Deep Learning and its Benefits in Prediction of Patients Through Medical Images

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Deep Learning and its Benefits in Prediction of Patients Through Medical Images

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***Abstract*—The ability to comprehend the medical images and make prediction on diseases, significantly depends on any medical doctors' experiences. In the wireless medical communications, this process is not developing effectively, and significant tasks are required to make it of high accuracy. Hence, advanced methods are required for accurately diagnosing the various diseases and in the shortest time. Use of deep learning techniques can be a proper solution due to their suitable accuracy in the image segmentation giving rise to pathologic prediction by considering the medical images. In this paper, we employ the deep neural network for predicting the various cysts that can be exist in the human's brain. This intelligent method can estimate and predict the types of brain cysts by the provided medical images. The experimental results demonstrate the well-performance of the presented method to be used for predicting the patients with affections by the help of scanned medical images.**

***Index Terms*—Brain cysts, classification, deep neural network (DNN), disease, medical images, prediction.**

I. Introduction

Over the last decade implantable medical devices that provide wireless connectivity with the systems and outside world, get the attention of researchers. However, it is a big challenge to provide a confident environment between these inside and outside devices [1]. Since all the operations and performances are done in a remote access environment, providing smart approach and technique becomes significant for handing these wireless communications.

On the other hand, medical imaging is fastly evolving and developing day by day that results in suitable image segmentation and can be used in the clinical applications. However, the medical image segmentation is not straightforward due to insufficient edge, boundary information, sizes, and shapes [2]. Hence in order to diagnose and detect the type of a proper malady, an accurate and strong approach is required.

Recently, deep neural networks (DNNs) have proved their advancement in computer vision and medical images [3]. DNNs are one part of the artificial intelligence and are appropriate techniques for being used for the image segmentation [4]–[7]. These type of networks learn the patterns as the doctors do. The main difference between the doctor and DNN is the learning way that DNNs require large amount of data to learn. Once the DNNs are trained, these networks can diagnose patients, faster develop drugs, and predict the next pandemic [8].

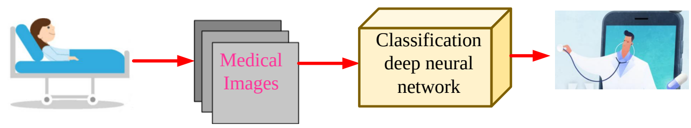

Fig. 1. The use of classification DNN for predicting diseases.

In an even more advanced structure, it is also possible to vision a monitoring system for remotely acquired images, where doctors should not visit patients staying at their home. Figure 1 presents such a healthcare system based on the wireless communication between the sick person's home and clinic, where the patient is monitored by the medical doctor. Such an arrangement benefits to both the patients well-being but also strongly reduces the healthcare system costs.

In this paper, we present the practical use and benefits of the classification DNN in predicting the type of illness and cysts that can be existed in the brain of any humans. This approach is useful as it reduces the dependency to any medical doctor's distinguishing and can be used effectively in the wireless medical communications.

The medical images of various existed cysts in the brain are prepared and then the accurate DNN is constructing using the presented procedures. The practical simulated results demonstrate the efficiency of the presented classification DNN in medical filed where by providing any scanned medical image, the type of brain cyst can be predicted by the DNN.

This paper is organized as follows: Section II provides the typical theory, definition, and construction of the classification

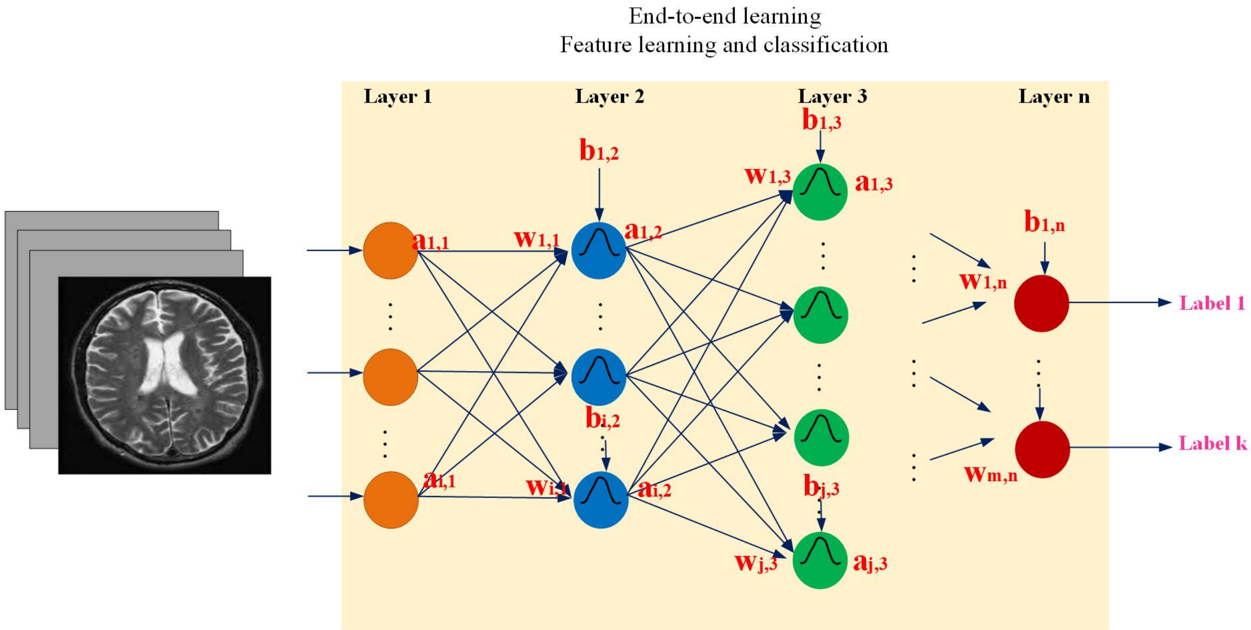

Fig. 2. A comprehensive overview of deep learning and its application in classifying images.

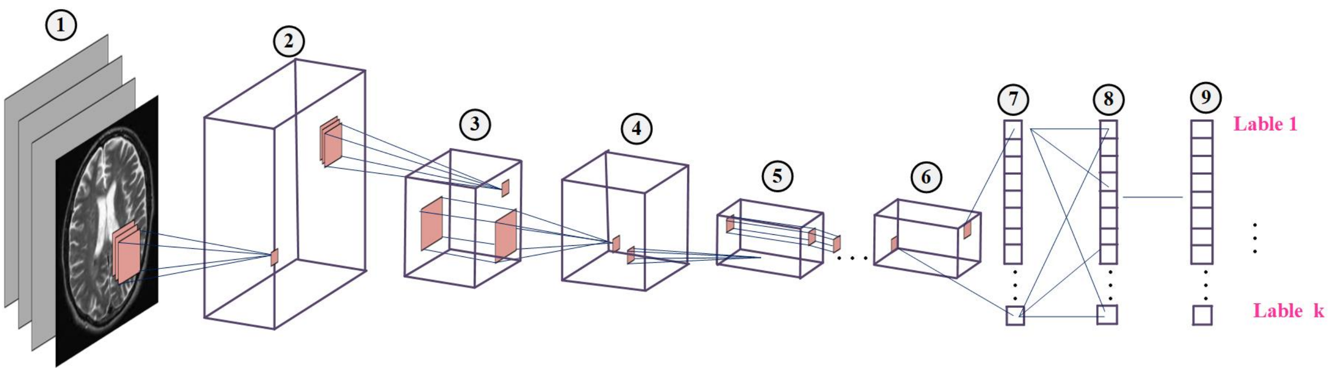

Fig. 3. Image segmentation process using the DNN.

DNN. The practical implementation and simulation results are presented in Sec. III. Finally, Sec. IV concludes this paper.

II. Classification DNN in a Nutshell

This section presents the generation and training procedure of the convolutional neural network (CNN) for deep learning classification. Firstly, the general explanation around this type of network is provided and then the application of classification DNN for predicting the type of brain cysts through medical images is illustrated. The classification DNN is the network for predicting the label of pictures. It refers that to which group of labels, the inserted image belongs to.

A. Theory of CNN based deep learning classification

In wireless medical communications, providing precise models for diagnosing the diseases is crucial. The CNNs play an important role in deep learning and they can be applied in different areas of medical science for image recognition and prediction. They can be beneficial in radiotherapy, radiological diagnostic, and scanned-image interventions. Figure 2 presents an overview of the classification DNN for classifying the medical images and predicting the type of cysts using the scanned images.

In any networks, weights (w) and biases (b) are basic units where each neuron is connected to another neuron in the sequential layers. In expression (1), the general definition of output responses is defined where weights are applied for controlling the connection between two neurons and biases are the additional input into the next layer. Each of these parameters can be defined with the neurons where the optimal number of these neurons can be determined with the *rule of thumb* method.

$$\text{output} = \sum(\text{weight} \times \text{input}) + \text{bias} \qquad (1)$$

The practical procedure of image segmentation is shown in Fig. 3 and the detail steps of each process is explained in Fig. 4.

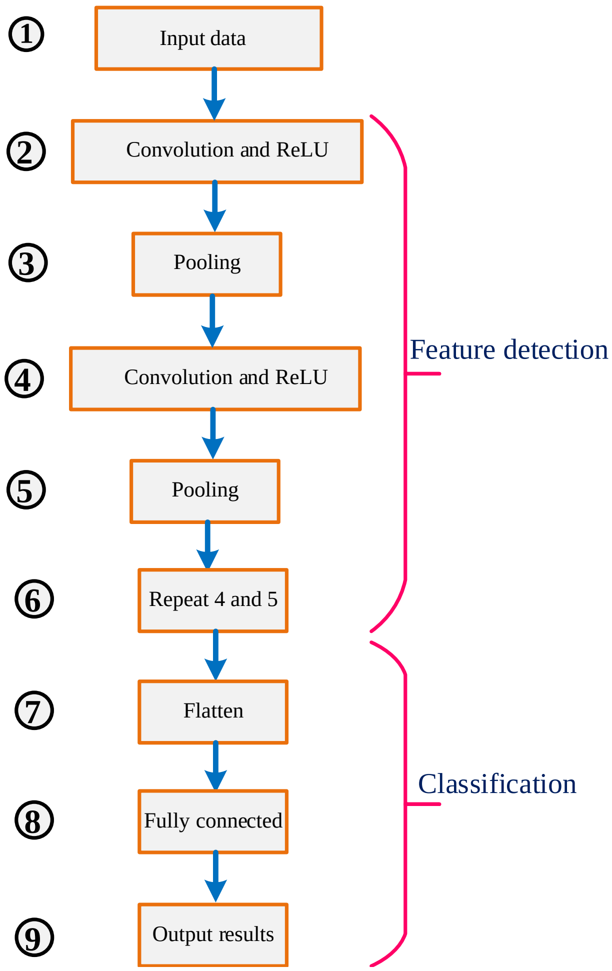

Fig. 4. Step descriptions of Fig.3.

The first layer is the 'Image Input Layer' where the size of image is determined. The second step is defining the 'convolutional Layer' with the 'Rectified Linear Unit (ReLU)' layer to define the *'filterSize'* to be used along the images and speeding up the network training, respectively. The ReLU layer is as a 'Batch Normalization Layer' to normalize the activations and gradients propagating (Step-2). The other following layer is the 'Pooling Layer' that provides the maximum values of rectangular regions of the inserted input data (Step-3). Applying convolutional, ReLU, and pooling Layers are continued into partitioning the images into small parts (Steps 3-6). Afterwards, 'flatten layer' is employed for converting all the received data into one-dimensional set of data. This task is useful for generating long feature vector of data (Step-7). After collecting data in to one vector, 'fully connected layers' are applied for connecting the neurons to all the neurons in the previous layers (Step-8). The final layer is the 'classification layer' for providing the probabilities return to each class input. This classification is performed using the 'softmax' activation function and is computing the loss (Step-9).

B. Classification DNN for predicting the brain cysts

As previously defined, the classification DNN is used for predicting that to what category (i.e., label) the input image belongs to. In the medical filed, the scanned images are provided for predicting and diagnosing the diseases. The cysts are pockets of membranous tissues that are useless for the body and sometimes very dangerous. Hence the type, location and sizes of these cysts must be determined carefully in order to specify the type of illness.

The brain is one of the important part of body that controls all the body and tissues. Hereby, any unnecessary conditions can damage the duty of the brain. The brain may face with the listed cysts that can cause the problems and must be diagnosis correctly to do the treatment by the medical doctor.

Various types of brain cysts are as following:

- Arachnoid cyst (leptomeningeal cyst)
- Colloid cyst
- Dermoid cyst
- Epidermoid cyst
- Pineal cyst
- Brain abscess
- Neoplastic cyst

For this case, various scanned pictures of each type of diseases must be gathered and with this input data the classification DNN is trained for our problem. As Fig. 2 demonstrates, label 1 to label k donate to cysts of arachnoid cyst, colloid cyst, dermoid cyst, epidermoid cyst, pineal cyst, brain abscess, and neoplastic cyst, sequentially. Afterwards by applying the presented procedures and steps, the related classification DNN is trained and constructed. For this case, the input data is divided into training, validation, and testing data sets with the rate of 70%, 15%, and 15%, respectively namely as: imdsTrain, imdsValidation, and imdsTest. The classification DNN is trained using the training data as (2) presents.

$$\text{net} = \text{trainNetwork}(\text{imdsTrain}, \text{layers}, \text{options}) \quad (2)$$

After training the network, the accuracy of the network must be calculated. Hence by using (3), the output responses of the trained network using the imdsTest must be achieved. The accuracy is the difference derivation between the predicted data (Y_{Pred}) using the imdsTest and the actual output responses without using the network Y_{Test}.

$$Y_{\text{Pred}} = \text{classify}(\text{net}, \text{imdsTest}) \quad (3)$$

III. Simulation Results

In this section the practical results of the image segmentation using the presented classification DNN is explained.

As the primary step of DNN development is providing the data image, we provide various data from [9]–[11]. Then, we specify the size of image as 28-by-28-by-1 that represents height, width, and the channel size, respectively. Afterwards, the various layers are substituted sequentially as: *imageInputLayer*, *convolution2dLayer*, *batchNormal-*

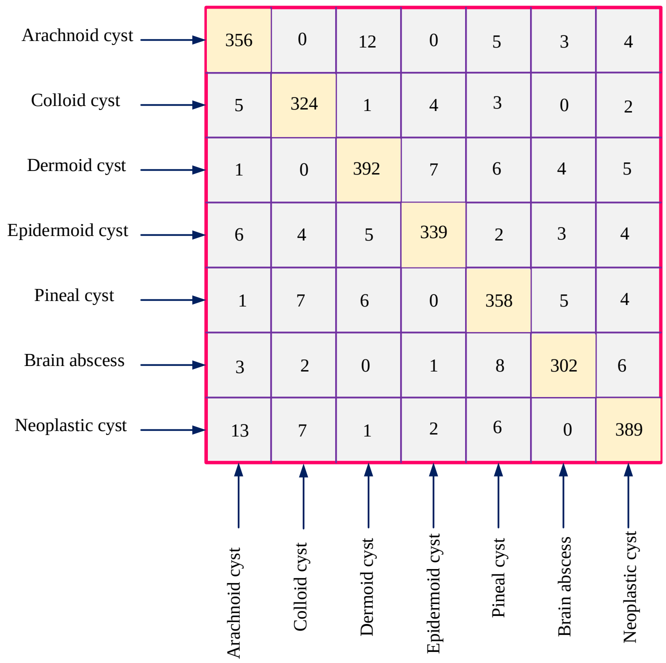

Fig. 5. Confusion matrix of the trained DNN.

izationLayer, *reluLayer*, *maxPooling2dLayer*, *fullyConnectedLayer*, *softmaxLayer*, and *classificationLayer*. The classification DNN is trained and constructed with the accuracy of 98.4% where each layer consists of 150 neurons.

Figure 5 presents the confusion matrix of the constructed classification DNN for distinguishing various existed cysts in the brain. This matrix demonstrates the suitable prediction of the DNN in various diseases through the medical images.

IV. Conclusion

Diagnosing the existed cysts in the human body like the brain, requires the experiences of medical doctors. To reduce the dependency and to be used in the wireless medical communications, intelligent methods are required that result in accurate modeling and disease prediction. This paper presents the efficient approach for predicting various existed cysts in the brain using medical images. The presented method is based on employing the classification DNN that results in 98.4% accuracy. Hence, by providing any medical images that are related to the brain, the trained DNN can determine and make prediction on the type of cysts and can pave the way of doctors in the treatment and cure processes.

Acknowledgement

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