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Deep learning for Arabic letters recognition

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Abstract

The main objectives of our work is using the effectiveness of the Deep learning methods for Arabic manuscript recognition.

In this work, we used Convolution Neural Networks where we train and test them using Tensorflow library that support machine learning in Python in order to obtain the required results.

Keywords: Handwriting, deep learning, Neural Networks, Convolution Neural Networks.

Résumé

Les principaux objectifs de notre travail est l'utilisation de l'éfficacité du Deep learning méthodes pour la reconnaissance des manuscrits en arabe.

Dans ce travail, jai utilisé des réseau neuronal convolutif où nous les avons formés et testés à laide de bibliothèques Tensorflow qui prend en charge lapprentissage automatique en Python afin dobtenir les résultats requis.

Mots-clés: écriture manuscrite, apprentissage en profondeur, réseaux de neurones, réseaux de neurones de convolution.

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General Introduction

Deep learning methods have proven an excellent result in the field of pattern recognition. The objective of this work is using the effectiveness of the Deep learning methods for Arabic manuscript recognition.

In many classic machine learning methods, an image is represented by a number of features. Selecting this feature is often a hard procedure because of the number of the choice to deal with. Unlike the classical machine learning methods, the deep learning (DL) can extract automatically and implicitly the feature of an image. DL deals directly with all the images contents. Thus, we decide to use one of the DL methods to recognize Arabic text manuscript. We will use of one of the well-known frameworks of DL in a real data set and discuss the results.

Chapter 1

Handwriting recognition

1.1 Introduction

Writing is one of the most important things to teach science, it is one of the oldest ways of communication. The human being used the writing by hand using many tools to communicate with each other. The handwriting texts are in all kind of books before the invention of the writing machine and computers. However, we need to use the science inside the handwritten books and documents and use the skill of handwriting of the human and its better to automate his writing by the handwriting recognition. So what is the handwriting recognition? and what is there importance, applications ??

1.2 Definition

Handwriting recognition can be divided into two categories:

- 1. On-line handwriting recognition.
- 2. Off-line handwriting recognition.

On-line recognition involves live transformation of character written by a user on a tablet or a smart phone.

Off-line recognition is more challenging, which requires automatic conversion of scanned image or photos into a computer readable text format.[17]



Figure 1.1: Handwriting recognition

1.3 Motivations of handwriting recognition

Motivated by the interesting application of off-line recognition technology, for instance the USPS (United State Postal Service) address recognition system, and the Chase Quick Deposit system, this project will mainly focus on discovering algorithms that allow accurate, fast, and efficient character recognition process works.[17]

1.4 Application

1.4.1 Bank check recognition

The Banking industry is a major consumer of handwriting recognition (HR). The most frequent use of handwriting recognition is to handle cheques: a handwritten cheque is scanned, its contents converted into digital text, the signature verified and the cheque cleared in real time, all with human involvement.

While near 100% accuracy has been achieved for printed cheques.

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Figure 1.2: Bank check industry

1.4.2 Health care

This is another industry that does well with handwriting recognition. Having ones entire medical history on a searchable, digital store means that things like past illnesses and treatments, diagnostic tests, hospital records, insurance payments etc can be made available in one unified place, rather than having to maintain unwieldy files of reports, X-rays and other papers.

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1.4.3 Legal

Few industries generate as much paperwork as the legal industry, and so handwriting recognition has multiple applications herein. Reams and reams of affidavits, judgments, filings, statements, wills and other legal documents, especially the printed ones, can be digitised, stored, databased and made searchable using the simplest of handwriting recognition readers.

1.5 Conclusion

In this chapter we had talked about Handwriting definition, it motivation and the application of handwriting. we concluded that the handwriting recognition is very useful for most our work. So how we recognize the handwriting ?

Chapter 2

Machine learning

2.1 Introduction

To make our works easier, human want to create machines has same thinking of them. He tries to create a machine that imitates humane brain and his intelligence. In 1943 Pitts McCulloch invent the first Mathematical model of neurons after that the artificial neural networks had began, then Rosenblatt created a single neuron for classification, Perceptron learning rule, Perceptron convergence theorem in 1958. So, a perceptron in context of neural networks is an artificial neuron which works similar to the biological neuron and uses weights in order to classify the inputs. Machine Learning is the core subarea of artificial intelligence.

What is the definition, process and importance of machine learning ?

2.2 Definition

A subset of artificial intelligence (AI), machine learning (ML) is the area of computational science that focuses on analyzing and interpreting patterns and structures in data to enable learning, reasoning, and decision making outside of human interaction. Simply put, machine learning allows the user to feed a computer algorithm an immense amount of data and have the computer analyze and make data-driven recommendations and decisions based on only the input data. If any corrections are identified, the algorithm can incorporate that information to improve its future decision making.[6]

Machine learning is the science of getting computers to act without being explicitly programmed.Machine learning is so pervasive today that you probably use it dozens of times a day without knowing it. Many researchers also think it is the best way to make progress towards human-level AI [2].

2.3 Process machine learning

2.3.1 Gathering Data

Once we have our equipment and booze, its time for our first real step of machine learning: gathering data. This step is very important because the quality and quantity of data that you gather will directly determine how good your predictive model can be.

2.3.2 Data preparation

Data preparation its the next step of machine learning: where we load our data into a suitable place and prepare it for use in our machine learning training.

2.3.3 Choosing a model

The next step is choosing a model. There are many models that researchers and data scientists have created over the years. Some are very well suited for image data, others for sequences (like text, or music), some for numerical data, others for text-based data.

2.3.4 Training

Now we move onto what is often considered the bulk of machine learning: the training. In particular, the formula for a straight line is y = m * x + b, where x is the input, m is the slope of that line, b is the y-intercept, and y is the value of the line at the position x.

In machine learning, there are many ms since there may be many features. The collection of these m values is usually formed into a matrix, that we will denote W, for the weights matrix. Similarly for b, we arrange them together and call that the biases.

The training process involves initializing some random values for W and b and attempting to predict the output with those values. As you might imagine, it does pretty poorly. But we can compare our models predictions with the output that it should produced, and adjust the values in W and b such that we will have more correct predictions.

2.3.5 Evaluation

Its time to see if the model is any good, using Evaluation. Evaluation allows us to test our model against data that has never been used for training. This metric allows us to see how the model might perform against data that it has not yet seen. This is meant to be representative of how the model might perform in the real world.

2.3.6 Parameter Tuning

You can improve your training by tuning our parameters. There were a few parameters there implicitly assumed in your training, and now is a good time to go back and test those assumptions and try other values.

2.3.7 Prediction

Machine learning is using data to answer questions. So Prediction, or inference, is the step where we get to answer some questions. This is the point where the value of machine learning is realized. [4]



The Machine Learning Process

Figure 2.1: Machine learning process

2.4 Importance of Machine Learning

Recent years have shown that Machine Learning can be used to automate a lot of different tasks that where thought of as tasks that only humans can to like Image Recognition, Text Generation or playing games [3].

The importance of machine learning stems from its very nature itself. Unlike conventional model, the machine learning model relies heavily on the inputs provided by the user. In the conventional model it is arguable that inputs are only accessory even though a basis to the result as the process will take place on the basis of any valid input.[8]

There is one crucial reason why data scientists need machine learning, and that is: High-value predictions that can guide better decisions and smart actions in real time without human intervention. [7]

2.5 Conclusion

Machine learning, this is what we wrote in this chapter.we've mention it process end it importance of course in handwriting. After this chapter, we must know what is the type of the ML we choose to deal with my problem of manuscript recognition ?

Chapter 3

Deep learning and CNN

3.1 Introduction

One year ago (2018), the Turing Award has been given to a godfathers of AI.Yoshua Bengio, Geoffrey Hinton, and Yann LeCun they had invented the deep learning that requires an extensive and diverse set of data contrary to machine learning that needs fewer data to train the algorithms. Deep learning is better than machine learning because in deep learning methods include multi-layer processing with less time and better accuracy performance. Sub sampling layers give better result, by use of CNN. What is the deep learning and the CNN ??

3.2 Definition of deep learning

Deep Learning a class of machine learning techniques, where many layers of information processing stages in hierarchical architectures are exploited for unsupervised feature learning and for pattern analysis/classification. The essence of deep learning is to compute hierarchical features or representations of the observational data, where the higher-level features or factors are defined from lower-level ones.[14]

3.3 Why Deep Learning?

Its probably most helpful to think of Deep Learning as the cutting-edge of the cuttingedge. ML takes some of the core ideas of AI and focuses them on solving real-world problems with neural networks designed to mimic our own decision-making. Deep Learning focuses even more narrowly on a subset of ML tools and techniques, and applies them to solving just about any problem which requires thought human or artificial.

Though traditional machine learning algorithms solve a lot of our cases, they are not useful while working with high dimensional data, that is where we have a large number of inputs and outputs. For example, in the case of handwriting recognition, we have a large amount of input where we will have a different type of inputs associated with different type of handwriting. The second major challenge is to tell the computer what are the features it should look for that will play an important role in predicting the outcome as well as to achieve better accuracy while doing so [5].

3.3.1 Difference between deep learning and machine learning:

The major difference between deep learning and machine learning is its execution as the size of data increases. Deep learning algorithms need a large of data, when the data is small those algorithms dont perform that well. [9]



Figure 3.1: Machine learning vs deep learning

3.4 Convolution Neural Network

3.4.1 Definition of convolution neural network

In deep learning, a convolutional neural network (CNN) is a class of deep learning, feed-forward artificial neural networks. Is a particular kind of a supervised multilayer perceptrons.

Convolutional neural networks (CNN) are a class of deep models that were inspired by information processing in the human brain. In the visual of the brain, each neuron has a receptive field capturing data from certain local neighborhood in visual space. They are specifically designed to recognize multi-dimensional data with a high degree of in-variance to shift scaling and distortion.[15]

3.4.2 Application

- 1. Object recognition, segmentation, detection, classification
- 2. Natural language processing.
- 3. Drug discovery-Health Risk Assessment and Biomarkers of Aging discovery.
- 4. Video analysis

3.4.3 CNN architecture

CNN architecture is made of one input layer and multitypes of hidden layers and one output layer. The fist kind of hidden layers is responsible for convolution and the other one is responsible for local averaging, sub sampling and resolution reduction. The third hidden layers act as a traditional multi-layer perceptron classifier.[15]



Figure 3.2: Convolution neural network

3.4.4 Convolution layer

Convolution layer is the core of CNN. It applied a convolution operation which takes as inputs image represent as a matrix of pixels and learnable kernel (filter) applied a calculation and then produce a result which is an image usually smaller, leading to reduce the numbers of features. As shows in figure:



Figure 3.3: Convolution layer

3.4.5 Activation functions

In a neural network, the activation function is responsible for transforming the summed weighted input from the node into the activation of the node or output for that input.

Popular types of activation functions:

- 1. Sigmoid function
- 2. Tanh function
- 3. Leaky ReLU function
- 4. ReLU function
- 5. Maxout function
- 6. ELU function ect



Figure 3.4: Some activation functions

3.4.6 RELU Layer

The Rectified Linear Unit is the most commonly used activation function in deep learning models. The function returns 0 if it receives any negative input, but for any positive value x it returns that value back. So it can be written as R(z) = max(0, z). Graphically it looks like this:

 $y = Activation(\sum (weigth \times x) + bias)$

3.4.7 Pooling layer

Pooling layer will perform a downsampling operation along the spatial dimensions (width, height). Pooling is a simple operation which consist to replace a square of pixel (usually 2^{*2} or 3^{*3}) by a single value. We can consider 3 types of pooling:

- 1. Average pooling: take the average value of the pixels in the selected square.
- 2. Max pooling: take the max value of the pixels in the selected square.
- 3. Sum pooling: take the sum value of the pixels in the selected square.

Figure 3.5: Types of pooling max, average and sum pooling

3.4.8 Fully connected layer

Fully-connected layer (FC) will compute the class scores, resulting in volume of size $[1 \times 1 \times N]$.

Where each of the N numbers correspond to a class score, such as among the N categories.

3.4.9 Cost function

A cost function can be any function that outputs scalar that quantifies the error of your neural network's performance.

3.4.10 Back propagation

Once the cost is measured, the back propagation algorithm will calculate its partial derivatives. In a CNN, the most interesting parameters are the filters in the different layers.

3.4.11 Gradient Descent

Gradient Descent finds the minimum of the cost function (used to calculate the output error) and is used to adjust the weights.

3.4.12 Stochastic gradient Descent

The stochastic gradient descent algorithm however has been shown to be faster, more reliable, and less prone to reach bad local minima than standard gradient descent .

A stochastic gradient descent algorithm [13]:

$$w_{t+1} = w_t \Delta J(z, w_t)$$

3.5 Conclusion

In this chapter we described briefly the definition of the Deep learning and different classes of the CNN. We have explained the different layer of a CNN and what are the application of a CNN. In the next chapter we will explain the implementation of the CNN for Arabic manuscript recognition.

Chapter 4

Implementation

4.1 Introduction:

In this chapter, we will explain my work in handwriting. We describe the used framework and the language used to reach our objectives. We will explain the used environment of programming for our work.

4.2 Preparation of the Implementation Environment

In preparing of the implementation environment we was installed the Anaconda distribution for Windows 7 operating system. we used the version Anaconda 1.9.7. This is the installation: https://www.anaconda.com/distribution/

4.2.1 Anaconda Distribution

The open-source Anaconda Distribution is the easiest way to perform Python/R data science and machine learning on Linux, Windows, and Mac OS X. With over 11 million users worldwide, it is the industry standard for developing, testing, and training on a single machine, enabling individual data scientists to:

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Figure 4.1: Installation of anaconda

- 1. Quickly download 1,500+ Python/R data science packages.
- 2. Manage libraries, dependencies, and environments with Conda.
- 3. Develop and train machine learning and deep learning models with scikit-learn, TensorFlow, and Theano.
- 4. Analyze data with scalability and performance with Dask, NumPy, pandas, and Numba.
- 5. Visualize results with Matplotlib, Bokeh, Datashader, and Holoviews
- [1]

Figure 4.2: Anaconda interface

4.2.2 Python language

Python is an easy to learn, powerful programming language. It has efficient highlevel data structures and a simple but effective approach to object-oriented programming. Pythons elegant syntax and dynamic typing, together with its interpreted nature, make it an ideal language for scripting and rapid application development in many areas on most platforms.

The Python interpreter and the extensive standard library are freely available in source or binary form for all major platforms from the Python Web site, https://www.python.org/, and may be freely distributed. The same site also contains distributions of and pointers to many free third party Python modules, programs and tools, and additional documentation.[16]

4.2.3 Jupyter notebook

Since 2011, the Jupyter Notebook has been our flagship project for creating reproducible computational narratives.

The Jupyter Notebook enables users to create and share documents that combine live code with narrative text, mathematical equations, visualizations, interactive controls, and other rich output. It also provides building blocks for interactive computing with data: a file browser, terminals, and a text edit.

4.2.4 Colab

Definition

Colab (short for Colaboratory), a tool for machine learning education and research, created as a Google research project. Creating and running Jupyter Notebook on Colab is super easy and its free. You can save your notebook to Google Drive or GitHub and even train your deep learning on GPU.[10]

Advantages of colab

- 1. Map your Google Drive
- 2. Work with your files transparently in your computer
- 3. Reduce manual interactions on every run
- 4. Don't compile libraries on every run, just once.
- 5. Clean your root folder on Google Drive
- 6. Copy your data sets to VM local file system to improve training speeds.
- 7. Work with the config files directly from your computer.
- 8. Get your trained weights directly synced in your computer in real-time during the training

4.3 Dataset preparation

Our data is a numeric data .. that contain 16800 caracter writing by right-hand. Each characters is writing from alef to yeh ten times on 2 forms. The database is partitioned into 2 sets: a training set (13,440 characters to 480 images per class) and a test set (3,360 characters to 120 images per class).[11] In future work, we plan to work on improving the performance of handwritten Arabic character recognition.

4.4 Deep learning with Tensorflow

4.4.1 Definition of tensorflow

TensorFlow is a machine learning system that operates at large scale and in heterogeneous environments. TensorFlow uses dataflow graphs to represent computation, shared state, and the operations that mutate that state. It maps the nodes of a dataflow graph across many machines in a cluster, and within a machine across multiple computational devices, including multicore CPUs, generalpurpose GPUs, and custom-designed ASICs known as Tensor Processing Units (TPUs).[12]

4.4.2 Pre-preparation

Though we already installed Tensorflow in anaconda, that we was spent lot of time in it installation too but we had discovered Colab that made my implementation easier.So these is the steps that we was followed:

1. First we open Colab

2. Then we chose my work notebook

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Now, we'm ready to train and test my Arabic character dataset in Colab

4.4.3 Start training with Tensorflow

After we was accessed to our dataset in my google drive, we will explain our train with the Convolution neural network method after we import Tensorflow as 'tf'. In this CNN we have twelve layers: One Input layer of course, two Convolution layer, two Pooling layer, two Normalization layer, two Dropout layer and three Fully connected layer.

Input layer:

The input layer is the first layer in the neural network. It contain one gray level image. The size image is (32^*32) .

Tow Convolution layer:

- 1. The first convolution layer Has eighty kernels, the size of each one is 3*3. The activation function of this convolution layer id the most popular function "ReLU" and it has a normalize activation function.
- 2. The second convolution layer has sixty four kernels that also have size of (3^*3) .

Tow pooling layer:

As we said, there is different pooling layer and we used the max pooling. So:

 After the first convolution layer, we apply the max pooling in all the eighty matrices result and the size filter of pooling is also (3*3).

For every one in the eighty features, we segment it with the filter pooling and we take the max value to put it in a new small filter.

2. In the second pooling layer we have apply the max pooling size (3*3) sixty four times after the second convolution layer.

Tow normalization layer:

After each pooling layer we have a normalization layer too.

Three fully connected layer:

- After all input layer, convolution layer, pooling layer, normalizing layer and the flatting of features we have connected layer that use ReLU activation function to new vector (1024*1). This is first full connected layer.
- The second fully connected use ReLU activation function too, to an author new vector (512*1) also.

 The third and the final fully connected as out put layer apply Softmax activation function to final vector (28*1).

Tow dropout layers:

each tow layers Are removing, or dropping out, inputs to a layer, which may be input variables in the data sample or activations from a previous layer.

In the final we use 'sgd' as optimizer an 'Crossentropy' as a loss function for reducing the erreur.

4.5 Results

Activation functions (Conv1, Conv2,Full1,Full2)	Optimization method	Loss	accuracy
(ReLu,ReLu,ReLu,ReLu)	SGD	0.33	93%
$({ m ReLu, ReLu, ReLu, ReLu)}$	ADAM	22.18	3.57%
(Sigmoid,ReLu,ReLu,ReLu)	SGD	1.26	80.39%%
(Sigmoid, Sigmoid, ReLu, ReLu)	SGD	1.17	65.60%
(Sigmoid,Sigmoid,ReLu,ReLu)	ADAM	22.26	3.75%

Table 4.1: Comparison of the different configuration of parameters and the obtained accuracy

4.6 Discussion

In the table of results, we note that the latest values of accuracy are who contain "ADAM" optimizer. we noted also that all that we change the activation function "relu" by "sigmoid" function the accuracy will decrease. So,we concluded that:

- 1. ReLU is the activation function for a Convolution neural network that made a higher accuracy.
- 2. The optimization method that made a higher accuracy is: SGD optimizer.

4.7 Conclusion:

In the last chapter we tried to explain the implementation of convolution neural network in the arabic latter dataset. we was made the combination of different parameters for give different results then we discussed it.

General Conclusion

In this thesis we use to learn the different concept attached with deep learning and exactly the Convolutional Neural Network (CNN). The Deep learning field is very growing in this recent year and takes many interest in the research and industry and as we know this year the Turing Award goes to people who work on this field.

As an exploratory study, in our work we have used the CNN to recognize the Arabic manuscript letters as a start to the word manuscript recognition. We have choose a very well known dataset to train our CNN then test it using the test dataset inside it.

The first step of the work was the understanding of the difference between a simple Deep Neural Network which is a neural network with many layers that takes the hole image as it is and return the output desired. A neural network is based on the perceptron concepts which was detailed in our thesis.

The special Deep Neural Network used in this work as mentioned is the CNN. The CNN differ from the simple Deep Neural network in the layers of the network because they have a different aspect and they are adapted to the use of images.

To implement the CNN we have used the very well known framework of the giant Google which is Tensorflow by using the Python Languages which is used also in the field of data science this last years. The environment used to run our experiments is the Colab environment. The Colab environment offer remotely access to power-full machine with an adapted GPU (Graphical Processing Unit) to Deep learning.

The experiments we performs by changing the parameters of the CNN perform show

that Deep learning and specially CNN have the ability to recognize the Arabic manuscript letters with very good accuracy and gives us the idea to extend the work by using words and sentences instead of letters.

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