# A DIRECTIONAL MORPHOLOGICAL OPERATION AND ITS APPLICATION TO IMMUNOLOGICAL IMAGE PROCESSING

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## ABSTRACT

A directional morphological operation can be performed by utilizing a rotational structuring element with a directional information, and its associated processing methods for overlapping and enclosing are proposed. As an example of overlapping method derived from the directional morphological operation, a distribution of high/low atmospheric pressures is obtained from the wind direction of weather report. The enclosing method obtained from the directional morphological operation is applied to a shape recognition system utilizing multi-ultrasonic sensor, and also this method is applied a immunological image processing which utilizes the function of self or non-self discrimination in immune system of a living body. From simulation and experimental results, it has been cleared that these methods are effective for image to extract mutual relationship among data including directional information and that object categories are discriminated by applying directional morphological operation for immunological discrimination.

## 1. INTRODUCTION

In this paper, a directional morphological operation with a directional structuring element is proposed, and its associated processing methods for overlapping and enclosing are also presented. The enclosing method derived from the directional morphological operation is applied to immunological image processing which utilizes the function of self or non-self discrimination in immune system of a living body.

## 2. DIRECTIONAL MORPHOLOGICAL OPERATION

Morphological operation is a non-linear operation which treats the target image with a structuring element. For computing elementary morphological operations, structuring elements are fixed directional. Therefore the directional morphological operation is proposed to perform the operation by utilizing a rotational structuring element with a directional information.

Figure 1 illustrates the diagram for the dirctional translation, and Minkowski addition is also extended to have dirctional factors. It is difficult to add the directional information on the continuous image B, however it may be possible to extend, if each point in the image B is assumed to have directional information, because the image B is a set of discrete points as show in Figure 2. Thus, the operation of the directional dilation can be possible to perform. The directional dilation is realizing in two methods :Overlapping and Enclosing, as follows.

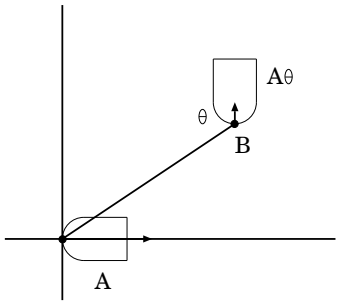


**Figure 1. Directional Translation**

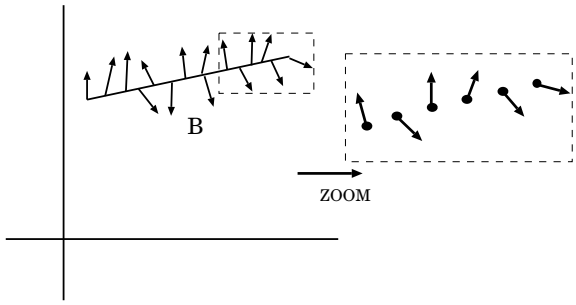


**Figure 2. Adding directional information each point of set B**

### 2.1. Overlapping Method

When directional data do not have exactly locationanl relationship, the directional dilation can be assigned by using a directional structuring element. The distribution of overlap is calculated by averaging the overlapping times with a number of data surrounding its point. This procedure is defined as the *overlapping* method. The distribution of relationship for each data is obtained as shown in Figure 3.

### 2.2. Enclosing Method

When the directional data have exactly locational relationship and direction, execution of enclosing on Dilation can

be operated rotational factor in proportion to a direction of data. This procedure is defined as the *enclosing* method. A relationship of each data is obtained from the enclosed area. Typical enclosing method derived from a directional morphological operation is shown in Figure 4. In actual process for the enclosing method, at first directional dilation is executed, and then the whole pattern is inverted as the outer point is the starting point. Finally,, the image is extracted to express the directional relationship for the original image.

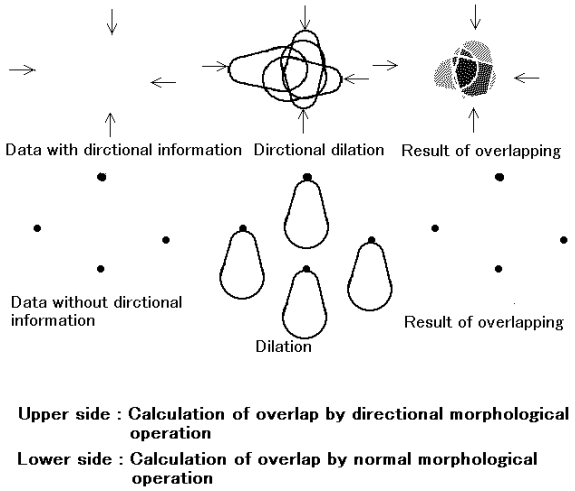


**Figure 3. Overlapping method by directional morphological operation**

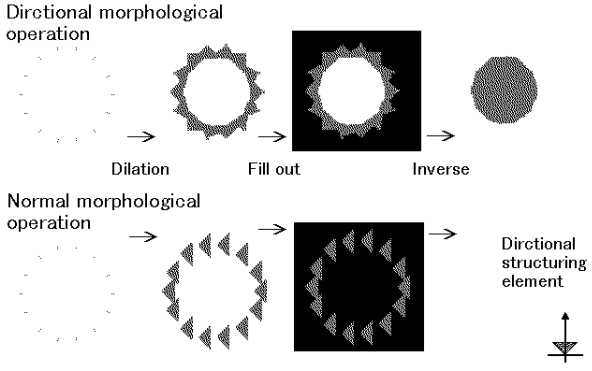


**Figure 4. Enclosing method by directional morphological operation**

## 3. EXPERIMENT FOR OVERLAPPING METHOD

As an example of overlapping method, a distribution of high/low atmospheric pressures is obtained from the wind direction of weather report using a structuring element. Figure 5 shows the relation of high/low atmospheric pressures and wind directions. The experimental result is shown in Figure 6. The extracted shape is similar to the air pressure distribution of that day.

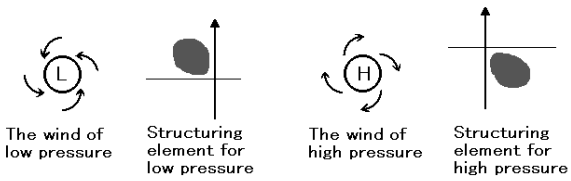


**Figure 5. Structuring elements for low and high atmospheric pressure**

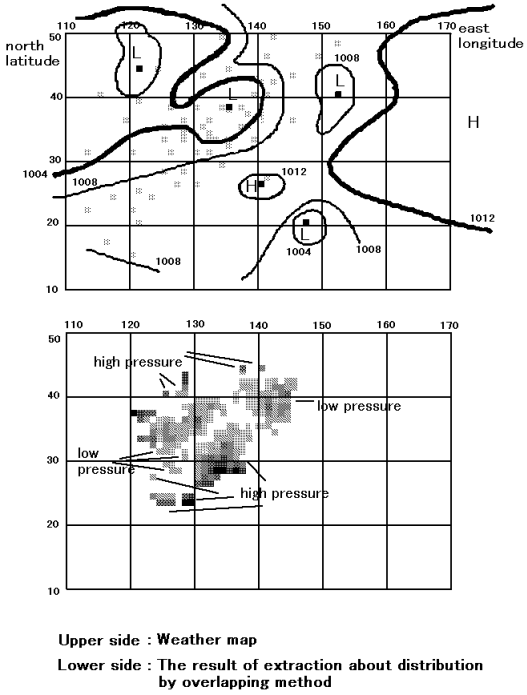


**Figure 6. Extraction of high and low atmospheric puressures by overlapping method**

## 4. EXAMPLE OF APPLICATION USING ENCLOSING METHOD

In a shape recognition, an object shape can be reconstructed by pasting the measured segment disks. The authors have been suggested a shape recognition system apply the pasting method is proposed to identify the object shape by utilizing multi-ultrasonic sensor[1]. The ultrasonic sensor are arranged to sense the object by means of a manipulator as shown in Figure 7. The shape recognition is carried out by pasting the measured segment disks as shown in Figure 8. The distance and the inclination are determined by the time differences received by each sensor as shown in Figure 9.

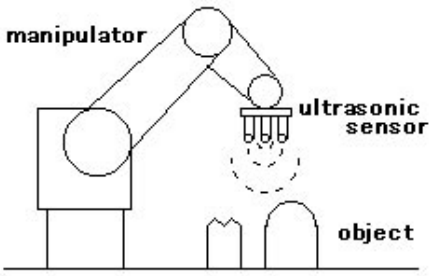


**Figure 7. A sensor system for recognizing object**

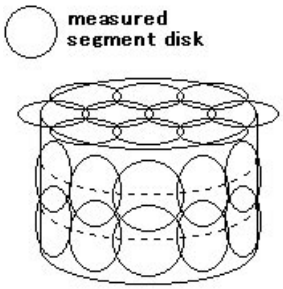


**Figure 8. Shape recognitions from points or faces**

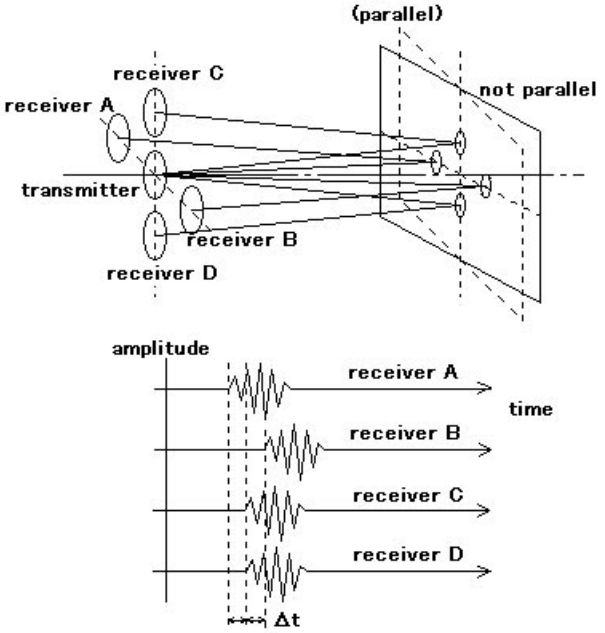


**Figure 9. Determination of distance and inclination(case of not parallel)**

The object shape is reconstructed by enclosing directional structuring elements with the inclination data obtained from segment disks. There are two types in enclosing method, one is enclosed by using the structuring element placed to the outside of the segment disks for the object like placing molds, another enclosed by structuring element positioned to the inside like placing walls. Figure 10 illustrates simulation results of both type of enclosing with ideal face data. Figure 11 shows experimental result obtained from the shape recognition which has recognized the wood wood block of the "P" shape.

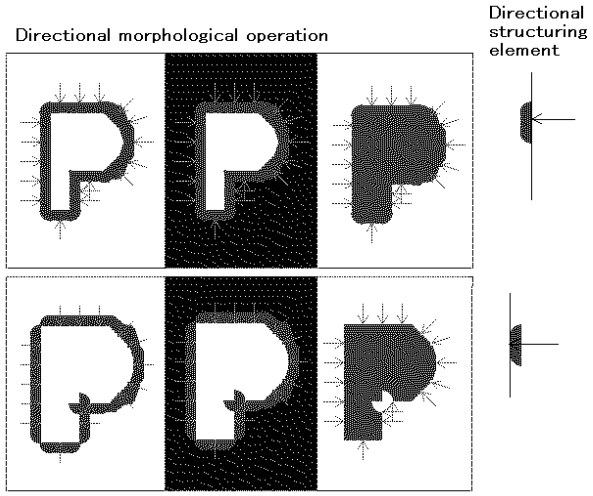


**Figure 10. Placing molds and placing walls**

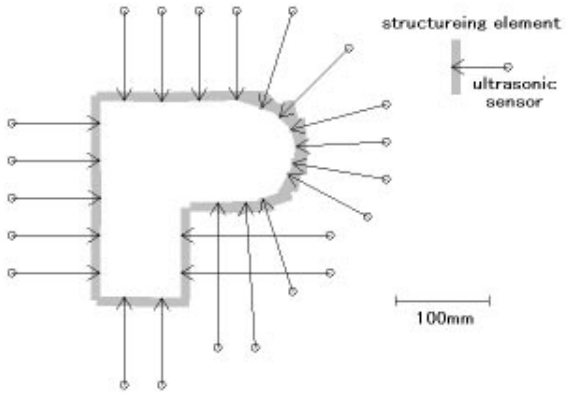


**Figure 11. result of shape recognition for wood block "P"**

## 5. APPLICATION THE ENCLOSING METHOD TO A IMMUNOLOGICAL IMAGE PROCESSING

By processing the operation of erosion or opening for the sets of image, the sets of images are separated to the subsets of images into the appeared image and vanish images. The sets of appeared images Ia is expressed as follows.

$$Ised = \{in \mid in - is \neq \emptyset, in \subset I\}$$

$in$ : Continuous pixels sets which are constituent of one image
$is$ : symmetric structuring element
$I$ : The sets of whole images
$-$ : Operation of erosion

By using this equation, the specified images can be remained after the erosion processing by using a specific structuring element as shown in Figure 12. From the standing point of immunological self-nonself discrimination, this behavior is quite similar to that antigen presentation cells correspond to morphology filter and antibody cells correspond to the result of filtering process[2].

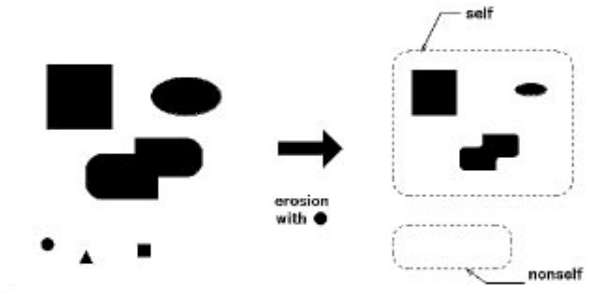


**Figure 12. Discrimination of self-nonself by Erosion**

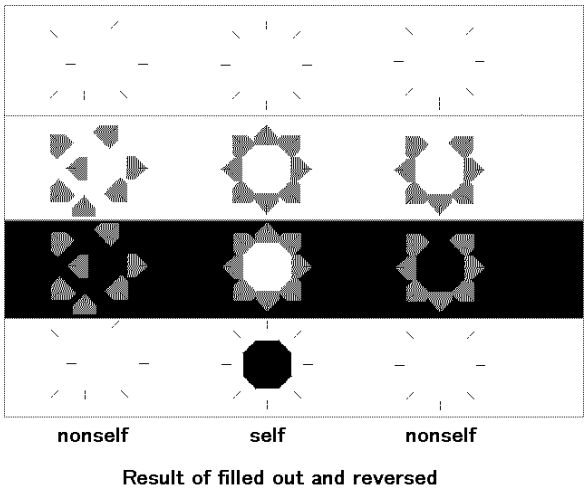


**Figure 13. Discrimination of self-nonself by enclosing method**

Figure 13 shows the result of simulation for the enclosing method to the point sets which have directional information, and those points are divided into three groups. In Figure 13, the left group which have irregular direction and the right group which lacks constituent are recognized to be nonself, because the result of processing is the zero set. And the center group which have both the arranged direction and the complete constituent are recognized to be self, because the image is extracted.

## 6. CONCLUSION

The directional morphological operation is proposed and the overlapping and enclosing methods are also demonstrated. It has been cleared that these methods are effective for image to extract mutual relationship among data including directional information and that the object categories is also discriminated by applying directional morphological operation to the antigen-presenting process for immunological self-nonself discrimination.

## REFERENCES

[1] S.Doi, H.Takahashi and M.Matsuda, "Signal Processing using Scale-Space Filtering for Ultrasonic Shape Recognition System," *T.IEEJapan*, vol.115-C, No.11, pp.1310-1316, 1995, (Japanese)

[2] E.Ueda, S.Doi and M.Matsuda, "Morphological Image Discrimination using Immune System Model," *Proc.MIRU'96(Japan)*, vol.2, pp.7-12, 1997, (Japanese)