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Jakób CICHOŃ, Mariusz Piotr HETMAŃCZYK*

Institute of Engineering Processes Automation and Integrated Manufacturing Systems,
Silesian University of Technology, Faculty of Mechanical Engineering, Gliwice, Poland
*mariusz.hetmanczyk@polsl.pl

THE VISION SYSTEM DEDICATED TO THE DIAGNOSIS OF TECHNICAL OBJECTS USING THE OpenCV LIBRARY

Abstract: This paper presents the authorship vision system that allows for the diagnostics and classification of flat geometrical objects. The authors described the developed structure and key design steps. A particular attention was paid to: functional dependencies contained inside described vision system, a capture process of images (from an environment), images processing and their analysis, structures and selection of functions contained in the OpenCV library. In an extended way the authors have described the program structure used with built laboratory stand, the principle of operation of subprograms (myCalib, myAnalizator, BrokerGI) and analysis of their applicability.

1. Introduction

The sense of sight is a basic element used to perceive external stimuli. It is a very complex tool providing a wealth of information (to the brain), which are then processed in order to draw the necessary conclusions. In case of technical implementations the human sight is replaced by the vision system. Such applications allow assessing the quality of items as well as their compliance with agreed objectives and quality control requirements (especially at early stages of production, especially in case of a rejection of defective products assembled in groups).

The vision system is defined as a set of cooperating devices whose function is automatic analysis of images, similarly like the human sense of sight [1]. Described systems always consist of information capture devices (digital or analog cameras, scanners etc.), devices for acquisition and processing of data, as well as entities engaged in the analysis of the obtained information (processors or PCs equipped with specialized software) [2,3].

Industrial vision systems are usually used to the validation of elements performance, i.e. shapes, dimensions, tolerances, colours or visible failures (e.g. surface defects, mounting positions).

Moreover, these systems are increasingly used as a tool to support the work of industrial robots. Such cooperation is used in case of necessity a trajectory assessment (in the real time) or in determining the best path for the transition (collision elimination).

2. Key elements of the designed vision system

The structure of the developed system consists of a High Quality camera, a host computer and the dedicated software. Figure 1 shows a graph of elements and operations of industrial vision systems in relation to the described case.

The main tasks of the developed vision system include:

- an identification of the object (in this case flat plates),
- determination of a quality (on the basis of established requirements - most often inspection of geometrical shapes),
- identification of a type of geometrical errors (irregularities of shapes, size deviations, discontinuity of structure),
- cooperation with other control and monitoring equipment (ability to setting of appropriate states of analog outputs, depending on the type of registered errors).

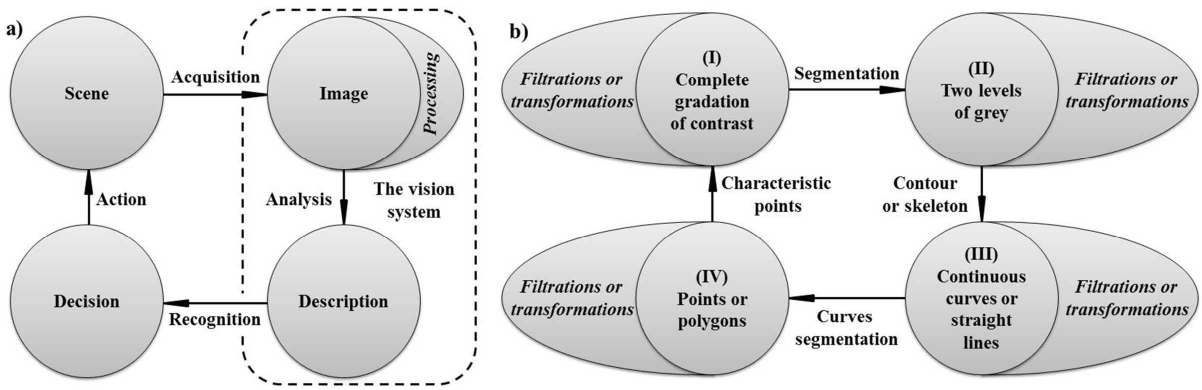

Fig.1. Graphs of: a) activities and relationships related to industrial vision systems, b) functions used in phase of transformations between different classes of images

The principle of operation of the considered system is based on a webcam connected to the computer via a USB port. The dedicated program analyses an image (camera send the information about the resolution of captured images) and then retrieves captured image.

The next step is connected with image filtration, an analysis (in terms of isolation of necessary features) and their appropriate interpretation. After analysis, information connected with results is dispatched to the BrokerGI module (Fig. 2).

The basic tasks of the BrokerGI module are, among other things:

- a visualization of results of the analysis,
- an execution of actions (taken based on detected type of errors) in consequence of forcing of analog outputs.

The program that analyses the image (myAnalizator) has been written in the C language, using the features of the OpenCV library [4,5]. The structure of the code has been split into two independent files. The first one (named myAnalizator) contains main features of the program while the second definitions of functions used in the analysis. In addition the authors have elaborated a program, used to a calibration of the camera image. The calibration is a necessary step that leading to a correct evaluation of a size of the analysed object.

A communication between described subprograms is done by readout of relevant information from text files. Elements specified on the Figure 2 (myAnaliz_data, myBrokerGI_data, myCalib_data) are text files used for reading or writing information.

The myCalib module is used to determine the calibration coefficients. These factors determine the number of pixels per one millimetre. Described module does not require a graphical interface, and performed actions are linked with instructions available from the Windows console.

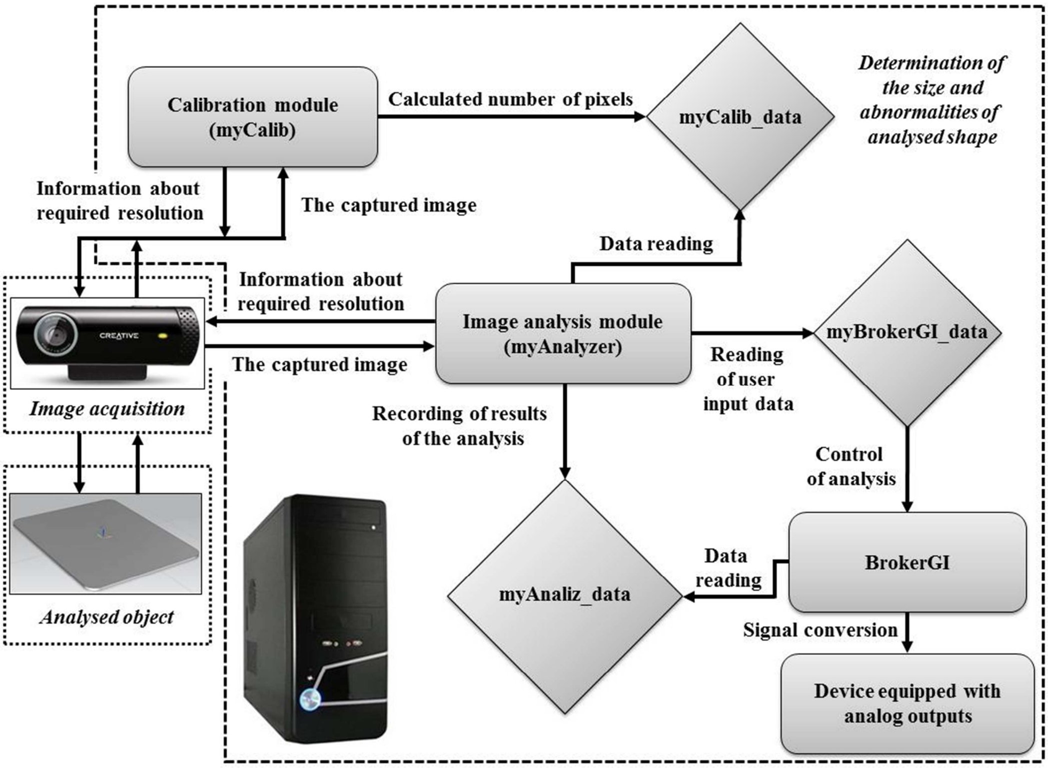

Fig.2. The structure of the flow of information in the considered vision system

Table 1 includes the specification of used OpenCV libraries. Output services are realized on the basis of a microcontroller (forcing of outputs) connected with a PC computer (database of errors and switching rules) via the USB port.

Data exchange is realized as follows: a graphics program (after downloading information to the window) retrieves information about the analog outputs (user defined outputs), and then sends the data to the frame with defined structure (Fig. 3).

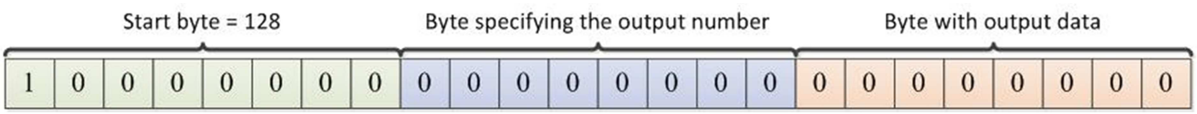

Fig.3. View of the data frame transmitted to a device with analog outputs

Tab. 1. Matching of necessary OpenCV libraries used in presented project

Necessary libraries
opencv_calib3d241d.lib, opencv_contrib241d.lib, opencv_core241d.lib, opencv_features2d241d.lib, opencv_flann241d.lib, opencv_gpu241d.lib, opencv_haartraining_engined.lib,opencv_highgui241d.lib, opencv_imgproc241d.lib, opencv_legacy241d.lib, opencv_ml241d.lib, opencv_nonfree241d.lib, opencv_objdetect241d.lib, opencv_photo241d.lib, opencv_stitching241d.lib, opencv_ts241d.lib, opencv_video241d.lib, opencv_videostab241d.lib.

The first eight bits define the start byte (stored value is always equal to the 128). The next eight bits contain definition of forced outputs. The last eight bits specify the data to be written, that is values of the voltage or current intensities which appear at the outputs.

The overall principle of operation of described approach is shown in Figure 4. The data entered by the user (to the BrokerGI module) are dispatched through the USB connection to the FT232RL converter. Then converter transmits data to the microcontroller ATMEGA644p, that interprets and transmits commands to the individual DACs (via Serial Digital Interface SDI).

The FT232RL chip is responsible for conversion of the digital signals (from the USB port to the UART interface). The FT232RL unit is widely used as an intermediate interface between a PC and AVR microcontrollers. The available drivers make possible an identification of the FT232RL chip as a RS232 port. Used AVR microcontroller belongs to a group of 8-bit devices manufactured by the Atmel Company, characterized by execution of an arithmetic calculation based on the RISC scheme. The microcontroller program is written in the C language. A clock signal is generated by a hardware counter that works in CTC mode. Chosen mode of counter generates a clock frequency within the limits equals 30kHz. Maximum operating frequency is 20 MHz but the signal must be supplied by an external crystal oscillator or the PLL (fed to the XTAL1 or XTAL2).

In the same frequency interval is generated an interruption inside the transmission process performed for each data bit. The microcontroller (ATMEGA644p) is equipped with 64K Bytes Flash Memory, 2K Bytes non-volatile EEPROM memory and 4K bytes SRAM memory.

AVR microcontrollers are equipped with numerous groups of peripheral functions. Such advantage makes possible usage of described systems in complicated applications (with relative small number of calculations) as simple control units, safety modules in automatic processes, etc.

Assumptions connected with utilization of analog outputs are as follows:

- connecting with a PC via USB ports,
- two analog outputs with voltage-levels 0÷10 [V],
- two analog outputs with current intensity-levels 4÷20 [mA],
- possibility to disable of unused outputs.

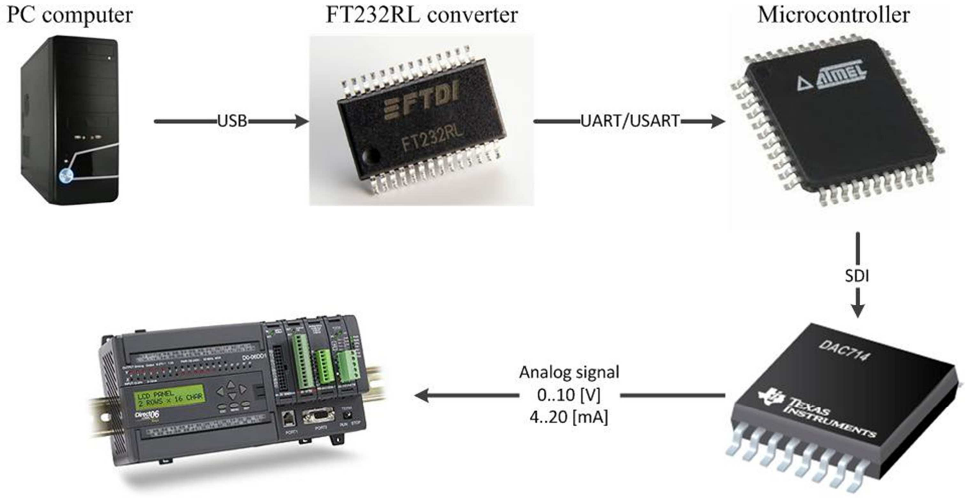

Fig.4. Schematic principle of operation of a device with analog outputs

Figure 5b shows the top layer of the device, which includes: feeding ports of current and voltage outputs, ISP connection (microcontroller programming), the Reset button, keepers (No 1 - microcontroller power supply via the USB port, No 2 - microcontroller power supply via the power connection terminal), supply terminal (DC, 15÷35 [V]), USB port (communication with the computer).

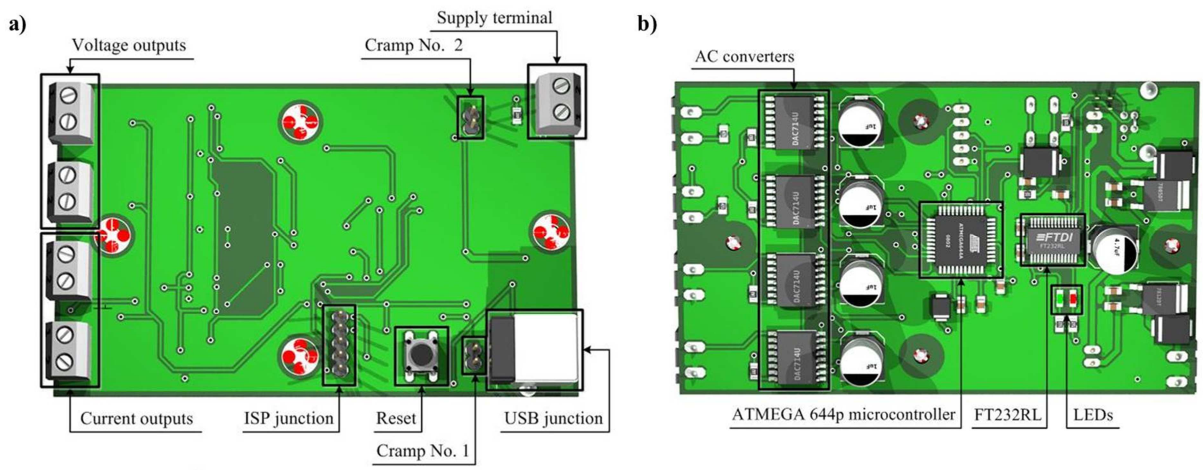

Fig. 5. View of the printed-circuit board: a) the bottom side, b) the top side

The presented concept enables an implementation of additional features that enhance the functionality (possibility of cooperation with the Programmable Logic Controller or programmable relays). The presented system, in the current phase of functionality is the basis for the further development of more advanced applications (expansion of the program, a wireless data exchange, increasing the number of Inputs/Outputs).

3. Conclusions

Vision systems are a rapidly growing field of the industrial automation. This is due to the wide range of possibilities offered with theirs use in processes [7,8].

The use of cameras, along with the appropriate software, can greatly increase the use of industrial robots, and thus lead to the automation of processes belonged to the autonomous group (previously not achievable for industrial automation tasks).

The advantage of presented solutions, in the process of analysing the correctness of the items, is high speed of data processing. Within the assumption they must be provided with adequate lighting devices. Discussed vision system can be used directly in several places of the production line, without interfering with the production process. This advantage significantly reduces the number of defects in parts and facilitates location of erroneously made products.

Analysis of objects using cameras is widely developed area of industrial diagnostics. The leading trend is increasing of the control ability of information processing with usage of real time computers and advanced software tools [6,7,8].

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