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Object Recognition Algorithm with Partial Information

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Abstract

Due to the development of video and optical technology today, video equipments are being used in a variety of fields such as identification, security maintenance, and factory automation systems that generate products. In this paper, we investigate an algorithm that effectively recognizes an experimental object in an input image with a partial problem due to the mechanical problem of the input imaging device. The object recognition algorithm proposed in this paper moves and rotates the vertices constituting the outline of the experimental object to the positions of the respective vertices constituting the outline of the DB model. Then, the discordance values between the moved and rotated experimental object and the corresponding DB model are calculated, and the minimum discordance value is selected. This minimum value is the final discordance value between the experimental object and the corresponding DB model, and the DB model with the minimum discordance value is selected as the recognition result for the experimental object. The proposed object recognition method obtains satisfactory recognition results using only partial information of the experimental object.

Keywords: *Image Comparison, Object Recognition, Partial Information, External Outline, Edge Detection, Image Device, Feature Extraction*

1. INTRODUCTION

Among the four fields of Artificial Intelligence [1], Virtual Reality [2], Internet of Things, and Autonomous Navigation [3] representing the 4th industry, Autonomous Navigation has developed with the development of electronic devices such as computers, cameras, and sensors. Autonomous Navigation was at first avoiding simple obstacles on the road, but now it has developed to the level of self-judgment and driving without the help of people in the downtown area. Image processing [4] and recognition technology [5] are two central axes supporting Autonomous Navigation. In the field of Autonomous Navigation, object recognition is the process of identifying objects on the road using cameras and sensors. Better object recognition is possible through the image processing process.

2. THE RELATED WORKS

Object recognition is the process of comparing with the DB models stored in the system to identify the object in the input image obtained through the input camera equipment. As a general recognition method, the important key vertices in the input image are searched to detect the line segments representing the experimental object [6]. After analyzing these line segments, we define the features of the experimental object and then

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compare them with the features of the DB models stored in the system, and finally the best DB model is selected as the recognition result for the experimental object. Therefore, the method of selecting important key vertices that characterize the experimental object affects the recognition result. Especially in the Autonomous Navigation, which is a field of the 4th industry, the object recognizing process is an important part in developing an autonomous driving vehicle because the vehicle must arrive safely to the destination while avoiding obstacles by sensing the surroundings in real time. For example, autonomous driving vehicles must recognize the surroundings [7] by using the camera equipment installed on the vehicles, and also recognize the crosswalk and the moving directions of vehicles [8]. Therefore, the portion of image processing and recognition processes might be large in the development of these autonomous driving vehicles. In this paper, we propose a method of recognizing an experimental object with only partial information when a problem occurs in a part of the input image due to the mechanical problem of the camera device.

3. THE MAIN SUBJECT

The object recognition system detects line segments constituting the outer shape of the DB model and then compares the directions of these line segments and constructs the outline of the DB model with line segments having different directions. The first vertex of each line segment serves as a key point constituting the outline of the DB model. When a problem occurs in a part of the input image of the experimental object due to the mechanical problem of the input camera system, the recognition system extracts the outline representing the part of the experimental object in the same manner as above. The object recognition system moves and rotates the vertices constituting the outline of the experimental object to the positions of the respective vertices constituting the outline of the DB model. Then, for each vertex making up the outline of the experimental object, calculate the distance to the outline of the DB model. The average value of these distances is the discordance value between the moving and rotating version of the experimental object and the corresponding DB model. Then, the minimum value among the discordance values for all the movement positions and all the rotation angles is found. This minimum value is the final discordance value between the experimental object and the corresponding DB model. The DB model with the minimum discordance value is selected as the recognition result for the experimental object.

3.1 Object Recognition Algorithm with Partial Information

The object recognition technique with partial information will be described in more detail in the following steps.

Step 1) The object recognition system selects line segments constituting the outer shape of DB model after detecting the line segments of the DB model to be used as comparison data. Then, the recognition system simplifies the outline of the model by removing unnecessary vertices among the vertices constituting the selected line segments. The recognition system determines the connecting direction by examining the positional relationship with the next vertex for each vertex constituting the outline of the model, and changes vertices with same direction to a line segment. Through this process, the outline of the model is composed of line segments having different directions. The first vertex constituting each line segment serves as an important key point constituting the contour line of the model. The recognition system stores the total numbers and positions of these vertices constituting the outer shape of the model in order in the DB file.

Step 2) Object recognition system generally extracts the outline of the experimental object in the input image in the same manner as above. However, a problem might arise in a part of an input image of an experimental object due to a surrounding situation or a mechanical problem of input camera device. In this case, incorrect result might be obtained in the recognition process because sufficient information about the experimental object can't be offered and only partial information for the experimental object is used.

Step 3) The object recognition system first reads the number of vertices constituting the outline of the DB model from the DB file, stores it in the variable Number_of_DB_Vertex, reads the positions of the vertices from the file, and stores them in the array DataBaseModel. After that, the system draws the outline of the DB model on the screen by connecting two consecutive locations stored in the array DataBaseModel in the form of straight line. Finally, the recognition system connects the position of the last vertex with the position of the first vertex in order to form a closed curve.

For reference, the outline of the DB model is drawn on the screen because only a part of the information about the experimental object is provided, not the whole. Therefore, it is impossible to determine which part of the experimental object is the object in the input image with only such incomplete information. In order to resolve this problem, it is necessary to consider the case that the starting vertex of the outline constituting the experimental object is moved to each of the vertices constituting the outline of the DB model, and then rotation is performed at a given unit rotation angle at that vertex. Therefore, in order to reduce the calculation error in calculating the discordance value between the experimental object and the DB model, the recognition system calculates the distance between the vertices of the outline constituting the experimental object and the outline of the DB model instead of calculating the distance between the vertices of the outline of the experimental object and the vertices constituting the outline of the DB model.

Step 4) The recognition system reads the number of vertices constituting the outline of the experimental object from the Test file, stores it in the variable Number_of_Test_Vertex, reads the positions of the vertices from the file, and stores them in the array TestModel. Then, the system translates the positions of the vertices of the outline of the experimental Object so that the position of the first element of the array TestModel is located at (0,0). For reference, the reason why the position of the first element in the array TestModel should be (0,0) is that the experimental object moves and rotates about the first element. Therefore, the experimental object is rotated by a certain angle around the first element and then moved to the positions of the vertices constituting the outline of DB model.

Step 5) For each vertex number i of DB model from 0 to Number_of_DB_Vertex - 1,

Step 5.1) Let Unit_Rotation_Angle be the unit rotation angle that the experimental object rotates every time. Then, for each RotationAngle from 0 to 360 by Unit_Rotation_Angle,

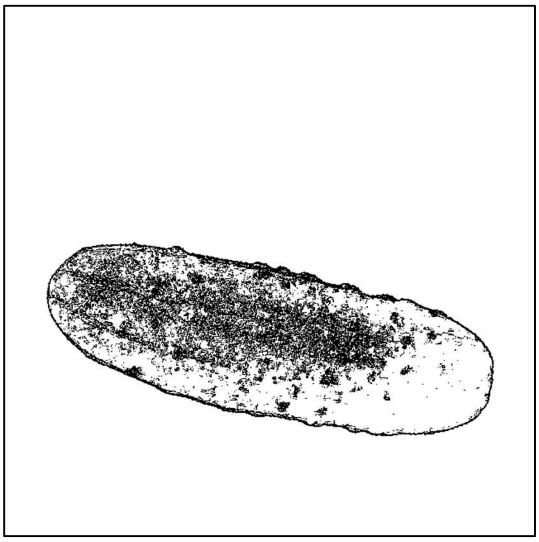
Step 5.1.1) Rotate the vertices constituting the outline of the experimental object stored in the array TestModel by the given angle, RotationAngle, about the origin, and then, store the result in the array TestModelRotation.

Step 5.1.2) Move the positions of the vertices in the array TestModelRotation so that the position of the first element in the array TestModelRotation is equal to the position of the vertex number i constituting the outline of the DB model. And then, store the result in the array TestModelTranslation.

Step 5.1.3) For each vertex in the array TestModelTranslation that is the rotated and also translated version of the experimental object, calculate the distance from the vertex to the outline of the DB model and store the distance in the array TestModelTranslation. This distance becomes the discordance of the vertex and the DB model.

Step 5.1.4) Calculate the average of the distances stored in the array TestModelTranslation. This average value means the discordance value between the experimental object and DB model when the first vertex of the experimental object moves to the position of vertex number i of DB model and also rotates by the given RotationAngle degree. This discordance value is stored in the array DiscordanceResult(i,RotationAngle).

Step 6) Find the minimum value in the array DiscordanceResult. This minimum value is the discordance value between the experimental object and the corresponding DB model. For reference, let's say that the element having the minimum value in the array DiscordanceResult is DiscordanceResult(P, Q). Then, P indicates the vertex number of the DB model that the first vertex of the experimental object has moved to, Q does the angle of rotation of the experimental object, and DiscordanceResult(P, Q) is the discordance value between the experimental object and the corresponding DB model.



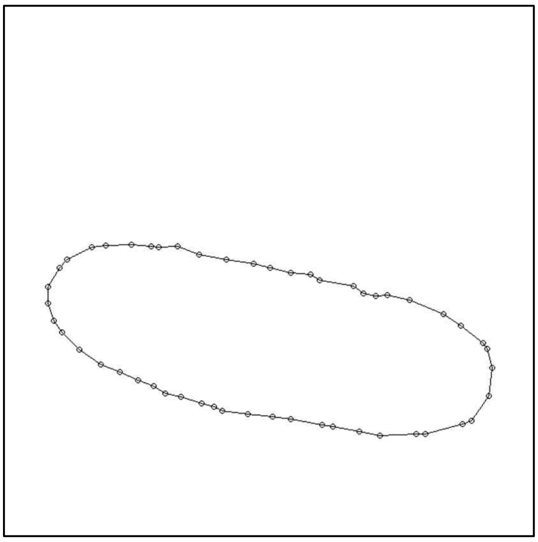
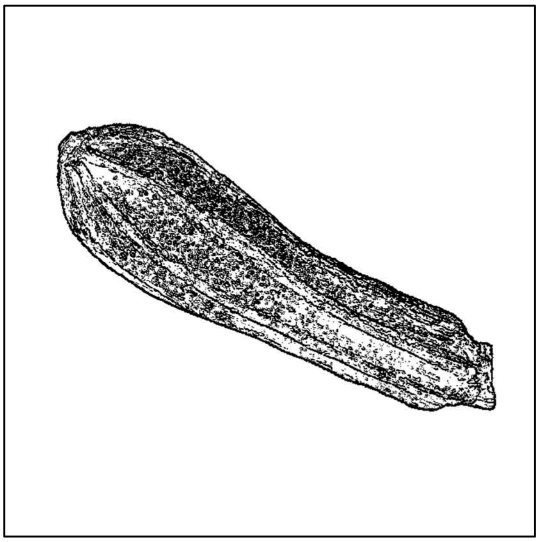


Figure 1. (a) DB Model #1 - Cucumber (b) Simplified Outline of Cucumber

3.2 The Results

The following figures show the results of executing the object recognition algorithm with partial information. Figure 1(a) shows the edge detection of cucumber used as DB model #1, and Figure 1(b) does the simplified outline of cucumber composed of 51 vertices. The simplified outline of the cucumber is drawn on the screen by connecting adjacent vertices in the form of straight line.



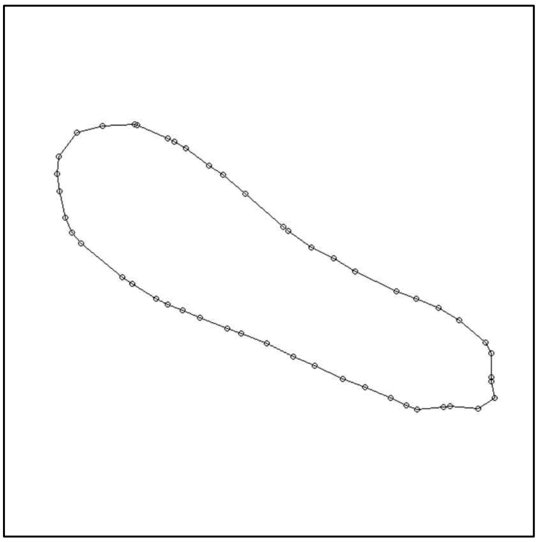


Figure 2. (a) DB Model #2 – Pumpkin (b) Simplified Outline of Pumpkin

Figure 2(a) also shows the edge detection of pumpkin used as DB model #2, and Figure 2(b) does the simplified outline of pumpkin composed of 49 points.

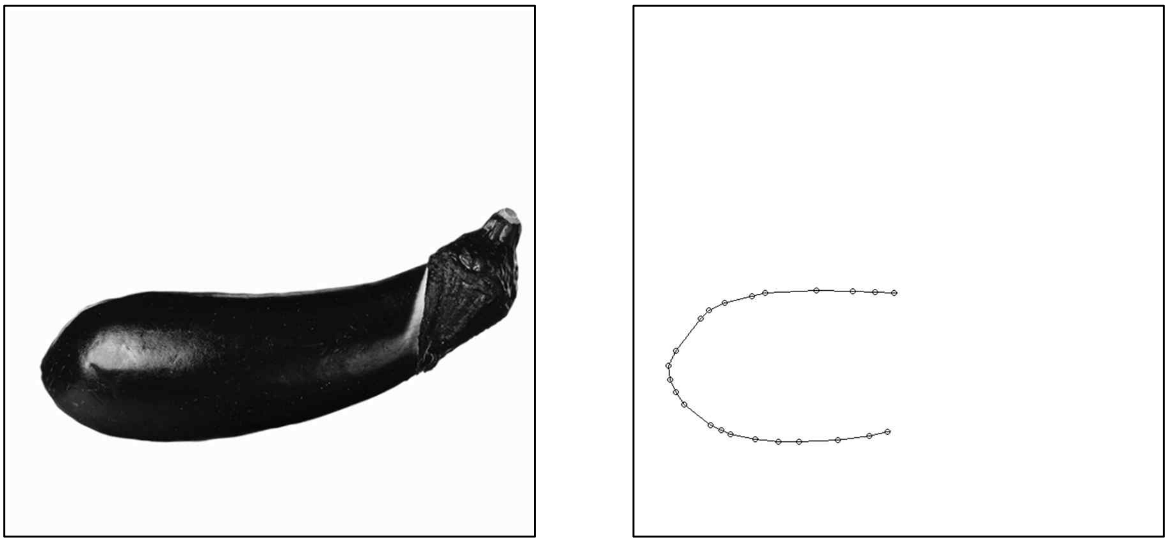


Figure 3. (a) Eggplant **(b) Partial Outline of Eggplant**

Figure 3(a) shows black and white image of the eggplant that the recognition system should recognize. However, it is assumed that almost the right half of the input image is not generated due to the mechanical problem of the camera system or the surrounding environment. Figure 3(b) does a simplified outline of the portion of the eggplant consisting of 23 vertices with this problem.

Table 1. Computation Results of Cucumber and Experimental Object

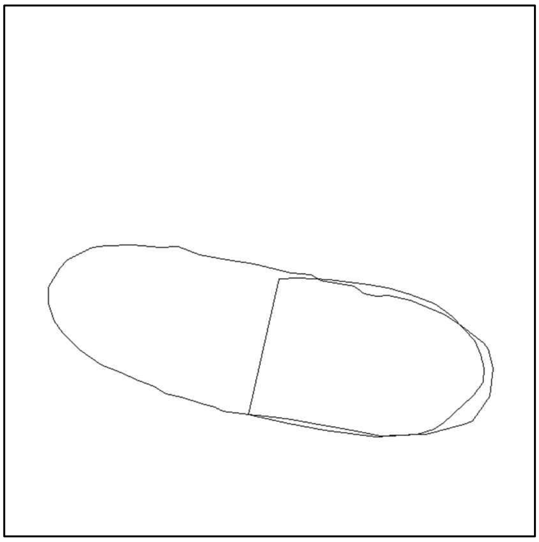
Variables	Values
Minimum Discordance	5.9130
DB Model Starting Vertex #	25
Rotation Degree	190
X-Position of DB Model Starting Vertex	294
Y-Position of DB Model Starting Vertex	493
Number Of Vertices Composing DB Model	51
Number Of Vertices Composing Experimental Object	23
Unit Rotation Angle(Degree)	10

The object recognition system obtains information about the DB model from the DB file and then draws the outline of the DB model on the screen. In the same way, the recognition system obtains information about the experimental object from the Test file and then stores it in the array TestModel. After that, the system translates the positions of all vertices constituting the outline of the experimental object so that the position of the first element of the array TestModel is located at (0,0). The unit rotation angle, Unit_Rotation_Angle, used in this object recognition system is set to 10 degree. The object recognition system first rotates the vertices stored in the array TestModel by every Unit_Rotation_Angle around the origin, and then translates them so that the position of the first element is located at each of the positions of the vertices constituting the outline of the DB model. Then, the recognition system calculates distance to the outline of the DB model for each vertex constituting the rotated and translated version of the experimental object, and stores the average value of these distances in the array DiscordanceResult. Finally, the minimum value in the array DiscordanceResult is the discordance value between the experimental object and the DB model.

Table 2. Computation Results of Pumpkin and Experimental Object

Variables	Values
Minimum Discordance	4.0869
DB Model Starting Vertex #	47
Rotation Degree	40
X-Position of DB Model Starting Vertex	343
Y-Position of DB Model Starting Vertex	271
Number Of Vertices Composing DB Model	49
Number Of Vertices Composing Experimental Object	23
Unit Rotation Angle(Degree)	10

Table 1 shows the computation results between the DB model, cucumber, and a part of the experimental object, eggplant. The experimental object consisting of 23 vertices has the minimum discordance value, 5.9130, when the first element of its outline is rotated 190 degree at the position of the 25th vertex constituting the outline of the DB model, cucumber, consisting of 51 vertices. Table 2 shows the computation results between the DB model, pumpkin, and a part of the experimental object. The experimental object has the minimum discordance value, 4.0869, when the first element of its outline is rotated 40 degree at the position of the 47th vertex constituting the outline of the DB model, pumpkin, consisting of 49 vertices. As a result, the experimental object, eggplant, has a discordance value of 5.9130 with DB model #1, cucumber, and a discordance value of 4.0869 with DB model #2, pumpkin. Therefore, the experimental object is recognized as a pumpkin in these two DB models.



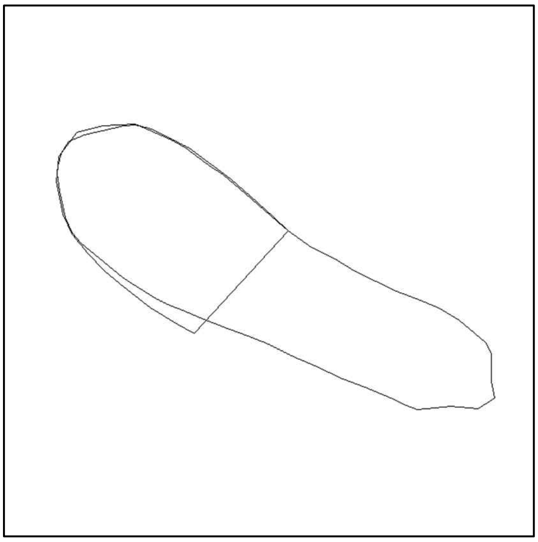


Figure 4. (a) Overlapping Translated and Rotated Version of Partial Eggplant on Cucumber(DB model #1) (b) Overlapping Translated and Rotated Version of Partial Eggplant on Pumpkin(DB model #2)

Figure 4 (a) shows the result of overlapping the outline of the translated and rotated version of the experimental object on the outline of cucumber, where the first element of the outline of the experimental object is rotated by 190 degree at the position of the 25th vertex constituting the outline of the DB model. In the same way, Figure 4 (b) shows the result of overlapping the outline of the translated and rotated version of the experimental object on the outline of DB model #2, pumpkin, where the first element constituting the outline of the experimental object is rotated by 40 degree at the position of the 47th vertex of the outline of the corresponding DB model.

3.3 The Pros and Cons of the proposed Object Recognition Algorithm

Like other object recognition techniques, there are advantages and disadvantages in the proposed algorithm. Advantages include: 1) even when a mechanical problem occurs in the input camera device, the experimental object can be recognized using only a part of the information. 2) The experimental object can be recognized regardless of the position and rotation of DB models. Disadvantage is that the rotated version of the experimental object looks different depending on the value of Unit_Rotation_Angle. Therefore, when it is compared with DB models, discordance value might be calculated differently, and hence it can result in failure to recognize the experimental object correctly. The smaller the value of Unit_Rotation_Angle is, the more accurate recognition result can be achieved, but the computation time increases proportionally.

4. CONCLUSION AND FUTURE WORK

The object recognition algorithm proposed in this paper calculates the degree of structural discordance between the experimental object and the DB model by moving the vertices constituting the outline of the object to the positions of the respective vertices composing the outline of the DB model. We can give significance to the fact that the experimental object is effectively recognized through this process even if only partial information for the experimental object is provided due to the mechanical problem of the input imaging device. In the future research, we are studying a method of tracking the position of the object by examining the change of the external shape of the object on time change.

REFERENCES

[1] N. Bourbakis, *Artificial Intelligence and Automation*, World Scientific, pp.10-26, 1998.

[2] A. Wexelblat, *Virtual Reality Applications and Explorations*, Academic Press, pp.3-33, 2014.

[3] H. Cheng, *Autonomous Intelligent Vehicles*, Springer, pp.13-20, 2011.

[4] C. Leondes, *Image Processing and Pattern Recognition*, Academic Press, pp. 22-35, 1998.

[5] K. Nam, “The Image of Elderly Perceived by Age of 4 and 5 Years”, *Journal of the Convergence on Culture Technology(JCCT)*, Vol.2, No.2, pp.1-8, 2016.

[6] S. Yoo, “Adaptive Thinning Algorithm for External Boundary Extraction”, *International Journal of Advanced Culture Technology (IJACT)*, Vol.4, No.4, pp.75-80, 2016.

[7] W. Pratt, *Introduction to Digital Image Processing*, CRC Press, pp. 139-154, 2013.

[8] M. Friedman, A. Kandel, *Introduction to Pattern Recognition*, World Scientific, pp. 55-68, 1999.