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IMPLEMENTATION & COMPARISON OF DIFFERENT SEGMENTATION ALGORITHMS FOR MEDICAL IMAGING

D. Palani [#1], K. Venkatalakshmi [*2] E. Venkatraman [#3]

[#1] AP, Department Of ECE, University College of Engineering Villupuram, Tamilnadu, India.

[*2] AP, Department Of ECE, University College of Engineering, Tindivanam, Tamilnadu, India.

[#3] AP, Department Of ECE, University College of Engineering , Villupuram, Tamilnadu, India.

ABSTRACT--- Medical image segmentation refers to the segmentation of known anatomic structures from medical images. Structures include organs or parts such as cardiac ventricles or kidneys, abnormalities such as tumours and cysts, as well as other structures such as vessels, brain structures etc. The complete objective of this segmentation is referred to as computer-aided diagnosis that are used for assisting doctors in evaluating medical imagery or in recognizing abnormal findings in a medical image. Segmentation is done using clustering, region growing, otsu method which separates the cell core structure from background and here input image is a myocardial images obtained with biopsies of a Transplanted heart patient. The above three methods to diagnose the similarity of cell core or tissue of a transplanted heart patient and they identify clearly cell core, fibrous tissue, muscles and tissue rejection in myocardial images of biopsies from heart transplant patients. In this paper, we compared the above three methods using the nonlinear objective assessments like energy and entropy and concluded the best among them is OTSU method.

KEYWORDS--- Segmentation, Clustering, Region growing, Otsu method, Energy and Entropy.

I. INTRODUCTION

In computer vision, segmentation refers to the process of partitioning a digital image into multiple regions (sets of pixels). The objective of segmentation is to simplify and change the representation of an image into something that is more meaningful and easier to analyse. The outcome of image segmentation is a set of regions that collectively cover the whole image, or a set of contours extracted from the image. Each of the pixels in a region is alike with respect to some characteristic or computed things, such as color, concentration, or texture [1]. Adjacent regions are significantly different with respect to the same characteristics. A rugged segmentation procedure brings the process a long way towards successful solution of an image difficulty. Output of the segmentation stage is raw pixel data, constituting both the boundary of a region and all the points in the region itself.

During segmentation, an image is preprocessed, which can involve restoration, enhancement, or simply representation of the data. Certain features are extracted to segment the image into its key components. The segmented image is routed to a classifier or an image-understanding system. The image classification process maps different regions or segments into one of several objects. Each object is identified by a label. The image understanding system then determines the relationships between different objects in a scene to provide a complete scene description. Some of the practical applications of image segmentation are: Measure tissue volumes, Computer-guided surgery, Study of anatomical structure.

Medical image segmentation refers to the segmentation of known anatomic structures from medical images. Structures of interest consist of organs or parts, such as cardiac ventricles or kidneys, abnormalities such as tumours and cysts, as well as other structures such as vessels, bones, brain structures etc [2]. The overall objective of such procedures is referred to as computer-aided diagnosis they are used for assisting doctors in evaluating medical imagery or in recognizing abnormal finding in a medical image.

II. SEGMENTATION METHODS

Several general-purpose algorithms and techniques have been developed for image segmentation. As there is no general solution to the image segmentation problem, the techniques often have to be combined with domain knowledge in order to effectively solve an image segmentation problem for a problem domain are Thresholding approaches, Classifiers, Clustering approaches, Region Growing approaches and Artificial neural networks [3]. Among these methods only four methods are used to implement in a cardiac medical image.

A. Clustering Methods

The clustering technique attempts to access the relationships among patterns of the data set by organising the patterns into groups or clusters such that patterns within a cluster are more similar to each other than patterns belonging to different clusters. That is clustering technique; an attempt is made to extract a feature vector from local areas in the image. A standard procedure for clustering is to assign each pixel to the class of the nearest cluster mean.

I). K Means Clustering

K-means is one of the simplest unsupervised learning algorithms that solve the well-known clustering problem. The procedure follows a easy way to classify a given data set through a certain number of clusters (assume k clusters) fixed a priori. The chief idea is to define k centroids, one for every cluster. These centroids must be placed in a cunning way because of different location causes different result. So the improved choice is to place them as much as possible far away from each other. The following step is to take each point belonging to a given data set and associate it to the nearest centroid. When no point is incomplete, the first step is completed and an early group age is completed. At this point we need to re-calculate k new centroids as bar centers of the clusters resulting from the previous step.

After we have these k new centroids, a new binding has to be done between the same data set points and the nearest new centroid. A loop has been produced. As a result of this loop we may notice that the k centroids change their location step by step until no more changes are done. In other words centroids will not move any more. In conclusion, this algorithm aims at minimizing an objective function, in this instance a squared error function.

a. Algorithm

Using K Means clustering we can segment Angiographic images. The goal is to propose an algorithm that can be better for large datasets and to find initial centroids. K-Means Clustering is an iterative technique that is used to partition an image into *K* clusters [4]. The simple algorithm is:

1. Pick k cluster centers, either randomly or based on some heuristic.
2. Assign each pixel in the image to the cluster that minimizes the variance between the pixel and the cluster center.
3. Recompute the cluster centers by averaging all of the pixels in the cluster.
4. Repeat steps 2 and 3 until convergence is attained.

In this case, variance is the squared or absolute difference between a pixel and a cluster center. The difference is naturally based on pixel color, intensity, texture and location or a subjective combination of these factors. K can be certainly manually, randomly or by a heuristic. This algorithm is definite to converge, but it may not return the optimal solution. The quality of the solution be subject to on the initial set of clusters and the value of K. A drawback of the k-means algorithm is that the number of clusters k is an input parameter. An unsuitable choice of k may yield poor results.

II). Improved K Means Clustering Method

Original K-means algorithm choose k points as initial clustering centers, different points may obtain different solutions. In order to diminish the sensitivity of initial point choice, we employ a modification, which is the most centrally located object in a cluster, to obtain better initial centers. Comparing two solutions generated by clustering sample drawn from the original dataset and itself using K-means respectively, the location of clustering centroids of these two are almost similar. So, the sample-based method is applicable to refine initial conditions. To avoid dividing one big cluster into two or more ones for adopting square-error criterion, we assume the number of clustering is *K'*.

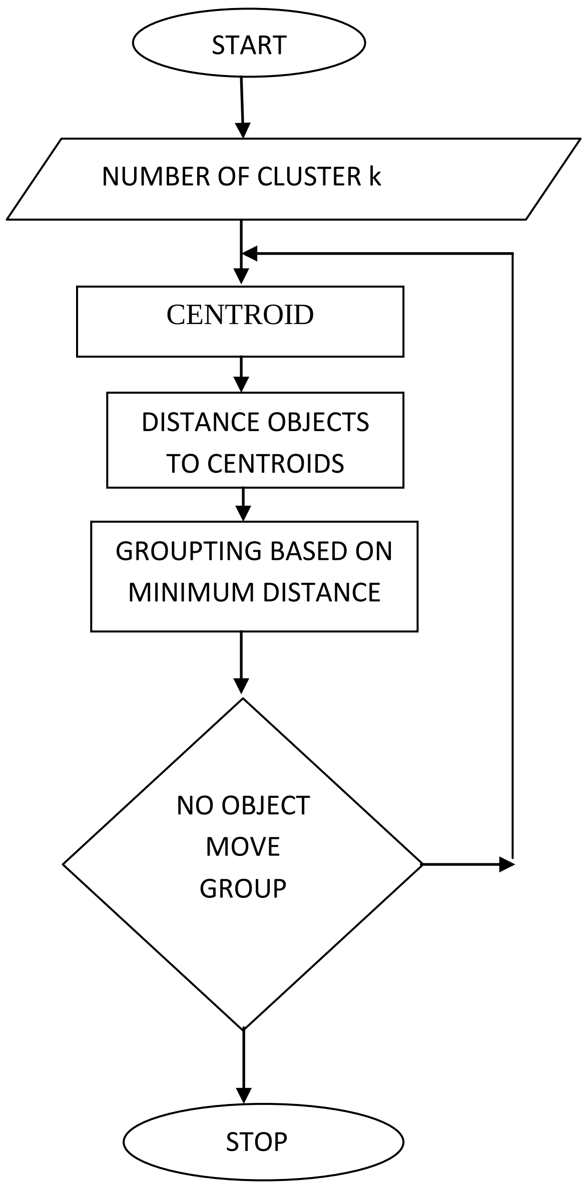

Fig. 1 Algorithm for k-means clustering

a. Algorithm

In general, bigger K' can expand searching area of solution space, and decrease the situation that there are not any initial values near some extremis. Subsequently, re-clustering the dataset through K-means with the chosen initial conditions would produce K', then merging K' clusters until the number of clusters reduced to k. Improved algorithm needs significantly less iteration. Experimental results shows that choosing initial centroids by our algorithm is stable when compared with randomly selected Initial centroids.

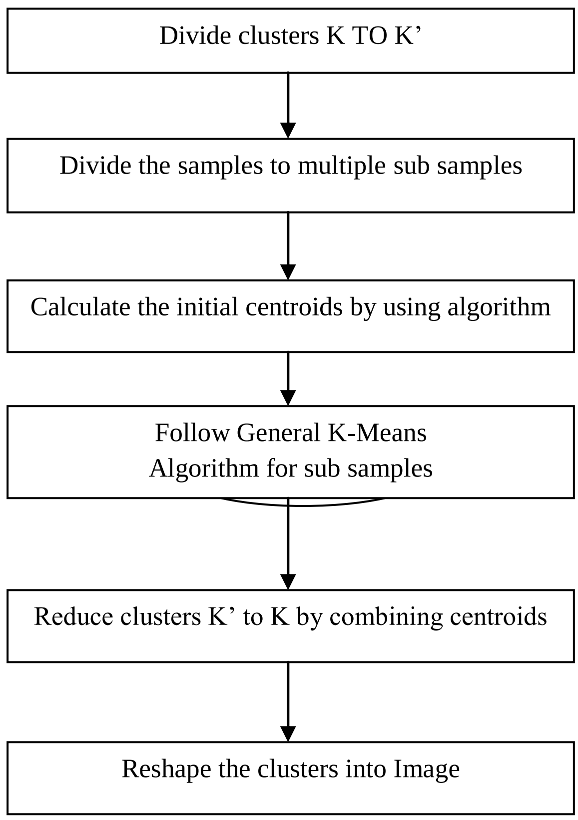

Fig. 2 Algorithm for improved k means clustering

B. Region Growing Methods

In Region growing technique, segment an image pixel that belongs to an object into regions. Segmentation is performed based on some predefined criteria. Two pixels can be grouped together if they have the same intensity characteristics or if they are close to each other. It is assumed that pixels that are closed to each other and have similar intensity values are likely to belong to the same object. The simplest form of the segmentation can be achieved through threshold and component labeling. Another method is to find region boundaries using edge detection. Region growing is a procedure that groups pixels or sub regions into larger regions [5].

The simplest of these approaches is pixel aggregation, which starts with a set of "seed" points and from these regions grow by appending to each seed points to those neighboring pixels that have similar properties (such as gray level, color, texture, shape). Region growing based techniques are better than the edge-based techniques in noisy images where edges are difficult to detect segment in the image into different regions R_i.

- The regions cover the whole image.
- Two regions do not have the same elements.
- A region fulfils some property *P*.
- The union of two regions does not satisfy the P.

a. Algorithm

1. Define seed point.
2. Add n-neighbors to list L.
3. Get and remove top of L.
4. Test n-neighbors p, if p not treated, if P(p,R)=True then p→L and add p to region, else p marked boundary.
5. Go to 2 until L is empty.
6. Two Regions R and ¬ R.

- P is a predicate that defines whether an element belongs to a region.
- L is ordered, for example, according to P.
- We can define several seed points.

The main disadvantage of region growing approach is that it often requires a seed point as the starting point of the segmentation process. This needs user interaction. Due to the differences in image intensities and noise, region growing can effect in holes and over segmentation.

(I) (II) (III) (IV)

Fig. 3 An example of image segmentation: (I) Original image, (II) Segmentation result by multiscale segmentation method showing over segmentation, (III) Segmentation result by region growing method described in this project, (IV) manually marked proper segments in the image.

C. Thresholding

Histogram based methods are very efficient when compared to other image segmentation methods because they typically require only one pass over the pixels. In this technique, a histogram is calculated from all of the pixels in the image, as well as the peaks and valleys in the histogram are used to locate the clustersing the image. Color or intensity could be used as the measure. A refinement of this method is to recursively apply the histogram-seeking method to clusters in the image in order to divide them into smaller clusters [6]. This is monotonous with smaller and smaller clusters until no more clusters are produced. One difficulty of the histogram-seeking method is that it may be difficult to identify significant peaks and valleys in the image. In this method of image classification distance metric and integrated region matching are aware.

Histogram-based approaches can also be quickly adapted to occur over several frames, while maintaining their single pass efficiency. The histogram can be done in numerous fashions when multiple frames are measured. The similar approach that is taken with one frame can be used to multiple, and after the results are combined, peaks and valleys that were previously difficult to recognize are more likely to be unique. The histogram can also be used on a per pixel basis where the information result is used to determine the most frequent color for the pixel location. This approach segments shaped on active objects and a static atmosphere, causing in a different type of segmentation useful in Video tracking.

I). Otsu's Method

Otsu's thresholding chooses the threshold to minimize the intra class variance of the threshold black and white pixels [7]. Otsu's Thresholding Method based on a simple idea. Find the threshold that minimizes the weighted within-class variance. This turns out to be the same as maximizing the between-class variance.

Assumptions for OTSU's method:

• Histogram (and the image) is bimodal.
• No usage of spatial coherence, nor other notion of object structure.
• Assumes stationary statistics, but can be altered to be locally adaptive.

Now, we could actually stop here. All we want to do is just run through the full range of t values [1,256] and pick the value that minimizes.

Thresholding is a technique frequently applied to image segmentation. It is simple objective is to classify the pixels of a given image into two classes: those pertaining to an object and those pertaining to the background. As the image with clear objects in the background, the bi-level thresholding method can simply divide the object from the background. But to segment complex images, a multilevel threshold technique required. The multilevel threshold segments the pixels into several distinct groups in which the pixels of the same group have gray levels within a specific range.

A hybrid algorithm based on a self-adaptive thresholding method is proposed to optimize the threshold of the Otsu's method. This method of segmentation is very time-consuming because of the inefficient formulation of the between- class variance. A faster version of Otsu's method is proposed for improving the efficiency of computation for the optimal thresholds of an image. First, a measure for maximizing a modified between-class variance that is equivalent to the criterion of maximizing the usual between-class variance is proposed for image segmentation. Next, in event with the new criterion, a recursive algorithm is intended to efficiently find the optimal threshold [8].

III. NON LINEAR OBJECTIVE ASSESSMENTS

The objective assessment of image quality in medical imaging systems is a topic of growing importance. Scientific and medical images are acquired for precise purposes, and the quality of an imaging system is ultimately determined by how well the images fulfill those purposes. In extensive terms the purpose or event of the imaging system is to learn something about the object that produced the image. The task-based approach to image quality, frequently called objective assessment, is currently well established in radiological imaging, and in detail virtually mandatory in that field, but it is broadly applicable to other areas of imaging also [9]. For a complete review and discussion of both medical and nonmedical applications, the two major nonlinear objective assessments are Energy and Entropy.

A. Energy

The gray level energy indicates how the gray levels are distributed. It is expressed as

$$E(x) = \sum_{i=1}^{X} p(x) \qquad (1)$$

Where,

E(x) - represents the gray level energy

P(x) – represents probability distribution function

TABLE I

COMPARISONS OF DIFFERENT ALGORITHMS FOR CARDIAC IMAGE BASED ON ENERGY

S.No.	Algorithm	Energy
1	K-means clustering	0.82
2	Improved k means	0.53
3	Region growing	0.31
4	Thresholding-Otsu method	1.62

The larger energy value corresponds to the lower number of gray levels, which is simple. The smaller energy value corresponds to the higher number of gray levels, which means complex. From the tabulation the Otsu method has high energy value which means it has low gray levels.

B. Entropy

Entropy is a measure of unpredictability or information content. Entropy is a statistical measure of randomness that can be used to characterize the texture of the input image [10]. Entropy is well-defined as

$$H(x) = -\sum_{i=1}^{k} p(i)\log_2 p(i) \qquad (2)$$

Where,

H(x) - represents entropy

P(i) - represents probability distribution function

TABLE II

COMPARISONS OF DIFFERENT ALGORITHMS FOR CARDIAC IMAGE BASED ON ENTROPY

S.No.	Algorithm	Entropy
1	K means clustering	4.36
2	Improved k means clustering	7.39
3	Region growing	15.42
4	Thresholding – Otsu method	1.43

From the above table, the otsu method gives smaller entropy values compared to other segmentation algorithms.

IV. IMPLEMENTATION AND RESULTS

We have implemented the above algorithms and assessed using nonlinear objective assessments using MATLAB. MATLAB is a specific language for technical computing. It assimilates computation, visualization, as well as programming in an easy-to-use environment where problems and solutions are expressed in familiar mathematical notation.

MATLAB features a family of application-specific solutions called toolboxes. Highly important to most users of MATLAB, toolboxes permit you to learn and apply specialized technology. Toolboxes are inclusive collections of MATLAB functions (M-files) that extend the MATLAB environment to solve particular classes of problems. Areas in which toolboxes are accessible include signal processing, control systems, fuzzy logic, neural networks, wavelets, simulation, and numerous others.
MATLAB implements Graphical User Interface(GUI) as figure windows containing various styles of uicontrol objects. You should program each object to perform the intended action when activated by the user of the GUI. In count, you must be able to save and launch your GUI. All of these tasks are shortened by GUIDE, MATLAB's graphical user interface development environment. The process of implementing a GUI involves laying out the GUI components and Programming the GUI components [11].

GUIDE primarily is a set of layout tools. However, GUIDE also produces an M-file that contains code to handle the initialization and launching of the GUI. This M-file delivers a framework for the implementation of the call backs - the functions that execute when users activate components in the GUI.

While it is possible to write an M-file that contains all the commands to lay out a GUI, it is easy to use GUIDE to lay out the components interactively and to generate two files that save and launch the GUI:

A FIG-file comprises a complete description of the GUI figure and all of its children (uicontrols and axes), as well as the values of all object properties.

An M-file contains the functions that launch and control the GUI and the call-backs, which are distinct as sub functions. This M-file is mentioned to as the application M-file in this documentation. The application M-file does not contain the code that lays out the uicontrols; this information is saved in the FIG-file. The following figure illustrates the parts of a GUI implementation.

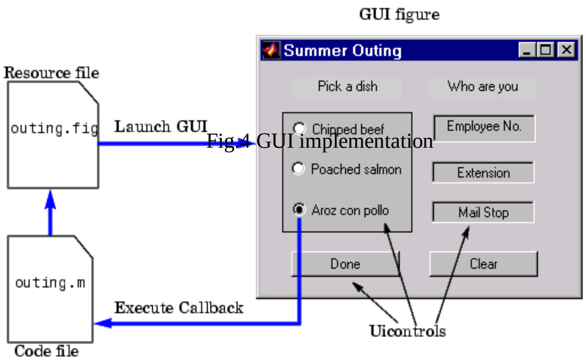

Fig.4 GUI implementation

A. Segmentation of Cardiac Image

Here input image is a myocardial image obtained with biopsies of a Transplanted heart patient. In the studied image we used three methods to diagnose the matching of cell core or tissue of a transplanted heart patient [12]. For evaluation of the segmented regions, elsewhere the strategy of maximum entropy, we related the results with those provided by the Otsu's method.

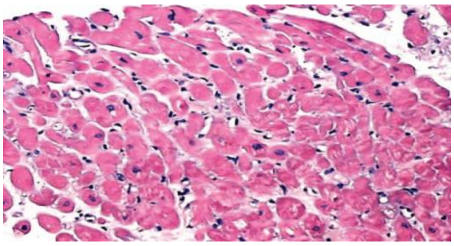

Fig. 5: Myocardial images obtained with biopsies of a Transplanted heart patient

B. Simulation Results

By selecting the input image and segmentation method the output will be shown using FIGURE screen.

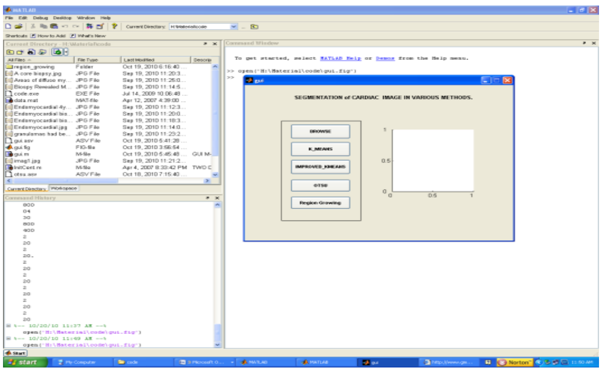

Fig. 6 Output window of segmented image in GUI

By clicking the icon browse, we can select the cardiac image, then click k-means (i.e. segment the cardiac image using k-means segmentation). Figure 7 shows the segmented cardiac image using k-means segmentation by setting k=4.

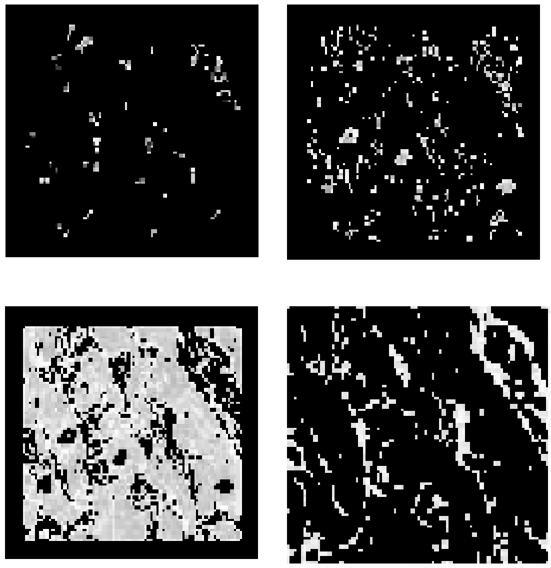

Fig. 7 Segmentation using k-means clustering where k = 4

By clicking the icon browse select the cardiac image, then click improved k-means (i.e. segment the cardiac image using improved k-means segmentation) Figure 8 shows the segmented cardiac image using improved k-means segmentation.

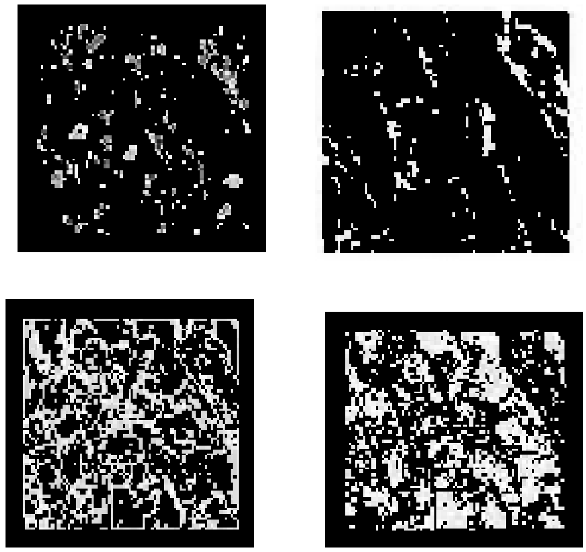

Fig. 8 Segmentation using improved k means clustering where k = 4

Then click Region growing method (i.e. segment the cardiac image using region growing segmentation) Figure 9 shows the segmented cardiac image using Region growing.

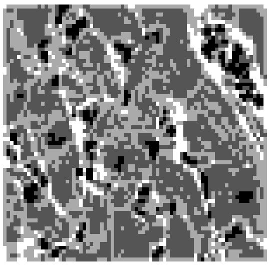

Fig. 9 Segmentation using region growing method

Finally by clicking otsu method (i.e. segment the cardiac image using Thresholding segmentation) figure 10 shows the segmented cardiac image using otsu method.

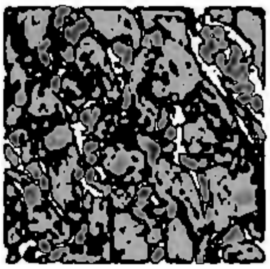

Fig. 10 Segmentation using Thresholding otsu method

V. CONCLUSION

The algorithms taken for the comparison are fuzzy k means, fuzzy improved k means, region growing and Otsu methods for segmentation of myocardial image obtained with biopsies of a transplanted heart patient. The quantitative measures (energy end entropy) are the non-linear objective assessments used to evaluate the different segmentation algorithms techniques. After the evaluation it is concluded that the Otsu method have high energy value and low entropy value which is most suited for medical image segmentation.

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