Memoirs of the Faculty of Engineering, Okayama University, Vol. 33, No.2, pp. 85-89, March 1999

A Method of Shape Recognition Using CAD Data and Vertex-Dictionary

Mitsuru YAMADA* * and Hirokazu OSAKI**

(Received March 1 , 1999)

We reason the circumstances around the three-dimensional vertex from the information about the intersection point in the two-dimensional image data inputted from a camera on the premise that we use this method as the eye of the robot.

In this method, we use the Vertex-Dictionary. We make the Vertex-Dictionary by calculation from CAD data of object figure (these data are already known) and the position data of the point of view. This dictionary includes the data of position and relations of connect surface etc. about a vertex. We get the data of three-dimensional vertex by comparison the data of two-dimensional intersection point in image data and Vertex-Dictionary. And we get the three-dimensional object by reasoning about the information of circumstances of all vertexes. Then we can recognize the three-dimensional object from image data. In this report, we explain the process to calculate the Vertex-Dictionary and some examples about this method.

1. INTRODUCTION

Recently the studies of shape recognition have been recognized to be important as "Robot vision system", and many studies have been done and proposed many methods. But conclusive method isn't proposed yet. We gave attention to intersection points in two-dimensional (2D) image[1] and we have proposed the method to recognize and differentiate the three-dimensional (3D) subject using the information about intersection points.

In this report we explain the process of calculate the Vertex-Dictionary and some examples about this method to recognize and differentiate. This dictionary is referred to reason 3D vertex from 2D intersection point. And we make it from CAD data about the subject to differentiate and position data about every point of view.

2. METHOD

2.1 A Method of Shape Distinction

Fig.1 shows the process that we propose. Firstly we extract intersection points on 2D image data by the general image processing (thresholding , thinning , line extraction, etc.). And secondly we gave attention to edges and intersection points on the 2D image data in this method. But in this report we confined diacritical subjects to 3D shapes composed by lines because our object is verification of algorithm. And we extracted 2D intersection points. Fig.2 shows 4 types of 2D intersection points that we treated. Next, we reason the circumstances around the 3D vertex from the information about the 2D intersection point that were already known as the Vertex-Dictionary. When we want to differentiate one subject, we use one 2D-image. When we want to recognize one 3D shape, we use two 2D-images inputted from different points of view in order to differentiate. We reason 3D shape by putting together information about the circumstances around the same 3D vertex gotten from two 2D-images. We repeat this procedure about all intersection points. So we can recognize and differentiate the 3D shape by comparison the data that is prepared as the "Vertex-Dictionary".

---

* Industrial Technology Center of OKAYAMA prefecture
** Department of Systems Engineering

2.2 Relation of 3D Vertex and 2D Intersection Point

Fig.3 shows relation of one 3D vertex and two 2D intersection points which are projected from two different points of view. In this report we set up 26 viewpoints as indicated in Fig.4. One viewpoint is expressed by the direction vector such as (1,1,0). In order to reason the 3D vertex from the 2D intersection points, we prepare the following information[2] on each vertex about all points of view.

(1) Data of figure element
  2D position data of the intersection point
  Direction unit vector and length about all lines (2D)
(2) Type of intersection point
(3) Relation of connection of lines
(4) Existence of surface
(5) Relation of connection of surfaces
(6) Depth of surfaces from point of view

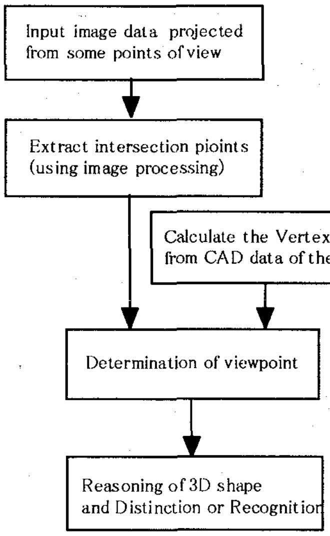

Fig.1 Flowchart of this method

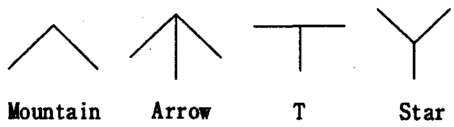

Fig.2 Types of intersection points

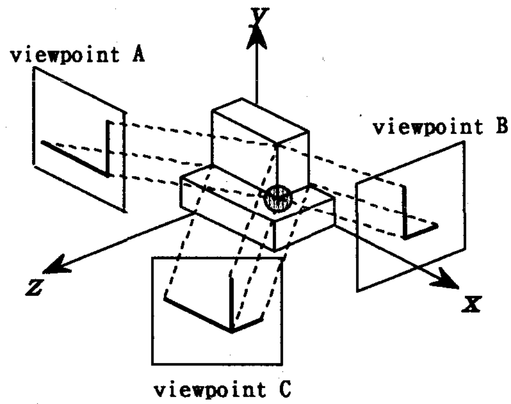

Fig.3 Relation of 3D vertex and 2D intersection point

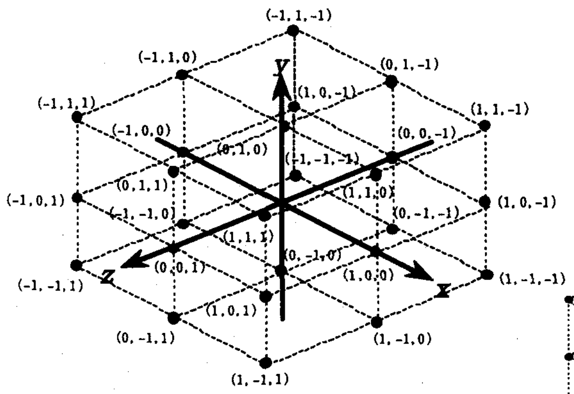

Fig.4 Points of view

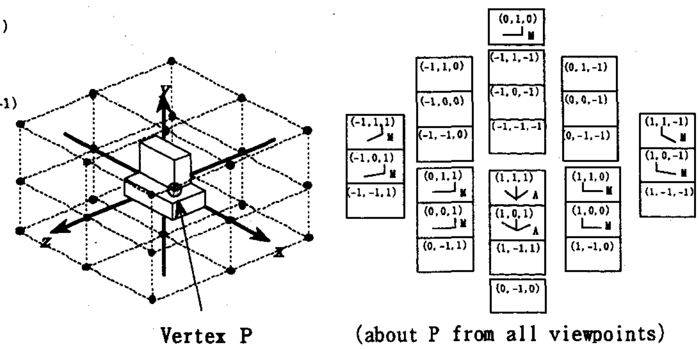

Fig.5 Sample of Vertex-Dictionary

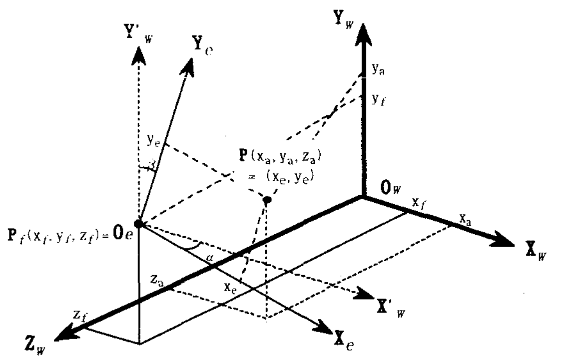

Fig.6 Relation of the world coordinate and the local coordinate projected from a point of view

The "Vertex-Dictionary" is constituted by these all data about the target shape. Using this information, we can reason 3D shape. Fig.5 shows the sample of "Vertex-Dictionary".

2.3 Calculation of Vertex-Dictionary

The Vertex-Dictionary is calculated from the position data of all viewpoints and CAD data of the target shape. We calculated these data by using transformation of position data from the world coordinate system to the local coordinate system projected from all viewpoints. Fig.6 shows the relation of the world coordinate system and the local coordinate system. 3D vertex data are transformed to the 2D intersection data by the following transformation formula.

$$\begin{bmatrix} x_e \\ y_e \\ z_e \\ 1 \end{bmatrix} = T_v \begin{bmatrix} x_a \\ y_a \\ z_a \\ 1 \end{bmatrix}$$

$$T_v = \begin{bmatrix} \cos\alpha & \sin\alpha\sin\beta & \sin\alpha\sin\beta & 0 \\ 0 & \cos\beta & -\sin\beta & 0 \\ \sin\alpha & -\cos\alpha\sin\beta & -\cos\alpha\sin\beta & 0 \\ -x_f\cos\alpha - z_f\sin\alpha & -x_f\sin\alpha\sin\beta - y_f\cos\beta + z_f\cos\alpha\sin\beta & -x_f\sin\alpha\cos\beta + y_f\sin\beta + z_f\cos\alpha\cos\beta & 1 \end{bmatrix}$$

$$\cos\alpha = \frac{z_f - z_a}{\sqrt{(x_f - x_a)^2 + (z_f - z_a)^2}}, \sin\alpha = \frac{x_a - x_f}{\sqrt{(x_f - x_a)^2 + (z_f - z_a)^2}}$$

$$\cos\beta = \frac{\sqrt{(x_f - x_a)^2 + (z_f - z_a)^2}}{\sqrt{(x_f - x_a)^2 + (y_f - y_a)^2 + (z_f - z_a)^2}}, \sin\beta = \frac{y_f - y_a}{\sqrt{(x_f - x_a)^2 + (y_f - y_a)^2 + (z_f - z_a)^2}}$$

All 3D-lines and 3D-vertexes in CAD data are transformed to the 2D-lines and intersection points data. And 2D intersection points are classified 4 types as indicated in Fig.2 by making reference to connections of lines and surfaces.

By this process, we can get the information that is above-mentioned (1)-(3),(5). Existence of surface is also gotten by the surface information of CAD data. And depth of surface from point of view is also gotten by making reference to position data that is transformed.

3. EXPERIMENT

3.1 Sample of Distinction

In order to test this method, we deskchecked one simple experiment of distinction. Fig.7 shows two sample 3D shapes and Fig.8 shows samples of a part of the "Vertex-Dictionary". In this case we used the data of four intersection points in order to differentiate.

3.2 Flow of Shape Distinction and Result

Fig.9 shows the sample of 2D image data inputted from one camera. We can differentiate Shape-A by the following process as indicated in Fig.10.

(1) Extraction of 2D intersection points

We extract intersection points on 2D image data by the general image processing and classified intersection points to four types ("M":Mountain,"A":Arrow,"T":Large T,"S":Star).

(2) Determination of viewpoint

When we suppose that the shape on sample image is Shape-A, we can reason that the position of viewpoint is (1,1,1) by using the Vertex-Dictionary about from P1 to P3. And when we suppose that the shape is Shape-B, we can also reason that the position of viewpoint is (1,1,1).

(3) Distinction

Next, we pay attention to P4 on sample image. P4 is type "S". Then we can differentiate two sample shapes to compare the Vertex-Dictionary about Shape-A and Shape-B.

The result of this experiment was that we could differentiate a 3D shape by using only one 2D image.

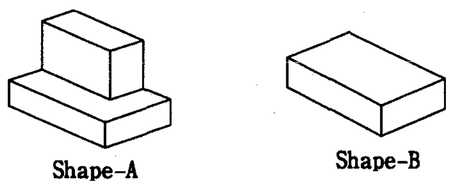

Fig.7 Sample shapes

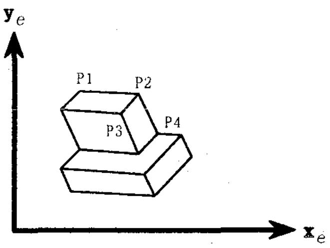

Fig.9 Sample of 2D image data

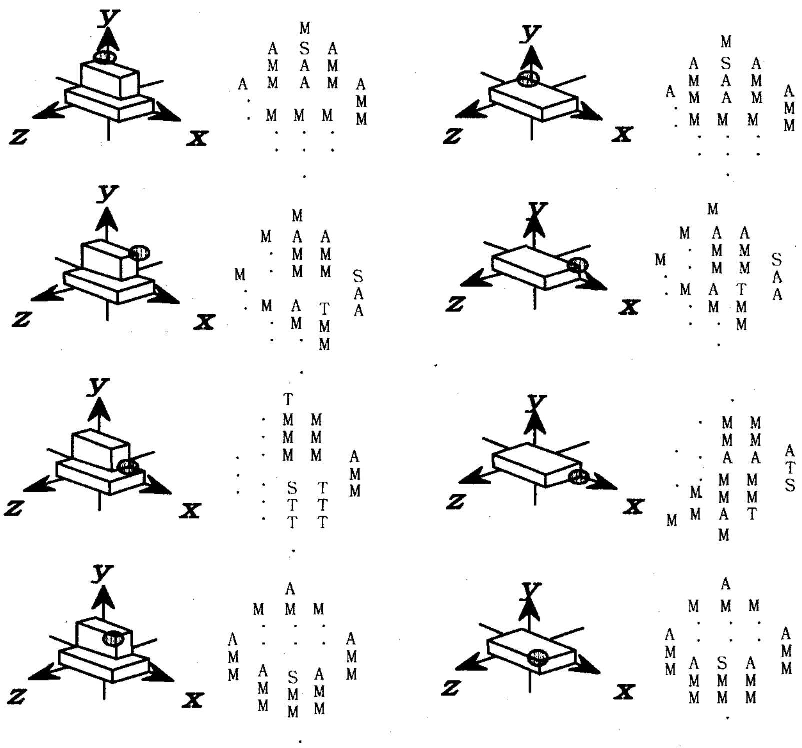

Fig.8 Sample of a part of the Vertex-Dictionary

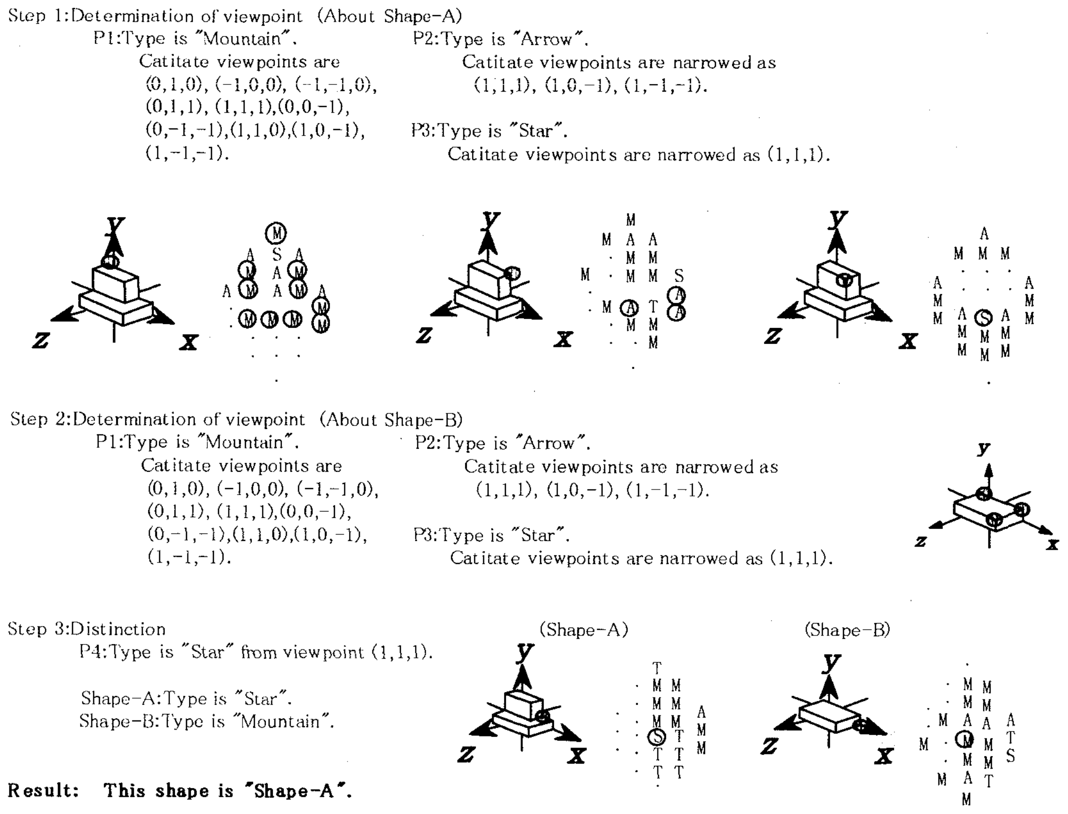

Fig.10 Process of sample experiment

4. CONCLUSION

In this report we have suggested one method to recognize and differentiate 3D shapes by using 2D images. And we did simple experiment in order to test this method. We could differentiate 3D shapes. This method has the following feature because it uses CAD data of subjects to recognize or differentiate and the Vertex-Dictionary.

(1) The point of view can be determined by only one or two 2D-image data.

(2) By using the Vertex-Dictionary that is calculated ahead from CAD data, the steps of calculation are less than usual methods to recognize and differentiate.

(3) The shape of the blind side can be reasoned because 3D shape is recognized as the object.

But these feature are verified incompletely because we only deskcheked the simple experiment. So we have to do some experiments in order to demonstrate merits of this method.

And we want to use this as the method of input image data to the figure data of 3D CAD systems, the eyes of robot and so on.

REFERENCES

[1] Mitsuru Yamada, Hirokazu Osaki, A Method of Shape Recognition Using Geometry Information, Memories of the Faculty of Engineering, Okayama University, Vol.31,No.2,March(1997)

[2] Makoto Nagao, Pattern Recognition of Computer, Univ. of Tokyo Press, (1988) , 187