

DETEKCIJA, LOKALIZACIJA I RASPOZNAVANJE OBJEKATA POMOĆU PROGRAMSKOG ALATA LABVIEW

DETECTION, LOCALIZATION AND RECOGNITION OF OBJECTS USING LABVIEW

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Stručni članak

Sažetak: U ovom radu opisana je izrada vizijskog sustava za detekciju, lokalizaciju i raspoznavanje objekata. Vizijski sustav ispisuje rezultate detekcije pomoću grafičkog korisničkog sučelja. Vidljivi rezultati detekcije objekata vizijskog sustava su koordinate i dimenzije objekta. Vizijski sustav signalizira koji je objekt raspoznan. Ovaj vizijski sustav može se koristiti za navođenje robota. Vizijski sustav izrađen je u programskom alatu LabVIEW.

Cljučne riječi: vizijski sustav, LabVIEW, detekcija objekata, lokalizacija objekata, raspoznavanje objekata

Professional paper

Abstract: This paper describes the development of a vision system for detection, localization and recognition of objects. The vision system lists results of detection on a graphical user interface. Visible results of detection in the vision system are represented by coordinates and dimensions of the object. The vision system indicates which object is recognized. This vision system can be used for robot navigation. The vision system is made in the programming tool LabVIEW.

Key words: vision system, LabVIEW, detection of objects, localization of objects, recognition of objects

1. INTRODUCTION

Vision systems are a new step towards automation of machines, robots and plants. In mobile robotic vision systems are used for guidance of mobile robots [1]. This system enables a machine or a robot to “see”. Robots decide on manufacturing processes based on the image acquired from camera and image processing. Vision system requires high-speed data analysis and strong hardware resources. For the purpose of this article, due to high-speed data analysis and speed of creating a vision system for object detection, localisation and recognition, the LabVIEW program tool was used. It was used due to the speed of data analysis and speed of creating a vision system for detection, localisation and object recognition.

LabVIEW is a program tool which enables graphical programming by connecting the existing blocks and functions. Vision system developed in LabVIEW performs object detection, localisation and recognition. The results of object localisation and recognition are coordinates, orientation and dimensions of the object. Based on these results a robot has the possibility to take the detected object and relocate it or isolate a defective object from the valid ones. Possible application of this vision system is separating valid chips from the defective ones and their assembling and packaging.

This paper is structured in the following manner: the second paragraph deals with vision systems and the third one describes equipment and tools used for creating robot vision. Program code for robot vision is described

in the fourth paragraph, whereas the results of robot vision operations are presented in the fifth paragraph.

2. VISION SYSTEM

Vision system is a technology and method which, based on image analysis, provides various opportunities such as automatic inspection, process control or robot guidance in industry. The aforementioned system enables the computer to “see”. Basic part of the vision system is a camera which transfers an image directly to the computer which processes and analyses the imported image. Image analysis determines output parameters for further production process. The camera has a role of a sensor, i.e. a feedback for robot guidance or production process control. Image analysis can detect specific product malfunctions within a short time interval and thus isolate defective products from further production process. When robot guidance is discussed, specific objects can be detected in robot’s operating area and some characteristics of these objects can be determined, such as shape, dimensions and position; and on the basis of the mentioned characteristics one may give the robot an order to e.g. relocate the detected object to the given location (Figure 1).

Organisation of the vision system greatly depends on application. This system is typically an independent system for image processing which is included in a more complex system such as robot guidance or production

process. Vision system's operating procedure consists of several steps which are shown in Figure 2.

The first step is image capturing. In order to acquire a digital image, one or more image sensors are required, i.e. one or more cameras. After an image is acquired, the next step involves the preparation for image processing.

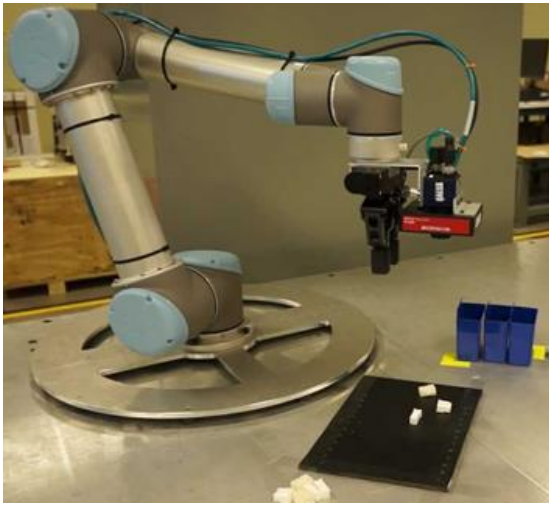


Figure 1. Vision robot guidance [2]

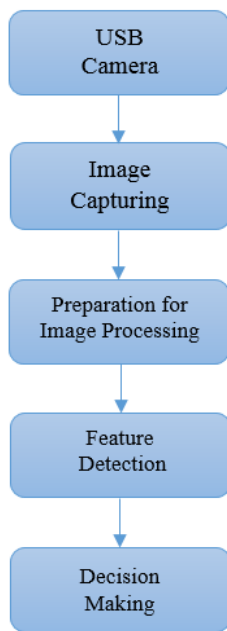


Figure 2. Block diagram of vision system's operating procedure

Image parameters are adjusted in step three - preparation for image processing. Some of the parameters are contrast, colour intensity, image dimensions and other. Besides adjusting image parameters, there is the possibility of converting the image from a coloured image (RGB Image) into a Greyscale Image. After all the parameters have been adjusted, one of the image filters can be used. This is a very important step for gaining better quality and precision in image processing, and all the options and possibilities during the preparation of the image for processing depend on the process in which the vision system will be used. The following step is feature detection. Features are detected on various levels. The

simplest features are lines, edges and ridges, and more complex ones are shapes, figures, textures and movements. It is necessary to define the features which are to be detected and to determine the area of interest, i.e. the area of the image which is relevant for finding the features. The last step in the vision system is making the final decision necessary for application. If production process control is considered, then the decision is whether the examined object passes or fails. When robot guidance is discussed, decision-making is much more complex because more parameters should be determined for the detected feature such as shape, coordinates and dimensions of the feature. Robot system reads output parameters of the vision system on basis of which it collects the detected object.

3. EQUIPMENT AND TOOLS USED FOR CREATING THE VISION SYSTEM

3.1. Program tool LabVIEW

Vision system for robot guidance was created in LabVIEW Program Tool (Figure 3) of the National Instruments Company. LabVIEW is a development environment for graphical programming.

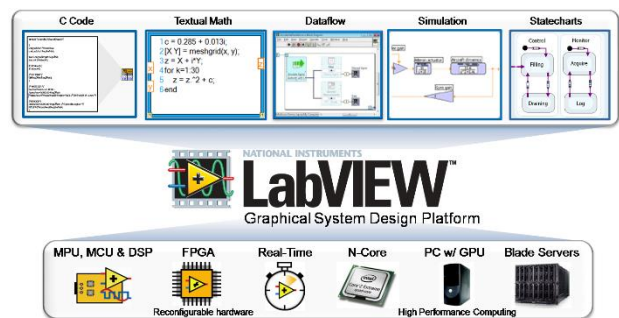


Figure 3. LabVIEW Program Tool [3]

LabVIEW is also known as a Virtual Instrument. After LabVIEW is launched, a new project should be made, i.e. a Virtual Instrument, or an existing project should be launched. Every virtual instrument consists of two windows. The first window is the so-called Front Panel, and the second one is the Block Diagram. The Front Panel is the Graphical User Interface. Controls and indicators are placed on the Front Panel (Figure 4).

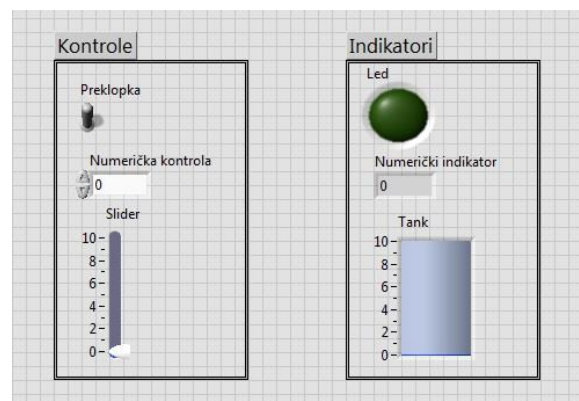


Figure 4. Controls and indicators in LabVIEW

Controls are inputs which enable the user to control the system or to enter data into the virtual instrument. Indicators are outputs which represent the results in graphical form.

The back panel, i.e. the Block Diagram contains the graphical source code. Any object placed on the front panel will appear in the block diagram as a block with attachments terminal (Figure 5). Besides controls and indicators from the front panel, block diagram contains structures and functions. Structures and functions are in a form of blocks with attachments which perform operations and display results on the front panel of the indicator. All the blocks are interconnected by wires. This type of programming enables simple and fast application development.

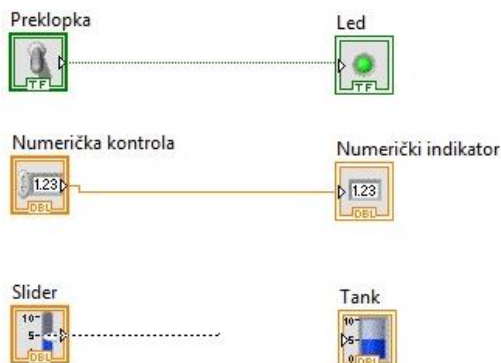


Figure 5. Connecting blocks in LabVIEW Program Tool

3.2. USB camera Logitech C310

Camera is fixed on a stand and records operating area as shown in Figure 6.



Figure 6. Logitech C310 USB camera placed on the rack

Camera used for the vision system was produced by Logitech, model C310. It is connected to the computer via USB port. Focus of the camera and brightness are

adjusted automatically. This is a high resolution camera of 1280x720 pixels with maximum frame frequency of 30 images per second.

3.3. Vision System Operating Area

Operating area is an aluminium plate shown in Figure 7 of 350 mm in length and width. The plate was varnished with white colour in order to achieve a greater contrast between the object and the plate. There are two markers on the plate which are made from black adhesive tape. The marker in the bottom left corner is for determining the origin of the coordinate system, and the straight marker of width amounting to 100 mm is for determining object's dimensions (Figure 7).

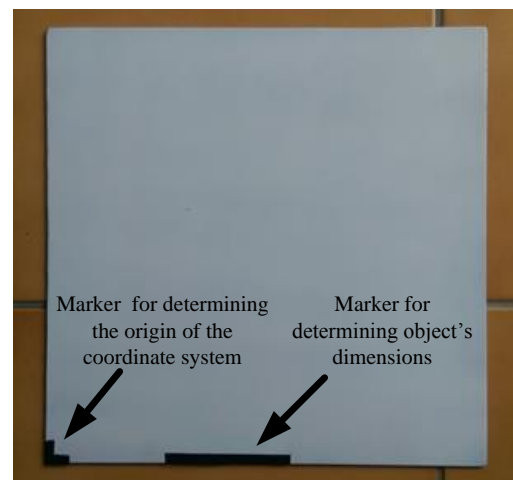


Figure 7. Desktop with markers

4. ROBOT VISION PROGRAM CODE DEVELOPED IN LABVIEW

Program code for robot vision is an algorithm which allows the robot to "see" objects in its operating area and enables decision-making for further robot tasks based on the analysed image. Objects which are detected by the vision system are demo, and all circular or rectangular objects can be detected as long as their dimensions do not exceed the borders of the operating area. Program signalizes the user which object was detected, coordinates are shown with the centre of the object's mass and object's dimensions are measured and shown. If the object is circular in shape, the program shows its diameter, and if the object is rectangular in shape, the program shows its length, width and the angle of rotation, i.e. object's orientation. Besides circular and rectangular objects, vision system can detect microcontroller ATmega16 placed on an electronic plate. For the detected microcontroller coordinates of its centre of mass are written and the microcontroller is rounded. Vision system enables the detection of geometric irregular shape (scalpel) and detection of a sample based on colour intensity (bank card). Vision system's program code developed in LabVIEW is shown in Figure 8 [4], [5], [6].

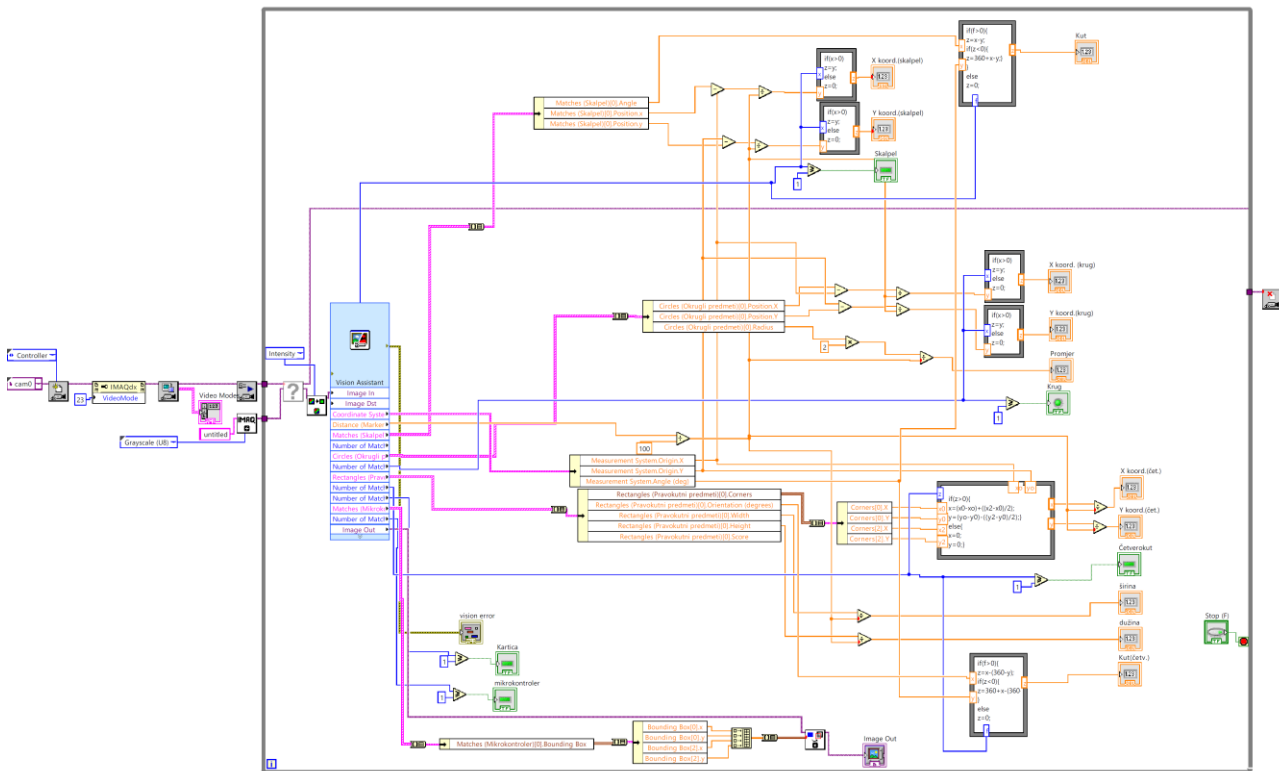


Figure 8. Vision system program code created in LabVIEW

4. ROBOTIC VISION PROGRAMMING CODE RESULTS DEVELOPED IN LABVIEW

Samples which were taken for testing the operating procedure of robot vision program code created in LabVIEW are:

- rectangular object, dimensions 93 mm × 47 mm,
- round object (circle), diameter 55 mm,
- object of irregular shape (scalpel),
- microcontroller ATmega16 on an electronic plate,
- bank card.

Detection, localisation and recognition of a rectangular object are shown in Figure 9. The indicator which shows that the rectangle is detected shines green. Centre of the mass of the detected rectangle is in point (154.63, 188.61) mm of the coordinate system. Dimensions of the rectangle, which were measured with the help of the robot vision system, are 92.48 mm × 46.97 mm, and the measured rotation is 317.85°. The error which appears during the measurement of the dimensions occurs due to insufficient camera resolution and bad illumination.

Detection, localisation and recognition of a round object (circle) are shown in Figure 10. The indicator which shows that the circle is detected shines green. Centre of the mass of the detected circle is in point (173.57, 193.43) mm of the coordinate system. The diameter of the circle was measured with the help of the robot vision system and amounts to 54.41 mm.

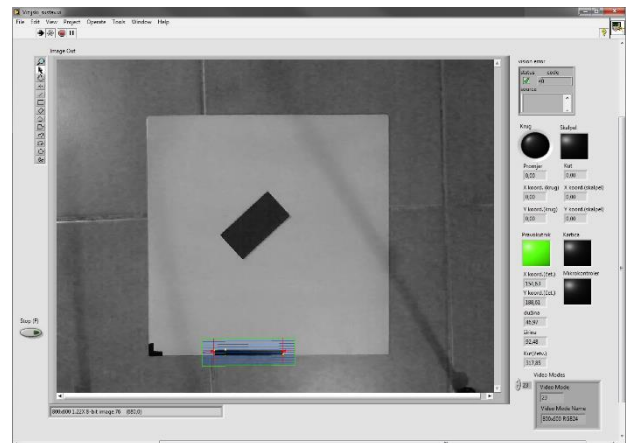


Figure 9. Detection, localisation and recognition of a rectangular object

Orientation of the circle is not important in robot vision systems. The error which occurs during the measurement of the circle diameter is the result of camera resolution and bad illumination.

Detection, localisation and recognition of an object of an irregular shape (scalpel) are shown in Figure 11. The indicator which shows that the scalpel is detected shines green. Centre of the mass of the detected scalpel is in point (161.99, 203.35) mm of the coordinate system. Measured orientation of the scalpel is 43.41°.

Detection, localisation and recognition of a microcontroller ATmega16 on electronic plate are shown in Figure 12. The indicator which shows that the microcontroller is detected shines green.

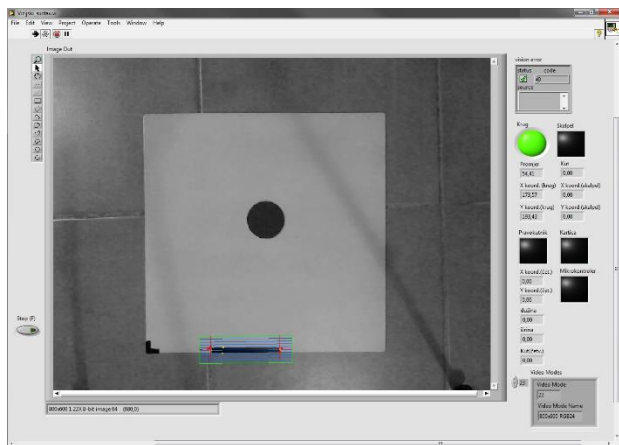


Figure 10. Detection, localisation and recognition of a round object (circle)

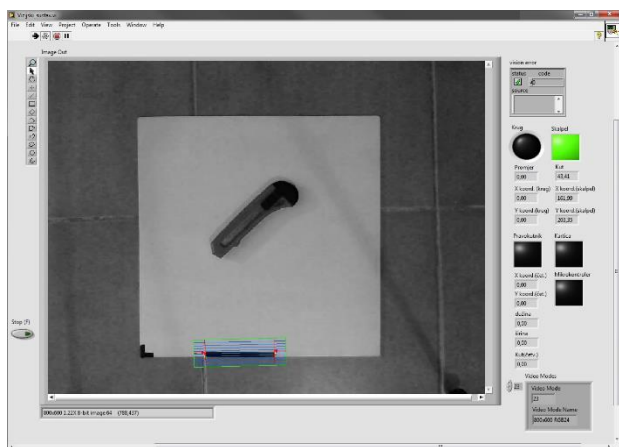


Figure 11. Detection, localisation and recognition of an irregular shape (scalpel)

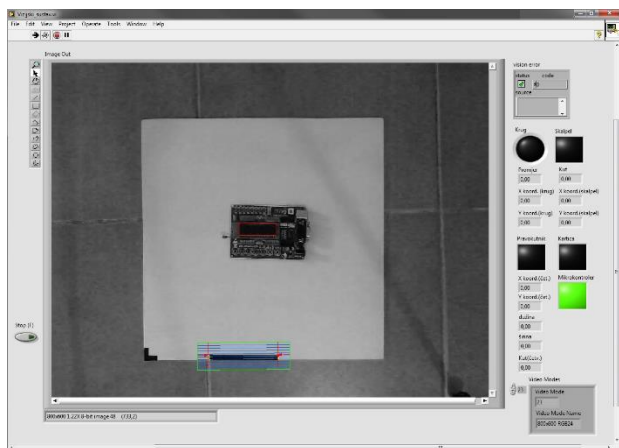


Figure 12. Detection, localisation and recognition of a microcontroller ATmega16 on an electronic plate

Detection, localisation and recognition of a rectangular object (bank card) are shown in Figure 13. The indicator which shows that the rectangle is detected and the additional indicator which shows that the rectangular object is a bank card both shine green. Centre of the mass of the detected bank card is in point (177.66, 197.76) mm of the coordinate system. Dimensions of the bank card measured with the help of the robot vision system are 83.84 mm \times 49.14 mm, and measured

orientation is 20.56°. Camera resolution in all measurements is 800 \times 600.

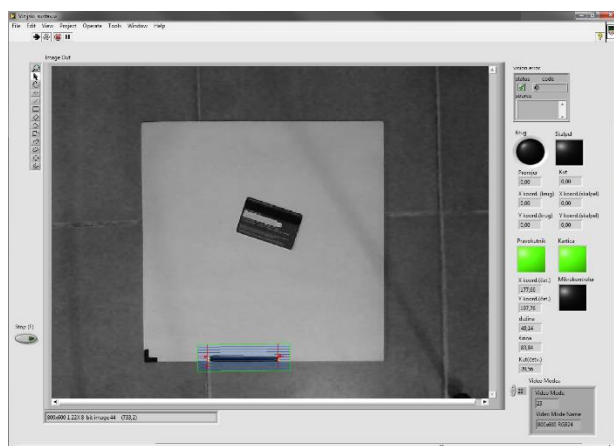


Figure 13. Detection, localisation and recognition of a rectangular object (bank card)

5. CONCLUSION

Vision systems are very complicated systems, but very efficient and requiring low maintenance once they are adjusted. Program development requires a lot of time to test all the options that LabVIEW offers. Every filter, every processing or detection option needs to be tested so that the results can be compared and the user can choose the best settings for objects that are to be detected. Illumination plays the most important role in the operating procedure of the vision system. Illumination has to be configured in a quality way so that the objects do not form shadows or reflection due to too strong light. When the light/illumination is well adjusted, vision system works perfectly and very precisely. Vision system for object detection, localisation and recognition is an ideal algorithm for robot upgrade. Such vision system enables the robot to “see” and turns it into a smart system. Robot makes decisions about its next move based on the image analysis in its operating area. An important advantage of the LabVIEW Program Tool is that it enables development of the graphical user interface which additionally simplifies program development.

Vision system test results show that the vision system is very precise. Higher precision in measuring object dimensions can be achieved by increasing the camera resolution and finding a better source of light.

6. LITERATURE

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