Memoirs of the Faculty of Engineering, Okayama University, Vol.31, No. 2, pp.61-65, March 1997

A Method of Shape Recognition Using Geometry Information

Mitsuru YAMADA* and Hirokazu OSAKI**

(Received February 25, 1997)

At present , the two dimensional CAD systems which are used to make drawings go around widely. But in order to use design data at the lower stream of production process , the replacement from the two dimensional CAD systems to the three dimensional CAD systems have started . Accordingly it is necessary to exchange the past design data which was expressed in the two dimensional drawings for the three dimensional shapes. And it is also necessary to store them in the three dimensional CAD systems. And in the studying of the machine vision which is often used as "Eyes of robot" , it is being studied the method to recognize the three dimensional objects from the two dimensional image. This is the problem about data exchange, too. Therefore in this report , we propose the method to exchange the plural two dimensional figures for the three dimensional shapes. At first, we extracted the two dimensional elements of figure from image data by using image processing technology. And the connections and the positional relations between elements were found from reference of the element coordinates. Next, the three dimensional shapes were reasoned from reference of the knowledge (for example, the connection and the position between elements, a construction of surface and corner, etc.) prepared beforehand. Then that data were exchanged to the three dimensional CAD data. We report one example about this method.

1. INTRODUCTION

When knowledge information processing is used to promote efficient design process by using CAD system , it is important that the past design examples and design know-how are stored as the knowledge database[1]. Accordingly a study of knowledge discovery method is being studied in order to make the existing design knowledge into the database. We are considering about the knowledge discovery method in order to use the past design examples and standard design examples which were represented into two dimensional drawings[2]. In this report , we describe the method which uses neural networks to distinguish three dimensional shapes from two dimensional figures.

2. METHOD

Fig.1 shows a flow of this processing . Because we assumed to distinguish three dimensional figures that are represented in the drawings , we assumed to treat gray scale images. Therefore, in the first half of processing , we converted raster data which represents the gray level of pixels into vector data which expresses figures (for examples , one line is expressed by two points data) by using the image processing technique. And in the later half , we obtain the feature extraction from figure data by paying attention to the connect situation. And by using knowledge database which is prepared beforehand , we utilized the neural networks to distinguish a kind of solid shape which were represented on two dimensional drawing.

2.1 Extraction of the figure elements

Generally , because drawings are expressed black or blue lines on the white background , shapes are easy to be extracted to the gray scale image by using thresholding. So, at first we get image data that is expressed as the two value (black and white) by thresholding. Next, by

* Industrial Technology Center of Okayama Prefecture
** Department of Systems Engineering

referring the histogram of continuous element length gotten by vertical and horizontal scanning, we get the pixel length which was composed width of one line. And we do thinning (also known as skeletonizing or medial axis transform) by using this length. As a result , the drawing becomes the image data described by the one pixel width lines . Next , we extracted figures from two value image data (raster-to-vector conversion) , but we limited figures composed simple lines without circles and arcs because the purpose of this experiment is the propriety confirmation of procedure.

The procedure are

① Extraction of vertical and horizontal lines by using spatial filtering[3].

② Extraction of slanted lines by Hough conversion[4].

Then ,the figure data is expressed to the CAD data. For examples , one line data is expressed by the initial point coordinates , the terminal coordinates , length and the direction unit vector.

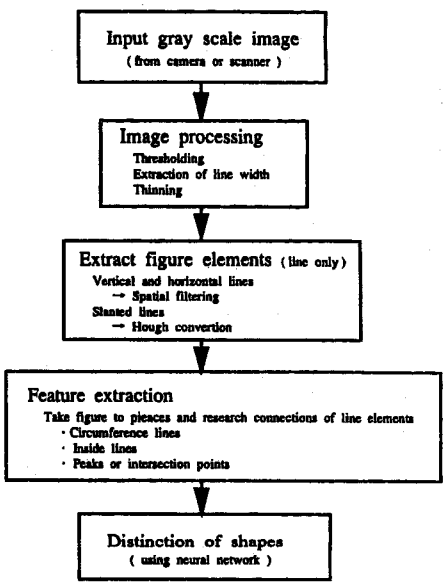

Fig.1 Data flow of this method

2.2 Feature extraction

In order to represent the figure feature by some value , we get the feature extraction by paying attention to the kind and number of peaks and points of intersection , the connect situation among lines from the two dimensional figure data. Peaks and points of intersection are limited to three kinds shown by Fig.2. And they can express fundamental solid shape by these combinations and lines. And , by referring the position relation among lines connected points of intersections, we divide lines that constituted circumference from other lines.

Therefore , next seven items represented as figure feature.

① Ratio circumference lines : inside lines
② Number of total lines
③ Number of peaks (mountain type)
④ Number of intersection points (arrow type)
⑤ Number of intersection points (star type)
⑥ Number of circles
⑦ Number of arcs

Fig.3 shows example of feature extraction .

Fig.2 Kinds of peaks and intercention points

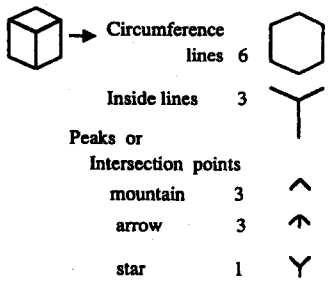

Fig.3 Sample of feature extraction

2.3 Distinction of shape by referring to knowledge database

(1) Knowledge database

Distinction method of three dimensional solid is to find a basic shape which is most similar to the objects by searching through the knowledge database which is prepared beforehand. The contents of database is composed of each basic figure data such as

① Number of segments of circumference lines
② Number of other lines
③ Each number of the kind of peaks and points of intersection
④ Method of coordinate calculation

And they are putted in order as the tree structure.

(2) Distinction method by neural networks

Image data inputted from cameras or image scanners often lose figure information because it is influenced from illumination blur , a shade or a dust . So we used neural networks in order to search the database by regarding figure feature as a pattern. And in order to increase certainty of distinction , we tried to add the re-learning function to the neural networks . Fig.4 shows data flow of distinction process in this system . The re-learning process is executed when the most influential candidate of shape gets certainty over 75% and the second candidate gets certainty less than the half of the most. Because the neural networks learn the good case in every time , the certainty of distinction is increased little by little.

In this case , because the neural networks certainly select the most similar data from pattern data learned beforehand , it can make up for the defective information of image data . And it also has multiusability because we can change distinction function by setting the initial data .

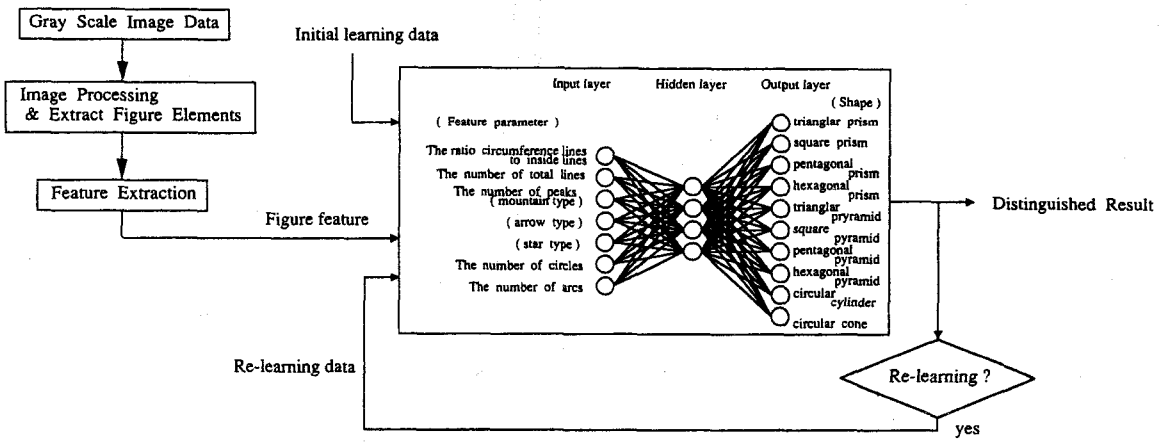

Fig.4 Data flow of distinction process

3. SAMPLE EXPERIMENT

3.1 Sample problem

In order to inspect the propriety of this method , we did distinction experiment for a standard three dimensional shape which are represented in the two dimensional drawing . In this time , we tested two functions of this method . One is the function of distinction among some other shapes , another is the function of distinction when image data is lacked .. Our objects were 3~6 prism , 3~6 pyramid , a circular cylinder and a circular cone. The size of image data was about 500×400 pixels and the data of brightness were 256 scales.

Table 1 Initial learning data

		inside lines / circumference lines	total lines	arrow mountaion	arrow star	circles	arcs
prism	triangular	1 / 5	6	3	2	0	0
		3 / 5	8	2	3	1	0	0
	square	1 / 6	7	4	2	0	0	0
		3 / 6	9	3	3	1	0	0
	pentagonal	3 / 7	10	4	3	1	0	0
		5 / 7	12	3	4	2	0	0
	hexagonal	5 / 8	13	4	4	2	0	0
		7 / 8	15	3	5	3	0	0
pyramid	triangular	0 / 3	3	3	0	0	0	0
		1 / 4	5	2	2	0	0	0
	square	1 / 4	5	2	2	0	0	0
	pentagonal	1 / 4	5	2	2	0	0	0
		2 / 5	7	2	3	0	0	0
	hexagonal	2 / 5	7	2	3	0	0	0
		3 / 6	9	2	4	0	0	0
	circular cylinder	1 / 4	5	2	2	0	0	3
	circuler cone	0 / 3	3	3	0	0	0	1

3.2 Initial learning data

Table 1 shows the initial learning data in this experiment . In this data , there were two pattern data from two view points about one solid shape . But there were same figures such as

a triangular pyramid and a square pyramid. But human maybe can not distinguish these shapes from that data. The initial learning repeated 3000 times on one pattern.

3.3 Result and discussions

(1) Distinction among some shapes

In this experiment, we set up the initial shapes as the objects in order to test the function of distinction. Next six figures were samples.

S_1: Triangular prism
S_2: Square prism
S_3: Pentagonal prism
S_4: Hexagonal prism
S_5: Triangular pyramid
S_6: Pentagonal pyramid

Fig.5 shows figure samples and outputs of neural networks. About prisms, this method was able to distinguish shapes but it was not about pyramids. But we think that human maybe can't distinguish them from the initial data.

(2) Distinction when image data is lacked

In this experiment, next four figures were samples.

S_1: A perfect square pillar (same as the initial learning data)
S_2: The figure which contains a line that part ended
S_3: The figure which contains one unnecessary line
S_4: The figure which loses one whole line

Fig.6 shows figure samples and outputs of neural networks. The result came up to our expectation about S_2 and S_3. But S_4 wasn't identified. About this, we think that human maybe can't understand that S_4 is a square pyramid from the initial data. We guess that the reason why S_4 wasn't identified is the influence of assortment about the initial data and expression of figure feature. We will have to consider about these problems in the future.

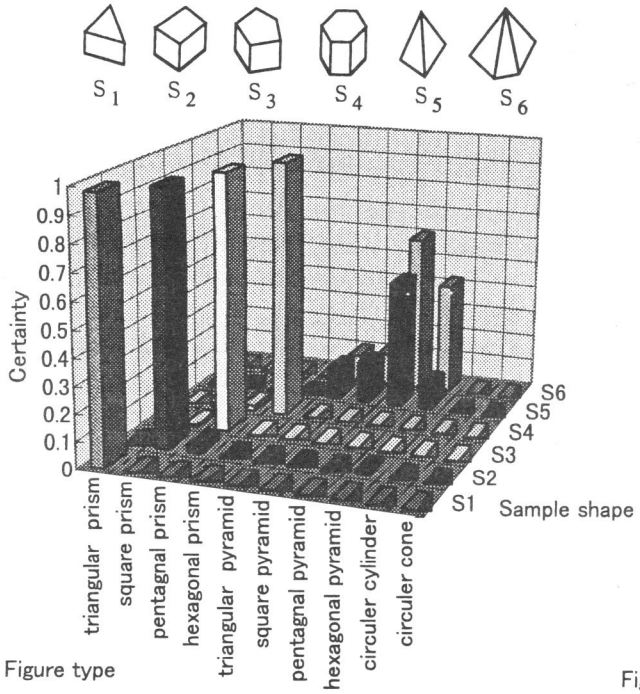

Fig.5 Result of distinction (1)

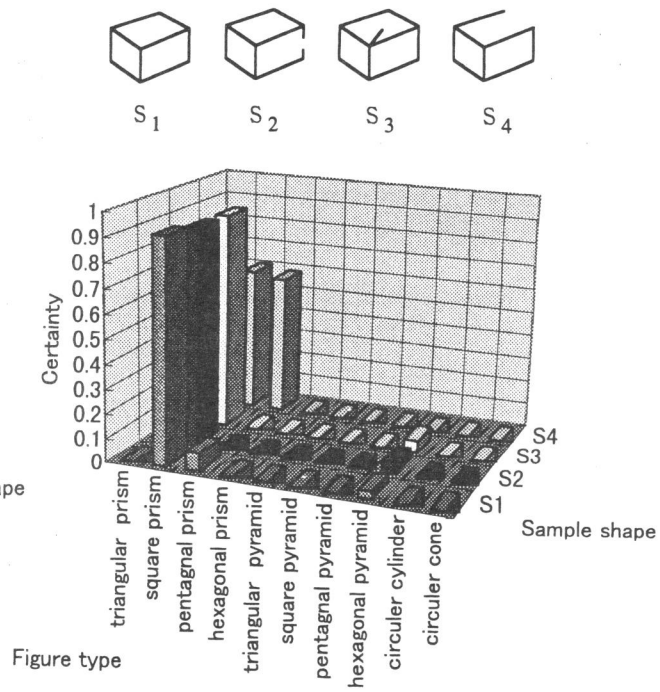

Fig.6 Result of distinction (2)

4.. CONCLUSION

In this paper we describe about the method by using image processing and neural networks in order to distinguish three dimensional shapes from two dimensional figures. As a result , we were able to distinguish some three dimensional shapes from two dimensional drawing. And we were able to ignore an omission of information that was contained in image data by using neural networks and knowledge database . Then we found a guiding principle about the automatic understanding of drawings . We expect that we will be able to use this method as knowledge discovery of the intelligent CAD system in the future.

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