Object positioning in storages of robotized workcells using LabVIEW Vision

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Abstract. During the manufacturing process, each performed task is previously developed and adapted to the conditions and the possibilities of the manufacturing plant. The production process is supervised by a team of specialists because any downtime causes great loss of time and hence financial loss. Sensors used in industry for tracking and supervision various stages of a production process make it much easier to maintain it continuous. One of groups of sensors used in industrial applications are non-contact sensors. This group includes: light barriers, optical sensors, rangefinders, vision systems, and ultrasonic sensors. Through to the rapid development of electronics the vision systems were widespread as the most flexible type of non-contact sensors. These systems consist of cameras, devices for data acquisition, devices for data analysis and specialized software. Vision systems work well as sensors that control the production process itself as well as the sensors that control the product quality level. The LabVIEW program as well as the LabVIEW Vision and LabVIEW Builder represent the application that enables program the informatics system intended to process and product quality control. The paper presents elaborated application for positioning elements in a robotized workcell. Basing on geometric parameters of manipulated object or on the basis of previously developed graphical pattern it is possible to determine the position of particular manipulated elements. This application could work in an automatic mode and in real time cooperating with the robot control system. It allows making the workcell functioning more autonomous.

1. Introduction
The rapid development of electronics and the increasing demand for faster and faster processing the data on surrounding environment significantly accelerated the development of methods for image processing and analysis being a part of vision systems. These systems are already widely used in almost all fields of industry and science. These systems have also been used to create devices used in police and military applications. Modern manufacturing enterprises use different CAE application that are added with artificial intelligence methods [1, 2, 3]. These applications utilize vision systems beginning from delivering and tracking raw materials on production lines [4], through their orientation of robotized manufacturing work cells [5], ending in checking the quality of the products and the protection of the entire production process [6,7,8]. It helps to supervise the production system and scheduling it in real time [9, 10].
With the rapid development of microprocessors the computing power increases allowing for faster and more accurate (the use of more precise calculation method) processing and analyzing digital images. Also the cost of vision systems is getting smaller. In the paper is presented a tool for image acquiring, processing and analyzing of National Instruments. It is the Vision Builder environment.

The main parameters to be taken into account using vision systems are:

- Resolution,
- field of view,
- working distance,
- sensor size,
- depth of field,
- image,
- pixel,
- pixel resolution.

Depending on the resolution, it is possible to identify smaller or larger parts of the image (the higher resolution the more accurate measurements [11] and also increasing quantity of received image data to be processed). Field of view is the area seen by the camera. Working distance is the distance between the scene (investigated object) and the lens of the camera. Knowing the field of view, working distance and sensor size, it is possible to determine the focal length. Depth of field is the ability to obtain a sharp image of the analyzed object, and maintain its sharpness throughout the entire process of image analysis and processing. Reliability of vision systems also depends on two elements: light (stronger light does not always mean better image) and the inclination angle of the camera relative to the FOV. The ideal position of the camera is, when it is aligned perpendicular to the plane of the viewing area. Camera inclinations from the angle of 90 degrees could lead to errors associated with the change of perspective.

Lighting is one of the most important factors [12] of the vision systems. With well-matched lighting for carried out image analysis in the vision systems it is possible to obtain more precise results and the analysis itself could be faster. Bad lighting of a scene could lead to erroneous results as well as to measurement-control errors. Insufficient lighting of a scene could lead to blurring the images of a scene, while too strong lighting could introduce distortions associated with the reflection of light from the smooth, drooling elements.

2. Vision Builder application

The first step in programming using the Vision Builder tool from National Instruments is choosing the camera that is connected to the given computer (desktop one or real-time one). After obtaining the test image, checking the camera settings and scene lighting one should convert the image from the camera to a monochrome one (figure 1) to obtain a smaller amount of data to be processed (one pixel of a monochrome image is represented in the binary system as $2^8$, which gives 256 points in a grayscale; the color image in the RGB palette contains three color components and therefore the number of processes data is three times larger).

To obtain a monochromatic image one should use the tools Vision Assistant, in which is determined the area of a scene containing the analyzed object, or a full view of the camera. Using the function Extract Color Planes it is possible to get a monochrome image. To sharpen the image and to get details of the analyzed image, it is needed to adjust the contrast and saturation of a scene with light (figure 2). Using the Vision Assistant one should choose the function Brightness to make appropriate adjustments of contrast, brightness and color saturation which, in order to extract the elements being the object of the analysis.
To obtain better image quality, for further processing, in Vision Assistant should be utilized the tool Table Lookup. Depending on the characteristic of the element analyzed in the work scene one could use one of functions of this tool. In this case it is the function Reverse (figure 3).

After all the operations related to improvement of the displayed image needed for further processing, during the elements identifying process, one could close Vision Assistant [13, 14]. The next step, to search the work scene, is to determine matching elements in the form of templates (patterns). These patterns are obtained using the tool Geometric Matching in the Template Editor (figure 4). During a pattern modeling one should remember to mark the possible smallest area of a work scene, which contains the analyzed element, to obtain the possible fast processing of data by the program.

Figure 3. Sequent contrast improving and colors reversing.
With the functions: Edge Threshold, Edge Filter Size, Minimum Lenght, Row Search Step Size and Column Search Step Size it is possible to set the area which should be seen as a template. The function Draw Regions to Ignore allows omitting places, which deform the template image. After the template setting one should go to the next step, it means to the Template Editor – Specify Match Offset. The function Specify Match Offset allows determining the reference point of the template in relation to the camera view (figure 5). Having determined this function it is possible to find the desired element and determine its location in the working scene.

![Figure 4](image1.png)

**Figure 4.** Determining the template basing on the element recorded by the camera.

![Figure 5](image2.png)

**Figure 5.** Setting the reference point for the analyzed element.

After closing the Template Editor, it is possible go to the function Geometric Matching Setup, where it is possible to set the parameters characteristic for the analyzed task. In the tab Main, one could set the name of the process of the template searching and the Region of Interest, where this template should be localized. In the tab Template it is possible to improve the template, which was previously determined or store it again. In the tab Curve it is possible to set parameters considering the template detection process, i.e. Extraction Mode, Edge Filter Size, etc.

3. **Testing the application**
After setting all options one should repeat the operation as many times as is need to store all templates being localized in the analyzed work scene. Is presented an example of the application functioning
It was used to localize two different templates in the work scene. In figure 6 (upper image) is presented the process of locating the single elements matching to two stored templates. Each of the following elements has its own characteristics by which it is possible to determine the position and the element mapping level in relation to the template.

Figure 6. Elements localized in the work scene basing on the previously generated templates.

In figure 6 (lower image) is presented the localities process for the case of higher number of analyzed elements [16, 17]. With the function Scaling, using the base dimensions of template elements, it is possible to determine the distance from the camera to the element and the rotation angle in relation to the template.

4. Conclusions
Vision systems could not yet be used as the only tool for work cell supervision because of the difficulty of data acquiring and processing. Despite this inconvenience the vision systems should be treated as future tool for control systems of businesses projects. Realizing investigations considered with such automatic system one should solve both problems considered with work of particular system components and with data flow within the entire system.

Development of these systems is directed to business systems creation that could control all business production including planning operations or automatic data acquisition. Such integration seems to be the new challenge in this field of systems engineering.

Acknowledgements
The work is realized within the project titled: “Modular automated production stand with instrumentation for non-invasive confirmation of product quality” funded by The National Centre for Research and Development, agreement No UOD-DEM-1-495/001.
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