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Diagnosis of Glioma, Menigioma and Pituitary brain tumor using MRI images recognition by Deep learning in Python

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Abstract

Medical image processing is a very difficult and new field. One thing they do in this field is analyze pictures of people's brains to look for signs of tumors. They use a special computer program to help with this. This paper talks about a new way to use the program to find brain cancer early by looking at the texture of the tumor. This paper explains how we can find and understand brain tumors using special pictures called MRI scans. We use computer programs to help us do this. First, we find the tumor, then we separate it from the rest of the brain, and finally we measure how big it is. We can also figure out how serious the tumor is by looking at different kinds of tumors. To make it easier for people to use, we made a special program in a computer language called COLAB for python codes about using CNN network for deep learning. We tested this program on 8 patients and learned a lot about their tumors. In this work, many innovations have been made in coding and detection methods, and it can be observed that the results have been presented with 100% accuracy compared to previous works, and the error rate is so low that it can be ignored.

Keywords: Brain tumor, MRI, Detection, Analysis, Deep learning, CNN neural network, Python

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1. Introduction

Brain tumors are a heterogeneous group of neoplasms that threaten human health, well-being and life. Early detection and treatment of brain tumors are essential to assess the potential malignancy of the tumor, prevent further growth of these abnormal cells and save lives. Early and accurate detection of brain tumors using magnetic resonance imaging (MRI) can significantly improve the diagnosis and prognosis of patients. MRI is a key imaging modality for diagnosing brain tumors, providing detailed cross-sectional images of the brain. Traditional methods for classifying and detecting brain tumors on MRI images rely on human assessment, which can be costly and inconsistent. Although people can identify tumors manually, the process is error-prone and time-consuming [1-6].

The standard approach in many image processing applications involves extracting important features from image data, allowing the machine to provide representation, interpretation, or insight scenes. Addressing the low accuracy of traditional brain tumor detection methods, this study proposes a computational approach for detecting brain tumors in MRI using advanced image processing techniques and a probabilistic neural network (PNN) method based on neural networks (NN) and our previously developed brain tissue segmentation. This study proposes practical applications of artificial neural networks (ANNs) to improve existing diagnostic methods, as ANNs are currently an important research area in medicine, especially in radiology, cardiology and oncology. In this study, a computer-aided diagnosis (CAD) system was developed using ANN to detect and classify brain tumors based on magnetic resonance (MR) images, determining the optimal ANN type and activation function for image recognition. The purpose

of this study is to segment and classify brain tumors using MRI images using a deep neural network architecture with seven layers for classification. The study applies modified image segmentation methods to detect brain tumors in MRI scans and proposes a modified probabilistic neural network model based on learning vector quantization for automatic classification of brain tumors [7–10].

Automation of tumor detection has long been in demand due to the shortage of qualified Radiologists in this field. The introduction of computer-aided diagnostics and biomedical informatics has greatly benefited neuro-oncologists. Machine learning algorithms have recently been used to process medical images and data, offering superior results compared to manual tumor diagnosis methods, which are time-consuming and prone to human error. Computer-based tools have been proven to provide better results than traditional manual diagnostic methods [11-12].

Biomedical advancements are crucial for detecting and treating life-threatening diseases, including brain tumors. Early detection and treatment are essential to prevent further growth of abnormal cells and save lives. Magnetic Resonance Imaging (MRI) scans are used to detect brain tumors, and accurate analysis of these scans is vital for identifying the presence of a tumor. Image processing plays a significant role in the early detection of diseases like breast, lung, and brain tumors, enabling timely and appropriate treatment. Current cancer diagnosis methods rely heavily on visual examination, which can be tedious, subjective, and inconsistent due to variations between observers. MRI is a key imaging technique for diagnosing brain tumors, and early detection is crucial to assess the potential malignancy of the tumor. Deep learning algorithms, such as artificial neural networks, offer an efficient and effective approach to image classification for tumor diagnosis. Tumors are abnormal masses of cells that disrupt normal tissue function and can be detected through imaging techniques like MRI, which provide detailed cross-sectional images of the brain [14-17].

We present a new approach called Multi-CNN, which combines multimodal data fusion and convolutional neural network algorithms for brain tumor detection. By extending 2D-CNN to multimodal 3D-CNN, this approach can accurately localize brain lesions based on various features in 3D space [18–20].

Deep learning algorithms, such as artificial neural networks, offer an efficient and effective approach to image classification for tumor diagnosis.

2. Classification and Epidemiology

2.1. Brain tumor and its types

Brain tumors are abnormal growths of cells within the brain, which can be either benign or malignant. Benign tumors are non-cancerous and tend to grow slowly, often causing symptoms due to their size and location within the brain. Malignant tumors, on the other hand, are cancerous and can grow and spread rapidly, posing a greater risk to the patient's health. Both types of tumors can cause symptoms such as headaches, seizures, vision or hearing problems, and changes in behavior or cognitive function. Tumors are generally categorized in 15 types [43]:

- Gliomas, glioneuronal tumors and neuronal tumors
- Ependymal tumors
- Choroid plexus tumors
- Embryonal tumors
- Pineal tumors
- Cranial and paraspinal nerve tumors
- Meningiomas
- Mesenchymal, non-meningothelial tumors
- Chondro-osseous tumors
- Melanocytic tumors
- Hematolymphoid tumors
- Histiocytic tumors
- Germ cell tumors
- Tumors of the sellar region
- Metastases to the CNS

2.2. Scanning brain utilizing MRI

MRI is a key tool for detecting and characterizing brain tumors, providing detailed images for treatment planning. Advanced techniques like diffusion-weighted imaging and fMRI offer insights into tumor malignancy and impact on brain function. MRI plays a crucial role in brain tumor diagnosis and monitoring, improving treatment outcomes. It is a non-invasive method that identifies abnormalities and provides information on brain structure and function. Advanced MRI techniques like fMRI enhance our understanding of brain functions. Biopsy and pathological analysis are necessary to diagnose the type of brain tumor in patients.

3. Methods and Materials

The structure and framework of this work are aligned with the standards of international journals to accurately present and describe the validity of the proposed claim in this research step by step so that the reader can properly understand the details of the work. The MRI dataset utilized in this study was obtained from the Tehran Faculty of Medical Sciences and the affiliated hospital of the medical Faculty. Among the 200 MRI images included for work, 12 images were selected for training purposes using the proposed method.

The proposed method involves several steps, starting with the conversion of input MRI images into grayscale. Subsequently, a pattern is generated, and correlation calculations are performed to detect the location of tumors. The proposed method also includes the classification of brain tumor information, such as tumor location, type, and degree of progression. This classification process is carried out using the input MRI images that have undergone grayscale conversion, pattern generation, and correlation

calculations. The brain tumor segmentation and training framework of the proposed method are illustrated in Figure 1.

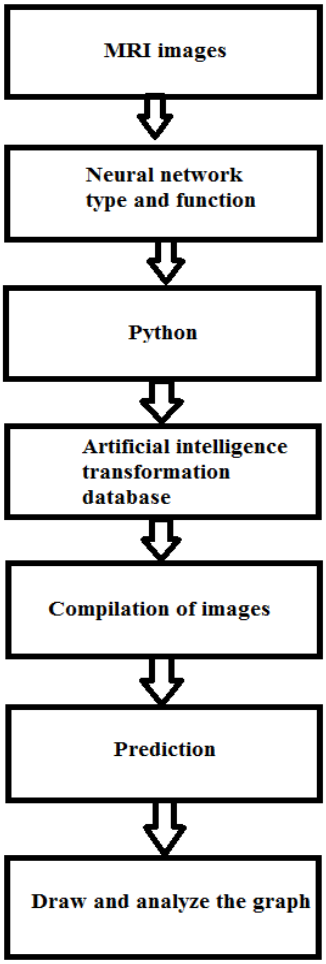

Figure 1. Structure of Methodology

3.1. Neural network type and function

The CNN neural network is one of the state-of-the-art networks in neural network design. In this section, by reviewing several topics and materials in the field of deep learning, with the help of several complementary points that have resulted from research and coding during network learning, which are very important, have been addressed. This type of network has been formed through trial and error, accuracy in design, experimentation, and implementation using several new functional types and materials that have not been done before in other matters, and the programmer's accuracy in designing and building the network can be clearly seen in the results. One of the most up-to-date methods of data analysis and review in the world in the field of artificial intelligence is the use of deep learning. This discussion is currently much studied by scientists and programmers in the field of artificial intelligence and neural network. With a more detailed look, it can be seen that the use of artificial intelligence is currently an interdisciplinary perspective that can be used to do different things in the field of study and research.

For analysis in the field of artificial intelligence, you can examine the neural network, which includes different types. One of the most important parts in topic analysis using neural network is deep learning. Deep learning is done using the CNN network, which can be designed and implemented in all kinds of networks according to the skills of people in implementing networks. This type of network, Convolutional Neural Networks (CNN), is a type of neural network commonly used for image and video recognition tasks. They use convolution layers to extract features from images and have been successful in tasks such as object detection and image segmentation. Convolutional layers are the biggest structure and building blocks used in convolutional neural networks.

Convolutional neural networks were a special type of neural network that almost imitated human vision. The architecture of CNN or convolutional neural network consists of several types of layers:

- Convolutional layer
- Pooling layer
- Fully connected input layer
- Fully connected layer
- Fully connected output layer

CNN convolutional neural network that takes an image as input and assigns a value to it. In all types of neural networks, pre-processing is required (it is better to perform operations to reduce noise and missing values to achieve better results), however, convolutional neural networks require less pre-processing [23-38]. The architecture of this neural network is like this, it can reduce the dimensions of the data obtained from the image, in other words, it has the ability to train the network to better understand the complexities of the image. In deep learning, a convolutional neural network is a class of deep neural networks commonly used to analyze visual images. The main point is that the role of convolution is to reduce images in a form that is easier to process, without losing features that are very important to obtain a prediction [36-41].
There are various architectures of CNNs available which have been key in building algorithms which power and shall power AI as a whole in the foreseeable future. Some of them have been listed below:

1. LeNet
2. AlexNet
3. VGGNet
4. GoogLeNet
5. ResNet
6. ZFNet

This type of network was used in this work and Python programming language was used for its implementation and design. The overall structure of CNN model [23-29]:

Table 1: CNN model parameters

Model	Hyper parameters	Setting
CNN	Loss function	Sparse-categorical-cross entropy
	Optimizer	Adam
CNN Pre-trained Model	Metrics	Accuracy
	Epochs	100
	Batch-size	28
	Learning-rate	0.0001
	Loss function	Categorical-cross entropy
	Optimizer	Adam
	Metrics	Accuracy
	Epochs	50
	Batch-size	6
	Learning-rate	0.0001

3.2. Python

The newest and most accurate programming language is currently Python, which can achieve very accurate and favorable results by using the convolution network and its design and coding in Python.
To write convolution network code in Python and run it, there are different methods, including different coding with different types of coding, which are different depending on the skill of the person doing the coding.
In this discussion, using the Python programming language in the COLAB environment, an optimal implementation and implementation method with maximum efficiency has been obtained.
Python coding should be such that it analyzes and examines any type of image with any degree of difference.
So, for this purpose, two types of Python code were written in a suitable space so that the accuracy in doing the work can reach its maximum level and validate the results after comparison.
The codes have been written based on coding experience and an attempt has been made to achieve maximum efficiency with the shortest and most accurate amount of coding.
There are many choices for choosing the Python language coding space, but considering the experience in coding, you can understand that COLAB is the best option for the final practice of the codes and recording the results.

3.3. Artificial intelligence transformation database

In this section, you can take a closer look at Python coding, you can pay attention to the beginning of two types of written code. It can be seen that the initial version of each code is different from the other.
First, you can familiarize yourself with COLAB's coding space in order to draw a more accurate picture of how to do the work in your mind.
In this section, you can take a closer look at Python coding. In the previous part, it was explained how to reach the conclusion of what kind of code can be used and what is the reason for choosing it. You can pay attention to the beginning of the two types of written code. It can be seen that the initial version of each code is different from the other, the second code that is executed on the platform can be seen. Then, you can see the codes written in the Python environment, which were written in the beginning, validated and executed in the beginning, the second code can be seen in Python. The Python codes were written on the simple Python platform, and rewritten and run on

COLAB for validation, debugging, and execution, each of which provided the same solution algorithm and results. In this section, default images are provided to specify the points of each image in order to correctly analyze the neural network of various types of medical images and also to understand the details by the network. To put it more simply, these images were first entered into neural network codes and coding was done on them, and finally after the end of coding and analysis of these images by the network, the brain images of 12 patients were used for prediction and new analysis and testing. The neural network is given.

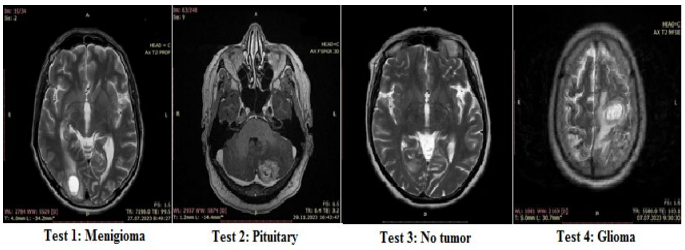

Figure 2. Structure of Methodology

3.4. Compilation of images

In the first part, it was explained that the obtained images are the result of several months of examination and analysis of patients' information to conduct medical tests, and finally, the obtained images from the final tests of 8 patients were collected and analyzed, analyzed and predicted in this research. Figure 3 shows the MRI information of 8 patients, which includes general information without details. In this section, the images of the patients that we have given to the neural network for analysis in order to diagnose the results are presented. By inserting MRI in the section related to uploading images in the Python code, the results are shown in numerical form, tumor diagnosis with the text yes or no, and the location of the tumor with 99.8% accuracy in a table at the beginning. It has been reported that the presence or absence of tumors in them is known and the location has not been determined. Also, its type and some other information have not been specified.

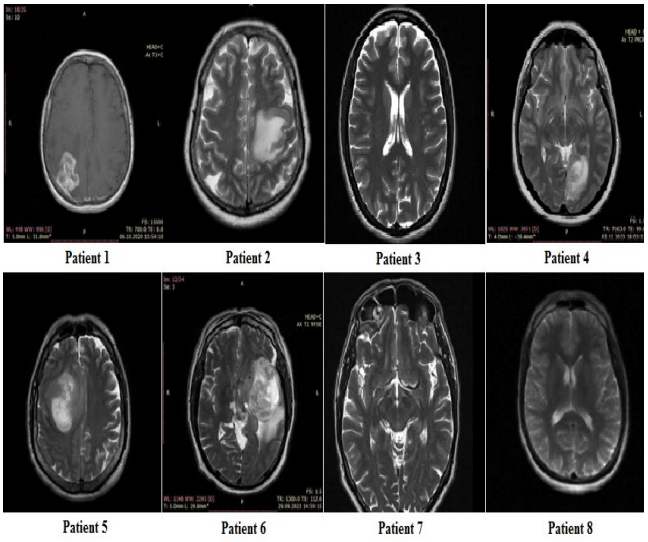

Figure 3. The MRI of patients

3.5. Prediction

Now, by inserting each image in the code checking the information related to it, and obtaining the desired results, first the numerical analysis of each code, which includes the location and period, is done, and In this code, it is specified that four models are recognized. First sample without tumor, second Glioma, third Menigioma and fourth Pituitary. By classifying the images and the following results, a detailed analysis of the presence or absence of a tumor, as well as its location and type, can be obtained from the analysis. There are 6 formulas for accuracy, precision, recall, FPR, TNR and FI-score that the results are shown in table 2.

Table 2: Patient's MRIs detection 14 results

All in (%)	Tumor or Not	Accuracy	Precision
Patient 1	Yes, Menigioma	97.7	96.6
Patient 2	Yes, Menigioma	98.2	96.9
Patient 3	No	98.5	95.8
Patient 4	Yes, Pituitary	97.9	96.4
Patient 5	Yes, Glioma	99.2	97.1
Patient 6	Yes, Glioma	99.1	96.9
Patient 7	No	98.9	95.9
Patient 8	No	99.3	97.2

FI-Score	Recall	MA	FA
94.9	97.2	15	17
94.3	97.2	16	17
94.2	96.8	12	15
94.9	96.3	13	15
95.5	95.4	13	16
95.3	95.2	15	17
96.1	95.3	15	16
95.7	95.8	16	16

G-Mean	Training time	Macro average	Weight average
98.1	200	96	97
98.4	200	97	97
99.2	200	93	95
99.1	200	94	97
99.5	200	96	94
99.5	200	97	95
99.7	200	96	93
98.9	200	95	96

Specificity	Sensitivity	MCC
99.9	99.9	99.2
99.8	99.9	99.1
99.7	99.9	99.3
99.7	99.8	99.4
99.8	99.9	99.1
99.8	99.8	99.5
99.9	99.8	99.6
99.8	99.8	99.2

In the conclusion of the second code, the same results have been shown with a slightly different expression, which includes the accuracy in coding and analysis, and the results are all very accurate.

4. Results and Analysis

The efficiency and accuracy analysis of the process is marked with a linear line, and the work evaluation is also marked in the next figure.

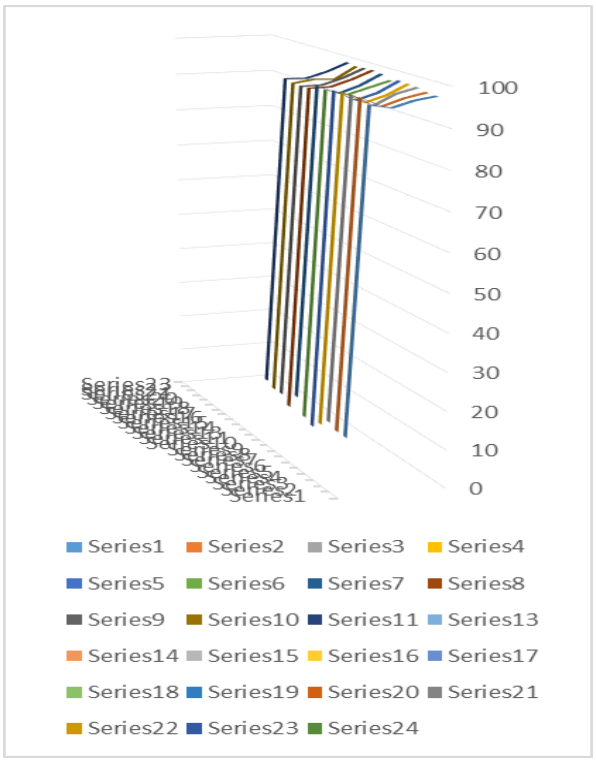

Figure 4. The process efficiency and accuracy analysis

This issue is done in the cases that are done before that, to be accurate in the processing process as well as validation, two types of Python code are used. The graph below shows the results of the second simulation compared to the first simulation and its accuracy.

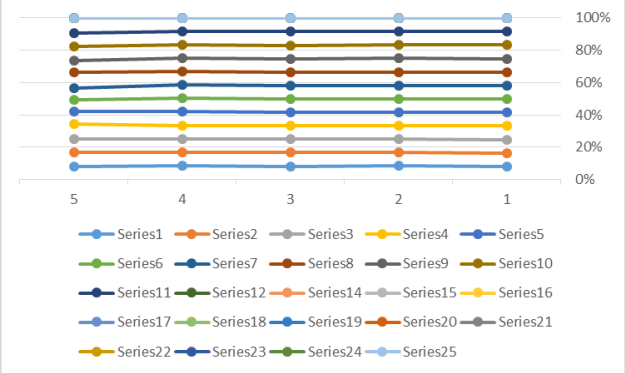

Figure 5. Comparative results

The above result shows that the accuracy of both codes was the same and the results are completely similar, and the accuracy of both results is confirmed and can be cited. According to the obtained results, it can be seen that due to the high accuracy of the written codes as well as the results obtained from both codes; A graph can be designed to compare both parts to get the efficiency and accuracy of the work process.

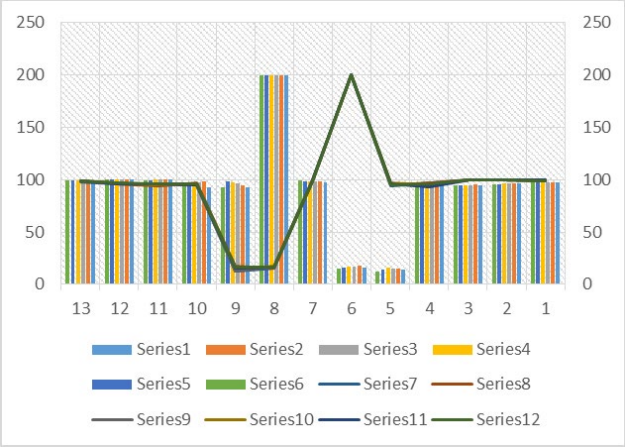

Figure 6. Efficiency and results

The results show that due to the collision and relative adaptation of the two lines of the graphs, the efficiency and conclusions of the work have been very accurate, the results can be cited.

One important aspect of this work is the high accuracy in the precise coding that has been achieved. It can be considered that in future works, more elements can be added and by changing the codes, more tumors or mental and physical problems can be detected and predicted.

5. Discussion

In other studies, as described in the introduction section, similar work has been done; however, it is noteworthy that in previous works there was a percentage of error and the work was not up to date because old coding and detection methods were used, resulting in imprecise reporting of results. Another notable point is that the results of any research should be reliable, so in this work, two types of coding were used to accurately measure the detection accuracy and the results can be used in future research. Briefly, in this work, at first, the neural network was created using coding in COLAB using Python programming language. To design the network, real images, whose shape is specified, have been used and the code has been finalized.

In the next step, for this new research plan, which is more updated and accurate than other previous research, the images of patients who went to medical centers for the diagnosis of diseases and the medical images of their brains were received to the neural network to be trained, then for accuracy check, other MRI pictures were given to the neural network to diagnose.

The results and other cases of the research were received. Then, to ensure the results obtained and to obtain the accuracy of the work as well as its reliability, a new code with more detailed items was written again like the previous code, and after the completion of the coding, the images were uploaded to view the results. The obtained results were completely similar to the previous results and the accuracy of the work was 100%. Comparative tables were presented and both codes were compared with each other [13-18].

In this work, compared to other works that have been done in the past, you can see the variety of coding and its transparency, and you can also analyze the high accuracy of the work, which is 100% and there is no doubt about it. In programming, the most important factor is accuracy in network design and coding to provide the result with the highest efficiency, which fortunately, in this work, has been done very skilfully [2-12]. Finally, it is necessary to mention that it should be pointed out more accurately that this work has been done in a completely innovative way because the network has been formed without any plagiarism and entirely based on the experiences and knowledge of the programmer. Other research was such that they only predicted one or two models approximately and only provided one code, so the results obtained were not reliable. However, in this work, coding was done twice in two different ways, and the results were presented with 100% accuracy. Additionally, all aspects have been presented in a completely new and reliable manner for the reader. In further research work, considering the high performance of this work, it is possible to design and present networks with higher power to detect various other problems and issues.

6. Conclusion

By using the analysis of MRI images using the design and coding of the CNN neural network in Python, very significant results were obtained in the form of diagnosis, prediction, and determination of some analytical parameters in the images. Undoubtedly, for a detailed analysis and proper consideration of the performance of Deep Learning, the use of two types of code could show how accurate the verification and validation process was and how reliable the results are. The 99% accuracy of the work process and the results prove how useful neural networks can be in various sciences and to perform complex and long life and processes in a shorter period of time.

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