Development of an Intelligent Robot for an Agricultural Production Ecosystem (VI) : Counting of Snails in Laboratory and Paddy by using Developed Programs of Image Processing

Luna Maldonado, Alejandro Isabel
Laboratory of Agricultural Ecology, Division of Agricultural Ecology, Department of Plant Resources, Faculty of Agriculture, Kyushu University

Yamaguchi, Yusuke
Laboratory of Agricultural Ecology, Division of Agricultural Ecology, Department of Plant Resources, Faculty of Agriculture, Kyushu University

Nakaji, Kei
Laboratory of Agricultural Ecology, Division of Agricultural Ecology, Department of Plant Resources, Faculty of Agriculture, Kyushu University

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Development of an Intelligent Robot for an Agricultural Production Ecosystem (VI) – Counting of Snails in Laboratory and Paddy by using Developed Programs of Image Processing –

Alejandro Isabel LUNA MALDONADO[1], Yusuke YAMAGUCHI[1] and Kei NAKAJI*

Laboratory of Agricultural Ecology, Division of Agricultural Ecology, Department of Plant Resources, Faculty of Agriculture, Kyushu University, Fukuoka 811–2307, Japan

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An image processing analysis to segment and count the golden apple snails in paddy field was done in order to develop an intelligent robot for a rice production ecosystem. The Simulink models for counting snails were constructed for three different condition of the paddy and for the case they are mating. It was found useful to use the color of the reflection of the sunshine on the shells of the snails in the daytime and the color of the snail itself after raining at night in order to count the number of snails in paddy field by image processing. These models enable the robot to count the number of snails in paddy.

INTRODUCTION

The development of a robot for an artificial ecosystem of agricultural production (Luna and Nakaji, 2008) demands the number of the snails to be removed from paddy field. Therefore, a vision system should be constructed and it will allow to the agricultural production ecosystem robot to count snails in paddy and determine the suitable time to pick up the snails in paddy. The model could have an image acquisition and processing system to convert the RGB images into L*a*b* color space and get binary images. In addition the image processing should execute morphological operations in order to have as white objects only to the snails or part of them in the binary image. We can analyze and process images captured by a digital camera using software such as Matlab, Simulink and their Toolboxes In this researching, we separated and counted snails in laboratory test and paddy by the Simulink models that we constructed to process images and videos. The counting of the number of snails in paddy should take into account the condition of the paddy field and we considered three cases as follows: a) when it is dry and b) irrigated terrain in the daytime and c) after the raining at night. We also constructed the Simulink model to separate the mating snails in order to count the exact number of them in paddy.

EXPERIMENTS

1. First case

1.1 RGB–L*a*b* conversion of the sunshine reflectance by snails inside of an image of paddy.

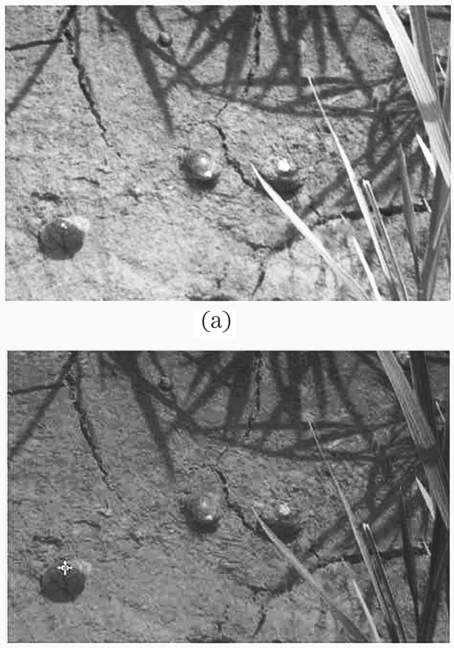

Fig. 1. The original image taken of three snails in the dried paddy field (a) and image displayed in RGB space using date converted from RGB color space to L*a*b* color space (b).

Firstly, we export the image of snails in paddy (Figure 1a) to Matlab folders. In Matlab workspace, we can read the image and convert it from RGB color space into L*a*b* color space (Hwang *et al.*, 2007) (Figure 1b) which makes it much easier for us to estimate the value of color space by intuition new paragraph. Then, we should use the MatLab command Imtool and magnify the snail until we can see the L*a*b* value of each pixel in order to know the specific value of color of the snails and determine the ranges of L*a*b* values to separate only snails from the rest of the image (Fig. 2).

When we determine the value of L*a*b*, we can use

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[1] Laboratory of Agricultural Ecology, Division of Agricultural Ecology, Graduate School of Bioresources and Bioenvironmental Sciences, Kyushu University

* Corresponding author (E–mail: knkjfam@mbox.nc.kyushu–u.ac.jp)

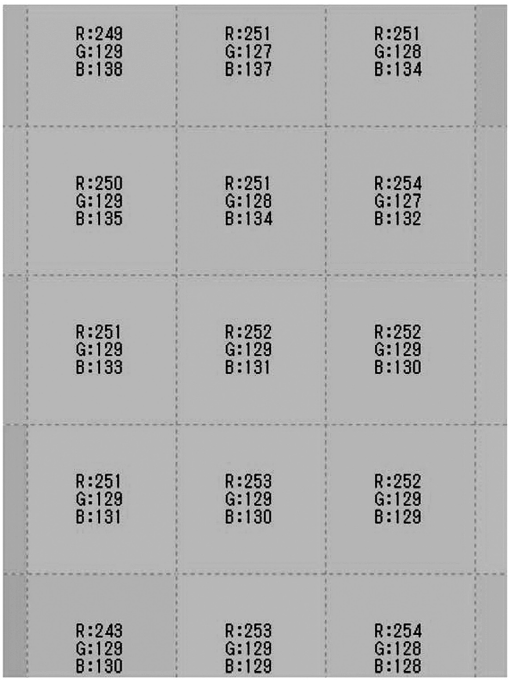


Fig. 2. Magnified image from image in Figure 1b in order to see the specified value L*a*b* on the shell of the snail using command Imtool.

the reflection of the sunshine caused by the shell of the snail. It depends on the condition of a paddy field and weather. We will introduce how to extract and count the snails in five different cases.

1.2 Snails on paddy field recently drained.

The image of Fig. 1a was taken from a paddy field recently drained. In this case, we can make good use of the reflection of the sunshine through the shells of the snails in the daytime to determine the range of the value of L*a*b*. Because this reflection of the sunshine by the snails is a unique color, we can use its value L*a*b*, and then easily separate only snails from the rest of the picture. In this occasion, we decided the range of values as follows: L* values range from 250 to 255, a* from 127 to 133 and b* from 128 to135. After determining the value range, we introduce those values to the Simulink model that we thought and constructed (Fig. 3). Since Matlab has 8 bits integral values (uint8) of color space, the screen of the computer display 8bits values image even after we convert RGB color space to L*a*b* color space. The uint8 ranges from 0 to 255 where as L* usually ranges from 0 to 100 and both a*and b* range from –128 to 127. This is why we multiply minimum and maximum L* values by 0.39215 and subtract 128 from each of the minimum and maximum values of a* and b* in this model.

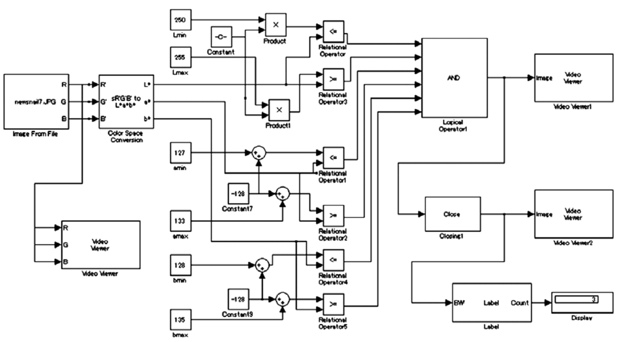


Fig. 3. Simulink model uses the Video and Image Blockset to count three snails. from image of Figure 1a.

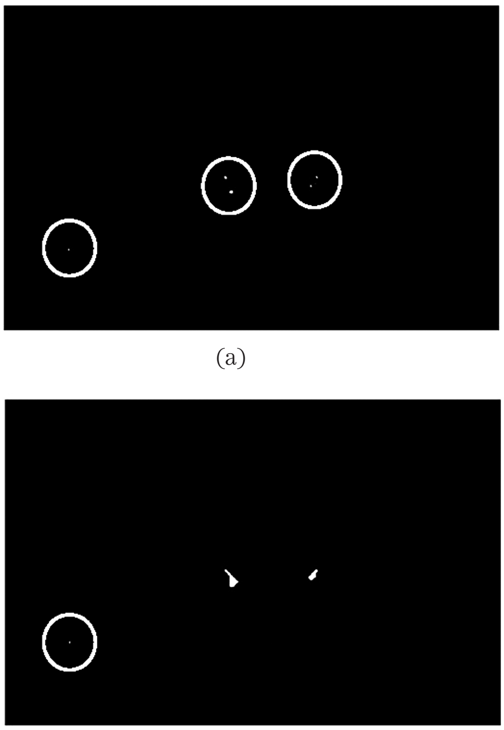
The uint8 ranges from 0 to 255 where as L* usually ranges from 0 to 100 and both of them a*and b* range from –128 to 127. This is why we multiply minimum and maximum L* values by 0.39215 (conversion factor) and subtract 128 from each of a*b* minimum and maximum values in this model.

1.3 Segmentation

After each value is set up and inputted in an Excel file, the Simulink model (Fig. 3) can import the data of values from Excel file via running up an m file Matlab program and the binary image in Fig. 4a is obtained. The binary image shows in white color the reflection of sunshine by snails as an object and the rest of the objects inside of the image show up in black color because the range of L*a*b* values of them are out of those we previously set.

1.4 Morphological operations

The binary image of Fig. 4a shows five objects in white color but four out of them are produced by two snails, therefore we should use morphological operations. The block Close performs a dilation operation followed by an erosion operation according to a predefined neighborhood or structuring element. Therefore, Close block is very useful in order to fill up the opening in the snail.



(a)

(b)

Fig. 4. Binary images before close operations with five objects (a) and after close operation with only three objects or snails (b).

1.5 Results for first case

We set up 120 pixels for neighborhood and use structuring element named disk. After that, we perform a closing operation (Fig. 4b) and we finally get three white images, which are the snails.

2 Second case

2.1 Snails on paddy field recently irrigated.

There is some water in the paddy field when we took the picture of Fig 5. In this case the reflection of the sunshine by snails is still useful for determining L*a*b* values, but also there is diffused reflection from the wet soil, therefore we obtained the image of Fig. 7a after setting the L*a*b* values. The image had many small white points (noisy) other than those of snails because of the reflection of the sunshine was caused not only by snails but also by soil of the paddy field.

In this case, it is useful to use Opening block to delete the small white points that do not belong to the snail reflectance. We constructed this model (Fig. 6) by adding the Opening block to the first Simulink model (Fig. 3). The Opening block performs an erosion operation followed by a dilation operation according to a predefined neighborhood or structuring element, therefore it is very useful in order to get rid of small white images which do not derive from the snails. We set 2 pixels for neighborhood and use disk structuring element. Closing box is set by 8 pixels for neighborhood and disk structuring element.

Fig. 5. Image of four snails in paddy field reflecting the sunshine.

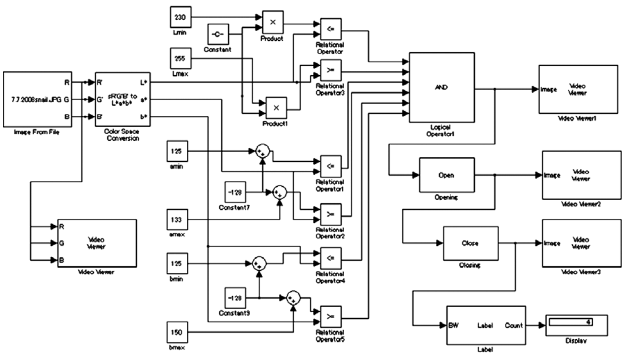


Fig. 6. Simulink model to count 4 snails from image of Fig. 5.

2.2 Results for second case

After performing an opening operation, we get the image of Fig. 7b. Then we follow the same procedures as we did in previous cases of image processing to extract snails (Fig. 7c) and get the number of snails.

3 Third case

3.1 Snails on paddy rained at night.

Next picture was taken at night just after raining (Fig. 8). In that image there is no reflection of the sunshine in this picture. Snails are usually covered with soil of the paddy field. That makes it difficult to use the shell color for L*a*b* values to separate snails from the background of the picture. But the rain can remove the soil from shell of the snails and then we can make use of the shell color for L*a*b* setting.

3.2 Results for third case

After setting L*a*b*.We followed the same proce-

(a)

(b)

(c)

Fig. 7. Binary image after setting the range of L*a*b* values (a), the binary image after performing an opening operation (b) and binary image showing only the four snails after processing of image of Fig. 5 (c).

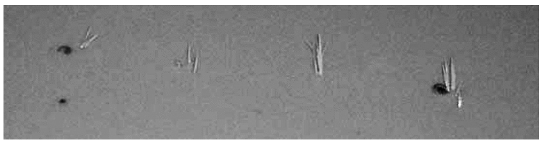


Fig.8. Image of three snails predating small rice plants at night in paddy field.

(a)

(b)

Fig. 9. Binary images before close operations with four objects (a) and after close operation with only three objects or snails (b).

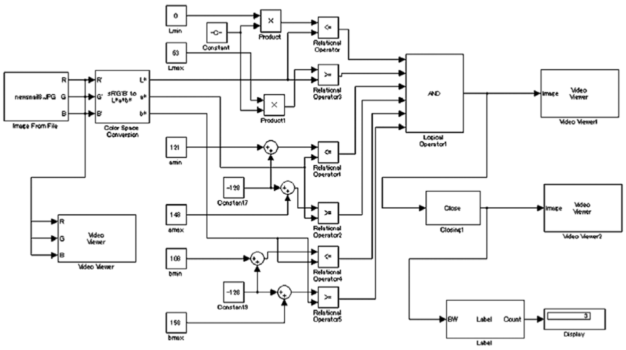


Fig. 10. Simulink model to segmenting and counting the snails of image of three snails predating small rice plants at night from Figure 8.

dure as the first case. Fig. 9 shows the binary images before close operations with four objects (a) and after close operation with only three objects or snails (b). Figure 10 show the Simulink model and the number of snails (3) on the Display block.

4. Fourth case

4.1 Snails mating in the laboratory

When we try to count the exact number of snails in the paddy field, it becomes problem that they are mating because the computer counts them as one whereas there are two in reality. We putted the mating snails on the paper which makes it much easier to separate them from the background and took the picture in our laboratory for the first step (Fig. 11). After setting each of L*a*b* value is set up, the binary image in Fig. 12a is obtained. After that, we perform a closing operation to fill up the opening in the snails and get the image of Fig. 12b. In this model we added the Erosion block to the first Simulink model we constructed (Fig. 13). The Erosion block slides the neighborhood or structuring element over an image, finds the local minimum, and creates the output matrix from these minimum values. It is useful to reduce the size of the image obtained.

Fig. 11. Image of the two snails mating on the white paper.

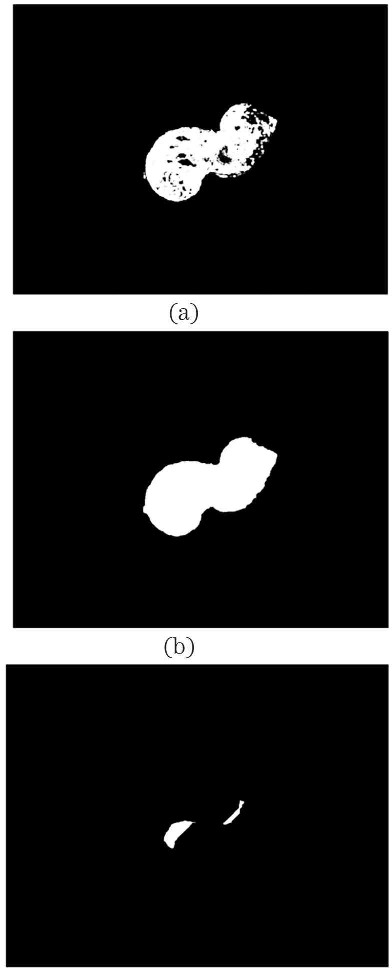
4.2 Results for fourth case

After performing an opening operation, we get the white two images (Fig. 14c) and can finally count them as two in Display block of Fig. 12.

5 Fifth case

5.1 Snails mating in paddy field

In the image of Fig. 14, we can observe that some part of mating snails are covered with paddy soil, therefore we should perform a closing operation to fill up the opening in the snails and opening operation to get rid of small white images which do not represent the snail.



(a)

(b)

(c)

Fig. 12. Binary image with the opening before closing operations (a), binary image filled up with white image after a closing operation (b) and binary image showing two white images for counting.

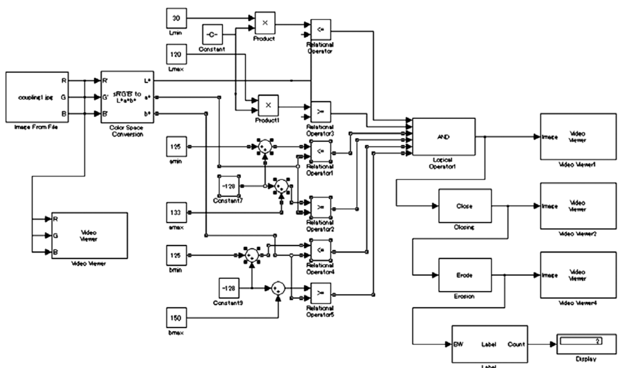
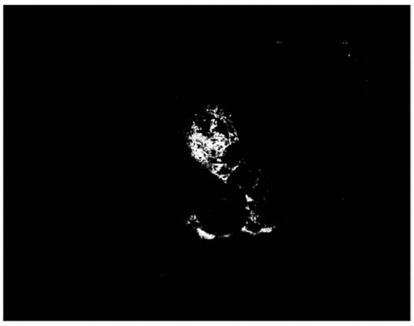


Fig. 13. Simulink model to separate the mating snails and count the number of them from Figure 11.

5.2 Results for fifth case

After each of L*a*b* value is set up and inputted, we get the binary image which has already separated the mating snails (Fig. 15b). Our model counted three snails which two are mating in the field (Fig. 16).

Fig. 14. Image of three snails from which two of them are mating in paddy field.



(a)

(b)

Fig. 15. Binary image after setting the range of L*a*b* values (a) and the binary image after performing a closing and opening operation (b).

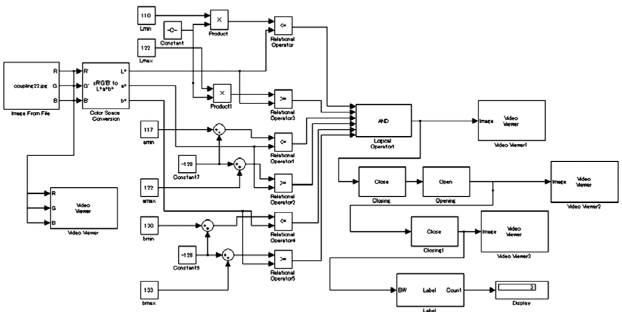


Fig. 16. Simulink model to separate the mating snails and counting the number of them from Figure 14.

DISCUSSION AND CONCLUSION

The snails could be separated and counted in images processed by our Simulink models even if the picture were taken over the season of rice and under different conditions such as after drainage of water, during irrigation and after raining. We found it is useful to make use of the reflection of the sunshine by snails when the paddy is drained or irrigated and to use the color of snails themselves after raining. Using the model we constructed we can also count the collect number of snails even if they are mating. If these models are installed to the intelligent robot, the robot equipped with a digital camera can count the snails and determine the time suitable to pick up the snails by the agricultural production ecosystem.

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