PERFORMANCE COMPARISON OF K-MEANS & CANNY EDGE DETECTION ALGORITHM ON MRI IMAGES

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ABSTRACT

MRI segmentation plays a crucial role in many medical imaging applications .Various approaches are applied for the Segmentation of the MRI depending on the medical application, Image modality and other factors. The objective of this paper is to perform a segmentation process on MR images of the human Brain using Kmeans Algorithm and Canny Edge Detection Algorthm. K-means Clustering algorithm gives us the segmented image of an MRI having the same intensity regions. K-means Clustering segments all the three matters of the brain i.e. Grey matter, White matter and Dark matter. Also the edge detection algorithm is implemented that gives us the boundaries of the various regions of the MRI depending on scale and threshold values used for the segmentation. Implementation of each algorithm is then discussed. Finally, the experimental results of each algorithm are presented and discussed. Following algorithm are used in this paper. Clustering is an unsupervised way of data grouping with a given measure of similarity. Clustering algorithms attempts to organize unlabeled feature vectors into clusters, such as samples within a cluster, that are more similar to each other than to samples belonging to different clusters, in which a validity measure is computed for each set of clusters. The number of clusters, which optimizes this measure, is the optimum number of clusters in the data set. The purpose of multi-resolution image analysis is to decompose the image into multi-frequency representations to visualize contents of interest in variable resolutions. Multi-scale filtering such as the canny operator can detect the edges in the low contrast or low S/N images. They are good edge detectors because they follow the optimal filter design criteria: good localization and high S/N output.

KEYWORDS

Clustering Analysis, Medical Imaging, Thresholding Techniques, k-Means, Canny edge detector.

1. INTRODUCTION

Segmentation refers to the process of partitioning a digital image into multiple segments (sets of pixels, also known as superpixels). The goal of segmentation is to simplify and/or change the representation of an image into something that is more meaningful and easier to analyze.[11] Image segmentation is typically used to locate objects and boundaries (lines, curves, etc.) in images. The result of image segmentation is a set of segments that collectively cover the entire image, or a set of contours extracted from the image.[15]

Medical imaging refers to the techniques and processes used to create images of the human body (or parts thereof) for clinical purposes (medical procedures seeking to reveal, diagnose or examine disease) or medical science (including the study of normal anatomy and function). As a discipline and in its widest sense, it is part of biological imaging and incorporates radiology (in the wider sense), radiological sciences, endoscopy, (medical) thermography, medical photography and microscopy (e.g. for human pathological investigations). Measurement and recording techniques which are not primarily designed to produce images, such as electroencephalography (EEG) and magneto encephalography (MEG) and others [16], but which produce data susceptible to be represented as maps (i.e. containing positional information), can be seen as forms of medical imaging. In the clinical context, medical imaging is generally equated to radiology or "clinical imaging" and the medical practitioner responsible for interpreting (and sometimes acquiring) the image is a radiologist[1]. Magnetic resonance imaging (MRI) is an imaging technique used primarily in medical settings to produce high quality images of the inside of the human body. MRI is based on the principles of nuclear magnetic resonance (NMR), a spectroscopic technique used by scientists to obtain microscopic chemical and physical information about molecules. Magnetic resonance imaging (MRI) is a noninvasive medical test that helps physicians diagnose and treat medical conditions [2]. MR imaging uses a powerful magnetic field, radio frequency pulses and a computer to produce detailed pictures of organs, soft tissues, bone and virtually all other internal body structures. The images can then be examined on a computer monitor, printed or copied to CD. MRI does not use ionizing radiation (x-rays).Detailed MR images allow physicians to better evaluate various parts of the body and certain diseases that may not be assessed adequately with other imaging methods such as x-ray, ultrasound or computed tomography MRI, or magnetic resonance imaging, is a means of “seeing” inside of the body in order for doctors to find certain diseases or abnormal conditions. MRI does not rely on the type of radiation (i.e.,ionizing radiation) used for an x-ray or computed tomography (CT) scan. The MRI examination requires specialized equipment that uses a powerful, constant magnetic field, rapidly changing local magnetic fields, radiofrequency energy, and dedicated equipment including a powerful computer to create very clear pictures of internal body structure.

MR imaging of the head is performed to help diagnose:

- Tumors of the brain.
- Developmental anomalies of the brain.
- Disorders of the eyes and the inner ear.
- Stroke.
- Trauma patients (in selected patients).
- C+auses of headache.

The main advantages of MR imaging system are:.

- It has an excellent capability for soft tissue imaging
- It has very high resolution of the order of 1mm cubic voxels
- It has high signal to noise ratio
- Multi channel images with variable contrast can be achieved by using different pulse sequences; this can be further utilized for segmenting and classifying different structures.[12]

2. MRI SEGMENTATION ALGORITHM

2.1 MRI Segmentation using Clustering Algorithm

Clustering is an unsupervised way of data grouping with a given measure of similarity. Clustering algorithms attempts to organize unlabeled feature vectors into clusters, such as samples within a cluster, that are more similar to each other than to samples belonging to different clusters, in which a validity measure is computed for each set of clusters. The number of clusters, which optimizes this measure, is the optimum number of clusters in the data set. The flowchart of the clustering approach is shown in Figure 1. The critical part of the clustering approach is choosing the additional cluster center.[3,4]One of the most common clustering methods is the *K* means algorithm. In its first step, an initial mean vector iteration is arbitrarily specified for each of the *K* clusters. Each pixel of the training set is then assigned to the class of which the mean vector is closest to the pixel vector, forming the first set of decision boundaries. A new set of cluster mean vectors is then calculated from this classification, and the pixels are reassigned accordingly. In each iteration, the *K* means will tend to gravitate toward concentrations of data in nearby regions of the feature space. The algorithm iterates until there is no significant change in pixel assignments. The criterion for terminating the iterative process can be defined in terms of the net mean migration from one iteration to the next.

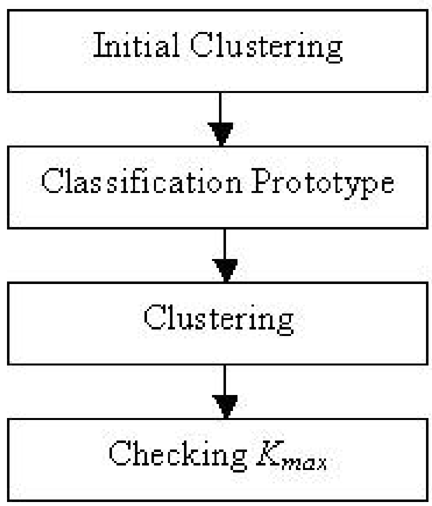

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Figure 1: Flowchart of the clustering approach.

Kmeans clustering algorithm was developed by J. MacQueen (1967), k-means clustering is an algorithm to classify or to group your objects based on attributes/features into K number of group. K is positive integer number. The grouping is done by minimizing the sum of squares of distances between data and the corresponding cluster centroid. Thus the purpose of K-mean clustering is to classify the data.[14]

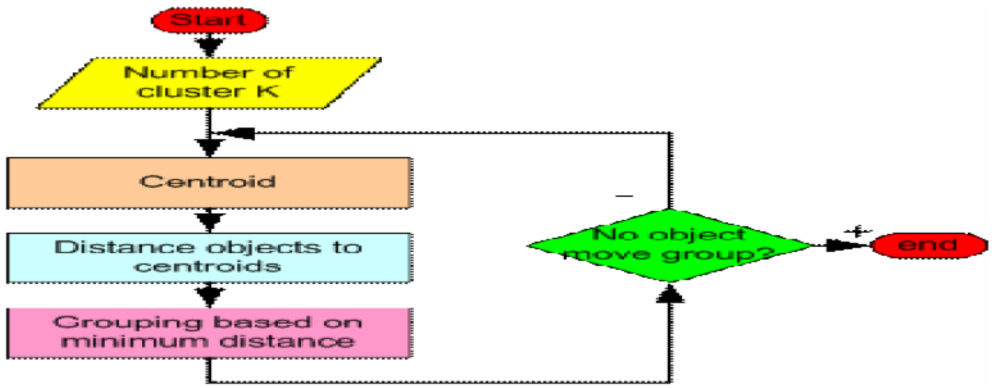


Figure 2 : flow chart for K- Means algorithm

2.1.1 Following are the algorithm of K Means

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, recomputed 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. [5,6,7]

2.2 MRI Segmentation using Canny Edge Detection Method

First of all, we have to clarify what is Edge Detection. Here are some definitions of edge detection: An edge is not a physical entity, just like a shadow. It is where the picture ends and the wall starts. It is where the vertical and the horizontal surfaces of an object meet. It is what happens between a bright window and the darkness of the night. Simply speaking, it has no width. If there were sensor with infinitely small footprints and zero-width point spread functions, an edge would be recorded between pixels within in an image. In reality, what appears to be an edge from the distance may even contain other edges when looked closer. The edge between a forest and a road in an aerial photo may not look like an edge any more in an image taken on the ground. In the ground image, edges may be found around each individual tree. If looked a few inches away from a tree, edges may be found within the texture on the bark of the tree. Edges are scale-dependent and an edge may contain other edges, but at a certain scale, an edge still has no width .Edges characterize boundaries and are therefore a problem of fundamental importance in image processing. Edges in images are areas with strong intensity contrasts – a jump in intensity from one pixel to the next. Edge detecting an image significantly reduces the amount of data and filters out useless information, while preserving the important structural properties in an image.

The Canny edge detection algorithm is known to many as the optimal edge detector. Canny's intentions were to enhance the many edge detectors already out at the time he started his work. He was very successful in achieving his goal and his ideas and methods can be found in his paper, "A Computational Approach to Edge Detecti*on*". In his paper, he followed a list of criteria to improve current methods of edge detection. The first and most obvious is low error rate. It is important that edges occuring in images should not be missed and that there be NO responses to non-edges. The second criterion is that the edge points be well localized. In other words, the distance between the edge pixels as found by the detector. and the actual edge is to be at a minimum. A third criterion is to have only one response to a single edge. This was implemented because the first 2 were not substantial enough to completely eliminate the possibility of multiple responses to an edge. [8] Canny specified three issues that an edge detector must address. They are:-

- Error rate:-The edge detector should respond only to edges, and should find all of them; no edges should be missed.
- Localization:- The distance between the edge pixels as found by the edge detector and the actual edge should be as small as possible.
- Response:- The edge detector should not identify multiple edge pixels where only a single edge exists**. [9,10]**

2.2.1 Steps:

Step 1. Apply derivative of Gaussian

Step 2. Non-maximum suppression .

- Thin multi-pixel wide “ridges” down to single pixel width

Step 3. Linking and thresholding

- Low, high edge-strength thresholds
- Accept all edges over low threshold that are connected to edge over high threshold

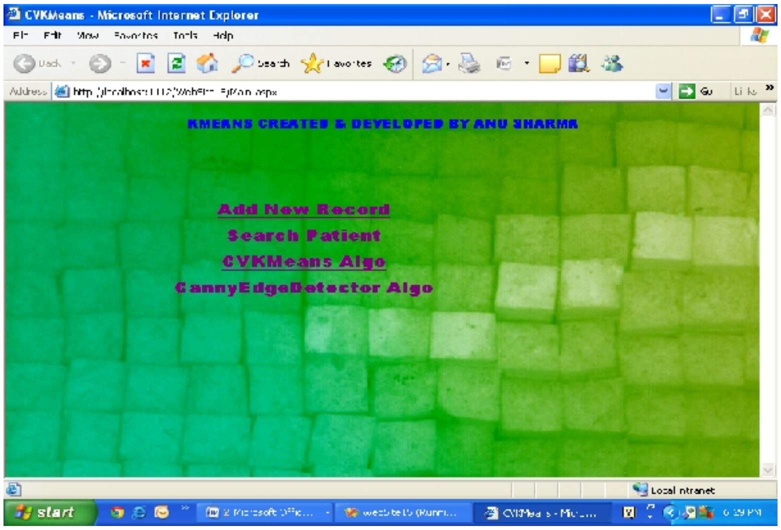
To improve current methods of edge detectors we must follow:

- The first and most obvious is low error rate. It is important that edges occurring in images should not be missed and that there be no responses to non-edges.
- The second criterion is that the edge points be well localized i.e., the distance between the edge pixels as found by the detector and the actual edge is to be at a minimum.
- A third criterion is to have only one response to a single edge [13]

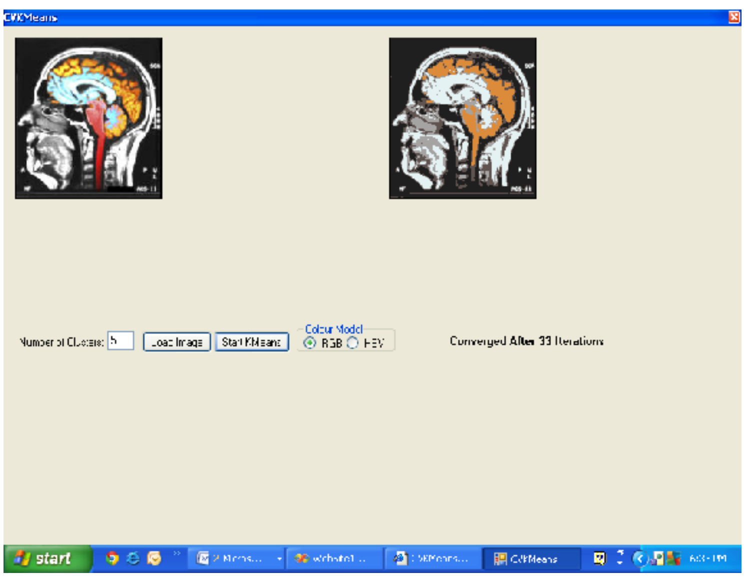
3. IMPLEMENTATION

Proposed algorithm is implemented in .Net using C# language. Here we have presented some snapshots of main page as well as comparisons of our algorithm with k means and canny edge detector.

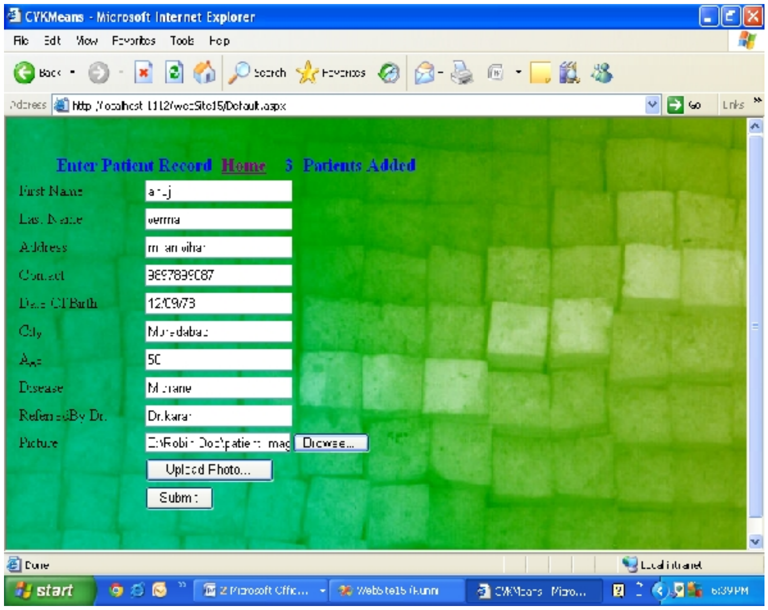
3.1Main Page



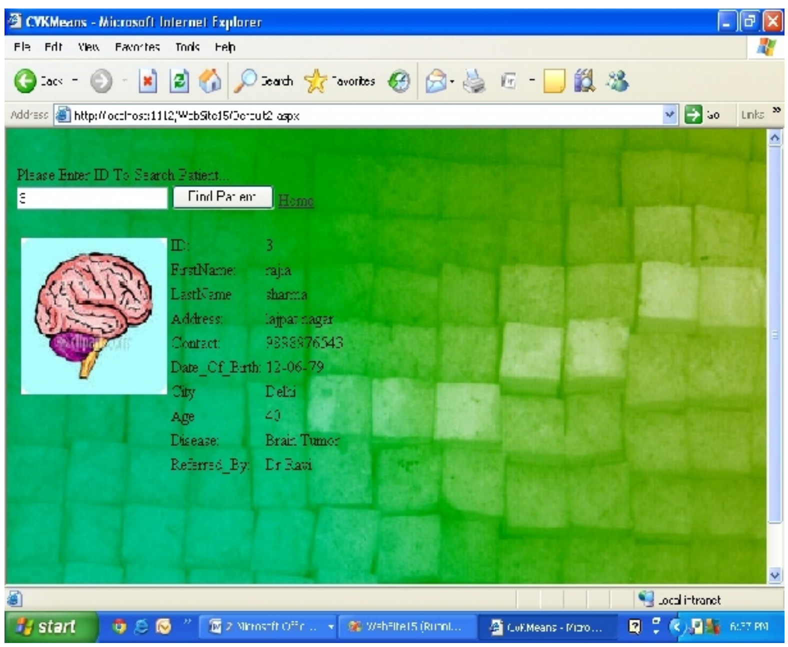
3.1 Implementation of K-Means Clustering Algorithm.



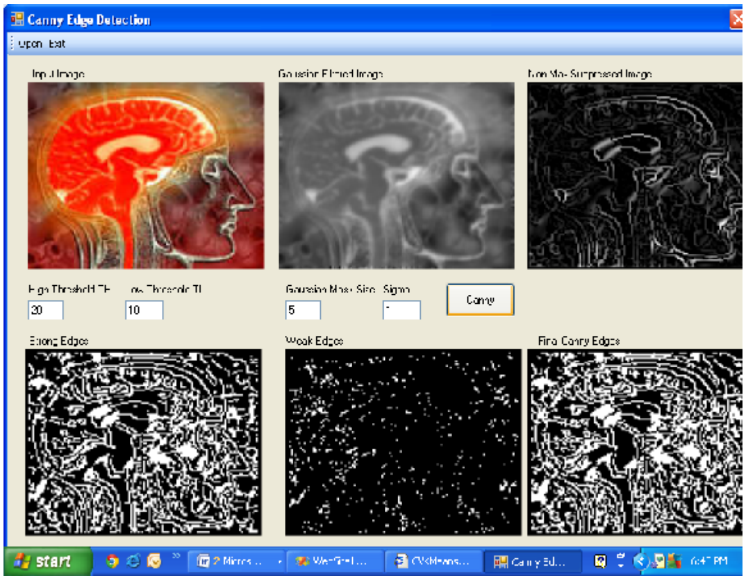
3.2 IMPLEMENTATION OF SAVE PATIENT RECORD



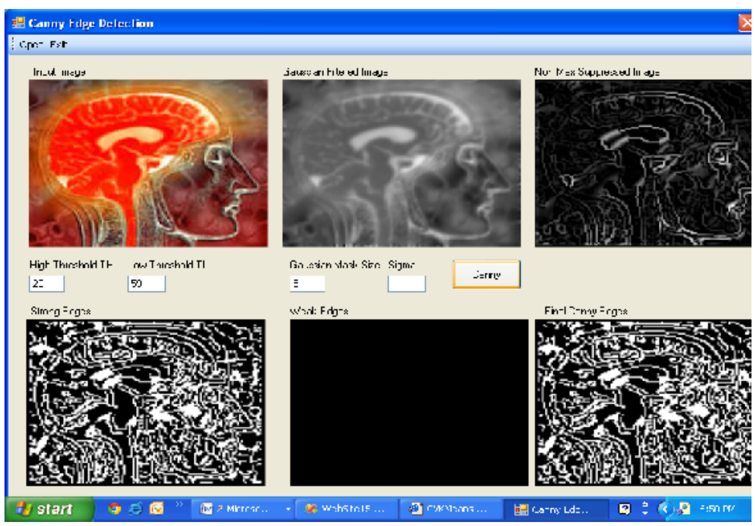
3.3 Implementation of Search Patient Record



3.4 Implementation of canny edge detection algorithm with T1= 20 and T2=10



3.5 Implementation of Canny Edge Detection Algorithm with T1= 20 and T2=59



4. RESULTS AND DISCUSSION

We have shown that Canny Edge Detection and K-means clustering algorithms are quite useful for retrieval of relevant images from image database. Our results indicate that the proposed approach offers significant performance improvements in retrieval of medical images.Further, by fine tuning of shape feature extraction and using other shape feature extraction methods, performance of the retrieval process can be improved more.

1) The k-mean clustering provides a lower localization error, and qualitatively, a dramatic improvement in edge detection performance over an existing edge detection method for speckled imagery.

2) The k-mean clustering meant to allow for balanced and well localized edge strength measurements in bright regions as well as in dark regions.
3) The performance of the k-mean clustering has been demonstrated for edge-detection speckle reducing anisotropic diffusion.
4) This segmentation method can be develop by other project to get better view for medical image.

We conclude that following are the Disadvantages of Canny Edge Detector

1) The Canny algorithm contains a number of adjustable parameters, which can affect the computation time and effectiveness of the algorithm.
2) The size of the Gaussian filter: the smoothing filter used in the first stage directly affects the results of the Canny algorithm. Smaller filters cause less blurring, and allow detection of small, sharp lines. A larger filter causes more blurring, smearing out the value of a given pixel over a larger area of the image.
3) Thresholds: A threshold set too high can miss important information. On the other hand, a threshold set too low will falsely identify irrelevant information (such as noise) as important. It is difficult to give a generic threshold that works well on all images. No tried and tested approach to this problem yet exists.
4) Complex Computations,
5) Time consuming

4.1 Error Analysis .

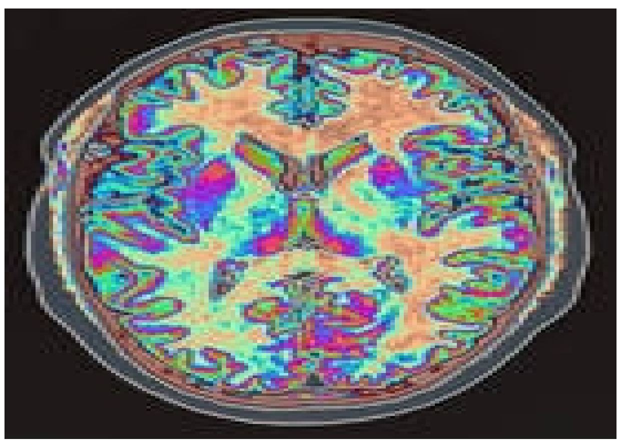


Figure 3:Image

TABLE 1: Noise Ratio of K-MEANS & CANNY Edge Detector

% ERROR RATE			
Noise Ratio	0	20	50
CANNY	4.1667	13.4766	21.5386
K-MEANS	2.8212	5.3277	20.4861

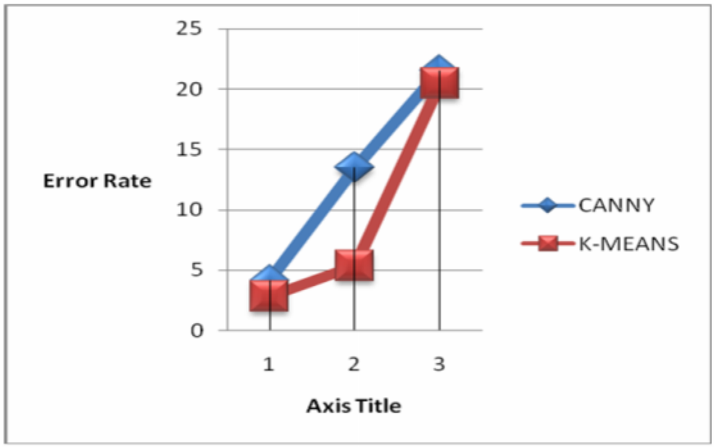


Figure 4: Noise Ratio Graph of K-MEANS & CANNY Edge Detector

TABLE 2: ENTROPY & MUTUAL INFORMATION (MI) OF CANNY EDGE DETECTORS & K-MEANS Algorithm

Edge detectors	MI	Entropy
Canny	0.0287	2.4095
Sobel	0.0302	1.7232
Roberts	0.0310	1.5261
Prewitt	0.0308	1.6631
K-Means	0.1369	5.6174

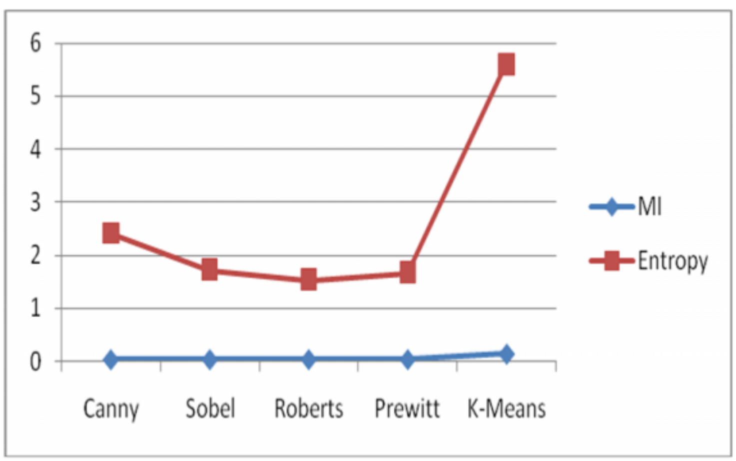


Figure 5: ENTROPY & MUTUAL INFORMATION (MI) GRAPH OF EDGE DETECTORS & K-MEANS Algorithm

The comparison of the segmented images are done by taking the entropy and mutual information measures.The entropy of an image can be defined as a measure of the uncertainty associated with a random variable and it quantifies, in the sense of an expected value, the information contained in a message. Entropy of an image E returns a scalar value representing the entropy of grayscale image I. Entropy is a statistical measure of randomness that can be used to characterize the texture of the input image. Entropy is defined as -sum (p.*log2(p)) where p contains the histogram counts.

5. CONCLUSION

The Canny Edge Detection Algorithm contains a number of adjustable parameters, which can affect the computation time and effectiveness of the algorithm. The size of the Gaussian filter used in the first stage directly affects the results of the Canny algorithm. Smaller filters cause less blurring, and allow detection of small, sharp lines. A larger filter causes more blurring, smearing out the value of a given pixel over a larger area of the image. A threshold set too high can miss important information.

On the other hand, a threshold set too low will falsely identify irrelevant information (such as noise) as important. It is difficult to give a generic threshold that works well on all images.
On the other hand, In K-Means Algorithm, the effect of noise is less than canny edge detector algorithm.Also in K-Means, quality of segmentation increases with increase in the number of clusters but here the value of K is decided by us according to the nature of the MRI and the according to the application used.

6. FUTURE SCOPE OF K-MEANS ALGORITHMS

Kmeans algorithm segments the MRI on the basis of region intensity into K clusters. Hence all the three matters of the Brain i.e. Grey matter, White matter and dark matter can be detected from the Segmented image. Also we note that quality of segmentation increases with increase in the number of clusters but here the value of K is decided by us according to the nature of the MRI and the according to the application used. For example we can decide by seeing the image that how many clusters should be there in the particular image. For example by seeing the number of colors in a colored MRI we can easily guess the value of k. In the snapshot a MRI is segmented with different value of k which will give different results each time.

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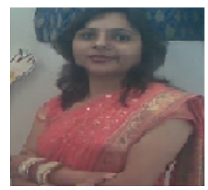

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