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An Emotion Classification Based on Fuzzy Inference and Color Psychology

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Abstract

It is difficult to understand a person's emotion, since it is subjective and vague. Therefore, we are proposing a method by which will effectively classify human emotions into two types (that is, single emotion and composition emotion). To verify validity of te proposed method, we conducted two experiments based on general inference and $\alpha-cut$, and compared the experimental results. In the first experiment emotions were classified according to fuzzy inference. On the other hand in the second experiment emotions were classified accroding to $\alpha-cut$. Our experimental results showed that the classification of emotion based on $\alpha-cut$ was more definite that that based on fuzzy inference.

Key Words : Fuzzy Inference, Color Psychology, Emotion Process, Emotion Classification

1. Introduction

The question of what an emotion is has been addressed by psychologists, philosophers and neuroscientists over many years. However, no consensus has yet been reached, the lack of an objective measure to conclusively establish whether a person is experiencing an emotion has led to many contrasting theories and views of emotion being formed. The traditional perspective of emotion is of something that is irrational and detracts us from inference. So, psychologists and artificial intelligence investigators have used fuzzy inference techniques to evaluate this vague and uncertain emotion quantitatively.

In this paper, we reviewed three emotion processing models that use fuzzy inference techniques. The first model explores the detection of domain-specific emotions, utilizing a fuzzy inference system to detect two emotion categories; positive and negative emotions. The input features are a combination of segmental and suprasegmental acoustic information; feature sets are selected from a 21-dimensional feature set and applied to the fuzzy classifier. The design of the fuzzy inference system has two phases: one for initialization for which fuzzy c-means method is used, and the other is fine-tuning of parameters of the fuzzy model. For fine-tuning, a well-known neurofuzzy method are used[1].

The second model creates linguistic expressions about some of the objects in a picture and infers some particularfeatures of the object (e.g., the relation between objects) subjectively, from the objective picture information (e.g, the spatial distance)[2].

The third one describes the image codes linked to the words of mixed emotion and the way to realize a mechanism using fuzzy inference, in which the internal emotion of a simulated person reacts on a sequence of inputted terms and evokes someemotional change[3].

Main weakness of the above three models is that ambiguity of implementation and subjective opinion of system designer can be considered in a system design.

We propose a method that can classify an uncertain and vague emotion (e.g, composition emotion) of human beings effectively, considering a system designer's objectivity.

We conducted experiments on emotion classification according to color psychology, which is used mainly in applied psychology, to consider system designer's objectivity in our proposed method. Experiments were conducted for six emotions (pain, reproach, anxiety, happy, joy, hope) in this paper.

2. Fuzzy Inference

2.1 The Structure of Fuzzy Inference

In the fuzzy theory, inference is considered to drive each fuzzy proposition (that is, approximative) deductively from some fuzzy propositions. This is called fuzzy inference[4].

In general, a fuzzy inference needs an inference rule described in IF-THEN form. Refer to IF-THEN rule below, which is used in a fuzzy inference.

$$Rule^{i}: IF\ C_1\ is\ A\ \text{and}\ C_2\ is\ B, \ldots, C_m\ is\ M\ \ THEN\ E\ is\ E_i$$

where, $C_1, C_2, \ldots, C_m$ are antecedent variables; and E is a consequent variable; and $A,\ B,\ M, \ldots, E_i (i=1,2,\ldots,n)$ are membership functions. If a rule is multiple, calculate relations among all the related rules and combine them with each rule that has been calculated, and then calculate their final relations.

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2.2 Four Steps in Fuzzy Inference

Fuzzy inference can be divided into four steps.

[Step 1] Calculate antecedent's fitness of the given input according to each rule. In other words, take the inputs and determine the degree to which they belong to each of the appropriate fuzzy sets via membership functions. The input is always a crisp numerical value limited to the universe of discourse of the input variable (in this case the interval between 0 and 10) and the output is a fuzzy degree of membership in the qualifying linguistic set (always the interval between 0 and 1).

$$W_j = \mu_A(C_1) \wedge \mu_B(C_2) \wedge \ldots \wedge \mu_M(C_m) \qquad (2.1)$$

where, $W_j (j = 1, 2, \ldots, l)$ denote antecedent's fitness.

[Step 2] Calculate the inference results of each rule based on their fitness calculated in Step 1. Before applying the implication method, we must take care of the rule's weight. Every rule has a weight (a number between 0 and 1), which is applied to the number given by the antecedent. Generally this weight is 1 and so it has no effect at all on the implication process.

$$\mu_{E_i}(E) = W_j \wedge \mu_{E_i}(E) \qquad (2.2)$$

where, $i = 1, 2, \ldots, n$ $j = 1, 2, \ldots, l$.

[Step 3] Calculate the final inference results (e.g aggregation) from the reasoning results of each rule. Aggregation only occurs once for each output variable, just prior to the final step, defuzzification. The input of the aggregation process is the list of truncated output functions returned by the implication process for each rule. The output of the aggregation process is one fuzzy set for each output variable.

$$\mu_{E_i}(E) = \mu_{E_1}(E) \vee \ldots \vee \mu_{E_n}(E) \qquad (2.3)$$

[Step 4] We do non-fuzzification and calculate the final reasoning results. In this paper, we did non-fuzzification using a center of gravity method.

$$D = \frac{\sum_{j=1}^{n} (W_j \times u_j)}{\sum_{j=1}^{n} W_j} \qquad (2.4)$$

3. A Classification Model of Emotion

3.1 The Structure of our Emotion Classification Model

The structure of our emotion classification model consists of input part, fuzzification part and non-fuzzification part.

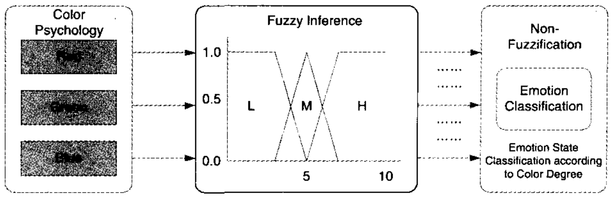

Figure 3.1 The Structure of Emotion Cassification

According the model, data (about color) is received in the input part, and fuzzification occurs in the inference part, and the inference result values are calculated through non-fuzzification process. Here, an inference value means an emotion state that is inferred according to the degree of color.

3.2 An Emotion Classficiation

We composed an IF-THEN rule for emotion states using color (e.g color psychology) that is used mainly in applied psychology. Refer to the following rule.

IF R is H and *G is M* and *B is L*
THEN Emotion is E_i

where, R, G, B are colors (Red, Green, Blue); and E_i denotes an emotion state. The membership function and area of each antecedent part R, G, B and the consequent part are shown in Figure 3.2.

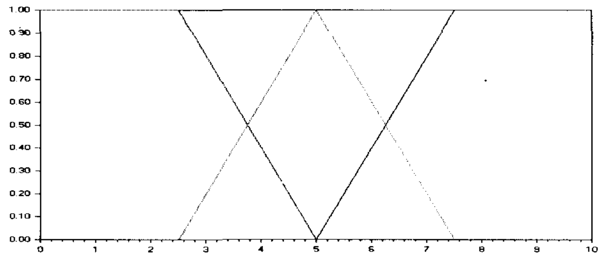

Figure 3.2 Membership Function about Input Variable

R, G, B : $0 \le L < 5$
R, G, B : $2.5 \le M \le 7.5$
R, G, B : $5 \le H \le 10$

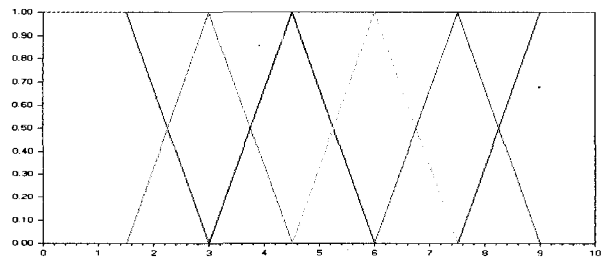

Figure 3.3 Membership Function by Emotion Degree

Emotion : $0 \le Pain < 3$
Emotion : $1.5 \le Reproach < 4.5$
Emotion : $3 \le Anxiety < 6$
Emotion : $4.5 \le Happy < 7.5$
Emotion : $6 \le Joy \le 9$
Emotion : $7.5 \le Hope \le 10$

In this paper, we composed a rule utilizing color psychology to classify the degree of an emotion state more definitely[5][6].

If a numerical value is inputted into each item in table 3.1, it is applied to one or more of 27 rules correspondingly.

In this paper, we applied equations 2.1, 2.2, and 2.3, to draw rules for inference part, and did non-fuzzification using a center of gravity method, equation 2.4. Based on general fuzzy inference and $\alpha - cut$, we conducted experiments to define emotion classification more precisely.

Table 3.1 Inference Rule

Rule	C1	C2	C3	E	Rule	C1	C2	C3	E
R1	H	H	H	Hope	R15	M	M	L	Pain
R2	H	H	M	Joy	R16	M	L	H	Pain
R3	H	H	L	Joy	R17	M	L	M	Anxiety
R4	H	M	H	Joy	R18	M	L	L	Happy
R5	H	M	M	Joy	R19	L	H	H	Anxiety
R6	H	M	L	Joy	R20	L	H	M	Reproach
R7	H	L	H	Joy	R21	L	H	L	Reproach
R8	H	L	M	Happy	R22	L	M	H	Pain
R9	H	L	L	Happy	R23	L	M	M	Reproach
R10	M	H	H	Anxiety	R24	L	M	L	Reproach
R11	M	H	M	Reproach	R25	L	L	H	Pain
R12	M	H	L	Reproach	R26	L	L	M	Pain
R13	M	M	H	Pain	R27	L	L	L	Pain
R14	M	M	M	Pain					

4. Experimental Results

We considered interval values between input value 2.5 to 7.5 in figure 3.2 to classify definitely six emotion states (pain, reproach, anxiety, happy, joy, hope). The number of input patterns considered in this paper is 3, and 375 input patterns are classified in the experiments.

4.1 The Emotion Classification of Fuzzy Inference

Table 4.1 Emotion Distribution by Inference Result Value

Inference Result Value	Emotion Distribution
1.0 ~ 3.0	Pain, Reproach, Anxiety, Happy
3.1 ~ 4.0	Pain, Reproach, Anxiety, Happy, Joy
4.1 ~ 7.0	Pain, Reproach, Anxiety, Happy, Joy, Hope
7.1 ~ 8.0	Reproach, Anxiety, Happy, Joy, Hope
8.1 ~ 9.0	Anxiety, Joy, Hope

In the table above, the emotion distribution by inference result value is the value resulted from the calculation of all membership values (inference values of each emotion state) in consequent part. In the emotion distribution column, emotion states are listed from the right to the left according to the degree of the strength of emotion; the left most item showed the strongest emotion.

When all the membership values in the consequent part from 0.0 to 1.0 being considered, it is impossible to draw one exact emotion classification. It is because most emotion states have two or more membership values. For example, 'pain' has three membership values; 0.6, 0.8, 1.0, and 'joy' has 0.2, 0.4, 0.6, 0.8.

Therefore, we classified an emotion state by applying $\alpha - cut$ to the consequent part.

Figure 4.1 shows the emotion distributions of the six emotion states, with all the consequent membership values being considered.

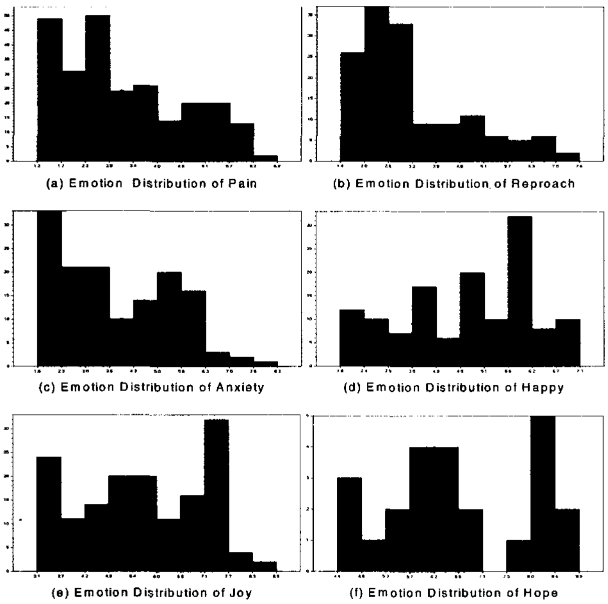

Figure 4.1 Emotion Distribution Histogram Before $E_{\alpha_{0.5}}$ Application

4.2 The Emotion Classification of Fuzzy Inference($E_{\alpha_{0.5}}$)

Table 4.2 Emotion Distribution After $E_{\alpha_{0.5}}$ Application

Inference Result Value	Emotion Distribution
1.0 ~ 2.0	Pain
2.1 ~ 3.0	Pain, Reproach, Anxiety
3.1 ~ 4.0	Pain, Anxiety, Happy, Reproach
4.1 ~ 5.0	Anxiety, Happy, Pain, Reproach
5.1 ~ 6.0	Joy, Happy, Anxiety, Reproach
6.1 ~ 7.0	Joy, Happy, Anxiety, Hope
7.1 ~ 8.0	Joy, Hope
8.1 ~ 9.0	Hope, Joy

Table 4.2 shows the inference results after $E_{\alpha_{0.5}}$ application. In the inference result value between 1.0 and 2.0, the emotion distribution of 'pain' appeared strong. In the inference value between 3.1 and 4.0, 'pain' and 'anxiety' appeared the strongest, 'reproach' the weakest, and 'happy' in

the middle. In the inference value between 6.1 and 7.0, the degree of strength showed the order of Joy, Happy, Anxiety, and Hope (indeed, the membership degree of Anxiety and Hope appears equal in the emotion distribution between 6.1 and 7.0).

Figure 4.2 shows the application of $E_{\alpha_{0.5}}$ to the membership function of the consequent part and figure 4.3 shows the histogram of emotion distribution between 1.0 and 9.0 after the application of $E_{\alpha_{0.5}}$.

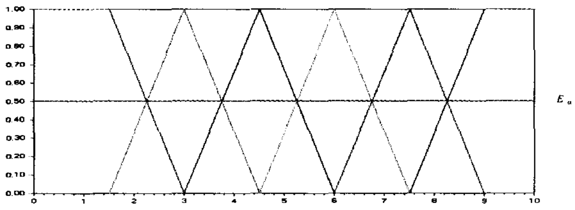

Figure 4.2 $E_{\alpha_{0.5}}$

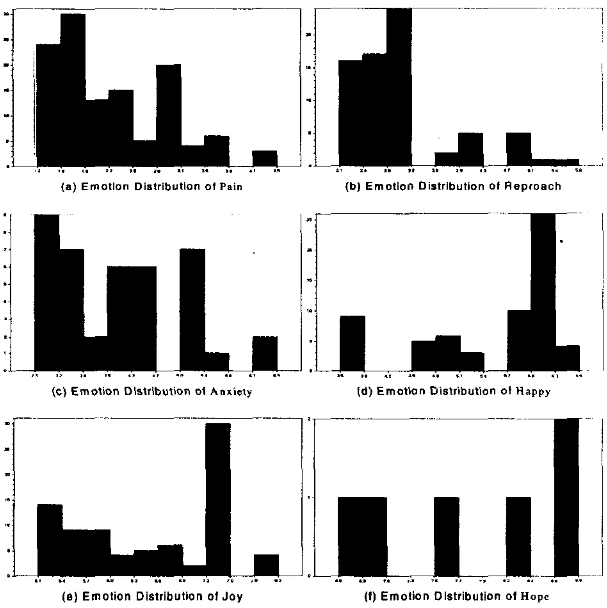

Figure 4.3 Emotion Distribution After $E_{\alpha_{0.5}}$ Appication

As shown in figure 4.3, we can see that an emotion state distribution gets a finer emotion classification after $E_{\alpha_{0.5}}$ setting. For example, if 4, 7, and 3 are inputted into red, green, and blue respectively, rules 11, 12, 14, 15, 20, 21, 23, and 24 are applied, and the reasoning result value reaches 2.405.

If $E_{\alpha_{0.5}}$ is not applied, the membership degree of Pain and Reproach become 0.2 and 0.6 respectively. However, when it is applied, the membership degree of Reproach becomes 0.6.

5. Conclusion

Human emotion is classified into single emotion and composition emotion.

However, most existing methods focus on the classification of single emotion. In this paper, we are proposing a method which will classify human emotion states using color psychology in applied psychology. The inference rule in this paper includes color psychology. And inference and $\alpha-cut$ were applied for the classification of single and composition emotion states.

The experimental results showed that we can classify emotion states more effectively by applying $\alpha-cut$. Therefore, it is expected that the proposed method will be used as a useful tool in the artificial facial expression processing technology of virtual character and psychical cure (e.g healthcare).

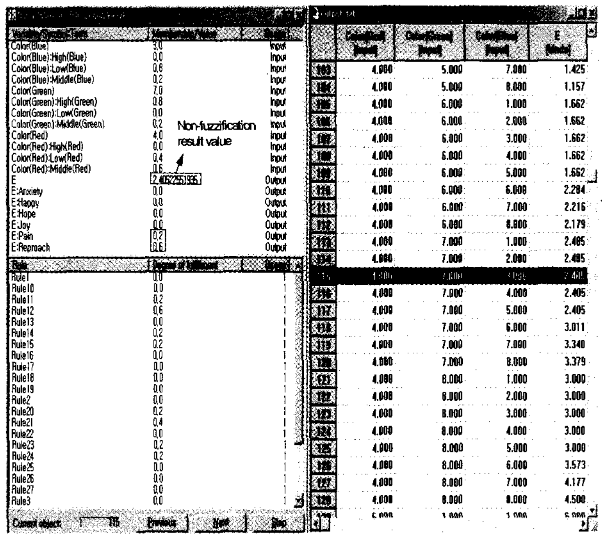

Figure 4.4 Result Screen(Red : 4, Green : 7, Blue : 3)

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