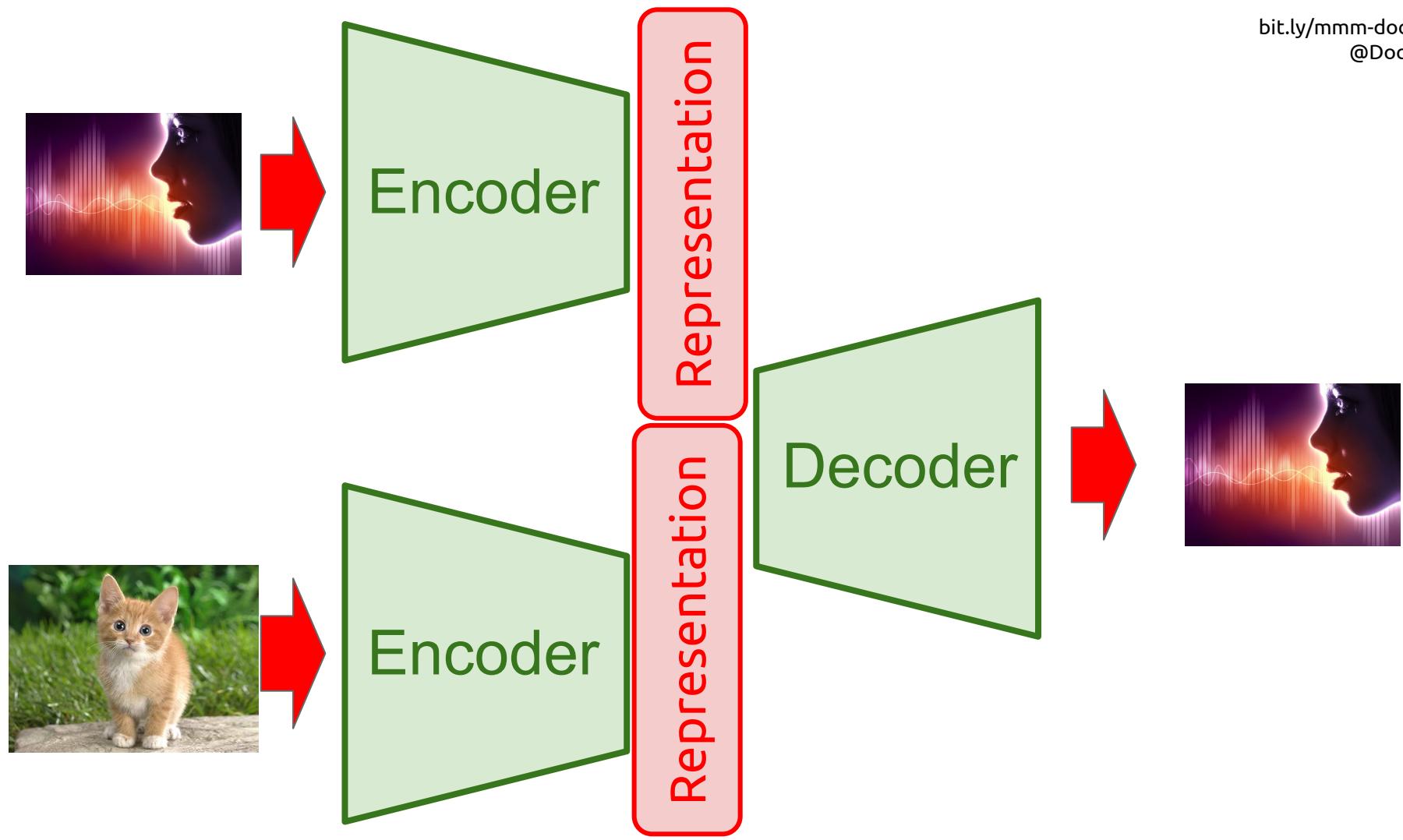
Visual Question Answering



AI System

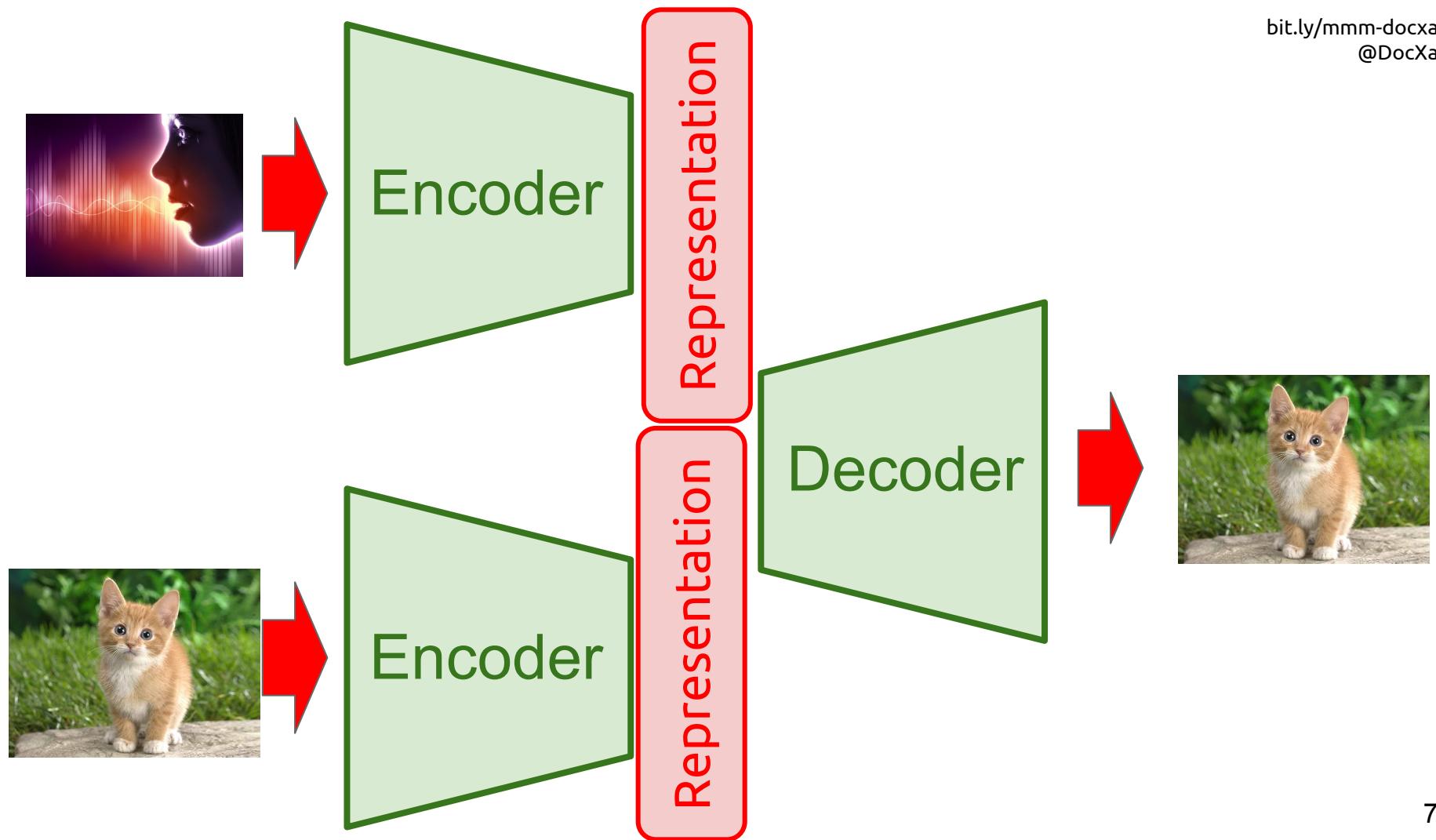
What is the mustache
made of?

bananas





Afouras, Triantafyllos, Joon Son Chung, and Andrew Zisserman. "[The Conversation: Deep Audio-Visual Speech Enhancement.](#)" Interspeech 2018..



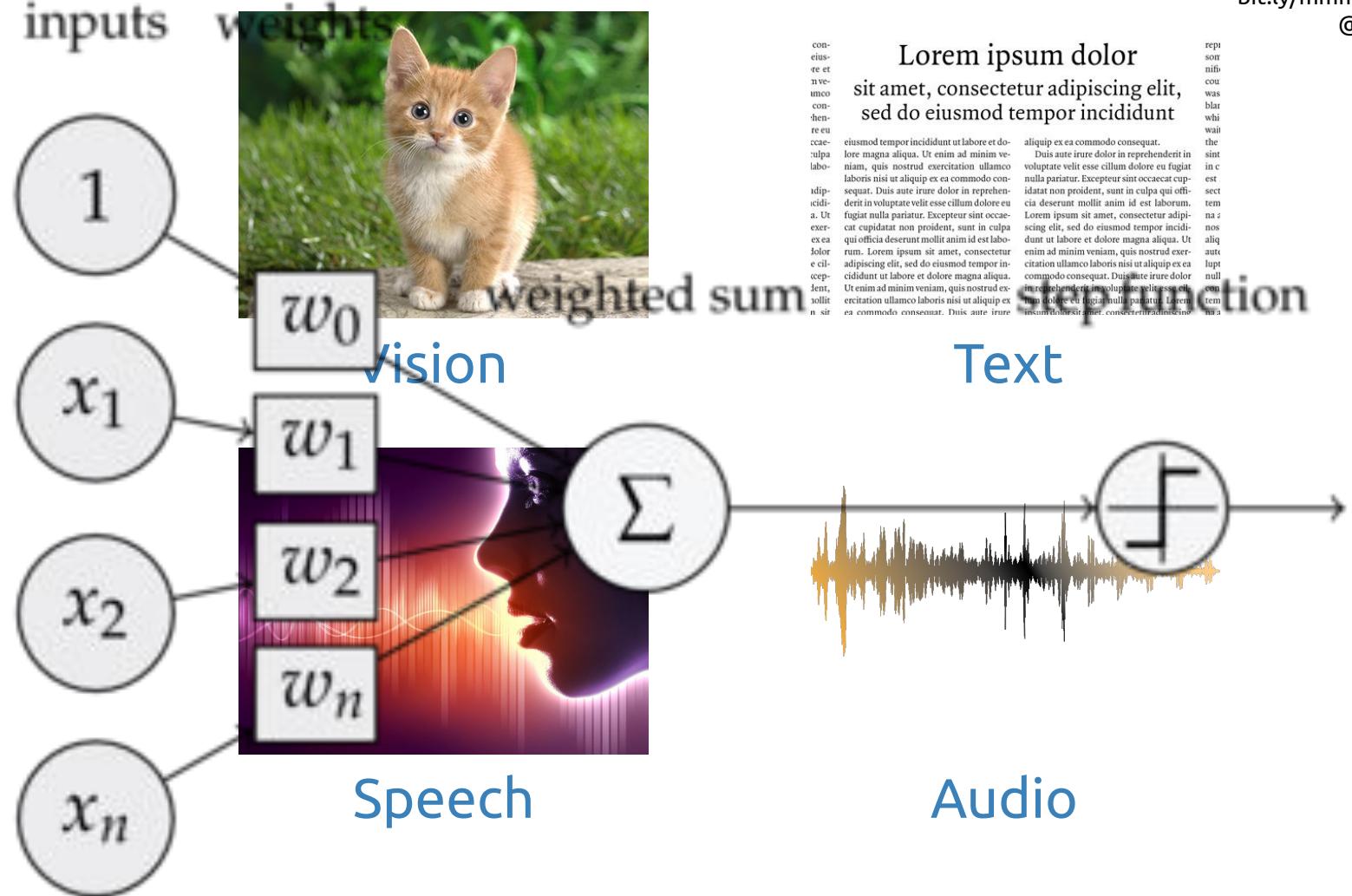


Without Re-timing



With Re-timing
(Our Result)

Karras, Tero, Timo Aila, Samuli Laine, Antti Herva, and Jaakko Lehtinen. "[Audio-driven facial animation by joint end-to-end learning of pose and emotion.](#)" SIGGRAPH 2017





Mnih, Volodymyr, Koray Kavukcuoglu, David Silver, Alex Graves, Ioannis Antonoglou, Daan Wierstra, and Martin Riedmiller.
"Playing atari with deep reinforcement learning." NIPS Deep Learning Workshop (2013).



Beyond Multimedia



#AlphaGo Silver, David, Aja Huang, Chris J. Maddison, Arthur Guez, Laurent Sifre, George Van Den Driessche, Julian Schrittwieser et al. ["Mastering the game of Go with deep neural networks and tree search."](#) Nature 2016.



Wayve, "Sim2Real: Learning to Drive from Simulation without Real World Labels" (2018)



Learning to imitate, from video, without supervision



3rd-person observation



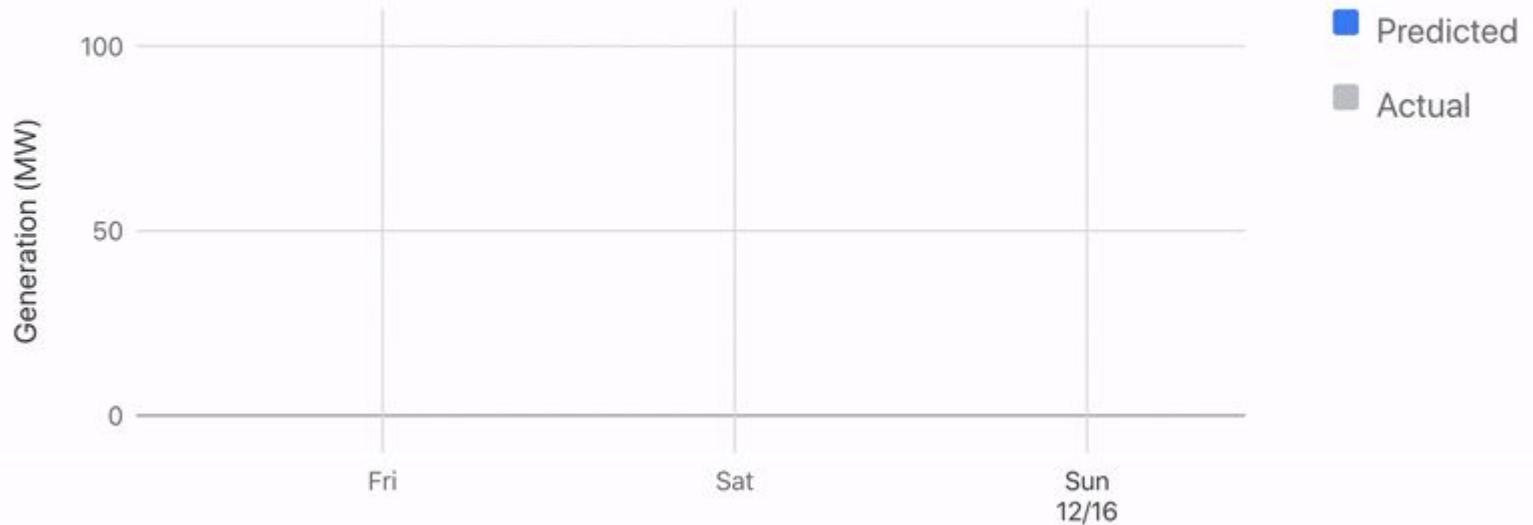
Learned policy



Sermanet, Pierre, Corey Lynch, Yevgen Chebotar, Jasmine Hsu, Eric Jang, Stefan Schaal, Sergey Levine, and Google Brain.
"Time-contrastive networks: Self-supervised learning from video." ICRA 2018.

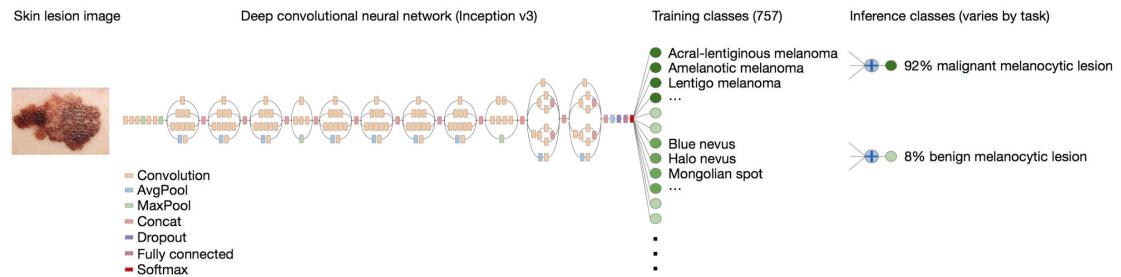
Beyond Multimedia

The DeepMind system predicts wind power output 36 hours ahead...





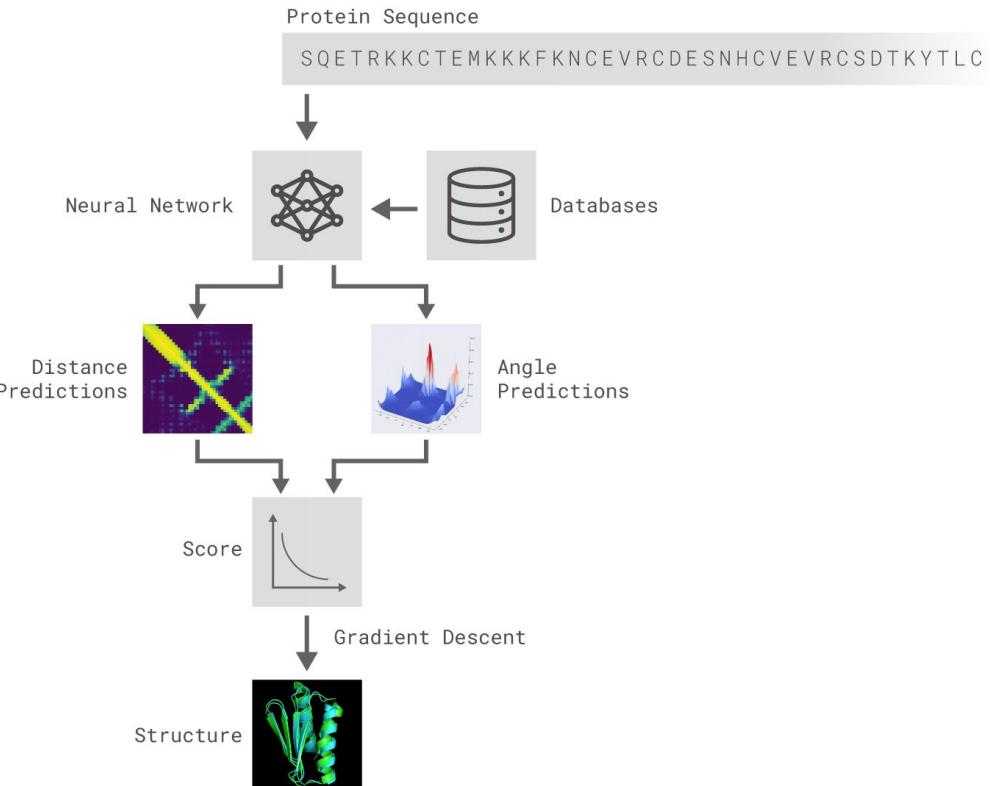
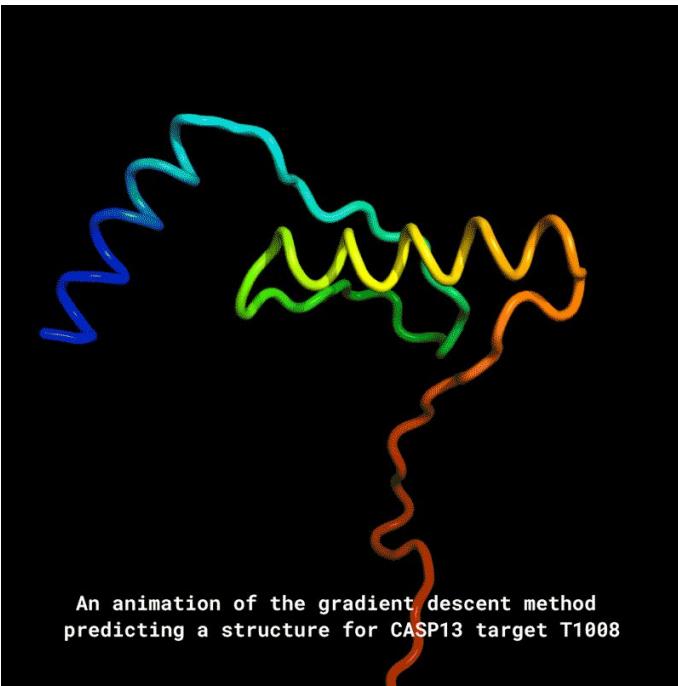
Beyond Multimedia



Esteva, Andre, Brett Kuprel, Roberto A. Novoa, Justin Ko, Susan M. Swetter, Helen M. Blau, and Sebastian Thrun. "[Dermatologist-level classification of skin cancer with deep neural networks.](#)" Nature 542, no. 7639 (2017): 115.



Beyond Multimedia

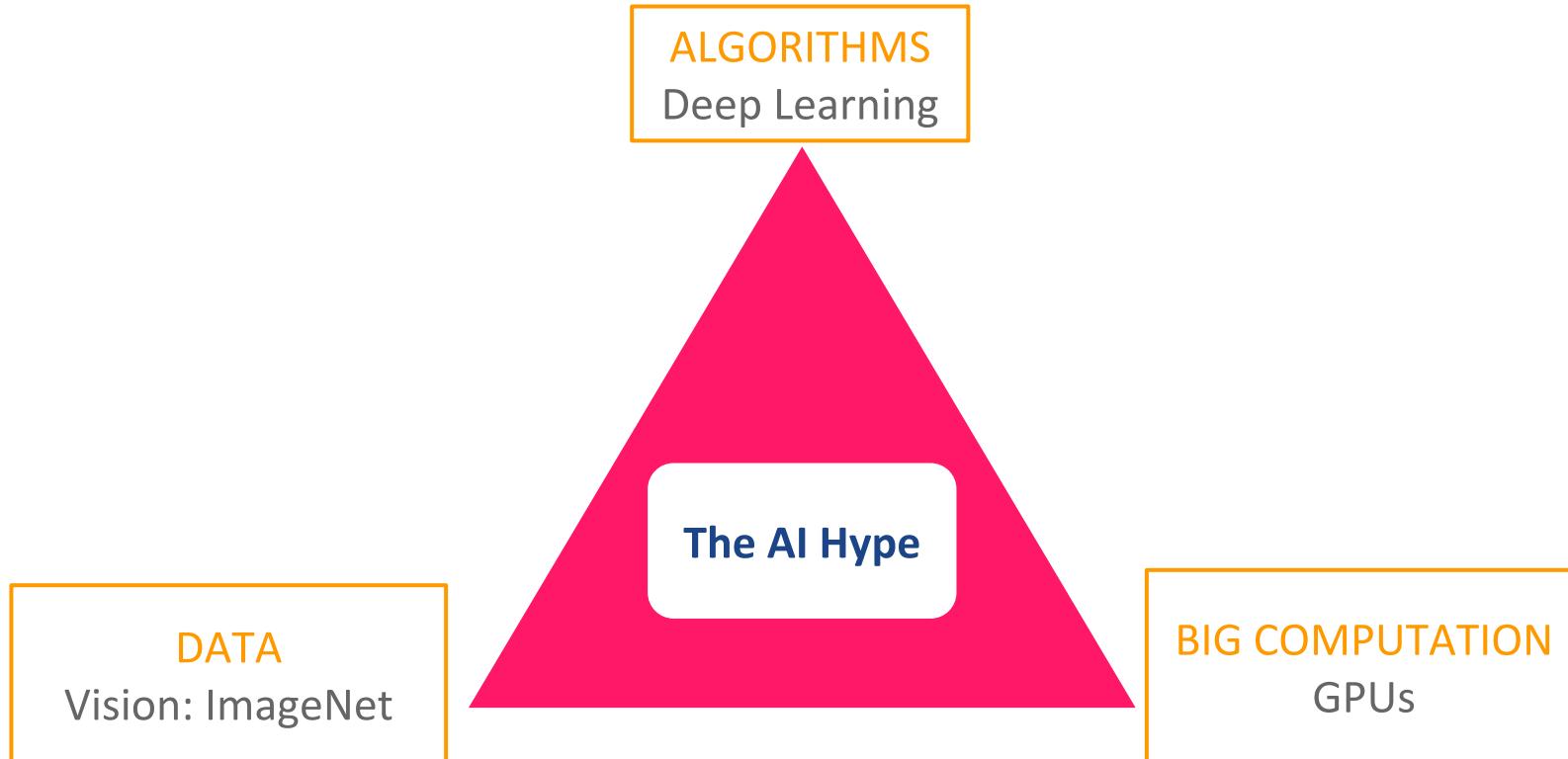


Beyond Multimedia



?

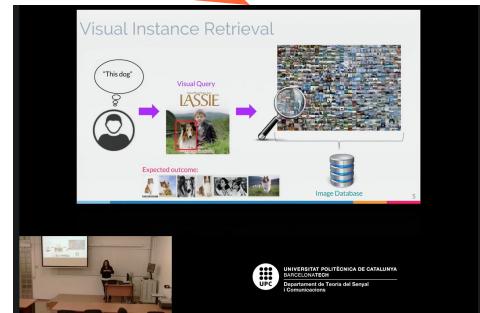
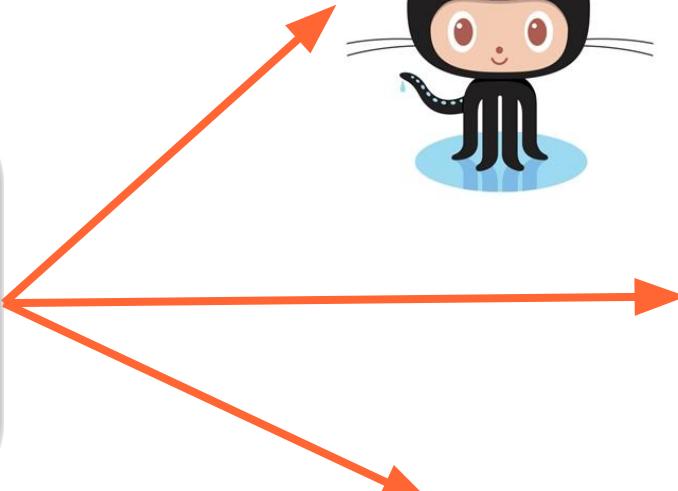
The AI Hype ?



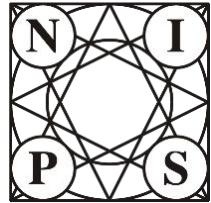


Open research

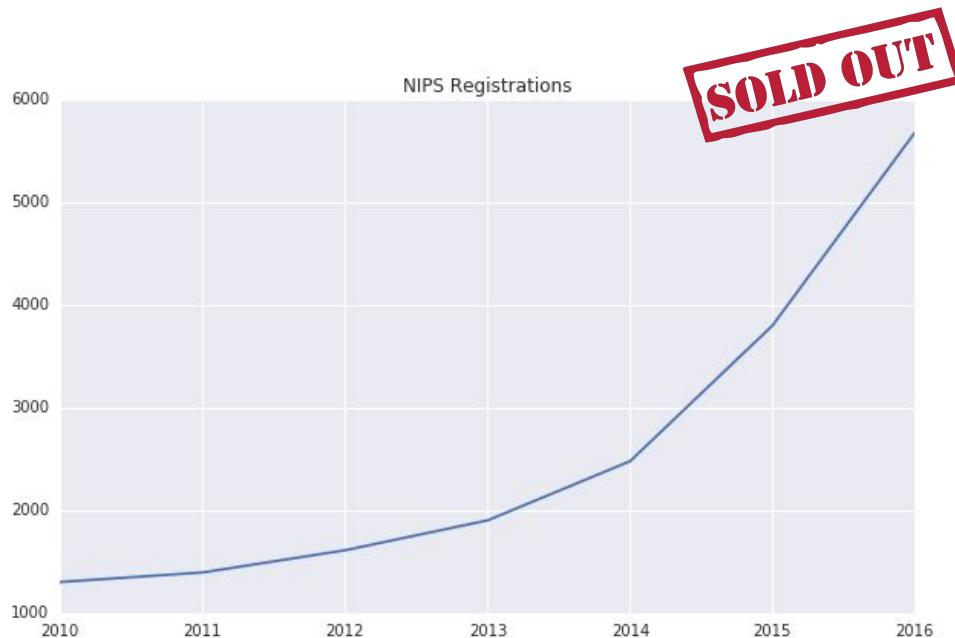
GitHub



The AI Hype (?)

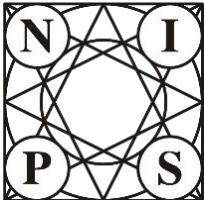


Annual Conference on Neural Information Processing Systems (NIPS) @ Barcelona (2016)

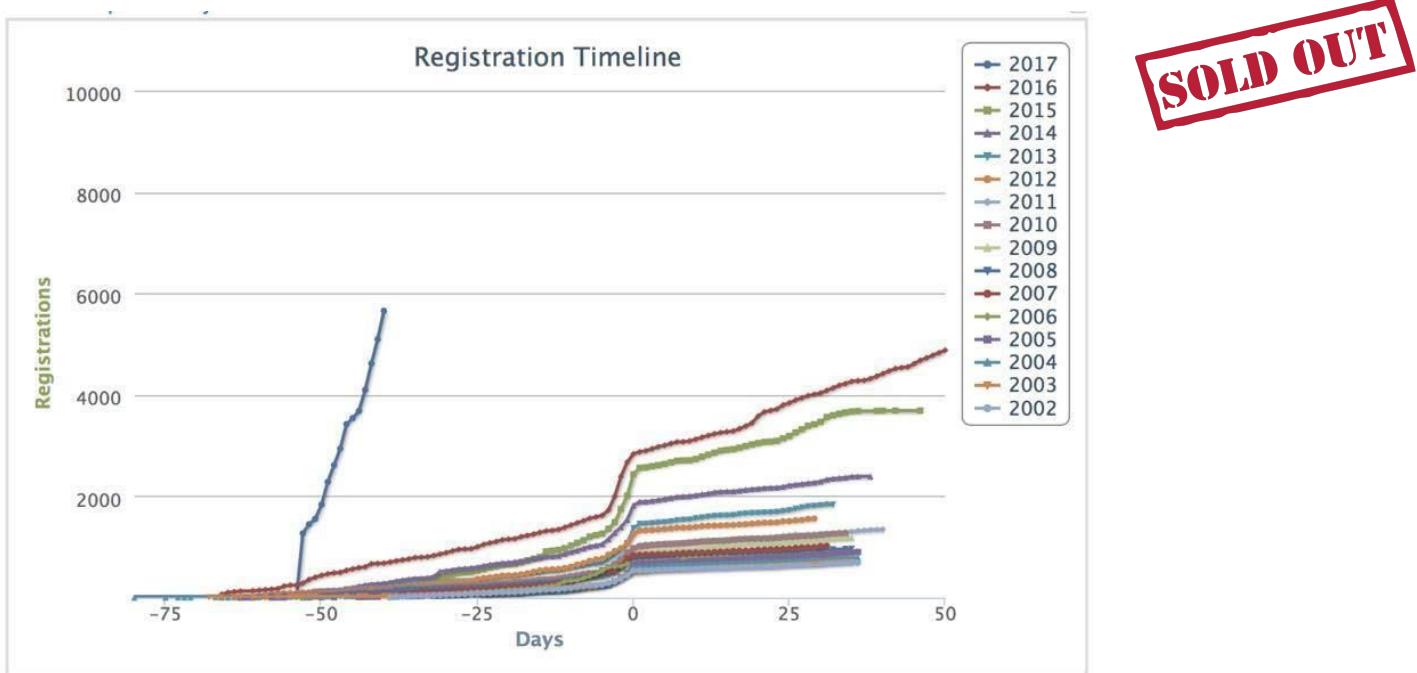




The AI Hype (?)

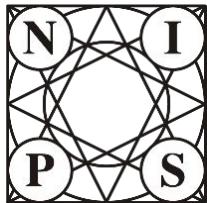


Annual Conference on Neural Information Processing Systems (NIPS) @ Long Beach (December 2017) - (Fig: [Alex Lebrun](#))





The AI Hype (?)



Annual Conference on Neural Information Processing Systems
(NIPS) @ Montreal (December 2018)



Seguint



#NIPS2018 The main conference sold out in
11 minutes 38 seconds

SOLD OUT

Tradueix el tuit

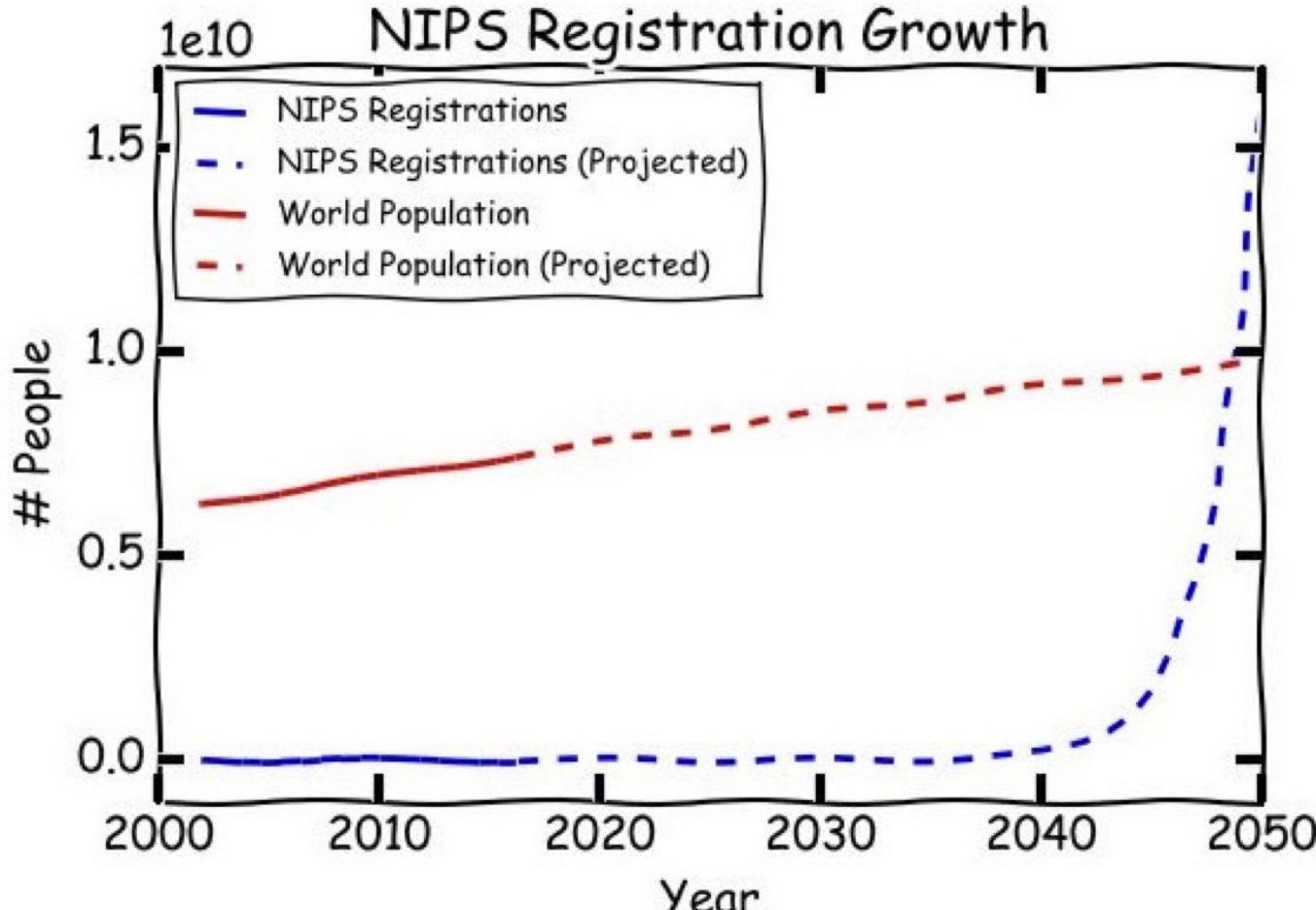
18:17 - 4 de set. de 2018

696 retuits 1.062 agradaments





The AI Hype (?)





The AI Hype (?)

CVPR is the top conference in computer science

(IN ALL COMPUTER SCIENCE !!)

Again

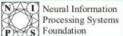
(IN ALL COMPUTER SCIENCE !!)

...and Top #2 & #4 are on machine learning

...as Top #3 & #5 are on computer vision.

Top Computer Science Conferences

Ranking is based on Conference H_5 -index ≥ 12 provided by Google Scholar Metrics

		Hindex	Publisher	Conference Details	
1	158		IEEE	CVPR : IEEE Conference on Computer Vision and Pattern Recognition, CVPR Jun 18, 2018 - Jun 18, 2018 - Salt Lake City , United States http://cvpr2018.thecvf.com/submission/timeline	<input type="checkbox"/> Show Due only All Categories <input type="checkbox"/> All Countries <input type="checkbox"/> Search by keyword
2	101		Neural Information Processing Systems Foundation	NIPS : Neural Information Processing Systems (NIPS) Dec 3, 2018 - Dec 6, 2018 - Palais des Congrès de Montréal , Canada https://nips.cc/	Deadline : Tue 26 Jun 2018
3	98		Springer	ECCV : European Conference on Computer Vision Sep 8, 2018 - Sep 14, 2018 - Munich , Germany https://eccv2018.org/	Deadline : Wed 14 Mar 2018
4	91		IMLS	ICML : International Conference on Machine Learning (ICML) Jul 10, 2018 - Jul 15, 2018 - Stockholm , Sweden https://2017.icml.cc/	
5	89		IEEE	ICCV : IEEE International Conference on Computer Vision Jan 30, 2018 - Jan 31, 2018 - Istanbul , Turkey http://waset.org/conference/2018/01/istanbul/ICCV	

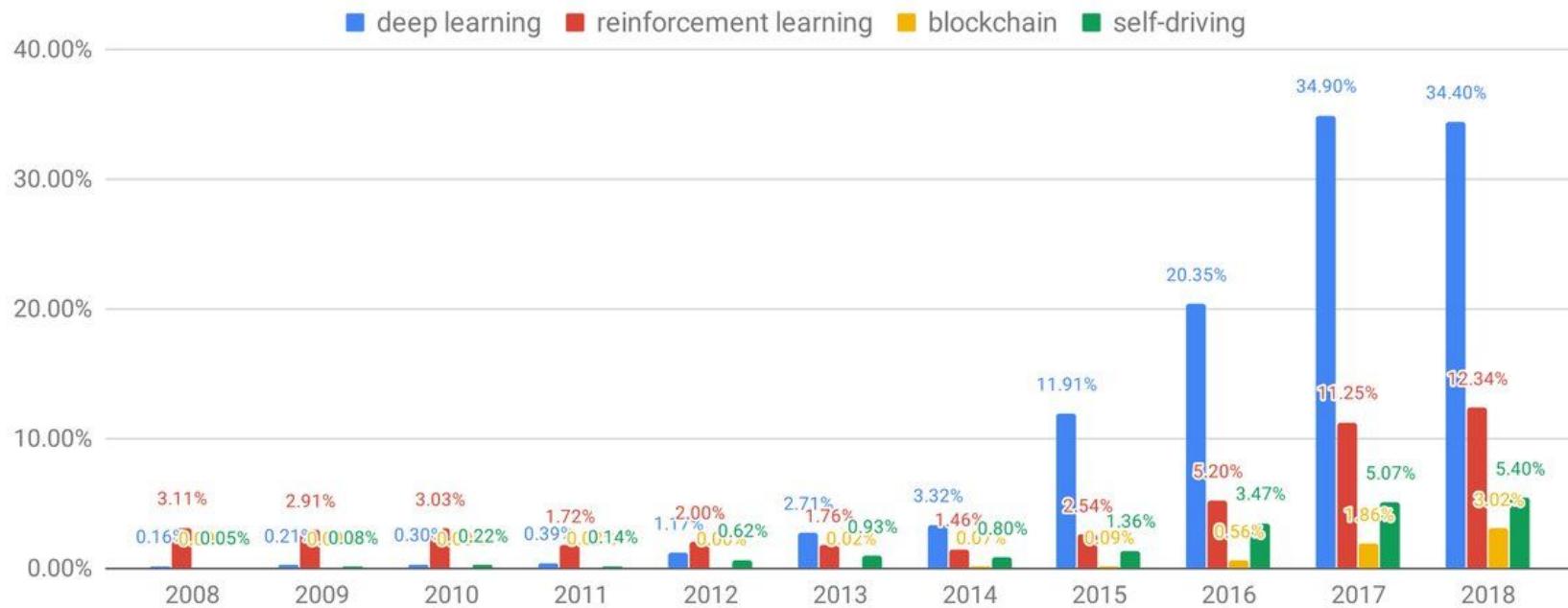
Source: [David Forsyth](#)
@ Good Citizen CVPR 2018 [\[video\]](#) [\[slides\]](#)



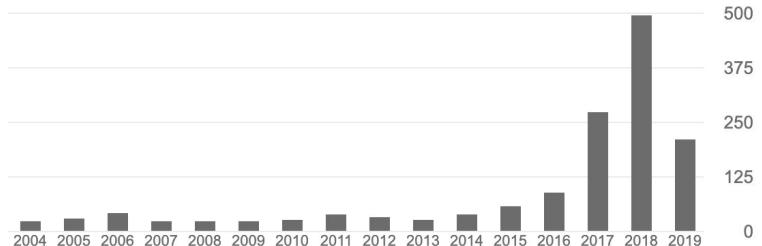
The AI Hype (?)

CMU School of Computer Science

Grad School Applications Keywords



The AI Hype (?)





The AI Hype (?)

Nature: Junior AI researchers are in demand by universities and industry (April 2019)

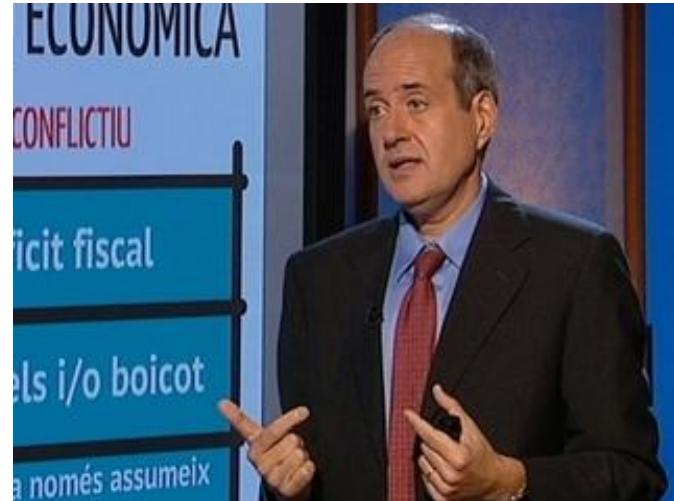


The AI Hype (?)

bit.ly/commsenselab
@DocXavi



Xavier Sala-i-Martin (Columbia University),
"Les conclusions del Fòrum de Davos"
(TV3, 03/02/2016) - in Catalan



Carles Boix (Princeton University),
"La quarta revolució industrial"
(Diari Ara, 08/02/2016) - in Catalan



The AI Hype (?)

Barack Obama, Neural Nets, Self-driving cars, and the Future of the World (Wired, June 2016)





The AI Hype (?)



Comissió Europea



@EUinBCN

Segueix



El projecte [@AI4EU](#) per crear la primera gran plataforma pan-europea d'intel·ligència artificial ha donat el tret de sortida aquesta setmana a Barcelona. També es posarà en marxa un observatori ètic sobre [#AI](#).

[@la_UPC](#) i el [@BSC_CNS](#) hi participen. 





The AI Hype (?)

A TIMELINE FOR EUROPE'S AI STRATEGY

- Commission adopts the Communication on Artificial Intelligence
- Starts a pilot project on explainable AI
- Commission publishes a report on the implications for and potential gaps in the liability and safety frameworks for AI
- Commission strengthens its AI research centers, supports digital skills, and creates a center for data sharing





The AI Hype (?)

Catalan News

POLITICS SOCIETY & SCIENCE BUSINESS LIFE & STYLE CULTURE SPORTS

SOCIETY & SCIENCE

Government aims to make Catalonia an AI hub in Europe

Strategic plan to boost artificial intelligence will involve public and private sectors, research institutions and universities

12 January 2019 12:14 PM by ACN | Barcelona

SHARE

The government is preparing a strategic plan for the area of artificial intelligence (AI) to attract investment and EU funding, and to help Catalonia "face the challenges" AI will bring with it in the future, according to digital policy minister, Jordi Puigneró.

"We want Catalonia to become a hub for artificial intelligence in Europe," the minister told the Catalan News Agency (ACN).



Catalan minister for digital policy, Jordi Puigneró (by Aina Martí)



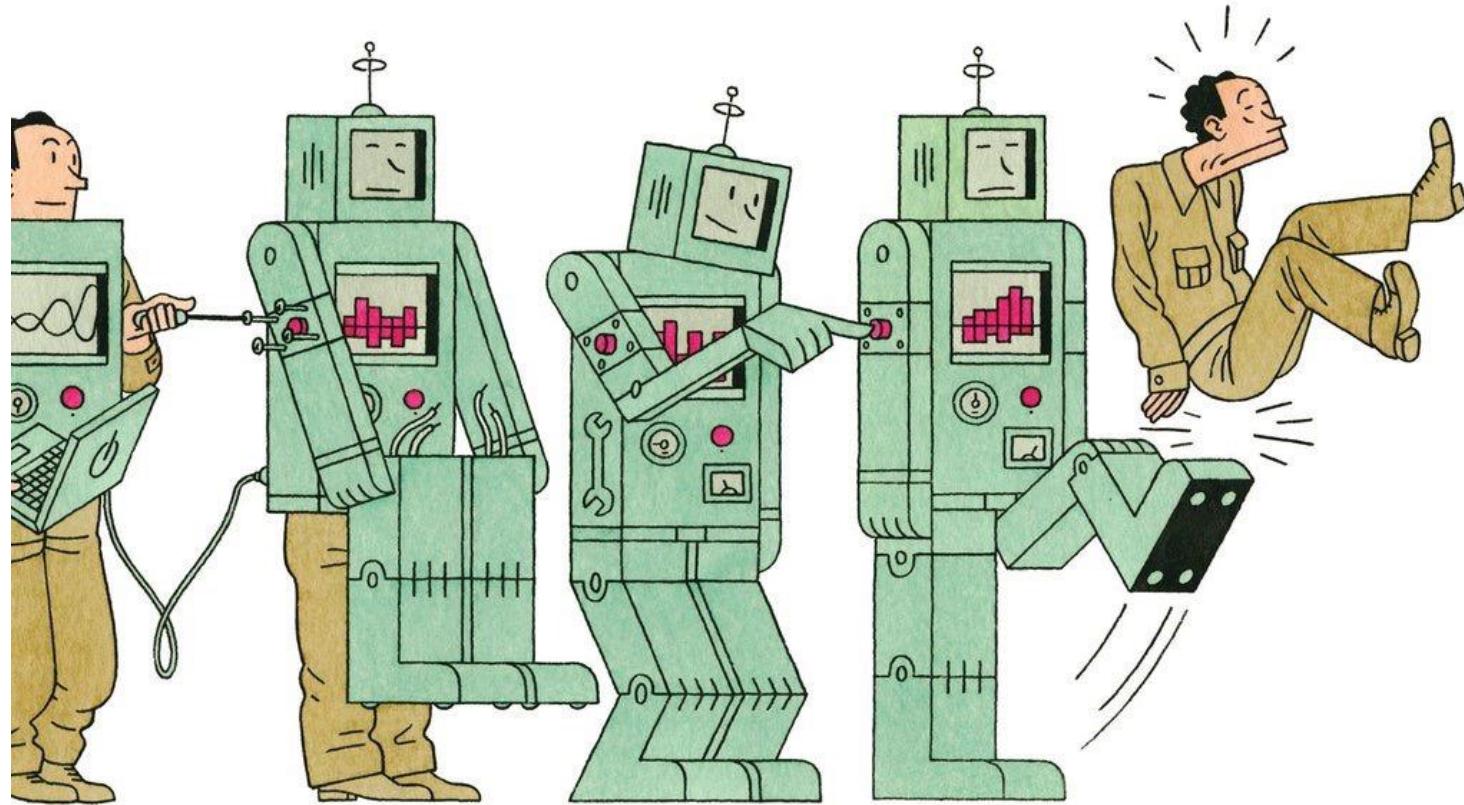
The AI Hype (?)



Llegiu l'informe des [d'aquí](#)

The AI Hype (?)

bit.ly/commsenselab
@DocXavi





The AI Hype (?)



The AI Hype (?)

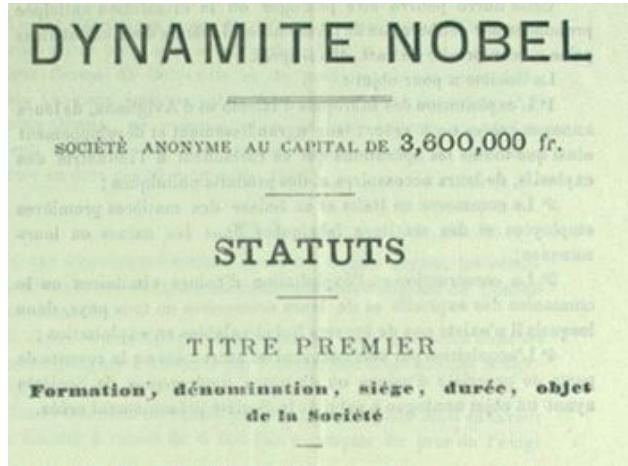
bit.ly/commsenselab
@DocXavi

OpenAI





The AI Hype (?)





Deep Learning courses @ UPC TelecomBCN:

DEEP LEARNING FOR ARTIFICIAL INTELLIGENCE

videos will be online

Master Course UPC ETSETB TelecomBCN Barcelona. Autumn 2017.



Instructors



Organizers



Supporters



+ info: <http://dlai.deeplearning.barcelona>

- MSc course [\[2017\]](#) [\[2018\]](#) [\[2019\]](#)
- BSc course [\[2018\]](#) [\[2019\]](#)

Next edition: Autumn 2019

DEEP LEARNING FOR VISION

4th Summer School at UPC TelecomBCN Barcelona. June 25-July 3, 2019



Instructors



Organized by



Supported by



+ info: <http://bit.ly/dlcv2019>

- [1st edition](#) (2016)
- [2nd edition](#) (2017)
- [3rd edition](#) (2018)
- [4th edition](#) (2019)

Included in ETSETB Master MATT Deep Learning Track + MET

DEEP LEARNING FOR SPEECH AND LANGUAGE

Winter School at UPC TelecomBCN Barcelona. 24-30 January 2018.



Instructors



Organized by



Supported by



+ info: <https://telecombcn-dl.github.io/2018-dsl/>

- [1st edition](#) (2017)
- [2nd edition](#) (2018)
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Deep Learning for Professionals @ UPC School

The banner features a dark background with a digital grid overlay. Large, semi-transparent binary digits (0s and 1s) are scattered across the grid. In the upper right corner, the UPC logo (a circle of dots) is positioned next to the text "UNIVERSITAT POLITÈCNICA DE CATALUNYA BARCELONATECH" and "School of Professional & Executive Development". In the lower left, the text "POSTGRADUATE COURSE" is followed by "ARTIFICIAL INTELLIGENCE WITH DEEP LEARNING" in large, bold, white letters. At the bottom center, the website "WWW.TALENT.UPC.EDU" is displayed.

Next edition starts November 2019. Sign up [here](#).

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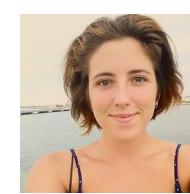
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