

Counting Brown Planthoppers in Light-Trap Images Using Morphological Operations

Nghi Cong Tran¹, An Cong Tran^{1,*}, Nguyen Huu Van Long¹, and Hiep Xuan Huynh¹

¹Can Tho University, Vietnam

Abstract

As brown plant hopper (BPH) is one of the most dangerous kinds of insect for rice plant, in recent years, there has been increased concern in counting them in light trap images to control their spread in order to reduce their damage on rice plant. This paper proposes an approach to counting BPHs in light trap images based on morphological operations. By applying these operations appropriately, combined with some noise removal techniques based on color, BPHs in the light trap images can be identified. In addition, it is common that the BPHs in the light-trap images are overlapped due to the layout of the light trap. Therefore, an approach to counting the overlapped BPHs based on their size is also introduced while the sequential region labeling algorithm is used to count the number of the separate BPHs. The experimental results show that our proposed approach is suited to identifying and counting the BPHs in images which are overlapped.

Keywords: brown plant hopper, morphological operations, overlapped BPHs, sequential region labelling.

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*Corresponding author. Email: tcn@cit.ctu.edu.vn

1. Introduction

Brown plant hopper (BPH) is one of the most dangerous insects for rice plants. It harms rice plants by directly feeding on them and transmitting many serious diseases such as ragged stunt virus and grassy stunt virus. This leads to serious losses of rice fields. As a result, BPH is causing serious damage on Vietnamese agriculture as well as other rice-growing countries [7, 8, 13, 14]. For example, in the Mekong Delta of Vietnam, the BPH outbreak caused the loss of approximately 1 million tons of rice in 2007, which resulted in a government freeze on the export of rice. The Office of Agricultural Economics in the Ministry of Agriculture and Cooperatives of Thailand reported that the outbreaks caused losses worth \$52 million during the dry season of 2010 [8]. In early 2012, the PRC's southwestern provinces lost about 10 million tons of rice due to heavy BPH outbreaks [8].

Therefore, reducing damage of BPH is a critical problem for these regions to maintain the food supply safety, not only for these regions but also for our whole world as they are the main rice suppliers for the world. Much research has been conducted to introduce several approaches focusing on different perspectives, including engineering or bio technologies. In this paper, we will propose an approach to counting BPH in light-trap images, which is able to deal with the overlapped BPHs in the images.

Section 2 discusses related studies, which is followed by the introduction of the BPH morphology and morphological operations in Section 3. Then, the proposed approach to identifying and counting BPH in images based in morphological operations is described in Section 4.2 and 4.3 respectively. Section 4.4 describes our method to tackle with noises in images. Section 4.5 presents the complete proposed algorithm. Finally, Sections 5 and 6 provide the experimental results, conclusions and future works.

shape and size of the BPHs. Their colour will be used to remove the insects other than BPHs. Figure 1 describe figure of some stages of BPH life.



Figure 1. Eggs, nymphs and adult BPHs

3.2. Morphological Operations

Mathematical morphology is a theory and technique for analysing and processing geometrical structures, based on set theory, lattice theory, topology and random functions [6, 18, 19]. It contributes a wide range of operators to image processing that is particularly useful for the analysis of binary images. The common usages of these operators include edge detection, noise removal, image enhancement and segmentation.

Morphological operators often take a binary image and a structuring element as input and combine them using a set operator. They process objects in the input image based on characteristics of its shape, which are encoded in the structuring element (also known as kernel). The two most basic operations in mathematical morphology are erosion and dilation. Other morphological operators are defined based on these operators including the opening and closing operators. In this section, we will introduce these operators applying to binary images only. A binary image I is generally considered as an array of values $I(x, y)$ such that $I(x, y) = 1 \mid 0$ for the pixel location (x, y) . Alternatively, a binary image can be represented as a set of all the foreground pixels, i.e. pixels that have the 1-value [2].

Structuring element. The structuring element consists of a pattern specified as the coordinates of a number of discrete points relative to some origin. For the binary image, a structuring element H is a small image in which each pixel has a value of 0 or 1: $H(i, j) \in \{0, 1\}$. Some basic structuring elements are square, diamond, cross, diagonal cross, horizontal line, vertical line.

Figure 2 shows some structuring elements that are widely used for binary image processing with the origins are circled.

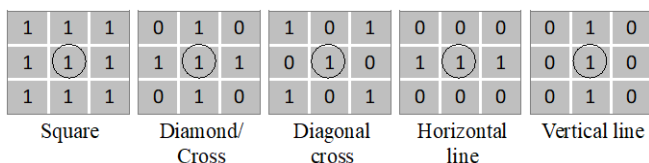


Figure 2. Basic structuring elements for binary image processing

Erosion. The erosion of a binary image B by a structuring element S , denoted by $B \ominus S$, is a set of points x such that H is included in B when its origin is placed at x : $B \ominus S = \{x \mid H_x \subseteq B\}$. The basic effect of the operator on a binary image is to erode away the boundaries of regions of foreground pixels (i.e. white pixels, typically). Thus, area of foreground pixels shrinks in size, and holes within those areas become larger.

The erosion removes small-scale details from the binary image but also reduce the size of region of interest. This operator can be used to find the boundaries of each region in the images by subtracting the eroded image from the original one.

Dilation. The dilation of a binary image B by a structuring element S , denoted by $B \oplus S$, is a set of points x such that H hits B when its origin coincides with x : $B \oplus S = \{x \mid S_x \cap B \neq \emptyset\}$. The basic effect of the operator on a binary image is to gradually enlarge the boundaries of regions of foreground pixels (i.e. white pixels, typically). Thus, areas of foreground pixels grow in size while holes within those regions become smaller.

Opening. The opening operators of a binary image B by a structuring element S , denoted by $B \circ S$, is defined as the erosion of B by S followed by the dilation by S : $B \circ S = (B \ominus S) \oplus S$. This operator makes stray foreground structures that are smaller than the S structure element will disappear while larger structures will remain. The structures that are survived after the erosion are restored to their original size by the dilation. This is an idempotent operator: once the image has been opened, subsequent openings with the same structure have no further effect.

Closing. This operator is also derived by the erosion and dilation operators. The closing operator of a binary image B by a structuring element S , denoted by $B \bullet S$, is defined as the dilation followed by the erosion operators: $B \bullet S = (B \oplus S) \ominus S$. This operator preserves background regions that have a similar shape to the structuring element, or that can completely contain the structuring element, while eliminating all other regions of background pixels. Like opening, this is also an idempotent operator.

Effect of the above operations is demonstrated in Figure 3. We also borrow an example from Wolfram² to demonstrate the application of these operators, which is shown in Figure 4.

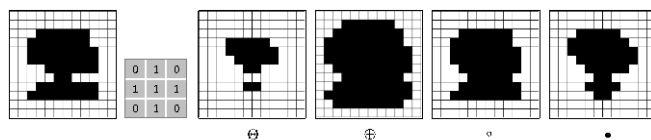


Figure 3. Effect of the morphological operations

² <http://www.wolfram.com/>

