Application of Modified Median Filter for Grading Produce

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ABSTRACT

Median filter(MF) has often been applied to color or gray images as a noise filter in image processing. Application of MF to binary images was tried in this study. For binary images, MF not only can remove noise but can also work as an indicator showing the dominant color in a region which is called window. For example, MF can be used to categorize clusters and to detect interested parts of an object. In other words, MF can also be used to remove unnecessary parts. The function of MF can be intensified by introducing a thresholding value, which is determined by the size of the interested part of an object. This improved MF for binary images is called the modified median filter(MMF), and its applicability to grade produce will be discussed in this paper.

Key Word: median filter(MF), modified median filter(MMF), binary image

INTRODUCTION

Binary images are often used to grade the produce in various fields. Binary images have only two colors, black and white, but contain much information such as position, length, width and shape of an object.

Normally binary images, however, contain undesirable noises against grading. The expansion and the contraction techniques have been often used to remove noises. Although being simple, these techniques may remove important information from an image and may result in unexpected effects. Hence, it is not effective to extract precisely the interested information from binary images. After removing the noise, binary images have several parts of an object. The labeling technique is then used to deal with each feature of the parts. The labeling technique is done to assign the distinct number to each part, and furthermore, makes it easy to count the number of the parts. Assuming that an interested color is black in a binary image, the labeling technique can be applied only to the part in which all black pixels are connected. These parts are not clusters. Cluster is a region which black pixels are close together within a distance. Hence, clusters can not be counted by the labeling. Therefore, to segment and to count the clusters, the clustering technique is used. However, if the number of clusters in a image is not known in advance, it is difficult to apply the clustering technique to the image.

Median filter(MF) is commonly used as a noise filter for the processing of color or gray images. However, only a few application of this filter to binary images were reported[1][2]. In this study, MF was used to extract an interested part, to remove noise and to count the number of clusters in an image. By modifying MF, this filter could have high applicability to the processing of binary images. This improved median filter is called modified median filter(MMF) in the present work.

MEDIAN FILTER AND MODIFIED MEDIAN FILTER

MEDIAN FILTER

Median filter(MF) is a nonlinear filter, that replaces the central value with the median[1] in a window. A window is composed of a interested pixel and some neighboring pixels. MF can have various window's sizes, e.g. $N_1 \times N_2$. Normally, the window's size is 3×3. In this study, taking into account the effect of the direction of an object, a square window was used. Fig.3-1 shows the effect of MF on a window. By using MF, the pixel which has much different value from neighboring pixels can be replaced with the median in a window. Hence, MF has been used mainly as a filter which can remove salt-and-pepper noises without loss of an important information such as the edge information in an image.

In this study, MF is applied to binary images. For binary images, MF can work as an indicator showing the dominant color in a window. That is, by decision of majority, MF can easily determine the color which will dominate the window, black or white. Consequently, MF will replace the central value with the dominant color in a window. Fig3-2 shows the effect of MF on binary images.

In this section, an image with black pattern, a square(150×150 pixel) and a narrow rectangle(450×16 pixel), is shown in Fig.3-3. If we want to extract the rectangle as an interested object from the image, the square will be extracted first, then the rectangle. Because the square is larger than the rectangle, therefore, to segment the two objects, the window's size is determined so that the square can occupy more than 50% of the window while the rectangle less than 50% of the window(Fig.3-4). Consequently, the window's size can be calculated using an interested object's size as shown in Eq.(3-1). In this case, the object's size is the width of the rectangle: 16 pixels.

$$\frac{Os \times Ws}{Ws \times Ws} \times 100 \leq 50 \quad [\%],$$

$$\frac{Os}{Ws} \times 100 \leq 50 \quad [\%], \qquad (3\text{-}1)$$

where Ws is the window's size, Os is the interested object's size.

Using Eq.(3-1), the minimum size of the window is 33 pixels. However, as the calculated window's size by MF is very large, it is possible that when more complex image is processed, the result may not be good due to the existence of uninterested parts in the window. Hence, MF must not have a window with too large size.

The result is shown in Fig.3-5. The rectangle was erased perfectly and the square was extracted without loss of the original size, but the shape at the corners was rounded. Because the corners are right-angled, the pixels at the corners can not occupy more than 50% of the window. However, if MMF is

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[1] The median is the quantity or value of that item which is so positioned in the series, when arranged in order of numerical quantity or value, that there are an equal number of items of greater magnitude and lesser magnitude, e.g. the median is the 5th biggest value among all 9 values in a 3×3 window.

applied to an object such as a circle, the shape will be kept.

MODIFIED MEDIAN FILTER

In this study, while keeping the fundamental effect of MF, MF was improved by introducing a thresholding value. In Eq.(3-1), as the window's size is calculated so that the interested part can occupy a little bit less than 50% of the window, the window's size might be large. However, the window's size can be also determined so that the interested part can occupy a little bit less than a thresholding value of the window. The thresholding value is the percentage of the interested part to the total area in a window. If the thresholding value is so determined as to be higher than 50%, the window will be calculated to be smaller than that by MF. Hence, Eq.(3-2) can be obtained by modifying Eq.(3-1). The median(50%) in Eq.(3-1) is replaced with the thresholding value in Eq.(3-2). Fig.3-6 shows the idea of MMF. This median filter improved by using the thresholding value is called the modified median filter(MMF). If thresholding value is 50% in Eq.(3-2), MMF is MF identically.

$$\frac{Os \times Ws}{Ws \times Ws} \times 100 \quad < \quad Tv \quad [\%],$$

$$\frac{Os}{Ws} \times 100 \quad < \quad Tv \quad [\%], \qquad (3\text{-}2)$$

where Tv is the thresholding value.

Firstly, in MMF, the window's size must be determined by the size of the interested object in a window. In this case, as the object's size is the width of the rectangle, the minimum size of the window is so determined as to be 17 pixels, which is 1 pixel larger than the width of the rectangle, because the window must contain the interested part inside. And the thresholding value is 95% using Eq.(3-2). By using MMF with these parameters, the rectangle was erased perfectly(Fig.3-7).

However, in this case, the square was contracted in all directions from the original size. If the parameters of MMF is determined so that the window's size is 17 pixels and the thresholding value is 5(=100 - 95)%, the square will be expanded to the original size approximately. This result is shown in Fig.3-8.

In both cases of MF and MMF, through the extraction of the uncommon area between the original image and the image only with the square, the interested rectangle could be extracted(Fig.3-9).

In Fig3-9, however, both images contain noises at the corners of the erased square, and the noise area using MF is larger than that using MMF. Because as the window's size of MF is larger than that of MMF, the area rounded by MF is larger. The noise can be removed by MMF easily. However, the corners of the rectangle will be also rounded simultaneously. Furthermore, the rounded area by MF is larger than that by MMF. Finally, only the part of the rectangle was extracted approximately(Fig.3-10).

From the above results, MMF is more effective for binary images than MF.

APPLICATION TO PEA AND FLOWER

In this section, two materials, a pea and a rose, are shown.

Fig.4-1 shows an image of a pea. Peas are harvested through picking by hand one by one. After that, they must be graded in 3 classes: S,M,L, in a grading room. Grade L has more than 4 beans, grade M has 3 beans, and grade S has less than 2 beans, which are determined by the market's needs, and the larger the number of beans is, the higher the price. However, as the pea has green opaque hull with a thickness, it can not be seen through directly. Hence, even experienced workers must grade peas by hand one by one, and must sometimes check the number of beans using the shadows of the beans inside pea pod against a light. The work is very monotonous and laborious.

Fig.4-2 shows an image of a rose. Many kinds of flowers have been produced all over the world. Especially, rose is the most popular and is used for various occasions, e.g. for party decoration, or a present to a girl friend. Therefore, the grading of rose quality is needed. Although the quality is hard to define, and no common criterion for all the markets, the curvature of the stem is one of the most important factors to grade.

RESULTS

Grading of peas using the number of beans and grading of roses using the stem curvature are conducted in this study.

GRADING OF PEAS

To get an image of the inside of a pea, an imaging system shown in Fig.4-3 was made. The image was taken using the background lighting, and its image is shown in Fig.4-4.

And the image was converted into a binary image by a thresholding value (Fig.4-5). The thresholding value is determined so that the parts of the beans can be kept and the uninterested parts can be removed.

We can count the number of beans at a glance. However, the computer can not count the number of them with the labeling technique, because all black pixels in each cluster are not connected perfectly to neighboring pixels. Moreover, as the number of beans are not known in advance, with the clustering technique, it is difficult to segment each bean, especially, the 5th bean and 6th bean in the image.

For this material, it is good that the outside of a circle with a radius at the center of the core of each bean will be removed, and the inside of it will be remained and compensated. The window's size was determined by the size of the smallest bean in the image. The thresholding value was 60%. The thresholding value was determined with some experimental results. As the pixels at the central part of the clusters can occupy more than 60% of the window, the part is kept by MMF. These parameters were listed in Table4-1.

In Fig.4-6, the extracted area and the removed area are shown using MMF. Consequently, the 6 beans were segmented clearly. the labeling technique could count the number of beans, and the number was 6. In this case, MMF can extract and compensate the interested part, and can contract and remove the unnecessary parts.

GRADING OF ROSES

The original image was taken using a black paper as the background, which could prevent the unnecessary image information reflected from the background. And, the image was expressed using the Hue, Saturation and Lightness(HSL) color system. Then, the image was converted into a binary image by a thresholding value with a hue value in about green color area visibly, consequently we could get the parts except the petals (Fig.4-7).

For the color system, the HSL color system was used, because it can express the color visibility better than Red, Green, Blue(RGB) color system. In

Fig.4-7, we can get easily the part of stem, but the computer can not.

Using the same method as the segmentation of a square and a rectangle in the above section of the algorithm about the median filter, the part of stem will be also extracted from the image. That is, it is assumed that the stem is the rectangle, and the parts except the stem is the square.

Regarding MMF parameters, the window's size was so determined as to be 11 pixels with the width of stem, about 10 pixels. Using Eq.(3-2), the thresholding value was 91%. The contracted and expanded parts except the stem are shown in Fig.4-8. And the parameters are listed in Table 4-2.

By extraction of uncommon areas between Fig.4-7 and Fig.4-8, the part of stem was extracted to some extent as shown in Fig.4-9. By using MMF (Ws=11, Tv=50%), the image was also removed some noises as shown in Fig.4-10.

However, some parts of the leaves remained in Fig.4-10. The regression-curve of 5 degrees with a width allowed to remove those noises (Fig.4-11). This curve was regressed by all black pixels in Fig.4-10. Finally, the grading of the rose was done by the curvature of the regression curve calculated from the top of stem to the bottom of it.

DISCUSSIONS

In this paper, pea and rose were examples for the application of MMF. In the case of grading peas, attention must be paid to the lighting condition. If the condition is good enough, MMF can extract each bean from a pea perfectly. In the case of grading roses using MMF, it is very easy for all samples to get the image as shown in Fig.4-9. However, it is difficult to remove unnecessary parts except the extracted stem. In this study, a technique by a regression curve was used to remove the noise. As this technique is not effective for all samples, this technique or other techniques must be improved or developed to remove the noise.

From the above results, MMF demonstrated the high applicability to binary images. MMF can segment, compensate and extract the interested part and can remove the unnecessary parts from binary images simultaneously. Furthermore, MMF is very simple, and the effect on binary image is easily understood.

REFERENCES

[1] Mikio Takagi and Haruhisa Shimoda, 1991. Handbook of image analysis, pp. 539-540

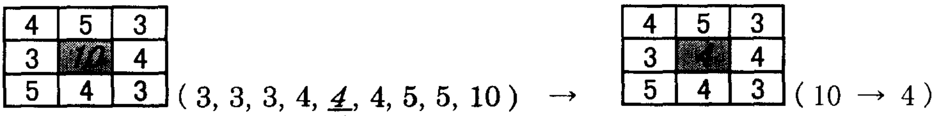
[2] P. M. Narendra, 1978, "A separable median filter for image noise smoothing", in Proc. IEEE Comput. Soc. Conf. Pattern Recognition and Image Processing '78,Chicago, pp. 134-141.

Table 4-1 Parameters of the MMF for extraction of beans

Window's size(Ws) [pixel]	9
Thresholding value(Tv) [%]	60

Table 4-2 Parameters for extraction of stem

Parameters	Contraction	Expansion
Window's size(Ws) [pixel]	11	11
Thresholding value(Tv) [%]	91	9 (= 100 - 91)



Original image Converted image

Fig.3-1 Effect of median filter on a color or gray image

Dominant color is black

Fig.3-2 Effect of median filter on binary images

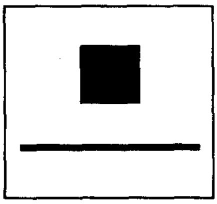


Fig.3-3 Sample image

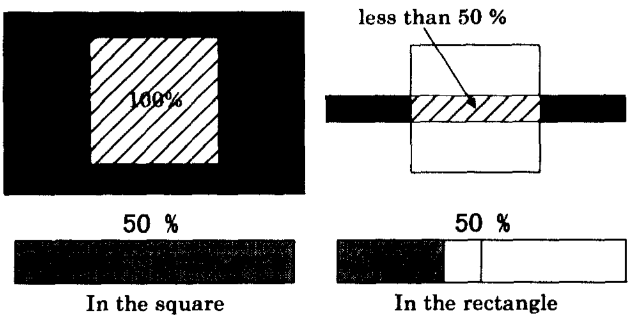


Fig. 3-4 Extraction idea of MF from binary images

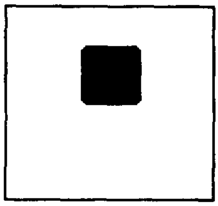
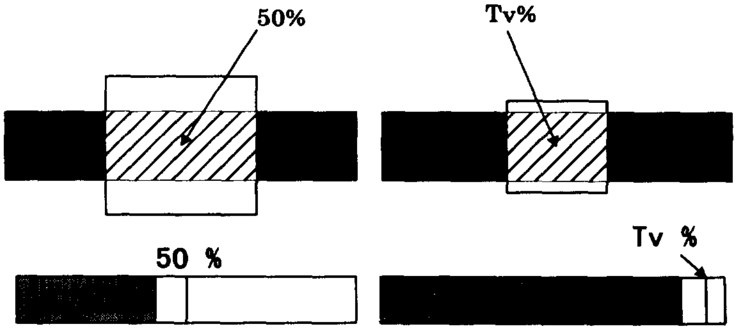


Fig.3-5 Extracted square



Idea of MF　　Idea of MMF

Fig.3-6 Comparison of MF and MMF

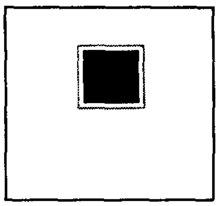


Fig.3-7 Extracted square

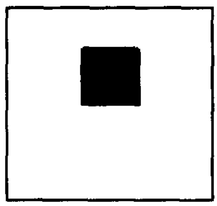
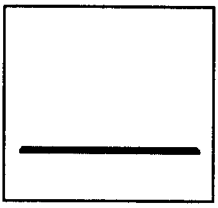


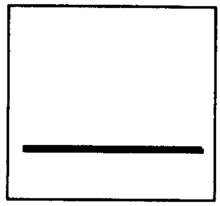
Fig.3-8 Expanded square

Uusing MF　　using MMF

Fig.3-9 Combined image with original image and the image extracted square



Rectangle using MF



Rectangle using MMF

Fig.3-10 Extracted rectangle using MF and MMF

Fig.4-1 Image of pea

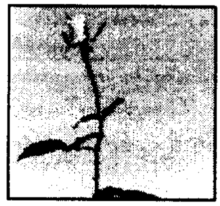


Fig.4-2 Image of rose

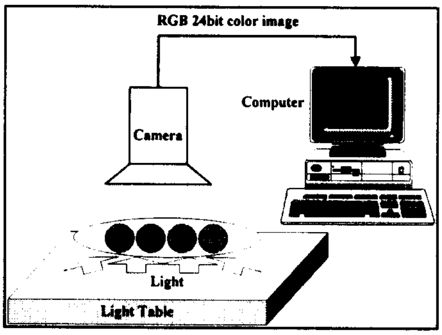


Fig.4-3 Imaging System

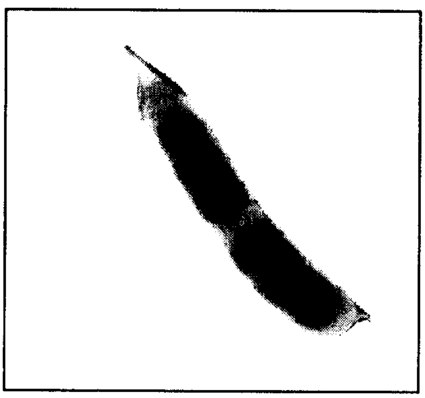


Fig.4-4 Original image

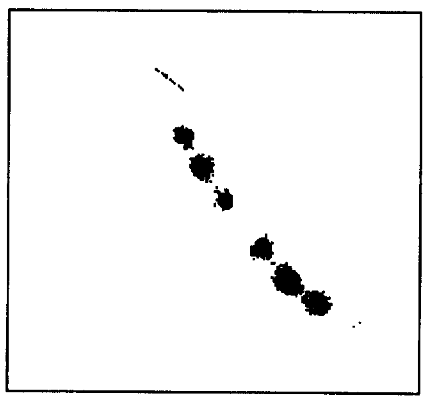
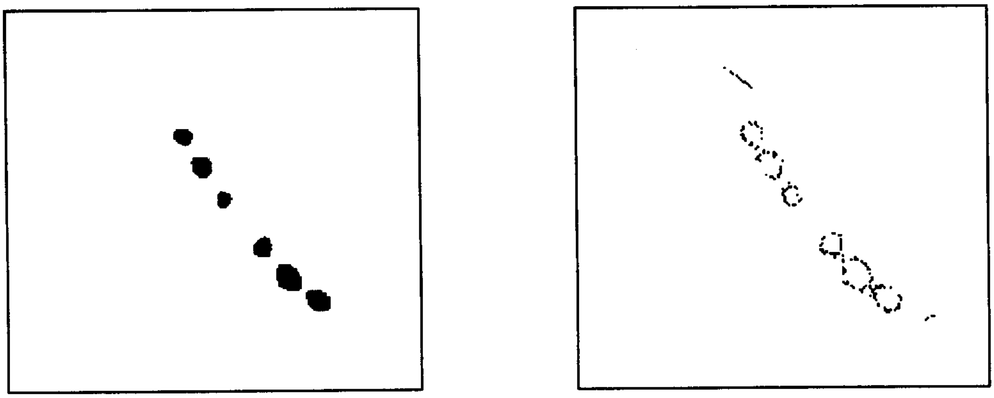


Fig.4-5 Binary image of inside pod



Extracted area   Removed area

Fig.4-6 Extracted area and removed area of beans using MMF

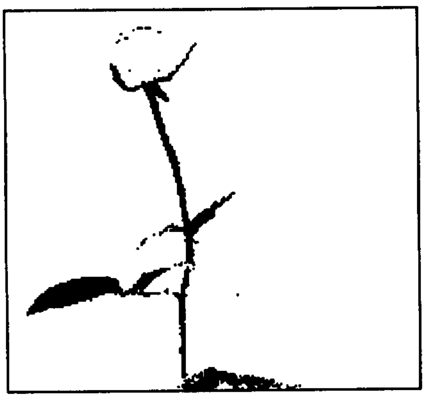


Fig.4-7 Parts except petals

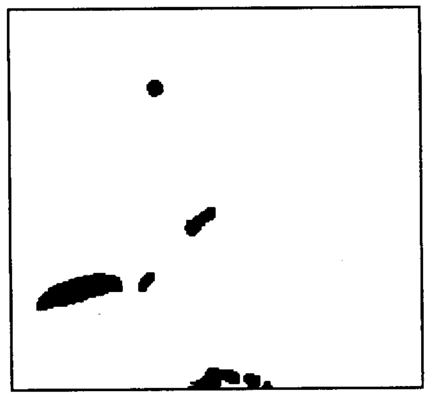


Fig.4-8 Extracted parts except stem

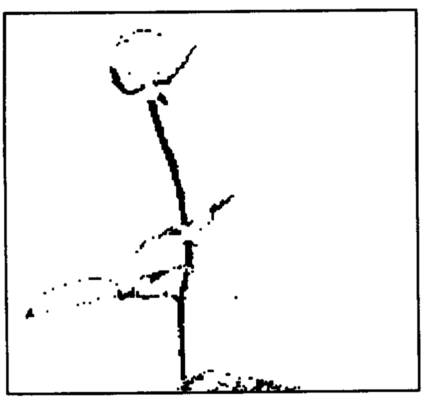


Fig.4-9 Extracted part of stem

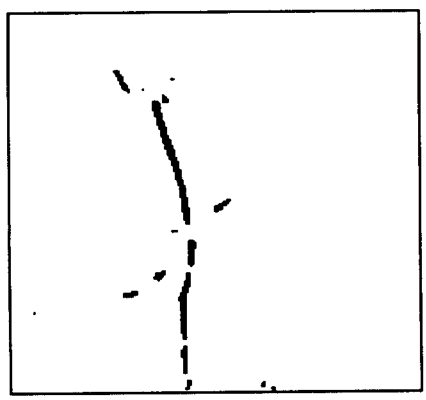


Fig.4-10 Part of stem with noises removed

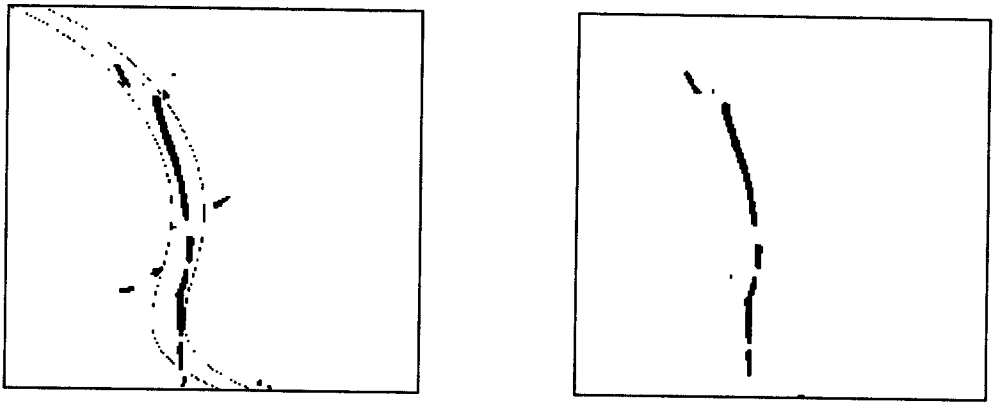


Fig.4-11 Noise reduction using regression curve of 5 degrees