# Propose a Mixture Edge Detection Method for Infrared Image Segmentation

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## Abstract

Interpretation of image contents is one of the objectives in computer vision specifically in image processing. In image interpretation the partition of the image into object and background is a severe step. Segmentation separates an image into its component regions or objects. Image segmentation needs to segment the object from the background to read the image properly and identify the content of the image carefully. In this context, edge detection is a fundamental tool for image segmentation. In this paper an attempt is made to study the performance of most commonly used edge detection techniques for image segmentation and also propose a mixture algorithm using edge detection for image segmentation. These methods are tested on infrared images that are an important type of images. The comparison of these techniques is carried out with an experiment.

**Keywords:** Image segmentation, Edge detection, Infrared.

## Introduction

Image segmentation is an essential step in image analysis. Segmentation separates an image into its component parts or objects. The level to which the separation is carried depends on the problem being solved. Segmentation algorithms for images generally based on the discontinuity and similarity of image intensity values. Discontinuity approach is to partition an image based on abrupt changes in intensity and similarity is based on partitioning an image into regions that are similar according to a set of predefined criteria. Thus the choice of image segmentation technique is depends on the problem being considered [1].

Edge detection is one of the most frequently used techniques in digital image processing. The boundaries of object surfaces in a scene often lead to oriented localized changes in intensity of an image, called edges. This observation combined with a commonly held belief that edge detection is the first step in image segmentation, has fueled a long search for a good edge detection algorithm to use in Image processing [2].

Classical methods of edge detection engage convolving the image through an operator, which is constructed to be perceptive to large gradients in the image although returning values of zero in uniform regions.

There is a very large amount of edge detection techniques available, each technique designed to be perceptive to certain types of edges. Variables concerned in the selection of an edge detection operator consist of Edge orientation, Edge structure and Noise environment. The geometry of the operator establishes a characteristic direction in which it is most perceptive to edges. Operators can be optimized to look for vertical, horizontal, or diagonal edges. Edge detection is a difficult task in noisy images, since both the edges and noise hold high- frequency content. Not all edges involve a step change in intensity [1].

Things such as refraction or reduced focus can result in objects through boundaries defined by a regular change in intensity. The method wants to be chosen to be receptive to such a regular change in those cases. So, there are some problems of fake edge detection, edge localization, missing true edges,

problems due to noise and high computational time etc. Hence, the objective is to do the comparison of a variety of edge detections and analyze the performance of the different techniques in various conditions.
In this paper an attempt is made to review some of the most commonly used edge detection techniques for image segmentation and also propose a mixture method of edge detection. Also the review of the performances of such techniques is carried out for an image. Section 2 introduces the basic concepts that are mostly employed in the literature. Section 3 presents the characteristics of infrared images. Section 4 provides a comprehensive theoretical and mathematical background for image segmentation for edge detection and explains different computing approaches to edge detection. Section 5 presents the mixture edge detection method and the comparison of various edge detection techniques with infrared images. Section 6 contains a quick discussion about the reviewed works as well as conclusion.

## Related Work

The main purpose of segmentation operation is to locate a specific object end proper extraction; there is a huge literature on segmentation dating back to decades, with applications in myriad areas. In this section, some of the related work is presented relevant to the approach of this paper. In classical threshold image segmentation [3] an image is segmented and simply sorted to object and background by setting a threshold. It is easy to get good results by threshold segmentation. However, if there is complex information in an image, the threshold algorithm is definitely not suitable. Edge detectors have been evaluated based on average risk [5]. It is the performance measure based on Bayesian decision theory. In this performance, edge detector is context dependent which makes it non-trivial. Edges are detected for the images in spatial domain and edge detectors are evaluated based on the relative frequencies of the edge detected pixels and edge differences [5]. Edge detection refers to the process of identifying and locating sharp discontinuities in an image. The main of this paper aim is to survey the theory of edge detection for image segmentation using soft computing approach based on the Fuzzy logic, Genetic Algorithm and Neural Network [6]. Edge flow-driven Geometric Snake or EDGS. The partial differential equation (PDE) resulting from this integration of image Edge flow and region term is implemented using a level set approach [7]. In this paper a mixture edge detection image segmentation method was proposed depending on infrared images.

## Characteristics of Infrared Image

Infrared images have the following characteristics: (1) Infrared thermal image characterize the temperature distribution of scene, it is grayscale image, not color or shading image (three-dimensional sense), so for the human eye, it is low resolution; (2) As heat balance, long wavelength, long transmission distance, atmospheric attenuation and other reasons, infrared images gets the features of strong spatial correlation, low contrast, the visual effect is unclear; (3) The detection ability of thermal imaging systems is bad and it's spatial resolution lower than visible light CCD array, makes the clarity of infrared image lower than visible light image; (4) the random interference of external environment, and thermal imaging system is imperfect, they can to bring a wide range of infrared image noise, such as thermal noise, shot noise, photon noise. The complex distribution noise makes the signal to noise ratio of infrared image is lower than ordinary television picture; (5) Since the inconsistency of response characteristics for infrared detector unit, results the non-uniformity of the infrared image, reflected in image as fixed pattern noise and distortion.

As the targets radiate more heat, we can see they have larger grey-scale, locating in the top-end of histogram, because the infrared image is formed by the thermal infrared rays of the targets and environment [8].

Infrared commonly found in nature, any temperature above absolute zero, the object is issued by the infrared, such as ice. Infrared thermal imaging technology is objects or features thermal radiation from the infrared to form visible images [9]. Infrared can be converted into electronic images use the infrared image tube, so infrared image acquisition does not depend on external visible light. Visible-light image and infrared image have the different imaging mechanism. Visible-light imaging is used to the light reflection intensity on the objects. Infrared imaging is used to objects reflects infrared radiation, objects and background radiation temperature is difference [10].

Infrared image contains less information; avoid the target internal details (such as character clothing patterns, etc.) interference of the edge detection. The corresponding processing is also simple, can be extracted with useful when the edge element extraction, the lower resolution is better to image segmentation. With the same sensor can also capture infrared images and visible-light images omitted registration process [10].

## Edge Detection for Image Segmentation

### Image Segmentation

Image Segmentation is the process of partitioning a digital image into multiple regions or sets of pixels. Essentially, in image partitions are different objects which have the same texture or color. The image segmentation results are a set of regions that cover the entire image together and a set of contours extracted from the image. All of the pixels in a region are similar with respect to some characteristics such as color, intensity, or texture. Adjacent regions are considerably different with respect to the same individuality. The different approaches are (i) by finding boundaries between regions based on discontinuities in intensity levels, (ii) thresholds based on the distribution of pixel properties, such as intensity values, and (iii) based on finding the regions directly. Thus the choice of image segmentation technique is depends on the problem being considered.

Region based methods are based on continuity. These techniques divide the entire image into sub regions depending on some rules like all the pixels in one region must have the same gray level. Region-based techniques rely on common patterns in intensity values within a cluster of neighboring pixels. The cluster is referred to as the region in addition to group the regions according to their anatomical or functional roles are the goal of the image segmentation.

Threshold is the simplest way of segmentation. Using thresholding technique regions can be classified on the basis range values, which is applied to the intensity values of the image pixels.

Thresholding is the transformation of an input image to an output that is segmentated binary image. Segmentation Methods based on finding the regions directly find for abrupt changes in the intensity value. These methods are called as Edge or Boundary based methods. Edge detection is the problem of fundamental importance in image analysis. Edge detection techniques are generally used for finding discontinuities in gray level images. To detect consequential discontinuities in the gray level image is the important common approach in edge detection. Image segmentation methods for detecting discontinuities are boundary based methods [1].

**Edge Detection Techniques**

Edge detection techniques transform images to edge images benefiting from the changes of grey tones in the images. Edges are the sign of lack of continuity, and ending [2]. As a result of this transformation, edge image is obtained without encountering any changes in physical qualities of the main image [11]. Objects consist of numerous parts of different color levels. In an image with different grey levels, despite an obvious change in the grey levels of the object, the shape of the image can be distinguished in Figure 1.

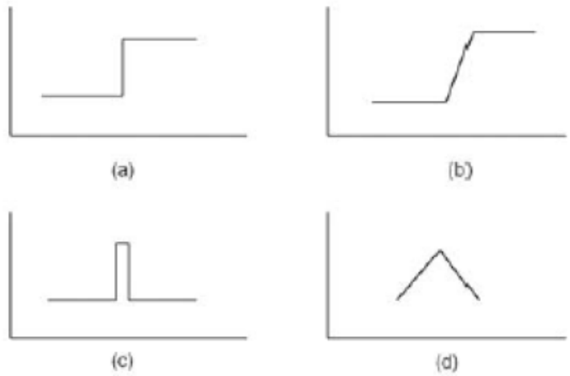



Figure 1: Type of Edges (a) Step Edge (b) Ramp Edge (c) Line Edge (d) Roof Edge

An Edge in an image is a significant local change in the image intensity, usually associated with a discontinuity in either the image intensity or the first derivative of the image intensity. Discontinuities in the image intensity can be either Step edge, where the image intensity abruptly changes from one value on one side of the discontinuity to a different value on the opposite side, or Line Edges, where the image intensity abruptly changes value but then returns to the starting value within some short distance[12]. However, Step and Line edges are rare in real images. Because of low frequency components or the smoothing introduced by most sensing devices, sharp discontinuities rarely exist in real signals. Step edges become Ramp Edges and Line Edges become Roof edges, where intensity changes are not instantaneous but occur over a finite distance [13]. Illustrations of these edge shapes are shown in Figure 1.

***A. Steps in Edge Detection***

Edge detection contains three steps namely Filtering, Enhancement and Detection. The overviews of the steps in edge detection are as follows.

***1) Filtering:*** Images are often corrupted by random variations in intensity values, called noise. Some common types of noise are salt and pepper noise, impulse noise and Gaussian noise. Salt and pepper noise contains random occurrences of both black and white intensity values. However, there is a trade-off between edge strength and noise reduction. More filtering to reduce noise results in a loss of edge strength [14].

***2) Enhancement:*** In order to facilitate the detection of edges, it is essential to determine changes in intensity in the neighborhood of a point. Enhancement emphasizes pixels where there is a significant change in local intensity values and is usually performed by computing the gradient magnitude [15].

***3) Detection:*** Many points in an image have a nonzero value for the gradient, and not all of these points are edges for a particular application. Therefore, some method should be used to determine which points are edge points. Frequently, thresholds provide the criterion used for detection [16].

### *B. Edge Detection Methods*

Three most frequently used edge detection methods are used for comparison. These are (1) Roberts Edge Detection, (2) Sobel Edge Detection and (3) Prewitt edge detection[17]. The details of methods as follows,

***1) The Roberts Detection:*** The Roberts Cross operator performs a simple, quick to compute, 2-D spatial gradient measurement on an image. It thus highlights regions of high spatial frequency which often correspond to edges. In its most
common usage, the input to the operator is a grayscale image, as is the output. Pixel values at each point in the output represent the estimated absolute magnitude of the spatial gradient of the input image at that point[17].

| | |
|---|---|
| +1 | 0 |
| 0 | -1 |

Gx

| | |
|---|---|
| 0 | +1 |
| -1 | 0 |

Gy

Figure 2: Roberts Mask.

***2) The Prewitt Detection:*** The pewit edge detector is an appropriate way to estimate the magnitude and orientation of an edge. Although differential gradient edge detection needs a rather time consuming calculation to estimate the orientation from the magnitudes in the x and y-directions, the compass edge detection obtains the orientation directly from the kernel with the maximum response. The prewitt operator is limited to 8 possible orientations, however experience shows that most direct orientation estimates are not much more accurate. This gradient based edge detector is estimated in the 3x3 neighborhood for eight directions. All the eight convolution masks are calculated. One convolution mask is then selected, namely that with the largest module [17].

| | | |
|---|---|---|
| -1 | +1 | +1 |
| -1 | -2 | +1 |
| -1 | +1 | +1 |

0°

| | | |
|---|---|---|
| +1 | +1 | +1 |
| -1 | -2 | +1 |
| -1 | -1 | +1 |

45°

Figure 3: Prewitt Mask

***3) The Sobel Detection:*** The Sobel operator performs a 2-D spatial gradient measurement on an image and so emphasizes regions of high spatial frequency that correspond to edges. Typically it is used to find the approximate absolute gradient magnitude at each point in an input grayscale image. In theory at least, the operator consists of a pair of 3x3 convolution kernels as shown in Figure 4. One kernel is simply the other rotated by $90^o$. This is very similar to the Roberts Cross operator [17]. The convolution masks of the Sobel detector are given below, Figure 5 shows the comparison of the edge detections for the example image.

| | | |
|---|---|---|
| -1 | 0 | +1 |
| -2 | 0 | +2 |
| -1 | 0 | +1 |

Gx

| | | |
|---|---|---|
| +1 | +2 | +1 |
| 0 | 0 | 0 |
| -1 | -2 | -1 |

Gy

Figure 4: Sobel Mask

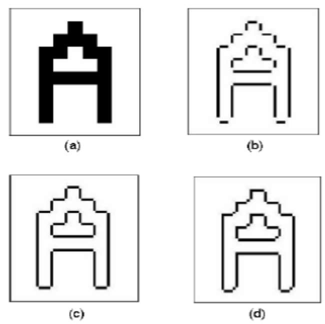


Figure 5: The comparison of the edge detections for the example image. (a) Original Image (b) using Prewitt Edge Detection (c) using Roberts Edge Detection (d) using Sobel Edge Detection.

**Edge Detection Evaluation**

Various people have demonstrated various ways of evaluation of edge detectors. While some of them follow the visual method of edge detection, where the edge map is shown to some people and various people rate the edge map on the basis of number of edges being detected. Most of them have also used the Receiver operating characteristic (ROC) curves for evaluating the performance of edge detectors [18].

Kevin Bowyer have used the edge map and the ground truth of the images where the statistical measure gives the true positive, true negative, misdetected and false alarm [19] The primary concern in any segmentation system is its ability to correctly verify a claimed edge or efficiently segment the image by determining the correct edges in the given image database. In order to assess a given system's ability to perform these tasks, a variety of evaluation methodologies have arisen. Performance evaluation of edge detectors have always been a biggest point of concern.

Some of the key measurements in evaluation the efficiency of edge detectors include:

- The False Acceptance Rate (FAR) and
- The False Rejection Rate (FRR)

The FAR, also known as a False Match Rate, describes the number of times the edges are inaccurately positively matched.

$$\text{False Acceptance Rate (FAR)} = \frac{\text{Incidences of False Acceptance}}{\text{Total Number of Sample}} \times 100 \qquad (1)$$

The FRR, also known as a False Non-Match Rate, derives the number of times an edge which should be identified positively is instead rejected.

$$\text{False Rejection Rate (FRR)} = \frac{\text{Incidences of False Rejections}}{\text{Total Number of Sample}} \times 100 \qquad (2)$$

The combination of the FAR and FRR can help determine which edge detector is more useful for a particular type of image. The performance of an edge detection system may also be summarized using the measures based on Receiver Operating Characteristic (ROC) such as the Receiver Operating Characteristic Area (ROCA). The lower the ROCA, the better the performance of edge detection system. In case of comparison of the various edge detectors the edge map is compared with the ground truth to determine the percentage of edges correctly detected (i.e., the best match). The best match edge detector can be determined by examining the FAR and FRR ratios in comparison with each other. And the edge detector with the lowest ROCA and highest RR is considered to be the best. The identification rate (Recognition rate) indicates the proportion (percentage) of the edges correctly identified (detected) by the edge detection system.

$$\text{Rcognition Rate (RR)} = \frac{\text{Incidences of True Identification}}{\text{Total Number of Sample}} \times 100 \qquad (3)$$

## Proposed Algorithm

Various edge detection techniques were implemented such as Roberts edge detector, Sobel Edge Detector, Prewitt edge detector, zerocross edge detector, LoG edge detector and Canny Edge Detector. Behind those methods we propose the mixture edge detection method that mix the previous methods with a threshold determined and a direction (vertical, horizontal, both) selected. So the overall algorithm was designed as followes:

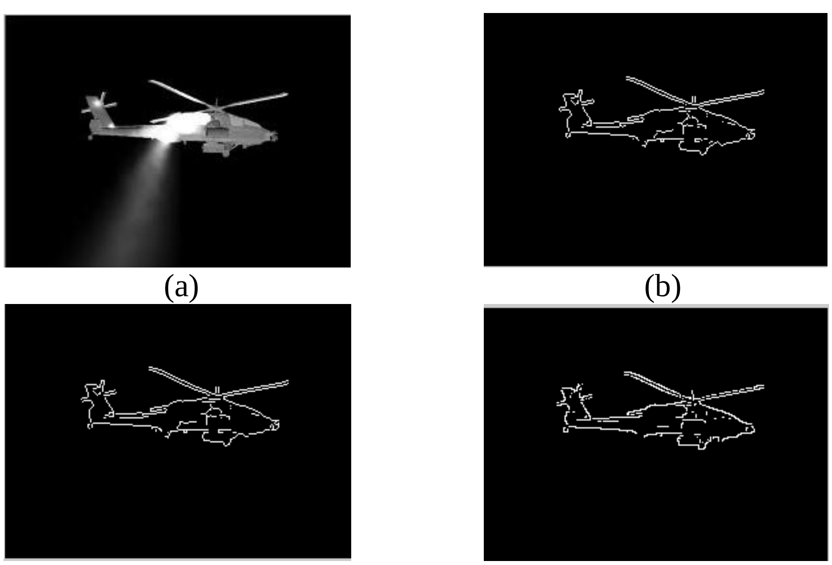
1. Input: 24-bit color jpg infrared image.
   R = Red component value in 24-bit color jpg image
   G = Green component value in 24-bit color jpg image
   B = Blue component value in 24-bit color jpg image
   Output: 24-bit segmented jpg infrared image .
2. Open RGB infrared image to read.
3. If edge detection method = sobel
   select the threshold (0.04<thr<0.08) and direction (vertical, horizontal, both) chosen then find sobel edge detection method.
4. If edge detection method = prewitt
   select the threshold (0.05<thr<0.09) and direction (vertical, horizontal, both) chosen then find prewitt edge detection method.
5. If edge detection method = roberts
   select the threshold (0.04<thr<0.08) and direction (vertical, horizontal, both) chosen then find roberts edge detection method.
6. If edge detection method = LoG (Laplacian of Gaussian method)
   select the threshold (0.001<thr<0.005) and sigma (using sigma as the standard deviation of the LoG filter. The default sigma is 2) chosen then find LoG edge detection method.

7. If edge detection method = zerocross
   select the threshold (0.003<thr<0.007) and horizontal direction chosen then find zerocross edge detection method. If you specify a threshold of 0, the output image has closed contours, because it includes all the zero crossings in the input image.
8. If edge detection method = Canny
   select the threshold (0.1<thr<0.2) and sigma (specifies the Canny method using sigma as the standard deviation of the Gaussian filter. The default sigma is 1; the size of the filter is chosen automatically, based on sigma) chosen then find Canny edge detection method.
9. Mix the above six edge detection methods as: e=(e1+e2+e3+e4+e5+e6)/6 then find mix edge detection method.

## Experimental works

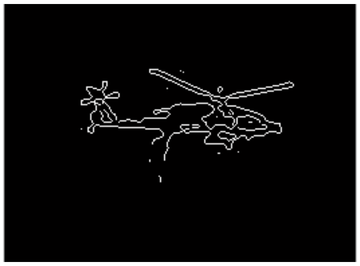
The edge detection techniques were implemented using MATLAB R2009a, and tested with infrared images. The objective is to produce a clean edge map by extracting the principal edge features of the image. The original image and the image obtained by using different edge detection techniques are given in figure 6.

Roberts, Sobel and Prewitt results actually deviated from the others. Zerocross, LoG and Canny produce almost same edge map. The mix edge maps is give a clear results. It is observed from the figure, mix result is superior by far to the other results. Figure 7 also shows the results of mixture technique for different images. Table 1 represent a comparisons results between the edge detection methods using edge detection evaluation (RR and ROCA).

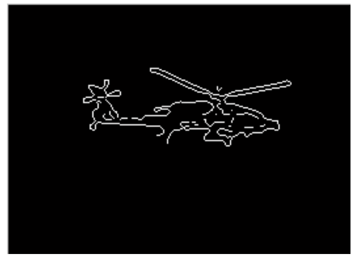


(a) (b)

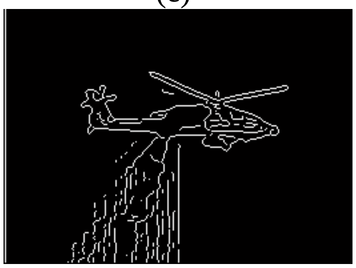
(b) (d)



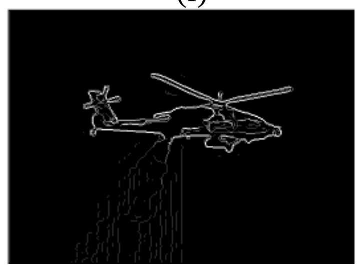
(e)



(f)

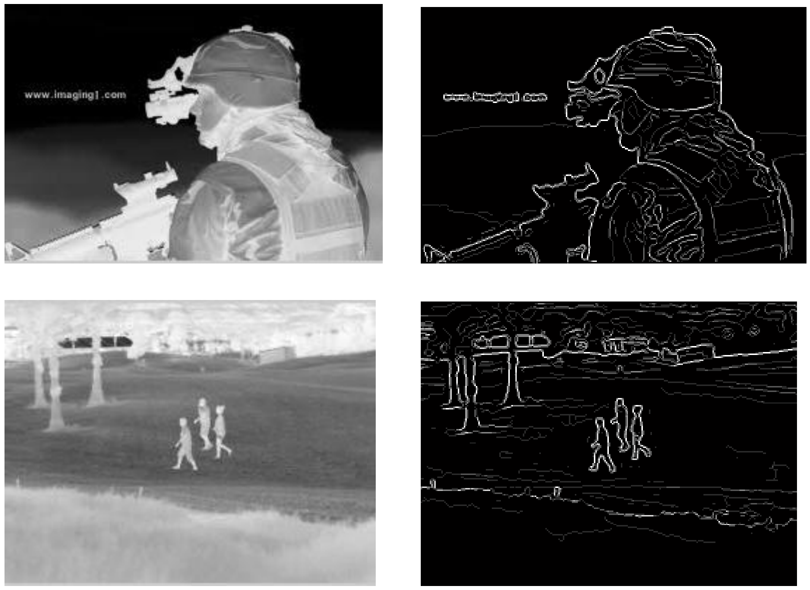


(g)



(h)

Figure 6: The comparison of the edge detections for the example image. (a) Original Image (b) using Sobel Edge Detection (c) using Prewitt Edge Detection (d) using Roberts Edge Detection (e) using LoG Edge Detection (f) using Zerocross Edge Detection (g) using Canny Edge Detection (h) using Mixture Edge Detection.



(a) (b)

Figure 6: (a) Original images, (b) mixture edge detection method

**Table 1**: Comparative result of the edge detectors

| Images | Edge Detectors | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Sobel | | Prewitt | | Roberts | | LoG | | Zerocross | | Canny | | mixture | |
| | RR | ROCA | RR | ROCA | RR | ROCA | RR | ROCA | RR | ROCA | RR | ROCA | RR | ROCA |
| **Image1** | **91.86** | **5.11** | **91.82** | **5.98** | **91.92** | **4.88** | **91.89** | **5.04** | **91.85** | **5.13** | **92.05** | **4.79** | **92.26** | **4.65** |
| **Image2** | **86.89** | **55.70** | **86.77** | **57.69** | **86.98** | **55.24** | **86.92** | **55.78** | **86.88** | **88.73** | **87.54** | **55.06** | **87.92** | **54.73** |

## Conclusion

This paper describes the various image segmentation techniques and discusses in detail the edge detection techniques and their evaluation. It gives an algorithm which is a combination of detection and evaluation of the edge detectors. The results show that the recognition rate depends on the type of the image and their ground truths. The relative performance of various edge detection techniques is carried out with an image by using MATLAB software. It is observed from the results Roberts, Sobel, Prewitt, zerocross, LoG, Canny and the proposed mixture edge detector Mixture result is superior one when compared to all for a selected image since different edge detections work better under different conditions. Even though, so many edge detection techniques are available in the literature, since it is a challenging task to the research communities to detect the exact image without noise from the original image.

An improved infrared image segmentation algorithm is put forward for the question that infrared image segmentation target area of aircraft appears internal hole after be split. This algorithm overcomes unfavorable control faults of operation times that hole to be filled more or lager by using mixture method. Experimental results show that different areas can be extracted effectively by this algorithm.

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