PERCEPTUAL RESEMBLANCE OF FACIAL IMAGES: A NEAR SET APPROACH

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Abstract

In this paper, we introduce a near set approach to image analysis. Near sets result from generalization of rough set theory. One set X is near another set Y to the extent that the description of at least one of the objects in X matches the description of at least one of the objects in Y. Near set Evaluation And Recognition (NEAR) system is used to measure the degree of resemblance between facial images. The goal of the NEAR system is to extract perceptual information from images using near set theory, which provides a framework for measuring the perceptual nearness of objects. In this work, we have used images from Japanese Female Facial Expression (JAFFE) database. The images were first converted into Local Binary Patterns (LBP) images and then divided into non-overlapping blocks. The degree of nearness of histograms of all the blocks of one image is measured with the corresponding blocks of another image by using NEAR system.

***Keywords*:** Near sets, Near System, LBP and Histogram.

1 Inroduction

This paper introduces an approach to measure the degree of resemblance between static facial images in context of near set theory [1][2][3]. Near sets grew out of a generalization of the approach to the classification of objects proposed by Pawlak's during the early 1980s (see, e.g. [4][5]), elaborated in [7][8][9]) and Orłowska's suggestion that approximation spaces are the formal counterpart of perception or observation [22]. Near set Evaluation And Recognition (NEAR) system [15] is used to measure the degree of nearness between facial images. The goal of the NEAR system is to extract perceptual information from images using near set theory, which provides a framework for measuring the perceptual nearness of objects. In this work, we have used static facial images from Japanese Female Facial Expression (JAFFE) database. The images were first converted into Local Binary Patterns (LBP) images and then divided into non-overlapping blocks (4, 9, 16…). The degree of nearness of histograms of all the blocks of one image is measured with the corresponding blocks of another image by using NEAR system. The NEAR system is a feature-based approach to solving the image correspondence problem, and a first step toward automating the extraction of perceptual information from images where there is interest in measuring the degree of resemblance between images.

2 Near Sets: Foundations

This section gives a brief introduction to a near set approach to classifying images. In this approach, facial images are separated into non-overlapping sets of images that are similar (*descriptively* near to) each other. The near set approach is well suited in image analysis [11].

Let <*O*, F> be a perceptual system, *i.e.*, a real valued total deterministic information system where *O* is a non-empty set of perceptual objects, and F is a countable set of probe functions. For every $B \subseteq$ F, the weak nearness relation $\simeq_B$ is defined as follows:

$$\simeq_B = \{(x, y) \in O \times O \mid \exists \phi_i \in B, \phi_i(x) = \phi_i(y)\}$$

The relation $\simeq_B$ is considered *weak*, since this nearness relation between the objects (*e.g.*, pixels in an image) in each pair (*x, y*) requires at least one (not every) probe function satisfying $\phi_i(x) = \phi_i(y)$ to establish that *x* and *y* are near each other. Furthermore, let $X, Y \subseteq O$. A set *X* is weakly near to a set *Y* within the perceptual system<*O*, F>($X \approx_F Y$) iff there are $x \in X$ and $y \in Y$ and there is $B \subseteq$ F such that $x \approx_B y$. Finally, define an elementary set (class) as:

$$x_{\simeq B} = x' \in X \mid x' \simeq_B x$$

and define a partition of O(quotient set) as

$$O_{/\approx B} = \{x_{/\approx B} \mid x \in O\}.$$

A nearness measure (NM) useful in determining the degree of resemblance between two images is given in (2). Let the sets *X* and *Y* be weakly near each other in<*O*, F>, *i.e.*, there exists $B \subseteq$ F such that $x \approx_B y$. Then, the degree of nearness between *X* and *Y* is measured using (2).

$$NM_{\sim B}(X,Y) = \frac{\sum_{x_{/\simeq B} \in X_{/\simeq B}} \sum_{y_{/\simeq B} \in Y_{/\simeq B}} \eta(x_{/\simeq B}, y_{/\simeq B})}{\max(|X_{/\simeq B}|, |Y_{/\simeq B}|)}$$

$$x_{\simeq B} = x' \in X \mid x' \simeq_B x$$

$$\simeq_B = \{(x,y) \in O \times O \mid \exists \phi_i \in B, \phi_i(x) = \phi_i(y)\}$$

where $\eta(x_{/\simeq B}, y_{/\simeq B})$ in (2) is defined as follows:

$$\eta(x_{/\simeq B}, y_{/\simeq B}) = \begin{cases} \min(|x_{/\sim B}|, |y_{/\sim B}|), \text{if } \phi_i(x) = \phi_i(y) \forall \phi_i \in B, \\ 0, \text{otherwise} \end{cases}$$

In other words, the nearness of two sets can be measured by the cardinality of their elementary (equivalence) classes. Sets that are similar with respect to the probe functions in *B* will have equivalence classes with similar numbers of objects producing a nearness degree close to or equal to 1. By contrast, sets that are not similar will have equivalence classes that share little with each other and will produce a nearness degree close to or equal to 0.

3. Local Binary Patterns

The Local Binary Pattern (LBP) operator is a non-parametric 3 x 3 kernel which summarizes the local special structure of an image. It was introduced by Ojala et al. [16][17][18][19] who showed the high discriminative power of this operator for texture classification. . At a given pixel position (x_c , y_c),LBP is defined as an ordered set of binary comparisons of pixel intensities between the center pixel and its eight surrounding pixels (Fig 1)

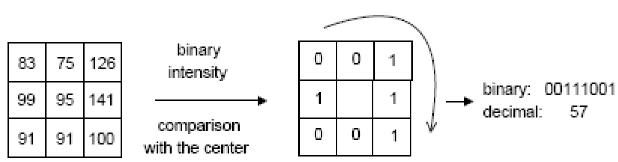


Fig.1 Calculating the original LBP code

The decimal part of the resulting 8-bit word (LBP code) can be expressed as follows:

$$LBP(x_c, y_c) = \sum_{n=0}^{7} s(i_n - i_c)2^n \qquad (3)$$

Where i_c corresponds to the grey value of the center pixel (x_c , y_c), i_n to the grey values of the 8 surrounding pixels, and function s(x) is defined as :

$$s(x) = \begin{cases} 1, \text{if x} \geq 0 \\ 0, \text{if x<0} \end{cases} \qquad (4)$$

Note that each bit of the LBP code has the same significance level and that two successive bit values may have a totally different meaning. Actually, The LBP code may be interpreted as a kernel structure index. By definition, the LBP operator is unaffected by any monotonic gray-scale transformation which preserves the pixel intensity order in a local neighborhood (Fig 2).

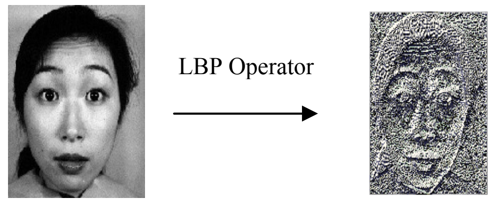


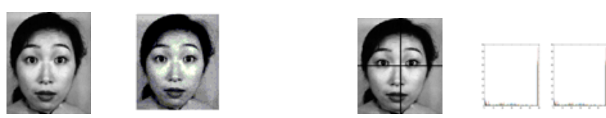
Fig.2 Original image (left) processed by the LBP operator (right)

Due to its texture discriminative property and its very low computational cost, LBP is becoming very popular in pattern recognition. Recently, LBP has been applied for instance to face detection [19], face localization [11], face recognition [18][19][20], image retrieval [21] etc..

4 Perceptual Image Resemblance

Near Set Evaluation And Recognition (NEAR) system [15] is used to measure the degree of nearness between facial images. The goal of the NEAR system is to extract perceptual information from images using near set theory, which provides a framework for measuring the perceptual nearness of objects. In this work, we have used static facial images from Japanese Female Facial Expression (JAFFE) database. The images were first converted into Local Binary Patterns (LBP) images and then divided into non-overlapping blocks (4, 16, see Fig. 3).

Fig.3 Non-Overlapping Blocks



(i)RGB Image (ii) Grey Image (iii) LBP Image with blocks and Histograms

Fig.4 (a) LBP Image with histograms

Fig.4 (b) Facial Images with gestures anger,surprise,happiness,sadness and fear

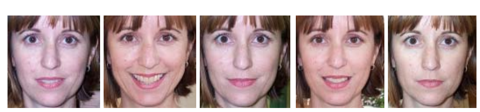


Fig.4(c) Facial Images with different gestures

The degree of nearness of histograms of all the blocks of one image (see Fig.4 (a)) is measured with the corresponding blocks of another image by using NEAR system. For this purpose we have used facial images with various gestures as shown in Fig.4 (b).

Fig.5 shows that variation of nearness between LBP image pairs with that of non-LBP image pairs without dividing the images into non-overlapping blocks. Fig.6 and 7 shows that variation of nearness between LBP image pairs with that of non-LBP image pairs by dividing the images into four and sixteen non-overlapping blocks respectively. Resemblance between image block pairs improved a greater extent (from 86% to 96 %) when the image is divided into four and sixteen non-overlapping blocks (see Fig 6 and 7).Similarly the results for Fig.4(c) is given in Fig.8,where the resemblance between non LBP image pairs with that of LBP image pairs are 85 % and 96 % respectively.

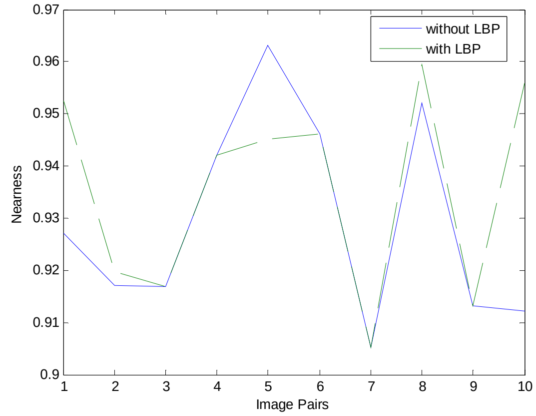


Fig.5 LBP Vs Non LBP(**No** blocks)

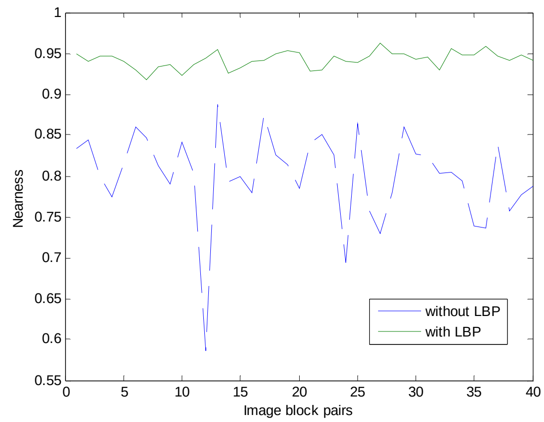


Fig 6 LBP Vs Non LBP(4 blocks)

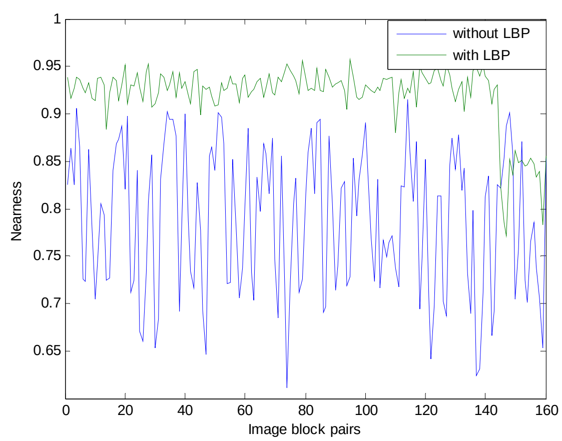


Fig.7 LBP Vs Non LBP(16 blocks)

5 Conclusion

This paper introduces an approach to measure the degree of resemblance between static facial images in context of near set theory. The goal of the NEAR system is to extract perceptual information from images using near set theory, which provides a framework for measuring the perceptual nearness of objects. In this work, we have used images from Japanese Female Facial Expression (JAFFE) database. The images were first converted into Local Binary Patterns (LBP) images and then divided into non-overlapping blocks. The degree of nearness of histograms of all the blocks of one image is measured with the corresponding blocks of another image by using NEAR system. It has been found that LBP images play a vital role in image analysis especially in face detection and recognition.

Acknowledgements

The author greatly acknowledges the inputs and suggestions by James F Peters, University of Manitoba, and Winnipeg, Canada.

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