Using depth map algorithms to improve the quality of object identification on digital stereo images

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Abstract. For the first time experimentally investigated the use of a vision system using the technology of depth maps, infrared depth sensor, laser rangefinder, lidar to determine the relief and geometric dimensions of the object on digital stereo images, which allows continuous monitoring of the state of any process. Methods of digital image processing are presented. The main advantages of such systems are considered.

Keywords: technical vision, quality control, automation, stereo, organoleptic, confection

1. Introduction
Currently, in various industries there is an active use of the most modern means of automation in order to improve the quality control of the process [1]. These tools include various vision systems that allow continuous monitoring of the process [2].

As the main advantages of vision systems can be identified: continuity, high fault tolerance, digital video and photo shooting of the object in different ranges of the electromagnetic spectrum [3, 4]. It is worth noting that in addition to the technical and hardware features of vision systems, the software-algorithmic part that provides digital image processing to identify the necessary information about the object under study [5, 6].

In turn, today there is a wide variety of types of vision systems, each of which is designed for a certain number of highly specialized tasks. The main results are obtained by using a vision system, the hardware of which consists of two cameras arranged in a certain way relative to each other. [7 – 9].

The result of such a system of technical vision is a map of the depth of space, which is a three-dimensional matrix of points, each of which corresponds to the pixel of the image. For clarity, this three-dimensional depth map has been converted into a flat digital colour image. The main results are obtained by using such a system of technical vision using the technology of space depth maps to determine the relief and geometric dimensions of the object under study [10].

The object of our experimental study is the influence of the upper layer of water-immiscible oil on the regularization of surface gravity waves excited by the parametric resonance. In experiments, a
layer of oil of finite thickness was placed on the free surface of water and the effect of regularization of a breaking standing gravity wave was estimated. The two-layer system oscillates like a homogeneous fluid, which, in terms of [10], refers to the barotropic mode of oscillations.

In the analysis of the model product, the most informative quality indicators were determined: geometric shape, length, width, which must be continuously determined in the production process. The determination of these indicators by digital image can be made using a computer vision system, which can consist of both one and two or more video cameras [11].

To date, there are many algorithms for processing stereo images, which show more effective results in image analysis to solve a wide range of production problems. One of these algorithms is a modified algorithm HH08 Dr. Hirschmuller, which is now widely used in various programming libraries, and in this study used the library OpenCV 3.4.3, in particular the class StereoSGBM [12].

2. Theoretical substantiation
The method of obtaining the depth map of the object by means of digital stereo images allows to solve a number of the following tasks in the food industry:
- more precise positioning of the object on the conveyor line
- selection of one object relative to others
- selection of the object relative to the background
- getting a map of the surface topography of the object

Each of the above solutions can be individually applied in different areas of production lines of various products to improve the efficiency of these productions and automation of quality control of the studied processes. In this study, we consider a method of obtaining a relief map of a model product to ensure automation of quality control of the product molding process.

3. Method
This article discusses the methods of digital image processing. As a hardware part, a digital camera is used, located on a movable platform-slider, which provides movement of the camera in a horizontal plane. This installation of equipment allows you to simulate stereo shooting, having only one digital camera. For the experimental part of the work we used parallel stereo images – digital images of the object under study. This method involves a survey of the objects under study, in which two digital images are taken, and the camera matrix for both images must be in the same plane, otherwise the stereo image can not be called parallel. The lack of parallelism of stereo images makes additional adjustments to the course of the experiment – such as the calibration of both cameras relative to the object under study.

4. Experimental procedure
A model product sprinkled with crumbs was used as the object of study (figure 1).

![Figure 1. Parallel digital stereo pair of the object under study.](image-url)
It is important to note that on this stereo pair, the object of study has a similar color palette with a background, which acts as a laboratory table, the table top of which has a wood texture. Therefore, when solving such a problem of identification of a model object in a digital image using a single digital camera and single image processing methods — methods such as cluster image analysis, the selection of object boundaries would be extremely inefficient compared to the method of obtaining a depth map from a stereo pair.

The stereo pair of subject images has a very small distance between the images, as the smaller distance between the stereo pair allows you to get a depth map at a shorter distance from the camera.

5. Results and discussion
The stereo pair of subject images has a very small distance between the images, as the smaller distance between the stereo pair allows you to get a depth map at a shorter distance from the camera. The depth map, which can be obtained as a digital image after processing the stereo pair, has no color and the result is presented in grayscale (figure 2.a), as well as in artificial coloring (figure 2.b), where the colors characterize the distance to the object.

As you can see in the pictures of the depth charts – the more bright pixels (figure 2a) characterize the close distance from the camera to the object, they correspond to the red-orange pixels on the digital image of the color depth map (figure 2b). This information allows you to most accurately and quickly solve the following tasks for an automated, robotic system:
- determination of the centroid of the object under study;
- determining the shape and topography of the object;
- defining the position of the object;
- determination of the geometric dimensions of the object.

The space depth map, which was obtained as a result of the experiment described in this study, was built from two stereo images with a resolution of 960x720 pixels, and the execution time of the algorithm for constructing a depth map was 0.189 s on a personal computer with an Intel core i3-6006U @ 2Ghz processor. The execution time of the algorithm depends on the following parameters:
- photo quality (amount of noise, sharpness and other parameters);
the number of parts of the object under study, the geometric dimensions of which in the projection on the matrix of the camera will have a size comparable to the size of the pixel matrix;
- shift stereography;
- correct calibration of the stereo pair;
- input parameters of the algorithm.

6. Concluding remarks
New experimental results on the use of depth map algorithms to improve the quality of object identification and positioning on digital stereo images are presented.

It is shown that the use of a vision system with the use of technology maps the depth of space allows continuous monitoring of the state of any process.

In conclusion, it should be noted that the solution of such problems with a single video camera and processing methods of single digital images do not give similar results in comparison with the algorithms of processing digital stereo images, since the processing and analysis of a single video or photo image modern algorithms are very difficult to distinguish the relief and shape of the object, as well as to identify the nearest objects relative to the objects of the background.

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