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MRI Brain Image Classification Based on S-Transform, Sammon Mapping and Naïve Bayes Classifier

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Abstract: *In this paper, an efficient method for Magnetic Resonance Imaging (MRI) brain image classification is presented using Stockwell (S)-Transform, Sammon Mapping (SM) and Naïve Bayes (NB) classifier. Initially, the MRI brain images are represented in frequency domain by S-Transform. As the representation in frequency domain provides more detailed information than spatial domain, S-Transform is used for feature extraction. The high dimensional S-Transform feature space increases the complexity. Hence, SM technique is used to reduce it and then classification is made by NB classifier. The performance measures such as sensitivity, accuracy and specificity are computed to evaluate the system. Result shows the better classification accuracy of 94% is obtained by S-Transform based SM technique with NB classifier with 94% of sensitivity and specificity.*

Keywords: *Brain images, Stockwell transform sammon mapping, Naïve Bayes classifier.*

I. INTRODUCTION

Different wavelet analysis using Support Vector Machine (SVM) is discussed in [1] for brain image classification. Initially, the brain images are decomposed by different wavelet families like Daubechies, Symlets and biorthogonal wavelets are used. The classification is made by SVM classifier. A brain disease named Alzheimer's disease classification is described in [2] using whole brain hierarchical network. Features are extracted by pearsons correlation coefficient. The features are selected by higher F-scores. At last, the classification is made by multiple kernel boosting.

Brain image classification using Dual Tree M-band Wavelet Transform (DTMWT) is discussed in [3]. The MRI brain images are decomposed by DTMWT and the statistical features are extracted. SVM classifier is used for the classification. Brain tumor classification using SVM and Principal Swarm Optimization (PSO) is described in [4]. At first, brain image features such as intensity, shape and texture features are extracted.

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Then, the dominant features are selected by PSO. The type of the tumor is classified by SVM.

MRI brain image classification using image mining algorithms is described in [5]. Gray Level Co-Occurrence Matrix (GLCM) based features are used. The classification is made by SVM and KNN classifier. Hybrid classification method for MRI brain image classification is described in [6]. Initially, from input brain MRI images region of interest are extracted by Otsu's thresholding approach along with the extraction of tissue. Maximum posteriori approaches are used to classify the MRI brain images.

The classification of super voxels for brain tumor classification is discussed in [7]. Initially, the image normalization and enhancement are employed as preprocessing techniques. The enhanced images are segmented by 3-dimensional super voxels. Then, the features are extracted by saliency detection algorithm. Edge-aware filter is used to enhance the boundary regions. The robust texture feature from super voxels is used for the classification. Probabilistic Neural Network (PNN) is discussed in [8] for brain tumor classification using MRI brain images. Features are extracted by GLCM. The PCA technique is used for image compression and recognition and data reduction. Segmentation is made by K-means clustering and then PNN is used to classify the MRI images.

Classification of MRI brain images for brain disease on multilevel brain partitions is discussed in [9]. The scale invariant feature transform and SVM classifier are used for feature extraction and classification respectively. Dynamic Angle Projection (DAP) features is described in [10] for brain tumor classification. It uses watershed algorithm for segmentation. At first, the images are segmented by watershed DAP. The dynamic angle projection and texture features are extracted. The classification is made by convolution neural network.

Tumor classification and detection using different wavelet transform and SVM is discussed in [11]. The input MRI brain image features are extracted by different wavelet transforms like Haar, Symlet, Morlet and Daubechies. Otsu's thresholding method is used for segmentation. The classification is made by SVM classifier. MRI brain tumor segmentation from single contrast is described in [12]. The input MRI brain images are normalized to image intensity. Then, multi-scale intensity, shape, template and texture based features are extracted. The classification is made by random forest classifier.

In this paper, MRI brain image classification system based on S-Transform, SM technique and NB classifier is discussed. The organization of paper is as follows" The methods and materials of MRI brain image classification system are discussed in section 2. In section 3, the obtained results of MRI brain image classification system are discussed. The conclusion arrived from the performance of the system is given in last section.

II. METHODS AND MATERIALS

In this section, MRI brain image classification using S-Transform, SM technique and NB classifier is presented. Figure 1 shows the workflow of the image classification system using MRI brain images. At first, S-Transform is applied to both abnormal MRI brain images and normal as well. Then, the redundant features which are obtained from the decomposition of S-Transform are reduced by SM technique. Finally, the system uses NB classifier for classification.

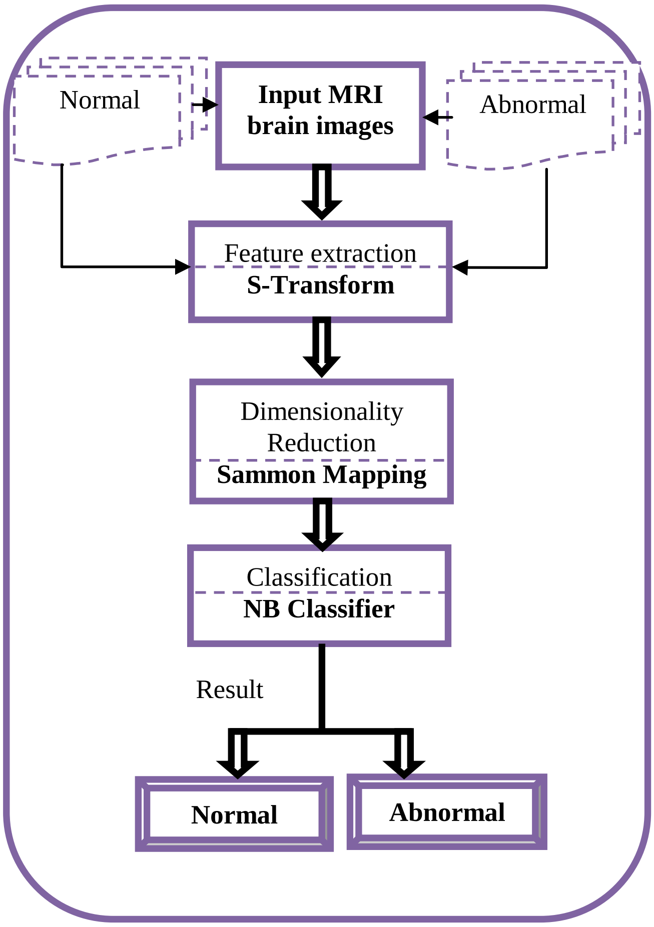

Fig. 1.Block diagram of MRI brain image classification system

A. S-Transform

S-Transform is a frequency decomposition tool. It overcomes the disadvantages of continuous wavelet transform and short time Fourier transform for better time frequency resolution based on Gaussian window. The S-Transform is applied to other fields like face recognition [13] and image fusion [14]. The S-Transform is defined by,

$$ST_k = \int_{-\infty}^{\infty} K(L)|g| e^{-\pi (l-L)^2 g^2} e^{-i2\pi gL} \tag{1}$$

The properties of S-Transform for multiple frequency voices for dimensional functions of time scale (l) and frequency (g) is defined by,

$$ST(l,g) = B(l,g) e^{i\psi(l,g)} \tag{2}$$

In this study, the S-Transform is applied to MRI brain images to represent it into their respective frequencies in the form of transform coefficients. In order to reduce the feature space from its high dimensional to low, SM technique is applied.

B. SM Technique

SM is an algorithm to map a high dimensional space with lower dimensionality space which is also known as sammon projection. The SM technique is used in many fields like agricultural datasets for precision agriculture [15]. It prevents the structure of high-dimensional space in lower dimension projection. It is suitable to use in data analysis. It is a non linear approach for mapping in linear combination. Let us consider, two objects m and n, the distance between two objects in the original space is defined by d^*_{mn} and the distance between their projections is defined by d_{mn}. The SM minimizes the error function known as sammon's stress or sammon's error.

$$SE = \frac{1}{\sum_{m<n} d^*_{mn}} \sum_{m<n} \frac{\left(d^*_{mn} - d_{mn}\right)^2}{d^*_{mn}} \tag{3}$$

The minimization can be performed by iterative methods. The number of iterations is needed to determine the errors. The SM technique is used to reduce the redundant feature which is obtained by the decomposition of S-Transform.

C. NB Classification

NB is a machine learning algorithm. It is a classification algorithm from a collection of Bayesian algorithm with strong inference of features. NB classifier is also used in other field like emotion recognition [16] and finger print recognition [17]. NB is highly scalable for obtaining linear parameters in the number of variables. In naïve Bayes classifier the value of a particular feature is free from the value of other features in the given class. The complicated classification methods are made by NB classifiers. The Bayes rule based on NB classifier is defined by,

$$H\left(Q/R\right) = \frac{H\left(R/Q\right) H(Q)}{H(R)} \tag{4}$$

The large numbers of data points are performed well by NB classifier. The MRI brain images are classified by NB classifier after obtaining features from S-Transform and SM technique.

III. RESULTS AND DISCUSSIONS

The evaluation of the system described in section 2 is carried on REpository of Molecular BRAin Neoplasia DaTa (REMBRANDT) database [18] images. From the vast number of MRI image collection in this database, a set of 50 brain images for both normal and abnormal categories are selected randomly. The original MRIO images are in DICOM format. All images are initially converted into gray scale images of size 256x256 pixels. Figure 2 shows sample images in the REMBRANDT database.

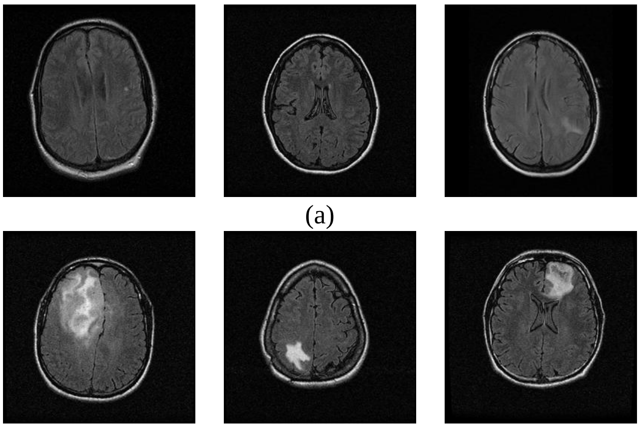

Fig. 2.Sample MRI brain images in REMBRANDT database (a) Normal and (b) Abnormal

The S-Transform is applied to input MRI brain images for feature extraction. The SM technique is applied to reduce the redundant features and they are the inputs for the classification. NB classifier is used for classification using 10-fold cross-validation. From the classifier outputs, a Confusion Matrix (CM) is formed. Then, the following measures; accuracy, sensitivity and specificity are computed from CM and also Receiver Operating Characteristic is drawn.

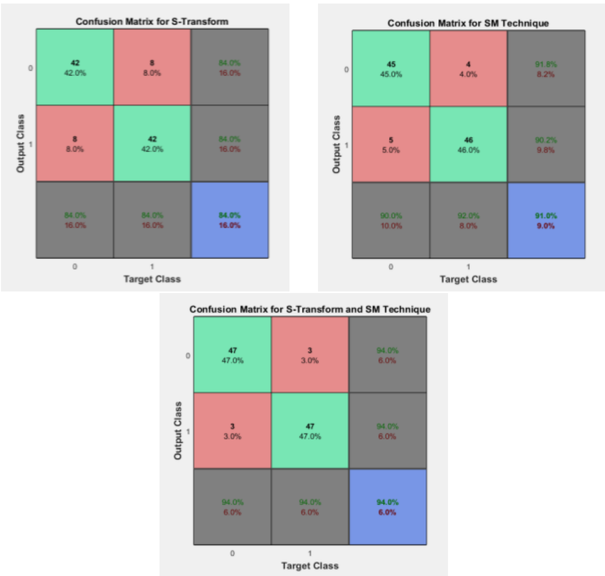

Fig. 3. CM for S-Transform, SM Technique and fusion of S-Transform and SM Technique

From the CMs shown in Figure 3, it is observed that the maximum classification accuracy of 94% obtained by the fusion of S-Transform and SM technique using NB classifier. Also, their sensitivity and specificity are 94% that means that among the 50 images used for testing the classifier only 3 images are misclassified in each category. Before feature reduction, the classifier gives 84% classification accuracy and it is noted that 7% accuracy is increased (84% to 91%) after feature extraction. Figure 4 shows the Receiver Operating Characteristics (ROC) for S-Transform, SM Technique and fusion of S-Transform and SM Technique using NB classifier.

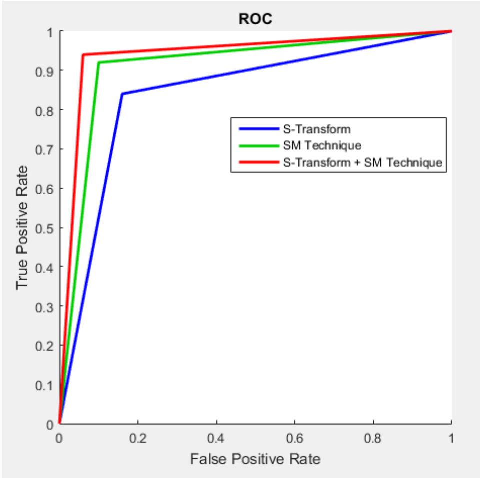

Fig. 4. ROC for S-Transform, SM Technique and fusion of S-Transform and SM

From the ROC, the maximum area of 0.94 is obtained by the ROC curve of S-Transform + SM technique. Among the three ROCs, the minimum area is 0.84 which is obtained from the features of S-Transform. Figure 5 shows the obtained performance measures of NB classifier using S-Transform and SM technique.

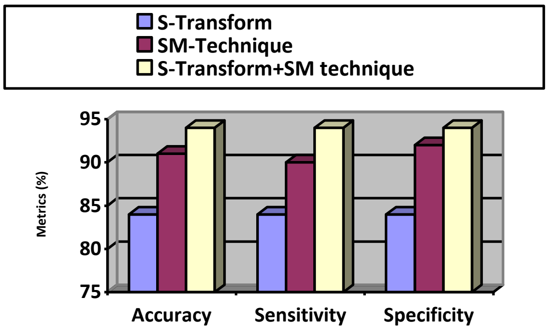

Fig. 5.Performance measures of the system for brain image classification

IV. CONCLUSION

In this study, S-Transform, SM technique and NB classifier are analyzed for MRI brain image classification. The MRI brain image classification system uses S-Transform for feature extraction which is a frequency domain analysis. It produces more detail information than spatial domain and also gives a high dimensional feature space. SM technique is used to reduce the S-Transform feature space. Then, the MRI brain image classification is made by NB classifier. Results show that 94% of MRI brain images are classified correctly by the fusion of S-Transform and SM technique by using NB classifier.

REFERENCES

1. S. Mohankumar, "Analysis of different wavelets for brain image classification using support vector machine," International Journal of Advances in Signal and Image Sciences, 2(1), 2016, pp. 1-4.
2. J. Liu, M. Li, W. Lan, F. X. Wu, Y. Pan, and J. Wang, "Classification of alzheimer's disease using whole brain hierarchical network," IEEE/ACM transactions on computational biology and bioinformatics, 15(2), 2016, pp. 624-632.
3. R. R. Ayalapogu, S. Pabboju, and R. R. Ramisetty, "Analysis of dual tree M-band wavelet transform based features for brain image classification," Magnetic resonance in medicine, 80(6), 2018, pp. 2393-2401.
4. A. Kumar, A. Ashok, and M. A. Ansari, "Brain Tumor Classification Using Hybrid Model Of PSO And SVM Classifier," In 2018 International Conference on Advances in Computing, Communication Control and Networking, 2018, pp. 1022-1026.
5. V. Solanki, M. V. Patel, and M. S. Pati, "Brain MRI Image Classification using Image Mining Algorithms," In 2018 Second International Conference on Computing Methodologies and Communication, 2018, pp. 516-519.
6. S. Lu, L. Lei, H. Huang, and L. Xiao, "A hybrid extraction-classification method for brain segmentation in MR image," In 2016 9th International Congress on Image and Signal Processing, BioMedical Engineering and Informatics, 2016, pp. 1381-1385.
7. M. Kadkhodaei, S. Samavi, N. Karimi, H. Mohaghegh, S. M. R. Soroushmehr, K. Ward, and K. Najarian, "Automatic segmentation of multimodal brain tumor images based on classification of super-voxels," In 2016 38th Annual International Conference of the IEEE Engineering in Medicine and Biology Society,2016, pp. 5945-5948.
8. R. Lavanyadevi, M. Machakowsalya, J. Nivethitha, and A. N. Kumar, "Brain tumor classification and segmentation in MRI images using PNN," In 2017 IEEE International Conference on Electrical, Instrumentation and Communication Engineering, 2017, pp. 1-6.
9. T. Li, and W. Zhang, "Classification of brain disease from magnetic resonance images based on multi-level brain partitions," In 2016 38th Annual International Conference of the IEEE Engineering in Medicine and Biology Society,2016, pp. 5933-5936.
10. T. A. Jemimma, and Y.J. Vetharaj, "Watershed Algorithm based DAPP features for Brain Tumor Segmentation and Classification," In 2018 International Conference on Smart Systems and Inventive Technology, 2018, pp. 155-158.
11. M. Gurbină, M. Lascu, and D. Lascu, "Tumor Detection and Classification of MRI Brain Image using Different Wavelet Transforms and Support Vector Machines," In 2019 42nd International Conference on Telecommunications and Signal Processing,2019, pp. 505-508.
12. H. Tang, H. Lu, W. Liu, and X. Tao, "Tumor segmentation from single contrast MR images of human brain," In 2015 IEEE 12th International Symposium on Biomedical Imaging, 2015, pp. 46-49.
13. B. H. Shekar, and D. S. Rajesh, "Stockwell transform based face recognition: A robust and an accurate approach," In 2016 International Conference on Advances in Computing, Communications and Informatics, 2016, pp. 168-174.
14. E. M. Babu, S. D. Maniks, N. M. Nandhitha, N. Selvarasu, S. E. Roslin, R. Chakravarthi, and M. S. Sangeetha, "Two-dimensional stockwell transform based image fusion for combining multifocal images," In 2017 International Conference on Intelligent Sustainable Systems, 2017, pp. 710-714.
15. Y. Sanghvi, H. Gupta, H. Doshi, D. Koli, A. Ansh, and U. Gupta, "Comparison of Self organizing maps and Sammon's mapping on agricultural datasets for precision agriculture," In 2015 International Conference on Innovations in Information, Embedded and Communication Systems, 2015, pp. 1-5.
16. S. K. Bhakre, and A. Bang, "Emotion recognition on the basis of audio signal using naive bayes classifier," In 2016 International Conference on Advances in Computing, Communications and Informatics, 2016 pp. 2363-2367.
17. Q. Song, X. Liu, H. Yuan, and C. Qiu, "Naive bayes classifier applied in droplet fingerprint recognition," In 2012 Third Global Congress on Intelligent Systems,2012, 152-155.
18. Brain MRI images: https://wiki.cancerimagingarchive.net/ display/Public/ REMBRANDT.

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