Ministry of Education and Science of Ukraine

Odessa National Academy of Food Technologies

International Competition of Student Scientific Works

BLACK SEA SCIENCE 2021

Information Technology, Automation and Robotics

Proceedings

Odessa, ONAFT 2021

UDC 004.01/08

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Black Sea Science 2021: Proceedings of the International Competition of Student Scientific Works. Information Technology, Automation and Robotics. / Odessa National Academy of Food Technologies; B.Yegorov, M. Mardar, S.Kotlyk (editors-in-chief.) [*et al.*]. – Odessa: ONAFT, 2021. – 526 p.

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ANALYSIS OF MIXTURES AT LASER SURFACING USING COMPUTER VISION

Author: ***Mykhailo Kovalevskyi***
Advisors: ***Dmitriy Kritskiy, Olha Pohudina***
National Aerospace University Kharkiv Aviation Institute (Ukraine)

Abstract. *A method of contour recognition is considered, which includes several stages of processing the original image. Some methods of contour recognition are highlighted and their characteristic features are described. A certain sequence of applying the stages of processing the input image is proposed. Examples of output data after applying image processing and the results of their analysis are given. The comparison of the quality of contour recognition for each type of powder is carried out, the error of the analysis is calculated, and the corresponding conclusions are drawn.*

Keywords: *computer vision, OpenCV, laser surfacing, Freeman chain code, Gaussian filter, threshold transformation.*

I. INTRODUCTION

Using of computer vision-based systems for the analysis of mixtures, powders, etc. already applied. In the presented work, it is proposed to use the OpenCV library to create software that allows analyzing the powder during laser surfacing in order to calculate the required operating modes of the machine.

The field of computer vision is quite popular now. Interest in it arose at the dawn of attempts to create artificial intelligence [4]. Currently, the number of new solutions and relevant applications for computer vision and artificial intelligence in general continues to grow.

With an increase in the number of proposed methods and algorithms for recognizing contours within an image, it becomes unclear the choice of any specific method for certain needs, since each separately taken method is good for some specific narrow range of tasks.

There are many approaches to the selection of boundaries, but almost everything can be divided into two categories [5]: methods based on finding maximums and methods based on finding zeros. Methods in the first category isolate boundaries by calculating the “edge strength”, represented as an expression of the image gradient, and then finding the local maximum of the edge strength using the assumed direction of the boundary, usually perpendicular to the gradient vector. Methods of the second category look for the intersections of the abscissa with the second derivative expression, which are usually the zeros of the Laplacian or the zeros of a nonlinear differential equation. As a preprocessing step, image smoothing is almost always applied to edge selection. As a rule, a Gaussian filter is used for these purposes [5].

Although many of the known boundary extraction techniques are based on the computation of the gradient of an image, they differ in the types of filters used to

compute gradients in different directions.

The complexity of this problem is significant heterogeneity of the contour boundaries on the powder granules.

II. LITERATURE ANALYSIS

Significant restrictions on the scope of contour analysis are imposed by problems associated with contour selection in images, namely:

- due to the same brightness with the background, the object may not have a clear boundary, or may be noisy with interference, which leads to impossibility to recognize the contour;
- overlapping of objects or their grouping leads to the fact that the contour is recognized incorrectly and does not correspond to the boundary of the object.

However, the transition to considering only the contours of objects allows to go from the image space to the space of the contours, which significantly reduces the complexity of algorithms and calculations.

Thus, we can conclude that the contour analysis has a rather weak immunity to interference, and any intersection or only partial visibility of the object leads either to the impossibility of detection or to false positives. However, the simplicity and speed of the contour analysis make it possible to apply this approach quite successfully (with a clearly defined object against a contrasting background and no interference).

III. OBJECT, SUBJECT, AND METHODS OF RESEARCH

The **object** of the article is the process of finding the contours of objects in the images of mixtures used in laser surfacing. The **subject** of the article is the methods of computer vision in the processing of graphic information in images obtained from a microscope. The **aim** is to improve the quality of laser surfacing by detecting granules of small, medium and large powder in the material to be used. **Objectives**: to analyze the characteristics of images of the material obtained under a microscope; consider methods to eliminate the noise of the original image; get a binary image with a binarization threshold that will allow you to detect the maximum number of objects; develop an algorithm that allows you to get at least 80% of the granules in the image and estimate their size. The used **methods** are: Gaussian filtering method, threshold transformation method for obtaining a binary image, contour detection method using approximation by horizontal, vertical and diagonal segments.

IV. RESULTS

4.1. Step-by-step image processing

Since it is known that a contour is a kind of boundary of an object that separates it from the background (other objects), in order to select it, as a rule, several stages are necessary.

The first step is to blur the image. This operation is performed for reasons of more precise detection of the boundaries, since the step between the color gradations

will be higher than in the original image. There are quite a lot filters that provide smoothing (Gaussian filter, median filter, etc.).

But how to get the contours directly? Of course, Canny's edge detector is remembered first, and then any other methods of obtaining a binary image can be cited. For example, threshold transformation and detection of an object by color.

In all these cases, we get a binary image that explicitly sets the boundaries of the object to us. This collection of pixels that make up the boundary of the object is the object contour.

To operate on the resulting contour, it must be somehow represented (encoded). For example, indicate the vertices of the line segments that make up the contour. Another well-known way of encoding a contour is Freeman's chain code.

Chain codes are used to represent a boundary as a sequence of straight line segments of a certain length and direction. This representation is based on a 4- or 8-connected grid. The length of each segment is determined by the resolution of the grid, and the directions are given by the selected code (to represent all directions in a 4-connected grid, 2 bits are enough, and for an 8-connected grid of the chain code, 3 bits are required).

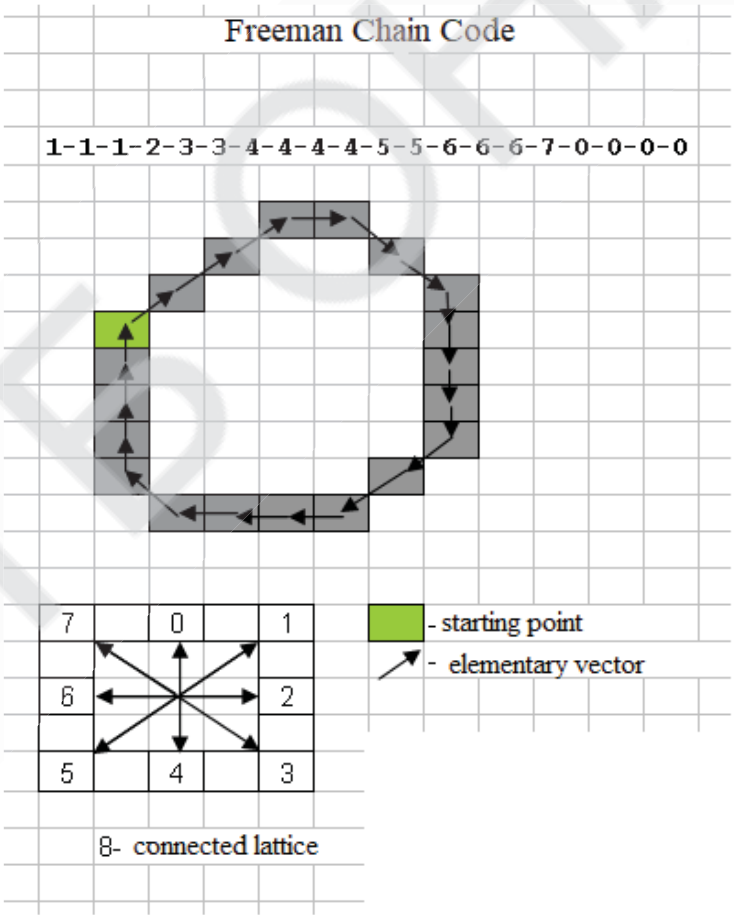

Fig. 1. Freeman chain code

Thus, the algorithm of actions for object recognition is as follows:

1. pre-processing of the image (smoothing, filtering noise, increasing the contrast);
2. binarization of the image;
3. objects contours detection;
4. filtration of contours (along the perimeter, area, etc.);
5. enumeration and display of found contours.

4.2. Description of the created software product

To solve the problem, namely to find and analyze powder granules on the image, a software product was developed using the OpenCV computer vision library.

The input to the software product is an image of the powder that must be analyzed. Powder, in turn, can be classified into 3 categories: small (Fig. 2), medium (Fig. 3) and large (Fig. 4).

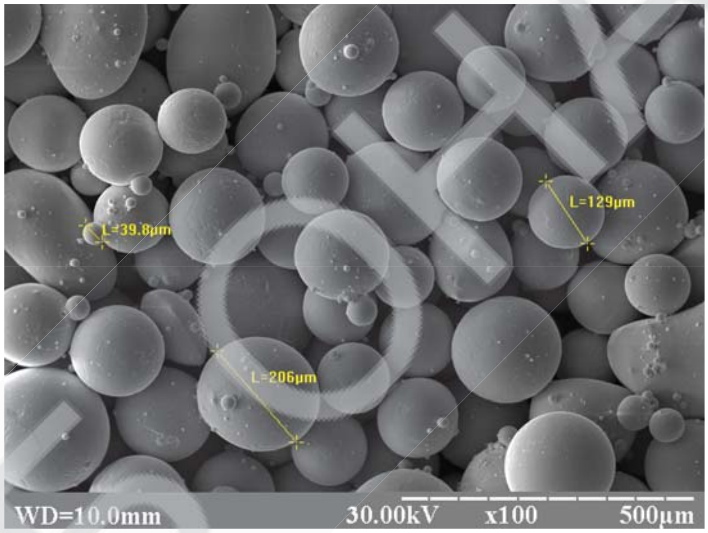

Fig. 2. Small powder

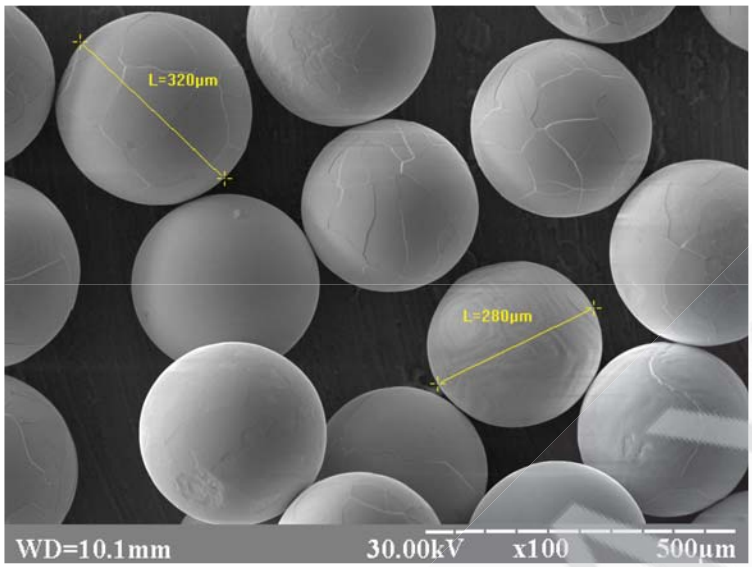

Fig. 3. Medium powder

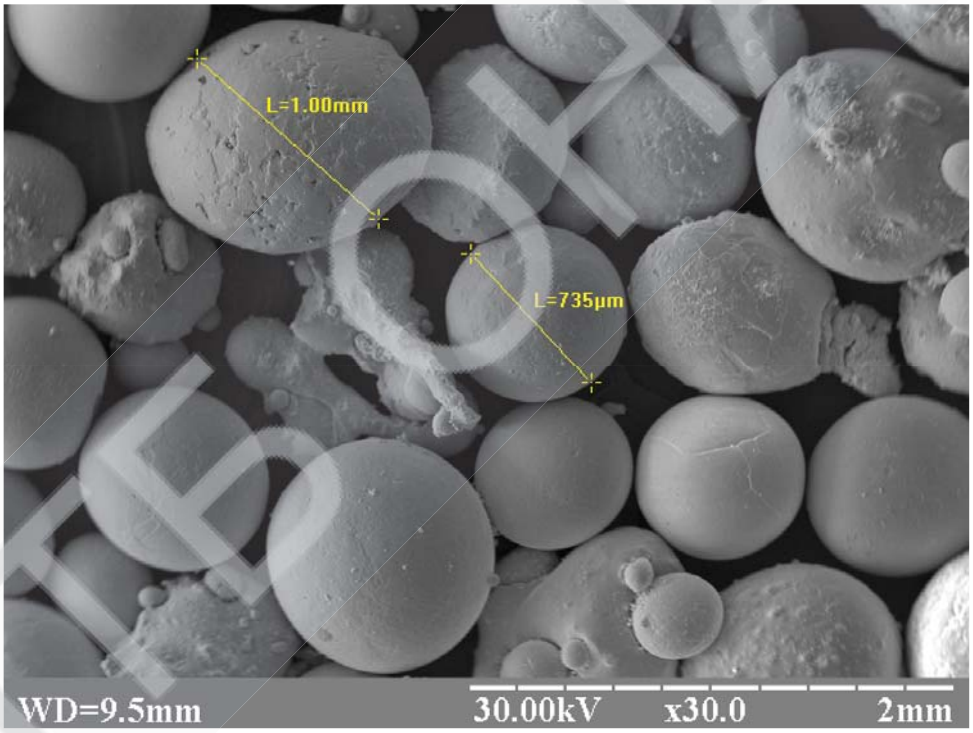

Fig. 4. Large powder

After the image has been submitted to the input, the program processes it according to the above described algorithm and analyzes it. As a result, two windows open:

1) window with the input image and the contours found on it (Fig. 5);
2) window with analysis results (Fig. 6).

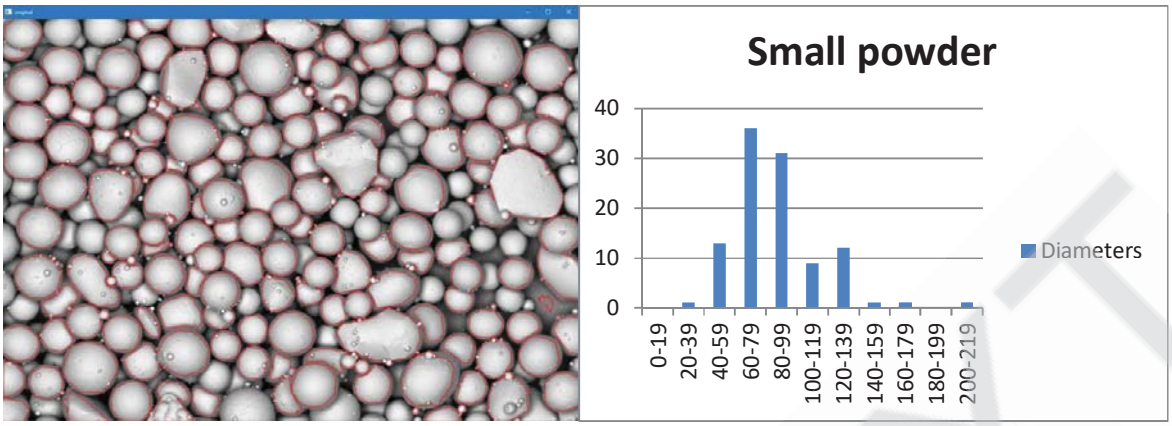

Fig. 5. Found contours for small powder and diameter distribution

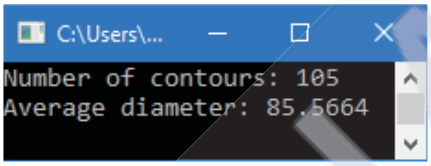

Fig. 6. Analysis results for small powder

As you can see from Figures 5-6, the program recognized the powder granules, calculated their number and the average diameter of one granule. Despite the blur and thresholding there are still some noise and darkening on the images, so the recognition algorithm has some error. This error depends not only on the quality of the image received at the input, but also on the quality of the powder, since on some granules the program was able to recognize the internal contours of the granule.

For example, when analyzing small powder, it was possible to recognize 105 granules, while the actual value is 175. Thus, the analysis error for small powder is:

$$\varepsilon_s = \frac{|175 - 105|}{175} = \frac{70}{175} = 0{,}4 = 40\%.$$

The medium powder is analyzed in the same way. The analysis results are shown in Figures 7-8.

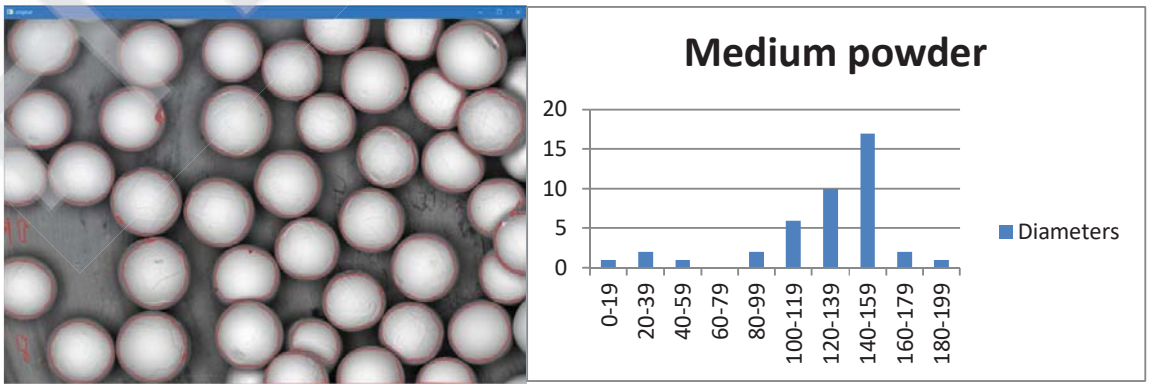

Fig. 7. Found contours for medium powder and diameter distribution

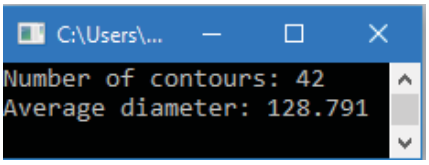

Fig. 8. Analysis results for medium powder

Analysis error for medium powder:

$$\varepsilon_m = \frac{|40 - 42|}{40} = \frac{2}{40} = 0{,}05 = 5\%.$$

Now let's also analyze the large powder. The analysis results are shown in Figures 9-10.

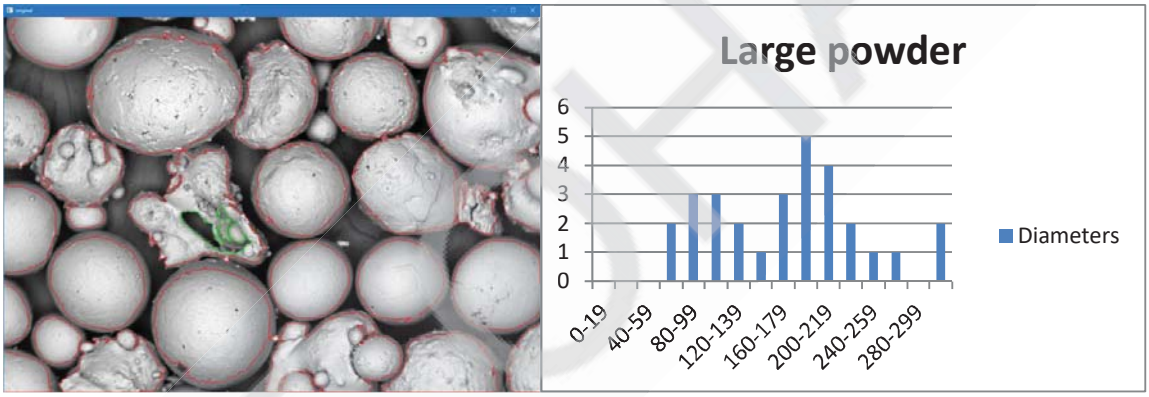

Fig. 9. Found contours for large powder and diameter distribution:
red color – external contours, green color – internal contours

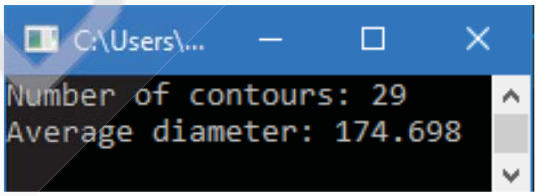

Fig. 10. Analysis results for large powder

Analysis error for large powder:

$$\varepsilon_l = \frac{|31 - 29|}{31} = \frac{2}{31} \approx 0{,}06 = 6\%$$

So the average error of the algorithm:

$$\varepsilon = \frac{\varepsilon_s + \varepsilon_m + \varepsilon_l}{3} = \frac{40 + 5 + 6}{3} = \frac{51}{3} = 17\%.$$

V. CONCLUSIONS

A step-by-step method for recognizing contours in an image using computer vision is proposed for analyzing powders and mixtures during laser surfacing, where the working conditions are quite difficult due to the presence of hardly distinguishable gray gradations in the images and strong heterogeneity of the boundaries of recognized objects. A similar approach is used to recognize phase and grain contours in steel microstructure images. We also analyzed the results of a software product built on the basis of the proposed object recognition approach. The comparison of the quality of contour recognition is carried out for each type of powder: small, medium and large. The analysis error was calculated, which average value is 17%.

Thus, the proposed solution showed quite good results for medium and large powder, where the error was 5% and 6%, respectively. However, it still needs further improvement when analyzing large powder.

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The collection includes student works of the participants of the competition, which were not included in the number of prize-winners. The texts of the competitive works are published in the form in which they were submitted by the authors. The authors of the articles are responsible for the content and form of submission of the material.

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Computer typesetting and layout: Oksana Sokolova

Odessa 2021