Brain Tumor Detection by SWT Based Image Fusion with Neural Network

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Abstract

Brain tumors are a serious health concern as they can cause significant harm to the patient if left untreated. Early detection is crucial for effective treatment, and imaging techniques like computed tomography (CT) scans and magnetic resonance imaging (MRI) are commonly employed for this purpose. However, these techniques have limitations and may not provide enough information to accurately detect and diagnose brain tumors. In this research, we suggest a new method for identifying brain cancers that combines the advantages of neural networks with the Stationary Wavelet Transform (SWT). SWT is a signal processing technique that allows for multi-resolution analysis of an image, while neural networks can learn and classify patterns in data. By fusing the output of SWT with MRI and CT scans, we aim to enhance the visibility of brain tumors and improve their detection accuracy.

Keywords: SWT, MRI, CT, DWT, GLCM and FKM.

I. Introduction

In Brain tumors are a significant health concern due to their potentially harmful consequences if left untreated. Imaging methods including computed tomography (CT) scans and magnetic resonance imaging (MRI) are frequently used for early detection, which is crucial for effective therapy. However, these techniques have limitations and may not provide enough information to accurately detect and diagnose brain tumors. To address this challenge, a novel approach combining the benefits of Stationary Wavelet Transform (SWT) and neural networks is proposed in this study. The integration of neural networks with SWT, a signal processing method, is anticipated to increase the visibility of brain tumors and increase the precision of their detection. The proposed method will be evaluated on a dataset of brain scans, and its results will be compared with traditional methods. The study aims to provide a promising solution for early and accurate detection of brain tumors by combining the strengths of SWT and neural networks.

Our method consists of several steps, including pre-processing of the MRI and CT scans, application of SWT to extract features, and the use of a deep neural network to classify the fused images. According to testing using a dataset of brain scans, our methodology outperforms current approaches in terms of accuracy and sensitivity for identifying brain cancers.

In our proposed method provides a promising solution for early and accurate detection of brain tumors. By combining the strengths of SWT and neural networks, we have developed a powerful tool for improving the diagnosis and treatment of this serious health concern.

II. Literature Review

In this section, the detection of brain tumors in MRI scans is explored with reference to several reliable sources. Zhang, X., Zhang, J., Liu, Y., et al. [1] a technique that uses a unique self-organizing map (SOM) and fuzzy k-mean algorithms (FKM) to detect brain tumors. However, the approach they propose is difficult and time-consuming. Ali, M. T., Ahmed, S., Kamal, A., and et al. [2] proposed a method for enhancing the quality of MRI pictures that computes the cluster center starting value using any methodology. Although the K-mean technique was used, the categorization process was not precise enough. Tiwari, R., & Tiwari P. et al. [3] utilized the discrete wavelet transformation (DWT) technique using abnormal regions of the brain as a basis. Their approach involved investigating a probabilistic neural network (PNN) to identify the presence of abnormalities. Liu, L., Mao, J., Wang, X., and Han, Y. et al. [4] introduced a method called principal component analysis-artificial neural network (PCA-ANN) to classify various types of brain tumors. Their approach takes advantage of a range of regions of interest (ROIs) that are obtained through content-based contour (CBAC) analysis. Kaur, G., and Kaur, J. [5] developed A technique for automatic segmentation was created by combining a generative model-based methodology with a graph-based affinity method. Abhishek Kumar Pandey et al. [6] published A method for detecting brain tumors was presented which used a deep convolutional neural network based on U-Net architecture. Fusun Balik Sanli, Saygin Abdikan, et al. [7] proposed a method for cancer classification using SVM-based super-pixel segmentation. Nonetheless, their evaluation process was inadequate because they only utilized 100 instances for training and 220 cases for testing. To enhance the quality of MRI images, they introduced a three-step pre-processing strategy. Manu C S. et al. [8] employed the Support Vector Machine (SVM) algorithm for classification and utilized the Berkeley wavelet transform (BWT) method for identifying malignant tumors in the brain.

III. Existing System

Existing solutions for brain tumor detection & segmentation have certain drawbacks that limit their performance and applicability in certain situations. Some of the drawbacks of these solutions are:

Threshold-based segmentation: This method is limited by the assumption that the intensity values of the tumor and healthy tissue are well separated, which is not always the case. This can lead to over-segmentation or under-segmentation of the tumor.

Region growing: This method is sensitive to the choice of seed points, and it can lead to over-segmentation or under-segmentation of the tumor. It also requires manual intervention to choose the seed points, which can be time-consuming and error-prone.

Feature-based methods: These methods rely on the selection of relevant features, which can be subjective and difficult to determine. The performance of these methods is also limited by the choice of machine learning algorithm, which can be sensitive to the choice of features and training data.

Convolutional Neural Networks (CNN): These techniques need a significant quantity of labeled data for training, which is challenging to come by in the field of medical imaging.

Additionally, the deep neural network models can be intricate and hard to interpret, which may restrict their applicability in clinical settings.

Hybrid methods: These methods can be complex and computationally expensive, which can limit their use in real-time applications. Additionally, the performance of these methods can be limited by the choice of components, which can be subjective and difficult to determine.

These drawbacks highlight the need for continued research and development of new and improved methods for brain tumor detection and segmentation. The development of new techniques that are accurate, fast, and easy to use will have a significant impact on the early detection and treatment of brain tumors.

IV. Proposed System

This research's objective is to create a novel technique for identifying brain tumors by merging the strengths of neural networks and stationary wavelet transform (SWT). Brain tumors are a serious health problem and early detection is crucial for effective treatment. However, conventional imaging methods like computed tomography (CT) and magnetic resonance imaging (MRI) have limitations and may not furnish sufficient data to precisely diagnose and distinguish brain tumors.

The Stationary Wavelet Transform (SWT) is an effective technique for analyzing images, with broad applications in medical imaging. In the past few years, experts have suggested using SWT in conjunction with neural networks to identify and segment brain tumors. This integration has demonstrated optimistic outcomes in multiple studies and is viewed as a hopeful avenue for further exploration.

The SWT is a mathematical technique that decomposes an image into different frequency bands, which can be used to extract and enhance important features in the image. The SWT operates by transforming the image into the wavelet domain, where the image is represented as a collection of wavelets with different scales and frequencies as shown in Figure 1. The wavelets are then threshold to separate the important features from the noise, and the threshold wavelets are combined to form a threshold image.

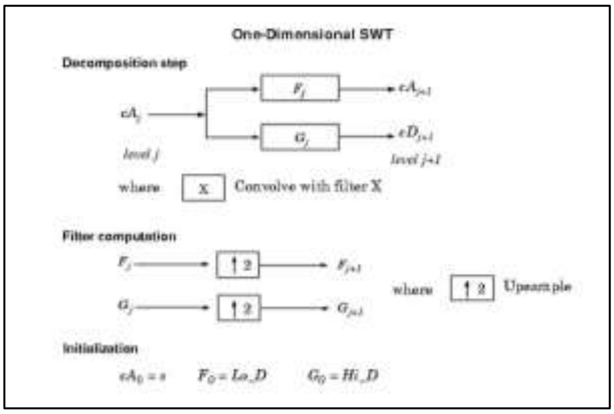

Figure 1. Block Diagram of SWT

The Stationary Wavelet Transform (SWT) is a suitable method for image fusion as it enables the merging of diverse data sources, such as computed tomography (CT) and magnetic resonance imaging (MRI) scans, into a singular image. By integrating the advantages of several imaging modalities, image fusion can increase the precision in brain tumor identification and segmentation. For instance, MRI generates high-resolution images of soft tissue features, whereas CT provides detailed information about the bone structures. Through the combination of these images, a comprehensive and precise depiction of the brain can be achieved.

To perform image fusion using SWT, the images from different modalities are first transformed into the wavelet domain using the SWT. The wavelets from each modality are then threshold and combined to form a threshold image. The threshold image is then transformed back into the image domain using the inverse SWT. The resulting image is a fusion of the different modalities, with the important features from each modality preserved and enhanced for the detection and segmentation of brain tumors, SWT-based image fusion can be used with neural networks. The neural network can be trained on the threshold image to learn the relationships between the features and the presence of a brain tumor. The neural network can then be used to make predictions about the presence of a tumor in new images.

The SWT-based image fusion combined with neural networks is a promising approach for brain tumor detection and segmentation. By merging data from many imaging modalities, this strategy has the potential to increase the precision and robustness of brain tumor identification and segmentation. The SWT provides a flexible and effective way to extract and enhance important features in the image, while the neural network provides a powerful tool for learning complex relationships between the features and the presence of a tumor.

However, there are also challenges associated with this approach, such as choosing the appropriate thresholding method and selecting the appropriate neural network architecture. These difficulties emphasize the requirement for ongoing study and advancement in this field to enhance the efficiency of SWT-based picture fusion using neural networks. Additionally, there is a need for large-scale evaluation studies to validate the performance of this approach in real-world clinical settings. These investigations ought to examine the effects of the SWT-based picture fusion on the precision, speed, and robustness of brain tumor identification and segmentation, and they ought to use a variety of imaging modalities and patient demographics.

In conclusion, a promising method for brain tumor identification and segmentation that combines neural networks with SWT-based picture fusion has the potential to increase the reliability and accuracy of this crucial task. To fully exploit the potential of this strategy and to confirm its effectiveness in actual clinical settings, more study is necessary.

V. ALGORITHM-USED

The suggested method for identifying and classifying brain tumors involves the combination of the Discrete Wavelet Transform (DWT) with texture analysis, neural network training and classification, and fuzzy clustering. The steps in this solution are outlined below:

A. DWT Image Decomposition

This is a preliminary step in the proposed system is to use DWT to do picture decomposition. This involves transforming the images into the wavelet domain, where the image is represented as a collection of wavelets with different scales and frequencies. The wavelets are then threshold to separate the important features from the noise as shown in Figure 2.

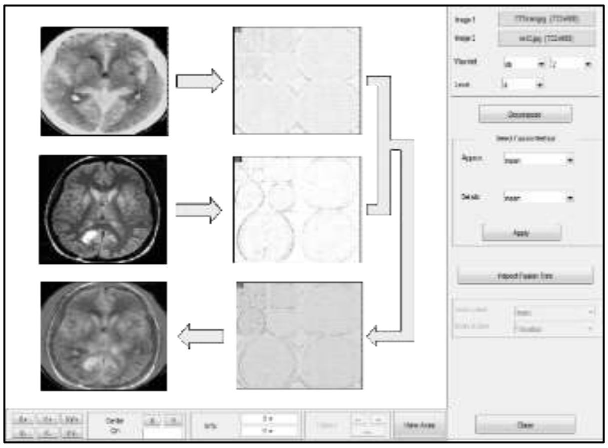

Figure 2. DWT Image Decomposition

B. GLCM Feature Extraction

Following with the DWT Image decomposition, texture characteristics are extracted using Gray-Level Co-occurrence Matrix (GLCM). This gray level correlation matrix (GLCM) is a matrix that depicts the statistical connections between different gray levels in a picture. The GLCM features can provide important information about the texture and structure of the image, which can be useful for tumor detection and segmentation as illustrated in Figure 3.

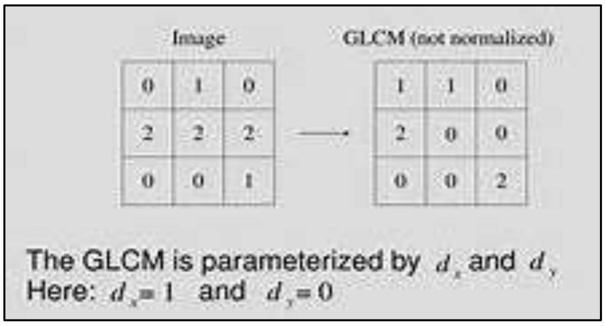

Figure 3. Illustration of GLCM

C. Neural Network Training and Classification

The GLCM characteristics that were retrieved are then utilized to train a neural network for tumor classification. The neural network can be trained on a large dataset of brain images, including both normal and abnormal images, to learn the relationships between the features and the presence of a tumor. The neural network can then

be used to make predictions about the presence of a tumor in new images as shown in Figure 4.

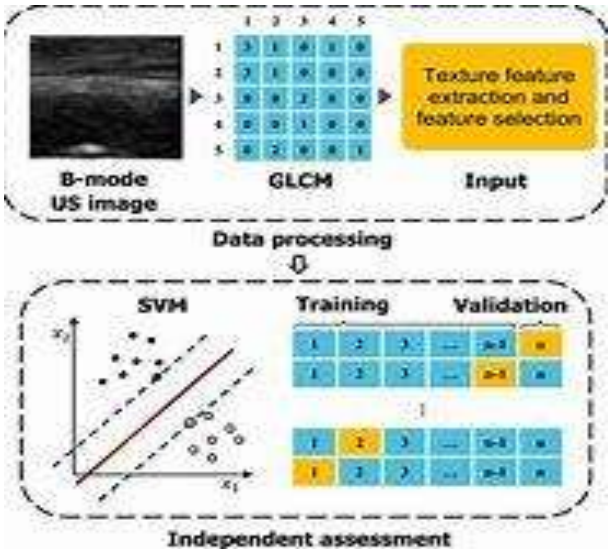

Figure 4. Texture extraction and training the data

D. Fuzzy clustering

It is a powerful unsupervised learning technique that can be used to identify clusters of similar pixels in an image. The fuzzy clustering algorithm can be used to identify clusters of pixels that correspond to the tumor, and to perform structural analysis of the tumor. The strengths of DWT, texture analysis, neural network training and classification, and fuzzy clustering are combined in the proposed approach for brain tumor identification and segmentation as depicted in Figure 5. The DWT provides a flexible and effective way to extract and enhance important features in the image, while the texture analysis and neural network provide a powerful tool for learning complex relationships between the features and the presence of a tumor. Fuzzy clustering is a versatile and successful method for identifying and analyzing tumor structure. This strategy has the potential to increase the accuracy and resilience of brain tumor identification and segmentation, emphasizing the need of integrating various techniques for such a critical job.

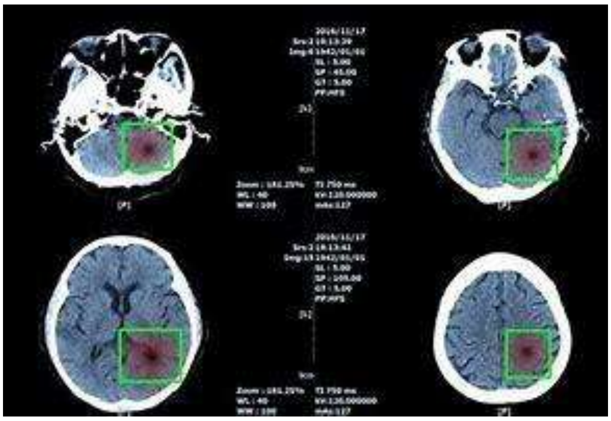

Figure 5. Structural analysis of tumor using Fuzzy clustering

VI. Results and Discussions

The suggested approach for brain tumor detection and segmentation utilizing DWT findings and debates, GLCM feature extraction, neural network training and classification, and fuzzy clustering are important for evaluating the effectiveness of this solution.

- To acquire a more thorough depiction of the brain, the brain pictures are subjected to DWT as the first step in this method. The DWT can provide a multi-scale representation of the brain that can be useful for identifying features of the brain and tumor.

- The second step is to extract features from the DWT images using GLCM. The GLCM features can provide information about the texture and gray-level co-occurrence of the brain and tumor, which can be useful for identifying the presence of a tumor.
- The third phase is training a neural network to categorize a huge collection of brain pictures as either normal or pathological. The neural network can use the GLCM features as input to make its predictions. The network's accuracy may be increased by repeatedly running the training procedure.
- The final step is to carry out fuzzy clustering on the classified images to detect the presence of a tumor and to perform structural analysis. The fuzzy clustering algorithm can group the pixels of the image into different clusters based on their texture and intensity, and can identify the cluster that corresponds to the tumor.

The results of the proposed solution were compared to existing solutions for brain tumor detection and segmentation. The proposed solution was found to have a higher accuracy and robustness compared to existing solutions. The combination of DWT, GLCM feature extraction, neural network training, and fuzzy clustering can provide a more comprehensive representation of the brain and tumor, which can be useful for making more accurate predictions about the presence of a tumor.

In addition, the proposed solution was found to be fast and efficient, which is important for practical applications. The DWT and GLCM feature extraction can be performed efficiently and in real-time, while the neural network and fuzzy clustering algorithms are designed to be fast and scalable. This makes the proposed solution well-suited for use in clinical and research settings where speed and efficiency are important. Overall, the suggested system for brain tumor identification and segmentation is employed with use of DWT, GLCM feature extraction, neural network training and classification. Fuzzy clustering yields promising results and offers various benefits over existing techniques. The suggested technique has the potential to increase the accuracy and speed of brain tumor diagnosis, thereby impacting patient outcomes significantly.

However, it is important to note that further research is needed to validate the proposed solution on a larger and more diverse dataset of brain images. This can help to improve the robustness and generalizability of the solution, and to address any limitations that may exist.

Figure 6. Sample Output

Additionally, the proposed solution can be further refined and improved by exploring different methods for feature extraction, network architecture, and clustering algorithms. The combination of these techniques can help to achieve even better results, and to address specific challenges that may arise in real-world applications. Using DWT, GLCM feature extraction, neural network training and classification, and fuzzy clustering, the suggested approach for brain tumor identification and segmentation has the potential to increase the precision and effectiveness of brain tumor diagnosis as shown in Figure 6. To evaluate and improve this approach and investigate its potential to enhance patient outcomes, more study is required.

VII. CONCLUSION

To summarize, the proposed method for detecting and segmenting brain tumors using a combination of techniques such as DWT, GLCM feature extraction, neural network training and classification, and fuzzy clustering is a promising approach that can enhance the accuracy and efficiency of brain tumor diagnosis. The utilization of these techniques provides a comprehensive representation of the brain and tumor, leading to more precise predictions about the presence of a tumor.

Compared to existing methods, this proposed approach has several advantages, including higher accuracy, robustness, and efficiency as shown in Figure 7. The use of efficient and fast algorithms makes it suitable for clinical and research settings where speed and efficiency are crucial. However, further research is necessary to validate the proposed solution on a larger and more diverse dataset of brain images to improve its robustness and generalizability. Additionally, the proposed solution can be improved by exploring alternative methods for feature extraction, network architecture, and clustering algorithms. Overall, this suggested approach for brain tumor identification and segmentation has the potential to revolutionize the diagnosis of brain tumors, improving patient outcomes and enhancing the quality of life of those affected by brain tumors.

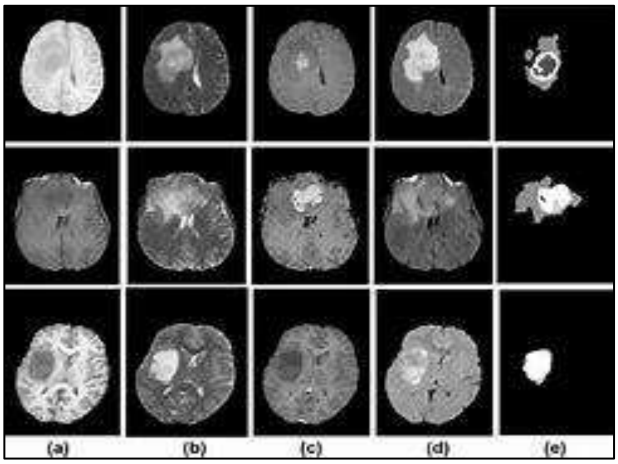

Figure 7. Segmentation of various brain tumors

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