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변환영역 기반의 시각특성 파라미터를 이용한 영상 분석

Image Analysis using Transform domain-based Human Visual Parameter

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요 약

본 논문에서는 DCT 변환과 퍼지추론을 이용하여 영상을 분석하는 방법을 제안 한 바, 병해충 과실 등의 특성을 분석 할 수 있는 퍼지추론 알고리즘과 변환계수에 시각특성파라미터를 접목하는 방법에 중점을 두었다. 전처리 과정에서 이산코사인 변환 계수로부터 엔트로피와 텍스처 등의 시각특징 파라미터들을 구하였고, 이 변수들을 이용하여 퍼지 추론의 입력 변수를 생성 하였다. 맘다니 연산자와 α-cut 함수를 적용하여 영상 분석을 실험한 결과, 제안한 방법의 응용가능성을 입증하였다.

Abstract

This paper presents a method of image analysis based on discrete cosine transform (DCT) and fuzzy inference(FI). It concentrated not only on the design of fuzzy inference algorithm but also on incorporating human visual parameter(HVP) into transform coefficients. In the first, HVP such as entropy, texture degree are calculated from the coefficients matrix of DCT. Secondly, using these parameters, fuzzy input variables are generated. Mamdani's operator as well as α-cut function are involved to simulate the proposed approach, and consequently, experimental results are presented to testify the performance and applicability of the proposed scheme.

Key words: DCT, Fuzzy Inference, Transform coefficients, HVP

I. Introduction

Image classification defined as a process of assigning an item or an observation to its proper place is one of the important tasks in such areas as industrial application, medical, sports, and so on. But, frequently, in the real field, the common problems in shape classification is the lack of homogeneity among feature parameters or attributes. In spite of the short of complete methods in the classification procedure, extensive research of these problems has led to some satisfying treatments of the subject in the non-fuzzy way [1-3]. On the other hand, fuzzy logic has a great advantage in comparison with discrete formal logical systems: it can approximate very well, it is suitable for the construction of approximation models as well as computationally effective algorithms of reasoning and control [4-5].

Further, fuzzy theory can describe the obscure

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nuances of meaning in language, and use it to create a qualitative logic reasoning procedure. Thus, the fuzzy system replicates the human way of thinking, and has an ability to support the flexible human thinking procedure.

In recent year, meanwhile, approximate reasoning is being studied as a way of dealing with uncertain knowledge or non-homogeneous attributes. It is extremely difficult to make an exact model of human knowledge, because of its essential incompleteness and uncertainty. And so, many related problems remain unsolved in supporting high-level decision making, because more undetermined factors are involved in this level. Even though fuzzy approximate reasoning provides a lots of concepts and techniques for representing and inferring from knowledge which is uncertain or lacking in reliability, what is used in practical applications is a relatively restricted and yet important part of fuzzy logic concentrating on the use of fuzzy if-then rules [6][7]. Indeed, the effective design and calculus of fuzzy if-then rules provide a good method for dealing with man-machine systems which can be regarded as a ultimate goal of fuzzy engineering.

This paper addressed the optimal design of fuzzy if - then rules, which can be adapted the wide variety of circumstance and analyzed a useful membership function to analyze the image. In the preprocessing, the extraction of image features are performed by using DCT. Using DCT coefficients, such feature parameters as standard deviation, texture degree are directly calculated. and the authors already have been reported in the literature, which treated these parameters are very useful in estimating feature vectors [7][8]. After the generation rule is made from the reference parameter, the fuzzy composition operation is performed. Furthermore, implication operator are compared by using proposed approaches.

Ⅱ. DCT-based Human Visual Parameter(HVP)

An important property of this DCT is that they preserve the spatial localization of image features. Feature extraction is often the first major operation in many image analysis application. In this point of view, we invoke the idea that taking the DCT as a preprocessor of image analysis system, and then incorporating DCT coefficients matrix into the human visual parameter. In a typical application, an image is subjected to a two-dimensional DCT whose coefficients are then quantized and to be used as a feature parameters.

The discrete cosine transform is given as;

DCT

$$X^{c2}(k) = \frac{2}{N} c_k \sum_{n=0}^{N-1} x(n) \cos\left[\frac{(2n+1)k\pi}{2N}\right], \qquad (1)$$

k=0,1,...,N-1

IDCT

$$x(n) = \sum_{k=0}^{N-1} ck\, X^{C2}(k) \cos\left[\frac{(2n+1)k\pi}{2N}\right],$$

n=0,1,...,N-1

단, ck = $\begin{cases} 1/\sqrt{2}, & k=0 \\ 1 & k \neq 0 \end{cases}$

The HVP has identified by several phenomena which is related with spatial resolution, intensity resolution, and intensity sensitivity and so on. Let me discuss in more detail the characteristics of these visual properties of HVP which can be described in many terms. Contrast sensitivity means variance or difference of the pixel's brightness. In addition, texture sensitivity.

T_s is calculated by DCT coefficients of an image. Namely, quantization results of the DCT coefficients are the same as integer and finally, T_s can be expressed by

$$T_s = \sum \{ rnd[X_k(x,y)/Q(x,y)] \} \qquad (2)$$

Where $X_k(x,y)$ means the $k'th$ DCT coefficients block and (x,y) refers to the location.

Entropy means the mathematical expectation of the information with respect to the occurrence of the events.

Entropy sensitivity $E_s$can be defined as

$$E_s = \sum_{x,y=0}^{7} p_k(x,y)\log\frac{1}{p_k(x,y)}$$
$$p(x,y) = \frac{X_k(x,y)}{\sum_{x,y=0}^{7} X_k(x,y)} \qquad (3)$$

Ⅲ. Structure of Adaptive Fuzzy Rule

Fuzzy logic formalize the idea that an object can belong to a class with a continuum of membership grade. It allows us to represent ambiguity or uncertainty about the membership of the object itself in a manner typical of human intuition. Namely, a crisp set is a collection of distant elements. Conversely, a fuzzy set is a collection of distant elements with varying degree of relevance or inclusion. Consequently. in order to design a fuzzy inference system, a crisp data must be translate into if-then language of fuzzy inference

This membership function can take interval values between 1 and 0 and is often shown inside straight brackets[1,0]. Using the same notation as Eq.(4), the fuzzy set A can be expressed as

$$A = \{(x, \mu_A(x))\},\ x \in X \qquad (4)$$

where μ denotes the membership function, and $(x, \mu_A(x))$ is a singleton, precisely, a fuzzy set in universe of discourse $\bigcup$ is characterized by membership function μ. Another common way of representing a fuzzy set is

$$A = \bigcup_{x_i \in X} \mu_A(x_i)/X_i \qquad (5)$$

where, the fuzzy set A is the collection or union of all singletons $\mu_A(x_i)/X_i$.

In general, fuzzy algorithm can employ relational, compositional or implicational inference method.

The implication relation is defined by

$$R(x,y) = \bigcup_{\chi, y} \mu(\chi, y)/(\chi, y) \qquad (6)$$
$$\mu(\chi, y) = \Phi[\mu_A(\chi), \mu_B(y)]$$
$$here, (\chi \in X, y \in Y)$$

where linguistic/fuzzy variable X and Y take the values of A and B, respectively, and $\mu(\chi, y)$ is the membership function of the implication relation.

Proposed image analysis algorithm can be described informally as follows:

* Pre processing stage *
Definition:
Image block size of 32*32: TH
$\alpha - cut$: 0.8
certainty factor: CF
Step 1. Pre processing
100: Perform the 2D DCT
Step 2. While image block is not empty repeat
Step 3. Calculate the HVP using DCT coefficients.
Step 4. if image block is TH than goto 100
* fuzzy inference stage *
Step 5. Repeat the step 6 - step 9.
Step 6. For each value of HVP applying fuzzy association map
Step 7. Find the defuzzification value.
Step 8. Calculate the CF
Step 9. If CF greater than or equal to 0.8 then current vector is equal to reference image else, not equal to reference image.
Step 10. Store the number of CF
Step 11. End of algorithm.

The geometrical shape of a membership function is the characterization of uncertainty in the corresponding fuzzy variable. The shape of membership function cannot be formed arbitrarily because arbitrary design can produce unpredictable results in the basic inference scheme. In here triangular form is utilized so as to consider the time complexity. Fuzzy inference rule(FIR) can also be represented in a tabular form as shown in Table 1. This FIR means that the bigger the En and Td, the less error is occurred.

Table 1 . Fuzzy Association Map for FIR

Td \ En	NB	NS	ZR	PS	PB
PB	PB	PB	PM	PB	PB
PS	PS	ZR	ZR	PM	PB
ZR	NS	ZR	ZR	ZR	PS
NS	NB	NM	ZR	ZR	NS
NB	NB	NB	NM	NB	NB

En= entropy, Td=texture degree,
PB=positive big, PM=positive medium,
PS=positive small, ZR=zero, NS=negative small,
NM=negative medium, NB=negative big.

Ⅳ. Experimental Considerations

The general structure of the fuzzy inference system for inferencing the image analysis is shown in Fig. 1. In the preprocessing, test images are transformed into the coefficients matrix after performing DCT. Thus, some human visual parameters such as texture degree, entropy can be calculated and finally, these crisp value is used for the input to the fuzzy membership function [9]. In fuzzy inference module, the two of them organize an information interface (the fuzzification and defuzzification) linking the fuzzy inference module. Secondly, basic three procedures-fuzzificaton, inference module, defuzzification are involved in classification stage. Fuzzification step transforms an input crisp value into a fuzzy representing a degree of membership.

In order to design the adaptive fuzzy rule, we calculated the maximum tolerance range of each HVP parameters due to environmental condition such as variation of background, unpredicted noise. Consequently, based on these tolerance ranges, fuzzy data which can directly be used in membership function are generated.

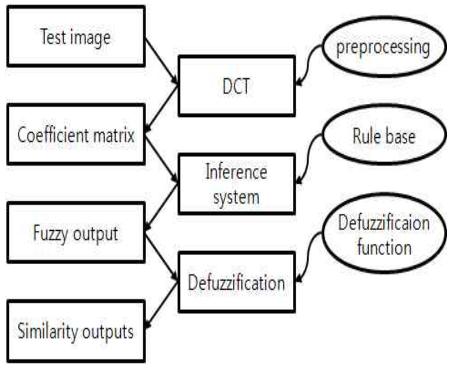


Fig. 1. Functional structure for proposed scheme

In our approach, the Mamdani operator is utilized to calculate the fuzzy relation operation, which are defined in Eq. (7)

$$\mu(x,y) = \Phi[\mu_A(j), \mu_B(k)] = \mu_A(j) \wedge \mu_B(k) \quad (7)$$

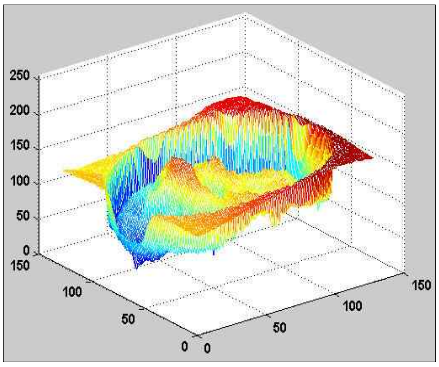
$$\mu_B'(y) = I(x) \times \mu(x,y)$$

where , $\mu'_B(y)$ is the implication result.

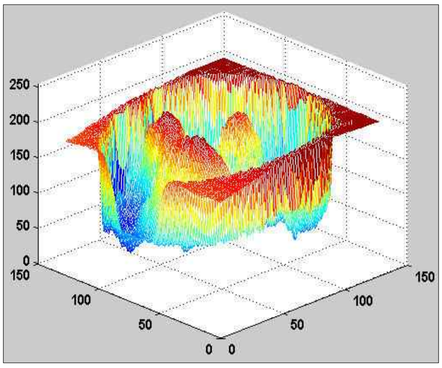
Lastly, defuzzification phase, translates the fuzzy output into a crisp value, which is the similarity value of the classified object. We used the center of gravity method that based on finding a balance point of a property that can be the total geometric figure of output. This function is calculated by Eq. (8)

$$x = \frac{\sum_{i=1}^{N} x_i \mu_0(x)}{\sum_{i=1}^{N} \mu_0(x)} \quad (8)$$

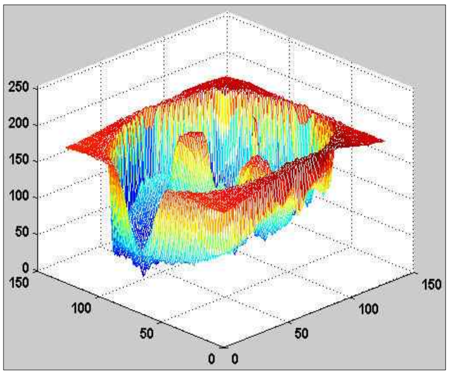
In order to evaluate the performance of proposed method, some kinds of fruits are chosen (Fig. 2). HVP is calculated as shown in fig. 3. Fig. 4 shows the classification results based on the Mamdani's operator with respect to the case of intensity variation. To find a classification rate, a threshold function or filter, which term called $\alpha - cut$ is applied to each membership value in the output of certainty factor. Even for the $\alpha - cut = 0.8$ in Fig. 4, the proposed algorithm is still very effective in analysing rate.



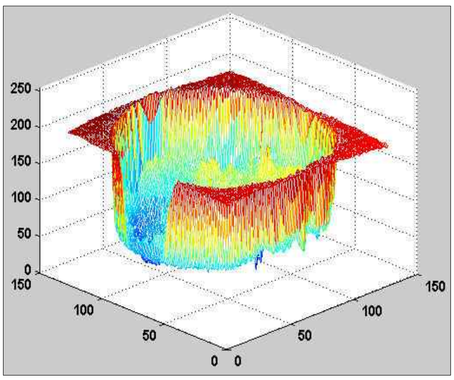
(a)



(b)

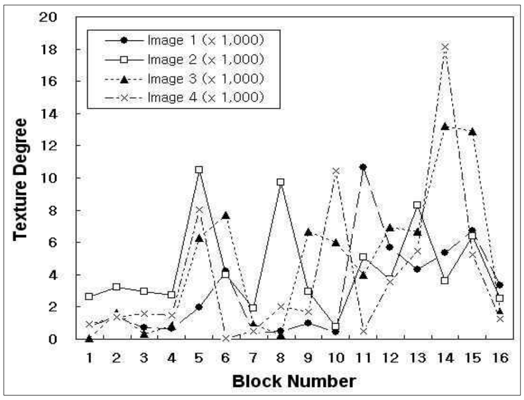


(c)

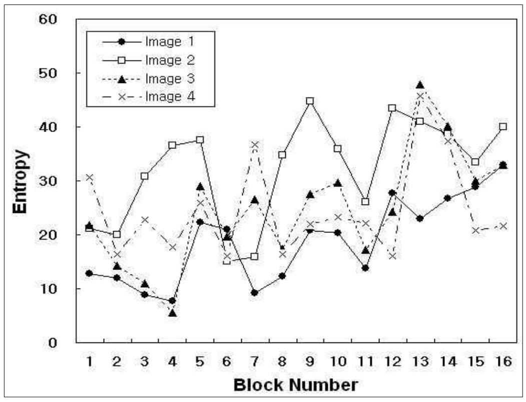


(d)

Fig. 2. Spectrum images of test images; (a) peach (b)peach-1, (c)peach with pest damage, (d)peach with pest damage-1.



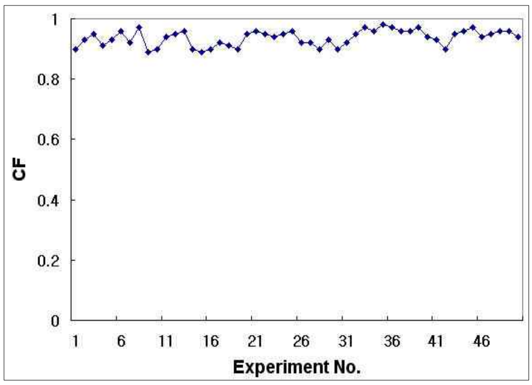
(a)



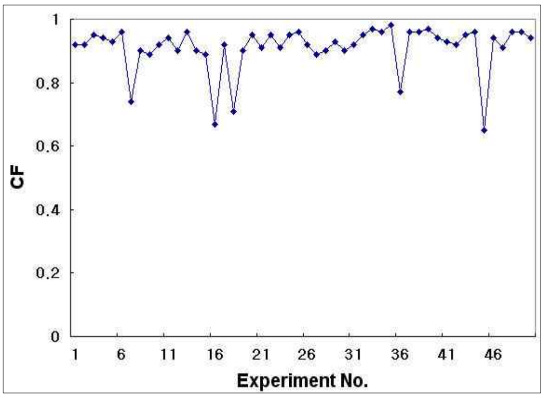
(b)

Fig. 3. Human visual parameter; (a) texture degree, (b) entropy

From the Fig. 4-(b), if we applying an α - cut =0.5 to the criteria of similarity, output solutions can not be obtained correctly which due to the change of environments. To overcome these kinds of appearance, it is also need to select an optimal value.



(a)



(b)

Fig. 4. Degree of similarity;
(a) in case of fixed illumination,
(b) in case of varied illumination

Ⅴ. Conclusion

In this paper, transform domain based adaptive fuzzy inference algorithm for adaptive image analysis is addressed. Some of experimental results showed that it can improve the performance for analysing the image under the such conditions as intensity varying circumstances. Furthermore, It is also showed that certainty factor(CF) of proposed algorithm can be adjusted by tuning the $\alpha - cut$. Proposed method can be applied to the automatic analysis of pest damage fruits such as apples, peaches.

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