Face detection in color video sequences

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Abstract – This paper proposes a method to detect human face in color video sequences. The method combines the boosting-based method of detecting faces in still images and facial tracking method which uses particle filter. This paper presents the results of experimental research method using test video sequences.

Key words – computer science, face detection, face tracking, Adaboost, particle filter.

I. Introduction

Recently, face detection and tracking in static images and video sequences is used in many practical applications such as human-computer interface systems, video surveillance systems, video conferencing, robot navigation, smart cameras, computer games, video-indexing, biometric systems based on face and iris recognition, virtual reality, head and face gesture recognition.

In recent years most of attention has been paid to boosting-based face detection approaches. These approaches show very good results both in terms of accuracy and speed, and are then well suited for real-time applications [1].

The particle filter, also known as sequential Monte Carlo, is the most popular approach which recursively constructs the posterior probability density of the state space using Monte Carlo integration. It approximates a posterior probability density of the state such as the object position by using samples or particles. The probability distribution of the state of the tracked object is approximated by a set of particles, which each state is denoted as the hypothetical state of the tracked object and its weight. It has been developed in the computer vision community and applied to tracking problem and is also known as the Condensation algorithm [2].

Some researches propose a schemes for integration of face detection and face tracking by combining tracking algorithm based on particle filters with the AdaBoost face detection algorithm [3, 4].

II.Formulation of a problem

The purpose of this study is to create a detection method in color video sequences which combines the method of detecting faces in still images and facial tracking method to improve detection performance.

To solve the considered problem is proposed:

1) Using boosting-based face detection method [1] which uses as weak classifiers modified local binary patterns.

2) Using color-based particle filter for face tracking.

III.Boosting-based face detection

Boosting-based face detector is a cascade of nodes (strong classifiers). When the image area to the input of the detector is first checked by the first node that either rejects or passes the image area processing for the following node stage. This process is repeated for all nodes until the image area is rejected or not a node or all nodes will be treated in the cascade. In this case will be decided on the presence of faces in the image area. Each node consists of an ensemble of simple classifiers, whose outputs are combined weighted decisions. Each simple classifier based on a small set of features which can be any function computed in the image area. As features used modified local binary patterns (MLBP). An output value on the MLBP operator can be obtained as follows:

$$MLBP = \sum_{i=0}^{7} s(k_i - k_c)2^i , \qquad (1)$$

where k_c is the average intensity of the center rectangle, k_i $(i=0,\ldots,7)$ are those of its neighbourhood rectangles, $s(x)$ is:

$$s(x) = \begin{cases} 1, & if \quad x \geq 0 \\ 0, & if \quad x < 0 \end{cases} . \qquad (2)$$

Cascade architecture designed for efficient processing of rare events, an example of which is to find faces. In practice, the detector scans the image receiving brute force, that checks all possible image area for the presence of their faces. To reliably detect faces without clogging false detection need to level false detection rate was at 10^{-7}. Because conjunctive principle stage, not all of the negative image area to decline by one node. Instead, each node next stage is the more simple task of cutting the negative class, leaving less and less false detections. This principle also makes the detector more quickly, as in most image areas no faces, because these areas of the image are rejected the first stage nodes, allocating more time for areas in which there face.

IV. Particle filter

Particle ltering was developed to track objects in clutter [2], in which the posterior density $p(X_t|Z_t)$ and the observation density $p(Z_t|X_t)$ are often non-Gaussian. The quantities of a tracked object are described in the state vector X_t while the vector Z denotes all the observations $\{z_1,\ldots, z_t\}$ up to time t. The key idea of particle ltering is to approximate the probability distribution of the object state by a weighted sample set $S = \{ s^{(n)}, \pi^{(n)} \mid n = 1 \ldots N \}$. Each sample consists of an element s which represents the hypothetical state of the object and a corresponding discrete sampling probability π where $\sum_{n=1}^{N} \pi^{(n)} = 1$.

The evolution of the sample set is calculated by propagating each sample according to a transition model. Each element of the set is then weighted using observation model and N samples are drawn with replacement, by choosing a particular sample with probability $\pi^{(n)} = p(z_t \mid X_t = s_t^{(n)})$.

The mean state of the object is estimated at each time step by

$$E[S] = \sum_{n=1}^{N} \pi^{(n)} s^{(n)} . \quad (3)$$

The transition model that predicts the state of a potential target state at the next time step

$$s_{t+1} = A * s_t + w_t , \quad (4)$$

where A is a deterministic component of the model and w_t a multivariate gaussian.

The observation model is used to measure the observation likelihood of the samples. The observation model is made based on color information of the target obtained by building the color histogram in the RGB color space. A color histogram is commonly used for object tracking because they are robust to partial occlusion, rotation and scale invariant [5].

The color histogram $p_y = \{p_y^{(u)}\} u = 1,\ldots,m$ at location is calculated as

$$p_y^{(u)} = f \sum_{j=1}^{I} g\left(\frac{\|y - x_j\|}{a}\right) \delta[h(x_j) - u] . \quad (5)$$

Here, I is the number of pixels in the region, x_j is the position of the pixels in the region, δ is the Kronecker delta function, a is the normalization factor, and f is the scaling factor de ned as

$$f = \frac{1}{\sum_{i=1}^{I} g\left(\frac{\|y - x_i\|}{a}\right)} , \quad (6)$$

to ensure that $\sum_{u=1}^{m} p_y^{(u)} = 1$.

The similarity between two color histograms $p = \{p^{(u)}\} u = 1,\ldots,m$ (sample) and $q = \{q^{(u)}\} u = 1,\ldots,m$ (target model) is measured using the Bhattacharyya distance, which is de ned as

$$\rho[p,q] = \sum_{u=1}^{m} \sqrt{p^{(u)} q^{(u)}} . \quad (7)$$

The larger ρ is, the more similar the distributions are. For two identical histograms we obtain $\rho = 1$, indicating a perfect match. As distance between two distributions is de ned as measure

$$d = \sqrt{1 - \rho[p,q]} . \quad (8)$$

Based on the Bhattacharya distance, the weight $\pi^{(i)}$ of the sample state $x^{(i)}$ is calculated as

$$\pi^{(i)} = \frac{1}{\sqrt{2\pi}\sigma} exp\left(-\frac{1 - \rho[p(x^{(i)}, q)]}{2\sigma^2}\right) , \quad (9)$$

where $p(x^{(i)})$ and q are the color histogram of the samples and target model, respectively.

Each sample s in the sample set S can be scanned as a rectangle and it can be represented as

$$s = \{x, y, \hat{x}, \hat{y}, H_x, H_y\} , \quad (10)$$

where (x,y) specify the location, $(\hat{x}, \hat{y})$ the velocity, (H_x, H_y) the rectangle size.

V. Proposed face detection method

Proposed method consists of two phases: an initialization phase and a tracking phase. In the initialization phase the boosting-based face detection model can provide the initial parameters for tracking model based on particle filter using observations of the image sequences during a certain time interval (first few frames). During the tracking phase, the boosting-based face detection model and the face tracking model improve the tracking performance via mutual interaction. The boosting-based detection model helps tracking model to find and define new faces, and to verify the current states of faces being tracked. General scheme of the proposed method is shown in Fig. 1.

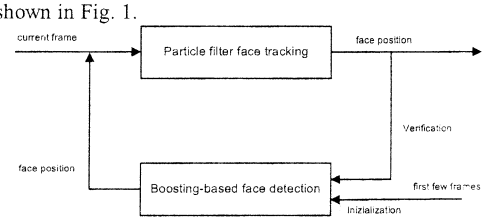

Fig. 1 General scheme of the proposed method

VI. Experimental results

In order to evaluate the proposed method has been used the NRC-IIT facial color video database. For experiments were used 5 single-face color video sequences in different pose and orientation of faces. Each video sequence is recorded in an indoor environment at 20 frames per second. The resolution of each video sequence is 160x120. The color histogram is calculated in RGB space with 8?8?8 bins. The number of particles in uences performance as well, where 100 particles proved to be enough in all experiments. The method was implemented in Matlab 6.0. The processing time of face detector is 5fps on P4 3.0 GHz. Face detection performance developed method is presented in a table 1.

TABLE 1

FACE DETECTION PERFORMANCE

Video sequences	Probability of detection	False detection
00-1	0.9	5
04-1	0.87	6
05-1	0.92	4
08-2	0.85	7
10-1	0.93	9

Conclusion

The proposed method was tested on the color video sequence and experimental results showed its reliability and computational efficiency.

The used approach to detect faces in color video sequence can improve the boosting-based approach so as to reduce the number of rectangular areas machined frame, especially when using video sequence with high resolution.

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Наукове видання

Сучасні комп'ютерні системи та мережі: розробка та використання

Матеріали
5-ої Міжнародної науково-технічної конференції
ACSN-2011

Відповідальний за випуск – Пищак І.І.

Підписано до друку 07.09.2011 р.
Формат 60х84 1/8. Папір офсетний
Друк на різографі. Умовн друк.арк. 32,29. Обл.-вид. арк.23,05.
Тираж 110. Зам. № 19.

НВФ "УКРАЇНСЬКІ ТЕХНОЛОГІЇ"
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Свідоцтво про внесення суб'єкта видавничої справи
до Державного реєстру видавців, виготівників
та книгорозповсюджувачів видавничої продукції
ДК – № 789 від 29.01.2002 р.