International Journal of Computer Applications (0975 – 8887)
Volume 29– No.2, September 2011

A Novel Approach to Face Detection Algorithm

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ABSTRACT

Face detection is one of the important problem of image processing and pattern recognition. Most of the existing algorithm takes the frame of fixed size in order to detect the faces in any image. In any image it is possible that the image that are near are larger in size in comparison to the faces that are in back side. In this paper we proposed a novel approach for detection of faces of variable size frame. To detect the location of face we used template based algorithm for detecting the circle of eyes. In proposed algorithm we used upright, frontal faces, for a single gray scale images with decent resolution and under good lighting condition. The experiment were performed in windows operating system with matlab2010a software.

General Terms

Pattern Recognition

Keywords

Face detection, Face localization accuracy.

1. INTRODUCTION

Face detection tasks are becoming required more frequently in the modern world. It's caused by the development of high security systems to prevent from terrorism. In addition to this algorithms are widely used in companies, video coding and for high security purpose. Face detection is initial phase of face recognition. According to Yang's survey[5], these methods can be categorized into four types: knowledge-based, feature invariant, template matching and appearance-based.

- Knowledge-based methods use human-coded rules to model facial features, such as two symmetric eyes, a nose in the middle and a mouth underneath the nose.
- Feature invariant methods try to find facial features which are invariant to pose, lighting condition or rotation. Skin colors, edges and shapes fall into this category.
- Template matching methods calculate the correlation between a test image and pre-selected facial templates. Nilamani Bhoi et. [6]Al has proposed template based eye detection algorithm in which first the template of eye is taken in gray scale. The normalized eye template is cross correlated with overlapping region of face. The mean square error of auto correlation is calculated ad minimum MSE is stored in memory.
- Appearance-based, adopts machine learning techniques to extract discriminative features from a pre-labeled training set. The Eigenface method is the most fundamental method in this category. Recently proposed face detection algorithms such as support vector machines, neural networks, and statistical classifiers also belong to this category.

2. PROBLEM DEFINITION

All Most of the existing algorithm uses fixed size window in order to detect the faces in any image. But most of the image especially 3D image projected in 2D plane the size of each face is varied based on distance. When we are taking the fixed size image the result may be not accurate, to solve that problem we propose a novel statistical based variable size window for each frame to detect the faces in any image.

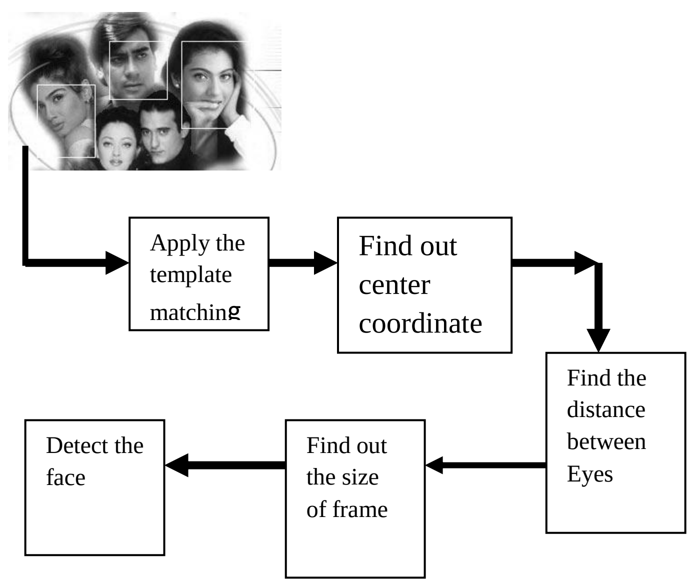


Fig. 1 : Block diagram of face detection Algorithm

3. LOCALIZATION OF FACE

There are many different models of face representation in images are proposed like by the center of the face and its radius, by rectangle (OCV, FDLib, FoI), by coordinates of the centers of eyes (SIF, UniS, FSDK, VL), by ellipse, etc.[1,2,], In this work we represent faces by coordinates of the centers of the eyes (i.e. centers of the pupils)[NSe10].

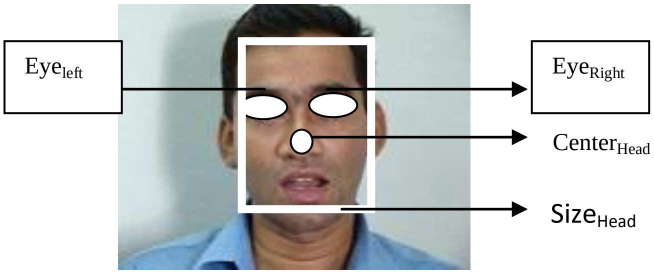


Fig. 2. Schematic face representation E_{left} and E_{right} shows absolute left and right coordinates of detected eyes respectively, l_{eyes} distance between eyes center. l_{Heyes} distance between top border of face and center of left and right eyes. Size $_{Head}$ size of the rectangle representing face. D_{size} diameter of the area representing eyes.

3.1 Localization Accuracy for Algorithms Describing Faces by Centers of the Eyes [3]

If detected faces are represented by the centers of the eyes (Fig. 1), let's consider them to be correctly detected, if and only if detected eyes belong the area around the true eyes location with the diameter *DEyes*. Which depends on the distance between eyes' centers and _, has been taken equal to 0:25 (This criterion was originally used by Jesorsky et al. [4]), and calculates as $DEyes = \alpha \times lEyes$.

3.2 Localization accuracy for faces by rectangle [3]

Nikolay Degtyarev et. al. [10] has proposed the localization accuracy algorithm in following manner If the algorithm found the center of face $Center_{Head}$ and size $Size_{Head}$ of Face . The eye of the image is located with symmetrical property in vertical axis and $I_{eys}/2$ distance between eyes and at the distance top border of the face l_{Heyes}.

Absolute coordinated for eyes

$Eye_{yRight} = Eye_{yLeft} = Center_{yHead} + l_{HEyes} - ½\, Size_{Head}$

$Eye_{xRight} = Center_{xHead} - I_{eys}/2$

$Eye_{xLeft} = Center_{xHead} - I_{eys}/2$

In order to estimate the parameter of the algorithm we require coefficient A and B.

$$A = \frac{1}{N}\sum_{i=1}^{N}\frac{l^{i}_{HEyes}}{Size^{i}_{Head}} \quad \text{……………………………….eq. 1}$$

$$B = \frac{1}{N}\sum_{i=1}^{N}\frac{l^{i}_{Eyes}}{Size^{i}_{Head}} \quad \text{……………………………….eq.(2)}$$

where I shows the parameter measured for ith image in the dataset. The coordinated for thee eye in the given face size and coefficient are calculated with the algorithm

$Eye_{yRight} = Eye_{yLeft} = Center_{yHead} + Size_{Head}\ (A - 1/2)$ …………………………..eq(3)

$Eye_{xRight} = Center_{xHead} - Size_{Head}(½B)$ ………………eq(4)

$Eye_{xLeft} = Center_{xHead} - Size_{Head}(½B)$ …………………eq(5)

If there are full face portrait image with any inclie , the length of head to eye $l_{HEye} = ½(\, l_{lHEyes} + _{lRHEyest})$

4. EXPERIMENTAL RESULTS

The [**3**] method is implemented in the MALAB 20101a software. All the images used for the purpose of simulation are of sizes 512×512. The algorithm is tested on the face images having the image of person of different age group. I experiment we calculated the center of left eye, right eye, the center position of nose, the distance between nose and top of face, the size of Head, diameter of eye and the distance between both the eyes.

Table 1. The center coordinate of left, right, center of Head, The size of Head, the Diameter of eye.

Sno	Eye_{Left}	Eye_{right}	$Size_{Head}$ coordinates	Center $_{Head}$
1	42,56	76,58	(60,41) (60,94)	(59,72)
2	55,58	101,57	(77,36) (77,117)	(78,84)
3	39,69	67,68	(57,54) (57,110)	(53,89)
4	(38,65)	85,61	(55,34) (66,128)	(58,84)
5	(58,110)	(124,108)	(85,62) (85,198)	(77,134)
6	24,43	(64,45)	(46,21) (37,102)	(44,68)
7	(53,91)	(129,94)	(96,40)(96,197)	(96,132)

8	(61,59)	(97,60)	(77,40) (77,110)	(76,79)
9	308,161	393,152	(341,104) (355,267)	(345,202)
10	313,685	699,689	(525,419) (535,1101)	(491,774)

l_{HEyes}	D_{Eyes}
(52,76) (75,56)	(41,51)(41,61)
(54,37)(54,59)	(98,50)(99,65)
(40,53)(39,69)	(39,65)(39,74)
(38,35)(38,64)	(35,61)(35,69)
(55,110)(124,107)	(55,93)(54,106)
(26,21)(24,44)	(24,45)(65,46)
(54,40)(55,92)	(57,92)(129,92)
(62,40)(62,60)	(59,55)(59,64)
(305,100)(305,161)	(308,161)(394,152)
(302,677)(309,423)	(309,623)(306,743)

From table 1 we computed the Size of Head, The distance between eyes, The diameter of eyes and the distance between head and center of eyes. The resultant values are shown in table 2. In order to implement [3] coefficient we obtain the value for A& B by equation (1) and we tried to obtain the center of left eye and right eye from equation (2).

Table 2. The size of Head, distance between eye, the distance from head to eye, diameter of eye.

Sno	$Size_{Head}$	leye	l_{HEyes}	D_{Eyes}	Centerx	Centery
1	53	34	20	10	59	72
2	81	35	32	15	78	84
3	46	28	16	9	53	89
4	94	47	29	18	58	84
5	136	66	35	13	77	134
6	81	40	23	23	44	68
7	157	76	52	72	96	132
8	70	36	20	19	76	79
9	163	85	61	86	345	202
10	682	386	254	120	491	774

$$A = \frac{1}{N}\sum_{i=1}^{N}\frac{l^{i}_{HEyes}}{Size^{i}_{Head}}$$ ………………………….eq. 1

$$B = \frac{1}{N}\sum_{i=1}^{N}\frac{l^{i}_{Eyes}}{Size^{i}_{Head}}$$ ……………………….eq. 2

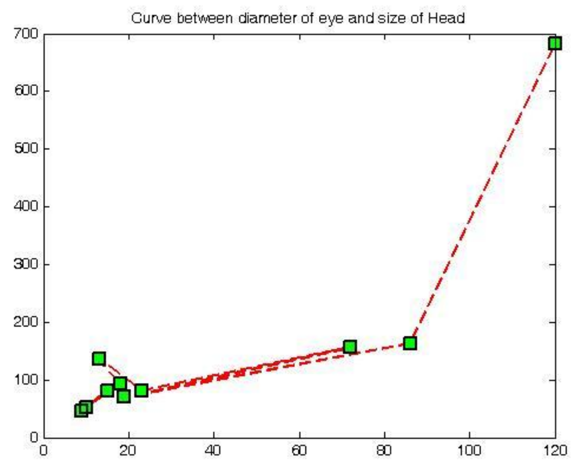
After applying the Coefficient A and B the coordinates of left and right eye center position can be computed with eq(3).eq(4) and eq(5). In experiment we found that the center coordinates for eyes variance is 24.35682989.

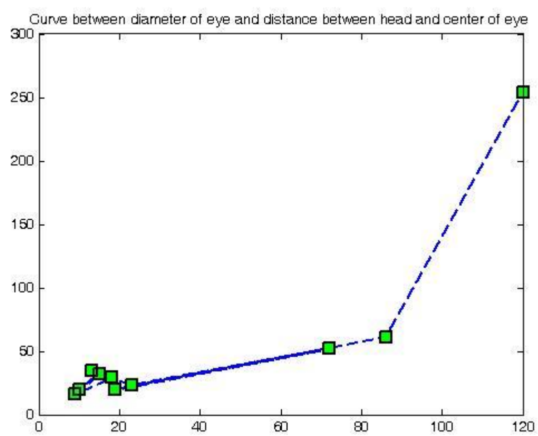
Table 3. Computation of center of Left and Right Eye coordinates

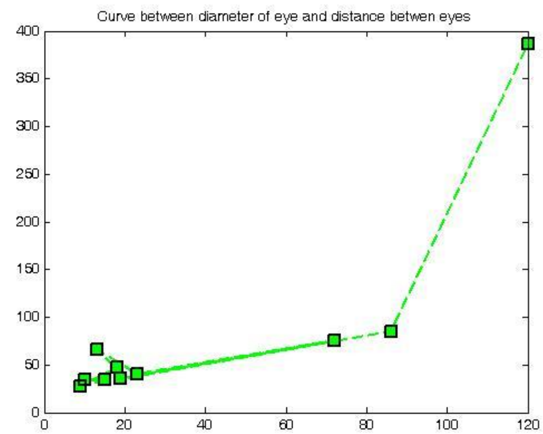
Sno	Leftx	Lefty	Rightx	Righty
1	23.9052	50.1684	-3.9052	50.1684
2	36.2513	64.5026	-6.2513	64.5026
3	21.0687	45.3348	-3.0687	45.3348
4	42.6620	42.3363	-6.6620	42.3363
5	48.6812	54.3377	-22.6812	54.3377
6	7 44.2513	30.5026	1.7487	30.5026
7	113.1909	69.8383	30.8091	69.8383
8	37.3653	64.3356	0.6347	64.3356
9	128.7650	317.8385	43.2350	317.8385
10	298.9310	377.3551	-58.93	377.3551

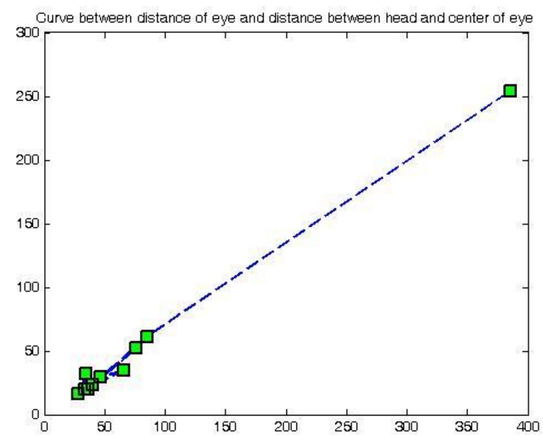
Proposed Algorithm

1. Find $template_R$ and $template_L$
2. Apply Cross correlation from $template_R$ and $template_L$ in order to detect eye region.
3. Compute leye = distance between(Left,Right) eye
4. Compute $Size_{Head}$ curve fitting equ
5. $Size_{Head} = p1 * leye + p2$ where p1 and p2 are linear curve coefficient.
6. Detect the frame size for face for each set of eyes.









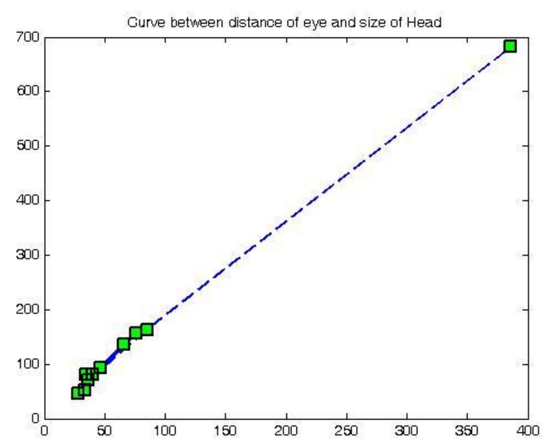


Fig 3(a), 3(b) and 3(c) D_{size} to $Size_{Head}$, leye and l_{HEyes} Fig 3(d) , Fig 3(e) curve between leye to $Size_{Head}$ and l_{HEyes}

Analysis. Experimental graph shows that the curve between the diameter of eye D_{size} to $Size_{Head}$, leye and l_{HEyes} the curve is not as smooth Fig (a), Fig (b) and Fig(c) as the curve between leye to $Size_{Head}$ and l_{HEyes} Fig(d) and Fig(e).

E_{left} and E_{right} shows absolute left and right coordinates of detected eyes respectively, l_{eyes} distance between eyes center. l_{Heyes} distance between top border of face and center of left and right eyes. Size $_{Head}$ size of the rectangle representing face. D_{size} diameter of the area representing eyes. After applying the curve fitting algorithm we found following values to smoothen the curve.

Table 4. Computation of curve fitting parameter

Sno	f(x) = p1*x + p Coefficients (with 95% confidence)	RMSE:
Diameter & Sizeof Head	p1 = 4.001 p2 = 2.265	111.3
Diameter & distance of head to center of eye	P1= 2.256 P2= -3.537	65.46
Diameter and distance between eyes	P1= 1.528 P2= -4.636	41.34
Distance between eye and size of head	P1= 1.748 ,P2=10.71	10.5
Distance between eyes and distance of head to center of eye	p1 = 0.6613 p2 = -0.8879	5.197

Table 5. Proposed Algorithm Result

Image Dataset	#face	Correctly classified	False positive	False Negative	Percentage
image1	21	21	1	0	100
Image2	23	21	5	2	91
Image3	23	33	0	1	96
Image4	24	22	0	2	92
image5	24	23	0	1	96
Image6	24	23	0	1	96
Sum	139	143	6	7	571
Average	23.167	23.84	1	1.167	95.1667

Analysis. Experimental results shows that the Root Mean Square Error is minimum we are taking distance between eyes and size of head or distance between eyes and distance of head to center of eye as a main parameter, whereas the root mean square error is maximum if we are taking the diameter of eye as a main parameter. With the help of distance between eyes and size of head the size of frame for face will vary instead of static size of frame window which increases the accuracy of face detection problem.

The algorithm is applied to training dataset, the result obtained from training data is shown in Table (5). We obtain up 95% accuracy to detect the different size of faces.

5. COCLUSION

In this paper a novel and variable size frame face detection method is proposed. The experimental result shows 95.16% accuracy for detecting the faces. This technique is better than [3] in order to verify the accuracy of localization of faces. The future work is the testing must be on large dataset by applying neural network algorithm and continue the work for recognition of faces.

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