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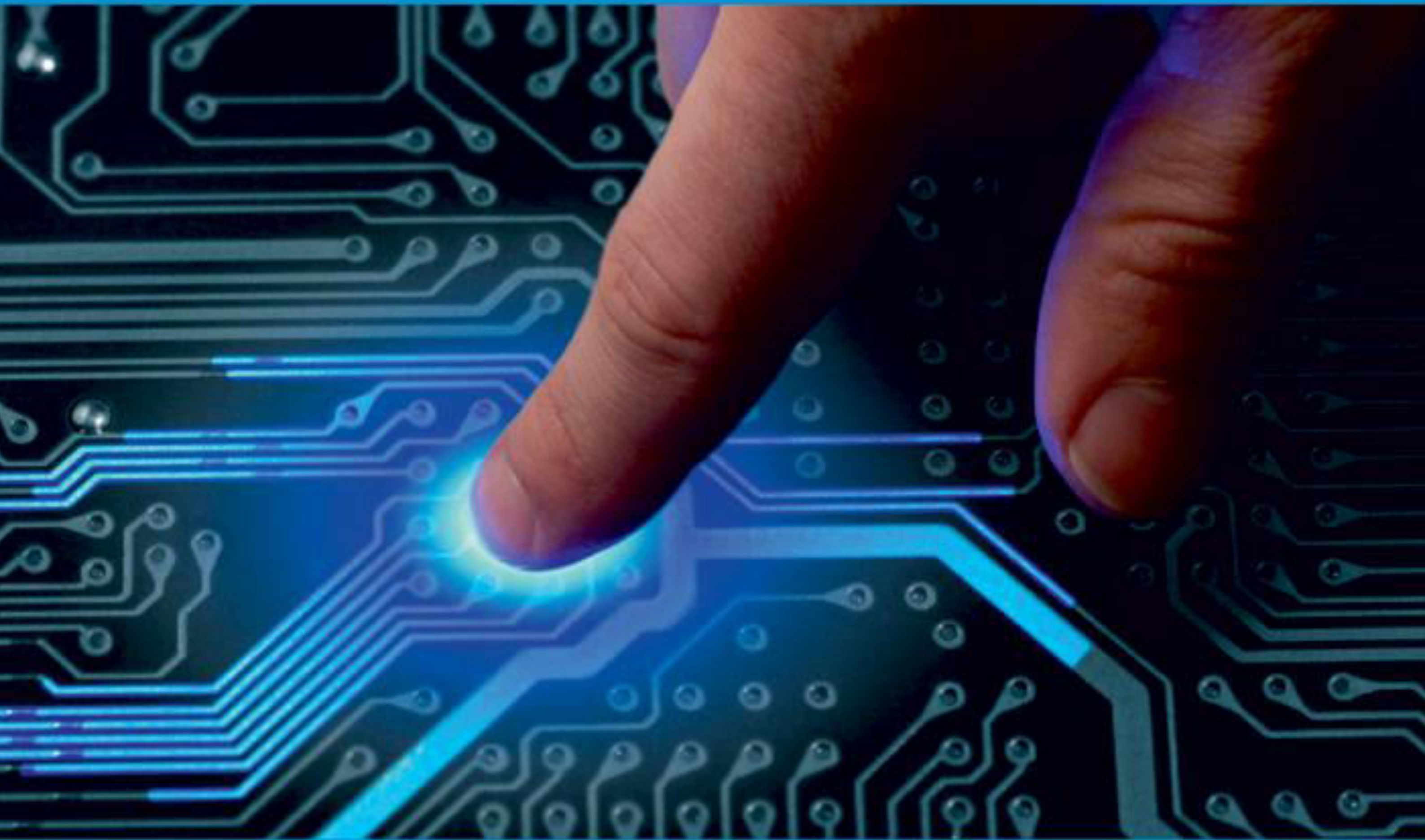

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Design and Analysis of an Intelligent Hybrid Model for Brain Tumor Detection and Classification Using Deep Learning

[1]Surabhi , [2]Vivek Kumar Sinha

[1]M.Tech Student, Dept. of CSE, Raipur Institute of Technology, Raipur, Chhattisgarh, India

[2]Assistant Professor, Dept. of CSE, Raipur Institute of Technology, Raipur, Chhattisgarh, India

ABSTRACT: Brain tumor cases have indeed increased at an extremely high speed in the previous few years globally. Multiple approaches and models have been investigated in recent years for effective screening and classification of brain tumors for early diagnosis of patients. But, all these previously developed approaches have indeed multiple major limitations owing to extremely increasing cases of brain tumors, huge time consumption in model execution, lower accuracy for categorization as well as recognition of the brain tumor in the growing phase, and several others. This research presents the design and analysis of an intelligent hybrid model for brain tumor identification and classification using the deep learning (DL) approach. All the performance parameters namely the model execution time as well as accuracy have been received optimal and enhanced in comparison with the existing schemes. Our suggested model offers an execution time of 0.3s and an accuracy of 98.36%, which are optimal and improved.

KEYWORDS:Brain Tumor Classification, Deep learning, Intelligent Hybrid Model, MRI Images.

1. INTRODUCTION

Nowadays, this field of healthcare informatics has indeed gained prominence as one where computing innovation meets the requirements of individual medicinal necessities. This assessment of picture information has indeed been the subject of many studies with a concentration on diagnosis as well as therapeutic studies. Employing a variety of diagnostic modalities, including magnetic resonance (MR) imaging approach, as well as CT (Computed Tomography) scanning, including the ultrasound, pictures being obtained utilizing computing-aided exploratory assessment [1], [2]. To get better categorization outcomes whenever it comes to picture categorization problems, it's indeed crucial to have a framework in position including characteristics that have strong discriminative properties. Picture classification and educational purposes are both served by healthcare picture libraries. Often it contains detailed explanations as well as photographs of diverse features shown within a variety of settings. Finding the greatest pertinent danger characteristic when in conjunction with the diagnosis of a disorder seems to be essential for clinical investigations. Conventional diagnostic image classification techniques rely heavily on factors like scale, structure, as well as color. The picture must be classified employing specific clinical expertise, which provides a substantial challenge inside the domain of picture categorization [3], [4].

One of the greatest terrifying maladies all across the globe age is indeed a brain tumor threat. As can be visualized in Figure 1, the greatest frequent reason seems to be the widespread alteration of abnormal cerebral neurons. When a tumor is already in its initial stages, it is small and therefore considered benign. Malignant tumors are those that have migrated from different parts of your organism inside the intermediate phase and thus are larger than benign tumors regarding dimensions. Estimated that a huge number of folks would be identified with glioma through 2030 [5], [6]. It is estimated that a greater number of people would receive a brain tumor diagnosis around 2028 globally, according to the WHO (World Health Organization) report. So, above the age group of forty, there is a huge chance of that person must require proper and fast testing and an early diagnosis. There are two types of tumorsi.e. higher-grade as well as low-grade gliomas, both of which have a significant death rate. Additionally, lower-grade gliomas are greater likely to survive compared to higher-grade gliomas. Early therapy is crucial since the average surviving time for severe grades is two years [7], [8].Figure 1 depicts diverse classes of brain tumors i.e. (a) shows glioma (b) shows pituitary (c) shows meningioma and (d) depicts no tumor.

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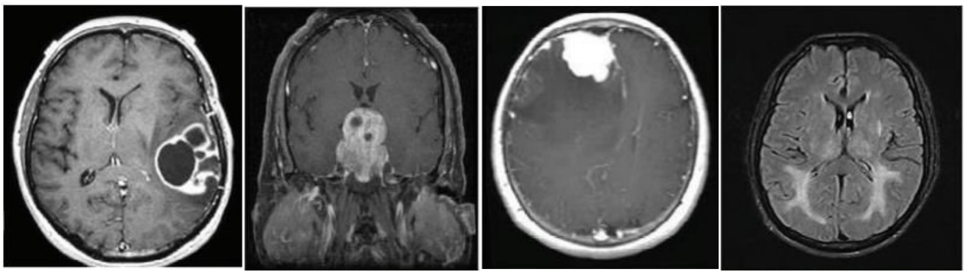

(a) (b) (c) (d)

Figure 1: Depicts diverse classes of brain tumors. (a) Shows Glioma (b) Shows Pituitary (c) Shows Meningioma and (d) Depicts No tumor.

II. RELATED WORK

For a sufferer to get good therapy, timely tumor detection, as well as categorization, seem to be essential. Through the usage of computerized medical equipment, professionals may currently manage clients more effectively owing to extraordinary technological advancements. Some experts M. Nazir et al. [9], had suggested investigations using models centered on ML (Machine-Learning) as well as DL (Deep Learning) to address clinical picture diagnostic issues. In, J. S. Patil et al. [10], CNN which is, another of the greatest well DL approaches, has produced very significant achievements in a variety of disciplines, notably, picture recognition. CNN-rooted methods are effective in identifying brain tumors as well as helping medical professionals choose the best course of action for their individuals. Human cerebral malignancy may be found using a variety of invasive as well as non-invasive screening techniques. Nevertheless, since there are so many sufferers, subjectively analyzing each MRI picture takes a lot of effort as well as comes with a significant probability of inaccuracy. In research [11], S. Maharjan et al. discussed the support vector machine i.e. SVM-based classifier was trained to categorize cerebral MRI pictures into discrete categories using the gray-levels co-occurrence array (for instance, normal as well as abnormal). Although the retraining duration seemed lengthy, their model's reliability remained comparatively excellent. The next research [12] by S. Kumar et al., used PCA (Principal Component Analysis) approach to shorten retraining times by lowering the dimensionality of model retraining elements. Since different forms of cerebral tumors have the similar look (width, brightness, thickness, and so on.), this same globally-featured-trained model's categorization accuracy level within multiple-class categorization seems to be very poor.

Furthermore, E. Noronha et al. employed another approach namely the DWT (discrete wavelet transform) for the image's features extraction purpose as well as SVM was employed for categorization to detect brain cancers [13]. The researchers obtained a 98.00% predicting accuracy level just upon the chosen 60 photos. El-Dahshan et al. subsequently used the KNN (K-nearest-neighbour) algorithm on 71 pictures, as well as the outcomes demonstrated 96.6% predicting correctness. Medical experts are using imaging therapies increasingly often these times because they are highly efficient as well as put sufferers in significantly lower danger. Clinical imagery information may be recorded using a variety of techniques, such as radiographs, magnetic-resonance-images (MRIs), as well as computing-based tomography, including echocardiography. Amongst these, MRI remains the greatest well since it offers radiation-free pictures with just a greater clarity. Radiologists may identify cerebral irregularities using clinical imaging information obtained via the quasi-invasive MRI method [14]. Another Computing-Aided Diagnostic (CAD) approach [15] by S. Bagyaraj et al., discussed on the contrary extreme, was created to find cerebral cancers in their initial phases eliminating the need for personal participation. Depending on MRI pictures, CAD-based systems may generate diagnostic summaries as well as provide the clinician advice.

III. METHODOLOGY

3.1. Design:

A brain tumor is constantly becoming a very critical disease in the modern era for effective and early diagnosis. Brain tumor cases are increasing rapidly all across the world due to the lack of identification of brain tumors and other related symptoms on time in the beginning phase. In the last few years, many investigators developed various types of approaches and presented effective models for brain tumor identification. But, such existing models are ineffective nowadays due to gigantic datasets and do not perform to classify and detect brain tumors in an accurate, fast manner. In this research, we developed an intelligent hybrid model, which is capable to detect and classify brain tumors and other related symptoms in a faster manner and helps clinicians with tumor identification in the initial, middle or advanced stages. The overall working of this suggested intelligent hybrid model is given as follows.

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First of all, we selected hybrid input datasets i.e. primary datasets are live picture datasets from hospital testing and secondary image datasets were chosen from BRATS datasets. This hybrid input dataset is applied to the median filter which aids in the filtration of the data effectively. Once the filtering operation over entire datasets using the median filter is done. After that, the data augmentation and pre-processing are accomplished. Preparation (sanitizing as well as arranging) unstructured datasets to make them acceptable for creating as well as retraining deep Learning models is known as dataset pre-processing. In dataset analytics, procedures called "dataset augmentation" are utilized to expand the quantity of dataset by inserting slightly changed versions of either existing dataset or brand-new synthetic dataset that is derived using extant dataset. Once the data pre-processing and data augmentation procedure is completed, then the acquired datasets are translated into the segmentation model.

This segmentation model used herein is based on the GrabCut approach. These segmented pictures are translated to the DL-based enhanced CNN model which performs picture classification operation. After that, we integrated the ResNet-50 model which is 50 layers deep CNN architecture and provides aid in real-time picture categorization. In the next stage, model training is done. Once the model training is completed, in a subsequent phase, model testing and validation were completed with accuracy and precision. Then, the proposed DL-based intelligent hybrid model was performed for brain tumor detection. The key advantage of the proposed model is that if it detects the brain tumor then it further classifies that the detected brain tumor is in the initial, middle, or advanced stage. Figure 2 depicts our proposed intelligent hybrid model for brain tumor classification and detection.

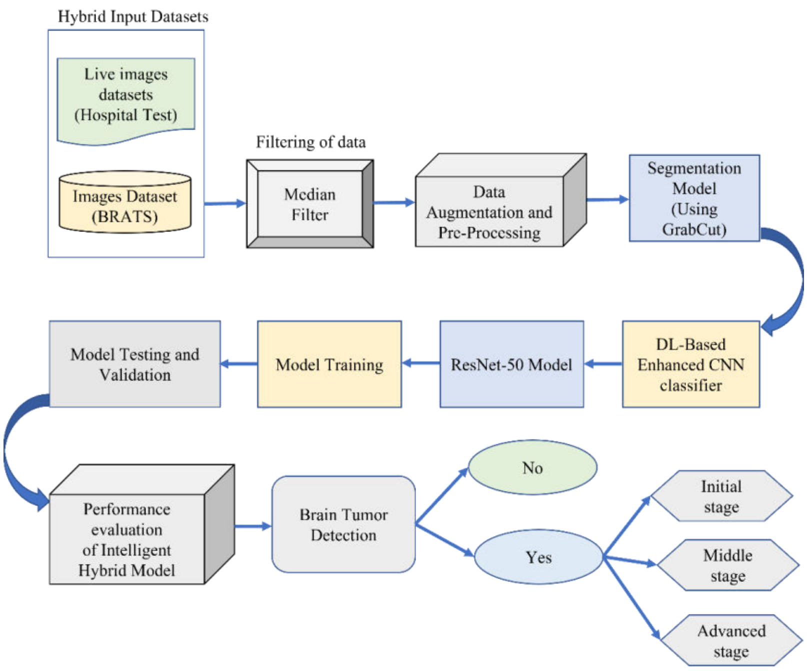

Figure 2: Depicts our proposed intelligent hybrid model for brain tumor classification and detection.

3.2. System Configuration:

This study was performed using the MATLAB R2021b version installed within a personal computer which has the following system configuration: the processor of the computing machine was intel i7, the installed RAM was 16GB, as well as operating system 64-bit, and Windows 11. MATLAB is being utilized worldwide nowadays by researchers for design, analysis, and simulation purposes for multiple kinds of new models and many other computing tasks. For science and technology, MATLAB seems to be an immersive development tool. Numerous technological domains largely rely upon MATLAB for datasets analytics, problem-resolving, experimenting, including algorithms creation, and many more.

3.3. Data Collection:

Based on the location, phase of advancement, kind, and the overall pace of development of the cerebral tumor, this may be classed as a benign class or malignant class. As per a report given by WHO, brain cancer cells may be

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additionally classified based on tumor location, seriousness, and the overall pace of development. Cancer-affected tumor tissues remain contained at phase 0 as well as do not influence surrounding normal tissues. During phases 1, 2, as well as 3, these malignant tumor tissues start to harm the nearby undamaged cells. Carcinoma is virtually often fatal in its fourth as well as last phase, which impacts everybody. Thus, early-phase cancer identification, as well as categorization (meningioma, or may be pituitary, including the glioma), are crucial for carcinoma therapy to preserve the individual's life.Figure 3 illustrates the collected datasets for the model training and validation.Table 1 depicts the chosen parameters for suggested model training.

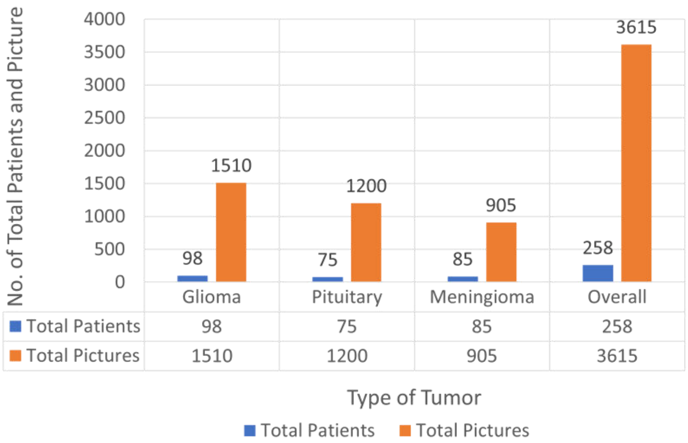

Figure 3: Illustrates the collected datasets for the model training and validation.

Table 1: Depicts the chosen parameters for suggested model training.

S. No	Chosen Parameter	Value(s)
1	Rate of Learning	1e-6
2	Chosen Epoch	40
3	Optimizer Selected	SGDM
4	Mini-batch Dimension	20

3.4. Data Analysis:

This age of big datasets in healthcare is rapidly coming due to this speedy advancement of healthcare technologies. The forecast, tracking, diagnosis, as well as therapy of tumor problems, are strongly influenced by the assessment as well as extraction of these datasets. Malignant brain tumors are generally recognized as the worst as well as greatest destructive illness due to their broad variety of characteristics, short mortality probability, and extremely violent attitude. Cerebral tumors that are incorrectly identified result in subpar clinical care, which lowers a patient's likelihood of survival. Owing to the ability to discriminate between abnormal as well as regular cells, detecting cerebral tumors is very difficult. A proper diagnosis enables the individual to get appropriate treatment as well as survive over the longer term. Due to the peculiar spreading structure of the diseases, there remain significant limits in the detection of cerebral tumors notwithstanding substantial study. Smaller regions may seem normal, therefore it might be challenging to locate a zone with few abnormalities. Overall categorization accuracy becomes immediately lowered, therefore this is difficult to identify as well as choose relevant characteristics. Accurately categorizing initial-phase brain cancers using DL as well as ML techniques plays a key contribution. For the suggested model, diverse performance matrices are evaluated utilizing the following main equation as illustrated herein.

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The accuracy of the proposed DL-rooted model may be evaluated by employing the following equation 1.

$$Accuracy = \frac{TP+TN}{TP+FN+TN+FP'} \tag{1}$$

Another very important performance metric i.e., recall may be evaluated by using equation 2.

$$Recall = \frac{TP}{FN+TP'} \tag{2}$$

The F1 score is also a very key performance metric for estimating the performance of the proposed Dl-based model. The F1 score value may be calculated according to equation 3.

$$F1\ score = \frac{TP}{TP+\frac{1}{2}(FP+FN)} \tag{3}$$

The precision value for the proposed DL-based model can be calculated using the following equation 4.

$$Precision = \frac{TP}{FP+TP'} \tag{4}$$

IV. RESULTS AND DISCUSSION

For the proper management of brain tumor illnesses, timely detection as well as appropriate feasible therapies seem to be necessary. Overall pathogenic nature of the illness, the tumor phase at the time of the first assessment, including possible therapies are all specified. These original investigation findings have been compared to cutting-edge methods for the primary tumor identification problem or to established deep learning-rooted systems which have been proposed. During the initial stages of crucial component extraction, traditional identification techniques utilize several essential machine-learning-based methodologies which only gather lower- as well as higher-level attributes.

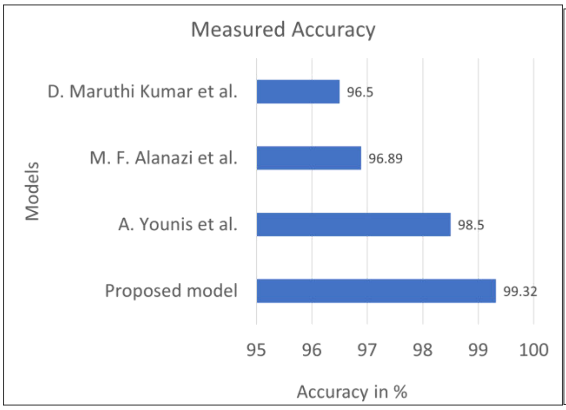

Figure 4: Shows measured accuracy.

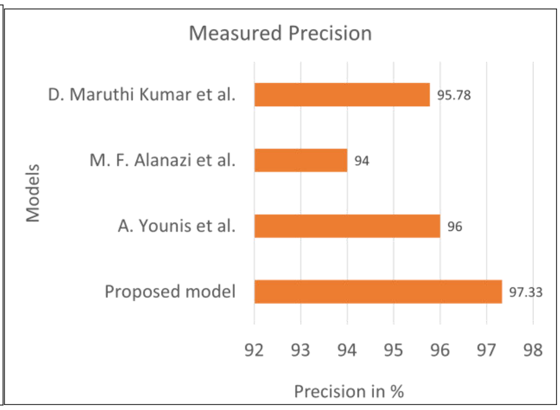

Figure 5: Shows measured precision.

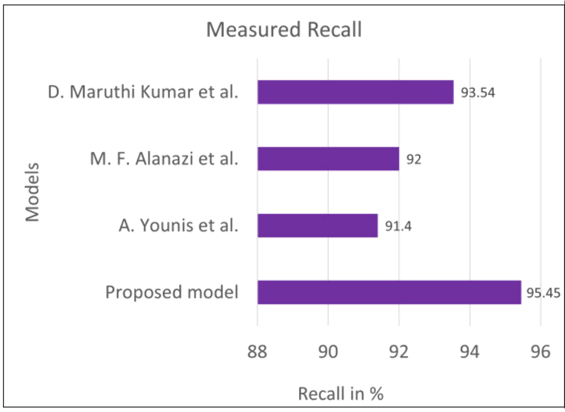

Figure 6: Shows measures recall

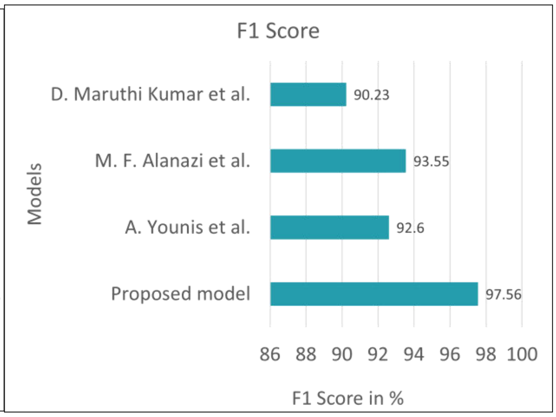

Figure 7: Shows measured F1 Score

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When a cerebral tumor is not found in time, it may be deadly. The radiologist's skill, as well as knowledge, are necessary for a clinical diagnosis of cerebral tumors, although they might not constantly be accessible. Moreover, mechanical methods waste effort, are inaccurate, as well as expensive. As a result, an efficient approach is necessary to guarantee an appropriate diagnosis. Such tumors may harm the human brain's walls. Therefore, before using any cerebral invasive method or treatment procedure, medical professionals should pinpoint the precise part of the head that is afflicted. Segmenting cerebral tumors involves extracting stronger as well as thinner components from the damaged regions to separate the malignancies. As just a consequence, the greatest difficult job in screening procedures is skull fragmentation. Most exclusivist strategies rely on generic edge-rooted datasets rather than being focused just on the cerebral tumor area. Deep learning-based approaches have recently been applied for tumor classification jobs because of their effectiveness in recognizing aspects of photos.

Figure 4 shows the measured accuracy of the proposed model. The accuracy of existing A. Younis et al. [16] model, M. F. Alanazi et al. [17] model, and D. Maruthi Kumar et al. [18] model are 98.5%, 96.89%, and 96.5%, while the proposed model obtained an accuracy level of 99.32% which is optimal and higher in comparison to the existing models. Figure 5 shows the measured precision of the proposed model. The precision of existing A. Younis et al. [16] model, M. F. Alanazi et al. [17] model, and D. Maruthi Kumar et al. [18] model are 96%, 96%, and 95.78%, while the proposed model obtained and precision of 97.33% which is optimal and higher in comparison to the existing models. Figure 6 shows the measured recall of the proposed model. The recall value of existing A. Younis et al. [16] model, M. F. Alanazi et al. [17] model, and D. Maruthi Kumar et al. [18] model are 91.4%, 92%, and 93.54%, while the proposed model obtained recall value of 95.45% which is optimal and higher in comparison to the existing models. Figure 7 shows the measured F1 score of the proposed model. The F1 score value of existing A. Younis et al. [16] model, M. F. Alanazi et al. [17] model, and D. Maruthi Kumar et al. [18] model are 92.6%, 93.55%, and 90.23%, while the proposed model obtained F1 score value of 97.56% which is optimal and higher in comparison to the existing models.

Table 2: Depicts the comparison of proposed and existing model execution time.

S. No	Chosen Parameter	Value(s)
1	A. Younis et al.	0.7s
2	M. F. Alanazi et al.	0.9s
3	D. Maruthi Kumar	0.8s
4	Proposed Model	0.3s

Table 2 depicts the comparison of the proposed and existing model execution time. While comparing the proposed model with existing models it is found that A. Younis et al. [16] model consumes 0.7s in execution, M. F. Alanazi et al. [17] model consumes 0.9s in execution and D. Maruthi Kumar et al. [18] model consumes 0.8s in execution. On the other hand, the proposed model consumes only 0.3s in execution which is optimal and very less in comparison to the previously developed model for brain tumor identification.

V. CONCLUSION

This intricate structure of such kinds of lesion sites means that despite extensive research into the detection of cerebral tumors, there remain limitations throughout this field. Due to such a tiny area's appearance as just a normal zone, it might be difficult to spot the tiny area with tumors. Additionally, it's challenging to identify as well as choose relevant characteristics since doing so immediately reduced categorization effectiveness. However, a simple paradigm has still been required for the study of cerebral cancers. In this study, an intelligent hybrid model for brain tumor detection and classification using deep learning has been presented. Overall findings gained demonstrate the effectiveness as well as reliability of the suggested strategy for classifying brain tumors. To correctly identify as well as categorize cerebral cancers, clinicians may benefit from the suggested methodology. When comparing the suggested model to existing models, it is discovered that the suggested model takes only 0.3 seconds to execute, which is far less time than the previously produced model for identifying brain tumors. Moreover, the proposed model offers a greater accuracy level which is 99.32%, while the precision, recall, and F1 scores are 97.33%, 95.45%, and 97.56%, respectively, which are also higher and optimal in comparison to the existing models. In the future, more research possibilities are available to develop new advanced models for brain tumor detection quickly from larger image datasets.

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BIOGRAPHY

Surabhiis currently pursuing her M.Tech degree in Computer Science and Engineering from Raipur Institute Of Technology affiliated to Chhattisgarh Swami Vivekanand Technical University, Bhilai, Chhattisgarh, India. She has completed Bachelor of Engineering (B.E.) in Computer Science and Engineering from Raipur Institute of Technology affiliated to Chhattisgarh Swami Vivekanand Technical University, Bhilai, Chhattisgarh, India in 2018. Her research interest fields are Artificial Intelligence, Machine Learning, Deep Learning, Data Analytic.

Vivek Kumar Sinhais currently working as an Assistant Professor in the Computer Science and Engineering Department at Raipur Institute of Technology, affiliated to Chhattisgarh Swami Vivekanand Technical University, Bhilai, Chhattisgarh, India. He is having 14 years of experience in teaching. He is currently Research Scholar at Lovely Professional University Phagwara, Jalandhar, Punjab, India.

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