A New Method Based on Wavelet Packet Transformation in 3D Face Feature Extraction

Yiyi Xu [1, a],Hong Liu [1,b] and Jun Zhao [1,c]
1 Guangxi University of Science and Technology, Liuzhou, 545006, China
[a]winxyy@qq.com, [b]chpliu@aim.com [c]zhaojun@163.com

Keywords: 3D face feature extraction; compression; Wavelet packet transformation;large-scale data set.

Abstract. Transition from 2D to 3D in face pattern recognition in order to seek richer human face information but feature extraction as an important step among them can be seen as information compression. Obviously the two are contrary. For the fast effective locate and extract features in the large-scale 3D face data set, the highly effective digital compression computation becomes very important. This paper study a feature extraction method based on the wavelet packet transformation compression, proposed the specific method and the principl.When the actual data which distributed in 2D or higher dimensional projection space disobeyed assuming require or sample parameters inaccurate estimated ,it cannot be correctly classified drawbacks or be correctly classified. Our experiment is indicated that our method can not only conquer this disadvantage but also meet the actual demand at the processing time. The experiment is indicated that our method towards3D face feature extraction data sets compress processing is effective and feasible.

Introduction

The wavelet theory is rapidly expanded to be a new mathematical theory and method in the recent several years, but the wavelet analysis is rapidly expanded emerging disciplines in the nearly more than ten year. It simultaneously has the double meaning that the theory is profound and the application is very widespread. The wavelet packet theory is developed from the foundation of wavelet theory, which has overcome flaw and the insufficiency that the wavelet transformation in high frequency signal or the signal's high-frequency component frequency resolution low [1].In the 3D face extract ,large scale feature data sets must be compression which has the high request to the compression efficiency and the compression quality. As a result of digital image including massive information content, moreover increases along with the resolution increases suddenly, this gave the image without doubt the memory and the transmission has brought the difficulty. For the information memory and the transmission, the highly effective digital compression computation becomes very important.

But in the practical application, we are always interesting in the specific region, the special time or the frequency range section's signal; therefore we hoped to enhance resolution in these place that is interested. The wavelet analysis has been meeting this kind of requirement, and it carries on the frequency band to divide the multi-level[2]. The resolution analysis did not decomposed high-frequency unit decomposed in further, and auto-adapted to select the corresponding frequency band according to the characteristic which is analyzed, caused this to match with the signal frequency spectrum, thus raises the time-frequency resolution. Therefore, the wavelet packet has widespread application value.

The developing process wavelet packet analysis theory

Wavelet packet theory is developed from the foundation of wavelet theory, which has overcome flaw and the insufficiency that the wavelet transformation in high frequency signal or the signal's high-frequency component frequency resolution low [3].For the information memory and the transmission, the highly effective digital compression computation becomes very importan.But in the practical application, we are always interesting in the specific region, the special time or the frequency range section's signal, therefore we hoped to enhance resolution in these place that is interested. The wavelet analysis has been meeting this kind of requirement. Many research show the wavelet packet function is the promotion of wavelet function [4].Wavelet packet decomposition and restructuring algorithm will now be givenlet n be the negative binary integer , $n=\sum_{i=1}^{+\infty}\varepsilon_i 2^{i-1}$, $\varepsilon_i = 0or1$ then the wavelet packet function $u_n(t)$'s Fourier transformation nation is given by the equation below：

$$\hat{u}_n(\omega)=\prod_{i=1}^{+\infty} m_{\varepsilon_i}(\frac{\omega}{2^i}),. \tag{1}$$

where, $m_0(\omega)=H(\omega)=\frac{1}{2}\sum_{k=-\infty}^{+\infty}h_k e^{-ik\omega}$, $m_1(\omega)=G(\omega)=\frac{1}{2}\sum_{k=-\infty}^{+\infty}g_k e^{-ik\omega}$ (2)

It suppose $\{u_n(t)\}_{n\in Z}$ is orthogonal cscale function $\phi(t)$ under has the orthogonal wavelet packet, then $<u_n(\cdot-k),u_n(\cdot-l)>=\delta_{k,l}$, namely $\{u_n(t)\}_{n\in Z}$ constitution the standard orthogonal basis of $L^2(R)$.

In the multi-resolution analysis, uses the above definition and property, and supposes:

$$W_j=U_j^1=U_{j-1}^2\oplus U_{j-1}^3, U_{j-1}^2=U_{j-2}^4\oplus U_{j-2}^5,\ U_{j-1}^3=U_{j-2}^6\oplus U_{j-2}^7, \tag{3}$$

Then we can obtain the wavelet subspace W_j which can be decomposing as follows:

$$W_j=U_{j-1}^2\oplus U_{j-1}^3 \tag{4}$$

$$W_j=U_{j-2}^4\oplus U_{j-2}^5\oplus U_{j-2}^6\oplus U_{j-2}^7 \tag{5}$$

$$W_j=U_{j-2}^{2^k}\oplus U_{j-2}^{2^k+1}\oplus\cdots\oplus U_{j-2}^{2^{k+1}-1} \tag{6}$$

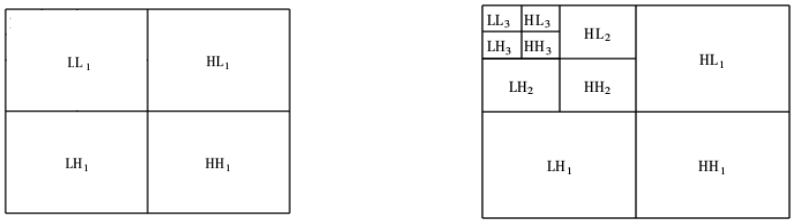
$$W_j=U_0^{2^j}\oplus U_0^{2^j+1}\oplus\cdots\oplus U_0^{2^{j+1}-1} \tag{7}$$

W_j Space decomposes the subspace sequence may write $U_{j-l}^{2^l+m}, m=0,1,\cdots 2^l-1; l=1,2,\cdots; j; j=1,2,\cdots$, standard orthogonal basis of the subspace sequence $U_{j-l}^{2^l+m}$ can be writen as $\{2^{-\frac{j-1}{2}}u_{2^l+m}(2^{j-l}t-k);k\in Z\}$. It's easy to see that an $l=0,m=0$, the subspace sequence $U_{j-l}^{2^l+m}$ are simplified as $U_j^1=W_j$, the corresponding orthogonal basis are simplified as $2^{-\frac{j}{2}}\psi(2^{-j}x-k)$, which exactly are standard orthogonal basis bunch $\{\psi_{j,k}(x)\}$.

If n is an octave thin division parameter, namely let $n=2^l+m$, and defines the wavelet packet the briefly written as $\psi_{j,k,n}(t)=2^{-\frac{j}{2}}\psi_n(2^j t-k)$. and $\psi_n(t)=2^{\frac{l}{2}}u_{2^l+m}(2^l t)$, $\psi_{j,k,n}(t)$ is called scales index j, position index k and the frequency index n of wavelet packet.Defines the function $\psi_n(t)$ which produces by the function bunch $\psi_{j,k,n}(t)$ (and $n\in Z_+$; $j,k\in Z$;) is called sheaf of functions which constructs by the scale function $\phi(t)$. Then,for each j= 0,1,2…, $L^2(R)=\oplus_{j\in Z}W_j=\cdots\oplus W_{-1}U_0^0\oplus W_0U_0^1\oplus U_0^2\oplus U_0^3\oplus\cdots$,Where $\psi_{j,k,n}\ \big|\ j=\cdots,-1,0; n=2,3,\cdots$, and $k\in Z$ is an orthogonal basis of $L^2(R)$.

After fig.1 is carries on the third-level young Pood criterion decomposes the result, LL_3 is the low frequency component; HL_i is the vertical edge detail; LH_i is the horizontal edge detail; In HH_i correspondence 45° ,135° direction detail (i=1,2,3,).

The wavelet packet's decomposition algorithm is as simply showed as follows:



a. The first layer of wavelet decomposition b. The third layer of wavelet decomposition

Fig1. Level tower system wavelet decomposition

By $\{d_l^{j+1,n}\} get\ \{d_l^{j,n}\} and \{d_l^{j,2n+1}\}$, (8)

$$d_l^{j+1,2n} = \sum_k h_{k-2l} d_k^{j+1,n} \tag{9}$$

$$d_l^{j,2n+1} = \sum_k g_{k-2l} d_k^{j+1,n} \tag{10}$$

wavelet packet restructuring algorithm:

by $\{d_l^{j,2n}\} and \{d_l^{j,2n+1}\} obtain \{d_l^{j+1,n}\}$ (11)

$$d_l^{j+1,2n} = \sum_k (h_{k-2l} d_k^{j,2n} + g_{l-2k} d_k^{j,2n+1}) \tag{12}$$

3D face Feature extraction Based on wavelet packet

When the wavelet packet carries on the 3D face feature extract, it must choose a quite good wavelet packet base, uses for to express the signal the characteristic. In order to select a quite good wavelet packet base, first assigns a sequence the cost function, then seeks in all wavelet packet base causes the cost function smallest base, assigned the vector regarding one, the minimum cost was the most effective expression, this base was called optimal base. Cost function and optimal base's selection method as follows [5]:

Cost Function

The cost function may define as the sequence real function M, but most practical is that which can survey the concentration degree the additivity cost function M.

The additivity is refers to, if, $M(0) = 0, M(\{x_i\}) = \sum_i M(x_i)$ M is called a additivity information cost function. Commonly used cost function including several kinds as followed:

(1) Bigger than some threshold the integer, namely initializes a random threshold $\varepsilon > 0$ and calculates the element integer ε which in the sequence the absolute value x is bigger.

(2) Basis's $l^p, p < 2$ norm's denseness, namely chooses one to count $p < 2$ and to make the $M(x) = \|\{x_i\}\|_p$.

(3) Information entropy willfully, namely the definition sequence's $x = \{x_j\}$ Shannon-Weaker entropy is $M(x) = -\sum_j p_j \log p_j$, where $p_j = \frac{|x_j|^2}{\|x\|^2}$ and $p = 0$. (attention: the information entropy only satisfies half additivity) .

(4) The logarithm entropy, namely ommand $M(x) = \sum_j \log |x_j|^2, \log 0 = 0$.

Optimal base's selection Method

Supposes $x = \{x_j\}$ for the space vector V, records B for an orthogonal basis which selects from the storehouse. B_x is x under B base's coefficient, for $x \in V$, if $M(Bx)$ smallest, B is the optimal base. If the orthogonal basis storehouse satisfies the following condition:

1. The base vector composition's subset equates in the nonnegative integer collection N has the following form sector:

$$I_{nk} = [2^k n, 2^k (n+1)]; k \in Z, n \in N \tag{13}$$

2.In storehouse's each base corresponds to one N by I_{nk} is composed cover which does not intersect.

3. If V_{nk} equates I_{nk}, so $V_{2n,k} \oplus V_{2n+1,k}$ .Then we said that this orthogonal basis storehouse is a dual tree structure. If the storehouse is a tree, then may through to the induction found the optimal base. Records $B_n k$ is corresponds to $I_n k$ the vector base, $A_{n,} k$ is limited to x the span B_n optimal base. For $k = 0$, existence single base, immediately most superior base $I_{n,0}$, this time $A_{n,0} = B_{n,0}$ to all $n \geq 0$ establishment. Presently to $n \geq 0$ constructs $A_{n,k+1}$ as follows:

$$A_{n,k+1} = \begin{cases} B_{n,k+1}, M(B_{n,k+1}(x)) < M(A_{2n,k}(x)) + M(A_{2n+1,k}(x)) \\ A_{2n,k} \oplus A_{2n+1,k}, else \end{cases} \tag{14}$$

So long as we satisfies about the cost function M orthogonal basis $A(x)$ which above equation the algorithm produces x namely for the optimal base.

Experimental result

We use the different valve value to carry on the compression to the face image experimental result as shown in Table 1, After different valve value processing image:

Table 1.Under different decomposition level image compression ratio

Decomposition level	Threshold value	Before (kb)	After (kb)	Compression ratio(%)
2	40	680	353	53.3%
2	80	680	366	55.2%
3	40	680	353	44.9%
3	80	680	370	50.0%

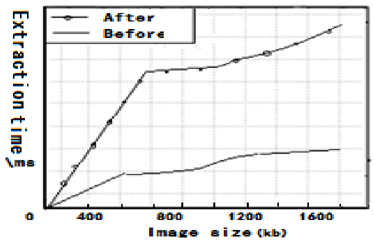


Figure2. Extraction time comparison diagram

We may know through the table 1 , under the different decomposition level, valve value's enlargement, the image compression ratio also increases, human eye obvious feeling image distortion.The method has good performance in improving the speed of extracting feature information, has good adaptive ability, enhance the overall performance as shown in Figure 2.

Acknowledgements

This work was financially supported by Guangxi Natural Science Foundation (2013GXNSFBA019268) , Guangxi Department of Education general project (YB2014208), Guangxi Department of Education established projects (LX2014182)

References

[1] Kim W, Suh S, Hwang W, et al. SVD Face: Illumination-Invariant Face Representation[J]. Signal Processing Letters, IEEE, 2014, 21:1336 - 1340.

[2] Coifman R R, Meyer Y, Wickerhauser V. Wavelet analysis and signal processing[C]//In Wavelets and their Applications. 1992.

[3] Xie X, Jin G, Ye T, et al. Free vibration analysis of functionally graded conical shells and annular plates using the Haar wavelet method[J]. Applied Acoustics, 2014:130–142.

[4] Deng J, Ban Y, Liu J, et al. Hierarchical Segmentation of Multitemporal RADARSAT-2 SAR Data Using Stationary Wavelet Transform and Algebraic Multigrid Method [J]. Geoscience and Remote Sensing, IEEE Transactions on, 2014, 52:4353 - 4363.

[5] Khoh W H, Ong T S, Pang Y H, et al. Score level fusion approach in dynamic signature verification based on hybrid wavelet-Fourier transform[J]. Security and Communication Networks, 2014, 7:1067–1078.