A Novel Approach Towards Enhancement of Image Characteristics using Partial Differential Equation

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***Abstract*: The Graphical properties of any image is one of it's most important feature to be taken care due to which the picture visible to us is pleasant and attaractive. It may be the case that the image can be distorted by some noise. Thus, here this research paper focuses on the use of image improvement and enhancement technique using Partial differential equations. It is majorly being used due to the fact that the picture analysis becomes more simplified and the model proposed is quiet effective, which also provides us an enhanced quality graphics of image.**

The higher order partial differential equation majorly used as they have the structure preserving capability and also exhibits in it the feature to dampen the oscillations at higher frequencies as compared to the second order partial differential equations. The proposed Graphics improvement method involves the use of intensity function from the clear images and the noisy images, and then the deployment of the higher order PDE with enhancement technique, taking into consideration the gradient curvature flow method of You and Kaveh, resulting into a clear enhanced image, which improves the performance of my suggested method. To analyze the result, the Signal to Noise ratio of the noisy images and the enhanced images are compared, which shows the success and limitation of the proposed method.

***Keywords*: Color level RGB-CMY, Enhancement, Image characteristics, partial differential equation**

1. Introduction

Color image improvement grows exceptionally quick and assumes a significant job in the introduction of an image as of late. Image upgrade is utilized to improve the nature of an image for visual impression of people. It is likewise utilized for low dimension vision applications. It is an undertaking wherein the arrangement of pixel estimations of one image is changed to another arrangement of pixel esteems with the goal that the new image framed is outwardly satisfying and is additionally progressively appropriate for examination. The fundamental strategies for image upgrade, for example, differentiate extending, cutting, histogram adjustment, for dark scale images are examined in numerous books. The speculation of these systems to color images isn't straight advance. Not at all like dark scale images, there are a few factors in color images like shade which should be appropriately dealt with for upgrade. On account of wide utilization of color image improvement people groups are more pulled in to this procedure, for instance, in sight and sound, biomedical science and web and so on field. Shade is the property of the color which characterizes what sort of color it is for example blue or a darker. Tint, immersion and power are the qualities of color. Tint is that quality of a color which chooses what sort of color it is, i.e., a red or an orange. In the range each color is at the most extreme virtue (or quality or wealth) that the eye can acknowledge, and the range of colors is depicted as completely soaked. In the event that a soaked color is weakened by being blended with different colors or with white light, its wealth or immersion is diminished. To upgrade a color image, it is to be seen that shade ought not change for any pixel. On the off chance that tone is changed, at that point the color gets changed, along these lines twisting the image. One needs to improve the visual nature of an image without twisting it for image upgrade.

Different calculations are accessible for difference upgrade in dark scale images, which change the dim estimations of pixels relying upon the criteria for improvement. George Color image upgrade and denoising task is performed by utilizing an advanced arrangement of channels. Scaling and moving are two tint protecting systems which are proposed by Yang for the preparing of luminance and immersion segments. Bockstein also proposed a color leveling technique dependent on both immersion and brilliance of the image. Weekset proposed a tone safeguarding color image upgrade system which alters the immersion and force segments in color contrast (C-Y) color space. Their calculation segments the entire (C-Y) color space n×k into number of subspaces, where n and k are the quantity of allotments in luminance and immersion parts individually.

In spite of the fact that the calculations announced above are fascinating and compelling for improvement, the majority of them don't successfully deal with the array issue – the situation where the pixel esteems leave limits in the wake of preparing. Because of the nonlinear idea of the uniform color spaces, change from these spaces with adjusted force and immersion esteems to RGB. Image upgrade (denoising) ia a functioning region of enthusiasm for image preparing analysts for a significant lot. The utilization of fractional differential conditions (PDEs) in image handling has become fundamentally over the previous years and an enormous number of PDE based strategies have especially been proposed to handle the issue of image upgrade (denoising) with a decent safeguarding of edges, and furthermore to unequivocally represent inherent geometry. Image rebuilding is a significant advance in image preparing and a vital pre-preparing for other image undertakings like image division. Image reclamation techniques, especially, denoising strategies have involved an exceptional position in image handling.

Since the rich plan of anisotropic dissemination presented by Perona and Malik, numerous specialists have been done for the comprehension of PDE-based rebuilding models. Other than the Perona-Malik model, other PDE-based strategies like TV model and their variations are altogether second request halfway differential conditions fundamentally.

In this research paper, I concentrated on Enhancement of Color Image utilizing Forth request Partial Differential Equation. The outcomes got from the proposed strategies have been contrasted and the outcomes got from the improvement strategy proposed by Mukherjee and the improvement strategies proposed by Murtaza. At that point based on result I can say that my proposed technique has a superior execution conversely upgrade and pinnacle sign to commotion proportion (PSNR) with both Mukherjee and Murtaza strategy.

A. *Objectives of Image Enhancement*

The objective of Image Enhancement is basically to improve the quality of an image and to remove the various noise factors such as shade present in the image. It is normally noticed that the image normally do not looks pleasent as the image is really distorted by noise and shade, pixel value are low and are not estimated to suitable level.

Hence, the main motive of the image enhancement and this research paper is to think and evaluate a novel idea to enhance the image characteristics using Fourth order Partial differential equation. On account of wide utilization of color image improvement people are widely using this technique in various fields of application.

The other objective of this Image Enhancement Technique is to provide a step wise approach to extract the noisy factors and to Improve the image characteristics.

B. *New Approach towards Image Enhancement*

The proposed model for color image enhancement utilizing fourth request PDE (Partial Differential Equation) by utilizing a square chart which utilizes a six stage ways to deal with discover a de-noising image for enhancement. The primary stage speaks to an image, which is utilized for enhancement. The second stage speaks to a fourth request PDE and the model appreciates the advantage of both nonlinear fourth request PDE and image enhancement.

Commotion decrease is normally the principal procedure that is utilized in the investigation of images. Image de-noising is a functioning territory of enthusiasm for image enhancement specialists for an extensive stretch. The utilization of fractional differential conditions (PDEs) in image enhancement has become fundamentally over the previous years and an enormous number of PDE based strategies have especially been proposed to handle the issue of image denoising and image enhancement.

In the third stage, standardized the RGB esteem, which procedures the yield of fourth request PDE and the image is changed from the RGB to the CMY, the image splendor or immersion is handled, and its tone is kept up so as to diminish the color bending, in particular, color reclamation. Fourth stage is S-type enhancement and S-type enhancement method is by and large and generally utilized complexity enhancement procedure for dim scale images and plays out the change in CMY color space. The philosophies of S-type enhancement strategies can be found in the writing.

For the most part the dim scale differentiate enhancement methods is utilized to upgrade the power of the color image and they are shade protecting. Upgrade them color level linearly is the Second last stage, which procedures the yield of S-type enhancement and in this stage return to the RGB esteem. Finally, we got the upgrade image in the last stage.

Image enhancement is utilized to improve the nature of an image for visual impression of individuals. It is additionally utilized for low dimension vision applications. It is an assignment wherein the arrangement of pixel estimations of one image is changed to another arrangement of pixel esteems with the goal that the new image framed is outwardly satisfying and is likewise progressively reasonable for investigation. From figure (2.1) the succession of stages is as-(I) image input (ii) fourth request PDE for an image, (iii) normalizing the RGB esteem, (iv) S-type enhancement work, (v) Enhance the color level linearly (vi) improved image.

Figure 1, show the process of color image enhancement using fourth order PDE:

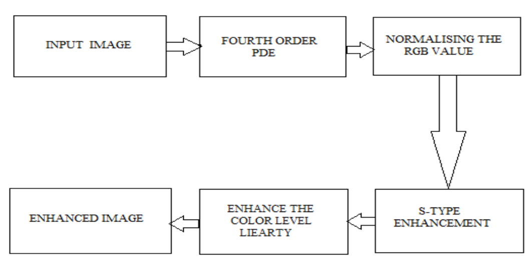

Fig. 1. process of color image enhancement using fourth order PDE

The proposed model for color image enhancement utilizing fourth order PDE (Partial Differential Equation) comprises of two phases. The principal stage comprises of a fourth order PDE and the second stage is an image enhancement, which procedures the yield of fourth order PDE.

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In the course of the most recent decade, the issue of image de-noising has been tended to utilizing various procedures including greatest a posteriori estimation technique, hearty measurements based channels, wavelets, fractional differential conditions (PDE)- based calculations, and variational strategies. The utilization of halfway differential conditions (PDE) in image handling has become altogether over the previous years. Here the essential thought is to distort an image or a surface with a PDE and acquire the normal outcomes as an answer for this condition. One of the principle focal points of the use of fractional differential conditions (PDEs) is that it takes the image investigation to a constant space streamlining the formalism of the model, which winds up free from the lattice utilized in the discrete issue. Among the halfway differential condition based techniques, because of its auxiliary protecting capacity, non-straight PDEs are normally utilized for image.

A significant part of the intrigue of PDE-based techniques lies in the accessibility of an immense munititions stockpile of scientific instruments, which in any event go about as a key guide in accomplishing numerical exactness just as strength. A significant part of the intrigue of PDE-based techniques lies in the accessibility of an immense munitions stockpile of scientific instruments, which in any event go about as a key guide in accomplishing numerical exactness just as strength.

At some point separating idea is use for image de-noising and there are different strategies for image de-noising. For example, normal channel, middle channel and Gaussian channel are a portion of the strategies utilized for image de-noising. These channels diminish commotion at the expense of smoothing the image and subsequently mellowing the edges. To conquer the previously mentioned issues, the incomplete differential conditions (PDEs) – based strategies have been presented in the writing. These techniques expect the power of enlightenment on edges differs like geometric warmth stream in which warmth changes from a warm domain to a cooler one until the temperature of the two conditions achieves a decent point. It was demonstrated that these progressions are as a Gaussian capacity. Thus, abrupt changes in edges may be because of the presence of commotion. Indeed, an image incorporates a progression of locales where various areas may have distinctive standard deviations. Image reclamation is a significant advance in image preparing and an important pre-handling for other image errands like image division. Image reclamation strategies, especially, de-noising techniques have involved an exceptional position in image preparing. Since the rich plan of anisotropic dissemination [32] presented by Perona and Malik, numerous scientists have been completed for the comprehension of PDE-based reclamation models. Other than the Perona-Malik model, other PDE-based techniques like TV model and their variations are on the whole second order incomplete differential conditions basically.

Despite the fact that these systems have been shown to have the option to accomplish a decent exchange off between clamor evacuation and edge protection, they will in general reason the handled image to look "blocky" as can be seen from the images in and particularly as detailed in. This impact is outwardly horrendous and is probably going to cause a PC vision system to erroneously perceive as edges the limits of various obstructs that really have a place with a similar smooth region in the first image. This blocky impact is, to an enormous degree, innate in the idea of every one of these conditions, which are second order. Since second order subsidiaries are zero just if the image force capacity is planar, these kinds of PDEs will advance toward and settle down to a planar image if the image backing is unending. For images of restricted help, be that as it may, symmetric limit condition is normally utilized so as to stay away from mutilation at the limits. By symmetric limit condition, we imply that the image power capacity has equivalent qualities at the two sides of the limit. Since the image angle is clearly zero at these limits, an image will develop toward a dimension (on a level plane planar) image to fulfill this limit state of zero slopes. So as to protect edges while evacuating clamor, this sort of PDEs are typically intended to advance quicker in smooth regions than around edges. Accordingly, after certain season of development, the image will seem as though one comprising of level territories of different powers. The limits of these dimension zones may concur with edges, yet may show up amidst huge smooth and inclination territories.

Since the blocky impact is intrinsic normal for second order conditions, high order PDEs has been considered.

C. Steps of Enhancing Image characteristics

1) Initiating the Enhancement Process

Images are put away in a computer as a lattice of picture components, or pixels. These pixels contain the image's color and splendor data. Image editors can change the pixels to improve the image from numerous points of view. The pixels can be changed as a gathering, or independently, by the complex calculations inside the image editors. Color image enhancement grows exceptionally quick and assumes a significant job in the introduction of an image as of late. Image enhancement is utilized to improve the nature of an image for visual impression of people. It is likewise utilized for low dimension vision applications. It is an assignment where the arrangement of pixel estimations of one image is changed to another arrangement of pixel esteems with the goal that the new image framed is outwardly satisfying and is additionally progressively reasonable for examination.

The technique for color differentiate enhancement works in xy-chromaticity outline, which comprises of two stages: (I) change of each color pixel into its maximally soaked variant as for a specific color array and (ii) desaturation of this new color toward another white point.

2) Normalizing the RGB Values

By and large, a pixel in a color image has a color vector with three segments R, G, and B and the color images are put away and saw utilizing RGB color space. The procedure of an image enhancement in any of the previously mentioned spaces (i.e., CMY, and so on.), the image should be changed to that space. The changes associated with changing the color image from RGB space to other referenced spaces and again the converse arrange change must be actualized for showing the images. Accordingly, the supposition is made as pursue: the image is changed from the RGB to the CMY, the image brilliance or immersion is handled, and its shade is kept up so as to decrease the color mutilation, to be specific, color reclamation. R, G, and B components of a pixel of an image are denoted by a vector $\tilde{x}$, where, $\tilde{x}=(x_1, x_2, x_3)$, x_1, x_2, x_3 , correspond to the normalized red, green and blue pixel values respectively. That is $0 \le x_k \le 1$, k=1,2, 3.

Scaling: Scaling the vector $\tilde{x}$ to $\tilde{x}'$ by a factor α>0 is defined as $\tilde{x}' = (x_1.\alpha, x_2.\alpha, x_3.\alpha)$

Shifting: Shifting a vector $\tilde{x}$ to $\tilde{x}'$ by a factor β is defined as $(x_1+\beta, x_2+\beta, x_3+\beta)$

A transformation which is a combination of scaling and shifting can be written as $\tilde{x}' = (\alpha x_1+\beta, \alpha x_2+\beta, \alpha x_3+\beta)$

Note that in (1),x'_k is linear in x_k for α and β , and are not dependent upon $\tilde{x}$. A general transformation in which α and β vary with $\tilde{x}$ each but same for k=1, 2, 3, is defined as

$$X'_k = \alpha(\tilde{x})x_k + \beta(\tilde{x}), \quad k=1,2,3$$

3) Including S-Type Enhancement Function

S-type enhancement method is for the most part and broadly utilized contrast enhancement strategy for dim scale images. The approaches of S-type enhancement techniques can be found in the literature. For the most part the dim scale contrast enhancement techniques is utilized to improve the power of the shading picture and they are tint protecting. Tone is that property of a shading which characterizes what sort of shading it is, i.e., a yellow or a green. The fundamental goal is to keep the changed qualities inside the scope of the RGB space, i.e., the changes ought to be free from range issue. But the S-type enhancement method, some various techniques are likewise use for contrast enhancement of dark scale images like as piecewise linear stretching, cutting and so forth. Just S-type change is recorded underneath for dark scale images.

Taking the equation in consideration: $x'_k = \alpha(x_k)x_k + \beta(x_k)$, for $\tilde{x} \in I$, k=1,2,3,

This change is a most summed up change, where α and β can be any two capacities. Investigating the expanding multifaceted nature of the issue, the moving capacity $\beta(x_k)$, is taken to be zero for k=1,2,3 and x ∈ I to streamlines the mappings.

4) Enhancing the Color Level Linearly

Finally, the picture is recuperated by improve the color level linearity and this is conceivable by contrast enhancement of dim scale images by playing out a similar task on the RGB plane changes the tint of the pixel estimations of the picture. This upgrades the picture without influencing the tone of the pixels. In any case, over enhancement of specific pixels prompts array issue when the picture is changed back to RGB plane. So by utilizing the above technique, we can stay away from this issue. For example, S-type transformation is listed earlier in this section.

In the present case we can take $\delta_1 = 0$ and $\delta_2 = 3$ i.e., $l\tilde{x}$, $f(l\tilde{x}) \in [0,3]$. As $\alpha(l\tilde{x})$ is a ratio of $f(l\tilde{x})$ and $l\tilde{x}$, when $f(l\tilde{x}) > l\tilde{x}$, value of $\alpha(l\tilde{x})$ will be greater than 1.

In such a case value of x'_k may exceed 1 and thus resulting in gamut problem.So a possible solution to this is to transform the color vector to CMY space and process it there. This will be dealt with in two separate cases.

Case 1) $\alpha(l\tilde{x}) \le 1$, where $l\tilde{x} = (x_1 + x_2 + x_3)$.
$x'_k = \alpha(l_{x'})x_k$, for k=1,2,3

Case 2) $\alpha(l\tilde{x}) > 1$

1) Transform the RGB color vector $\tilde{x}$ to CMY color vector $\tilde{y}$ by $\tilde{y} = (y_1 + y_2 + y_3)$ where $y_k = 1 - x_k$, k=1, , 2, 3.
2) Find $l\tilde{y} = (y_1 + y_2 + y_3) = 3 - l\tilde{x}$,
3) Find $g(l\tilde{y}) = 3 - f(l\tilde{x})$, $\alpha(l\tilde{y}) = g(l\tilde{y}) / (l\tilde{y})$,
4) $y'_k = \alpha(l\tilde{y})\, y_k$ for k=1,2,3,
5) Back to RGB space by the transformation- $\tilde{x}' = (1-y'_1, 1-y'_2, 1-y'_3)$

A color image enhancement principle has been stated above.

D. Proposed Technique (using Partial differential equation)

The whole process of image enhancement by using fourth order partial differential equation (PDE) can be described as with the help of following steps. It consists of 7 key steps:

(1) Laplacian of the image function ($u^n_{i,j}$) (2) Numerate the value of $g(\nabla^2 u)$ (3) Calculation of $\nabla^2 g^n_{i,j}$ (4) Find the $u^{n+1}_{i,j}$ (5) Normalizing the value of RGB color vector (6) Perform the transform by S-type transform (7) Enhance the color level linearly

In the first step numerate the Laplacian of the image function ($u^n_{i,j}$) as,

$$\nabla^2 u^n_{i,j} = (u^n_{i+1,j} + u^n_{i-1,j} + u^n_{i,j+1} + u^n_{i,j-1} - 4u^n_{i,j}) / h$$

with symmetric boundary conditions. Where $\nabla^2 u$ is the Laplacian of the image u, h is space grid size and n=1, 2, 3 .... Since the Laplacian of an image at a pixel is zero if the image is planar in its neighbourhood.

In second step calculate the image intensity function of laplacian of image as:

$$g(\nabla^2 u) = f'(|\nabla^2 u|)\,[\nabla^2 u / (|\nabla^2 u|)] = c(|\nabla^2 u|)\,\nabla^2 u \text{ and } g^n_{i,j} = g(\nabla^2 u^n_{i,j})$$

Where g is the image intensity function, f ′ is function of laplacian of an image and c is the diffusion coefficient.

In the third step taking the Laplacian of image intensity function ($g^n_{i,j}$)

$$\nabla^2 g^n_{i,j} = (g^n_{i+1,j} + g^n_{i-1,j} + g^n_{i,j+1} + g^n_{i,j-1} - 4g^n_{i,j}) / h^2$$

with symmetric boundary conditions

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$g^{n}_{-i,j} = g^{n}_{0,j}$, $g^{n}_{I+1,j} = g^{n}_{I,j}$, $j = 0, 1, 2, 3, \ldots\ldots J$
$g^{n}_{i,-1} = g^{n}_{i,0}$, $g^{n}_{i,J+1} = g^{n}_{i,j}$, $i = 0, 1, 2, 3, \ldots\ldots I$

The Fourth step is to Numerate the factor as:-Now Numerate the: $u^{n+1}_{i,j}$

$$u^{n+1}_{i,j} = u^{n}_{i,j} - \Delta t\, \nabla^2 g^{n}_{i,j}$$

In the Fifth step,we are normalizing the RGB color space value,

$$\tilde{x}' = (\alpha\, x_1+\beta,\ \alpha\, x_2+\beta,\ \alpha\, x_3+\beta)$$

Where $\tilde{x}'$ represent a transformation which is combination of scaling and shifting of an image, α is a scaling factor and β is a shifting factor.

The Sixth Step is to Perform the transform in the RGB color space by using S-type enhancement. A generalized transformation changing $\tilde{x}$ to $\tilde{x}'$ is given as,

$$x'_k = \alpha\,(x_k)x_k + \beta(x_k),\ \text{for}\ \tilde{x} \in u,\ k=1,2,3$$

where x_k is define the value of pixels, k = 1,2,3 for red, green and blue respectively. If taking the shifting function $\beta\,(x_k)$ to be zero, the transform would be-

$$x'_k = \alpha\,(x_k)x_k\ ,\ \text{for}\ \tilde{x} \in I,\ k=1,$$

The Seventh Step is to Enhance the color level linearly:

In the above equation, modifies the three components of the color vector by three different scales. This condition leads to change in hue of the color vector, which is against our aim. So a possible solution to this is to transform the color vector to CMY space and process it there. This will be dealt with in two separate cases.

Case I) $\alpha\,(l\tilde{x}) \leq 1$, where $l\tilde{x} = (x_1+ x_2+ x_3)$.

$x'_k = \alpha\,(l_{x'})x_k$, for k=1,2,3

Case II) $\alpha\,(l\tilde{x}) > 1$

i) Transform the RGB color vector $\tilde{x}$ to CMY color vector $\tilde{y}$ by $\tilde{y} = (y_1+ y_2+ y_3)$ where $y_k = 1-x_k$, k=1, , 2, 3.

ii) Find $l\tilde{y} = (y_1+ y_2+ y_3) = 3- l\tilde{x}$.

iii) Find $g(l\tilde{y}) = 3-f(l\tilde{x})$, $\alpha(l\tilde{y}) = g(l\tilde{y}) / (l\tilde{y})$.

iv) $y'_k = \alpha(l\tilde{y})\, y_k$ for k=1,2,3.

v) Back to RGB space by the transformation-

$\tilde{x}' = (1-y'_1,\ 1-y'_2,\ 1-y'_3)$

This will result into an enhanced level of image. The image will be more pleasant and with lower noise level.

2. Conclusion and Outcome

This Research paper evaluates the performance of the new method "A Novel approach towards enhancement of Image using fourth order Partial Differential Equation". The results obtained from the proposed methods have been compared with the results obtained from the enhancement techniques proposed by Mukherjee and Murtaza. Then on the basis of result it can be say that the proposed method has a better performance in contrast enhancement and peak signal to noise ratio (PSNR) with both Mukherjee and Murtaza method. Figure shows the comparing between the enhanced image and original image. After comparison, it is shown that the detail information of enhance image is more accurate and resolving power is increased in the modified image. The test set for this evaluation experiment randomly selected from the internet with 256*256 and 512*512 sizes. Matlab 7.0 software platform is use to perform the experiment. Enhancement has been tested with excellent performance with wide variety of set of images, so that it can say that the proposed method has a strong and impressive approach to images enhancement in normal and noisy environment.

Table 1
Comparison of performance of the proposed method for enhancement with various existing method

Images	PSNR		
	Proposed Method	Mukherjee Method	Murtaza Method
Lena noisy	13.41	13.16	3.27
Shop noisy	16.10	13.14	5.78
Girl	18.63	15.32	6.83
Watch	17.90	14.20	7.43

Table 1 show the comparison of performance of my proposed method for enhancement with various existing method (Mukherjee and Murtaza where my proposed method has a better performance in contrast enhancement and peak signal to noise ratio (PSNR).

A. *Some Experimented Image Results are shown below*

(c) (d)

Fig. 2. Lena noisy Image (a) Original image (b)Enhanced from Mukherjee method (c) Enhanced from Murtaza method (d) Enhanced from Proposed method.

(a) (b)

Fig. 3. Shop noisy Image (a) Original image and Enhanced from Mukherjee method (b) Enhanced from Murtaza method vs Enhanced from Proposed method.

Hence, Color image enrichment with noise extraction is performed using this proposed method. This method makes use of different intensity information from normal and noisy images; therefore, the performance of the proposed method is better than that of existing color enhancement algorithms. The proposed method in this research paper represents an image enhancement processes which was done by an image filtering process and enhancement process. From the results, filtering with the fourth order Partial differential equation and enhancement parameter performed the most accurate result of all the processes. This is proved by the peak signal to noise ratio value which is considered a great amount of value. Different experiments are conducted to evaluate and compare the performance of this new proposed algorithm and other methods, and Experiments shows that my method obtains better enhancement result, and it is effective for color image enhancement in normal and noisy environment. Experimental results tested from a large data set have demonstrated that the proposed method is effective and practical. Parameters like PSNR are analyzed for both existing and proposed method to determine the success and limitation of this approach.

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