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Author(s)	Jeong, Sungmoon; Lee, Hosun; Hamdi, Younes El; Chong, Nak Young
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Description	

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Weighted Census Transform for Feature Representation

Sungmoon Jeong, Hosun Lee, Younes El Hamdi, and Nak Young Chong
School of Information Science, Japan Advanced Institute of Science and Technology, Ishikawa, Nomi, 923-1211, Japan
(Tel : +81-761-51-1362; E-mail: {jeongsm, hosun_lee, yelhamdi, nakyoung}@jaist.ac.jp)

Abstract - This paper presents a new visual feature representation method as a weighted census transform (WCT) based on modified census transform (MCT) and entropy information of training dataset. The proposed feature representation model can offer robustness to represent same visual images such as MCT feature and sensitivity to effectively classify different visual images. In order to enhance the sensitivity of MCT feature, we designed the different weights for each MCT feature as binary code bit by statistical approach with the training dataset. In order to compare the proposed feature with MCT feature, we fixed classification method such as compressive sensing technique for two features. Experimental results shows that proposed WCT features have better classification performance than traditional MCT features for AR face datasets.

Keywords – Weighted Census Transform, Pattern Classification, Feature Representation, Face Recognition

1. Introduction

Visual feature representation method is important to have a good classification performance for machine vision application. One of the main feature representation approach is to extract texture descriptor of visual image. Among the various feature representation methods based on texture descriptor, modified census transform (MCT) shows a good classification performance in real world applications such as face and eye detection within various illumination conditions. In case of MCT method, the CT relies on the local intensity order is unaffected by linear and monotonic transformation on the reflectance [1]. Based on this, the traditional MCT model encoded local image pixels to binary codes by comparing with average of neighborhood pixel around center pixel for robustly analyzing spatial structure of image. Based on binary codes, the similarity between each image is calculated by hamming distance to classify visual images. Therefore, MCT feature has robustness characteristics to represent same image class because of binary encoding and each binary code bit has equal effect to represent the visual images.

However, each binary code bit has different effects to represent visual images according to the training set. For examples, some binary codes are almost same values even though binary codes are generated by different visual image classes. Also, some binary codes are totally different values even though binary codes are generated by same visual image classes. Therefore, we should design that which binary code bit is more informative to represent visual images. Therefore, in this paper, we proposed a weighted census transform (WCT) based on the MCT and entropy information of each binary code bit of training dataset. If we are able to design the appropriate weights for each binary code bit, WCT can have sensitivity characteristics to represent different image class. In order to enhance the sensitivity of MCT feature, we selected the different weights for each binary code bit by entropy information of each binary code bit with the training dataset.

2. Proposed Feature Representation Model

2.1 Traditional Modified Census Transform (MCT)

The Census Transform (CT) is a non-parametric local structure extraction which was first proposed by Zabih and Woodfill [2]. It is defined as an ordered set of comparisons of pixel intensities in a local neighborhood representing which pixels have lesser intensity than the center. Therefore, center pixel is not contained to represent local spatial structure. The MCT used average value within local spatial structures instead of center pixel to obtain a result for the center pixel. Within the kernel structure information is coded as binary information and the resulting binary patterns can represent oriented edges, line segments, junctions, ridges, saddle points, etc [1]. Local spatial structure $\Gamma(x)$ of the pixel at x is calculated as

$$\Gamma_{x\in X}(x) = \bigotimes_{y\in N_x} \zeta\left(\bar{I}(x), I(y)\right) \tag{1}$$

where $\otimes$ denotes the concatenation operation, N_x is the neighborhood pixels within x position, $\bar{I}(x)$ is mean intensity on the neighborhood pixels, and $\zeta\left(I(x), I(y)\right)$ be 1 if $I(x) < I(y)$ and otherwise 0.

2.2 Weighted Census Transform (WCT)

Using the original formulation of the MCT as shown in Eq. (1), every encoded bits have same effects to represent local spatial structure because of binary encoding. Based on this local spatial structure, we can compare each local spatial structure to verify local structures are same or not. However, depending on the image dataset, each binary code has to need different weights for representing local structure. We reformulate Eq. (1) to consider different weights for each binary code bit and called weighted census transform as

$$\Gamma'(x) = \bigotimes_{y\in N} \alpha_y \zeta\left(\bar{I}(x), I(y)\right) \tag{2}$$

where α_y denotes weights for binary code bit at pixel y. The weights can be calculated by supervisor manners based on training dataset such as evolutionary strategy, statistical approaches, and various optimization techniques. In this paper, we simply applied entropy information of training dataset. In information theory, information entropy is a measure of the uncertainty. Information entropy is the average unpredictability in a random variable, which is equivalent to its information content. It means that informative contents have much information entropy value than useless information contents. Therefore, informative contents are useful to distinguish for different visual images. Based on this idea, the weights for each binary code bit are calculated by following equation

$$\alpha_y = \left[1 + \left(\sum_c H_c(y)/C \right) \right] \Big/ 2 \tag{3}$$

where $H_c(y)$ is the entropy value of training dataset of class c, C is the number of classes and $0.5 \le \alpha \le 1$. This entropy value is calculated as

$$H_c(y) = -\sum_{i-1}^{2} p_c(y_i) \log p_c(y_i) \tag{4}$$

where $p_c(y_i)$ denotes probability distribution of binary value i at pixel position y within training dataset with class c and this probability is calculated as

$$p_c(y_i) = n_c(y_i)/M_c \tag{5}$$

where $n_c(y_i)$ is the number of binary value i at pixel position y within training dataset with class c and Mc is the number of training dataset with class c.

3. Experimental results

3.1 AR face dataset

The AR database consists of over 4,000 frontal images for 126 subjects [3]. We select a subset of the data set consisting of 50 male subjects and 50 female subjects. For each subject, 26 pictures consist of 14 non-occlusion faces and 12 occlusion faces. We considered 2 experimental conditions: 1) half of each non-occlusion faces and occlusion faces are used for both of training and test phase, respectively and 2) non-occlusion faces are used for training and occlusion faces are tested to show the classification results. These images include facial variations, including illumination change, and expressions. In the experiment, the images are cropped and converted to gray scale with size normalization.

3.2 Classification Results

In order to verify the advantage of proposed WCT feature, we fixed the classifier as compressed sensing with QR decomposition [4] for both of the proposed WCT and traditional MCT feature with 3x3 kernel structure. Each pixel was encoded by using kernel structure as 9 binary code bits. Based on this binary code, we can measure the reconstruction error between test dataset and training dataset. Finally, we can classify the test dataset by finding minimal reconstruction error from training dataset with specific class labels.

A. Same environment setting for training/test phase

Table 1 shows the classification results with different features within same environment conditions for training and test dataset. The proposed feature has better classification performance than the traditional MCT feature to classify both of non-occlusion and occlusion face dataset as shown in Table 1.

Table 1 Comparison of classification performances under the same environment conditions

Feature types	Classification performance (%) (normalized image size)	
	20x15	40x30
MCT	82.54	96.92
WCT	83.54	97.46

B. Partial occlusion for test phase

Table 2 shows the classification results with different features within different envrionment conditions between test and training dataset. As shown in Table 2, the proposed feature has better classification performance than the traditional MCT feature to classify the partially occluded face dataset.

Table 2 Comparison of classification performances considering partial occlusion for test phase

Feature types	Classification performance (%) (normalized image size)	
	20x15	40x30
MCT	79.42	98.25
WCT	79.92	98.42

4. Conclusion and Further work

In this paper, we proposed new feature representation method such as WCT based on the traditional MCT with weights for each binary code bit using entropy information. Experimental results show that proposed feature have better classification performance than traditional MCT feature. As a further work, we are considering various kinds of optimization algorithm, statistical approaches to optimally select the weights for each binary code bit based on the proposed method.

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