UNIVERSITÉ PARIS DESCARTES
UFR DE MATHÉMATIQUES ET INFORMATIQUE
USPC Université Sorbonne Paris Cité

Department of Mathematics and Computer Science
Specialization : Machine learning for data science

Supervised research project presentation
Title

Deep learning and machine learning methods for image classification

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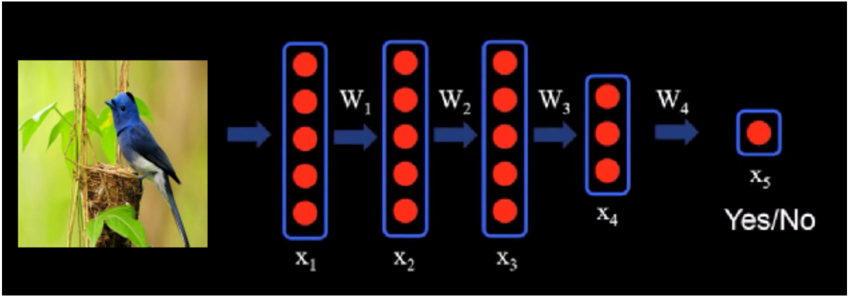
Outline I

Problem description and goal I

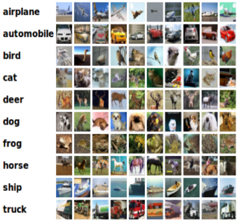


Problem description and goal II

1-How to classify images ?
2-What are the criteria of decision making ?
3-What's the appropriate learning algorithm for computer vision ?
4-Is deep learning making machine learning obsolete ?

Our approach :
1-Choose two different datasets.

MNIST dataset



CIFAR-10 dataset

2-Select four different learning algorithms and implement them.
Logistic Regression, *Multi Layer Perceptron*, *Support Vector Machine* and *Convolution Neural Networks*
3-Evaluate the performance of each algorithm with the accuracy criterion.

Scope of deep learning I

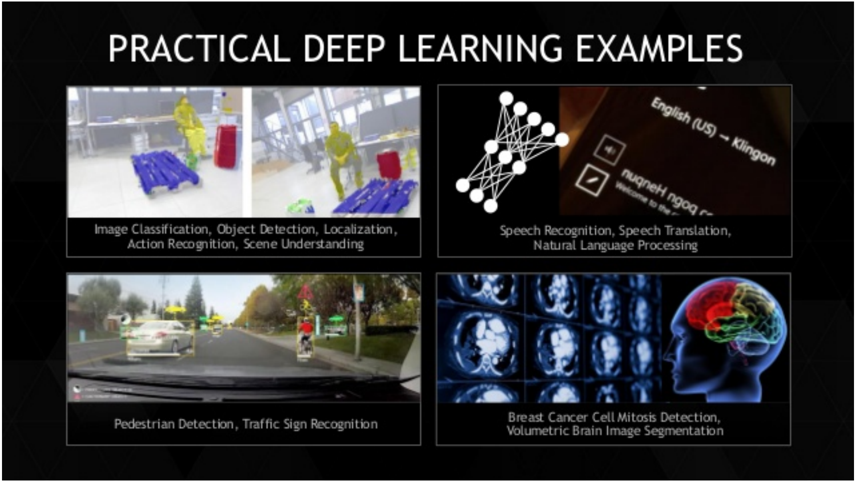
1-High energy physics : higgs boson discovery.

2-Cancer detection : breast cancer .

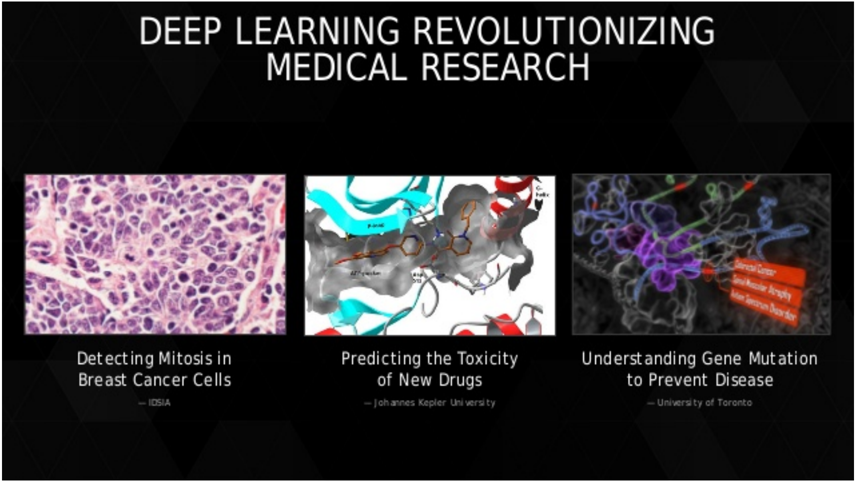
3-Medical diagnosis and decision support.

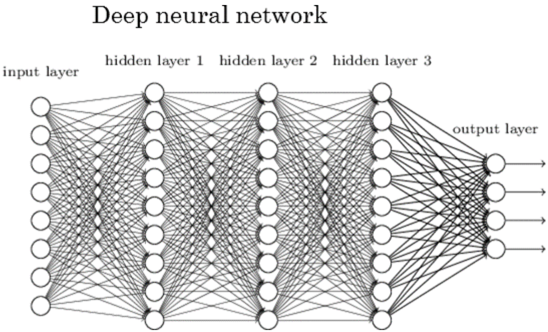
4-The inner structure of DNA and the the close relationship between chromosomes.

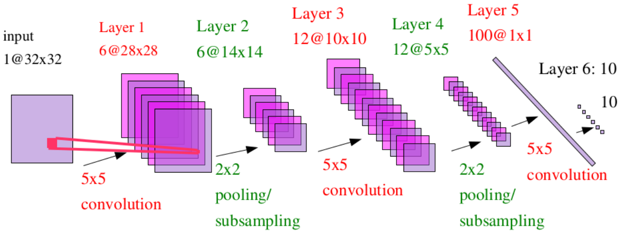
5-Predict earthquakes and climate change.


PRACTICAL DEEP LEARNING EXAMPLES
Image Classification, Object Detection, Localization, Action Recognition, Scene Understanding
English (US) → Klingon
Speech Recognition, Speech Translation, Natural Language Processing
Pedestrian Detection, Traffic Sign Recognition
Breast Cancer Cell Mitosis Detection, Volumetric Brain Image Segmentation

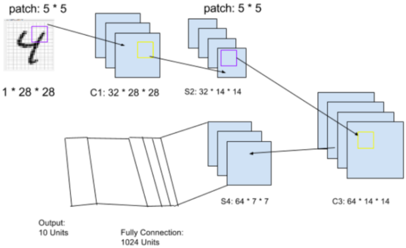
Example of application II



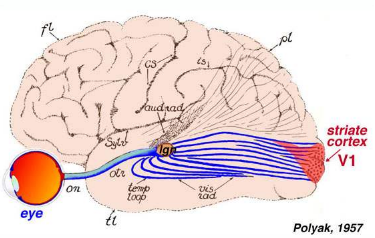

Deep neural network
input layer
hidden layer 1
hidden layer 2
hidden layer 3
output layer



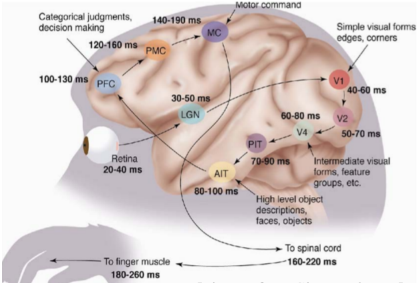
Yann Lecun, Convolutional Neural Networks, University of New York



Convolutional Neural Network for MNIST handwritten digit recognition



Visual input to the brain goes from eye to LGN and then to primary visual cortex, or area V1, which is located in the posterior of the occipital lobe. Adapted from Polyak (1957).



[picture from Simon Thorpe]

[Gallant & Van Essen]

Learning algorithms \ Gradient iterations	Accuracy with different number of gradient iterations: 20	25	100	200	500	1000
Logistic Regression			95.9%	96.32%	**96.46%**	96.46%
Multi layer perceptron with 25 hidden neurons	89.14%	90.14%	91.05%	92.02%	92.74%	**92.85%**
Multi layer perceptron 300 hidden neurons	96.28%	96.62%	98%	98.12%	98.21%	**98.22%**
Multi layer perceptron 300-150 hidden neurons			10.05%			
Multi layer perceptron 300-150-75 hidden neurons			11.35%			

Learning algorithms \ Accuracy		Accuracy
Support Vector Machine (SVM)	Linear Kernel	93.98%
	Polynomial Kernel	**98.08%**
	Gaussian Radial Kernel	94.46
Convolutional neural network (CNN)	5 epochs with two hidden layers	95.11%
	10 epochs with two hidden layers	**95.66%**

Our results on MNIST dataset

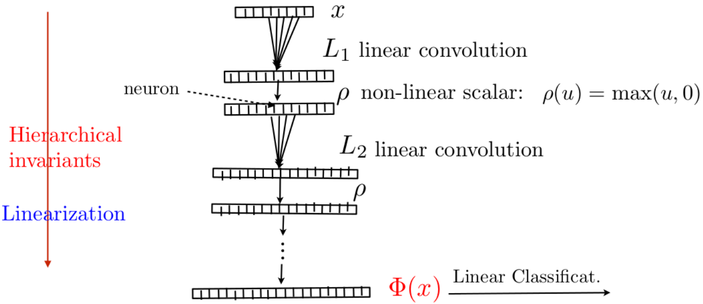
Learning algorithms \ Accuracy		**Accuracy**
Multi Layer Perceptron (MLP) [13]	4 hidden layers (2000-1500-1000-500) with **5% translation**	99.06%
	5 hidden layers (2500-2000-1500-1000-500)	98.53% after 14 epochs
Multi-Column Deep Neural Network (MCDNN) [14]		99.77%
Neural network with DropConnected [15]		**99.79%**

Benchmark results on MNIST dataset

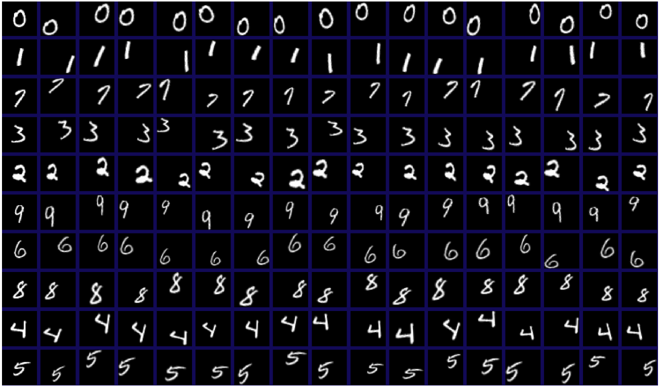
Accuracy / Learning algorithms	Accuracy on CIFAR-10
Fractional max-pooling [18]	96.53 %
Simple CNN [19]	95.59 %
Init CNN [20]	94.16%
MCDNN [14]	88.79%

Benchmark results on CIFAR-10

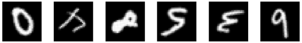
1-Fractional max pooling [18] : αxα is non integer $=>$ reduces overfitting.
2- Striding : the convolutional layer uses a filter of 2x2 and slides it over the entire image.
3- Good initialization [20] : pre-initialize weights of each convolutional layer then normalize the variance of the output of each layer to be equal one. Layer sequantial unit variance (LSUV).
4- MCDNN [14] : different way of training for each column (deep). The final prediction is the average of individual prediction of each DNN.
5- DropConnect [15] : improvement of Dropout $=>$ DropConnect sets a randomly selected subset of weights within the network.
Dropout, randomly select subset of activations and set them to zero within each layer.



Stephane MALLAT, Mathematical understanding of deep neural networks, Ecole normale supérieure



Translation phenomenon in MNIST dataset



Elastic deformation and rotation in MNIST dataset

1-There is no learning algorithm better than the other regardless context and type of data.

2-Deep learning methods are not always required to do classification.

3-Deep convolutional neural networks are able to reduce dimension.

4- Deep Convolution neural networks are able to compute hierarchical invariants of complex symmetries.

5-Deep neural networks are biologically inspired of humain cortical cortex.

6- What do next ? strong mathematical and theoretical foundation, convergence guarantee, notion of complexity and approximation
brain neuro-plasticity understanding, close relationship with particle and statistical physics.

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