A wavelet and metric indexing approach for content-based two-dimensional signal retrieval.

Marcelo Franceschi de Bianchi,
Rodrigo Capobianco Guido, Thais Lorasqui Escarpa
Paula Padovan, Vladisa S. Ramos,
Reinaldo Masuko, Wellington F. Bastos
Núcleo de Estudos de Computação, Centro Universitário do Norte Paulista, UNORP,
R. Ipiranga 3460 - Jd. Alto Rio Preto - 15020-040 - São José do Rio Preto - SP - Brazil.
E-mail: nec@unorp.br

Abstract

This work describes an efficient algorithm for content-based image retrieval based on discrete wavelet transform (DWT) filter banks and Euclidian distance operator, an ordinary criterion for distance measurement. The former is used to turn the query image into a signature-vector, a compressed frame which holds the main features of the original data, and the latter is used to calculate the lowest distance between the query signature-vector and all the signature-vectors stored in the data base, each one related to a particular image. Interestingly and according to the tests, we have found that, for one particular query, the worse the frequency response of the filter bank used for compression is, the better the classification is, 96.73% being the best accuracy we have reached. The system's input consists of a query image and its output corresponds to the most similar image found in the data-bank, according to the distance criterion adopted.

1 Introduction

So much literature has appeared recently describing algorithms for content-based image retrieval [1], [2], [3], a widely explored technique used for security, personal identification and so on. This work presents a novel algorithm for this purpose based on Euclidian distance operator [1] and Discrete Wavelet Transform (DWT) [4], [5], [6], [7].

The system's input, a black-and-white query image, is compared with all other black-and-white images stored on the data base by means of the Euclidian distance operator. Mainly, the data base stores only a signature vector for each image instead of the actual images. Each vector, obtained by using a DWT, consists of a compressed version of each image so that the search delay is optimized. We have tested different DWTs and different facial expressions. The accuracy in the results is over 96 % with a so simple algorithm which has linear order of complexity. The implementation uses MATLAB 7.0 running under Windows operating system.

The remainder of this paper is comprised of 3 sections. Section 2 describes the proposed algorithm for image retrieval. Section 3 lists the tests and results. The conclusions are described in section 4, followed by the acknowledgments and references.

2 The Proposed Procedure

Table 1 completely describes the proposed algorithm. All the subjects used are black-and-white images, 256 gray levels, 128 x 128 pixels of resolution. There are two data bases of signature vectors, $DB1$ and $DB2$. The former, the query data base, consists of 32 image signatures, each one for one different person. The latter contains 153 image signatures regarding different face expressions, images contaminated with Gaussian noise [8] and 10-degrees rotated images from the 32 above-mentioned persons' faces.

3 Tests and Results

The algorithm produces the results summarized in table 2. Figure 1 illustrates some particular results. The first and second lines show the retrieval of different facial expressions. The third line contains a query image contaminated with Gaussian noise. The next two contain rotated query images. Only the last example shows a failure so that the system's output corresponds to someone else's face.

———————————————————————

- BEGINNING
- *Step S-1:* Assure that all the images from $DB1$ and $DB2$ are normalized according to the above-mentioned conditions (128 x 128 pixels, 256 gray levels, black-and-white);
- *Step S-2:* Generate and store the signature vectors for all the images of $DB1$ and $DB2$. Each vector consists of the *trend* part [4] of the wavelet transform of the image so that the signature length varies according to the level of the wavelet transform applied to the data. The tests are performed by using a j-level of the DWT_x, according to the table 2;
- *Step S-3:* Input the query image signature vector, q.
- *Step S-4:* For each wavelet x in table 2:
  - *Step S-4-1:* For levels $j = 1$ to 3, according to table 2:
    - *Step S-4-1-1:* For images $i = 1$ to 153 from $DB2$:
      - *Step S-4-1-2:* $distance[x][j] \leftarrow Euclidian(q, i)$;
- *Step S-5:* The lowest value in vector $distance[][]$ corresponds to a particular image in $DB2$, that is the system's output.
- END.

———————————————————————

Table 1: The complete algorithm for image retrieval where $Euclidian(a, b) = \sqrt{(a-b)^T(a-b)}$ corresponds to Euclidian Distance between the vectors a and b;

4 Conclusions

We have proposed a simple algorithm for content-based image retrieval that uses the Discrete Wavelet Transform and Euclidian distance operator. According to the tests the best decomposition level and wavelet to this purpose is the 1-level Haar wavelet. It indicates a compression rate [9] of 50% between the original images and the corresponding signature vectors.

An interesting open discussion regarding this result: as the filter nears the ideal, the image retrieval worsens. It may indicate that the higher frequencies are important to the selection since the Haar filter bank has a frequency response distant from the ideal curve so that its selectivity is poor.

Please send questions and comments directly to the corresponding author (R.C.G.).

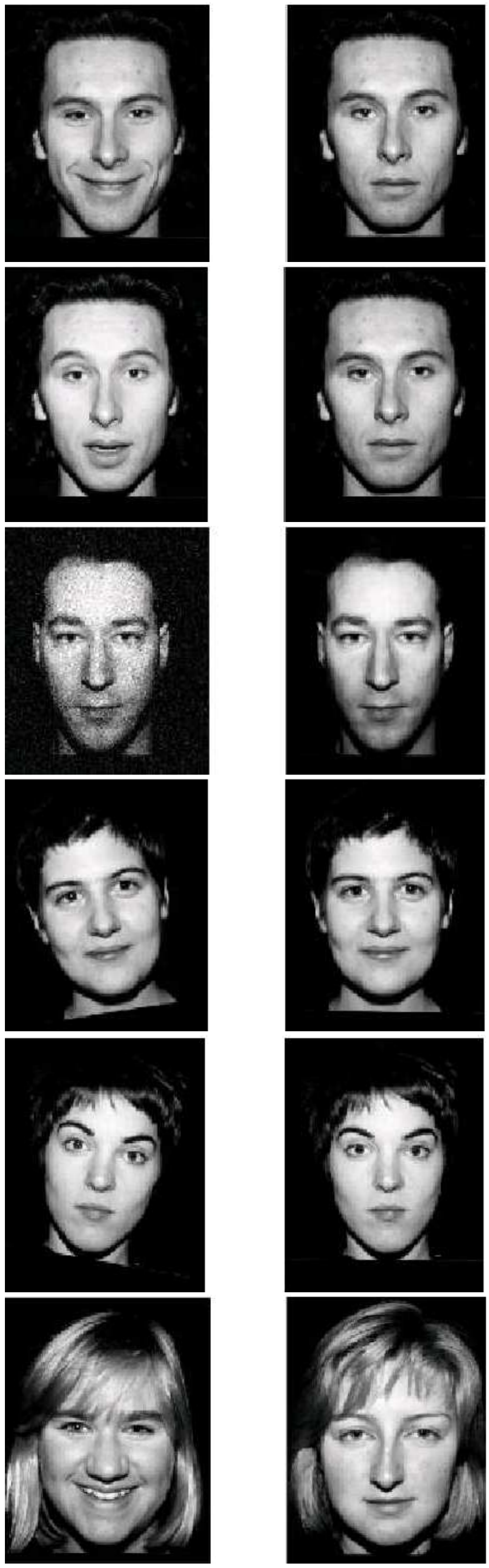

Figure 1: (from top to bottom): Six tests performed with the proposed algorithm, one per line. The system's input, the query image, is on the left and its output, the retrieved image, is on the right. The last line consists of a failure. The other ones correspond to successful results.

level(j)	wavelet(x) and support	accuracy
1	**Haar-2**	**96.73%**
1	Coiflet-6	96.72%
1	Coiflet-12	72.54%
1	Coiflet-18	31.37%
1	Coiflet-24	38.56%
1	Coiflet-30	42.48%
1	Symmlet-8	96.07%
1	Symmlet-16	27.45%
1	Daubechies-4	95.42%
1	Daubechies-20	36.60%
1	Daubechies-60	79.73%
1	Daubechies-80	86.92%
1	Daubechies-90	70.58%
1	Biorthogonal-2	96.72%
1	Biorthogonal-4	94.11%
1	Biorthogonal-6	35.94%
1	Biorthogonal-8	31.37%
1	Biorthogonal-12	32.02%
2	Haar-2	95.42%
2	Coiflet-6	94.11%
2	Coiflet-12	92.81%
2	Coiflet-18	88.23%
2	Coiflet-24	79.08%
2	Coiflet-30	45.75%
2	Symmlet-8	95.42%
2	Symmlet-16	88.88%
2	Daubechies-4	95.42%
2	Daubechies-20	77.12%
2	Daubechies-60	82.35%
2	Daubechies-80	86.27%
2	Daubechies-90	64.05%
2	Biorthogonal-2	95.42%
2	Biorthogonal-4	94.11%
2	Biorthogonal-6	87.58%
2	Biorthogonal-8	75.81%
2	Biorthogonal-12	90.19%
3	Haar-2	91.50%
3	Coiflet-6	94.77%
3	Coiflet-12	92.81%
3	Coiflet-18	92.15%
3	Coiflet-24	91.50%
3	Coiflet-30	90.84%
3	Symmlet-8	93.46%
3	Symmlet-16	92.15%
3	Daubechies-4	93.46%
3	Daubechies-20	92.15%
3	Daubechies-60	79.73%
3	Daubechies-80	88.88%
3	Daubechies-90	80.39%
3	Biorthogonal-2	93.46%
3	Biorthogonal-4	92.81%
3	Biorthogonal-6	91.50%
3	Biorthogonal-8	90.19%
3	Biorthogonal-12	92.15%

Table 2: Accuracy of the proposed algorithm according to the level of DWT and the basis used.

5 Acknowledgments

We would like to thank our sponsors at *Centro Universitário do Norte Paulista* (http://www.unorp.br) by the grants and support given to this work. We are very grateful to the reviewers for all their relevant suggestions.

References

[1] S. Deb, "Multimedia Systems and Content-Based Image Retrieval". Hershey-US: Idea Group Publishing, 2003.

[2] S. Deb, Y. Zhang. "An overview of content-based image retrieval techniques". in AINA 2004 - 18th International Conference on Advanced Information Networking and Applications, (2004), v. 1, pp. 59 - 64.

[3] I. Andreou, N. M. Sgouros. "Computing, explaining and visualizing shape similarity in content-based image retrieval". Elsevier Information Processing and Management, v. 41, n. 5, pp. 1121-1139, 2005.

[4] P. S. Addison, "The Illustrated Wavelet Transform Handbook: Introductory theory and applications in science, engineering, medicine and finance". Edinburg: Institute of Physics Publishing, 2002.

[5] G. Strang, T. Nguyen,"Wavelets and Filter Banks". Wellesley: Wellesley Cambridge Press, 1997.

[6] R.C. Guido, J.C. Pereira, E. Fonseca, L.S. Vieira, F.L. Sanchez. "Trying different wavelets on the search for voice disorders sorting", in *37th IEEE International Southeastern Symposium on System Theory*, Tuskegee-AL-US, v. 1 (2005) p. 495-499.

[7] R.C. Guido, J.F.W. Slaets, L.O.B. Almeida, R. Koberle, J.C. Pereira, "A new technique to construct a wavelet transform matching a specified signal with applications to digital, real time, spike and overlap pattern recognition", *Digital Signal Processing*, Elsevier, v. 15, (2005), n. – , pp. – (article in press, available on www.sciencedirect.com website, to appear in 2005).

[8] R.C. Gonzalez, R.E. Woods. "Processamento de Imagens Digitais". São Paulo: Edgard Bluscher, 2000.

[9] D. Hankerson, G.A. Harris, P.D. Johnson, "Introduction to Information Theory and Data Compression", 2nd ed. Boca Raton: CRC Press, 2003.