Technological process supervising using vision systems cooperating with the LabVIEW vision builder

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Abstract. One of the most important tasks in the production process is to supervise its proper functioning. Lack of required supervision over the production process can lead to incorrect manufacturing of the final element, through the production line downtime and hence to financial losses. The worst result is the damage of the equipment involved in the manufacturing process. Engineers supervise the production flow correctness use the great range of sensors supporting the supervising of a manufacturing element. Vision systems are one of sensors families. In recent years, thanks to the accelerated development of electronics as well as the easier access to electronic products and attractive prices, they become the cheap and universal type of sensors. These sensors detect practically all objects, regardless of their shape or even the state of matter. The only problem is considered with transparent or mirror objects, detected from the wrong angle. Integrating the vision system with the LabVIEW Vision and the LabVIEW Vision Builder it is possible to determine not only at what position is the given element but also to set its reorientation relative to any point in an analyzed space. The paper presents an example of automated inspection. The paper presents an example of automated inspection of the manufacturing process in a production workcell using the vision supervising system. The aim of the work is to elaborate the vision system that could integrate different applications and devices used in different production systems to control the manufacturing process.

1. Introduction

Modern companies increasingly use computer systems allowing integrate many areas of their business. In this regard, it is possible to distinguished, among others, advanced systems of the CAE class in which are realized complex projects of technical means [1,2]. It should also be mentioned the systems designated for specialized areas of technical applications [3,4] and even the inspection of material features of manufactured parts [5-7]. Another direction of development are mechatronic systems which combining both mechanical and electrical components together with controls systems, basing on electronics and computer techniques [8,9]. In the latter range more and more important become vision systems.

The vision systems are increasingly used in industry and automation due to lower and lower manufacturing costs of their components and lighting systems. With the rapid development of technology of light-sensitive matrices, used in vision systems, their price and the resolution are more and more satisfactory. By increasing the resolution of photosensitive matrices the accuracy of vision
systems is also increasing. The vision systems enable full control of the production process and the final quality control of manufactured products. Unfortunately, vision systems also have limits resulting from the need to integrate video systems with the real-time computers of high computational capabilities and hence also expensive ones. Another problem in machine vision systems is the lighting of a work scene. Wrongly determined could cause erroneous measurement results. One of the basic processes in which are used vision systems is the inspection of manufacturing operations realized in workcells. In the LabVIEW Vision Builder it is possible to realize the automatic inspection which allows initially preparing the program for controlling the entire production process.

2. Creating the application for object recognition

The work in vision systems required preparation of the environment in which these systems should realize the tasks. It is necessary to appropriately select the workplace exposure because it is one of the most important criteria for correct work of vision systems. The less lighted work scene the greater shadows fall on the elements. Hence it is harder to get an accurate picture of the analyzed object, as well as of the whole work scene. If, however, the lighting would be too intensive one could achieve reflections which can cause erroneous work of the system. The first step in the process of automated inspection is choosing and setting the camera parameters due to which one can get the image of a work scene (figure 1). It should be stated that the better is given camera the more data should be processed (what is considered having higher resolution). Whereas the weaker are the parameters of a camera, the more probable is situation of obtaining erroneous results.

![Figure 1. Work scene seen by the camera.](image1)

In order to improve the viewing area, after connecting the camera, some parameters such as brightness, contrast, exposure, etc. have to be set. The obtained image of the camera is in the RGB color palette and hence the amount of data is large enough that it could cause long work of the whole vision process. In the next step the color image in RGB color palette should be changed into monochromatic one in order to reduce the amount of processed data (figure 2). For this purpose, in the Vision Builder program, should be used the option Vision Assistance in the tool Enhance Images.

![Figure 2. Changing the image from RGB palette to monochromatic one.](image2)
The function Vision Assistance allows selecting the range of a camera view to be processed (Region of Interest) according two options:

- Constant – chosen area of the camera view is constant during the entire operation of the vision system
- Full Image – the work area during image processing is equal to the area of the camera view.

Selecting the option Region of Interest, it is possible to use the program Vision Assistance by editing the option in the function Image Processing Steps. In the tool Processing Functions: Color there is the option Extract Color Planes. To improve the monochrome image (Luminance Plane function), it is possible to change settings in the tool Processing Functions: Image (figure 3). In this function it is possible to set brightness, contrast and gamma in order to improve the image seen by the camera. Incorrect settings of these parameters may result in inaccurate measurements and object recognition.

![Figure 3. Image improving using Brightness function.](image1)

When the image is improved it is possible to realize the next step of automated inspection and namely to create the template of an object (figure 4). The template could be created using the option Match Pattern. This is an option that allows locating regions of an image and also defining the templates. The option Match Pattern let to omit problems with image noise, blur, and uniform lighting changes. It bases only on 2D intensity and edge information.

![Figure 4. Template determining in the program Vision Builder.](image2)

In the tool Select Region Template, it is possible to select the area in which is located the object being analyzed. After selecting the analyzed area, considered with the object, one should use the option Define Pattern Matching. In this option the image of an object is contoured using the tool Draw Template Regions. The area, which is indicated with the red color will not be considered as a part of the template. After obtaining the area consistent with the desired pattern it is possible to continue the process of the application creation. At this stage one could set the other specific parameters for the template. It is also possible to modify the parameters set previously. Among setting parameters one could distinguish:
• Number of Matches to Find which determines the number of items we want to see in the picture,
• Minimum Score which allows specifying the minimal compliance of an element in the image, relative to the standard: from 0 - no mapping (no match) till 1000 - exact matching to the template (perfect match).
• Search Level Specifies how thoroughly the step searches for matches.
• Search for Rotated Patterns which allows searching the work area for rotated and reflected images of the original template.

3. Utilization of the created application
Vision systems could be used in a wide range of technical applications. They replace, inter alia, applications basing on sensors measuring different indirect signals [10,11]. Vision systems consist of a camera, lens, and computer processing data in real time as well as equipment illuminating the work scene. Because of realized tasks, and related with them needs, the vision systems could be divided into the following types:
• vision sensor (soft sensor) - integrated unit, having in one housing both the camera, the computational processor as well as the system illuminating the workspace. Due to the low resolution (up to 640 - 680 pixels) this type of sensor is used in less complex tasks (reading bar code, simple measurements, etc.),
• intelligent camera - camera with high image parameters (up to 1200 to 1600 pixels), integrated with a computer and software allowing to perform difficult tasks. It is the most commonly used type of video systems in the industry,
• camera with the PC-class computer - the most optimal type of vision systems allowing for quick modification of the entire system (including cameras changing), depending on the needs of the production supervision process as well as for rapid task modification by changing the software of the real-time computer.

For practical use of the presented applications one must specify the scope of its work. To accomplish this it is needed, in the tab Limits, set the minimal and maximal number of templates to be found that are used in the process of automatic inspection (figure 5). Using this method we could analyze and visualize the process of automatic inspection [12,13].

![Figure 5. Identification of images consistent with templates.](image)

As seen in figure 6, regardless of the number of stored templates and depending on the settings of correctness of lighting exposure and processing of the received image, the application allows correctly recognizing many static and moving elements that are in the workspace of the camera. It is determined by the parameters of a compliance with the template, image position and finally with the rotation, relative to the original template.

In figure 7 is seen the code in the LabVIEW program that has been obtained by exporting data from program LabVIEW Vision Builder, where was prepared the application. To obtain the code in the LabVIEW program one must use tools form program migration to the LabVIEW graphical user interface. The graphical interface allows to analyzing all relations defined in the program and easy...
modifying particular functions and procedures. The developed application is used to test functioning of a robotized manufacturing workcell.

Figure 6. Searching elements that are consistent with stored template.

Figure 7. Migrating the program code from Vision Builder to the LabVIEW program.

The purpose of these researches is to develop automated procedures for controlling the robot working in a workcell by equipping it with an external vision system. It is also planned to connect the vision system with other sensors systems [14,15]. To realize the automatic control of a production process the vision control system should be integrated with other system what provides correct data acquisition [16,17]. The most appropriate are proximity sensors and ultrasonic ones. However, with the increase in the accuracy of the technology they are one of the most important branches of non-contact sensors used in automation. They should allow creating independent production planning system [18] that could operate in automatic cycles. It is also possible to use them in independent, autonomous production systems utilizing artificial intelligence [19-21].

4. Conclusions
In the article is presented the integrative approach to the problem of vision systems creating basing on the LabVIEW program. The use of this software facilitates the production monitoring process. Information on the amount of semi-finished products and their positions allow improving the supervising process. It should be, however, taken into account the quality of lighting of a work scene as the factor influencing the monitoring process. Unfortunately, current technology of vision systems could not be fully independent to control industrial processes because of the possibility of erroneous results. Because of this they are utilized with other types of sensors like lidars or sonars.

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