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ISSN (Online) 2394-2320

International Journal of Engineering Research in Computer Science and Engineering (IJERCSE)
Vol 5, Issue 3, March 2018

Abnormality Feature Extraction in the Spinal Cord MRI Using K-Means Clustering

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Abstract: **- Research on Medical Image proposes an efficient platform for automatic analysis and detection of any Deformations in a given medical image data set especially in Spinal Cord for an effective and better understanding of diagnosis. The abnormality of the spinal cord may include Tumor, Disc a hernia, Fracture, swelling etc., which has been detected from any given modality of Medical images such as MRI, CT, and fMRI etc. In this work, Automated Decision support system is introduced for fast and accurate analysis which will help to confirm the existence of affected part of the Spinal Cord MR image. It has two phases. Phase I: Identifying any anomaly features or distortion is found to have existed in the given image or not by using histograms. Phase II: Involves in Clustering of the image which is used to find the depth of the existence of the calcification in the MRI Spinal Image. The performance of the algorithm and the time taken to complete every cluster phase is analyzed. Further, the algorithm's efficiency is being observed to prove that it gives a perfect accuracy.**

Keywords**: Medical Images, Image Pre- processing techniques, Histogram, Feature Extraction, K-Means Clustering.**

I. INTRODUCTION

Spinal Cord plays an important role in our body. Many are not aware of the importance of the spinal cord. It is the main path which carries all the information from brain to all of the human system. It passes the information from one place to other place of the body. Spinal cord has vertebrae column, disk and spinal canal. Whole vertebra of spinal is classified in to four types, cervical (8) controls the neck and hand functions, thoracic (12) cares the ribs muscles to above waist functions, Lumbar (5) takes hip and thigh functions[1], sacral (5)leg functions. From cervical to sacrum, one can count 150 articulations where movements can occur. Injury in spinal cord is the common phenomena around the world. There are two types of Spinal injury such as incomplete injury or a complete injury. This happens due to trauma, long standing, improper postural sleeping and heavy lifting. Incomplete injuries can be cured and complete injuries will be sustained.

In previous studies, tumour in the brain is common and even in other internal parts of the body but not in spinal cord. Now a day's tumour in the spinal cord vertebrae is common .There is no age limit in occurrence of spinal abnormality. Reason for the calcification in the spinal vertebrae is not known. Mainly calcification occurs in cervical and between thoracic and lumbar spine vertebrae. Pains due to complete and incomplete dispute may aggravate. At the initial stage, symptoms such as numbness, swelling, weakness and gait difference can be seen. It is always better to cure in the pre-operative stage. To visualize the suspected area or issue through MRI seems to be best for diagnosis. Aim of this paper is to make the visualized area clear or to understand the area accurately automated decision support is implemented.

In this work, Different techniques used to diagnose at the initial stage of the unhealthy situation to avoid advanced complications. Clustering is the important partitioning method which is used by many researchers for their successful work .It distinct the related and unrelated objects in the given medical data. K-Means Clustering is the very famous and commonly used algorithm implemented using MRI Spinal Cord Tumour. Data from different set of age group has been clustered. This method gives the best result. This paper has following sections: Section II Describes Related works done in same and different domains. Section III Theoretical and Mathematical Representation of the proposed work are explained. IV Result and Discussion of the work done is tabulated with images. Finally, Section V concludes the paper work.

II.RELATED WORK

K-Mean Clustering is used in different domains. The concept of the K-mean Clustering is considered and the Important Work carried out by different authors are analysed and applied in this paper. Mohamed Amine Larhmam et.al,[2] presented a novel method to identify manually a vertebrae column in the spinal cord. They preprocessed the image using Contrast and edge detection method and then Generalised HT used to mark the alignment manually. Finally, it seems to be identified the region using k-means clustering. Vertebrae alignment is extracted. Future work is to automate their work and improve their learning models and segmentation process.

Piyush M. Patel [3] used K means algorithm on different set of medical images and determined the specific region of the image. Nor Ashidi Mat Isa[4] is proposed automated technique for pap smear image using K-Means and Modified seed based region growing algorithm (MSBRG).First, K-means clustering is used to find the threshold value and with this MSBRG is applied for edge detection. As per the result it has given better outcome after comparing with different algorithm for the same.

Selvamani.K et.al [5], implemented K-means algorithm to segment the Brain image. This Work is done by Segmenting MRI brain tumour with k tissue values. Estimated mean intensity at each location for each tissue types. Performance of the algorithm is tested using different and large patient data. The future and on-going work is segmenting coronary arteries in a sequence of angiographic image while preserving the topology of the vessel structure.

K. Vijay, K. Selvakumar [6] developed a new model for segmenting FMRI images integrating both PCA and K means algorithm. First, it is applied to avoid the problems occurred while segmentation. After this interaction K mean clustering is applied on the FMRI for the same clustering purpose. The result shows that it performed well and gave the accurate result.

Ming-Ni Wu1 et.al [7], proposed a colour based method to segment the brain MRI. K means clustering is used to perform this task. It is not a common one, this k mean first convert the grey scale image to colour space image then partition the tumour from the given image. This result is compared with the histogram clustering method. Result shows that this method works efficiently and as per the statement defined, it is an easiest method for the segmentation.

Shiv Ram Dubey et al [8], Presented the work which implements the k means in two different ways. First, clustered the pixels based on the colour and spatial feature. Second, the clustered objects are merged to a particular region value. By this they believed that computational efficiency is increased to avoid the feature extraction of every pixel in the image. Result shows that the approach is promising.

H.P. Ng1, 2 and S.H. Ong3 [9] is given a methodology for segmenting medical images using watershed algorithm and k means clustering method. Over–segmentation and sensitive false edge detection are the drawback of watershed segmentation algorithm. These issues rectified using K means clustering algorithm. Number of partitions in the segmentation maps of 50 images is compared. The given proposed methodology produced segmentation maps with 92% fewer partitions than the segmentation maps produced by the traditional watershed algorithm.

B. Ramamurthy [10] is described the shape based feature extraction using canny edge detection methods. Images classified using k means clustering techniques. The work is to retrieve a given image from the huge volume of medical databases. Shape feature extracted using canny edge detection. And then k means classification is used for the retrieval of image for diagnosis.

Nameirakpam Dhanachandra et.al [11] segmented the medical image using K means clustering and subtractive clustering algorithm. K means algorithm is an unsupervised algorithm which is used to partition the objects in the image. Before this clustering, feature enhancement was performed as a pre-processing technique. Subtractive clusters are implemented to generate initial centres. These centres are used in k means clustering algorithm. As a final point, the segmentation is done. After all these process, median filtering applied to remove the unwanted region from the segmented image. It gave a better performance. Further implement the concept using morphological operation and other clustering algorithm with this subtractive clustering method.

Meenakshi S R et.al [12], detected the tumour region in the brain using k means clustering under morphological image processing. Morphological segmentation is the binary segmentation method which has two method dilation and erosion. After this k means clustering is done, the region of interest is identified and defined. The same concept implemented for RSI Images.

III THEORETICAL AND MATHEMATICAL REPRESENTATION OF THE PROPOSED WORK

The proposed methodology is explained in 2-stage process. In the beginning Spinal MR medical images are taken as input and then pre-processing of the images done in order to improve the flexibility of the images for further processing. To automate the decision support system First Given data primarily checks for the existence of anomaly features by using Image Enhancement technique histogram. Inage with no issues are need not to process. If data has anomaly goes to the Second Process and apply k-means algorithm to the clustering to attain the Feature extraction. The framework of the methodology is in Figure 1. Next process is to determine the depth of the anomalies.

ISSN (Online) 2394-2320

International Journal of Engineering Research in Computer Science and Engineering (IJERCSE)
Vol 5, Issue 3, March 2018

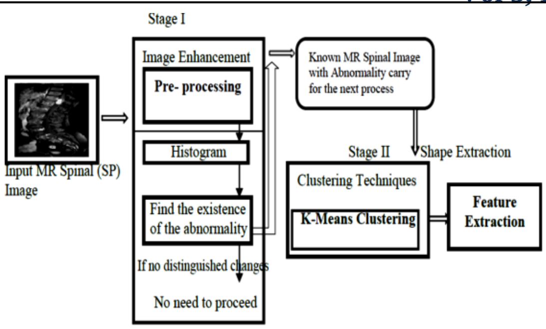

Fig 1: Over view of the different steps of the proposed framework.

a) Dataset

This research work uses MRI Spinal cord cervical images taken from normal and abnormal patient images from Dr. G. Balamurali, Spine Specialist at Cauvery Hospital in Chennai. DICOM means Digital Imaging and Communications in Medicine. It is an International Standard for medical images and related information of DICOM defines the formats for medical images. The DICOM file format supports any information object definition. This type of images has patient information like age, sex, modality, study description, date of image taken, image size and type etc. Normal and abnormal data are processed in this methodology. The Tumor MR Spine images with sagittal t2-weighted are taken. 20 images of the patient are tested in the proposed Method.

b) Histogram

Histogram is graphical representation of a pixel values of the image at different intensity value found. Suitable image data file or the histogram statistics must be given for the required output of the histogram. All pixel count distributed among the given dataset displays in histogram graphically in Fig 2. For 8 bit grayscale image there are 256 possible numbers shown. Finding the image with deformation is by comparing the intensity modification values in the image. Histogram Modification is the one way to find the distinctions among the images. Hence Histogram modification for this method has to be implemented. The Let Ho is the histogram of the input image and let Hu be the uniform histogram. The main idea is to attain values of intensity variation histogram H c from the input histogram Ho such that the difference between H c and Hu is sufficiently small, keeping the H c closer to H. Now it is an optimization problem and can be formalized as:

$$H' = \alpha H + (1 - \alpha) Hu, \qquad (1)$$

Where $0 \leq \alpha \leq 1$.

In the above equation different α values with their mapping functions are explained. Firstly, α take the value of 1(α =1).This function get most saturated point at earlier to the maximum value. It leads to the over enhancement for the spinal dataset When it reaches this condition. But whenever it gain a point 0(α=0), values gradually meet the maximum value.

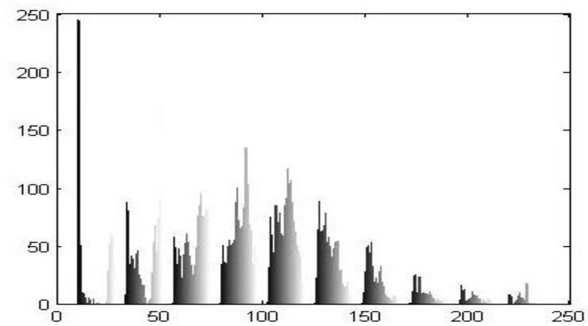

Fig 2: Histogram of MR Spinal Image

c) K-Means algorithm

K means clustering is the simple and commonly used clustering algorithm. It is the task performs by partitioning the given data in to number of mutually k clusters that is grouping object which are similar to one another based on the cluster groups. This algorithm works by assigning the multidimensional values to a single K cluster. It returns the index of clusters for the assigned estimation data. This process will minimize the difference of the vectors given to clusters. After each vector is allocated the cluster value will be iterative and the value of cluster center will be changed (reallocated).The same process will continue with the different vectors for the k value. Finally, this cluster process is the unsupervised grouping method for the cluster or the collection [13] [14]. This clustering is used to find the hidden features from the given raw set of data's so that it is used all applications especially in image processing, Data mining This algorithm assigned the input parameter k, and divides a set of n objects into k clusters so that the resulting one cluster similarity is high but another cluster similarity is low. Given a set of interpretations (x1, x2, x3, x4…xn), where each observation is a 2-dimensional real vector, If it is not in prescribed dimension that should be changed. This is aim to partition the n observations into k sets (k < n) S = {S1, S2… Sk} so as to minimize the inner-cluster sum of squares.

$$\arg\min_{S} \sum_{i=1}^{k} \sum_{xj \in si} \|X_j - \mu_i\|^2 \qquad (2)$$

Where μi is the Mean value in si.

Implemented K-Means Algorithm Explanation:

This clustering algorithm is implemented based on the Mean value.

Input: n objects in the given Dataset. Number of cluster value K.

Output: Set of cluster based on the K value.

Method:

Step 1: Input the Image

Step 2: Convert datatype of the given image

Step 3: Initialize the no of clusters.

Step 4: Calculate the k center value.

Step 5: Determine the Mean value

Step 6: Calculate the distance between the each cluster center for the process .If the object distance are near to the center value then move to the next cluster. Rather exit and carry to the next cluster.

Step 7: Continue the process until the center value is reached.

V RESULT AND DISCUSSION

In this research work, tumor is detected by identifying the pixel values in MR Spinal are taken for analysis. The DICOM Image format of the image is used for processing the image. The source code is written in MATLAB software. The Result discussed as following method. First insert the original images as input and then Preprocessing is completed. For this resulted image Histogram is used for automation. Next step is to perform Sample Cluster for given images. The results of all the above are tabulated in tables and shown in figures. Finally, Quantitative analyses are done.

a) Insert the original images as input:

Data which is given in the DICOM format must be converting in to .JPG format for the processing in Fig 3.The image may contain noise and uncertain edges.

b) Pre-processing image: Clustering or Segmentation is very difficult when the medical image with noise. So Preprocessing or Enhancement is needed, this includes RGB to Grayscale, sharpening and smoothening of image. Sharpening gives the image details clear. Smoothening removes the noise in the image. Here Input image of MR Spinal is given.

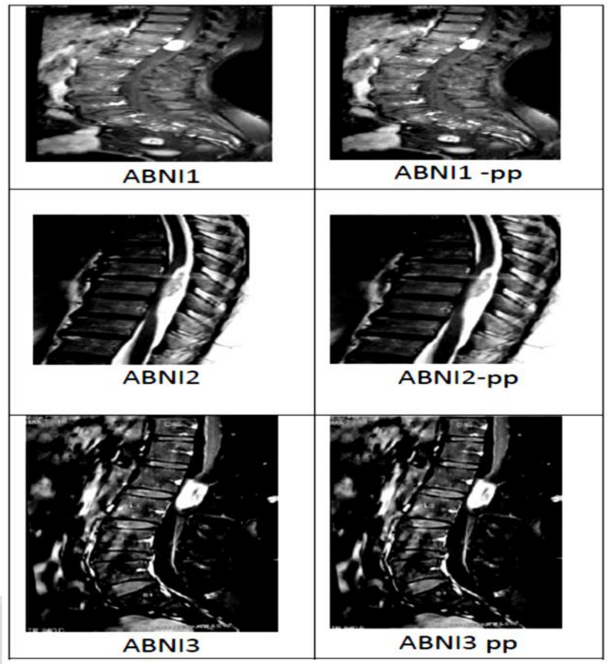

Fig 3: Input image (with pre-processing)

c)Histogram

In this section the distributed histogram pixel values are Identified and Examined to find the existence of the amalgamation by this the system is automated. We predicted that the range value may occur in 40-89.If the pixel distribution shows in the above values then the data contains calcification leads to clustering process. If not, no issues in the given data then the process will terminate. The Presence of abnormal values highlighted in red rectangle box in Fig 4. This value tested with the 50 seeds. This gives the approximate pixel range distribution of the highest density area (suspicious) in MR Spinal image. Hence, we automated the model and Time consuming is achieved for a decision making system. This must be tested with more number of dataset and check the performance of the methods used.

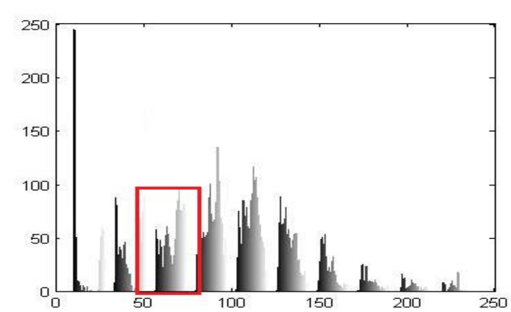

Fig 4: Histogram of MR Spinal Image with suspicious amalgamation.

International Journal of Engineering Research in Computer Science and Engineering (IJERCSE)
Vol 5, Issue 3, March 2018

Sample Cluster Result for the given Image

There are 50 seeds taken for the implementation of algorithm. The following table shows that the clustering results of the various three tumour affected images. As explained before the numbers of clusters are 4 and 8. ABNSI is Abnormal Spinal Image.C1-C4 and C1-C8 Cluster results of the Tumor Spinal Image based on the cluster centre value k. It is explained in Fig 5 & Fig 6.

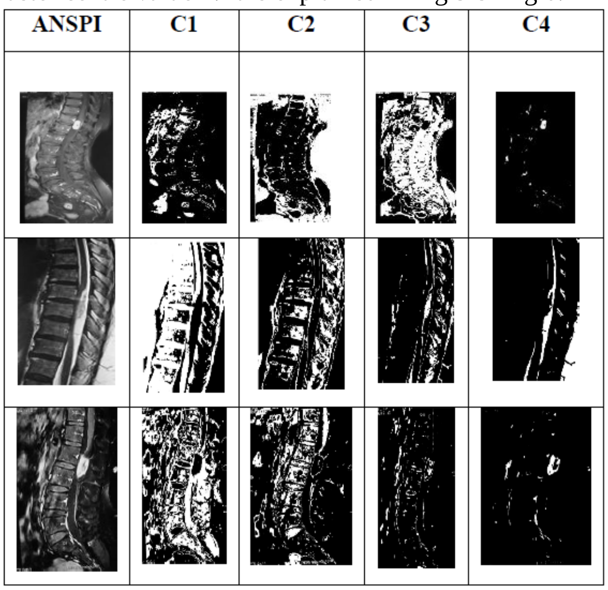

Fig 5- Figures (ANSPI) of k mean algorithm when k=4

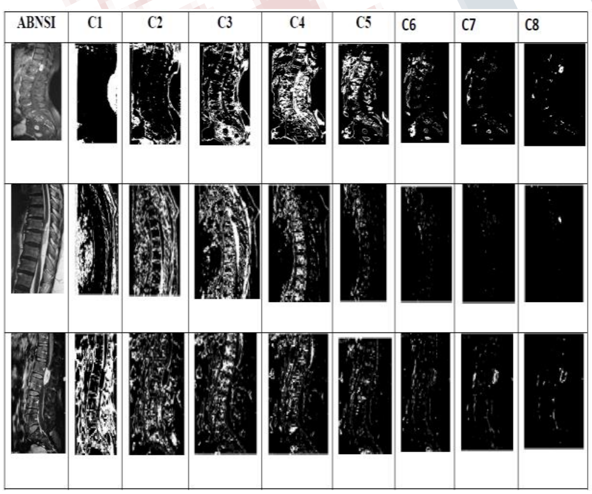

Fig 6- Output of k means algorithm at k=8

The performance of the K means algorithm is tested with sample of three different ABNSI .Time taken to execute all these three seeds are analysed and also the density of the tumor pixel obtained at each 4 and 8 clustering are expressed in the following chart. Bar chart shows the significant performance of the ABNSI

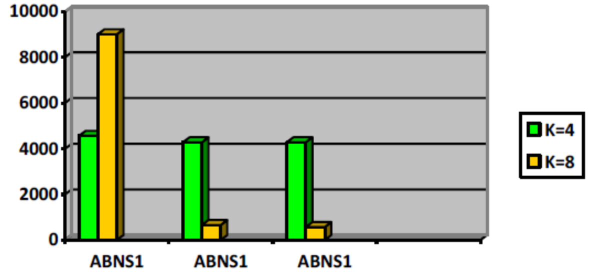

Fig 7- Performance of the K means Algorithm

Quantity Analysis of the K-Means Algorithm

SEI and SPI is sensitivity and specificity index is calculated based on the following values True Positive (TP), True Negative (TN), False Positive (FP), and False Negative (FN) respectively.

JI and DC indicates Jaccard index and Dice Coefficient

GT and PM are ground truth region and area detected by the Proposed Method respectively.

$$\%SEI = (TN/(TP+FN))/100 \quad (3)$$

$$\%SPI = (TN/(TN+FP))/100 \quad (4)$$

$$JI = \frac{\Theta GT \cap \Theta PM}{} \quad (5)$$

$$DC = 2 \times \frac{\cap \Theta_{PM} \quad PM}{\Theta_{GT} + \Theta_{PM}} \quad (6)$$

All the indices are c ng the sample of three seeds under study listed in Table 1.Values obtained by substituting these values in the above formulas. The result gained shows the higher performance on the given dataset.

	ABNS1	ABNS2	ABNS3
SEI	85.49	86.23	88.14
SPI	90.23	93.41	91.28
JI	0.863	0.849	0.873
DC	0.913	0.875	0.812

Table 1 -K means algorithm performance Indices

V CONCLUSION

A smart method to automate the decision support system which consists of Histogram followed by K-Means algorithm is explained in this paper. This method is applied on MR Spinal Images for grouping tumor region. The clustered result consistent to the biggest centroid represented the tumor region. Correctness and compatibility of the algorithm is tested. This will give the clear Automated segmented Spine images and also to assist neurologist for better Spinal-tumor ratio extraction. Further it is framed to test with more number of dataset and classification will be applied to find the depth of the tumor images and also with this result to find the type of the tumor being in the image.

VI ACKNOWLEDEGEMENT

The authors gratefully acknowledge Dr.G Balamurali for Tumor MRI Spinal dataset to carry out the research work.

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