International Journal of Soft Computing 9 (3): 189-193, 2014
ISSN: 1816-9503

Classification of Brain Tumor Images using Orthogonal Based Composite Operators and Artmap of Mirror Neurons

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Abstract: Tumor as the definition goes is an abnormal growth of cells which can occur in any part of the human body. Such growth when occurs in brain is called brain tumor. Only symptoms and no causes have been found so far. Brain tumors give very normal symptoms like nausea or headache which may occur due to other reasons also. Therefore, early identification of such tumor is very much necessary. Its threat level depends on a combination of various factors like the type of tumor, its location, size and developmental stage. Many techniques exist for scanning the brain like Computed Tomography (CT) scan, Magnetic Resonance Imaging (MRI), etc. to test the tumor existence. MRI is most common one used for used for analyzing the brain as the images produced are of high precision and applicability. The main objective of this study is to classify the brain MRI dataset for the existence or non existence of tumors. The proposed method uses convolution of orthogonal operators with edge detection operators which is applied on the image. Classification of the image is done using ARTMAP of mirror neurons. The classification accuracy is 90% for the proposed method which is better when compared to BPN based classification.

Key words: MRI, Adaptive Resonance Theory Mapping (ARTMAP), sobel operator, orthogonal polynomial operator, orthonormal operator

INTRODUCTION

Mirror neurons: The human brain has an action matching system done by certain neurons and these neurons are called mirror neurons. The discoverer of these neurons, Rizzolatti, felt it was a bridge between doing and communication. It can be described as a link between the sender and the receiver (Rossi and Rossi, 2006). To mirror neurons associated the representations of visual features and motor action (Murata *et al*., 1997). These associations formed a link between manipulable objects and their information. The information could be about the actions and their uses. A person visualizing the object gets these action associations automatically evoked (Chao and Martin, 2000). The association done by the mirror neurons is taken advantage of, for classifying the brain MRI's.

Brain tumor: Brain tumor usually affects the central nervous system. World Health Organization (WHO) has given some codes and grades to the tumor affecting the nervous. Brain tumor is one of the major causes for the increase in mortality among children and adults (Jaya *et al*., 2009). For detection of brain tumor, MRI has become one of the most common tools. The knowledge gained from this data has become a critical component in diagnosis and treatment planning (Archibald *et al*., 2003) of brain tumors. Early detection and treatment of tumor is inevitable in order to increase the mortality rate in both children and adults all over the world.

Literature review: Xu *et al*. (2004) have used semi supervised ellipsoidal ARTMAP which is a modified ARTMAP for classifying the types of tumor with gene data. Further, to this he has used the same ARTMAP for tumor classification and included Particle Swam Method to find the gene pattern (Xu *et al*., 2007).

Xu *et al*. (2009) has used ARTMAP to classify Mature mIcro RiboNucleic Acid (miRNA) expression fingerprints. These are high-throughput messenger RNA (mRNA) found to be effective in diagnosis and treatment of cancer. The found ARTMAP to classify the RNA's better than others (Xu *et al*., 2009).

In the survey study, Rajalakshmi and Prabha (2013) has mentioned the various classification techniques and preprocessing techniques. Researchers has mentioned about the use of fuzzy ARTMAP for feature selection using Genetic algorithm. There is also a mention of use of ARTMAP for classification applications which in turn used Genetic algorithms. The drawback of this approach was different results for different sets.

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It is clear from the above, ARTMAP is used for classification based on which ARTMAP is used for classifying brain MRI's in the proposed approach.

MATERIALS AND METHODS

In this proposed method, classification of brain MRI is done using the combination of convolution of orthogonal operators with edge operators and Adaptive Resonance Mapping (ARTMAP) of mirror neurons. Convolution of operators is done to have the advantage of both the orthogonal operators as well as edge detection operators. Classification of tumour from non tumour is done by ARTMAP of mirror neurons.

This proposed research presents a method of convolving the orthogonal operators with edge detection sobel operator. This convolved operator is applied on the image to obtain the feature space. The resultant is a feature space which is grouped. The result of this group for all the images is put tighter and given to ARTMAP of mirror neurons for classification. The performance of mirror neurons classifier is dependent on measuring the classification of tumour from non tumour images. The combination proposed in this research using ARTMAP of mirror neurons classifier enables proper classification thereby reducing the physical classification complexity involved. The developed classification system is expected to provide a valuable and accurate classification process for the physicians. This proposed method, gives the highest classification accuracy of 90% when compared with other conventional texture analysis methods.

The system architecture of the proposed research is shown in Fig. 1. Figure 1 shows the steps that the proposed research follows while classifying the tumor MRI from the database. From the database of brain MRI's each image is considered for processing. The database consists of a total of 70 images. Out of these, 50 are taken for training and 20 for testing. In the training images 11 images are non tumor images and 28 images tumor images. In the training images 10 images are non tumor images and 10 images tumor images. The size of each image is 256×256.

The performance of the proposed technique in tumor identification is evaluated by using the positive and negative cases. This means if a brain MRI is one with tumor then it must be identified as a tumor image, i.e., True (T) and Positive (P). The other combinations in this include:

- True Negative (TN): in this case the given tumor image is not identified as one

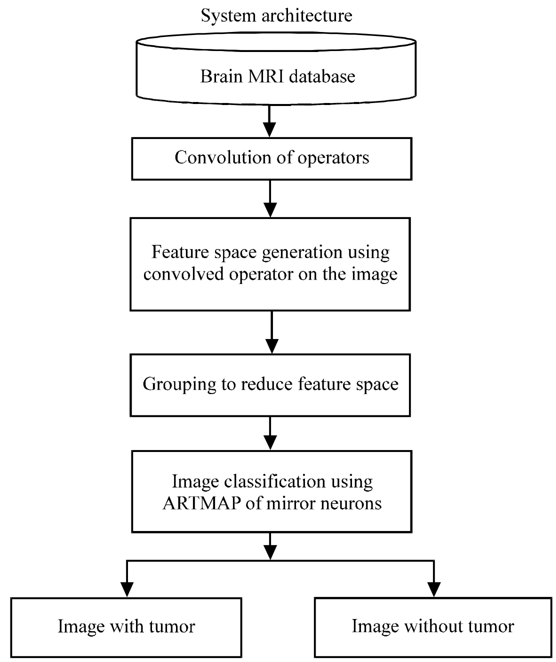

Fig. 1: System architecture for the combination of convolution of operators and ARTMAP of mirror neurons

- False Positive (FP): in this case the given non-tumor image is identified as one
- False Negative (FN): in this case the given non-tumor image is not identified as one

Using these cases the sensitivity, specificity and accuracy are defined as follows:

$$\text{Sensitivity} = \text{TP+FN} \quad (1)$$

$$\text{Specificity} = \frac{\text{TN}}{\text{Total No. of tested images}} \quad (2)$$

$$\text{Accuracy} = \frac{\text{Sensitivity}}{\text{Total No. of tested images}} \quad (3)$$

$$\text{Total percentage of accuracy} = \text{Accuracy} \times 100 \quad (4)$$

The orthogonal operators have been applied to give precise input to the classifier while the classification of MRI is done using ARTMAP of mirror neurons classifier. The research proposed takes advantage of grouping to give a better classification result. Proposed research handles brain images as a combination of grouping and classification algorithms. The system has an image database of MRI's. From this database, laborious research will be needed to classify the tumor images if it contains any of the two characteristics viz., abnormal pixels and hazy borders. The following are the challenges that inhibit the task of tumor classification:

- Tumor heterogeneity
- Inter-slice intensity variations

The use of orthogonal operator will overcome all the above-mentioned challenges since convolution of operators takes place. This way of classification makes for better accuracy because proposed research takes advantage of ARTMAP of mirror neurons classifier which is more efficient in classification.

For each MRI, a convolved operator is applied on it to generate feature space. When representing images in feature space, all the feature values correspond to the pixels of an image. The dot product method is used to combine the feature values. The operator taken into account for feature space generation and image processing has various sizes like 3×3, 4×4 and 5×5 and also an operator set for each size is included within. The proposed research also uses orthonormal operator for the basis of comparison. ARTMAP of mirror neurons classifier is used for classifying the image as tumor or non-tumor. The entire system overview is given in Fig. 1.

In the Fig. 1, there is a brain image database, i.e., MRI database. As a next step in the procedure convolution of operators done. The convolved which is said as composite operator contains sobel, orthogonal polynomial and orthonormal operators. The combination of these operators has the advantage of combining the features of orthogonal which is masking and sobel which is edge detection. When the convolved operator is applied on the image it is like applying both the features at a time on the image.

The orthogonal operator of size 3 gives nine sets of operators as result of convolution of this operator with edge detection operators. All these are applied one by one to all the images. The result of this operation gives a feature space for each image. The reduction of feature space is done using histogram and result is given to ARTMAP of mirror neurons classifier for classification.

RESULTS AND DISCUSSION

The evaluation metrics used as TP, FN, TN and FP for evaluating the percentage of accuracy in identifying the tumor in the given image. Here, TP means True Positive, FN means False Negative, TN means True Negative and FP means False Positive. The combination of convolution of operators and ARTMAP of mirror neurons classification is used to identify the tumor in a MRI of the brain. Orthogonal operators of sizes 3, 4 and 5 are used and all the sets of these sizes are applied on the image for further process and evaluation. The grouping is done using the built-in hist operator which groups the whole feature space based on the values of the bin size. Therefore, instead of finding the features from the feature space the values are divided into two thereby reducing the length of the vector formed just to two. This result is given to ARTMAP of mirror neurons for classification of tumor in the image.

Table 1 shows the values of the evaluation parameters TP, FN, TN and FP. It depicts the percentage of accuracy for the orthogonal operator sizes of 3, 4 and also 5. Table 2 shows the value details when orthonormal operators are used for the same purpose as that of orthogonal operator. Both the operators give the same percentage of accuracy for size 4×4 and 5×5.

Table 3 depicts the comparison of percentage of accuracy for convolution and with no convolution of orthogonal operators of various sizes. Table 4 depicts the comparison of percentage of accuracy for convolution and with no convolution of orthonormal operators of various sizes.

Figure 2 shows the recognition rate against the orthogonal operators sizes 3, 4 and 5 for both ARTMAP

Table 1: Sensitivity factor for various sizes of orthogonal operators combined with ARTMAP of mirror neurons

Operator size	3×3	4×4	5×5
TP	10	9	9
FN	8	6	6
TN	0	0	0
FP	2	5	5
Accuracy (%)	90	75	75

Table 2: Sensitivity factor for various sizes of orthonormal operators combined with ARTMAP of mirror neurons

Operator size	3×3	4×4	5×5
TP	10	9	9
FN	7	6	6
TN	0	0	0
FP	3	5	5
Accuracy (%)	85	75	75

Table 3: Comparison of percentage of accuracy for convolution and with no convolution of orthogonal operators of various sizes and classification using ARTMAP of mirror neurons

	Operator size		
Methods	3×3	4×4	5×5
Percentage of accuracy with convolution of orthogonal operators and ARTMAP of mirror neurons classification	90	75	75
Percentage of accuracy without convolution of orthogonal operators and ARTMAP of mirror neurons classification	80	75	65

Table 4: Comparison of percentage of accuracy for convolution and with no convolution of orthonormal operators of various sizes and classification using ARTMAP of mirror neurons

	Operator size		
Methods	3×3	4×4	5×5
Percentage of accuracy with convolution of orthonormal operators and ARTMAP of mirror neurons classification	85	75	75
Percentage of accuracy without convolution of orthonormal operators and ARTMAP of mirror neurons classification	70	70	80

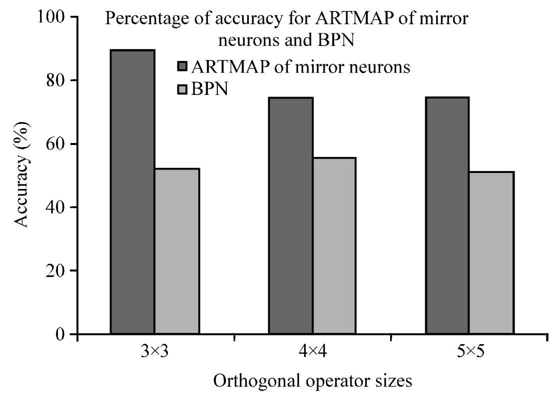

Fig. 2: The percentage of accuracy for orthogonal operator of various sizes and classifiers

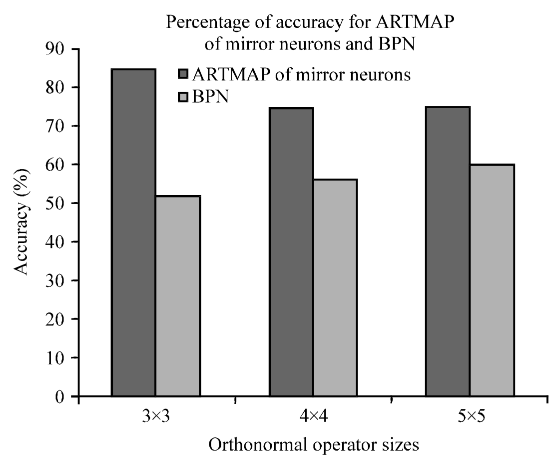

Fig. 3: The percentage of accuracy for orthonormal operator of various sizes and classifiers

of mirror neurons classifier and BPN classifiers. ARTMAP of mirror neurons classifier gives 90% accuracy for the orthogonal operator size 3×3 whereas BPN gives only 52.9% for this size.

Figure 3 shows the recognition rate against the orthonormal operators sizes 3, 4 and 5 for both ARTMAP of mirror neurons classifier and BPN classifiers. ARTMAP of mirror neurons classifier gives 85% accuracy for the orthogonal operator size 3×3 whereas BPN gives only 60.23% for this size.

CONCLUSION

Tumor classification, physically a tough job has been automated using the proposed work of use of ARTMAP of mirror neurons classifier and orthogonal operators since it is automated. The features of masking operators and edge detection operators are combined and applied to the image and classified for tumors.

The orthogonal polynomial and orthonormal operators used here are the most commonly used masking operators used to generate the feature space of the given image. In these operators for each size all the operators, i.e., for example for size 3 all the sets from set 2-8 are considered. Each of these are used with a brain MRI to get a feature space. The feature space is reduced using histograms and the result is classified using ARTMAP of mirror neurons. For comparison BPN is used. Experiments were done without convolution of operators of sizes 3, 4 and 5 and considering all its sets. The accuracy was a maximum of 80% only.

The present research work has limited number of images of brain MRI. The number of images can be increased. The proposed research can be extended to other MRI images of liver or breast. It could also be extended to colour images if needed or even videos.

The proposed technique is effective since it has produced a detection accuracy of 90% for the operator size 3×3 as a result of applying a convolved operator on the image and combining it with ARTMAP of mirror neurons for classification. This research work can be further extended by using the optimal operator set. This can also be extended for different sizes of orthogonal polynomial operators.

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