A STUDY OF DIFFERENT EDGE DETECTION METHODS AND DIFFERENT COMPUTING APPROACHES

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ABSTRACT

An Edge in an image is the boundary between two different regions. Edge detection is important in image processing and computer vision, particularly in the area of feature detection. An edge often indicates the physical extent of object within the image. An edge detection process ultimately aims to obtain a binary edge map. Edge detection is a fundamental tool for image segmentation. In this paper an attempt is made to study of most commonly used edge detection techniques for image segmentation and also the study of different soft computing approaches base on this techniques .

Keywords: Image Segmentation, Edge detection, Fuzzy logic.

1.INTRODUCTION

Edge detection is a very important area in the field of Computer Vision. Edges define the boundaries between regions in an image, which helps with segmentation and object recognition. They can show where shadows fall in an image or any other distinct change in the intensity of an image. Edge detection is a fundamental of low-level image processing and good edges are necessary for higher level processing. [1]. 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.

In This paper we have study about different edge detection methods like Canny edge detection ,Sobel edge detection,Prewitt edge detection, Robert edge detection, Laplician of Gaussian(LOG) and we have to study about different computing approaches like Wavelet approach, Genetic Algorithm Approach, Fuzzy based approach. This paper is organized as follows. Section 2 flow of edge detection. Section 3 is focused on showing Classification of edge detection methods. Section 4 explains different computing approaches of edge detection. Section 5 comparison of various edge detection methods. Section 6 showing the Conclusion.

2.FlOW OF FIND EDGE

There are main three steps of find the edge detection.
1)Filtering
2)Enchancement
3)Detection

FILTERING

Most applications in computer vision and computer graphics involve the concept of image filtering to reduce noise and/or extract useful image structures. There are various kinds of noise, but the most widely studied two kinds are white noise and "salt and pepper" noise. Simple explicit linear translation-invariant (LTI) filters like Gaussian filter, Laplacian filter, and Sobel filter are widely used in image blurring/sharpening, edge detection, and feature extraction . LTI filtering also includes the process of solving a Poisson Equation, such as in high dynamic range (HDR) compression , image stitching , and image matting , where the filtering kernel is implicitly defined by the inverse of a homogenous Laplacian matrix.

ENHANCEMENT

The principal objective of enhancement is to process an image so that the result is more suitable than the original image for a specific application Enhancement is the modification of an image to alter impact on the viewer. Generally enhancement distorts the original digital values; therefore enhancement is not done until the restoration processes are completed.
Image Enhancement alters the visual impact that the image has on the interpreter in a fashion that improves the information content.

a. Contrast enhancement
b. Intensity, hue, and saturation transformations
c. Density slicing
d. Edge enhancement
e. Making digital mosaics
f. Producing synthetic stereo images

DETECTION
Some methods should be used to determine which points are edge points or not.

3 TYES OF EDGE DETECTION METHODS

There are different types of edge detection methods are used in image processing Sobel edge detection, Canny edgr detection, Prewitt edge detection, Robert edge detection, Laplician edge detection.

3.1 SOBEL EDGE DETECTION

Sobel edge detection is used in image processing techniques .The sobel kernals are more suitable to detect edges along the horizontal(180 degree) and vertical axis(90 degree)[2]. The sobel operator is based on convolving the image with a small, separable, and integer valued filter .

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

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

3.2 CANNY EDGE DETECTION

Canny edge detection is a multistage algorithm to detect a wide range of edges in images. It was presented in 1986 by Canny. The problem with this type of traditional edge detection approach is that a low threshold produces false edges, but a high threshold misses important edges.

3.3 PREWITT EDGE DETECTION

Prewitt operator edge detection masks are the one of the oldest and best understood methods of detecting edges in images. The strength of the edge at given location is then the square rote of the sum of the squares of two derivatives.

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

Gx

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

Gy

3.4 ROBERT EDGE DETECTION

In Robert edge detection, the vertical and horizontal edges bring out individually and then put together for resulting edge detection. The two individual images Gx and Gy will be combined to get result.The Robert cross kernels are relatively small .Therefore they are highly susceptible to noise.

+1	0
0	-1

Gx

0	+1
-1	0

Gy

3.5 LAPLICIAN OF GAUSSIAN(LOG)

This method of edge detection was invented by Marr and Hildreth in 1980.In this method, the Gaussian filtering is combined with Laplician to break down the image where the intensity varies to detect the edges effectively.The Laplician L(x,y)of an image with pixel intensity values I(x,y)is given by:

$$L(x,y)= \frac{\partial^2 I}{\partial x^2} + \frac{\partial^2 I}{\partial y^2}$$

. It finds the correct place of edges and testing wider area around the pixel .The disadvantage of LOG operator is that it can not find orientation of edge because of laplician filter

1	1	1
1	-8	1
1	1	1

-1	2	-1
2	-4	2
-1	2	-1

4 DIFFERENT APPROACHES

4.1 WAVELET APPROACH

The concept of wavelet analysis has been developed since the late 1980's. However, its idea can be traced back to the Littlewood-Paley technique and Calderón-Zygmund theory in harmonic analysis. Wavelet analysis is a powerful tool for time-frequency analysis. Fourier analysis is also a good tool for frequency analysis, but it can only provide global frequency information, which is independent of time. Hence, with Fourier analysis, it is impossible to describe the local properties of functions in terms of their spectral properties, which can be viewed as an expression of the Heisenberg uncertainty principle .Edges in images can be mathematically defined as local singularities. Until recently,the Fourier transforms was the main mathematical tool for analyzing singularities. However,the Fourier transform is global and not well adapted to local singularities. It is hard to find the location and spatial distribution of singularities with Fourier transforms. Wavelet analysis is a local analysis, it is especially suitable for time-frequency analysis [1], which is essential for singularity detection. This was a major motivation for the study of the wavelet transform in mathematics and in applied domains.

Wavelet transforms are classified into discrete wavelet transforms (DWTs) and continuous wavelet transforms (CWTs). The Discrete Wavelet Transform (DWT) has been a successful technique used in edge detection.

With the growth of wavelet theory, the wavelet transforms have been found to be remarkable mathematical tools to analyze the singularities including the edges, and further, to detect them effectively. This idea is similar to that of John Canny [4]. The Canny approach selects a Gaussian function as a smoothing function θ ; while the wavelet-based approach chooses a wavelet function to be θ o. Mallat, Hwang, and Zhong ([5], [6]) proved that the maxima of the wavelet transform modulus can detect the location of the irregular structures. Further, a numerical procedure to calculate their Lipschitz exponents

has been provided. One and two-dimensional signals can be reconstructed, with a good approximation, from the local maxima of their wavelet transform modulus.
The wavelet transform characterizes the local regularity of signals by decomposing signals into elementary building blocks that arewell localized both in space and frequency. This not only explains the underlying mechanism of classical edge detectors, but also indicates a way of constructing optimal edge detectors under specific working conditions

4.2 Genetic Algorithm Approach

In A.I areas in the image feature extraction regards the *Evolutionary Algorithms* (EAs). these kinds of algorithms use a heuristic approach to find approximate solutions to optimization and search problems.The EAs are inspired by Darwin's theory about biological evolution

Genetic Algorithm (GA) is a search heuristic that mimics the process of natural evolution. It belongs to the larger class of evolutionary algorithm, which generates solution to optimization problems using natural evolution, such as mutation, selection and crossover. Initially developed in biology context, such methods find application in bioinformatics, phylogenetics, economics, chemistry, manufacturing, physics, and other fields.
A typical genetic algorithm requires a genetic representation of the solution domain and a fitness function to evaluate the solution domain. Once these functions are defined, GA proceeds to initialize a population of solution randomly, them improve it through repetitive application of selection ,crossover and mutuation operators.

There are three steps to implement genetic alogorithm

Selection
selection evaluates each individual and keeps only the fittest ones in the population[23]. In addition to those fittest individuals, some less fit ones could be selected according to a small probability[14]. The others are removed from the current population. The crossover recombines two individuals to have new ones which might be better.

Crossover:
The crossover recombines two individuals to have new ones which might be better.

Mutuation
The mutation operator induces changes in a small number of chromosomes units. Its purpose is to maintain the population diversified enough during the optimization process[3].

4.3 Neural network

Neural networks are formed by several elements that are connected by links with variable weights. Artificial neural networks (ANN) are widely applied for pattern recognition. Their processing potential and nonlinear characteristics are used for clustering. Self organization of Kohonen Feature Map (SOFM) network is a powerful tool for clustering. Ji and Park proposed an algorithm for watershed segmentation based on SOM. This method finds the watershed segmentation of luminance component of color image. The method can be explained as follows. It consists of two independent neural networks one each for saturation and intensity planes. The neural network consists of three layers namely input layer, hidden layer, and output layer as depicted in the

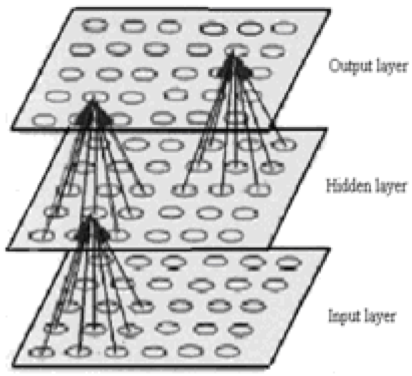

Fig-1:three layer of neural network

Generally, the neural network consists of three layers such as input layer, hidden layer and output layer as in the fig . Each layer consists of fixed number of neurons equal to the number of pixels in the image. The activation function of neuron is a multi sigmoid. The major advantage of this technique is that, it does not require a priori information of the image. The number of objects in the image is found out automatically.

The feed-forward error-back propagation neural networks are trained with 3 × 3 to 11 × 11 inputs, 4 to 8 units in the single hidden layer, and a single output. All units used sigmoid activation functions. Hidden nodes, whose weights were regarded as a template, which is similar to any image filter (e.g. Kirsch or Sobel templates), and its Taylor series coefficients, were used to analyze the order of this template. Interesting results were found when some small neural networks edge detectors were trained with sharp edges whilst others were trained with sharp, blurred, and noisy variants of the same images.

A three-layer neutral network is employed to determine the structure elements in the morphology method, so that the image can be smoothened and all probable edge points can be detected. Zernike moments operator is adopted to locate the edge to sub pixel accuracy degree. The system consists of a neural network that performs the segmentation using multilevel thresholding activation function. The main advantage of this method is that, it segments the color image without prior knowledge of the image. The threshold and target values are used to construct an activation function of neuron. The error of the system is calculated and back propagated to change the weights of neural network. This process continues until a minimum error is achieved. The output of the system at this stage is a colored segmented image.

4.4 Fuzzy Base Approach

There are different rules to develop fuzzy logic based edge detection. The first is study the image processing and the second is study the fuzzy sets and membership function and the third is study the fuzzy inference rules definition.

A. Fuzzy Image Processing

Fuzzy image processing is the collection of all approaches that understand, represent and process the images, their segments and features as fuzzy sets. The representation and processing depend on the selected fuzzy technique and on the problem to be solved. Fuzzy image processing has three main stages: image fuzzification, modification of membership values, and, if necessary, image defuzzification as shown in Fig. 2. The fuzzification and defuzzification steps are due to the fact that we do not possess fuzzy hardware. Therefore, the coding of image data (fuzzification) and decoding of the results (defuzzification) are steps that make possible to process images with fuzzy techniques. The main power of fuzzy image processing is in the middle step (modification of membership values). After the image data are transformed from gray-level plane to the membership plane (fuzzification), appropriate fuzzy techniques modify the membership values. This can be a fuzzy clustering, a fuzzy rule-based approach, a fuzzy integration.

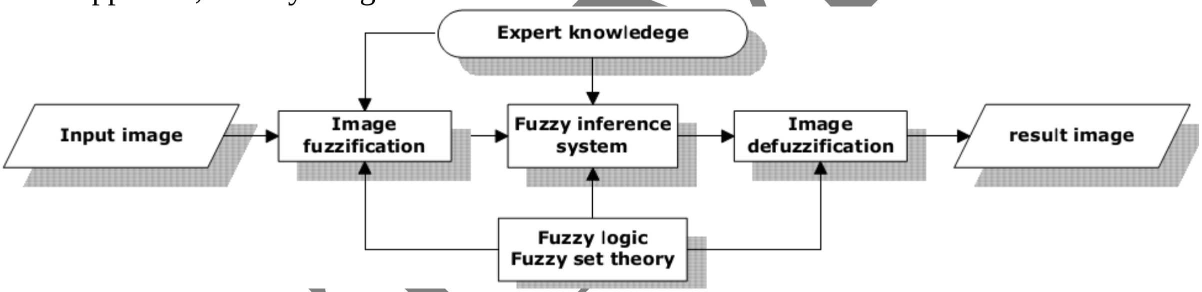

Fig-2: Structure of fuzzy image processing

B. Fuzzy Sets and Fuzzy Membership Functions

The system implementation was carried out considering that the input image and the output image obtained after defuzzification are both 8-bit quantized; this way, their gray levels are always between 0 and 255. The fuzzy sets were created to represent each variable's intensities; these sets were associated to the linguistic variables "Black", Edge and"white". The adopted membership functions for the fuzzy sets associated to the input and to the output weretriangles,as

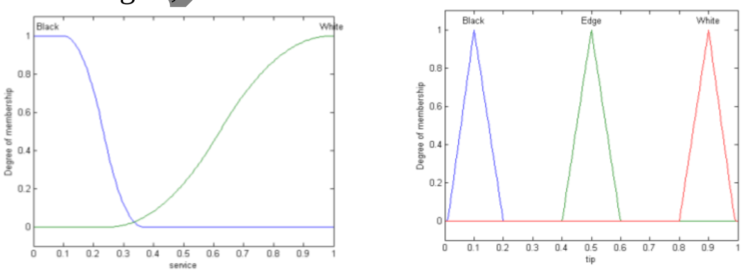

Fig 3:Membership Functions of fuzzy set associated to the input and to the output

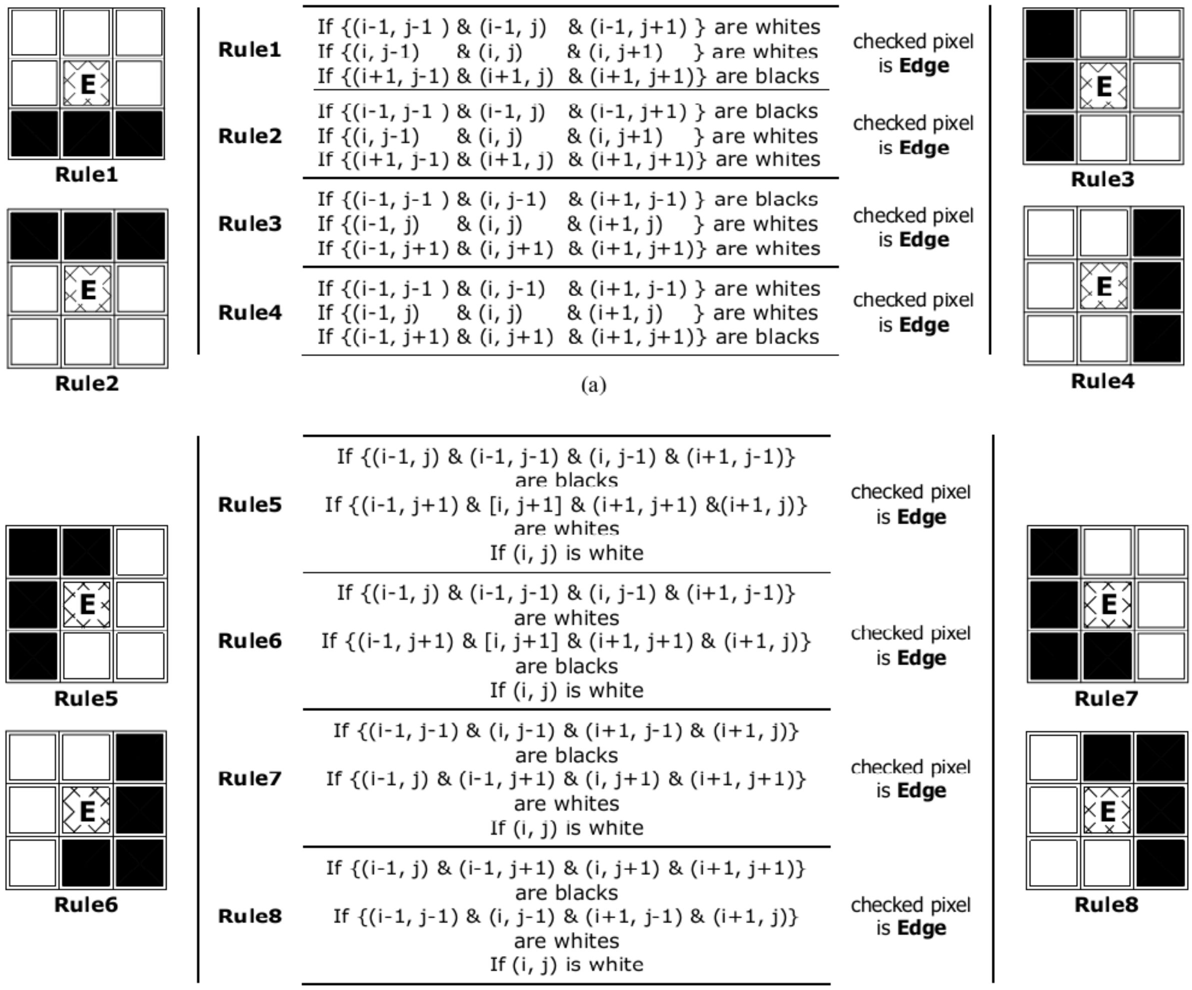

Fig-4:Fuzzy System Rules

[i-1, j-1]	[i-1, j]	[i-1, j+1]
[i, j-1]	[i, j]	[i, j+1]
[i+1, j-1]	[i+1, j]	[i+1, j+1]

Fig-5 Floating Mask3*3

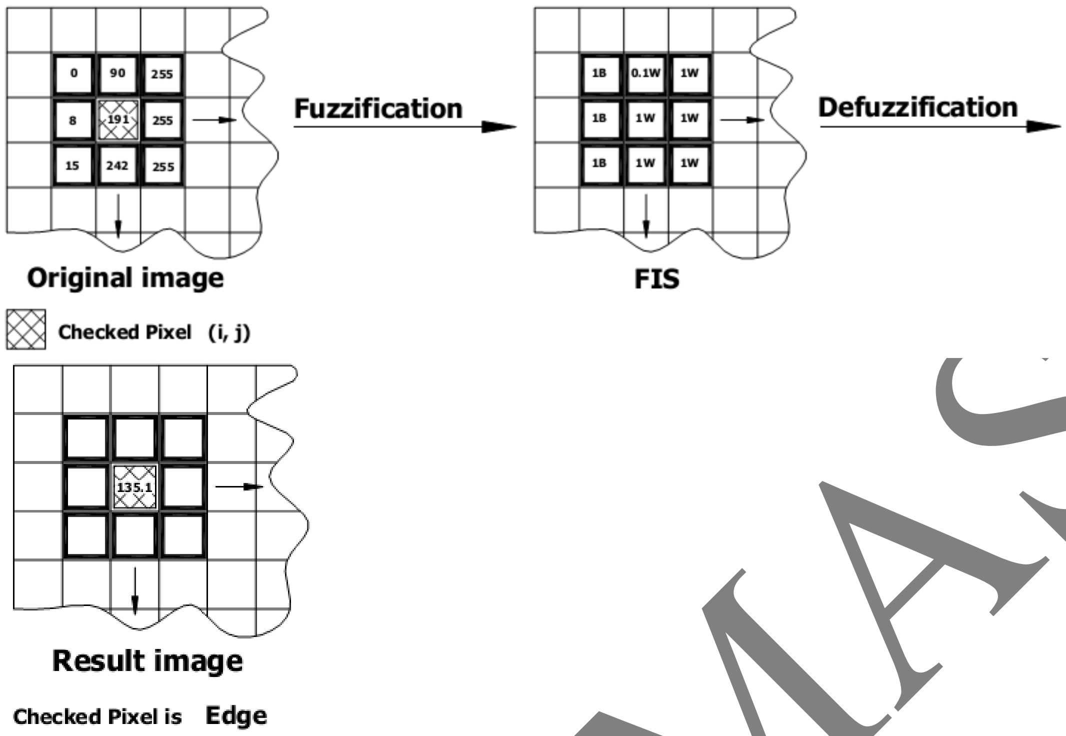

Fig-6:Steps of fuzzy image processing

The functions adopted to implement the “and” and “or” operations were the minimum and maximum functions, respectively. The Mamdani method was chosen as the defuzzification procedure, which means that the fuzzy sets obtained by applying each inference rule to the input data were joined through the add function; the output of the system was then computed as the lom of the resulting membership function. The values of the three memberships function of the output are designed to separate the values of the blacks, whites and edges of the image.

C. Inference Rules Definitions

The inference rules is depends on the weights of the eight neighbours gray level pixels, if the neighbours weights are degree of blacks or degree of whites. The powerful of these rules is the ability of extract all edges in the processed image directly. This study is assaying all the pixels of the processed image by studying the situation of each neighbour of each pixel. The condition of each pixel is decided by using the floating 3x3 mask which can be scanning the all grays. In this location, some of the desired rules are explained. The first four rules are dealing with the vertical and horizontal direction lines gray level values around the checked or centered pixel of the mask, if the grays represented in one line are black and the remains grays are white then the checked pixel is edge (Fig.4-a). The second four rules are dealing with the eight neighbours also depending on the values of the gray level weights, if the weights of the four sequential pixels are degree of blacks and the weights of the remain fours neighbours are the degree of whites, then the center pixel represents the edge (Fig.4-b). The introduced rules and another group of rules are detecting the edges, the white and the black pixels. The result images contribute the contours, the black and the white areas. From the side of the fuzzy construction, the input grays is ranged from 0-255 gray intensity, and according to the desired rules the gray level is converted to the values of the membership functions as shown in Fig. 5. The output of the FIS according to the defuzzification is presented again to the values from 0-255. and then the black, white and edge are detected. From the experience of the tested images in this study, it is found that the best result to be achieved at the range black from zero to 80 gray values and from 80 to 255 meaning that the weight is white.

5 **COMPARISON OF EDGE DETECTION METHODS**

The edge detection result of various edge detectors are most commonly compared to commonly used or algorithms like as the Canny, Sobel and Robert's edge detection algorithms. Technical techniques for accurate detection of edge features, as exemplified by Canny operator, demands such expensive operations as the iterative use of Gaussians, Laplacians and their designs are largely sequential. Wavelet based edge detectors provide a facility for varying the scaling factor, which helps in differentiating the weak edges from strong edges. objective methods use to measure the performance of edge detectors using signal to noise ratio and mean square error between the edge detectors images and the original one. Evaluation is done using both a Receiver Operating Characteristics (ROC) analysis and a Chi-square test, and considers the tradeoff between information and noisiness in the detection results. The best **edge detector parameter set** (PS) is then selected by the same statistical approach. Results are demonstrated for several edge detection techniques, and compared to published subjective evaluation results. Simulation results indicate that the proposed edge detector outperforms competing edge detectors and offers superior performance in edge detection in digital images corrupted by noise.

The visualization comparison of images are as under

(a) (b) (c) (d) (e)

Figure :Comparison of Edge Detection Techniques on Lena Image Original Image (b)Sobel Edge (c)Prewitt Edge(d)Canny Edge(e)Robert Edge

6. CONCLUSION

These edge detection operators can have better edge effect under the circumstances of obvious edge and low noise. But the actual collected image has lots of noises. So many noises may be considered as edge to be detected. In order to Solve the problem In this paper an attempt is made to review the edge detection techniques which are based on discontinuity intensity levels. The relative performance of various edge detection techniques is carried out with an image by using MATLAB software. It is observed from the results Sobel, Prewitt Canny edge detectors produce almost same edge map. Canny result is superior one when compared to all for a selected image since different edge detections work better under different conditions.

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