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Prediction Alzheimer's disease from MRI images using deep learning

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***Abstract*— Alzheimer's is one of the diseases that are the most publicized type of dementia. Alzheimer's disease will be born every 3 second the world. Previous research shows that early prediction of AD in the medical field for reduced cost of treatment and time of it. To this end, construct an efficient prediction system for AD, which is the goal of this paper, often reduces time to treatment, medical errors, and overall healthcare cost. We used Deep Learning to predict and diagnose AD and for this reason using python code in Colaboratory as platform environments. In particular, we used 2D CNN and vgg16 to achieve the research goal, we used experiments conducted on MRI images from Kaggle dataset. Our experiment achieved accuracy of 67.5% for 2D CNN algorithm, while the vgg16 algorithm achieved accuracy of 70.3%. We conclude by showing that deep learning can improve the prediction AD and using algorithm vgg16 is better than 2D CNN.**

I.Introduction

AD is a Widely neurodegenerative disease that means permanent and advanced memory loss, resulting in the decline of intellectual and social skills [1]. According to the Centers for Disease Control and Prevention, Alzheimer's is one of the diseases that are the most common type of dementia. Its disease happens as advanced with mild memory loss orientation, language understanding, and judgment [2][3]. Sometimes possibly leading to loss of the ability to Continue in conversation and respond to the environment [4]. It seriously affects a person's ability to do the daily activities. The most common case of dementia is late in a person's life [5] it effects 65-year-old patients and increases with their age [2]

According to the 2018 World Alzheimer's Disease report [6], Alzheimer's disease will be born in a new case every 3 second in the world. In 2018, about 50 million people suffered from Alzheimer's disease. By 2050, the number will be increased to become 152 million people will suffer Alzheimer's disease, which is meaningful three times that of the present number of Alzheimer's. That means an estimates number of affecting people will double for the next two decades, so that one of 85 persons will have the AD by 2050 [5] In 2014, the 5 million American suffer from Alzheimer's disease and this number is expected to increase into nearly three time to become 14 million people by 2060 [7].

AD is not only the most Pervasive form of dementia, affect 14% of those over 70 years old and increase as the population ages, but it is also one of the most cost diseases in the United States [8] The costs of treating Alzheimer's disease are huge and expect in 2040, these costs will be between $379 and more than $500 billion annually [9].

Nowadays, there is no cure for AD, But the initial indication is necessary for effective treatment. The detection for AD is still a challenge. Artificial Intelligence based medical diagnosis is a new technique in the medical field, helping pathologists to identify the disease (medical imaging) without need to work with glass, but they are using pixels. We are using deep learning algorithms and machine learning algorithms to diagnose the diseases. Machine learning is one of techniques used to detect the disease. Brain images are used primarily and mostly to detectable Alzheimer's disease by Magnetic resonance imaging (MRI) [10].

Prediction from MRI image is one of the methods ML uses to detect the patients if they have that disease or not.

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We will be using it to predict Alzheimer's disease early and help patients who have this disease to do some exercise or take some drugs to slow it down. We can use the scanned images to send into any place in the world for testing by using the Artificial intelligence approach.

Our paper is organized as follows; The second section describes the related work and limitations in the Alzheimer's Disease field. The third section presents the Methodology; we discuss the data collection, processing of the dataset and the CNN algorithm and vgg16 which was used. The fourth section is discussed, finally the section provides a conclusion and future research.

II. Related work and limitations

In their study, the authors of [2] proposed the combined happens in which CNN, and BDN (Hybrid) and comparative with general methods like SVM, CNN, DBN, and MLP. They used a dataset from the database of the ADNI which contained a magnetic reverberation imaging (MRI) images axial with 256 ×256 and electroencephalography (EEG) flag. They classified the dataset in four severity based on conditions like normal, Alzheimer's disease, Huntington's disease and minor Alzheimer's disease, after that they applied the experiments on the MATLAB 2017 as a platform. Their experimental results appear that the new method offers improved classification accuracy compared to general methods with accuracy 92.5%.

The experiment has been conducted by [3] comparing the many machine learning approaches, such as RCNN, Support Vector Machine (SVM) and Faster RCNN, which are used to diagnose Alzheimer's. They used a dataset from database ADNI which contains two files Train and Test each file within a total of around 5000 images which divide into the severity of Alzheimer's. Their experiment results appear the Faster RCNN algorithm in the train and test is very quickly and more efficient by comparison with another algorithm. Also, authors in [11] compared many ML classifiers in MRI and analyzed the use of SVM with different multimodal scans for classifying patients with AD/MCI and healthy controls. They used a dataset from the National Alzheimer's Coordinating Center which contained 120 subjects. Their experiment result shows SVM is more efficient and accurate than other classifiers in the prediction.

The authors of [5] focuses to development an adaptable deep learning-based system for early diagnosis of the AD by using unsupervised learning. They used a dataset from the ADNI which contain 210 subjects and applied a 3D convolutional neural network (3D-CNN) pre-trained by 3D Convolutional Autoencoder (3D-CAE). Their experiment result appears to show the out-performance of the proposed DSA-3D-CNN with accuracy in AD/MCI has 100%.

According to the authors of [12] showed a preview of recent trends in classify of different brain imaging modality and how computer-aided diagnostics of Alzheimer disease and mild cognitive impairment (MCI). They used dataset from database ADNI which contain 214 subjects. They suggest a new algorithm by updates architecture of a CNN for binary classification, they divided it into three class AD/MCI/NC, the 3D volumes of hippocampal ROIs and explore fusion of two methods sMRI and DTI available for the same group of patients. Their experiment results appear to achieve scores of accuracies higher than 90%.

According to the authors of [13] recommended using unsupervised Convolutional Neural Networks because there often starting the issue that labeled data is often not enough to learn the filter in CNNs. They focus on the problem of not enough labels data and propose a fully unsupervised deep learning technology for AD diagnosis. That contains two parts. First, PCANet for achieving. Secondly, they address the unsupervised classification method that is based on k -means to achievement. They used a dataset from ADNI and contained 1075 subjects. Their experiment results appear the best prediction with the results for AD vs. MCI with accuracy 97.01%.

The authors of [14] suggested a new classification technique by propose a deformation-based machine learning method for preference of AD and prediction of MCI-to-AD, they used dataset from ADNI database which contain 427 subjects. Their experiment results appear to have better efficacy on both classification and prediction of AD, with 96.5% accuracy.

The author of [15] intended to create a method for evaluating a deep learning algorithm to predict the final clinical diagnoses in patients who undergo 18F-FDG PET of the brain. They used a dataset from ADNI database which contained 1921 imaging studies, 899 patients. Their experiment results appear to show that the new algorithm achieve an area under the ROC curve of 0.98 (95% confidence interval. Also, authors of [16] proposed a three-stage clustering the efficient the DBSCAN and the OPTICS, when combine with SFC and DFC features and using the matlab, they used a dataset from ADNI database which contained 132 patients. Their experiment results appear all algorithms are effective, but the OPTICS is the best and gives the (95.46%).

The majority of previous works were focused on using ADNI databases which contain small dataset, we will use another database from 2aggle which have more dataset. In general, the classification of these images can be applied

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to the whole brain, we can use Deep neural networks (DNN). In particular, the convolutional NN (CNNs) have become popular now. Also, most papers used 3D CNN while our dataset contained 2D images with (black and white color), so that we used in our paper 2D CNN, after that we applied the vgg16.

In this paper we aim to study the main objective to show how to predict Alzheimer's disease from MRI image 2D CNN and Vgg16. We will prepare this paper dataset from Kaggle which is largest dataset science community to help using code and dataset.

III. Methodology

To achieve our goal in this research, we used an online dataset from kaggle. However, we used algorithms 2D CNN and vgg16 to classify AD dataset. The overall framework of the research method is shown in "Fig. 1".

Next, our method presentation in four subsections starting with the AD dataset collection section. In the second subsection, some functions as preprocess steps which applied. After that, deep learning algorithms. Finally, the Decision making about the best algorithm which we found after we compared the results.

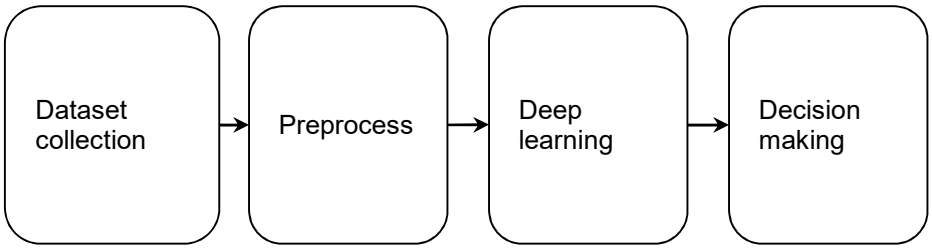

Fig. 1 the framework of research methods.

A. Dataset

We downloaded a dataset from Kaggle, which is largest dataset science community to help using code and dataset. Our experiment used data of 6400 MRI with patients who suffered disease or not, we can find these datasets from the link https://www.kaggle.com/tourist55/alzheimers-dataset-4-class-of-images.

After we downloaded dataset from kaggle, the dataset contain MRI images divided in four class of image; the first class is nondemented to person who not having Alzheimer's disease, the second class is moderate demented to person who having Alzheimer's disease in the start, third the mild demented to person who having more than the part two and still remember something, and the final part very mild demented to person who having high degree of Alzheimer's disease.

All these classes are divided into two files, the test file which contains four folder nondemented, moderate, mild and very mild another file is the train file which also contains four folder nondemented, moderate, mild and very mild. all datasets MRI images which find are removed noise.

B. Preprocessing

We preprocess our dataset to achieve high accuracy. We are using a manual preprocessing by combining image who have Alzheimer's in same folder, which is a moderate, mild and very mild in the first folder and rename it with demented, after that we also compining another folder contain image to person who does not suffer with Alzheimer's with folder nondemented.

We build this process to achieve a new dataset divided in two part the first part is demented person who having Alzheimer's disease and the second part is nondemented person who not having Alzheimer's disease.

B. 1. 2D CNN dataset preprocessing

In the first algorithm, we used these two parts to divide into testing dataset and training dataset. The part test dataset is containing two class with nondemented with 640 MRI image and demented 639 MRI image. The second part is train dataset contain two class nondemented with 2560 MRI image and demented with 2561 MRI image. We showed the number of MRI images dataset in the final phase which was used in the table 1.

Table 1	shows the number of MRI images dataset which was used.	
Dataset	Dementia	Non-Dementia
Train	2561	2560
Test	639	640

B. 2. Vgg16 dataset preprocessing

We used the same dataset, but we combined all images

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which have dementia in the same folder. It is not divided into tests and trains. The dataset is containing 3200 MRI image dementia. Also, we combined all images which have not dementia in the same folder. It is not divided into tests and trains. The dataset is containing 3200 MRI image dementia. We showed the number of MRI images dataset in the final phase which was used in the table 2.

Table 2	showed the number of MRI images dataset in the final phase.	
Dataset	Dementia	Non-Dementia
6400 MRI	3200	3200

The "Fig 2" is appearing the MRI image brain to patients demented with patients who suffered Alzheimer's disease, which is the brain contains two the black space in the Middle of the brain, the "Fig. 3" is appearing the MRI image brain to patients nondemented with patients who not suffered Alzheimer's disease, which is the brain does not contain any black space in the Middle of the brain.

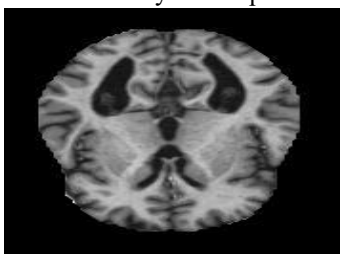

Fig. 2 the image has demented.

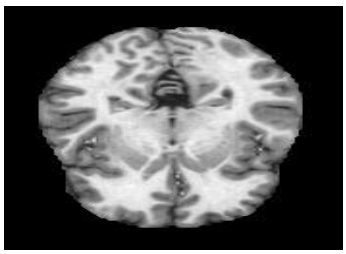

Fig. 3 the has not demented.

C. Convolutional Neural network

c. 1. 2D CNN algorithm

We use Google Colaboratory as a platform to build CNN code by using python language. In this work we use 2D convolutional neural networks with little different configurations and compared them. The base building block of the used networks consists of 2 consistent operations: 2D convolution, batch normalization as shown in "Fig. 4".

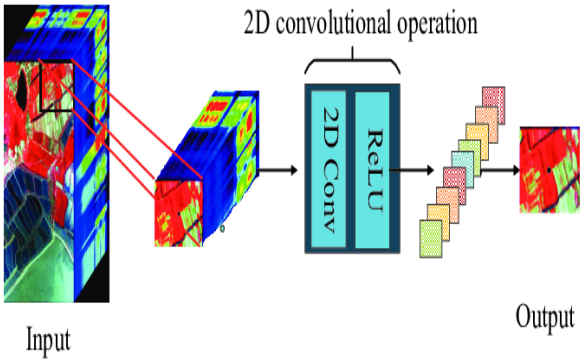

Fig 4 Main convolutional block of the proposed network architecture.[17]

Each convolution layer contains convolution 2D and max pooling 2D, and ends with a flatten operation, after which the outputs of the pipelines are concatenated and are passed to the fully connected layer. This fully connected layer follows with a relu layer and the softmax layer. finally, which produces the network output.

c. 2. Vgg16 algorithm

We use Google Colaboratory as a platform to build Vgg16 code by using python language. In this work we use several five convolutional neural networks with little different configurations and compare them. The first two convolutional contains two filters and the last three convolutional contains three filters. All the convolutional end with pooling after end the convolutional, we build three Dense in the end illustrated in "Fig. 5".

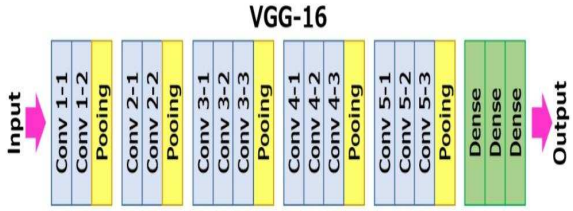

Fig. 5 Main convolutional block of the proposed network architecture [18]

D. Result

In the experiment, the dataset divided into training and testing data using 2-fold cross-validation. Finally, use the 2D CNN code to predict Alzheimer's disease.

After we apply the CNN algorithm and find the accuracy 67.5 %. We use the rule of the Precision, Recall

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and F1_score to find it. We use the code python to find which in the patients have Alzheimer's disease dataset with precision was 50%, recall 59%, F1 score 55%, while in the patients have not Alzheimer's disease dataset precision 51%, recall 42%, F1 score 46%. The table 3 shows the results in precision, recall and F1_score.

Table 3	shows the results in precision, recall and F1_score when applied 2D.		
Support	Precision	Recall	F1_score
Having Alzheimer	0. 50	0.59	0.55
Not have Alzheimer	0.51	0.42	0.46

Next, we applied Vgg16 in a dataset divided into Demonted and NotDemonted data. Finally, used the Vgg16 CNN code to predict Alzheimer's disease. After we apply the Vgg16 CNN algorithm and find the accuracy 70.3%

E. Discussion

According to the World Health Organisation, there were approximates In 2018, about 50 million people from all people world suffered from dementia. By 2050, the number will be increased to become 152 million people. AD is one of the dementia diseases that can cause a lot of things to happen as progressive with mild memory loss orientation, language understanding, and judgment. Sometimes possible leads to loss of the ability to carry on conversation and respond to the environment.

Previous research shows that faster prediction of AD is very significantly affected in the medical field for helping physicians' to make the decision, reducing the overall healthcare cost and patients' health and life. Limited research had focused on constructing an efficient prediction system for AD using a deep learning approach in 3D for predicting and diagnosing AD. Thus, this research aims to propose an efficient system for predict and diagnose AD in 2D approach.

Our dataset which is contained in black and white color, so that we used two dimensional techniques (2D). When we apply the 2D CNN, we use the two layers in the CNN algorithm. We apply many tests of our dataset and find many accuracies, finally, we depend on high accuracy.

First, we apply the adam as optimization, we use many different numbers in epoch, we try with 5, 10, 15, 20, 25, 30 in all this epoch the accuracy is not more than 49.9%. Also, we used another optimization nAdam and using many different numbers in epoch, we try with 5, 10, 15, 20, 25, 30 in all this epoch the accuracy is not more than 49.9%. Also, we used another optimization Adadelta and using mny different numbers in epoch, we try with 5, 10, 15, 20, 25, 30 in all this epoch the accuracy is not more than 56%. Also, we used another optimization RMSProp and using many different numbers in epoch, we try with 5, 10, 15, 20, 25, 30 in all this epoch the accuracy is not more than 60%.

Finally, we used SGD as optimization and using many different numbers in epoch, we try with 5, 10, 15, 20, 25, 30 in all this epoch the accuracy is higher in the 24 epochs with accuracy 67.5% as we show in “Fig. 6”.

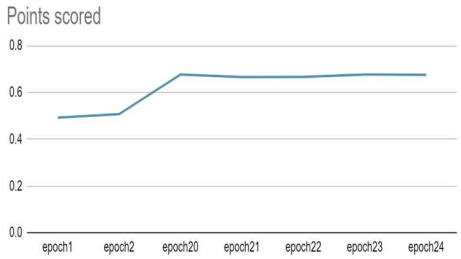

Fig. 6 shows the accuracy in 2D CNN algorithm.

After that, we apply VGG16 Code which has five convolutional and in final three Dense. Thus, this research aims to propose an efficient system for predict and diagnose AD in Vgg16 approach. When we apply the Vgg16 CNN, we use the five layers in the CNN algorithm. We apply many tests of our dataset and find many accuracies, finally, we depend on high accuracy.

we used RMSprop (lr=0.0001) as optimization and using many different numbers in epoch, we try with 5, 10, 15, 20, 25, 30 in all this epoch the accuracy is higher in the 8 epochs with accuracy 70.3%.

F. Conclusion and Future Work

Alzheimer's disease is one of the diseases that are the most publicized type of dementia. Its disease happens as advanced with mild memory loss orientation, language understanding and respond to the environment and leads to loss of the ability to carry on a conversation. AD is a widespread neurodegenerative disease**,** there is no cure for AD, but its initial indicator is necessary for effectiveness treatment. Because detection for AD is still a challenge, the use of a deep learning-based system helps to detect the AD.

After we apply the CNN algorithm in 2D and find the accuracy of 67.5% of the computer to predict Alzheimer's disease, and know if the machine prediction will be correct. After that, we apply vgg16 and find the accuracy

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of 70.3% and this allows the computer to predict Alzheimer's disease, and know if the machine prediction will be correct.

We find that applying the Vgg16 in the image is better to use artificial intelligence techniques to detect and predict Alzheimer's disease from MRI images using python code. Our contributions, we will collect real dataset from the Jordanian hospitals and do some preprocessing to prepare data to apply CNN algorithms to build a prediction model to Jordanian hospitals.

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