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Conceptual Fuzzy Sets for Picture Reference System with Visual User Interface and Command Recognition System without Keyboard and Mouse

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Abstract **- This paper proposes conceptual fuzzy sets for picture reference system with visual user interface and command recognition system without keyboard and mouse. The picture reference system consists of the associative picture database, the visual user interface and command recognition system. The associative picture database searches pictures by using conceptual fuzzy sets. To show pictures attractive, the visual user interface provides some visual effect functions. The command recognition unit, without keyboard and mouse, captures user's hand by camera and informs it to the system as a command. We implement and evaluate the picture reference system.**

I. Introduction

By progress of computer networks, we often search information through the Internet. There are some picture search engines, such as google[1], yahoo[2], but these picture search engines are not always effective, because these engines are based on keyword search in the filename. There is another image search engine that is based on image processing. But this requires much calculation time for searching pictures[3], [4], [5]. Any search engines that we can get today do not have friendly user interface and visual effects. This paper proposes conceptual fuzzy sets for picture reference system without using keyboard and mouse for friendly user interface. And this paper proposed a picture reference system with visual effects for showing pictures attractive.

II. Associative Picture Database

The system overview is illustrated in figure1. Each picture that is registered to the associative picture database has given index terms. Index term is the feature of the picture. For example it is a type of scenery or color.

At the beginning, the visual user interface offers some pictures to the user. The user selects one picture from them. It is similar to the picture that the user wanted to find. When the user selects a picture, the visual user interface sends the selected picture ID to the associative picture database. The associative picture database gets index terms from the picture database from the selected picture. So the user does not have to input keywords by keyboard. The picture database inferences and sends pictured to the visual user interface.

The keywords that are stored in the picture database are not always what the user wanted to input. This paper managed this problem by using conceptual fuzzy sets [6], because conceptual fuzzy set is able to give broad interpretation of the input word.

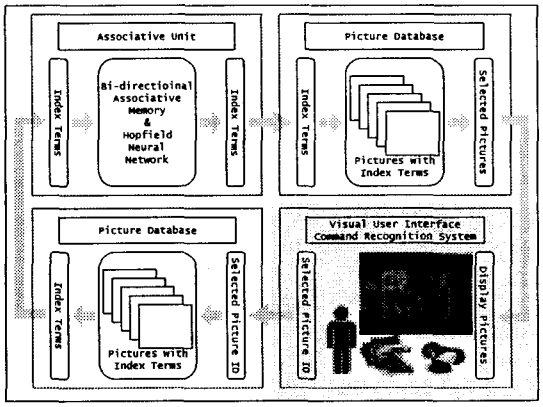


Figure 1 The system overview

The associative unit overview is illustrated in figure2. This paper used pictures, which are displayed with art museum. Index terms given to the pictures were decided by asking the authors who created the picture. These index terms are divided into fuzzy sets in concrete terms layer. This paper used bi-directional associative memory [7] for defining these index term connections. This paper also defined abstract terms. Abstract terms express relations between different index terms in concrete terms layer. Index terms in abstract terms are connected to some index terms in some different concrete terms layer, so this paper used hopfield neural network [8] to define these relations.

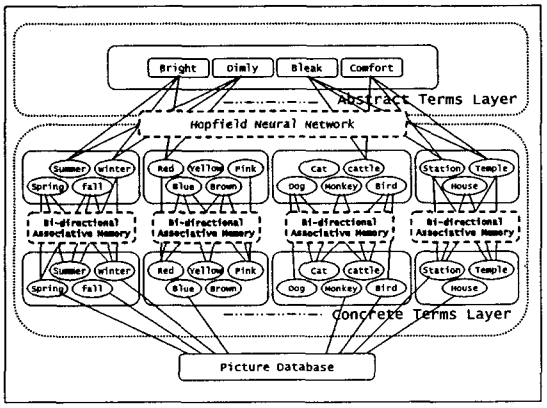


Figure 2 The Associative Unit

A: Conceptual Fuzzy Sets

Conceptual fuzzy set is able to express one word by different words. Different words are expressed in a shape of fuzzy sets. Fuzzy set is composed of activity distribution. Each activity belongs to each word. Activities are controlled

by associative memory. Associative memory is composed of label names and associative matrix that expresses relations between labels and labels.

This paper built conceptual fuzzy sets with bi-directional associative memory and hopfield neural network for searching an image.

B: Bi-directional Associative Memory

Bi-directional Associative Memory is composed of two layers shown in figure3. There are some nodes in each layer. The relation between nodes and nodes is defined by associative matrix.

There are some nodes in each layer. The relations among nodes are defined by associative matrix $M \in R^{n\times n}$. Each index term is fixed to a node. The two layers, L_a and L_b, have the same node sets. The association is executed by following formula.

$$B(t)=\phi(MA(t)),\quad A(t+1)=\phi(M^T B(t)) \tag{1}$$

$A(t)=(a_1(t),a_2(t),\ldots,a_n(t))^T$ and

$B(t)=(b_1(t),b_2(t),\ldots,b_n(t))^T$ are vectors of the activate value for each node and each element has a value {0,1}. ϕ is a sigmoid function

$$return=\frac{1}{1-\exp^{-argument}}$$

If pattern pair $(A_1^T,B_1^T)^T\ldots(A_k^T,B_k^T)^T$ is remembered, formulate (2) find associative matrix M.

$$M=\sum_{i=1}^{k}\beta B_i A_i^T,\quad M^T=\sum_{i=1}^{k}\beta A_i B_i^T \tag{2}$$

β is coefficient of association. Regulation of associative matrix M is necessary for preventing saturation. Regulated associative matrix M_e is given by (3). m_{ij} is an element of M

$$M_e=a(M+B) \tag{3}$$

$$a=\frac{2(Max(m_{ij})-Min(m_{ij}))}{3},\quad c=\left(\sum_{i,j}m_{ij}\right)/nn$$

$$B=\begin{bmatrix}-c & -c & \ldots & -c\\ -c & -c & \ldots & -c\\ \vdots & \vdots & \ddots & \vdots\\ -c & -c & \ldots & -c\end{bmatrix}$$

This paper set same layer to two layers. And this paper used bi-directional associative memory to have broad interpretation of the input word.

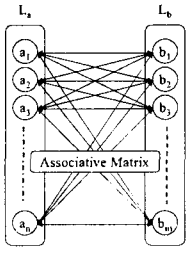


Figure 3 Bi-directional Associative Memory

C: Hopfield Neural Network

A constitution of hopfield neural network is shown in figure 4. All labels are connected to all labels. But each label has no connection to itself, so the diagonal ingredient of associative matrix becomes zero. If pattern vectors

$$A_i=\left[a_1^{(i)},a_2^{(i)},\cdots,a_N^{(i)}\right]^T,(i=1,2,\cdots,P)$$

are remembered, the weight matrix is defined by (4).

$$W=\begin{bmatrix}0 & w_{12} & \cdots & w_{1N}\\ w_{21} & \ddots & & \vdots\\ \vdots & & 0 & w_{N-1,N}\\ w_{N1} & \cdots & w_{N,N-1} & 0\end{bmatrix}$$

$$=\begin{bmatrix}0 & \sum_{i=1}^{P}a_1^{(i)}a_2^{(i)} & \cdots & \sum_{i=1}^{P}a_1^{(i)}a_N^{(i)}\\ \sum_{i=1}^{P}a_2^{(i)}a_1^{(i)} & \ddots & & \\ \vdots & & 0 & \sum_{i=1}^{P}a_{N-1}^{(i)}a_N^{(i)}\\ \sum_{i=1}^{P}a_N^{(i)}a_1^{(i)} & \cdots & \sum_{i=1}^{P}a_N^{(i)}a_{N-1}^{(i)} & 0\end{bmatrix} \tag{4}$$

Here, $w_{ij}=w_{ji}$, and $a_k^{(i)}$ has a value {0,1}. The status of the each node is updated by (5).

$$y_i^{new}=\begin{cases}1, & \sum_{j=1}^{N}w_{ij}y_j^{old}-\theta_i>0\\ y_i^{old}, & \sum_{j=1}^{N}w_{ij}y_j^{old}-\theta_i=0\\ 0, & \sum_{j=1}^{N}w_{ij}y_j^{old}-\theta_i<0\end{cases} \tag{5}$$

$y_i(i=1,2,\cdots,N)$ is a output of each node. θ_i is the threshold of i th node. When the energy function

$$E=-\frac{1}{2}\sum_{i=1}^{N}\sum_{j=1}^{N}w_{ij}y_i y_j+\sum_{i=1}^{N}\theta_i y_i$$

concentrates minimum value, the hopfield neural network stops updating. Then the inferred terms that are fixed activated node are outputted. This paper used hopfield Network for defining relations of labels between abstract terms and concrete terms.

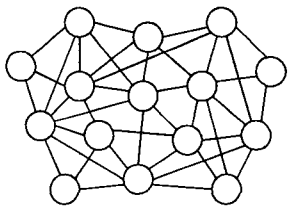


Figure 4 Hopfield Network

III. Visual User Interface

When the visual user interface receives pictures from the associative picture database, the visual user interface shows them in the display. The initial display window is shown in Figure 5. Four pictures are displayed in the display window at the same time, one is in front, the other one is behind, and the rests are on the right side and the left side.

When the visual user interface shows the new pictures, the visual effect is given. The visual effect is something like making the user seem to fly to the next room. The scene is

shown in Figure 6.

The user is able to rotate the displayed four pictures. When the rotation is executed, a picture goes out from the display window and a new picture comes into the display window.

When the user selects a picture, the picture ID is send to the associative picture database. And the visual user interface receives new pictures from the associative picture database. And the visual effects are executed again (Figure6).

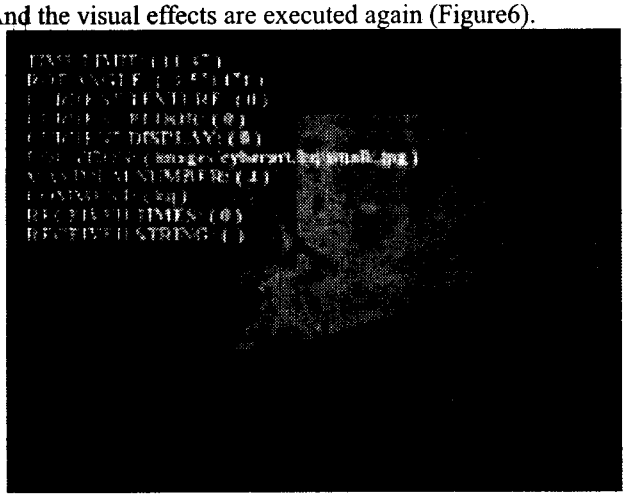
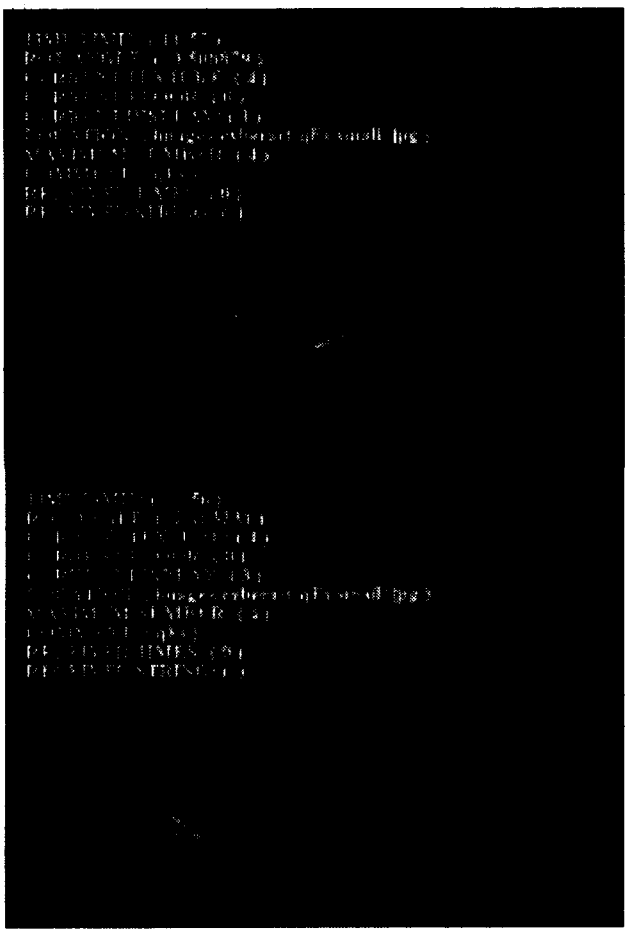


Figure 5 Initial display window



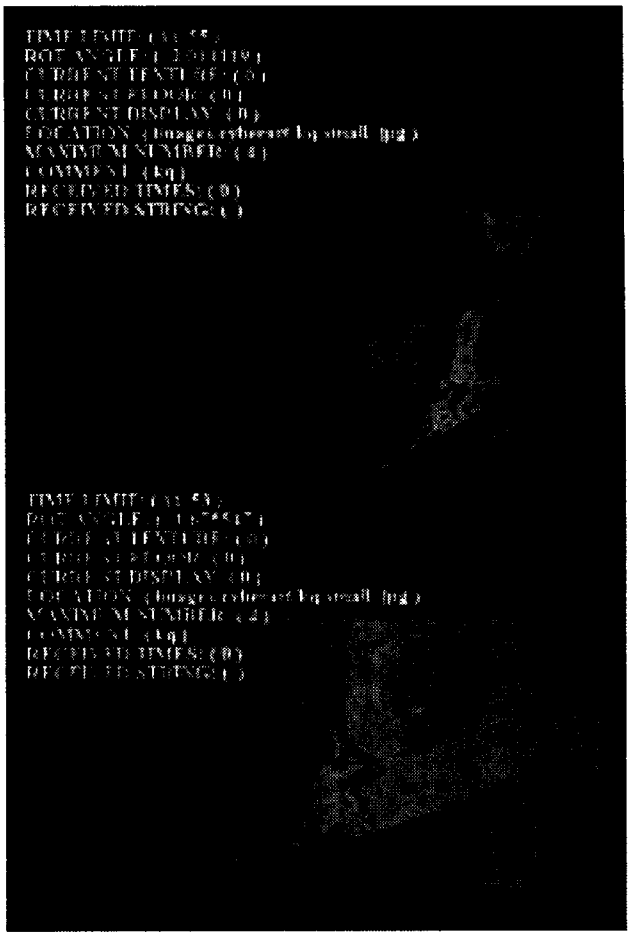


Figure 6 The scene : Fly to the next room

IV. Command Recognition System

The command recognition system enables the user to control without keyboard and mouse. The command recognition system overview is illustrated in figure 7. The command recognition system controls the visual user interface by remote control.

This system is composed of USB camera, image processing software, and recognition unit. We call this image processing software ∀ -Space. ∀ -Space captures user's hand by camera, applies the captured image to the CrCb color filter, and gets user's hand location. The user's hand location is send to the recognition unit, and it is used as a command. The recognition unit recognizes three commands by the location of the user's hand.

(1) Rotate to The Right Direction : The user moves his/her hand to the right direction, the visual user interface rotates pictures to the right direction.
(2) Rotate to The Left Direction: The user moves his/her hand to the left direction, the visual user interface rotates pictures to the left direction.
(3) Select Picture : The user moves his/her hand to the down direction, the visual user interface sends the picture ID, that is the center of the display.

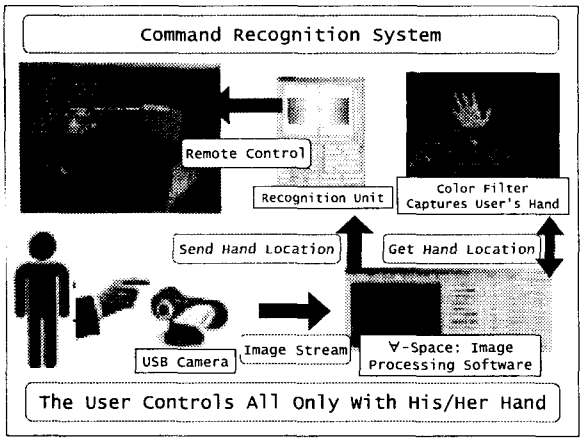


Figure 7 The command recognition system

V. Experiment and Results

A scene of the experiment is shown in figure 8. 64 pictures with index terms were registered to the associative picture database. The associative picture database and the visual user interface are connected by local area network. In this paper, two experiments ware executed.

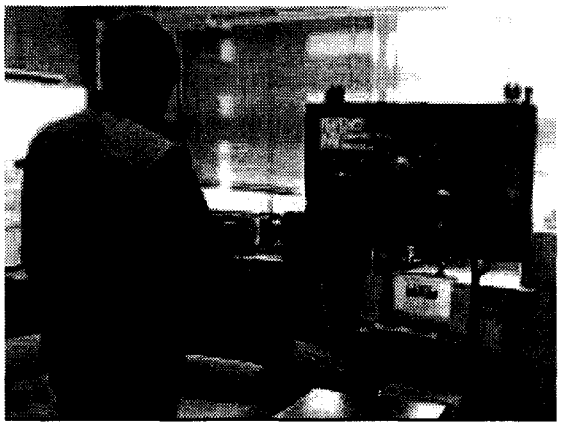


Figure 8 A scene of experiment

A: **Can we get the target picture quickly?**

In this experiment, we counted the number of referred pictures. First of all, the user was noticed the target picture. And, the user started to search it. When the user got the target picture, the user finished searching.

The result is shown in figure 9. More than 65% users can get to the target picture less than referring 20 pictures

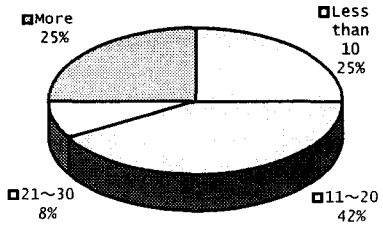


Figure 9 The number of referred pictures

B: **Did the command recognition system recognize commands correctly?**

In this experiment, we investigated the command recognition rate. The result is shown in figure 10.

The command recognition rate is 96%. The command recognition system with ∀ -Space has high performance command recognition.

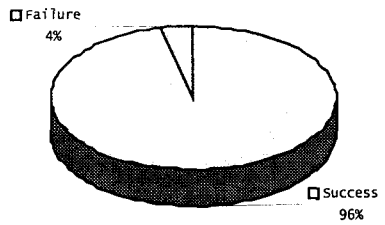


Figure 10 The command recognition rate

5. Conclusion

In this paper, we proposed the picture reference system that is composed of the associative picture database and the visual user interface. The associative picture database searches pictures by using conceptual fuzzy sets. The conceptual fuzzy sets are implemented by bi-directional associative memory and hopfield neural network. The friendly user interface, without keyboard and mouse, captured user's hand and informed it to the system as a command. To show pictures attractive, the visual user interface provided some visual effect functions. We implemented and evaluated the picture reference system. As a result, we confirmed that the picture reference system is effective and useful for searching pictures and has attractive visual effects.

References

[1] http://www.google.com/
[2] http://www.yahoo.com/
[3] D. S. Faulus and R. T. Ng, "An expressive language and interface for image querying," Proc. IAPR Workshop on Machine Vision and Applications, vol.10, pp.74-85, 1997.
[4] M. Flickner, H. Sawhney, W. Niblack, J. Ashley, Q. Huang, B. Dom, M. Gorkani, J. Hafner, D. Lee, D. Petkovic, D. Steele, and P. Yanker, "Query by image and video content: The QBIC system," IEEE Computer, vol. 8, no.9, pp.23-32, 1995.
[5] Y. Musha, A. Hiroike, and A. Sugimoto, "Visualization Interface of Image Feature Space in Similarity-Based Image Retrieval" (in Japanese), IEICE Trans. D-II, vol.J82-D-II, no.10, pp.1626-1633, Oct. 1999.
[6] T. Takagi, T. Yamagichi, and M. Sugeno, "Conceptual Fuzzy Set and Its Implementation Using Associative Memory" (in Japanese), 7th Fuzzy System Symposium, pp.359-362, 1991.
[7] B. Kosko, "Bi-directional associative memories," IEEE Trans. Syst., Man, and Cybern., SMC-18, 1, pp.49-60, Jan./Feb. 1988.
[8] J. J. Hopfield, "Neural networks and physical systems with emergent collective computational abilities," Proc. National Academy of Sciences, USA 79, pp.2554-2558, 1982.