Journal of Korea Multimedia Society Vol. 11, No. 12, DECEMBER 2008(pp. 1676-1687)

Multi-view Human Recognition based on Face and Gait Features Detection

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ABSTRACT

In this paper, we proposed a new multi-view human recognition method based on face and gait features detection algorithm. For getting the position of moving object, we used the different of two consecutive frames. And then, base on the extracted object, the first important characteristic, walking direction, will be determined by using the contour of head and shoulder region. If this individual appears in camera with frontal direction, we will use the face features for recognition. The face detection technique is based on the combination of skin color and Haar-like feature whereas eigen-images and PCA are used in the recognition stage. In the other case, if the walking direction is frontal view, gait features will be used. To evaluate the effect of this proposed and compare with another method, we also present some simulation results which are performed in indoor and outdoor environment. Experimental result shows that the proposed algorithm has better recognition efficiency than the conventional single view recognition method.

Key words: biometric recognition, gait recognition, face recognition, PCA

1. INTRODUCTION

Recently, a lot of researches about intelligent surveillance systems have been done. The main purpose of these systems is to bring the human intelligent to computer to track or recognize an object. Accurately recognition a person in a dangerous region is an important and necessary work. To recognize an individual from a video stream has several difficult problems. In these types of applications, often, only a single feature is suggested. However, in some camera view, human face can not be detected during person's appearance on video stream. To overcome this, we propose a method that associates face and gait for human recognition. When face is a common feature, gait is one of the new mentioned biometric features. Gait, or the way of walking, is assessed as a good feature for distance human recognition. At present, several methods were proposed that using face and gait for human recognition. For recognize human face, 2 main problems [1] are which information of face will be used and which method for computer training . Wenyi Zhao, Arvindh Krishnaswamy, Rama Chellappa, Danie L.Swets, John Weng describe a face recognition method based on PCA (Principal Component Analysis) and LDA (Linear Discriminant

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Analysis). The method consists of two steps: first they project the face image from the original vector space to a face subspace via PCA, second use LDA to obtain a best linear classifier. In the other method, Emmanuel Viennet and Francoise Fogelman Soulie use neural network for processing and recognition. The other methods extract eyebrows, eyes, nose, mouth and chin features for recognition. In the standard eigen-faces approach, the nearest center (NC) criterion is used to recognize a new face. In [2], a probabilistic visual learning (PVL) method is developed for face recognition. Another way of Bayesian classification of faces is proposed in [3], called probabilistic reasoning models (PRM), based on some assumptions of the class distributions. More recently, the support vector machine is popular for visual object recognition [4]. The SVM constructs a hyper-plane between two classes of examples based on the criterion of large margin. The face recognition accuracy based on SVM is relatively high [5]. However, in SVM, both the training and testing process is a little time consuming if the face database is very large. In some paper, the using YCrCb color space to detect human face as the first selection [6,7]. Otherwise, B.Wu, H.Ai, C.Huang, and S.Lao [8] used Ada-boost for multi-view face detection.

Similar to face, there are also many method which use gait as key feature for human recognition. Gait, or the way of walking, is one of biometric feature can be extract from a distance. With gait, we don't need any cooperate of the person who will be extracted. Furthermore, other characteristics can be change easily but for the way of walking, the more concealing the more suspicious. However, there are some disadvantages which we must notice. The gait of a person, after and accident or disease, can be changed. Drug, alcohol and clothing are also the factor will affect to the way of walking. Bobick and Johnson [9] compute body height, torso length, leg length, and step length for identification. Using a priori knowledge about body structure at the double support phase of walking (i.e., when the feet are maximally apart), they estimate these features as distances between fiducial points(namely, the midpoint and extreme) of the binary silhouette. M.S. Nixon, J.N. Carter, J.M. Nash, P.S. Huang, D. Cunado, and S.V. Stevenage [10,11] computing the width of the outer contour of the silhouette, the correlation between the probe silhouette image sequences and those in a data-set. Cutler and Davis [12] used self-correlation of moving foreground objects to distinguish walking humans from other moving objects such as cars. J. H. Acquah, M.S. Nixon and J.N.Carter [13] described a method which is rely on the borders of a shape or on general appearance, locates features by their symmetrical properties. A.V. Nguyen and E.J. Lee [14,15] proposed human biometric informations based methods. As any other recognition system, face and gait have their out challenging. In face system, the large change of different face images from one person includes feeling state, light and position. Moreover, image quantity limitation for training and recognition can not include all of possible change of a human face in real world. Gait, also is a biometric characteristic, so have some influences. A small physical change, example after an accident/disease or after weight gain/loss all can affect to the movement characteristic of a person. Or a person before and after using drugs and alcohol has differences gait features. The same person wearing different clothes may cause an automatic signature extraction method to create a widely varying signature for an individual.

In this paper, we propose a new method that associate face in gait feature for human recognition. Depend on the waking direction of human in video stream, which characteristic will be used as a key feature for recognition. The database is separated to 2 categories which are face and gait.

2. OVERVIEW OF PROPOSED METHOD FOR MULTI-VIEW HUMAN RECOGNITION

An overview of our propose method is showed in Figure 1. In this approach, we define a region in video frame called "violate area". When an individual enters this region, all features of this object will be extracted. Initial, the image subtraction method is applied to each frame of the video sequence in order to find the silhouette of the person. This method can overcome the background subtraction method of A.V.Nguyen and E.J.Lee [16]. Once the silhouette is detected, its bounding box is created and split into 3 main parts: head, hand and leg region. Base on these regions, features are extracted and the blob will be tracked during the time this individual appears in video stream. For every silhouette in video stream, based on the head and shoulder contour, we can decide the direction view of camera against to this human. This factor helps us decide which feature (face or gait) will be used to recognize this person. Depend on the view angle, if frontal direction, face characteristics become the key feature for recognition. On the other hand, gait feature will be used.

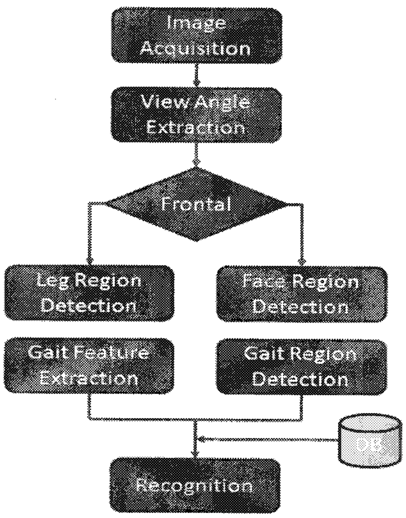


Fig 1. Overview of proposed algorithm.

3. WALKING DIRECTION DETERMINING

To determine the walking direction (frontal-view or side-view), we used the head and shoulder contour. The differences in the two models lie on then features used to represent the upper torso and the head. As show in Figure 2, the frontal model has a head-shoulder contour, while the side-view has the head-shoulder-back contour. By using the ratio of the bounding box of head- shoulder-back, we can determine this person is in frontal or side-view.

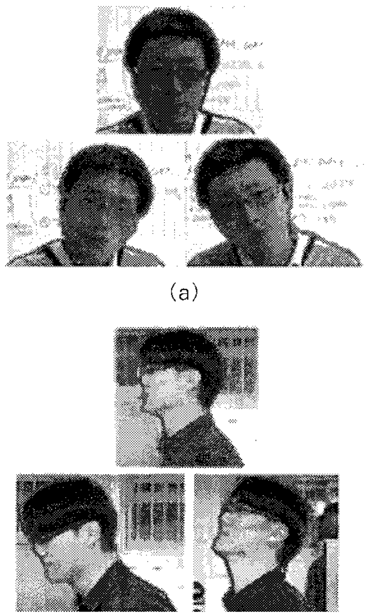
$$R = \frac{head\_shoulder\_back\_WIDTH}{ObjectBoundary\_HEIGHT} \quad (1)$$

$$D = \begin{cases} frontal\_view, R > threshold \\ side\_view, otherwise \end{cases} \quad (2)$$

Where:

R: ratio of head_shoulder_back_contour width and object boundary height.

D: direction of moving object to camera.



(a)

(b)

Fig 2. Head-shoulder-back contour, (a) is frontal-view and (b) is side-view.

4. FACE FEATURES EXTRACTION FOR FRONTAL VIEW RECOGNITION.

As we mention at previous part, every face recognition algorithms always consist of 2 main jobs: feature selection and method for recognition or identification. Recognition is the task of determining whether or not the face in a probe is one of the persons in database. In this paper, we use Principal Component Analysis (PCA) method to create the feature vector apply for recognition process.

4.1 Walking object detection

For detecting face region, a fast and accurate face detection based on Neural Network has been introduced by R.Feraud, O.J.Bernier, J.-E. Viallet, and M. Collobert, automatic analysis of facial expressions has been introduced by M. Pantic and L.J.M. Rothkrantz and theadvantage and disadvantage of these algorithms has been discussed by Rein-Lien Hsu and Mohamed Abdel-Mottaleb. For considering accuracy and efficiency of algorithms, algorithm based on human skin color feature is better than others. So we will use skin color information to detect human face. Usually normalized red-green (r-g) space is not the best choice for face detection because feature of face region is not independent of background very strongly in RGB color space, but as observed in Figure 3, we can find that in YCbCr color model, Cr values of face color is strongly independent of background.

$$Sum = \sum_{i=0}^{255} Histogram(i),$$
$$Cr_{Th} = Sum * Coeff \qquad (3)$$

Therefore, we can translate the input image from RGB color model to YC_bC_r color model, and C_r values can be employed to detect the region of face as in Figure 4. According to our framework, we enactment that face region possess 70% of total region, so the histogram method as shown in above equation can be employed to detect C_r threshold of face as in Figure 5. After getting the skin regions, the face region detection process is carried out by using the Haar-like features. The Figure 6 show the some results of Haar-like feature based face detection method. In comparison with L.Wei and E.J Lee [5], our method has higher result.

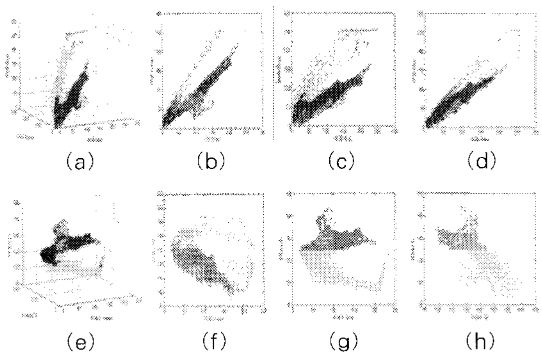


Fig. 3. RGB, YC_bC_r Color Spaces of human face region and the skin tone model, (a) the RGB Space, (b) R-G subspace, (c) R-B subspace and (d) G-B subspace, (e) the YC_bC_r Space, (f) $Y-C_b$ subspace, (g) $Y-C_r$ subspace and (h) C_b-C_r subspace.

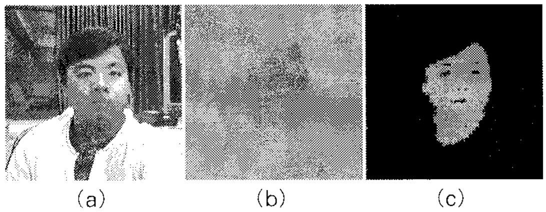


Fig. 4. Skin Region Detection: (a) Original Image, (b) C_r Image of Face and (c) Skin Region Image.

Fig. 5. Skin region detection results.

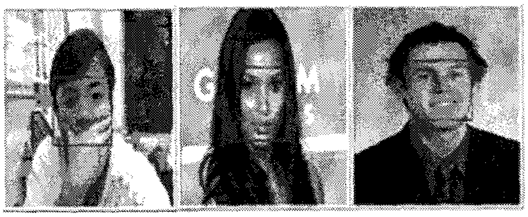


Fig. 6. Face region detection using skin color and Haar-like feature.

4.2 Face recognition based on principal component analysis (PCA)

PCA is a useful statistic technique that has found application in fields such as face recognition and image compression, and is common technique for finding patterns in data if high dimension. The main idea of using PCA for face recognition is to express the large 1-D vector of pixels constructed from 2-D facial image into the compact principal components of the feature space. Figure 7 shows the general flowchart of a PCA-based face recognition system.

Human tracking and extract the moving object in video stream is the pre-processing step in almost supervision system. In computer vision world, there are a lot of method are proposed to solve this problem. However, the object detection step in this algorithm is very important because all of the gait features are extracted from the detected object. The method we use here is the combination of comparison 2 continuous frames in video stream to detect the moving object and background subtraction

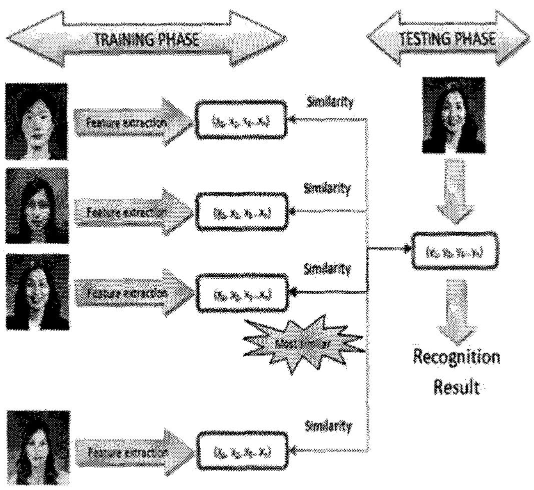


Fig. 7. Overview of face recognition using PCA method.

Principal components analysis (PCA) is a technique used to reduce multidimensional data set to lower dimensions for analysis. The face recognition process includes 2 main steps: features extraction and face recognition.

The computation of the eigen-faces:

- Represent every face as a vector.
- Compute the average face
- Subtract every face to mean face.
- Compute the covariance matrix.
- Compute the eigen-vectors.
- Sort eigen-values.
- Keep K eigen-vetor which has the K largest corresponding eigen-values. By using this method, we can select enough necessary principal components.

Recognition is performed by projecting a new image onto the subspace spanned by the eigen-faces and then classifying the face by comparing its position in the face space with the positions of known individuals.

- Represent unknown face as an vector Γ
- Normalize: Γ:Φ=Γ−Ψ
- Project on eigen-space: $\hat{\Phi} = \sum_{i=1}^{K} w_i u_i (w_i = u_i^T \Phi)$
- Represent Φ as Ω = (w1, w2,⋯,wk)
- Calculate error : $e_r = \min_l \|\Omega - \Omega^l\|$
- If $e_r < T_r$,Γ is recognized as face l from the training set

5. GAIT FEATURES DETECTION FOR FRONTAL SIDE VIEW RECOGNITION

And now we will describe how the gait features are extracted from the detected object in previous section. At first, all of gait features are list and the detail of how to detect this feature will be described in next step. For apply to any direction of walking person to camera, we use following main features:

- Stride length
- Walking velocity
- Knee angle
- Ratio of swing phase and stance phase
- The variant of silhouette perimeter on gait cycle

When a person walking, the most easily realization features in leg is speed and stride length. As any basic method of speed computation, we must have the distance and the time which that person walked. Here, we chose the gait cycle as the standard distance and time is the number of frame which that person needs for one gait cycle. However, the concept of gait cycle must be understood firstly.

A gait cycle is defined as the time interval which initial when 2 feet contact to floor and finish when 2 feet re-contact to floor in the same leg position". Simply, a gait cycle is composed of 2 consecutive strides. As in Figure 8, the above array image is a first half of a cycle which from the beginning state to the mid-point and the below array image is from the mid-point to the finish state. There are two main phases in every gait cycle: stance and swing as showed in Figure 9. During the stance phase, the foot is always contacted to ground while in swing phase one foot is in the ground and other leg is swinging through in preparations for the next foot stride. And with stance phase, we can subdivide into three separation phases: *first double support* (both feet are in contact with the ground), *single limb stance*(when a foot is swinging through and only other foot is in ground contact), second double support (when two feet are again in ground contact).

In normal gait, there is a natural symmetry between the left and right sides, but in pathological gait an asymmetrical pattern very often exists. This is graphically illustrated in Figure 10. Notice the symmetry in the gait of the normal subject between right and left sides in the stance (62%) and swing (38%) phases; the asymmetry in those phases in the gait of the two patients, who spend

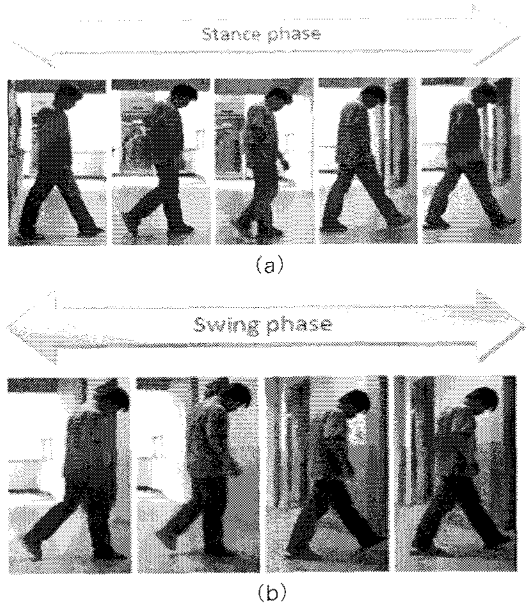


Fig. 9. Two main phases of one leg in a gait cycle, (a) Stance phase, (a) Swing phase.

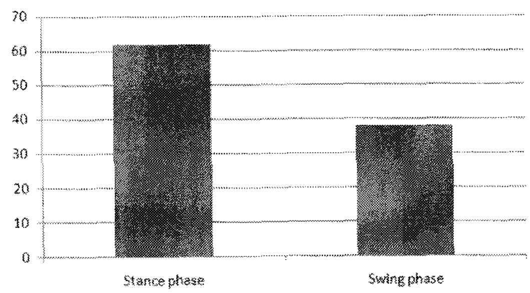


Fig. 10. Stance and swing phase in one gait cycle of a normal person.

Fig 8. One gait cycle

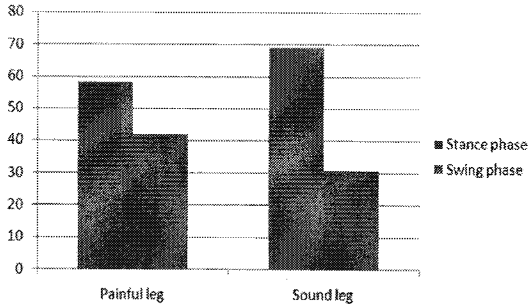


Fig. 11. Stance and swing phase in one gait cycle of a patient, left image represent for the painful leg, right image show for sound leg.

less time bearing weight on their involved (painful) sides; and the increased cycle time for the two patients compared to that of the normal subject.

And in Figure 11, the asymmetry of a patient is showed. With the painful leg, the stance phase is 58% and the swing face is 42% while in the sound one, these values are 69% and 31%, respectively. Base on this statistic data, we can choose the ratio of stance and swing component as a characteristic for human gait feature classification.

For easy to mark the starting and finishing state of a gait cycle, we determine base on the stride length. During a gait cycle, we can calculate the walking speed by using the number of frame on one cycle. For calculate the stride length value, we use the ratio of two knee distance and silhouette height. Because the captured silhouette is different in every capture time so we use the ratio with object boundary height instead of the absolute distance.

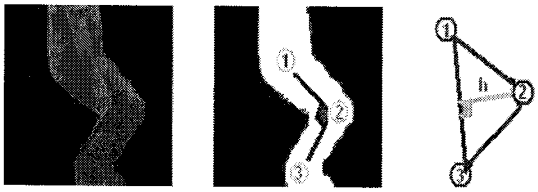


Fig. 12. Leg model for feature extraction

$$h_i = Dist(P_{i,} P_1 P_3)$$
$$P_{knee} = P_{h_{max}} \tag{4}$$
$$2FeetDist = Dist(LL_{Ankle}, RL_{Angle})$$

Where :

h_i is the distance from thigh and calf point to P_1P_3 $P_{h_{max}}$ is the point which has the distance to P_1P_3 is maximum.

$2FeetDist$ is the distance the leg foot and the right foot.

LL_{Ankle} is the left leg ankle point, RL_{Angle} is the right leg ankle point.

Furthermore, the angle at point (2) in Figure 12 is considered a good feature to separate human. And the last feature we use is the shape of the leg. Finally, the similar computation of these feature and the features are stored in database can help us have the decision for recognition.

$$Err_{Angle} = DistA(detectedAngle, dbAngle)$$
$$Err_{Speed} = DistS(detectedSpeed, bSpeed) \tag{5}$$
$$Err_{Swing} = DistSWA(detectedSwing, dbSwing)$$

Now, we will introduce the last important characteristic, the variant of silhouette perimeter, and the method for detecting it. If most of features which we analyzed in previous step belongs to separate part of human, this characteristic depend on the while silhouette. This characteristic not only affected by the leg region but also influenced by the swing arm. In the human waking phase, the free arm movement is important for maintain balance and moving effectively. Upon the specify person, the arm swing amplitude will give the different features. The arm swing with the maximum amplitude and the leg region width reach to the max value will give the large perimeter value. Otherwise, if the arm swing amplitude is small and two legs are overlap, the perimeter will be decreased.

6. EXPERIMENTAL RESULTS

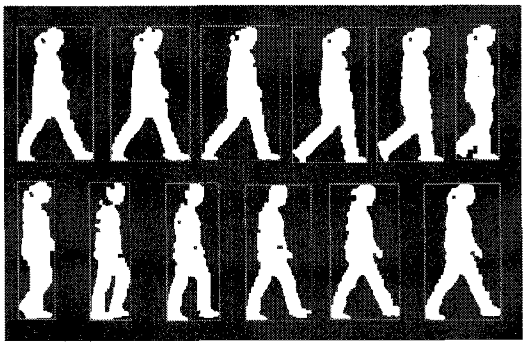
To illustrate for the effect of propose algorithm, we use video sequences from different types of realistic scenes, include outdoor surveillance and indoor video. The video frame size we used here is 640x480 and frame rate is 25frames/second. And from the beginning of video stream, we don't need any manual initialization. However, when our proposed algorithm is performed, we assume that the camera is static and the moving object appears in video stream is human. For detecting the moving object and extract silhouette, we use our database which is created in realistic scenes by ourselves. And in the test process for gait feature extraction from the silhouette, we used the CASIA, CMP gait database which has a lot of silhouette image include lateral, oblique and frontal view. For testing the face recognition process, we used FERET database

6.1 Side view recognition

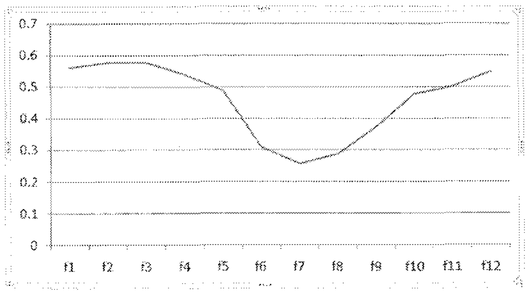
Next figure shows the result of gait feature detection. Figure 13 (a, c) and (b, d) show the covariant of the ratio of silhouette width and silhouette height on one gait cycle of two objects while Figure 14 show the result of silhouette perimeter computation process.

6.2 Frontal view recognition

In this part, we separate the result into 2 processes: face detection and face recognition. In Figure 14, we show 12 test images with many types. As in this figure, our algorithm can detect face region with any kind of skin color and can discriminate face region with other skin region (hand), which is better than [5]. In second part, we show the result of PCA method for recognition. Figure 15 is the training set, Figure 16 show the average image of this training set the figure 20 present eigen-face. And the last figure show the Eucledian distance of input image with training set.



(a)



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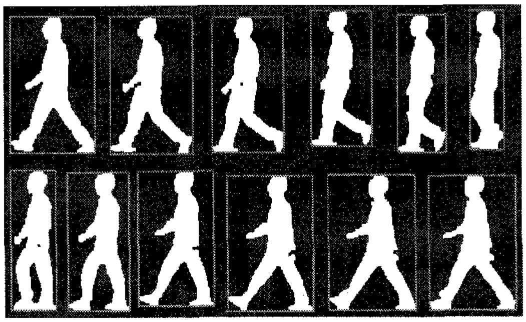
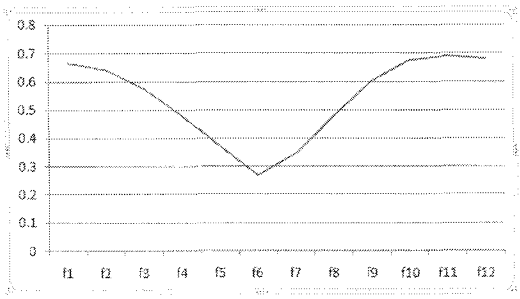


(c)



(d)

Fig. 13. The covariant of the ratio of silhouette width and silhouette height on one gait cycle of two objects, (a)(c) Detected object and boundary, (b)(d) The correspond graph on ratio of width and height

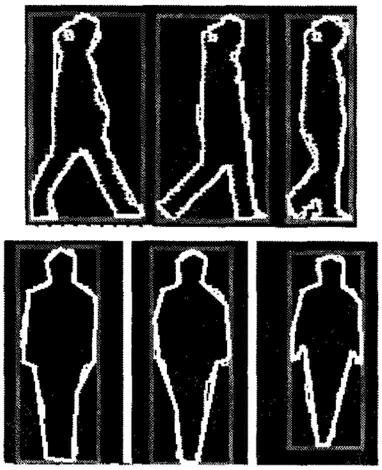


Fig. 14. Line boundary detection for perimeter calculation of 2 objects, white color is object edge, yellow color for object line boundary

Fig 15. Face detection results

Fig. 16. Training set.

Fig. 17. Average image

Fig. 18. Eigen face image.

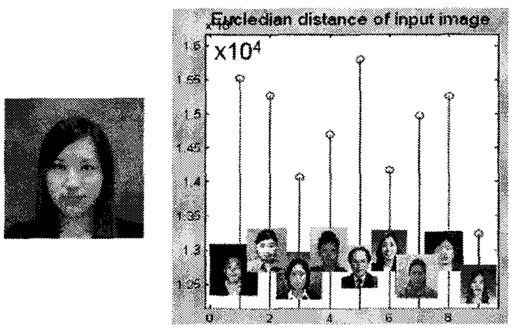


Fig. 19. Eucledian distance of input image to image in training set.

To show our propose algorithm quality, we separate the accuracy report into many parts include: walking direction, face detection, moving object detection and gait recognition. Object detection show the result of moving object detection process,

Table 1. Simulation Accuracy of Proposed Algorithm

	Number of Objects	Accuracy objects	Accuracy rate
Object Detection	50	48	96%
Walking direction	48	47	98%
Face recognition	20	17	85%
Gait recognition	27	24	88%

walking direction for the result of estimating frontal of side view and recognition phase result of face and gait.

7. CONCLUSION

We have presented a new method for human recognition by using the combination of face and gait features. Our method allows recognize an individual in both frontal-view and side-view. Depend on the view angle of the person who walked through the camera view. By using this combination, our propose method become one of the improvement of many human recognition algorithm, which just use only one feature. By using Haar-like features combine with skin color, this method can do well the face detection process. And also, gait speed, stride length, knee angle are good gait features for distance recognition. Therefore, our proposed algorithm can recognize human gait feature with any waking direction while another method just can apply on one direction. Future work will be focused on improvement of the performance and build a full system that can apply in the real environment.

ACKNOWLEDGMENT

This research was supported by the MKE (Ministry of Knowledge and Economy), Korea, under the U-Port ITRC (Information Technology Research Center) support program supervised by the IITA (Institute of Information Technology Assessment) (IITA-2008-C1090- 0801-0004).

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