7-2005

Multibiometrics based on palmprint and handgeometry

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Abstract

This paper described our approach of multibiometrics in a single image. Firstly, a new method for capturing the key points of hand geometry is proposed. Then, we described our new method of palmprint feature extracting. By using projection transform and wavelet transform, this method considered both the global feature and local detail of a palmprint texture and proposed a new kind of palmprint feature. We also proposed a twice segmentation method for handgeometry feature extraction. In the processing of feature matching, we analyzed the weakness of the traditional Euclidian Square Norm method, and introduced an improved method. The experimental results demonstrated the effectiveness and accuracy of these proposed method.

1. Introduction

Numerous distinguishing traits that have been used for personal identification include fingerprints, face, voice, iris, hand geometry and so on. Due to its stability and uniqueness, palmprint can be considered as one of the reliable means distinguishing a man from his fellows, and can be easily integrated with the existing identification system to provide enhanced level of confidence in personal identification.

Recent years, most of researches in biometrics have been focused on palmprint identification, and many approaches have been developed. According to the operating space in which palmprint features be extracted, those approaches can be categorized into spatial domain approaches ([5][6]) and frequency domain approaches [8]. According to the type of palmprint features, those approaches can be categorized into structural features-based approaches [5] and statistics features-based approaches [2].

For enhancing the accuracy of identification and reducing executive times of features matching, approach based on hierarchical structure was presented in [10]. Other approaches including K-L Transform-based in [11], Wavelet Transform-based in [12], Gabor Filter-based in [13] and Neural Network-based in [9], were also be developed.

Generally, these researches mainly focused on single biometric indicator. Single biometric indicators often have to contend with noisy sensor data, restricted degrees of freedom, non-universality of the biometric trait and unacceptable error rates. Therefore, Multibiometrics systems seek to improve the speed and reliability (accuracy) of a biometric system by integrating matching sources obtained from multiple biometric sources. However, in common multibiometric system, the users must undergo the inconvenience of using different sensors. Fortunately, palmprint and handgeometry image can be extracted from a hand image in a single shot. Therefore, we can build a multibiometric system by integrating palmprint indicator and handgeometry indicator. In 2003, Ajay etc. did this thing for first time in [2]. In our experiment, their approach was be implemented. But the result is not perfect enough. So this paper developed a set of our new features extracting approaches of palmprint and handgeometry. Especially to the palmprint features extracting approach, it is utterly different from previous approaches.

This paper is organized as follows. In Section 2 we introduce the image preprocessing used in this paper. The features extracting approaches, including our new palmprint features extracting method and improved handgeometry features extracting method, are described in depth in Section 3. Section 4 will introduce our features matching method. The experimental results obtained are described in both Section 5 and Section 6 while Section 7 contains the discussion and conclusions.

2. Image Preprocessing

2.1 Direction Alignment

The objective of direction alignment is to rotate all the hands into same direction. Ajay used an ellipse fitting based method to do this [2]. But the result of this method is sensitive to the captured wrist length and degrees of fingers opening. Han presented a wavelet-based method of alignment in [3], which search the corners along the outline of handgeometry and use these corners to do the alignment. However, the threshold value according to which corner points are classified is hardly to automatically choose. Based on above consideration, we designed a new hand image alignment method based on morphological operations as following.

By observing the hand image, we can find that the interval space between fingers except thumb forms three headstand triangle regions. There are three corner points (we called key points) exactly locate at the peaks of the triangles. Because their relative location is comparatively steady, these key points can be used as the reference point for the alignment operations.
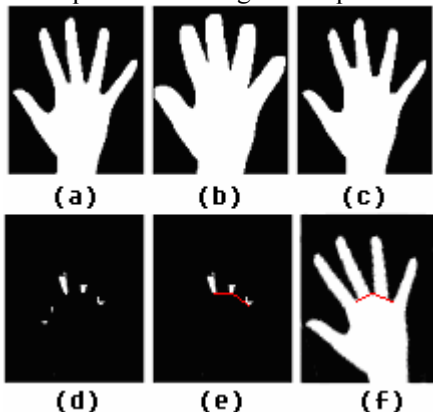

Fig 1: Get the triangle regions from binarized source hand image
(a) Binarized source hand image, (b) Dilated image, (c) Eroded image, (d) Triangle regions, (e) Connect the key points, (f) Rotate the source image

In our alignment method, there are three main steps. Step1: By using an array SE (known as structuring element) to dilate the binarized source hand image, a webbing will be added to the outline of source image, and some part of the triangle regions will also be filled (Fig 1b). Step2: The same SE in Step1 will be used again to erode the dilated hand image to cut off some webbings added in Step1(Fig 1c), because some parts of triangle regions have jointed with the fingers, the jointed parts will not be cut off. Step3: Subtracting source hand image from the result image obtained by

step2 will result in some parts of triangle regions (Fig 1d). It is obviously easy to get the key points now. The whole processing can be formulated as fellow:

$$T \arg et = (G \oplus SE) \Theta SE - G \qquad (1)$$

where G is the binarized source hand image and SE is structuring element.

After getting the headstand triangle regions, the pecks of each triangle regions are exactly the key points. Finally, as shown in Fig 1(f), we rotate the source image to normal orientation according to the relative location of key points. This method of alignment is simpler to be understood and faster than the methods in [2] and [3].

2.2 ROI Generation

To compute the region of interest (ROI), we can use key points obtained form 2.1 as reference points. By connecting the leftmost key point and the rightmost corner point, we can get a line as horizontal coordinate axis. Then draw a vertical line from the middle key point to horizontal coordinate axis, the cross point will be used as origin. After established above coordinate system, we can extract a rectangle region as ROI. A perfect ROI shall avoid the creasy region at thumb root and callus region at other fingers' root. As shown in Fig 2, it is obviously that the ROIs from same class (person) are accurately resembled each other in relative location of source image.

3. Feature Extraction

3.1 Extraction of Palmprint Features

In many papers, the position and orientation of palmprint lines are usually used as the features of palmprint (e.g., in [5][6]). Line matching methods are employed in these papers to do the verification. But skin of palm is too soft to endure extrusion. So non-linear transform of palmprint lines are inevitable and line matching methods are all sensitive to it. Instead of accurately characterize these palm lines, another method divides the palmprint image into a set of n smaller sub-regions, then calculates the mean and standard deviation of each sub-region as the palmprint feature (as in [2]). Consider with different sub-regions, which have different texture, only if they have approximate image histogram, their standard deviation would be same. Using only standard deviation as feature and ignoring relationship of each line's position will result in classes' unreasonably distributing in eigenspace. So we designed a new method that
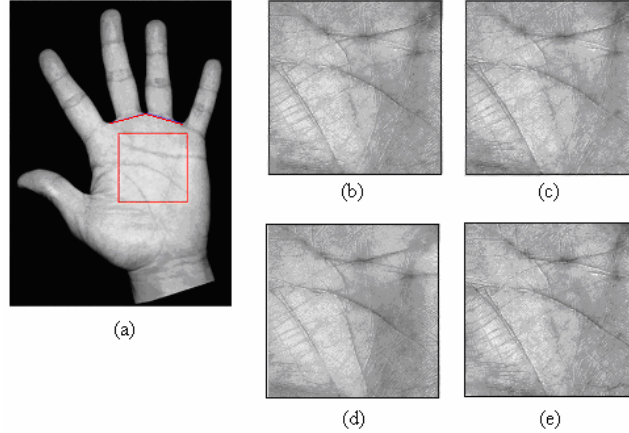
Fig 2: ROI Generation, (a) Key points' connected line and ROI rectangle, (b)(c)(d)(e) Captured ROIs from same class, ClassID=23 and SampleID=237,238,239,240
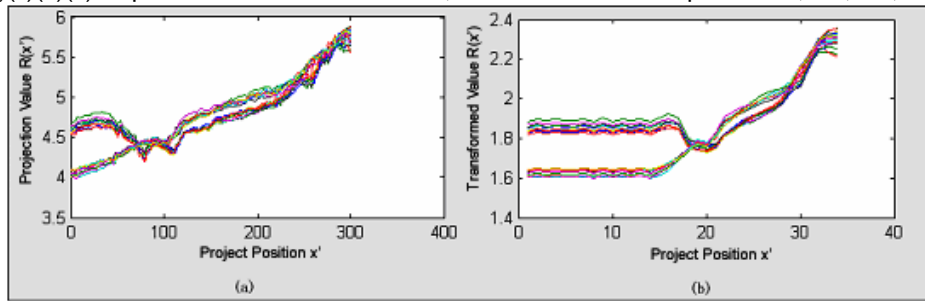

Fig 3: Classify capacity visualization, (a) Vp0 after projection transform, (b) DWTVp0 after DWT (b) Image transformed to coordinate system (x', y'), (c) Image projected to x'

considered both palm lines and their relative position to improve the performance of matching.

Firstly, use four line detectors (Masks) to detect lines oriented at 0°, 45°, 90° and 135° in ROI image.

$$G_i = G * Mask_i \quad \text{i=0,1,2,3} \quad (2)$$

where G is the ROI image and $Mask_i$ is line detector of different direction. With this operation, the lines with different orientation but blending in same ROI image can be separated into four images G_i. Then we transform the four G_i with projection transform:

$$R_\theta(x^{'}) = \int_{-\infty}^{\infty} G_i(x^{'}, y^{'}) dy^{'}$$

i =0,1,2,3 while θ =0,45,90,135

$$\text{where} \begin{pmatrix} x^{'} \\ y^{'} \end{pmatrix} = \begin{pmatrix} \cos\theta & -\sin\theta \\ \sin\theta & \cos\theta \end{pmatrix} \begin{pmatrix} x \\ y \end{pmatrix} \quad (3)$$

Our projection transform compute the image's linear integral at certain orientation for each x'. The coordinate of x' hold good representation of each line's position and value of $R_\theta(x^{'})$ can also represent the length of certain line at x'. After this transformation, G_i will be transformed to $R_0(x^{'})$, $R_{45}(x^{'})$, $R_{90}(x^{'})$ and $R_{135}(x^{'})$. They are four one-dimensional vectors of different length, which can be stored as Vpi, i=0, 1, 2, 3.

For having a visualized impression of the classification capacity these vectors attributed to, Fig 3 (a) has plotted Vp0, which from 20 samples of 2 classes (10 per class), in same figure. It is easily to see that 20 curves congregated into 2 bunches (10 per bunch). This is exactly corresponding to the fact that 20 samples are from 2 classes. Obviously, Vpi have powerful capacity of classify. However, we must notice that Vpi contains overfull details, which are disadvantage factors to the processing of feature matching. To solve that problem, we use DWT (known as Discrete Wavelet Transform) to do twice decompositions with Vpi. In the processing, wavelets Daubechies-9 is employed. Four transformed vectors obtained from this operation can be stored into DWTVpi as the features of a palmprint. We also plotted DWTVp0 in Fig 3(b) as a comparison. As you seen, transformed vectors DWTVpi have lesser details but better classification capacity than Vpi.

3.2 Extraction of Handgeometry Features

The research of handgeometry has evolved for a long time. But previous papers mainly discussed how to get handgeometry features in the environment that hand have been properly placed on the platen [1,7]. In

that environment, anchor points or pigs were used to aid placement. However, these pegs will lead to distortion of finger skin. So an environment, which has no anchor points and on which hand can be freely placed, will be better. Our experimental environment is exactly a good one. In previous processing, we have obtained three key points. By connecting each key point and prolonging the connected lines, a hand will be segmented into five parts which contains four fingers and remainder part of hand (as in Fig 4-a). We called this operation as Coarse Segmentation. But in Coarse Segmentation, forefinger and little finger was not be perfectly segmented. To get a perfect segmentation, we firstly use ellipse-fitting method [4] to compute the orientation of forefinger and little finger extracted from Coarse Segmentation, and then draw the computed orientation's vertical line from the key points to do a secondary segmentation that we called Refined Segmentation (as shown in Fig 4-c).
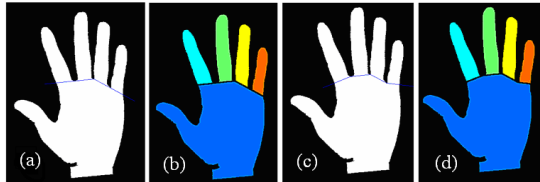

Fig 4: Segmentation of Handgeometry
(a) Coarse segmentation, (b) Result of coarse segmentation, (c) Refined segmentation, (d) Result of refined segmentation

From final segmented image, there are many features can be chose. Commonly, 16 features were used; 4 finger lengths, 8 finger widths (2 widths per finger), palm width, palm length, hand area and hand length (as in [2]). However, in the processing of direction alignment, we can find the relative position of three key points is comparatively steady. Therefore, in our method, the 2 lengths of connecting line and 1 angle between two connecting line were selected as features of handgeometry. So we got a one-dimensional features vector of handgeometry stored in Vh of length 18(hand length is discarded in our experiment).

4. Matching and Information Fusion

To measure the similarity of two vectors, Euclidian Square Norm (distance score) was widely employed in many applications(as in [1]). However, simplicity Euclidian Square Norm dose not considers the inner distribution density of a class. In our approach, we supposed that each class distributed in eigenspace as super sphere. By using appropriate training set, we can get the diameter (as D_k) and centroid(as template vector VC_k) of a super sphere of class k. To get the similarity of a test vector data (as VT) and claimed class k, we

firstly compute the Euclidian distance between test vector and the claimed class' centroid(VC_k), then use computed Euclidian distance divide the 10* D_k, the result of division will indicate the dissimilarity of test vector data and certain class k. This processing can be formulated as:

$$S_k = 1 - DS_k = 1 - \|VT - VC_k\| / 10 D_k \quad \textbf{(4)}$$

where DS_k denote the dissimilarity of test vector data and claimed class k and S_k denoted the similarity of test vector data and claimed class k. In the processing of computing, negative value will occur when the distance between VT and VC_k. This situation means VT and VC_k are utterly dissimilar. We can simply set the negative Sk to zero. This formulation has considered both distance and inner distribution density. Apply it to palmprint and handgeometry feature vectors (DWTVpi and Vh), we can get 4 dissimilarities of palmprint (as αi) and 1 dissimilarity of handgeometry (as β). To get a final similarity score between test data and claimed class, weighted mean is employed in our approach. In fusion of 4 palmprint dissimilarities, considering the weightiness of different orientation (e.g. in left hand, most of palm lines tend to 135°, so DWTVp3 has higher weightiness than other orientations), each orientation feature vector will be given a weigh value w_i. This rule can also be used in fusion of palmprint similarity and handgeometry similarity.

5. Experimental Results

In our experiment, the scanner reformed by us is employed [4]. To establish an experiment images database, we have collected 516 images of palmprints from 51 individuals with both sexes and different ages. The resolution of the original palmprint images is 768×1024 pixels. After use method of 2.1 to do direction alignment, we also get a ROI (size 290×290) per image.

5.1 Results of Features Extraction

For a class, by using the max difference of same feature between different samples to divide the mean value of that kind of handgeometry feature, we can get a percentage to estimate the inaccuracy degree of acquiring of that kind of feature. As shown in Table 1, this percentage can be controlled into [0.5%, 3.0%]. It indicated the successful performance of our handgeometry feature extraction method. By using method of 3.1, we get Vpi of each palmprint and then use wavelet Coiflets5 transforms them to DWTVpi with 5 times decomposition. Because the data is too

Table 1: Results of handgeometry feature extraction

| Cls ID	Sam ID	Forefinger			Middle Finger			Ring Finger			Little Finger			Palm Wid	Palm Hei	Palm Area	Angle	Len 1	Len 2
		Len	Wid 1	Wid 2	Len	Wid 1	Wid 2	Len	Wid 1	Wid 2	Len	Wid 1	Wid 2						
3	13	354	60	74	393	74	77	366	69	72	254	55	65	344	442	150623	146	115	107
	14	354	61	74	391	70	76	365	67	71	253	54	65	331	443	143031	145	117	110
4	23	328	61	70	363	64	67	351	62	65	236	46	48	354	441	152039	154	114	112
	24	325	59	68	364	64	66	353	62	63	241	49	53	353	444	152672	155	108	115
5	33	314	46	55	346	51	54	339	51	53	252	34	45	310	398	119454	147	93	98
	34	312	47	55	344	50	56	331	51	55	246	34	45	308	395	118041	147	92	98
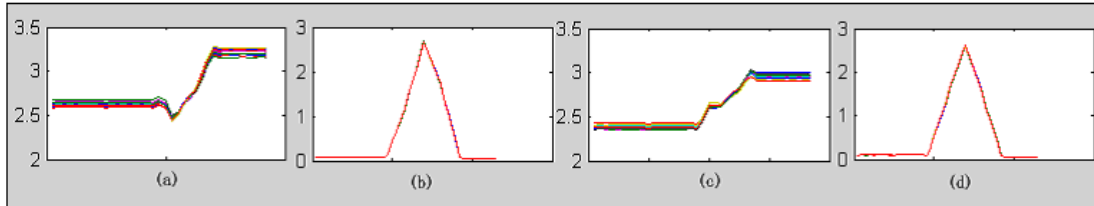
Fig 5: Feature extraction of palmprint: (from 10 samples of same class) (a) Curves Set of DWTVp0, (b) Curves set of DWTVp1, (c) Curves set of DWTVp2, (d) Curves set of DWTVp

Table 2: Test of classification capacity of different wavelet

Wavelet	Decom. Times	Accuracy %	Wavelet	Decom. Times	Accuracy %	Wavelet	Decom. Times	Accuracy %
Coiflets 5	2	95.44	Daubechies 1	2	95.39	Symlets 3	6	97.93
Coiflets 5	3	97.18	Daubechies 1	3	97.09	Symlets 3	7	96.95
Coiflets 5	4	97.13	Daubechies 1	4	97.37	Symlets 3	8	95.82
Coiflets 5	**5**	**98.36**	Daubechies 9	3	97.51	Symlets 4	3	97.42
Coiflets 5	6	98.07	Daubechies 9	4	97.46	Symlets 4	4	97.37
Coiflets 5	7	97.13	Daubechies 9	5	97.98	Coiflets 3	2	95.49
Coiflets 5	8	96.10	Daubechies 9	6	98.07	Coiflets 3	3	97.51

complex, we plotted them into Fig 5 to analyze the accuracy of acquiring palmprint features.

As shown in Fig 5, each curves overlapped well into 4 bunches. It indicated that the stability of extracting each features could be perfectly controlled.

5.2 Classification Capacity of Wavelet

We define max accuracy rate of palmprint verification based on certain wavelet and certain decomposition times to evaluate the classification capacity of a certain solution. In our experiment, 21 wavelets of Daubechies 1~9, Symlets 2~8 and Coiflets 1~5 were tested. Part of results are shown in Table 2. Obviously, Coiflets 5 with 5 decompositions will be a better solution.

6. Verification and Identification

6.1 Verification of One to One

In our experiment, we implemented 4 verification system: (1) handgeometry, (2) palmprint, (3) Multibiometrics with handgeometry and (4) Ajay's palmprint verification system in [2] as comparison. To get the FRR and FAR of each system, 133386(516×515/2+516) times verification will be

executed on each of them. We plotted their ROC curves in Fig 6.

From the figure, it is seemed that our approach is performed better than the method in [2] and system (3) have the best result. To get a more accurate comparison, Table 3 shows detailed digital comparative data stand on three different views: equal error rate view, total minimum error view and max accuracy view (defined in 5.2).

6.1 Identification of One to Many

We also used system (1)(2)(3) to do 40320(516×51) times identification test. The threshold of similarity from 0 to 1, which can determine acceptance or rejection, had be tested in each system and record the accuracy of classification at each threshold. The result was shown in Fig 7. The accurate rate is (1) 91.18%, (2) 98.04%, (3) 99.36. It also indicated that a multibiometric system fusion palmprint features and handgeometry features can improve the performance of the biometric system based on single indicator.

7. Conclusion and Future Work

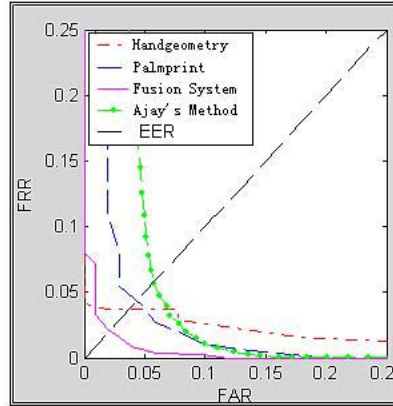We have presented an approach for multibiometrics identification. In our approach, a simpler and faster
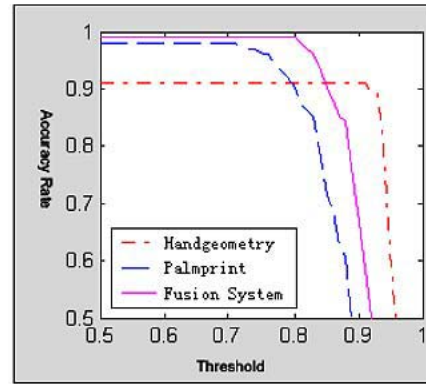
Fig 6: ROC of each verification systems   **Fig 7: Accuracy of each verification systems**

Table 3: Compare verification systems on different views

System	EER			Total minimum error				Max accuracy view
	threshold	Error rate	Accuracy	threshold	FAR	FRR	Accuracy	
(1)	0.7700	0.0441	95.98	0.7600	0.0294	0.0545	95.98	98.14
(2)	0.9100	0.0283	96.47	0.9000	0.0000	0.0414	96.27	96.86
(3)	0.8100	0.0207	98.82	0.8400	0.0588	0.0033	99.12	99.12
(4)	0.4900	0.0559	0.9440	0.5200	0.0715	0.0316	96.70	99.04

direction alignment method based on morphology is executed. Then we take advantage of the key points captured in the alignment processing to get the ROI. With the ROI, a new method of palmprint feature extraction has been proposed. We have also described a twice segmentation based method of handgeometry feature extraction, which effectively utilized the key points too. And then, we presented a new method of similarity measurement, which has considered the inner distribution density of each class.

However, these results may be biased by the small size of the data set. If more subjects are added, one should expect some overlap due to similar palms of different persons. To investigate this matter further, additional data will be collected. But accompanied by the increasing size of database, execution speed will be paid more attention. Some methods based on decision tree should be attempted to optimize the performance.

Acknowledgements

Reference

[1] Arun Ross, Anil Jain, "Information fusion in biometrics", Pattern Recognition Letters 24(2003) 2115-2125

[2] Ajay Kumar, David C.M Wong, Helen C.Shen, Anil Jain, "Personal Verification using Palmprint and Hand Geometry Biometric", AVBPA 2003: 668-678

[3] Chin-Chuan Han,Hsu-Liang Cheng,Chih-lung Lin,Kuo-Chin Fan, "Personal authentication using palmprint features", Pattern Recognition 36(2003) 371-381

[4] Wei Xiao-yong, Xu Dan,Yuan Guo-wu, "Research of Preprocessing in Palmprint Identification", The 13th national conference on multimedia technology (NCMT), Ningbo, China, pp155-164, Oct. 2004

[5] G.M.Lu, D.Zhang, and K.Q.Wang, "Palmprint recognition using eigenpalms features", Pattern Recognition Letters, vol. 24 pp. 1463-1467, 2003

[6] N.Duta, A.K.Jain, and Kanti V.Mardia, "Matching of palmprint", Pattern Recognition Letters, vol. 23, no. 4, pp. 477-485, Feb. 2002

[7] A.K.Jain, A.Ross, and S.Pankarti, "A prototype hand geometry based verific ation system, Proc.2nd Intl. Conf.Audio Video based Biometric Personal Authentication, Washington D.C., pp.166-171, Mar.1999

[8] W.Li, D.Zhang, and Z.Xu, "Palmprint identification by Fourier transform", International Journal Pattern. Recognition and Artificial Intelligence, vol. 16, no. 4, pp. 417-432, 2002.

[9] C.-C.Han, H.-L.Cheng, C.-L.Lin and K.-C.Fan, "Personal authentication using palm-print features", Pattern Recognition, vol. 36, pp. 371-381, 2003.

[10] J.You, W.Li, and D.Zhang, "Hierarchical palmprint identification via multiple feature extraction", Pattern Recognition., vol. 35, pp. 847-859, 2002.

[11] G. M. Lu, D.Zhang, and K.Q.Wang, "Palmprint recognition using eigenpalms features", Pattern Recognition Letters, vol. 24, pp. 1463-1467, 2003.

[12] A.Kumar and H.C. Shen, "Recognition of palmprints using wavelet-based features", Proc. Intl. Conf. Sys., Cybern., SCI-2002, Orlando, Florida, Jul. 2002.

[13] W.K.Kong, D.Zhang, and W.X.Li, "Palmprint feature extraction using 2-D Gabor filters", Pattern Recognition, vol. 36, pp. 2339-2347, 2003.

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