Research Journal of Applied Sciences 11 (10): 1137-1142, 2016
ISSN: 1815-932X

Classificstion of Brain MRI Images Using Classifier Techniques Supported by Genetic and Fuzzy C-Means

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Abstract: Computer techniques play important role in medical fields, especially in the classification and disease diagnoses. In this study, Brain MRI is classified using many techniques. Back propagation neural network, K-nearest and K-means used for classifying these images into normal and abnormal after clustering images using fuzzy C-means and minimizing the extracted features by GLCM using genetic algorithm. The system shows high efficiency through practical experiments that proves that the accuracy of system is reached to 100% through back propagation neural network.

Key words: Classification, GLCM, fuzzy C-means, genetic algorithm, K-means, neural network, K-nearest

INTRODUCTION

Among all types of cancer, one of the major cause of death is brain tumor. Classifier system for extraction of tumor region and diagnosis of brain tumor was used. This system is preprocee of brain MR images in many steps such as noise removal, skull striping and intensity normalization. The free noise brain MR images used to extract the texture and intensity features. Then method uses multiclass Support Vector Machine (SVM) to classify five types of tumor based on the WHO grading system, i.e., Astrocytoma (Grade-I), Glioblastoma Multiforme (Grade-IV), Meningioma (Grade-II), Medullo blastoma (Child tumor) (Grade-IV) and metastatic melanoma (Grade-III) (Awatif *et al*., 2016).

The fast and effective way to diagnosis of tumor is identifying the right class of brain tumor. Many steps to design the classifier system was used, beginning with taken MRI image as input and normalize its. After that, the system reduced a redundancy of data that acts the input of classifier by extracting the features from image. The classifier produced the output using each tuple of extracted features. Fuzzy Inference System (FIS) based classifier known as Adaptive Neuro Fuzzy Inference System (ANFIS) was used to classify input (Roy *et al*., 2016).

The classification of images is done by feature extraction using two methods for extraction which are Scale Invariant Feature Transform (SIFT) and Speeded Up Robust Features (SURF). SIFT method is used to detect the images with larger corners and extract them. SURF, the name itself represents a speed method to extract the features when compared to SIFT. KNN classifier is used to classify the images based on the features extracted from both techniques. So these combined processes are applied to classify tumor and non-tumor images more accurately (Amulya and Prathibha, 2016).

Introduction to genetic algorithm: Genetic algorithms have emerged in 1975 when John Holland suggests this approach in his book “adaptation in natural and artificial systems” to be one of evolutionary algorithms family members (Naveen *et al*., 2011).

Genetic Algorithm suggests a number of solutions, chromosomes, through particular steps. First, a population of feasible chromosomes is generated randomly (Singh *et al*., 2013).

In the next step, individuals are evaluated using fitness function. The algorithm does not stop when getting the primary population, it creates other generations through three main operators, Selection which equates the survival of the fittest, Crossover simulates human marriage by using individuals selected from the previous operation (selection) to produce new individuals (offspring) and Mutation which is considering the possibility of the occurrence of random modification in the new individuals.

The three operations continue until reaching the stop condition which is often: the access to a specific number of generations that have been determined by the algorithm designer, the stability of system performance at a certain level without change or the reaches of goal.

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Classification techniques: There is no doubt that there are many Algorithm that can be used to classify data and images. These methods usually included within two categories usually (supervised and unsupervised). In this study, the focus is placed on three classification techniques, two of them belong to supervised type and the third is unsupervised one.

Backpropagation neural networks: Neural networks are designed to simulate the way of thinking and treatment of information by nerves to implement a certain task by the human mind through distributed parallel system (Roy and Sharma, 2010).

Back Propagation Neural Network (BPANN) is most widely used artificial neural network. At first glance it seems complicated but it is much easier on the level of understanding and programming. This network characterized by the ability to deal with the non-linear problems (Chariatis, 2007).

Any BPANN has input cells and output cells with one or more layers of hidden cells. Layers communicate with each other through the weights which corresponds nerves in humans. Weights are organized in matrices. The importance of the weights comes from the fact it is responsible for the quality of the work of neural network. It is important to ensure that these weights accurate as much as possible.

BPANN learns under the supervision by comparing the real output of the network with optimal output and takes advantage of the difference between the two output, the error to adjust weights matrix. To give the network learning ability, patterns are provided and divided into two sets, one of them used to infer the weights are capable of making the network works properly and the other group used to verify the efficiency of the network (Hasson and Mohammed, 2010).

The BPANN passes through two stages. In the first phase the output signal for each cell in the network layers values are calculated starting from the input layer toward output layer, meaning that the output signal of any cell only affects the following layer. At the end of this process, the error between the real and optimal outputs is computed as follows equation:

$$\text{Error} = \frac{1}{2}\sum_{t=1}^{N}(\text{targeti-output})^2$$

Where:

N = Number of neurons in output layer
Target = optimal output
Output = Actual output

There is a need for the next stage if an error is encountered. The weights are adjusted in a manner allowing the error to be within reasonable level. The re-deployment of the error is taken place in reversal direction, i.e., from output layer to the input layer to update weights (Bassil, 2012).

K-nearest-neighbor: The KNN classifier is another example of the supervised methods (Hussein *et al*., 2013). KNN depends on another methodology that is differs from the back propagation, it does not extract any information from the training phase but it only divides the available patterns into two groups, one of them called the training set and the other is called the test group (Abdulrazzaq and Noah, 2015). The classifier compares each case in the test group with all the cases in the training set in order to find the nearest neighbor (s) by specifying the k similar case (s) to the one to be classified and then reports the appropriate class depending on the prevailing class (Sridevi and Murugan, 2014). The following algorithm describes the steps of KNN:

Algorithm 1: KNN classifier

```
For i = 1 to No. of cases in test group
 Begin
    Let Y be the current test instance.
    For j = 1 to No. of cases in train group
      Begin
         Let X be the current train instance
          Compute the distance between X and Y and store the result in D
  End
  Select First K minimum distance.
 Count the number of each class in the selected neighbors
  Choose the class with the larger occurrences to be the class of the test case
 End
```

K-means clustering: K-means clustering is a famous and simplest clustering algorithm (Chaturvedi and Rajavat, 2013). For datasets that contain n cases and m features, the method starts by specifying K, the number of groups, then the centers of each cluster is to be chosen. In simplest way, the choice of such centers is done randomly or by choosing K cases which are located at the beginning of the dataset. Then each case is allocated to the nearest cluster by calculating the similarity between the centers and that case (Karegowda and Kishore, 2014).

The importance of similarity measure is that it controls placing elements in the correct group. Different tactics can be adopted to form clusters, some of these include: distance, connectivity and intensity (Nock and Nielsen, 2006). The updating of each center is computed at the end of each iteration by calculated the mean of values and thus, each center is a representative of the values in the corresponding cluster this causes to strengthen the centers and amplifies their ability to attract similar cases (Sridevi and Murugan, 2014). K-means continues in applying these processes till the stop condition is achieved when there is no change in the centers, i.e., cases settled in clusters in final form.

Fuzzy C-means technique: In fuzzy clustering, data elements can belong to more than one cluster and allocated to each one of these elements membership degrees which refers to the strength of the relationship between the data element and a specific cluster. Fuzzy clustering is an operation of allocated degrees of membership and later using them to allocated data elements into one or more clusters. The most popular fuzzy clustering algorithm, known as fuzzy C-means algorithm (Nock and Nielsen, 2006).

FCM is a way of clustering which permits one part of data to belong to two or more clusters. FCM method is carried out through a series of steps.

Algorithm: Fuzzy C-means clustering:
Input: Image data matrix I, number of cluster (c = 4),height, width, m (1<m<8), threshold(0.01)
Output: Image data matrix partition into set of region
Begin: First step: should be initialize U = [u_{ij}] matrix, U(0)
Second step: at k-step computes center of each cluster by using the equation:

$$V_i = \frac{\Sigma_{k=1}^{n} u_{ik}^{m} xk}{\Sigma_{k=1}^{n} u_{ik}^{m}},\ i = 1, 2, 3 \text{ and } c$$

Third step: update membership matrix (U(k)) to provide U(k+1) by using the equation:

$$u_{ij} = \frac{1}{\Sigma_{J=1}^{C}\left(\frac{|X_i - C_j|}{|X_i - C_k|}\right)^{\frac{2}{(m-1)}}}$$

Finally, if |U(k+1)-U(k)| is less than threshold then stop, otherwise return to step second.

MATERIALS AND METHODS

GLCM method: Feature extraction is the operation of extracting helpful information from image or identifying characteristics found within the image, these characteristics are used to describe the object (Lindblad and Kinser, 1998). In this research, eight textural features based on the Gray Level Co-occurrence Matrix (GLCM) are extracted of every image. GLCM is computed for four directions: 0, 45, 90 and 135 degrees. The eight texture descriptors are extracted from each GLCM which are calculated in each of four angles (Joshi and Phadke, 2010; Roy *et al*., 2016).

Max pobability:

$$F1\ \ Max\,(Cnorm(x, y))$$

Entropy:

$$F2 = -\sum_{x=0}^{L-1}\sum_{y=0}^{L-1}(Cnorm(x, y)\,Log\,(Cnorm)(x, y))$$

Contrast:

$$F_3 = -\sum_{x=0}^{L-1}\sum_{y=0}^{L-1}(x-y)^2\ (Cnorm)(x, y)$$

Inverse Differesnce Moment (IDM):

$$F_4 = \frac{\sum_{x=0}^{L\ 1}\sum_{y=0}^{L-1} Cnorm(x, y)}{1+(x\,y)^2}$$

Angular second moment:

$$F_5 = \sum_{x=0}^{L-1}\sum_{y=0}^{L-1} Cnorm(x,y)^2$$

Mean:

$$F_6 = \frac{\sum_{x=0}^{L\ 1}\sum_{y=0}^{L-1} Cnorm(x,y)}{L+L}$$

Dissimilarity:

$$F_7 = \sum_{x=0}^{L-1}\sum_{y=0}^{L-1}(|x\,y|)Cnorm(x,\ y)^2$$

Homogeneity:

$$F_7 = \frac{\sum_{x=0}^{L\ 1}\sum_{y=0}^{L-1} Cnorm(x,y)}{1+|x-y|}$$

The structure of the suggested classifier system: The proposed method contains many different steps, including the data collection, feature extraction through gray level co-occurrence matrix, optimization with the help of Genetic Algorithm and classification through three techniques include back propagation Neural network, K-nearest and K-means. The database contains both normal brain and abnormal brain images. In the first, features of the MRI brain images are extracted through (GLCM) Gray Level Co-occurrence Matrix. There are various features obtained from the image such as homogeneity, contrast, entropy, mean, etc. After that, Genetic Algorithm optimization technique is used to reducing the features which helps for the classification purpose. Classifier techniques are used is used for diagnosing MRI brain images into normal and abnormal.

Image acquisition: A 100 brain images are collected from Marjan hospital of Babylon city in Iraq with the class 1 refers to existence of abnormal tumor and class 0 for normal.

Table 1: Extracted features for various images

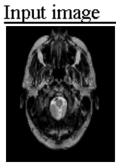
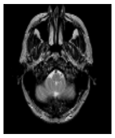
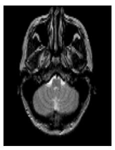
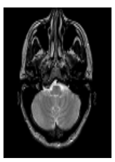
Input image	Dissimilarity	Inverse Difference Moment (IDM)	Angular second moment	Homogeneity	Contrast
	13.9768686868687	0.810662653861615	0.419295622895623	0.813663129288129	1399.70292929293
	13.9058585858586	0.822064023721316	0.440594694418937	0.824657223113010	1401.04383838384
	13.7264646464646	0.830554537398773	0.425200163248648	0.833139750796333	1536.80323232323
	13.6944444444444	0.832158204588289	0.446958534843383	0.840175756623957	1411.04474747475

Table 2: Parameter used in genetic algorithm

Parameters	Method	Notes
Chromosome coding	Binary	32 bits (bit per feature) encoded by 0 and 1
Mating method	Uniform (UX)	Probability of occurrence = 0.9
Mutation	Replacing two genes randomly	Probability of occurrence = 0.1
Selection technique	Binary selection	Elitism is used to increase the quality of population by replacing top 5 members in the previous population with 5 worst members in the current cycle
Fitness measure	F = (c/n)×100%	C: No. of cases classified correctly It is calculated by running classification method N = 100 (total number of images available for work)
Stop condition	No. of generations = 11	Ten cycles plus primary population

Fuzzy C-means clustering brain MRI images: In order to get more accurate features, fuzzy C-means method has been explained in section 5 is applied on images and the output of this step is getting 4 regions for each image. Figure 1 shows sample of the original and segmented image.

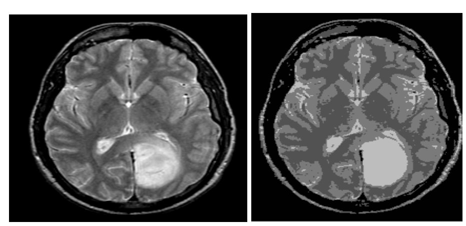


Fig. 1: Sample of The original and segmented image

Features extraction GLCM technique: Feature extraction is the process in which all the features are extracted for accurate classification of MRI brain images. In this study, feature extraction is done using the Gray Level Co-occurrence Matrix (GLCM).

GLCM method uses 4 angles (0, 90, 45, 135) and 8 features on the segmented images produced by the previous stage to obtain 32 features vector. These vectors are stored in a 100×32 Excel dataset. Table 1 shows part 5 features of 4 images from 32 features of 100 images) of database resulted from GLCM set of brain images. Only important features are entered to the classifier tools as inputs after reducing them using the robustness and efficiency of genetic algorithm.

Genetic algorithm for extraction important features: In this step, the genetic algorithm minimizes the number of features of dataset by selecting those features with important effect on the classification performance and the other (unnecessary) ones are neglected (Table 2). This

Table 3: Results of classifier methods and comparison among them

Classifier method	Accuracy	Selected features	Design information
K-nearest	97.1429%	5,7,8,10,11,12,19,21,28,29,31,32	K = 1
K-means	84%	8, 10, 11, 12, 14, 15, 17, 18, 21, 22, 32	K = 2
BP.N.N	100%	2, 3,4, 5, 7, 11,12, 13, 15, 17 18 19, 21, 22, 24, 26, 27	No. Input cell = 17 No. hidden cell = 8 No. output cell = 1 Train rate = 80% Test rate = 20%
BP.N.N	90%	1 3 5 6 7 8 9 10 13 15 16 17 19 20 21 22 23 24 26 30 31 32	No. Input cell = 24 No. hidden cell = 8 No. output cell = 1 Train rate = 70% Test rate = 30%
BP.N.N	91.4286%	1 3 7 8 12 13 19 21 23 26 32	No. Input cell = 11 No. hidden cell = 8 No. output cell = 1 Train rate = 65% Test rate = 35%

process improves the efficiency. Details of parameter used in genetic algorithm. The researchers steps of genetic algorithm is done as follows. Genetic algorithm generates 50 individuals randomly to be the primary population. The responsibility of determining the number and type of features that used in the classifier is entrusted to each chromosome. The length of chromosome equal 32 which is the total number of features of brain images. The genes of chromosome encodes by 1 when the feature is used and 0 when feature is ignored. The number of 1's in the chromosome represents the number of features that used in the classifier.

Each chromosome is evaluated by implementing the classifier to compute its accuracy. After 10 generations created by selection, crossover and mutation, the best chromosome (solution) has been gotten, the one with the important features using extracted features as inputs.

RESULTS AND DISCUSSION

The classification process is done using the tools which are described in the section 3 and the results of each classifier is explained in Table 3. To prove the power and efficiency of used method, many experiments used. The experiments and their results explained in Table 3 with comparison among performance of classifier techniques.

Discussion and performance analysis: The presented results in Table 3 shows the excellence in the performance of each of BPANN and KNN compared with K-means. BPANN has been tested through three categories of experiments differ in the sizes of training and testing sets, as mentioned in Table 3 and the result is that the accuracy of the system in the three categories exceeds 90%. When 80% of instances stored in excel dataset is allocated for training and 20% for the test, the accuracy reaches 100%. The BP net shares the same architecture in all experiments: one cell for output that produce 1 in the case of finding tumor and 0 if not, 8 cells in hidden layer and variable number of input cells depending on number of 1's in the chromosome.

Despite the simplicity of KNN, it shows high precision in classification. The performance is 97.1429% in the case of reliance on the most closely neighbor ($k = 1$). The system records a performance of 94.2857% with different features in other experiments where $k = 3$ and $k = 7$. K-means shows a good performance but it does not rise to the level of performance of the previous methods largely due to the fact that this method is one of the stars of clustering tools but it is considered as second degree method when used for classification.

CONCLUSION

This study is proved its success and efficiency as a classifier system of brain MRI images. Three methods are used as a classification tools, neural network, KNN and K-means. Results showed the superiority of neural network where its performance is reached to 100% when allocating 80% of the images to the training process. KNN comes second in terms of performance which amounted to 97% where K-means method get the third place with a performance that not exceeds 84%.

GLCM contributes converting images into a set of features after applying FCM while genetic algorithm is played an undeniable role in raising the accuracy of the system by deleting unimportant characteristics. In the future works, the following developments can be applied and the results are compared with current system:

- Extraction of features can be achieved using different method such as moment and histogram
- Using K-means for clustering phase instead of FCM

REFERENCES

Abdulrazzaq, M.M. and S.A.M. Noah, 2015. Improving the annotation accuracy of medical images in Image CLEFmed 2005 using K-Nearest Neighbor (KNN) classifier. Asian J. Appl. Sci., 8: 16-26.

Amulya, C. and G. Prathibha, 2016. MRI brain tumour classification using surf and sift features. Int. J. Mod. Trends Sci. Technol., Vol. 2,

Awatif, S.A., B.H. Khudair and S.K. Ali, 2016. Prediction of ryznar stability index for treated water of WTPs located on Al-Karakh side of Baghdad City using Artificial Neural network (ANN) technique. J. Eng., 22: 1-10.

Bassil, Y., 2012. Neural network model for path-planning of robotic rover systems. Intl. J. Sci. Technol., Vol. 2,

Chariatis, A., 2007. Very fast online learning of highly non linear problems. J. Mach. Learn. Res., 8: 2017-2045.

Chaturvedi, E.N. and E.A. Rajavat, 2013. An improvement in K-mean clustering algorithm using better time and accuracy. Int. J. Program. Lang. Appl., 3: 13-19.

Hasson, S.O. and S.H. Mohammed, 2010. General regression neural network application for dynamic data compression and decompression. Proceeding of the 3rd Scientific Conference on Information Technology, November 29-30, 2010, Symbiosis Centre for Information Technology, Pune, India, pp: 73-79.

Hussein, A., L. Esraa and A. Hussein, 2013. Design a classification system for brain magnetic resonance image. J. Babylon Univ. Pure Appl. Sci., 21: 2682-2689.

Joshi, J. and M.A. Phadke, 2010. Feature extraction and texture classification in MRI. Energy, 2: 130-136.

Karegowda, A.G. and B. Kishore, 2014. Enhancing performance of KNN classifier by means of genetic algorithm and particle swarm. Optim. Int. J. Adv. Found. Res. Comput. Vol. 1,

Lindblad, T. and J.M. Kinser, 1998. Image Processing using Pulse-coupled Neural Networks. Springer-Verlag, Berlin, Heidelberg.

Naveen, S., H.P. Chaturvedi and H. Komal, 2011. Computational intelligence in circuit synthesis through evolutionary algorithms and particle swarm optimization. Intl., J. Adv. Eng. Technol., 1: 198-205.

Nock, R. and F. Nielsen, 2006. On weighting clustering. IEEE Trans. Pattern Anal. Mach. Intell., 28: 1223-1235.

Roy, D.K. and L.K. Sharma, 2010. Genetic K-means clustering algorithm for mixed numeric and categorical datasets. Int. J. Artif. Intell. Appl., 1: 23-28.

Roy, S., S. Sadhu, S.K. Bandyopadhyay, D. Bhattacharyya and T.H. Kim, 2016. Brain tumor classification using adaptive neuro-fuzzy inference system from MRI. Int. J. Bio. Sci. Bio. Technol., 8: 203-218.

Singh, D., P. Rani and R. Kumar, 2013. To design a genetic algorithm for cryptography to enhance the security. Proc. Int. J. Innovations Eng. Technol., 2: 380-385.

Sridevi, T. and A. Murugan, 2014. An intelligent classifier for breast cancer diagnosis based on K-means clustering and rough set. Int. J. Comput. Appl., 85: 0975-8887.