

DEEP LEARNING FRAMEWORK USED IN PARKINSON'S DISEASE ANALYSIS

Key words: *deep learning framework, parkinson's disease, machine learning*

Açar sözlər: *Dərin öyrənmə çərçivəsi, Parkinson xəstəliyi, Maşın öyrənmə*

Ключевые слова: *структура глубокого обучения, болезнь Паркинсона, машинное обучение*

Introduction

Data collection is paramount to investigate and understand a given research subject. In Biomedical Engineering (BE) the data collected of physiological signals assist in the detection of diseases, treatment and rehabilitation [1] [2]. These data collections can come from a variety of characteristics, performed in short and/or long periods, medical imaging, genome mapping, monitoring of various symptoms, Brain Machine Interfaces (BMI), etc., and contribute to an increasing and complex volume of information [3][4].

The devices used to examine bio signals in BE can help to understand the symptoms of PD, like electrocardiography (ECG), electroencephalography (EEG), electromyography (EMG), etc. PD is an illness that remains incurable and present a diverse of motors and non-motors symptoms as tremor, problems in gait, speech, slow movements, depression, and so on [5]. The data collected of all these symptoms can be very huge.

Besides the large volume of data generated, another problem to analyze the data is the noise which is a common type of disturbance present in the signal that impairs its analysis [1], and manual interpretation under the conditions cited would be fatiguing and unfeasible. In this sense, the use of computational tools to process data, extract characteristics, classify or group are complex and essential tasks to aid in quality decision making.

There is a growing demand for efficient methods that can handle with a large volume of data and extract valuable information. Deep Learning (DL) is an area within Machine Learning (ML) that has been applied in the automated tasks of speech recognition, imaging, bio signal, natural language processing, and so on [3].

Some recent works illustrate the application of DL techniques and their efficiency in relation to other methods. The study [6], which proposes the extraction of information and classification of human emotions by breathing, used Deep Learning and Sparse Auto-Encoder; the work reached an average accuracy of 80.22%. In this other work [7], the automatic classification of polyps via colonoscopy images compared a traditional ML method, with Convolutional Neural Network (CNN), a DL technique, and obtained about 92% accuracy versus 81% using Support Vector Machine (SVM).

In [8] the authors used CNN to analyze sets of retinal images as input and produce segmented images as output and obtained 96% accuracy. Another interesting work using DL was shown in [9], which uses electrocardiogram (ECG) data and automatically classifies it for the patient's cardiac conditions, the accuracy reached was about 98%.

The article about the segmentation of radiographic projections of pedicular screws by CNN was shown in [10] and obtained 83% accuracy using real x-rays. In another paper described by [11], DL was used to identify, segment and classify cell membranes and nuclei of breast cancer images, reaching 96% accuracy.

Finally, the work [5] focused on predicting PD severity using patient voice monitoring in a Deep Neural Network (DNN) with 81.6% accuracy; and the study [12] performed segmentation of the brain structures by CNN to treat the symptoms of PD and dystonia.

It can be noticed that there are several works using DL in situations where there are complex data to be analyzed and that demonstrate high accuracy indices of solution about the proposals investigated. However, this work aims to identify the most used Deep Learning frameworks, the main features, and the methods supported by each one. Furthermore, verify if there are studies using some DL framework applied to Parkinson's disease surveys.

Materials and methods

In order to understand the basic concepts and the state of the art of the investigated theme, it was seeking the answers to the following questions:

- What are the most used deep learning frameworks in Biomedical Engineering?
- Have deep learning frameworks been used in research with Parkinson's disease?
- What are the main features of these most used frameworks?

In order to reach the objectives, exploratory consultations were carried out in at least five databases from different journals: Web of Science (multidisciplinary like sciences, arts and human), PubMed (predominance of biomedical literature), IEEE Xplorer (literature focused on engineering and computation), Scopus (science, technology and medicine) and ScienceDirect (science, health and technology).

N°	String description
1	"deep learning framework" AND "biomedical engineering"
2	"deep learning framework" AND "Parkinson's disease"
3	"caffe framework" AND "biomedical engineering"
4	"Keras framework" AND "biomedical engineering"
5	"Theano framework" AND "biomedical engineering"
6	"TensorFlow framework" AND "biomedical engineering"
7	"Cognitive Toolkit" AND "biomedical engineering"
8	"caffe framework" AND "Parkinson's disease"
9	"Keras framework" AND "Parkinson's disease"
10	"Theano framework" AND "Parkinson's disease"
11	"TensorFlow framework" AND "Parkinson's disease"
12	"Cognitive Toolkit" AND "Parkinson's disease"

Table 1 illustrates the twelve search strings created in order to query the databases:

The strings were searched in titles, abstracts, and keywords, without temporal restriction and considering conferences, journals, books and others. Later, the abstracts were analyzed, the relevance of these, and in the works found was aimed to understand which were the most used deep learning frameworks, their characteristics and, especially, if there are applications with Parkinson's disease.

Results

Table 2 lists the number of jobs found related to each search string. After the analysis of the abstracts, exclusion of the repeated, inaccessible and out of scope works, 15.7% of the 191 findings were used. Subsequently, with the separated articles focused on the issues raised. In addition to the articles, some information was also taken directly from the official web pages of the framework developers.

String	IEEE Xplorer	Science Direct	Scopus	PubMed	Web of Science	Total by string	Used
1	2	30	125	1	0	158	26
2	0	4	7	0	0	11	0
3	0	3	3	1	0	7	2
4	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0
6	0	2	2	1	0	5	1
7	0	2	1	0	0	3	1
8	0	1	0	0	0	1	0
9	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0
11	0	1	0	1	1	3	0
12	0	2	1	0	0	3	0
Total Papers						191	30

Table 2: Relation of paper found.

Deep Learning (DL) – is a branch that is part of the ML methods, being derived from the artificial neural networks (ANN), and it have the purposes of modeling structures of several layers of processing of linear and non-linear transformations. It is possible to use the central processing units (CPUs) and graphics processing units (GPUs) to calculate large and complex data [1][2].

For this task, there is a parallel computing platform along with an application programming interface (API) called CUDA, which was developed by Nvidia and enables developers to use the GPU for graphical processing in their applications by using some frameworks from DL [3].

Figure 1 illustrates the generic idea of the architecture of a DL network. Usually, it has its entries started with random values, and then the data is propagated and computed to the output. The output is then compared to the desired output, the calculated error returns to input to the point of optimizing the sample and sorting it correctly. This is the proper technique for analyzing large volumes of data [13].

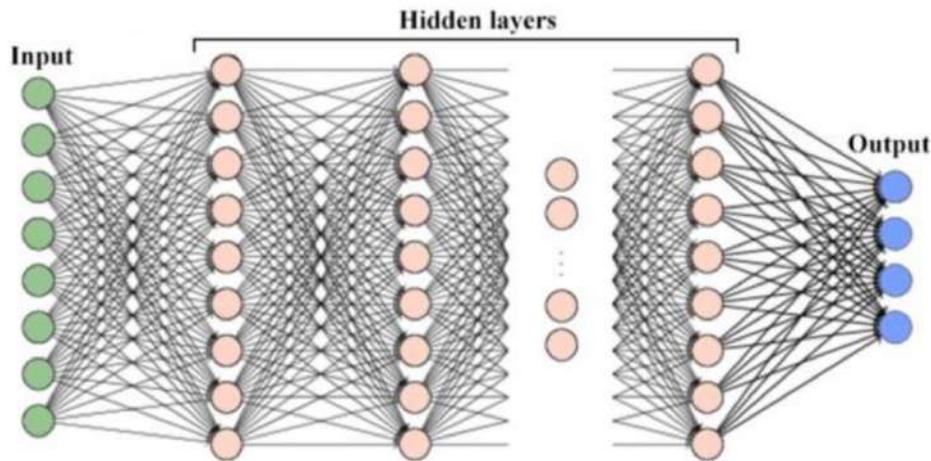


Figure 1: Deep learning architecture idea

There are some DL architectures that have been used extensively: CNN – it is a kind of multi-layer feedforward network widely used in digital image processing and analysis; Autoencoder - used to learn representations, dimensionality reduction, and data compression; Deep Generative Models (DGM) - used to learn data distribution using unsupervised learning; Recurrent Neural Network (RNN) - these networks maintain previously hidden layer processing memories, and used to process sequences and text mining [1][2][4].

These architectures have a high level of mathematical complexity and therefore difficult to implement. In this sense, several companies have been working to develop frameworks that contain the main architectures of Deep Learning, thus facilitating their learning, configuration and various applications of these tools in large volumes of data [3][14]. Some of these Deep Learning frameworks were listed in Table 3.

The frameworks cited in Table 3 are open source, which allows the free use of it. The articles found were referenced according to the use of each framework, and the Cognitive Toolkit and Theano framework were not used directly by any of the works found in this review.

The question regarding the work related to PD, in Table 3, resulted in only two research studies: [12] makes use of the Caffe and [5] TensorFlow framework.

Framework	Developer	Description	Languages supported	CUDA support	Methods supported	Papers found	Papers related with PD
Caffe	Berkeley AI Research (BAIR)	Specialized in image recognition, easy to switch between CPU and GPU by single flag, used in cluster or mobile devices. Caffe can process over 60M images per day with a single NVIDIA K40 GPU, and it works in large-scale industrial applications in vision, speech, and multimedia. Installation in Ubuntu, OS X, Windows, Docker, etc [15].	Python, C++, MATLAB	Yes	CNN, RNN	[13] [12] [16] [17] [18] [19] [20] [21] [22] [23] [15]	[12]
Cognitive toolkit (CNTK)	Microsoft	Implements stochastic gradient descent (SGD, error backpropagation) learning with automatic differentiation and parallelization across multiple GPUs and servers. Supports 64-bit Linux or Windows operating systems. It can use the ONNX that allows developers to move models between frameworks such as CNTK, Caffe2, MXNet, and PyTorch [24].	Python, C#, C++, Java	Yes	CNN, RNN, DGM	[25]	-
Keras	François Chollet	It is a high-level API to build and train DL models with an interface optimized for common use cases. It is possible to run TensorFlow, CNTK, or Theano by Keras. It is able to use the CPU and GPU. Support iOS (Apple system), Android, Web, etc [26].	Python, R	Yes	CNN, RNN, DGM	[5] [27] [28]	-

TensorFlow	Google	Numerical computing library that uses data flow charts. It uses XLA, a linear algebra compiler that speeds up the execution of the TensorFlow code in one or more CPUs, GPUs, TPUs (microprocessor to accelerate Intelligence Artificial). Used on servers, desktop, mobile device and others. Supported by the systems Linux, macOS, Windows, Android [29]	Python, C/C++, Java, Go, R, Julia	Yes	CNN, RNN, DGM	[14] [5] [27] [30] [31]	[5]
Theano	University of Montréal	Evaluate mathematical expressions involving multidimensional arrays efficiently, CPU and GPU support, detect and diagnose many types of errors, installation on Ubuntu, Mac OS, Windows, etc [32].	Python	Yes	CNN, RNN, DGM	[15]	-

Table 3: Features of most used and known deep learning frameworks

Discussion and Conclusion

Deep Learning frameworks are widely being used because they have presented a variety of applications, robustness, efficiency, performance, and accuracy better than traditional ML techniques. Although they are on the rise, the papers related to DL remains without expression in the vast and diversified scientific databases.

Another important point illustrated in Table 3 elucidates the greater use of the Caffe framework, despite the limitation of not having DGM methods, followed by TensorFlow and then by Keras. It is worth remembering that through Keras is possible to execute TensorFlow, Theano and Cognitive Toolkit.

However, Caffe presents a high performance in the execution of tasks, presents compatibility with well-known languages, and serves both the scientific and industrial areas [15]. Caffe despite to be like all frameworks shown here about support CUDA API, Caffe can process 60M images per day with a single NVIDIA K40 GPU.

In the work [13] was implemented a CNN using Caffe framework. It used six different CNN set up to do the segmentation of specific regions affected the brain by PD. The study proposed a Hough-CNN that shown better segmentation in poor images shape. It used a Tesla K40 GPU from NVidia to process 2D, 2.5D and 3D images demonstrating the robustness of Caffe framework.

The study [14] implanted a Neural Network applied to voice data of patients with PD, using the TensorFlow through Keras framework to classify PD in severe and non-severe. The study showed better accuracy than traditional methods despite having done a simple configuration of the network with 16 input, 3 hidden layers with 10, 20 and 10 neurons each one, and 2 neurons at the output.

When focusing on a specific area, such as studies of Parkinson's disease, it is clear that there is a large gap in the use of these types of frameworks to try to solve different tasks. The investigation of this specific area that is PD together with an optimized, robust, and well-known DL framework like Caffe could be promising.

In the future, researches may be carried out for more databases focused only on the DL and DP in order to further clarify this gap and, consequently, to understand other research opportunities in the area.

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Parkinsonun xəstəlik analizində istifadə olunan dərin öyrənmə çərçivəsi

Xülasə

Biotibbi Mühəndislikdə fizioloji siqnalların toplanmış məlumatları xəstəliklərin aşkarlanmasına, müalicəsinə və reabilitasiyasına kömək edir. Xəstəlik olan Parkinson xəstəliyində (PD) simptomları bilmək və anlamaq xəstənin həyatına daha yaxşı şərait yaratmağa kömək edir. PD müxtəlif simptomlara malikdir və məlumat toplama mürəkkəb və həcmli məlumatlar yaradan müxtəlif imtahan və monitorinq dövrləri tərəfindən həyata keçirilmişdir. Bu mənada bu tip məlumatları analiz etmək üsulları təkmilləşdirilmiş və bəzi inkişaf etdiricilər ayrıca bir alətdə fərqli metodları özündə cəmləşdirən Dərin Öyrənmə (DL) çərçivələrində süni intellektin istifadəsinə investisiya qoymuşlar. Bu araşdırmada əsas töhfələr Dərin Öyrənmə termini, ən çox istifadə edilən çərçivələrin əsas xüsusiyyətlərini konseptual hala gətirmək və anlamaq və hər birinin dəstəklədiyi metodları qeyd etmək idi. Bundan əlavə, PD məlumatlarını emal etmək üçün DL istifadə edilmişdirsə, izah edin.

Система глубокого обучения, используемая в анализе болезни Паркинсона

Резюме

В биомедицинской инженерии собранные данные физиологических сигналов помогают в выявлении заболеваний, лечении и реабилитации. При болезни Паркинсона (БП), которая является неизлечимой болезнью, знание и понимание симптомов помогают улучшить условия жизни пациента. БП имеет множество симптомов, и его сбор данных проводился различными экзаменами и периодами мониторинга, что позволило получить сложные и объемные данные. В этом смысле методы для анализа этих типов информации были улучшены, и некоторые разработчики инвестировали в использование искусственного интеллекта, в частности в среды глубокого обучения (DL), которые содержат различные методы в одном инструменте. В этом обзоре основной вклад состоял в том, чтобы осмыслить и понять термин «глубокое обучение», основные характеристики наиболее часто используемых структур и указать методы, поддерживаемые каждым из них. Кроме того, выясните, использовался ли DL для обработки данных PD.