Predictive Analytics in Healthcare System using Deep Learning Approach

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Abstract: During centuries, and since the appearance of science, the world of healthcare has known a noticeable positive progress. Not only on the researches and inventions term, but also on the intention's term. The first aim was to save people's lives and heal patients, from the illnesses which was known back then. After a period, and thanks to the improvement that was known in the field of both science & research, scientists level up to another aim which is preventing. This means, that they were looking for solutions by which doctors will be able to predict a possible disease infection, thus the possibility to prevent an exposure to a disease was being possible. Therefore, saving people's lives had a new road which needed to be developed with the cooperation of other domains, so a system can be put into action to realize this new mission. The purpose of this article, is to present a system which can predict a possible illness as well as suggest the adequate treatment for the patient's case. This includes discussing the system's main objectives and characteristics, in addition to describing its architecture main layers.

1 INTRODUCTION

Whith the evolvement of the information technology, many domains has been interested in using the knowledge provided by the IT to improve their services.

As shown in the Figure 1 and based on Mc Kinsey's report about the economic impact of IoT by 2025, the impact will reach the 6.2$ trillion.

So as we can see, on the presentation the higher percentage goes to the healthcare domain, which means that 43% of this domain is impacted by IoT. In the second rank, comes the industry with 34%, other domains such as transportation, agriculture, urban infrastructure, security and retail come next with 15% and finally the 7% left is reserved for Iot itself.

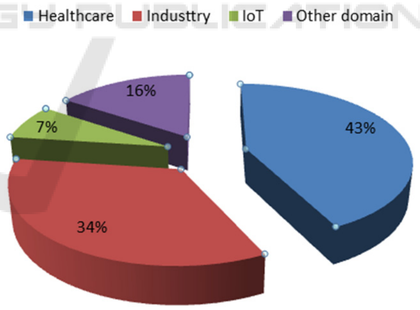

Figure 1: Percentage of impacted domain by IoT in 2025

As the world is progressing on every single way, the information has been the center of the interest of many sciences.

Therefore, many techniques have been developed. Such as, deep learning, which is known also as deep structured learning/ hierarchical learning.

It's a sort of machine learning methods that is based on learning data representations.

So, we have now two huge concepts: Information Technology & Deep Learning, if we succeeded to combine them, this will for sure make an impressive

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impact on getting the right results in the healthcare field.

It will increasingly improve the healthcare for both individuals and communities, that's because the deep models enable the discovery of high-level features, improve performances and provide additional understanding.

So we will be presenting an overview of deep learning, the most trending architectures and frameworks that have been introduced in recent years. Then, we will proceed to describe our contribution through presenting an intelligent system which was conceived to provide predictive analytics in healthcare, using deep learning approach. After that, we will denote this system's ability to predict the probability for a patient to develop a specific disease as well as to offer a personalized treatment.

2 STATE OF ART: DEEP LEARNING

Deep Learning architectures have gained more attention in recent years compared to the other traditional machine learning approaches. Deep learning refers to a set of machine learning techniques that learn multiple levels of representations.

Its architectures consist of multiple processing layers: the input layer, several hidden layers, and an output layer. Each one contains neurons.

In figure 2, the input image is convolved with three trainable filters and biases to produce three feature maps at the C1 level. Each group of four pixels in the feature maps are added, weighted, combined with a bias, and passed through a sigmoid function to produce the three feature maps at S2. These are again filtered to produce the C3 level. The hierarchy then produces S4 in the same way the S2 was produced. Finally, these pixel values are rasterized and presented as a single vector input to the "conventional" neural network at the output.

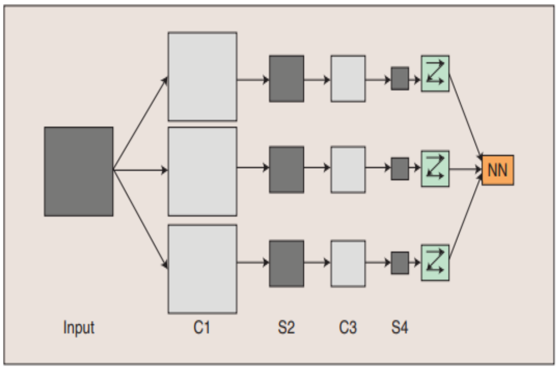

Figure 2: Conceptual example of convolutional neural network

The table 1 below presents a brief overview of the most trending architectures that have been introduced in deep learning in recent years:

Table1 : The most trending architectures introduced in Deep Learning last years

Model	Learning Model	Typical input data	Description
CNN	Supervised	2D	• Convolution layer take biggest part of computations ▪ Every hidden convolutional filter transforms its input to a 3D output volume of neuron activations ▪ Inspired by the neurobiological model of the visual cortex Application example: Alzheimer diagnosis
RNN	Supervised	Serial, time series	▪ Useful in IoT applications with time-dependent data ▪ All the layers share the same weights ▪ Application example: Human behavior monitoring

LSTM	Supervised	Serial, time series, long time dependent data	▪ Modeling the hidden state with cells that decide what to keep in memory given the previous state, the current memory and the input value. ▪ Good performance with data of long time lag
RBM	upervised Unsupervised	Various	▪ A variant of Boltzmann machines, which is a type of stochastic neural network ▪ Useful if it is required to model probabilistic relationships between variables 777 Application example: Human activity recognition
DBN	upervised, Unsupervised	Various	▪ A special BM where the hidden units are organized in a deep layered manner, only adjacent layers are connected, and there are no visible–visible or hidden–hidden connections within the same layer. Application example: cancer diagnosis
AE	nsupervised	Various	▪ Trained to minimize the reconstruction error ▪ Mostly used for representation learning ▪ Same number of input and output Application: 3D brain reconstruction

The trending of Deep Learning architectures imposes the introduction of Deep Learning frameworks. They help easily create and test various deep architectures. In this section, we list some of these frameworks:

- H2O: Use Java as a core language and can interface with R, Python, Scala, Java, JSON, and CoffeeScript/JavaScript. H2O is used for critical applications like predictive maintenance and operational intelligence. H2O includes many common machine learning algorithms, such as generalized linear modeling.12
- Tensorflow: It is an open-source software library Developed with C++. Tensorflow's platform includes interfaces for Python, Java, C, and C++. Tensorflow supports both large-scale training and inference. It can be a support to visualize networks. At the same time, it is flexible enough to support experimentation and research into new machine learning models and system-level optimizations. (9)
- Caffee: The framework is a C++ library with Python and MATLAB bindings for training and deploying general purpose convolutional neural networks and other deep models efficiently on commodity architectures. It powers ongoing research projects, large-scale industrial applications, and startup prototypes in vision, speech, and multimedia. 11
- Theano: is a free Python symbolic manipulation library. It has specifically been utilized for the gradient-based methods such as deep learning that require repeated computation of the tensor-based mathematical expressions. It offers for implementing standard and non-standard deep architectures. 10

3 SYSTEM ARCHITECTURE

Because prevention is better than cure, the main purpose of the system is to predict complexity and pathologies that any person can have in the near future. More importantly, the system will not only predict the diseases, but also propose the suitable treatment.

3.1 System Characteristics

3.1.1 Description

The main actors of the system are the patient and the doctor. The interaction of those two will be as follows:

- The doctor can have access to the system in order to consult the patient case permanently, or if a patient asks for help. The doctor must also intervene if he is notified for a probable disease for a patient.
- The patient interacts with the system to solicit a doctor's help or to follow the doctor's guidelines. The patient must be connected to IoT to collect information about the environment around it.

Example: EHS, Electronic Health Records

3.1.2 Characteristics

The system will:

• Be a source of almost everything that doctors will need about the patients.

• Be hosted in cloud.

• Include security measure to ensure that the access to the patient information will be limited to only the person whom the patient grants overt access.

The analyst will be in real time.

The figure 3 illustrates the interactions between the doctor, the patient and the healthcare system.

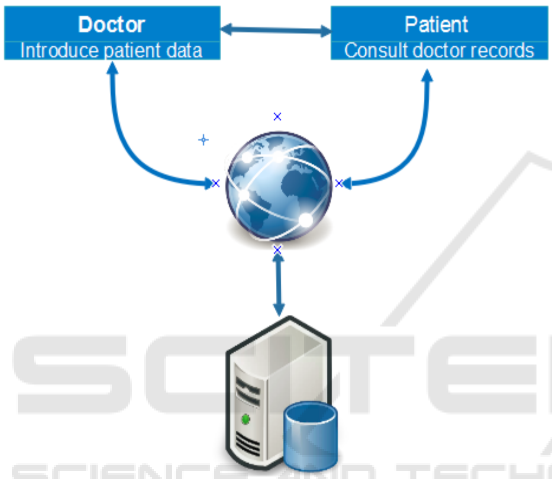

Figure 3: Schema of communication healthcare system

3.2 System Architecture

To describe the system's architecture, we should introduce the two layers of the system which are:

- Data collection & Treatment of Data layer.
- Predictive Analysis layer.

The figure 4 represents the layers of our predictive analysis system healthcare.

3.2.1 Data Collection & Treatment of Data

A formal data collection process is necessary. It ensures that the data is defined and accurate. The healthcare data coming from EHS, biomedical database and public health are one of the used IoT equipment. They have been enhanced not only on the availability and traceability but also on the liquidity of data.

Once the data is collected, the phase of treatment starts. This process is as important as the data collection process. To realize this huge task, we resort Spark. Apache Spark is an open-source platform for large-scale data processing that is well-suited for iterative machine learning tasks. It can be interactively used to quickly process and query big datasets.

3.2.2 Predictive Analysis Module

As mentioned above, our system's main goal is prediction. So, the predictive analysis module is the master of the system. At this level, the system analyzes the current state in addition to the medical history to make predictions about possible future illnesses.

To produce a tangible product that provides right decision with accessible and useful information, we need to choose the correct architecture and the adequate frameworks to the nature of the disease.

Identification, description, and quantification of the components of a disease cycle are foundational to plant disease.

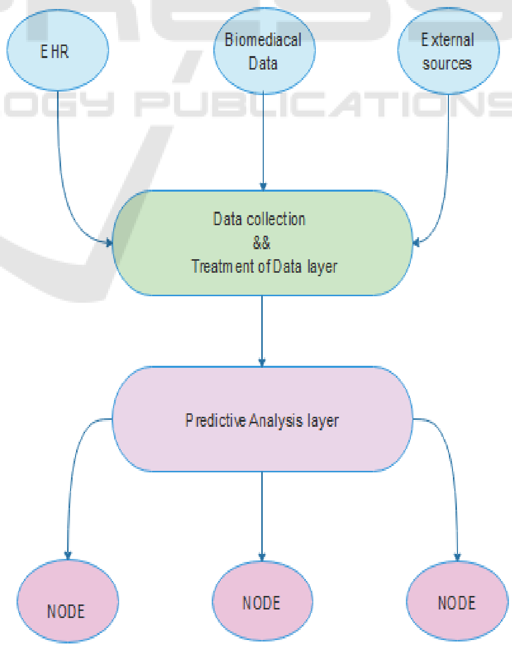

Figure 4: Architecture of the predictive analysis system-Health Care Application

4 CONCLUSION

The health industry has progressed due to the development of new computer technologies which gave birth to multiple fields of research. In this article, we are proposing a system that will help in reducing the death rate by providing preventive pre-treatment so that the patient is cured even before falling ill. The future vision is to implement this predictive system based on real data

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