A Study on Clustering Techniques for Medical Image Processing Applications

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ABSTRACT:

Image Processing plays a vital role in the field of medical science to visualize the different anatomical structures of the human body for medical diagnosis. The brain is the most important part of the central nervous system which posses sensory input and provide instructions to the body. Brain tumour is a disease which affects the brain and causes the abnormal growth of cells leading to brain cancer. It is one of the major causes of death among people, but the chances of survival can be increased if the tumour is detected and classified correctly at its early stages. Thus it is very important to detect the accurate size and location of brain. MRI(Magnetic Resonance Imaging) is the commonly used device for detection and visualization of the internal structures of the body. MRI has become an emergent research area in the field of Medical Imaging, as it produces the high quality images of the human body parts. This is a knowledge based review paper presenting a brief study of four techniques for analyzing and detection purpose by a comparative study of all these methods like; first one is Watershed segmentation, second k-mean, third EM-GM and fourth is fuzzy c-mean. The tumour area is identified by using these algorithms. The implementation of this proposed work can be used for the image processing tool box under MATLAB Software.

Keywords: Image Segmentation, Watershed method, K-means, Fuzzy c-means, EM-GM

I. INTRODUCTION

The brain is a soft, spongy mass of tissue. It is protected by the bones of the skull and three thin membranes called meninges. The body is made up of very small cells. Normal cells in the body grow and die in a controlled way. Sometimes cells keep dividing and growing without normal controls, causing an abnormal growth called a tumour.Brain tumours are not rare, thousands of people are diagnosed every year with tumours of brain and the rest of the nervous system. In 1946 Flex Bloch(stanford), Edward Purcell(Harvard)independently discovered NMR(Nuclear Magnetic Resonance) for which they received nobel prize in 1952. In 1971 Raymond Damadian showed changes in MR parameters. In 1972 computed tomography(CT)was invented by Hounsfield and Cormac for which they received Nobel prize in 1979 and In 1973 Lauterber described MRI in a similar way to CT. Brain tumour is an abnormal growth of cells within the brain it can be cancerous or non-cancerous. Brain tumour is categorised as either primary or secondary. Primary brain tumours can be either bending or malignant. Secondary brain tumours also known as matasic brain tumours are more common or malignant tumours.

There are over hundred types of brain tumours but they can be broken down into two categories benign and malignant. Benign tumours are non- cancerous but can cause severe pain, permanent brain damage, and possibly death. If the tumour invades and destroys nearby cells, it is called a malignant tumour or cancer. Cancer can sometimes be life threatening. Cancer treatments are used to kill or control abnormally growing cancerous cells [1,2].

The diagnosis of brain tumour is usually made after a careful history and physical examination are done, in addition to radiological tests. Some of the common imaging modalities are: Projection X-Ray, Computed tomography(CT), Ultrasound, MRI etc. CAT(computerised axial tomography) scans and MRI scans of the brain are very important in diagnosing brain tumours. The appearance of the tumour on the CAT scan or MRI may help the doctor determine what kind of tumour the patient has. Magnetic Resonance Imaging or simply MRI is a technique that is commonly used in the field of medicine. It is not only used to see the internal structures of the human body but can also visualize the functions. MRI, that uses radio waves, magnetism, and a computer to produce the images can directly visualizes the soft tissues in 3D.

Now a days Brain tumour segmentation is an important procedure for early tumour diagnosis. Although there are numerous brain tumour segmentation methods which have been presented the enhancing tumour segmentation methods is still challenging because brain tumour MRI exhibit complex characteristics, such as high diversity in tumour appearance. To address this problem we propose an automatic tumour segmentation method and then segment the tumour region from the non tumour region. By segmenting the tumour region from non-tumour region we can easily classify the affected region by using the scanned image itself. The purpose of image segmentation is to partition an image into meaningful regions with respect to particular application. The segmentation might be grey level, colour, texture, depth or motion [7, 8].

II. RESEARCH BACKGROUND

Tumours in the human sensory organs causes the highest number of deaths and considered as most dangerous medical condition in present situation. The recommended medical procedures are applicable to certain extend as recovery medication. However to apply the medication procedure, the patient has to undergo multiple phases of diagnosis in general.

The most popular technique is Magnetic Resonance Imaging to generate 2D/3D visual representation of the affected region in the sensor organs. MRI is an advanced medical imaging technique that provides rich information about the human soft-tissue anatomy. It is mostly used in radiology in order to visualize the structure and function of the human body. It produces the very detailed images of the body from any direction. Specifically, MRI is useful in neurological (brain), musculoskeletal, and oncological (cancer) medical diagnosis because it offers much greater contrast between the diverse soft tissues of the body than the computer tomography (CT). MRI is different from CT, since MRI will not use ionizing radiation, rather it uses an effective magnetic field to line up the nuclear magnetization of hydrogen atoms in water in the body [10-12].

III. CLUSTERING TECHNIQUES

K-MEANS CLUSTERING ALGORITHM

K-means algorithm given by Macqueen, is one of the simplest unsupervised learning algorithms that solve the well known clustering problem. The K-means algorithm is an algorithm to cluster n objects based on attributes into k partitions, where k<n. It is similar to Expectation-Maximization algorithm for mixtures of Gaussians in that they both attempt to find the centers of natural clusters in the data. It assumes that object attributes form a vector-space. K-means clustering is an algorithm to classify or to group the objects based on attributes or features into k number of groups, Where k is positive integer number. The grouping is done by minimizing the sum of squares of distances between data and corresponding cluster centroid.

Step 1: Begin with a decision on the value of k=number of clusters.

Step 2: Put any initial partition that classifies the data into k clusters. You may assign the training samples randomly, or systematically as the following.

Take the first k training sample as single-element clusters.

Assign each of the remaining (N-k) training sample to the cluster with the nearest centroid. After each assignment recompute the centroid of the gaining cluster

Step 3: Take each sample in sequence and compute its distance from the centroid of each of the clusters. If a sample is not currently in the cluster. With the closest centroid, switch this sample to that cluster and update the centroid of the cluster gaining the new sample and the cluster losing the sample.

Step 4: Repeat step 3 until convergence is achieved, that is until a pass through the training sample causes no new assignments.

FUZZY C-MEAN CLUSTERING ALGORITHM

The most well known fuzzy clustering algorithm is Fuzzy C-Means, A modification by Bezdek of an original crisp clustering methodology. Bezdek introduced the idea of a Fuzzyfication parameter(M), in the range(1,N) Which determines the degree of Fuzziness in the clusters. When M=1, the effect is a crisp clustering of points. When M>1 is the degree of fuzziness among points in the decision space increases. Fuzzy C-Means algorithm is slower than K-Means algorithm in efficiency but gives better results in cases where data is incomplete or uncertain and has a wider applicability. Fuzzy C-Means is an overlapping clustering algorithm.

EXPECTATION MAXIMIZATION(EM)ALGORITHM

The EM Algorithm was explained and given its name in classic 1977 paper by Arthur Dempster, Nan Laird and Donald Rubin. They pointed out that the method had been "proposed many times in special circumstances" by earlier authors. EM is typically used to compute maximum likelihood estimates given incomplete samples. The EM Algorithm estimates the parameters of a model iteratively. Starting from some initial guess each iteration consist of: 1. An E Step(Expectation Step) and 2. An M Step(Maximization Step). EM is applicable to wide range of problems. A Parameter Estimation Method falls into the general framework of maximum-liklihood estimation(MLE). EM algorithm is stablished in the following steps proposed by Balafar et al. in the 2010:

Step1: Using K-means initialize mean and Covariance matrix.

Step2: For each training data calculate membership probability.

Step3: Using membership function obtained in step 2, compute mean and variance of each Gaussian component. The step 2 and 3 are repeated until convergence.

By EM training data for that class, Gaussian mixture vector of each class is obtained. The applications of the EM algorithm to brain MR image segmentation were reported by wells et al. in the year 1996 and leemput et al. in the year 1999. A common disadvantage of EM algorithm is intensity distribution of brain images is modeled as a normal distribution.

HIERARCHIAL CLUSTERING

Hierarchical clustering method works by grouping data objects into a tree of clusters. Hierarchical clustering doesn't require specifying the number of clusters. Hierarchical clustering is deterministic. There are 2 types of hierarchical clustering. 1. Agglomerative clustering and 2. Divisive Clustering. The basic process of hierarchical clustering for a given set of N items to be clustered and NxN distance matrix is given as, [Kshitij et al. (2013)].

Step 1: Start by assigning each item to a cluster i.e., N items will have N clusters. Let the distance between the clusters be the same as the distance between the items they contain.

Step 2: Find the similar pair of clusters and merge them into a single cluster to reduce the number of clusters.

Step 3: Compute the distance between the new cluster and each of the old cluster.

Step 4: Repeat steps 2 and 3 until all items are clustered into a single cluster of size N.

AGGLOMERATIVE HIERARCHIAL CLUSTERING

In Agglomerative clustering, each element is treated as a singleton cluster and then merged (agglomerated) until all merge in a single cluster, which results in dendograms formation [Kshitij et al. (2013)]. Dendograms are horizontal lines which when cut at a point you get a specific part or element and explains how clustering helps forming an image.

Step 1: Compute NxN similarity matrix C

Step 2: Execute N-1 steps of merging the currently most similar clusters.

Step 3: In each iteration, the most similar clusters are merged and the rows and columns of the merged cluster 'i' in 'C' are updated.

Step 4: The clustering is stored as a list of merges in A.

Step 5: I indicates which clusters are still available to be merged.

Step 6: The function SIM(i,m,j) computes the similarity of cluster j with the merge of clusters i and m. Step 7: For some Hierarchical algorithm, SIM(i,m,j) is simply a function of C[j][i] and C[j][m] for example, the maximum of these 2 values for single link.

DIVISIVE HIERARCHIAL CLUSTERING

Divisive hierarchical is more efficient than Agglomerative hierarchical clustering [Kshitij et al. (2013)]. Divisive Hierarchical Clustering can be stopped when the goal is achieved. The divisive Hierarchical Clustering algorithm is given as [Kshitij et al. (2013)].

Step 1: Consider the whole image as one cluster.

Step 2: Find the most dissimilar point in the image and divide the image into 2 clusters.

Step 3: Repeat step 2& 3 for each cluster.

Step 4: Form a tree like structure.

Step 5: Continue until the tumour cluster is obtained

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IV. CONCLUSION

Previous researches shows that brain tumours can be detected at an earlier stage using various medical image processing techniques. The medical image processing techniques which they used to examine the location of tumour in the brain is Magnetic Resonance Imaging (MRI).For image segmentation watershed segmentation method is used successfully. The stage of tumour is based on the area of the tumour. So, size of the tumour can be calculated by calculating the number of white pixels (digit 0) in binary image. Tumour can be classified according to its type. Based on above said experts' research, we are also planning to develop certain algorithms in future for the development of medical field.

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