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Research Article

APPROACH FOR EMOTION RECOGNITION FROM FACIAL EXPRESSIONS

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ABSTRACT

The interaction between human beings and computers will be more natural if computers are able to perceive and respond to human non-verbal communication such as emotions. This paper recognizes human emotions based on facial expressions. This work is a primary step of an emotion detection system using which one specific emotion can be identified after extracting different facial features.

INTRODUCTION

There are many ways that humans can express their emotions. The most natural way to express emotions is using facial expressions. A human can express his/her emotion through lip and eye. A category of emotions which are universally accepted: sadness, angry, joy, fear, disgust and surprise without consider natural emotion. Several approaches have been proposed to classify human affective states. The features used are typically based on local spatial position or displacement of specific points and regions of the face. The basic process is shown in figure 1.

An image pyramid is calculated in order to detect faces at multiple scales. A fixed size sub-window is moved through each image in the pyramid. The content of a sub window is corrected for non-uniform lightning and subjected to histogram equalization. The processed content is fed to several parallel neural networks that carry out the actual face detection. The outputs are combined using logical AND, thus reducing the amount of false detections. In its first form this algorithm also only detects frontal upright faces [3-6]. The basic mechanics of this algorithm is also to calculate an image pyramid and scan a fixed size sub-window through each layer of this pyramid.

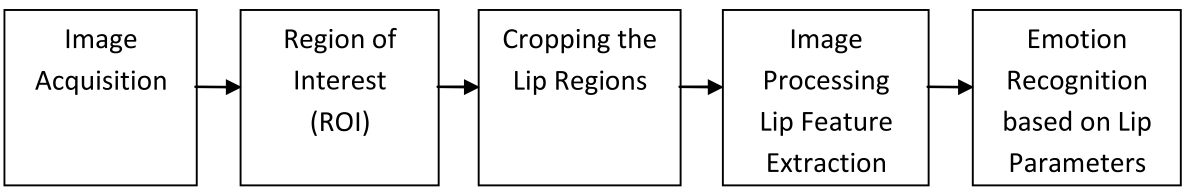

Figure 1 Emotion Recognition Process

Releted Work

During the last decade a number of promising face detection algorithms have been developed and published. Among these two stand out because they are often referred to when performance figures etc. are compared. This section briefly presents the outline and main points of each of these algorithms.

The content of the sub window is subjected to a wavelet analysis and histograms are made for the different wavelet coefficients. These coefficients are fed to different trained parallel detectors that are sensitive to various orientations of the object. The orientation of the object is determined by the detector that yields the highest output [7-10].

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Proposed Method

The basic principle of the work is to scan a sub-window capable of detecting faces across a given input image. The standard image processing approach would be to rescale the input image to different sizes and then run the fixed size detector through these images. Contrary to the standard approach to rescale the detector instead of the input image and run the detector many times through the image - each time with a different size. At first one might suspect both approaches to be equally time consuming, but a scale invariant detector that requires the same number of calculations whatever the size. This detector is constructed using a so-called integral image and some simple rectangular features reminiscent of Haar wavelets [1-2].

The intended input for the face detection algorithm is any conceivable image containing faces and the output is a list of face positions and their emotions [11-12].

Algorithm

The algorithm has four stages

1. Creating an Integral Image
2. Haar Feature Selection
3. Adaboost Training
4. Cascading Classifiers

Creating an Integral Image

The first step of the Viola-Jones face detection algorithm is to turn the input image into an integral image. This is done by making each pixel equal to the entire sum of all pixels above and to the left of the concerned pixel. This is demonstrated in Figure 2.

1	1	1
1	1	1
1	1	1

Input Image

1	2	3
2	4	6
3	6	9

Integral Image

Figure 2 The integral image.

This allows for the calculation of the sum of all pixels inside any given rectangle using only four values. These values are the pixels in the integral image that coincide with the corners of the rectangle in the input image. This is demonstrated in Figure 3.

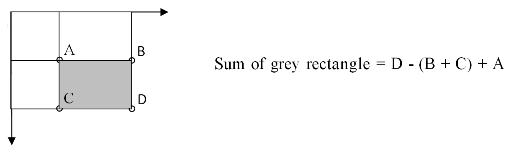

Figure 3 Sum calculation.

Since both rectangle B and C include rectangle A the sum of A has to be added to the calculation.

All human faces share some similar properties. These regularities may be matched using Haar Features.

A few properties common to human faces:

The eye region is darker than the upper-cheeks.

Haar Feature that looks similar to the eye region which is darker than the upper cheeks is applied onto a face

The nose bridge region is brighter than the eyes.

Haar Feature that looks similar to the bridge of the nose is applied onto the face

Composition of properties forming match to facial features:

- Location and size: eyes, mouth, bridge of nose
- Value: oriented gradients of pixel intensities

The four features matched by this algorithm are then sought in the image of a face.

It has now been demonstrated how the sum of pixels within rectangles of arbitrary size can be calculated in constant time. The Viola-Jones face detector analyzes a given sub-window using features consisting of two or more rectangles. The different types of features are shown in
Figure 4.

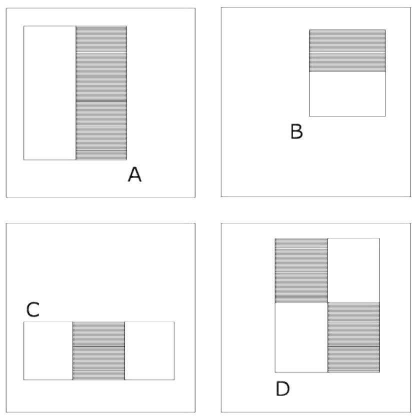

Figure 4 The different types of features.

Each feature results in a single value which is calculated by subtracting the sum of the white Rectangle (s) from the sum of the black rectangle(s).

Value = Σ (pixels in black area) - Σ (pixels in white area)

Ada Boost Training

Ada Boost refers to a particular method of training a boosted classifier. A boost classifier is a classifier in the form

$FT(x) = \sum f_t(x)$

Where each f_t is a weak learner that takes an object x as input and returns a value indicating the class of the object. For example in the two class problem, the sign of the weak learner output identifies the predicted object class and the absolute value gives the confidence in that classification. Similarly, the T_{th} classifier will be positive if the sample is believed to be in the positive class and negative otherwise.

Each weak learner produces an output, hypothesis $h(x_i)$, for each sample in the training set. At each iteration t , a weak learner is selected and assigned a coefficient such that the sum training error E_t of the resulting -stage boost classifier is minimized.

$$Et=\sum E[F_{t-1}(xi)+\alpha_t h(x_i)]$$

Here $F_{t-1}(x)$ is the boosted classifier that has been built up to the previous stage of training, E (F) is some error function and $ft(x)=\alpha_t h(x)$ is the weak learner that is being considered for addition to the final classifier.

The cascaded classifier

The basic principle of the Viola-Jones face detection algorithm is to scan the detector many times through the same image - each time with a new size. Even if an image should contain one or more faces it is obvious that an excessive large amount of the evaluated sub-windows would still be negatives (non-faces). This realization leads to a different formulation of the problem:

Instead of finding faces, the algorithm should discard non-faces.

The thought behind this statement is that it is faster to discard a non-face than to find a face. With this in mind a detector consisting of only one (strong) classifier suddenly seems inefficient since the evaluation time is constant no matter the input. Hence the need for a cascaded classifier arises.

The cascaded classifier is composed of stages each containing a strong classifier. The job of each stage is to determine whether a given sub-window is definitely not a face or maybe a face. When a sub-window is classified to be a non-face by a given stage it is immediately discarded. Conversely a sub-window classified as a maybe-face is passed on to the next stage in the cascade. It follows that the more stages a given sub-window passes, the higher the chance the sub-window actually contains a face. The concept is illustrated with two stages in Figure 5.

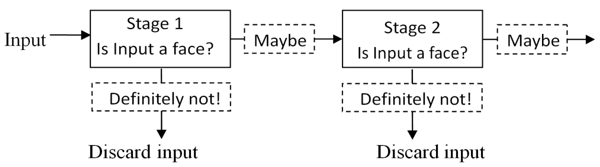

Figure 5 The cascaded classifier.

In a single stage classifier one would normally accept false negatives in order to reduce the false positive rate. However, for the first stages in the staged classifier false positives are not considered to be a problem since the succeeding stages are expected to sort them out. Therefore the acceptance of many false positives in the initial stages. Consequently the amount of false negatives in the final staged classifier is expected to be very small. This name implies that more attention (computing power) is directed towards the regions of the image suspected to contain faces. The results are shown in figure 6 and figure 7.

It follows that when training a given stage, say *n*, the negative examples should of course be false negatives generated by stage *n*-1.

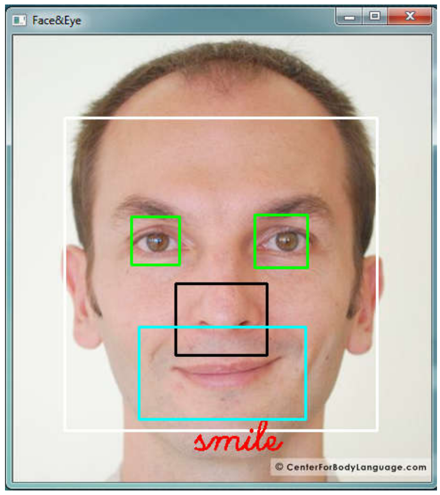

Figure 6 Detecting a smile face with different facial parts

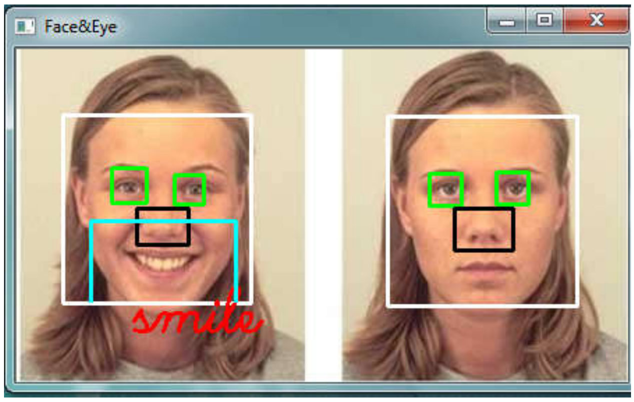

Figure 7 Detecting different facial parts of a same person with two different facial expression

CONCLUSION

Facial expression recognition or emotion detection system has numerous applications in image processing domains, security applications domain or any type of biometric system. This work is a primary step of an emotion detection system using which one specific emotion can be identified after extracting different facial features. Future work will be done to classify more different types of expressions in human face and identify each emotion properly. The proposed approach will help to define uniqueness of human face component accurately to some extent which can be used greatly in biometric recognition system. Also the algorithm can be used further in face recognition systems, machine learning system and other types of image processing applications.

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