



DEEP LEARNING - METHODS AND APPLICATIONS

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WHO AM I?



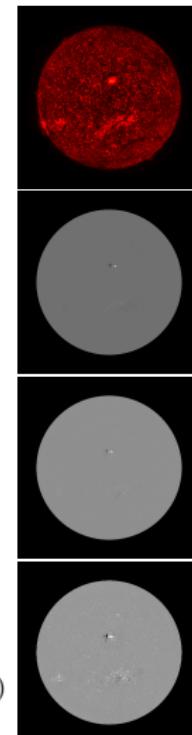
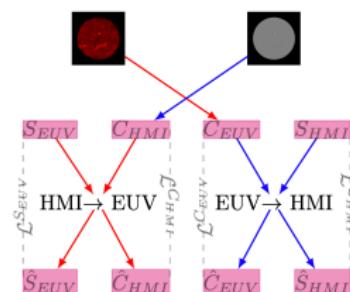
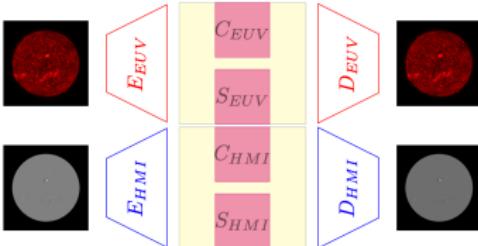
Brief CV

- ▶ Full professor in Computer Science, Clermont Auvergne University
 - ▶ **Research** : Machine Learning, Deep Learning
 - ▶ **Applications** : Solar Physics, Particle Physics, Volcanology, Image Processing, Medicine
 - ▶ **Teaching** : Numerical Analysis, Statistical / Deep Learning, Data Analysis, Image Processing
 - ▶ **Administrative** : Dean of ISIMA (2012-2017), Co-dean of LIMOS (2021-2025)



TRANSFER LEARNING

- ▶ **Context** : Collaboration LIMOS/ROB/NASA
- ▶ **Objectif** : image creation
- ▶ **Applications** : Dual generation $HMI \leftrightarrow EUV$
- ▶ **Contributions** : “Image to Image translation” model



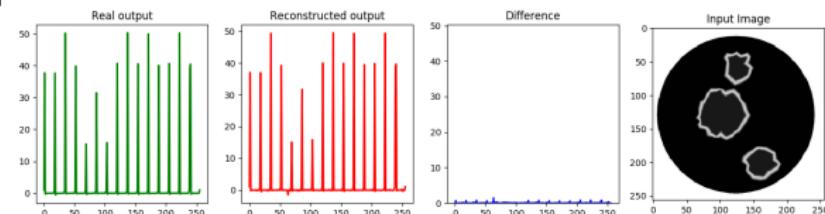
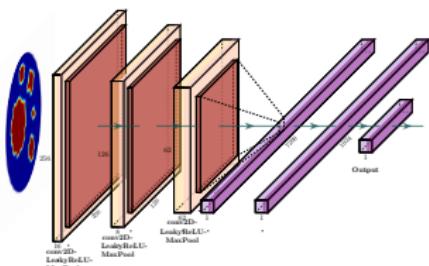
$$\min_{E_x, E_y, D_x, D_y} \max_{G_x, G_y} \mathcal{L}_G^x + \mathcal{L}_G^y + \lambda_1(\mathcal{L}^x + \mathcal{L}^y) + \lambda_2(\mathcal{L}^{C_x} + \mathcal{L}^{C_y}) + \lambda_3(\mathcal{L}^{S_x} + \mathcal{L}^{S_y})$$

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DIRECT AND INVERSE PROBLEMS : PDE's AND DEEP LEARNING

- ▶ **Context** : Collaboration LIMOS/ Clemson University, USA
- ▶ **Objectif** : PDE solving using Deep Learning
- ▶ **Application** : Electrical Impedance Tomography (EIT)
- ▶ **Contributions** : Deep networks for the direct and inverse problems



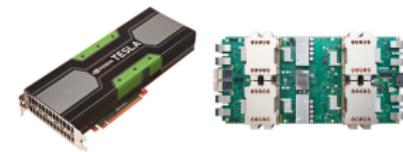
DEEP LEARNING ?

What is Deep Learning ?

- ▶ Neural Networks, but with more layers/modules
- ▶ Non-linear, hierarchical, abstract representations of data
- ▶ Flexible models with any input/output type and size
- ▶ Differentiable Functional Programming

Why Deep Learning ?

- ▶ Availability of data with labels
- ▶ Everyday (or almost), a new algorithm
- ▶ Computing power (GPUs, TPUs)
- ▶ Open source community

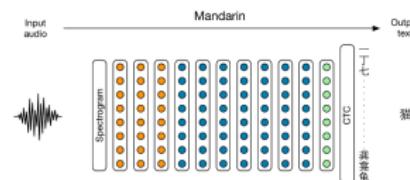
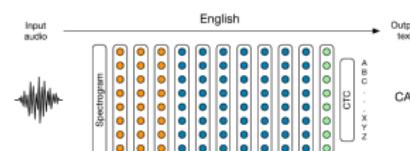


DEEP LEARNING TODAY

Natural Language Processing - Speech to Text



hello

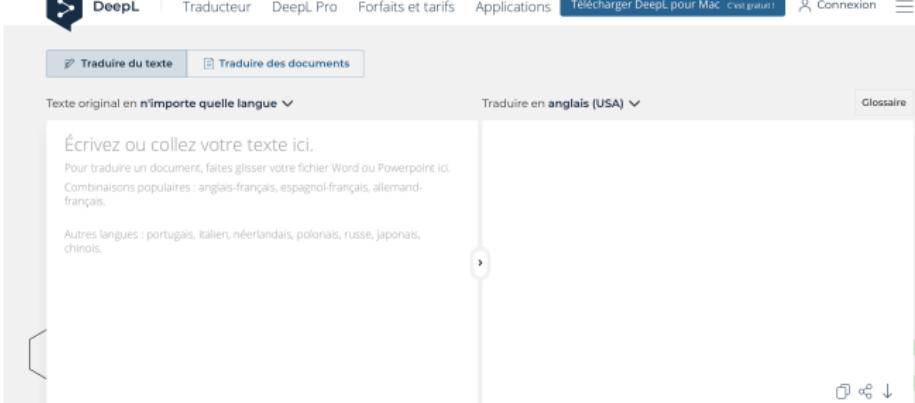


- Convolution Layer
- Recurrent Layer
- Fully Connected Layer

[Baidu 2014]

DEEP LEARNING TODAY

Natural Language Processing - Translation



The screenshot shows the DeepL website interface for translating text. At the top, there's a navigation bar with the DeepL logo, links for Traducteur, DeepL Pro, Forfaits et tarifs, Applications, Télécharger DeepL pour Mac, Connexion, and a menu icon. Below the navigation is a search bar with two tabs: "Traduire du texte" (selected) and "Traduire des documents". The main area has two text boxes separated by a vertical line. The left box is labeled "Texte original en n'importe quelle langue" and contains placeholder text: "Écrivez ou collez votre texte ici. Pour traduire un document, faites glisser votre fichier Word ou Powerpoint ici. Combinaisons populaires : anglais-français, espagnol-français, allemand-français." The right box is labeled "Traduire en anglais (USA)" and contains a small arrow pointing right. At the bottom right of the interface are download and refresh icons.

DeepL

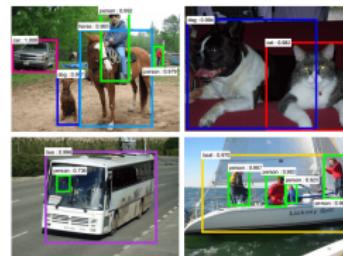
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Computer Vision - Detection, Classification, Segmentation, Annotation

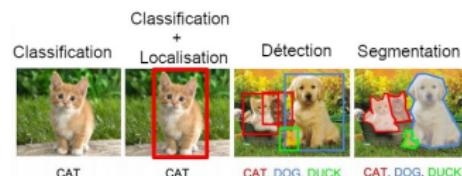


NVidia



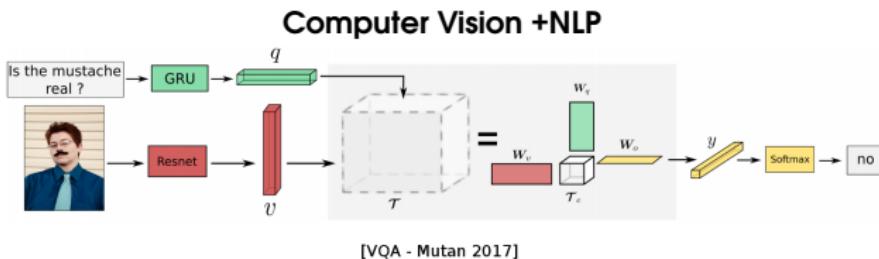
Facebook

Ren, 2015



Barra

DEEP LEARNING TODAY



"man in black shirt is playing guitar."



"construction worker in orange safety vest is working on road."



"two young girls are playing with lego toy."



"boy is doing backflip on wakeboard."

[Karpathy 2015]

DEEP LEARNING TODAY

Generative models



[DeepDream 2015]



[Gatys 2015]



[Ledig 2016]



Nvidia 2017



Zhang 2017

APPLICATIONS

- ▶ Medicine
- ▶ Security
- ▶ Internet
- ▶ Art
- ▶ Games
- ▶ Image and videos Analysis
- ▶ Speech recognition/synthesis
- ▶ Automatic translation
- ▶ Pattern matching
- ▶ Autonomous vehicles
- ▶ Robotics
- ▶ Domotics
- ▶ ...



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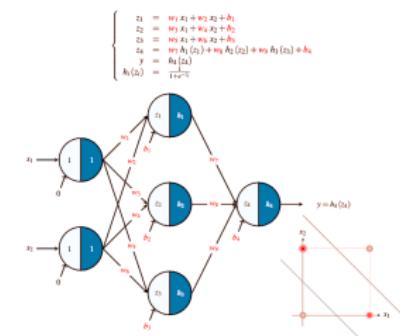
OBJECTIVES

- ▶ Overview
 - ▶ When and where to use Deep Learning
 - ▶ “How” it works
 - ▶ Frontiers of Deep Learning
- ▶ Deep inside Deep Learning
 - ▶ Implementation using Tensorflow (Keras)
 - ▶ Engineering knowledge for building and training Deep models

OUTLINE

Outline

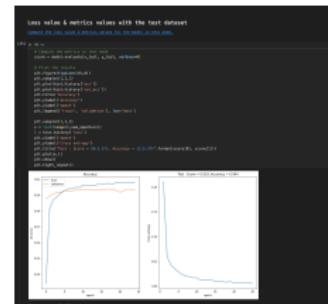
- ▶ Introduction to Machine Learning and Deep Learning
- ▶ Perceptrons and Multilayer perceptrons
- ▶ Convolutional Networks
- ▶ Recurrent Neural Networks
- ▶ Autoencoders
- ▶ Transfer Learning
- ▶ Generative Networks : GAN, VAE
- ▶ Matching Networks : siamese and triplet
- ▶ Recommandation systems
- ▶ Deep Reinforcement Learning



HOW DOES IT WORKS

Each week

- ▶ 1h30 lecture (slides, face to face... or zoom),
- ▶ 1h30 coding session (Jupyter Notebooks) with interactions (chat, zoom).



Assessment (after on-site teaching period)

A challenge, based on an unknown (for you) dataset :

- ▶ Use / adapt / create from the topics covered during the lectures
- ▶ Build your model on a training set to answer the problem
- ▶ Your model will be assessed on test data you will not have.

RECOMMENDED READINGS AND WEBSITES

Prerequisites

Basic knowledge on linear algebra, optimization. Python programming.

Some readings

- ▶ [Deep Learning Book](#) :a good overview (online)
- ▶ S Haykin. Neural networks and machine learning, Prentice Hall, 2008.
- ▶ F Chollet, Deep Learning with Python, Manning, 2018
- ▶ [Keras](#) : API for programming Deep Learning models
- ▶ [Tensorflow](#) : open source Platform for Deep Learning
- ▶ [Pytorch](#) : another Open source Platform for Deep Learning