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Face Recognition Using a Coarse-to-Fine Level Set Scheme

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Abstract: This study inscribes a new approach for determining face-recognition system's accuracy using a novel coarse-to-fine level set scheme. Recognizing a face in a facial database by using segmentation is a trivial challenge for many researchers. To distinguish facial photographic images from a background, the discrete wavelet transform is utilized to extract facial images. Novel energy function model is used for solving a contour extraction problem. In order to segment images, coarse-to-fine level set scheme is implemented. Finally face recognition process is done by face detection through the segmented images and matches the face with their same photograph, which is avail in the database. Extensive experiments have been carried out on capturing a facial photograph dynamically to validate the proposed method.

Keywords: Coarse-to-fine level set scheme, face detection, face recognition, wavelet transform

INTRODUCTION

A face-recognition system is a computer application for automatically identifying or verifying a person from a digital image or a video frame from a video source (Wang, 2010). One of the ways is performed by comparing selected features from the image and a database (Bonsor, 2006; Johnson, 2008). Face recognition is the technique that allows people and computer systems to interpret and understand human faces. The face is an important part of an individual's self-image, a means of identification of human and plays a large role in social interactions, psychological processes and domestic security. Both biological scientists and computer scientists have an interest in face recognition capabilities. Many face recognition systems are performed by using Eigen faces; Laplacian faces and principal component analysis.

Vinaya (2006) and Mayank *et al*. (2010) has been proposed Eigen face approach. Eigen faces are a set of Eigen vectors which are used in the face recognition Principal component analysis is a mathematical procedure that uses an orthogonal transformation to convert a set of observations of possibly correlated variables into a set of values of uncorrelated variables called principal components. PCA is used to calculate a linear variation in high dimensional data. The number of principal components is less than or equal to the number of original variables. Laplacian faces are obtained by finding the optimal linear approximation to the Eigen function which is based on a face manifold. However in later, face can recognize through a webcam for identifying persons in public areas. Once the camera captures a facial photograph and the process starts, the system uses an analyzing algorithm to compare and match the image against a collection of the known faces in the database. Some sample frames are captured via web cam with 480×320 dimensions which are shown in Fig. 1.

Contour extraction is a challenging image segmentation problem in computer vision. Luis-Garcıacute *et al*. (2011), Law *et al*. (2008), Yui *et al*. (2006), Lucet (2009) and Bin (2010) has been proposed unified level set method for recognizing a face. Contour extraction problem is otherwise called as "boundary extraction problem." i.e., image is out of the boundary. This rises when an image is partitioned as multiple segments.

Face detection is a machinery system which actuates the locations and sizes of human faces in capricious images. It exposes facial characteristics through the Haar profile. Face detection is used in face processing applications such as recognizing the face, tracking the face, extracting the face features, etc. Face detection is used for detecting the face, whether the given image is faced or not.

Coarse-to-fine level set scheme is a segmentation process. It is a numeric technique which is implemented through the Euler Lagrange numeric equation for image segmentation. The advantage of coarse-to-fine level set scheme is to segment images perfectly and also used for avoiding the contour extraction problems. In general, Coarse-to-fine level set scheme is applicable in the brain tumor system, satellite images, ocean logy, etc., But it is also applied in recognizing a face.

Our proposed idea is to efficiently recognize a face through a coarse-to-fine level set scheme whose facial

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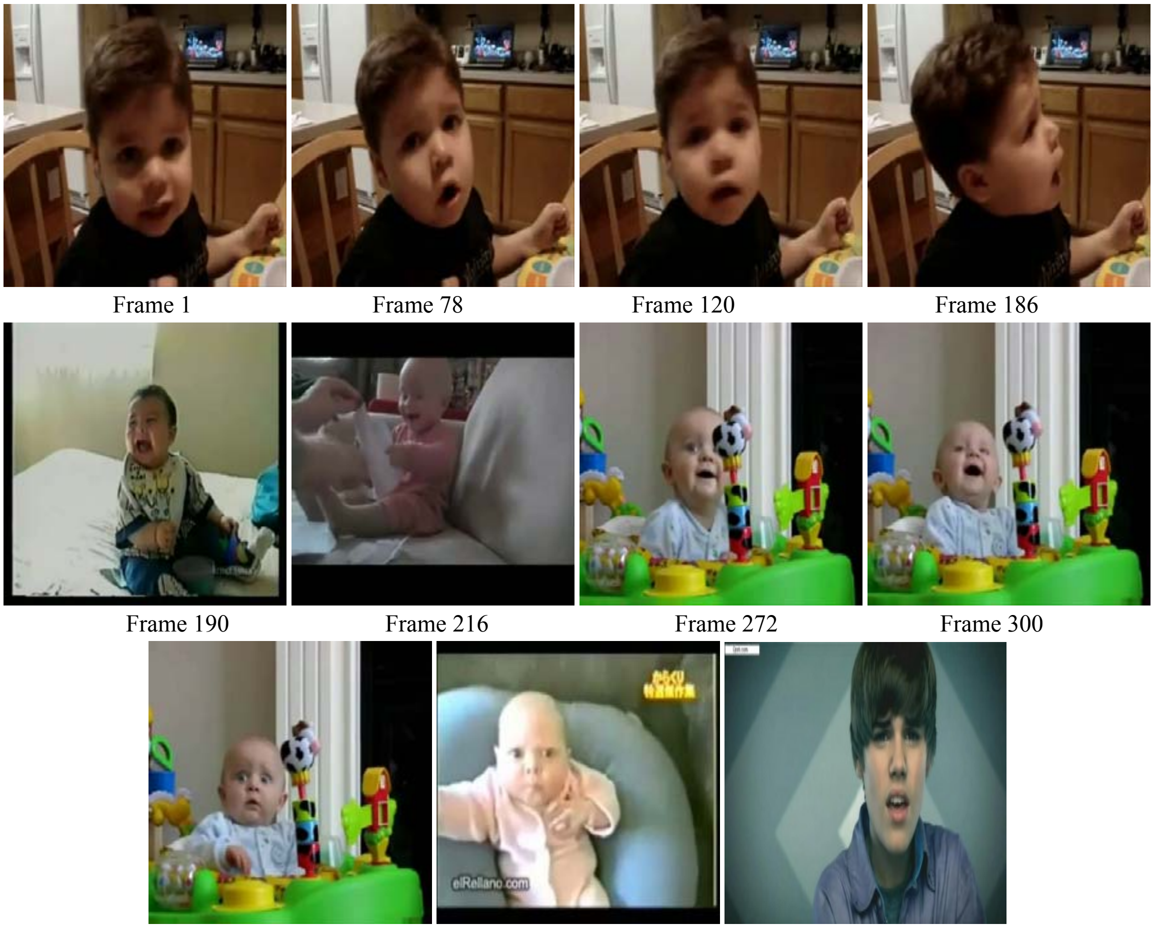


Frame 1 Frame 78 Frame 120 Frame 186

Frame 190 Frame 216 Frame 272 Frame 300

Frame 424 Frame 648 Adult image

(Not included in this video just for testing)

Fig. 1: Sample frames (480×320) getting from a webcam

photograph is captured dynamically via webcam. After capturing, intensity difference is calculated by using haar and/or Daubechies. Based on intensity difference, homogeneity metrical is validated. The homogeneity metric measures the variations of the faces between inside and outside contours. Based on the homogeneity metric, discriminative ability is also calculated. Weight distribution ratio is performed for tuning the relative weights of the images. The result of the homogeneity metric and the weight distribution ratio leads to novel energy function. Coarse-to-fine level set scheme is implemented through the Euler Lagrange equation for face segmentation. After segmentation is over, face is detected through the Haar profile. Finally, face recognition is done with the help of the detected face and matches their respective photograph, which is avail in a database. The purpose of this study is to improve the accuracy of the face recognition system.

LITRATURE REVIEW

Kshirsagar *et al*. (2011) have proposed an eigen face approach to recognize the face, but they met with many difficult challenges. He *et al*. (2005) has proposed a Laplacian approach in order to recognize the face which results in less accuracy. Xiang-Fei (2010) has proposed a bidirectional principal component analysis with wavelet transform approach in recognizing a face causes image decomposing a problem. The face can be recognized by the above methods cause a failure due to less accuracy. To improve the accuracy in recognizing the face, a coarse-to-fine level set scheme (2011) is proposed via face detection. The main contributions are as follows:

Face feature extraction: Starck *et al*. (2007) has proposed the undecimated wavelet transform for image decomposition. The face image is extracted from a background by using Undecimated Wavelet Transform (UWT). The undecimated wavelet transform is selected because it has a shift invariant property. Due to this property, it produces sub bands of the same size as the input image. These sub-bands are obtained by utilizing low-pass filter and high-pass filter. Low-pass filters are denoted by H0, H1 and High-pass filters are denoted by G0 and G1. These filters are used by scaling coefficients and wavelet coefficients of Haar and Daubechies wavelet. There are three types of Undecimated wavelet transform:

- Haar wavelet
- Daubechies wavelet
- Hough wavelet

Haar wavelet: Discrete signal is a function of time within the values occurring at discrete instants. In discrete form, Haar wavelets are related to a mathematical form called the Haar transform. Haar wavelet is used to calculate the intensity difference between face image and its background. Input is represented by a list of 2^n. Haar wavelet transform is considered to simply pair up input values, storing the differences and passing the sum. The result is in the difference of 2^n-1.

Haar wavelet coefficient is generated by calculating the averages and differences of the values in a pair. The coefficient of the Haar wavelet is shown in Table 1. The calculation is based on shifting two values. The Haar transform serves as a model for all other wavelet transforms. Like all wavelet transforms, Haar transforms decomposes a discrete signal into two sub signals of half its length. One sub signal represents the running average or trend; the other sub signal represents the running difference or fluctuation. The output of the Haar wavelet which are shown in Fig. 2.

Advantages:

- It is simple wavelet.
- Calculating intensity difference is fast. It increases the contrast of the image.
- Required memory in Haar wavelet is efficient.
- It performs a reversible process.
- It takes less time for decomposing process.
- It is suitable even to the large-size images.

Disadvantages:

- The high frequency coefficient can reflect their changes.

Table 1: Haar wavelet coefficient

H0	H1	G0	G1
0.5	1	1	0.5
0.5	-1	1	0.5

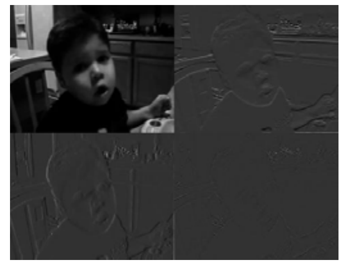


Fig. 2: Output of the haar wavelet

- If there is a change occurs between an even value and odd value; no reflection takes place in the high frequency coefficients.
- Haar wavelet is unsuitable to audio-demising.
- It can avoid by using Haar 2-tap wavelet.

Daubechies wavelet: Daubechies wavelets are a family of orthogonal wavelets defining a discrete wavelet transform and characterized by a maximal number of vanishing moments. Each wavelet has a number of zero moments or vanishing moments equal to half the number of coefficients. Scaling function of Daubechies is called father wavelets, which generates orthogonal multi-resolution analysis. Like haar, Daubechies wavelet transforms are also computed the running averages and differences via scalar products with scaling signals and wavelets. The coefficient of the Daubechies wavelet is shown in Table 2. The output of the Daubechies wavelet which is shown in Fig. 3.

Drawbacks:

- It is more complicated than haar wavelet.
- It is more expensive.
- It is unsuitable to the large-size images.
- It takes more time when compared with the Haar wavelet.
- Like Haar, the high frequency coefficient spectrum of Daubechies should reflect all high frequency coefficients.

Among these, Haar wavelet takes less time for decomposing images when comparing with the Daubechies wavelet. So, haar wavelet is selected for distinguishing images from a background.

Novel energy function: Homogeneity metrical is used to measure the intensity difference of the images between inside and outside contours. Homogeneity

Table 2: Daubechies wavelet coefficient

HO	HI	GO	GI
0.4830	0.1294	-0.1294	0.4830
0.8364	0.2241	0.2241	-0.8364
0.2241	-0.8364	0.8364	0.2241
-0.1294	0.4830	0.4830	0.1294

Fig. 3: Output of the daubechies wavelet

metrical's calculation is based on the intensity difference of the haar wavelet. The homogeneity metric of d^i in a region Ω_k(k = 0, 1, 2) is defined by:

$$E(d^i, \Omega_k) = \int (d^i(x,y) - d_k^i)^2 dxdy \quad (1)$$

The discriminative ability of d^i can be measured by:

$$\eta(d^i, c) = \frac{E_{i,0} + \varepsilon_0}{E_{i,1} + E_{i,2} + \varepsilon_0} \quad (2)$$

where, d^i_k is the mean value of d^i over region.

Distribution ratio is used to tune the relative weight of the features. Weight distribution ratio's calculation is based on the discriminative ability component.

$$\xi(d^i, c) = \frac{\eta(d^i, c)}{\sum_{j=1}^{4} \eta(d^j, c)} \quad (3)$$

The result of the homogeneity metric and weight distribution ratio are combined to form a model which is called as "Novel energy function." This function consists of energy set function.

Coarse-to-fine level set: The purpose of this level set is to reduce one resolution level at a time. It is used to produce a perfect segmentation. It consists of three sub modules. They are:

- Coarse scale contour extraction
- Fine scale contour extraction
- Euler Lagrange numeric solution

Coarse scale contour extraction: Coarse scale model is used for minimizing the energy set function. Energy function is obtained by summing the weighted components such as haar wavelet, homogeneity metric, discriminative ability component and weight distribution ratio. It is expressed by:

$$F_N = \mu \int |\nabla H\phi| dxdy + \sum \xi_{i,c} \int \left(d^i - d_1^{-i}\right)^2$$

$$H\phi dxdy + \sum_{i=1}^{4} \xi_{i,c} \int_{\Omega 0} \left(d^i - \overline{d_2^{-i}}\right)^2 (H_\phi) dxdy \quad (4)$$

Fine scale contour extraction: Contour position constraint is introduced for reducing the contour evolution space to a small region. It is measured by the space between a boundary of the face images. It is obtained by the following equation:

$$R_\alpha(x, y) = \exp\left(-\frac{d(x, y, \gamma_\alpha) - 1}{2}\right) \quad (5)$$

Euler Lagrange numerical solution: Euler Lagrange is used to reduce the energy set function from a coarse space to a fine space. It is implemented through the Eq. (3), (4) and (5) by introducing the artificial variable t to ϕ. It is defined by:

$$\frac{\partial \phi}{\partial t} = \delta(\phi) R_\alpha \left[\mu div\left(\frac{\nabla \phi}{|\nabla \phi|}\right) - \sum_{i=1}^{4}\left(\xi_{i,c}\left(d^i - \overline{d_1^i}\right)^2 - \xi_{i,c}\left(d^i - \overline{d^i{}_2}\right)^2\right)\right] \quad (6)$$

Finally, face images are segmented using Eq. (6). Euler Lagrange has one special property. It can convert 2D image into the 3D image. This property is based on the iterations.

Advantages of a Coarse-to-Fine level set scheme:

- It is used to solve the boundary extraction problems.
- This scheme is done with the less "N" number of iterations.
- Computer cost is low.

Face detection: Segmented face image is passed to the face detection process. This process is performed by using Haar profile. This profile consists of haar-like features for detecting faces and other body parts of the human. Generally, these features are represented with measurements. The variations of these measurements are based on the different features of the human body. Haar-like features are consolidated in an existence

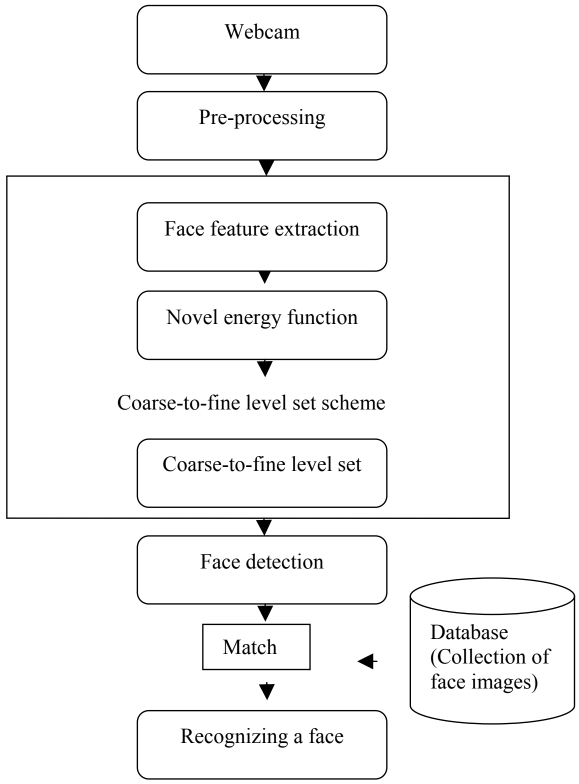


Fig. 4: Block diagram of the proposed face recognition system

called classifier cascade to form a strong learner. This classifier cascade is implemented via Haar classifier cascade in JJIL package. This cascade encodes a sequence of steps in detecting a face. It consists of low level feature detection and top level feature detection. At the lowest level, haar cascade consists of the rectangular shape image feature detectors which are integrated, multiplied by a coefficient and then aggregated together. This results in "Haar Weak Classifier Stump." The top level is implemented by "Haar Classifier Stump Base."It performs with a series of steps. Each step is passed with an association of feature detection operations that are aggregated to the image. If this aggregation is greater than a fixed threshold value, haar cascade is passed to the next step. If any step falls in a failure, then that image is judged as "not face." Otherwise it is said to be a face. After the face is detected, it should be checked whether a detected face is matched with the collection of the face images which are avail in the database.

INTERIOR ARCHITECTURE

This architecture demonstrates about how a coarse-to-fine level set scheme works for recognizing a face. This architecture's execution is carried out by the following steps. The block diagram of the interior Architecture is shown in Fig. 4.

This block diagram is executed by using proposed face recognition algorithm.

Algorithm:

Proposed face recognition algorithm: This algorithm consists of sequence of steps. They are as follows:

Step 1: Capturing images dynamically through the webcam or video.

Step 2: Preprocess the captured image.

Step 3: Distinguish image from a background by using Haar wavelet.

Step 4: Calculate homogeneity metric and a weight distribution ratio.

Step 5: Based on this novel energy function model is formed.

Step 6: Segment the images.

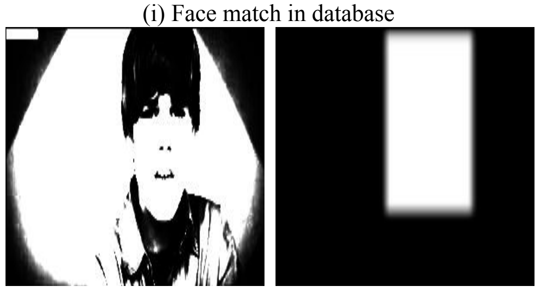
Step 7: Detect the face from the segmented image through a Haar profile.

Step 8: To recognize the face, detected face image is compared with the same facial photograph which is avail in the database.

Segmented image

Face is detected from a segmented image via haar profile

(i) Face match in database



segmented image

Face is detected from a segmented image via haar profile

(ii) Face match in database

Fig. 5: Output of the proposed face recognition system using coarse-to-fine level set scheme

Figure 5 shows that the face is recognized by using proposed face recognition algorithm.

Implementation: The proposed face recognition algorithm is completely implemented in java respectively. Performance analysis is done for face recognition. Face images are perfectly recognized where segmentation and face detection plays a vital role. Segmentation is done by passing the images as the input to the Euler Lagrange numerical solution. Euler Lagrange is mainly for segmenting 2D images and results in 3D images. Face can be detected from the segmented image via Haar profile to recognize the face which is avail in the database.

EXPERIMENTAL RESULTS

The result of the coarse-to-fine level set scheme is discussed in this section. Experiments are conducted on numerous people by capturing a video dynamically via webcam. Sample video takes place in this paper has a duration of 194 sec and 11.3 MB with 9216 kbps bit rate. It consists of 700 image frames with 480×320dimensions. Each frame is passed to the Haar filter for distinguishing images from a background. After coarse-to-fine level set scheme is applied for segmenting the images, face can be recognized from the segmented images. The overall process of the coarse-to-fine level set scheme is shown in images (i, ii). This figure indicates the result of the image segmentation with 10 iterations. Iterations can also be incremented for further perfect segmentation if necessary. The Fig. 5 represents the output of the proposed face recognition system. This system takes approximately 0.58 sec for matching the captured image with the facial photograph in the database. The result of this paper is achieving better performance by improving its accuracy in recognizing the face.

CONCLUSION

In this study, we have inscribed a new approach for recognizing the face in a facial database using a coarse-to-fine level set scheme. Weight distribution ratio is proposed to tune the relative weights of the face image features. Novel energy set function model is introduced at the level set for solving the contour extraction problems which causes in segmentation. In addition, the experimental results illustrate that the proposed idea is suitable for recognizing the face to improve its accuracy by matching the captured images with the collection of the known faces in the database. This method can perfectly recognize more than 650 images out of the 700 enrolled face images in the database. The success rate of the proposed face recognition system is approximately 93%. It also showed that the Haar wavelet is perfectly suited for distinguishing images from a background when comparing with the Daubechies wavelet. In future, we plan to recognize the face using EvoFit technology.

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