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An Improved Genetic Algorithm Based Weight Optimized RBF Kernel System for Face Recognition

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***Abstract*— Face recognition system is one of many biometric authentication systems which are used for authentication purpose. It provides an effective way for authentication with varied security features. Management of high dimension data is problem which arrives frequently in face recognition. In this paper a new method is proposed for biometric authentication based face recognition which is general and efficient approach using radial basis function (RBF) kernel to manage small training sets of high dimension. In order to avoid over fitting and reduce the computational complexity, face features are first extracted by the singular value decomposition (SVD) method. After that resulting features were further processed by the Fisher's linear discriminate (FLD) technique to acquire lower-dimensional discriminate features. Data mining techniques have been widely used in intruder detection decision support systems to obtain good accuracy. A fast learning genetic algorithm (GA) is used to train the RBF kernels so that the aspects of the search space are significantly reduced. Results will be obtained after conducting simulations on ORL database, which are more precise in classification and learning efficiency.**

Index Terms*— *RBF Kernels; Face Recognition System; Optimization; Genetic Algorithm.

I. Introduction

A biometric authentication system may be a laptop application for mechanically characteristic or confirming an individual from a digital image. Face Recognition occupies a colossal place in biometric based security systems. We conducted a thorough survey on various face recognition techniques and encountered that feature selection might be a major concern in face recognition system. There are many techniques to extract features from face image is available. In some advanced ways it may be extracted quicker than others in a very single scan through the raw image and belongs to a lower dimensional area, however still retentive facial data expeditiously. The ways that area unit want to extract options area unit strong to low-resolution face pictures. The planned technique might be a trainable system for choosing face options. Recognition algorithms might be divided into 2 main approaches; geometric (appearance at characteristic options) or menstruation (applied math approach that distills a picture into values and compare it with templates to remove variances). Many traditional face recognition algorithms are Principal Part Analysis, Linear Discriminate Analysis, Elastic Bunch Graph Matching, Fisher face algorithmic rule and Multiline mathematical space learning victimization tensor illustration etc.

Major advantage of face recognition to use as biometric recognizer is that it doesn't need the cooperation of the check subject to figure. Properly designed systems can be put at airports, multiplexes, and different public places for authentication and security purpose. On these places we cannot perform authentication by using traditional biometric techniques like speech recognition, fingerprint, scans and iris. However, some queries are raised on the effectiveness of biometric authentication system in some cases of railway and airport security, but most of the time it is very effective on these places.

Face recognition is employed for two principal tasks:

1. Verification (one to one matching): Whenever any person claim for his identity like driving license, passport, pan-card, voter id, employee id etc; verification is required. A good face recognition system fulfills this task.
2. Identification (one to many matching): Whenever a picture of unknown person is given and asked for information about that person who is in picture; then face recognition system plays very important role to fulfill this task.

There are many application areas available where face recognition may be used for these two functions. Some of them are discussed as:

- Security (access management to buildings, airports/seaports, ATM machines, border checkpoints

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email authentication and computer/ network security on multimedia system workstations).

- Police work (a considerable amount of CCTVs may be monitored to appear for illustrious criminals, drug offenders etc. Authorities may be notified once when suspect is located. For example this system was deployed at air-port entry when Super Bowl 2001 game conducted in Florida; in another instance, in another instance at palm Gymnasium in Phoenix, Arizona; two linked cameras with state and national databases of missing kids, alleged abductors and sex offenders are installed recently).
- General identification (electoral registration, banking, distinguishing newborns, electronic commerce, national IDs, passports, drivers' licenses, worker IDs etc).
- Criminal justice systems (post-event analysis, mug-shot/booking systems and forensics).
- Image information investigations (searching image databases of commissioned drivers, missing kids, profit recipients, police bookings and immigrants).
- "Smart Card" applications (instead of maintaining a database of facial pictures, the face-print may be keep in a positive identification, Universal Product Code or tape, authentication of it is performed by matching the present live image and also keep the template).
- Multi-media environments with adaptive human computer interfaces (part of present or context aware systems, behavior watching at child care or old people's centers, recognizing a client and assessing his needs).
- Video categorization (labeling faces in video).
- Witnesses face reconstruction.

In addition to these applications, face recognition techniques are modified and used for various connected applications like facial feature recognition, expression recognition and gender classification etc. Each of them has its utility in varied domains: for example, expression recognition may be utilized in the field of drugs for intensive care, facial feature recognition. This approach may be used to chase a vehicle driver, by recognizing his eyes and fatigue. It is also applied for stress detection.

Face recognition is additionally being employed in conjunction with other life science like speech, iris and fingerprint recognition to boost the popularity and performance of biometric authentication [15].

This paper is split into five varied sections. Section II gave brief explanation regarding the work. In section III, we gave details of the planned methodology and provided proposed model with mathematical explanation. To summarize the methodology a flow sheet is enclosed at the tip of this section. In section IV we discussed the expected outcomes planned during this work. Finally in section V we consolidated the work with future research direction.

II. RELATED WORK

Face recognition is natural, nonintrusive, and straight forward to use. Face recognition system addresses two key problems first feature extraction and reduction; and second classification. Several sure-fire face detection and extraction paradigms are developed by R. Brunelli et al [3]. Singular value decomposition (SVD) of a matrix was adapted to extract options from the patterns. It has been illustrated that singular values of a picture are stable and represent the pure mathematical attributes of it. The key plan is to calculate the simplest arrangement for compression. In this process each coordinate value (pixel) is referred to as associate degree Eigen picture.

Face recognition system can be categorized in two categories. First is primarily based image model and second is pure mathematical feature based model. In primarily based image model Robert J. et al (Robert J, 1981) discussed the correlation between different parameters of face image. and one or additional model of face image templates to estimate the face image identity from the info. Brunelli et al (R. Brunelli, 1993) recommend the optimum strategy for face recognition system that has close similarity to model matching. Different mathematical tools like Support Vector Machines (SVM) (E. Osuna, 1997), (Vladimir N, 1995) Freelance Element Analysis, Principal Element Analysis (PCA) (L. Sirovich, 1987), (Matthew Turki, 1991), Linear Discriminant Analysis (LDA) (Peter N. Belhumeur et.al, 1997), Kernel Strategies (Bernhard Scholkopf et.al, 1998), (M. H. Yang, 2002), and Neural Networks (A. Jonathan, 1995), (Steve Lawrence, 1998), (T. Poggio, 1994) are accustomed to construct an acceptable face recognition system.

Instead of applied mathematical theory, neural network based feature extraction strategies are used in recent works [9]–[12]. The main purpose of face dispensation using neural networks is to provide a compact inner illustration of faces; it is same as feature extraction. Hence the quantity of hidden neurons is less than to neurons at input or output layer. This less quantity of neurons provide smaller dimension of feature but it have all the desired information. Then, the hidden layers of the neural network can work as the input layer of another neural network model to classify face images.

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Neural Network based methods have learning capabilities; it is the greatest advantage of them. Many researchers have deployed Neural Network based approach for face recognition with statistical and structural approach. It has been proven that classification using neural network provide better results [S.H. Lin, 1997]. Many Artificial Neural Network models were used extensively in face recognition system. Many times it is used in combination with other methods as discussed earlier in this paper. Artificial Neural Network work same in the way as neurons work in the human brain. This capability enables ANN to play important role in face recognition system. Various combinations of different recognition rates and mean square error (MSE) were used by many researches in their work. Hence it is very important to find best ANN model and its different combinations with varied methods to get better recognition results.

The intention of this investigation is to develop an effective face recognition system based on four different ANN models:

1. Feed Forward Backpropagation Neural Network (FFBPNN),
2. Cascade Forward Backpropagation Neural Network (CFBPNN),
3. Function Fitting (FitNet), and
4. Pattern Recognition (PatternNet).

These models were designed separately by using seven layers, where one input, five hidden and one output layer is deployed. All the models were trained independently with six varied training algorithms. In general multilayered networks (MLNs) i.e. typically joined with the Back Propagation (BP) algorithms are most commonly used in face recognition system. However, two main problems are commonly raised adjacent to the Back Propagation algorithm:

1. It is computationally rigorous due to its slow convergence speed and;
2. There is no assurance that the supreme minima can be achieved.

In current scenario RBF neural networks have recently concerned great attention in the community of neural networks for large variety of applications [17]–[29]. Broomhead and Lowe first formulated RBFN in a 1988 for royal signals and radar establishment. The following is the basic equation of an RBF kernel and used for classification in proposed work.

$$\boldsymbol{\varphi(x) = \sum_{i=1}^{N} a_i p(|x - c|)}$$

The prominent qualities of RBF neural networks are given as:

- They are collective approximates [17].
- They have the simplest estimation quality [18].
- Their learning speed is high due to locally tuned neurons [19].
- They require supplementary compact topology than other neural networks [20].

When RBF neural networks are imposed in face recognition system, it possesses the succeeding characteristics:

- Higher dimensions. For example a (128X128) image can have 16384 options.
- Small sample sets. The sample patterns are very less for each category. It is stricter than the case shown in [16].

Thus the face recognition is totally distinct process from traditional pattern recognition system. There some advantages of face recognition system are listed to use it as biometric signature for authentication purposes:

1. Low resolution imaging
2. Stable options
3. Low meddlesomeness
4. Low detail loss
5. High acceptance quantitative relation

All the above advantages are considered in an authentication system [5], which uses unique features of face as a signature for authentication. On the basis of matching results this system allows or bar users to access the resources which are only accessible to authenticate persons. An authenticate person is one whose phase is successfully matched with available database. This system uses SVD (singular value decomposition technique) approach for feature extraction and radial basis function neural networks for classification. This system has an additional advantage i.e. it is capable of self-learning. Whenever system is used for authentication purposes it provides a feedback to master database about the user. This feedback has information that the tested face is authentic or a fraud user.

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A. G. Bors and I. Pitas [26] proposed a system which uses back propagation algorithmic rule for learning and training the neural network. This system has two major drawbacks with back propagation algorithmic rule.

1. A blind process is followed for initialization of the NN weights. Therefore it is very difficult to get globally optimized initial weights.
2. It is also possible that the network output might be run towards local optima; so the overall tendency of the network to find out a global solution is greatly affected.

This situation of local optimum solution can be overcome by optimizing the initial weights of neural network. Genetic Algorithm (GA) may be used for optimizing the initial weights which is required for global searching.

In a genetic algorithm uses phenotypes (a population of candidate solutions) for optimizing the problem. All candidate solutions have a set of properties which is its chromosomes or genotype. It can be mutated and altered for better solutions. A typical genetic algorithm requires:

- Genetic representation of the solution domain and
- A well defined fitness function to estimate the solution domain.

A detailed summary for related work is illustrated in pictorial manner in figure 1.

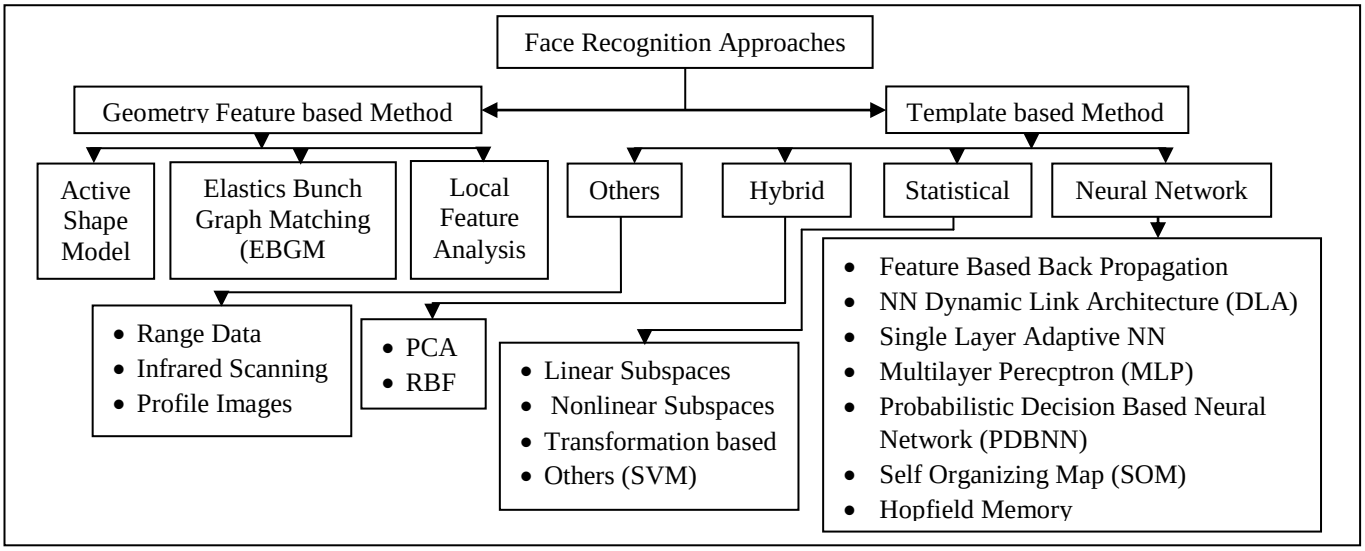

Fig. 1 Face Recognition Approaches at a glance

III. PROPOSED SOLUTION

In our proposed work entire system of face recognition is divided into six steps. It starts from acquisition of face image and end with final feedback to the database. These Steps are illustrated in figure 2 and explained as:

A. Face Image Acquisition:

A face image refers to a picture or image that is non inheritable to the face region of the body for the subject. It may be either a web image (i.e. taken by a scanner, or CCD) or offline image. CCD stands for a charged coupled device. Image of any subject is captured in different orientations that higher training and learning capability can be developed in our model.

B. Database Creation and Sorting:

Face images is given as input to database for its creation. The basic requirement for its creation contains, the image should be in its logical structure, and then sorting and storing technique can be applied on it. As per the users order preference, alphabetic are kept at very initial and least level of preference.

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C. Data Compression and Grayscale storing:

When compression algorithm applied on data, it is purely stored in CCD device as a form of gravy scale image. This means that the information has to move through a process that contains (a) segmentation and compression of data by the hardware. It is done so as we known the initial step is pre-processing technique where algorithm applied on the basis of biometric characteristic of the face image those results in false recognition in Print. (b) The original image is kept in gray scale with all its intensity value as to check the match of colored image intensity with gray scale intensity when filtering is applied .The property of spatial resolution continuously enhancing, when the image is stored in gray scale.

D. The Feature extraction from the face image and Threshold Detection:

Over the past decades, palm image compression, illustration and recognition has drawn wide attention from researchers in areas of computer vision, neural network, pattern recognition, machine learning, and so on. the applying of face recognition includes: Access management supported the face recognition, computer human interaction, information Security, enforcement, good automotive etc. once a picture is SVD remodeled, it's not compressed, however the data take a kind during which the primary singular price features a great deal of the image information. With this, we will use solely many singular values to represent the image with very little variations from the initial.

To illustrate the SVD compression method, detail procedures are:

$$A = \sum_{i=1}^{r} USV = \sigma_1 u_1 v1^T + \sigma_2 u_2 v2^T + \cdots .. + \sigma_r u_r vr^T \quad (1)$$

SVD or Eigen decomposition approach treats a collection of famous faces as vectors in a mathematical space, referred to as "Eigen face space", spanned by a tiny low cluster of "base faces". It's like Principal element Analysis (PCA) recognition is performed by sticking out a brand new image onto the palms house, then classifying the palms by scrutiny its coordinates (position) in face house with the coordinates (positions) of famous faces. However, the SVD approach has higher numerical properties than PCA.

In this case, we have a tendency to redefine the matrix A (equation (1)) as set of the coaching faces. Assume every palm image has m × n = M pixels, associated is delineated as an M × one column vector fi, a 'training set' S with N, variety of palm pictures of famous individual's forms associate M × N matrix:

$$S = [f_1 f_2 f_3 f_4 \ldots \ldots f_N] \quad (2)$$

The mean image $\bar{f}$ of set S (equation (2)), is given by $\frac{1}{N}\sum_{i=1}^{N} f_i$ Subtracting f from the initial faces provides a_i=f_i-$\bar{f}$ …..i=1, 2…N this forms another M x N matrix A:

$$A = [a_1 a_2 a_3 \ldots \ldots . a_N]$$

Since kind associate ortho normal basis for R (A), the vary (column) mathematical space of matrix A. Since matrix A is made from a coaching set S with N face pictures, R(A) is termed a 'face subspace' within the 'image space' of m × n pixels, and every u_i, i = 1, 2, ..., r , will be referred to as a 'base palms'.

Let x = [x1 x2…….xr] T be the coordinates (position) of any m × face image f within the face mathematical space. Then it's the scalar projection of f - $\bar{f}$ onto the base faces:

$$x = [u1\ u2\ u3 \ldots \ldots ur]\ T\ (f - \bar{f}) \quad (3)$$

This coordinate vector x is employed to seek out that of the coaching faces best describes the face f. that's to seek out some coaching face fi, i= 1, 2, ..., N , that minimizes the distance:

$$\in_i = ||x - x_i||_2 = [(x - x_i)^T (x - x_i)]^{1/2}$$

Where xi is that the coordinate vector of fi, that is that the scalar projection of f - fi onto the bottom faces:

$$xi = [u1\ u2 \ldots . ur]^T$$

A palm f is assessed as face fi once the minimum ∈_i is a smaller amount than some redefined threshold. Otherwise the face is assessed as "unknown face". If f isn't face, its distance to the face mathematical space is going to be bigger than zero. Since the vector projection of f - f onto the palm house is given by equation (3).

$$fp = [u1\ u2 \ldots . ur]x \quad (4)$$

The distance of, f to the palm house is that the distance between $f - \bar{f}$ and the projection f_p onto the face space:

$$\in_f = [(f - \bar{f} - f_p)^T (f - \bar{f} - f_p)]^{1/2} \quad (5)$$

If $\in_f$ is bigger than some predefined threshold ∈_1, then f isn't a face image.

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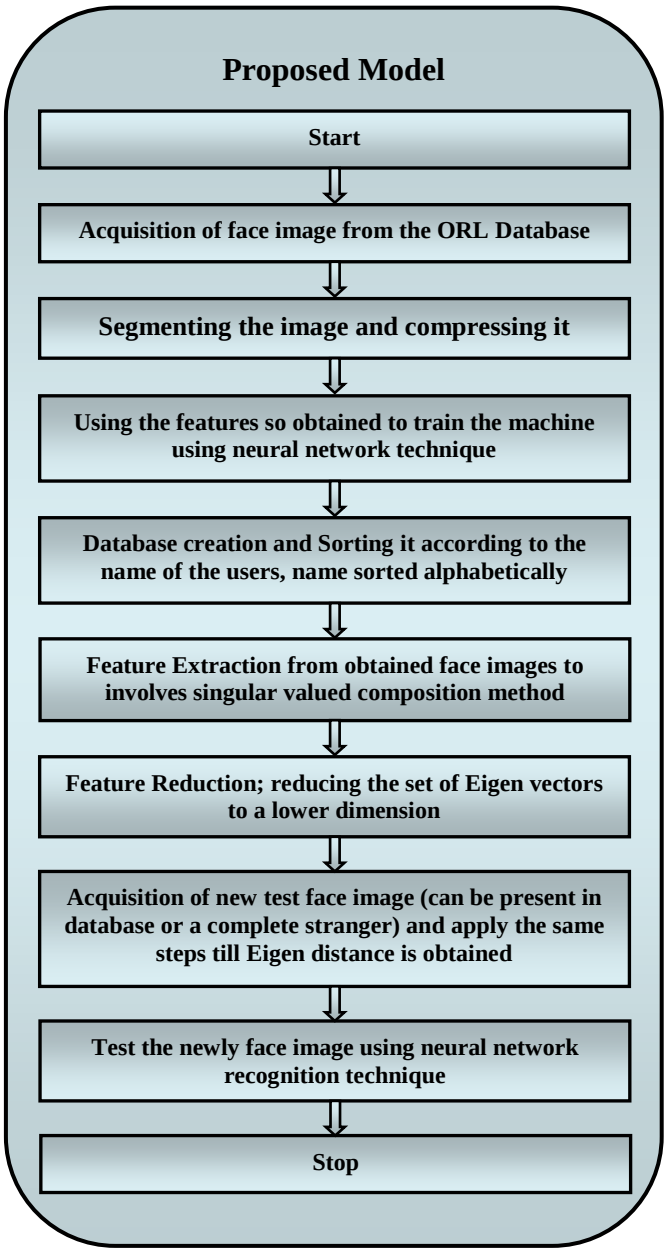

Fig. 2: Proposed Mode

E. Neural Network Training and Recognition:

Radial basis function (RBF) networks usually have 3 layers as illustrated in figure 3. First of them is input layer, second hidden layer having a non-linear RBF activation function and third linear output layer. The input will be sculptured as a vector of real numbers where $x \in \mathbb{R}^n$. The output of the network is scalar function of the input vector, $\varphi: \mathbb{R}^n \to \mathbb{R}$ and is given by:

$$\varphi(x) = \sum_{i=1}^{N} a_i \rho(||x - c_i||)$$

Where,
N is the variety of neurons within the hidden layer;
c_i is the middle vector for neuron i ; and
a_i is the weight of neuron i within the linear output nerve cell.

Functions that rely solely on the space from middle vector area unit radically symmetrical that vector, hence the name radial basis perform. Within the basic kind all inputs area unit connected to every hidden nerve cell. The norm is often taken to be the Euclidian distance (although the Mahalanob is distance seems to perform higher in general) and also the radial basis performs is repeatedly taken to be Gaussian:

$$\rho(||x - c_i||) = \exp[(-\beta\, ||x - c_i||)^2]$$

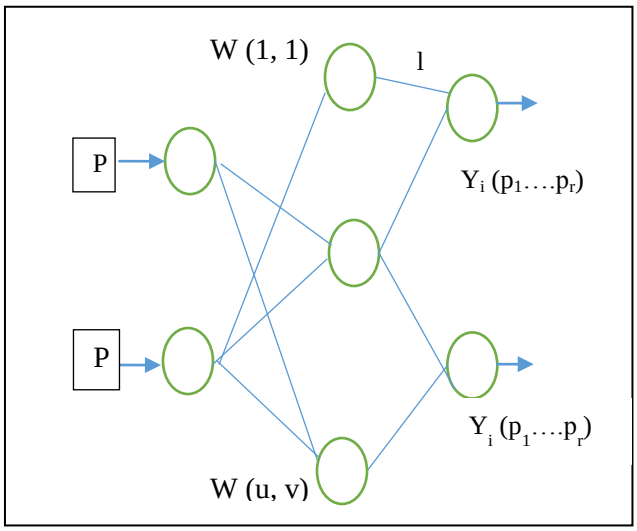

Fig. 3: RBF Neural Network

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The Gaussian bases perform area is unit native to the middle vector within the sense that:

$$\lim_{||x||\to\infty} \rho(||x - c_i||) = 0$$

i.e. dynamical parameters of 1 neuron has solely a little impact for input values that area unit far-off from the middle of that nerve cell.

Given bound delicate conditions on the form of the activation perform RBF networks area unit universal approximates on a compact set of R^n [4]. This implies that associate in nursing RBF network with enough hidden neurons will approximate any continuous perform with impulsive exactness.

The parameters, a_i, c_i, and β_i are determined in an exceedingly manner that optimizes the match between φ and also the information. The parameters, a_i, c_i, and β_i are determined in a manner that optimizes the fit between φ and the data.

IV. CONCLUSION

In this paper, we introduced a new concept for effective face recognition system. Management of high dimension data is well known problem which arrives frequently in face recognition. Therefore to overcome it we applied a radial basis function (RBF) kernel to manage small training sets of high dimension image data. We deployed singular value decomposition (SVD) method for feature extraction in order to avoid over fitting and reduce the computational complexity. Then, the resulting features are further processed by the Fisher's linear discriminate (FLD) technique to acquire lower-dimensional discriminate features. Finally data mining techniques have been applied to obtain good accuracy. To train the RBF kernels a fast learning algorithm can be used. After evaluating different mathematical expressions, it is expected that proposed method will provide better results. In our future work we will conduct all the experiments to support this concept and deploy it for real time applications.

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