РАЗДЕЛ II. РАСПОЗНАВАНИЕ ОБРАЗОВ И АНАЛИЗ ИЗОБРАЖЕНИЙ

THE COLOR IMAGES OF INFECTED CROP FIELD PROCESSING ALGORITHM

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Introduction

In this work we consider the problem of segmenting agricultural landed-fields in remote sensing data [1-3].

Our approach of agricultural images analysis contain following steps:

1. Blurring the image to avoid influence of noise and JPEG coding artifacts.
2. Color segmentation to detect area of field with different infection levels.
3. Improving segmented images.
4. Calculation of infection map of field.

1. Color Image Segmentation Algorithm

Lets consider two-stage method of image segmentation.

At the first stage we find sets of pixels which color have small deviation inside of each set and the number of pixels in each set is significant regarding to amount of all pixels. For that purpose we use a clusterization algorithm of pixels in image color space.

At the second stage we use some heuristics to make threshold separation of obtained set of clusters into two groups. To the first group belong clusters that include pixels of sought objects and to the second clusters that include pixels of background.

<u>Algorithm of image color space clusterization.</u>

1. Let source set of clusters $C = \varnothing$.
2. Chose pixel x_j from pixels set of X. $X = X \setminus \{x_j\}$.
3. If C is equal $\varnothing$

Then:

3.1. $C = C \cup \{x_j\}$.

Else:

3.2. Chose cluster c_i such as $\| c_i - x_j \| \to$ min.

3.3. If $\| c_i - x_j \| < \varepsilon$

Then

    3.3.1. Find new value of cluster center

$c_i = (c_i \cdot n_i + x_j)/(n_i + 1)$ where n_i is the number of pixels added to the cluster c_i.

    3.3.2. Find new number added pixels to the cluster c_i $n_i = n_i + 1$.

    Else

    3.3.3. Add new cluster $C = C \cup \{x_j\}$

4. If set X is not equal to $\varnothing$ then repeat from 2.

<u>Algorithm for finding the sought cluster center for segmentation.</u>

1. Chose cluster c_i such as $\| c_i - h \| \to$ min where h is color of objects set by user. Set new index $i = 1$ for c_i.
2. Sorting the set C according to rule

$\forall c_j$, $j < N - 1$, $\| c_j - c_i \|$ takes minimal value if $i = j + 1$ where $j < i \le N$.

3. Find $d_{max} = \| c_1 - c_N \|$

4. Find allowed deviation radius of objects color $R = d_{max} \cdot P / 100$ where P is allowed deviation percent from chosen object color. User sets value of P.

5. Join c_i such as $\| c_1 - c_i \| < R$ according to equation

$$h = \left(\sum_i c_i \cdot n_i \right) \Big/ \sum_i n_i$$

After applying of mentioned above algorithms we perform threshold segmentation of image. If $\| h - x_i \| < R$, then x_i is object pixel else x_i is background pixel.

2. Algorithm for improving the image after segmentation on the basis of soft morphology operations

The task of noise removal from the raster image in mathematical morphology usually is solved with the help of open and close operations, or their sequences. The open destroys narrow necks and smoothes ledges on the binary image, and the close swallows small hollows and closes gaps. Both open and close have property of idempotency. Hence, repeated using of function with same structuring element will not change the image. If it is required to improve filter outcome the set of structuring elements with a growing size is used. However increasing of a structuring element size reduces a resolving power of the filter. Thus, a shortage of classical morphological filters is low ability of the filter solving that leads to significant distortion of the initial image during filtering.

For noise removal on the image the modification of the soft morphological filter is offered [4]. For which the subset of a structuring element kernel is equal to an empty subset. Define operations of soft erosion and a dilatation in the following way:

$$SoftErode(A,B) = \begin{cases} a = 0, & n_o + t \le n_b \\ a = 1, & n_o + t > n_b \end{cases}, \tag{3}$$

$$SoftDilate(A,B) = \begin{cases} a = 1, & n_o + t \le n_b \\ a = 0, & n_o + t > n_b \end{cases}, \tag{4}$$

where n_o is a number of segment pixels that are same to appropriate pixel of the structuring element in current position of the structuring element window, n_b is a number of background pixels that are same to appropriate pixel, t is a filter threshold.

Thus, the soft open and close operations we can define as:

$$SotfOpen\ (A, B) = SoftDilate\ (SoftErode\ (A, B),\ B), \tag{5}$$
$$SotfClose\ (A, B) = SoftErode\ (SoftDilate\ (A, B),\ B), \tag{6}$$

Use of a threshold in the soft morphological filter allows operating the filter outputs. For example, in open and close operation it is possible to use different thresholds for erosion and dilatations.

The soft morphological filter works as follows - makes scanning the image by the structuring element. In a window of the structuring element the amount pixel the object (background), concurrent with nonzero pixel of structuring element is calculated. Depending on a function, according to formulas (3) - (4) the pixel value is appropriated.

3. Algorithms of segments description

The algorithms of segments description are used to find segments geometrical features. After finding geometrical features of segments we can apply mechanical treatment of field automatically. It is necessary to mention that description of field can be applied to all segments together (statistical approach) or to each segment separately.

Statistically map of field infection distribution can be evaluate as

$$f = \frac{\sum\limits_i C_i \cdot K_i}{\sum\limits_i C_i},$$ (7)

where K_i is coefficient of infection for i-th level of infection, C_i is a number of pixels that belong to i-th level of infection in window of given size.

Thus finding value of f in different position of scanning window we can obtain a map of infection distribution.

To find features of segments individually we apply following algorithms.

Algorithm of segment description using it raster edge pixels.

All pixels of image are checked. If pixel p(x,y) is the object pixel and one of neighbor pixels is the background pixel then the pixel is edge pixel. All the edge pixels are sorted corresponding to their segments. Corresponding array of edge pixels is chosen by criterion if in the array is the pixel with coordinates that differ from verifiable pixel by 1. If such pixels are found in several edge pixels arrays, that arrays are joint in one array. The image is increased three times to exclude the special processing of exclusive pixels that are members of two different edge pixels arrays.

After sorting all edge pixels the coordinates of pixels are set to the original image scale.

Chord segment description algorithm and segments feature calculation.

Chord segment description is represented by two-dimension array of horizontal chords of segment. Chords are ordered by coordinates y and x. Chord segment description can be obtained from edge segment description using the following algorithm.

1. Arrange edge pixels by coordinates y and x into two-dimension array.
2. Define to left or right chord end the each pixel belongs.
3. Pick out pare of left and right edge pixels in the increasing order of coordinates x and y. If edge pixel is left and right at the same time then that pixel is repeated two times. Selected pares are stored in new array of segment chords.

It is easy to the find following segment features using segments chord description.

1.   Segment area

$$S = \sum_{i=1}^{N} (xl_i - xr_i),$$

where xl_i, xr_i are left and right x coordinates of left and right ends of i-th chord, N is number of chords.

2.   Geometric center of the segment

$$x_c = \frac{\sum\limits_{i=1}^{M} x_i}{M}, \; y_c = \frac{\sum\limits_{i=1}^{M} y_i}{M},$$

where (x_i, y_i) are coordinates of i-th edge pixel, M is the number of segment edge pixels.

4. Tests

Test was performed using airplane-photo of potato field (fig. 1). Test shows good image segmentation results that allow high quality further processing.
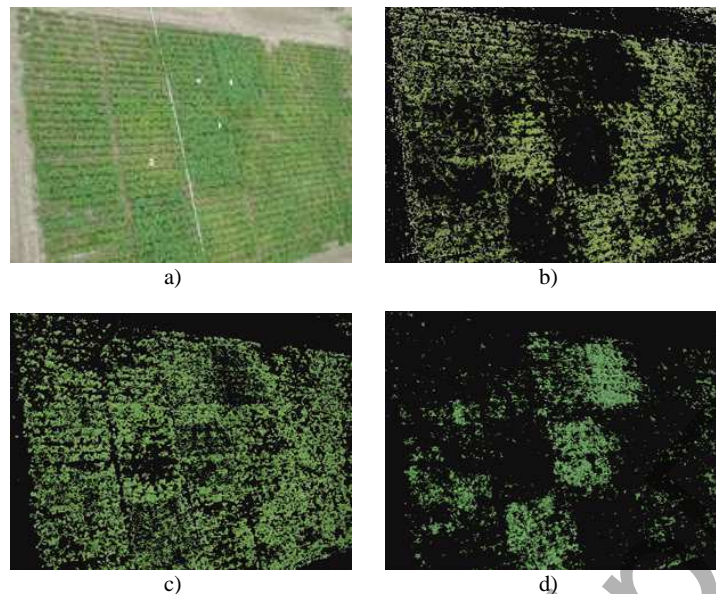
Fig.1 a) source image of field, b) the areas of field that are strongly infected, c) the areas of field that have average infection, d) the areas of field that are healthy

References

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АЛГОРИТМ УСТРАНЕНИЯ ЭФФЕКТА ПЕРЕСЕГМЕНТАЦИИ С ИСПОЛЬЗОВАНИЕМ ОПЕРАЦИИ ПОЛУТОНОВОГО ПСЕВДОСКЕЛЕТА

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Операция сегментации проводится для нахождения границ однородных областей на изображении. В разных задачах требуется проводить сегментацию по различным признакам - по яркости, по текстуре, по цвету. Для сегментации полутонового изображения по яркости можно использовать морфологической операции трансформации водораздела [1-4]. Отличительной особенностью данной операции является высокая точность сегментации, относительно невысокая вычислительная сложность и отказ от использования порогов.

На вход операции трансформации водораздела подается градиент изображения. Результатом будет являться граница однородных по яркости областей. Толщина границы равна одному пикселю. Связность элементов границы будет зависеть от выбора структурирующего элемента для операции трансформации водораздела.

Однако недостаток данного метода - это пересегментация изображения. Под пересегментацией понимается наличие большое количество сегментов малого размера на