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DIAGNOSIS OF SHAPES AND DIMENSION ERRORS OF SIMPLE GEOMETRIC ELEMENTS USING A VISION SYSTEM

Abstract: The paper presents the possibilities of using of the vision system which allows recognition of contours and shape deviations in case of simple geometric elements [1,2]. An evaluation and tests were realized on the basis of flat plates and the calibration standard. Authors also discussed the impact of lighting on the registration results, the current state of development, the description of an interface and example of the analysis on the basis of selected object. Described tests belonged to a group of tasks classified as easy (two-dimensional objects), but on the basis of obtained results exist a possibility of further continuation of work aimed at the development of presented concept. Adopted restrictions (concerning the testing phase and elements subjected to verification) have been limited due to equipment used in the laboratory stand.

1. Introduction

Considering that nowadays in the production the most important are a quality and the lowest cost of production (and thus reducing the amount of waste), the possibility of errors committing in the quality control realized by human becomes unacceptable. Therefore increasingly important, from the point of view of quality control, has become the use of vision systems.

Due to the type of equipment used for measurement, vision systems can be divided into few main elements [1]:

- o vision sensors - compound of cameras, processors and illuminators integrated into a single housing; such systems are characterized by a low resolution (most often 640x480 pixels) and low speed CPU units; as a result of enumerated features they are used rather to easy tasks (with assumption of elimination of a detailed analysis of the image),
- o smart cameras - cameras and computers integrated into a single housing, thanks to the high resolution (most often 1600x1200 pixels) and high performance computing such devices have been widely used in many tasks specially in detailed analysis of production processes,
- o cameras and computer systems - systems with multiple cameras connected with PC computers.

2. The course of vision inspection process

As object of analysis was chosen a set of flat plates (size and geometric form are shown in the Figure 1). The step preceding the inspection of object is calibration. Before starting the calibration it is required established a connection (between the vision device and a computer) and location of a calibration model within the range of the camera. The calibration model was adopted in the form of a rectangular object (Figure 1b).

Image analysis program performs actions in the case when identified object shapes are similar to the element presented in Figure 1a. At the testing phase are measured the radius of fillets and mutual parallel and perpendicular sides of the plate.
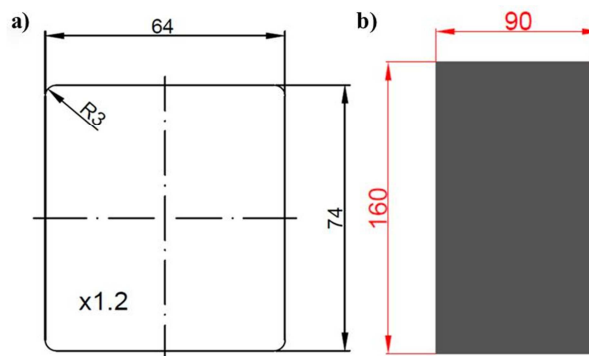

Fig.1. Views of: a) the object subjected to analysis, b) the contour master (calibration model)

Contours in OpenCV are defined as a list of points representing the edges of the image [1]. From several ways of contours representation the authors chose description in the form of the set of sequences (with usage of OpenCV library). After the contours detection is used the function that approximately defines the real shapes.

Comparison of shapes (in range of the contour master and tested element), using the OpenCV library commands, takes place by evaluation of their moments. Moments can be defined as the overall characteristics of the contours acquired by summing all of the pixels inside analysed shape.

Thus two-dimensional moment (p, g) can be defined as:

$$m_{p,q} = \sum_{i=1}^{n} I(x, y) * x^p * y^q \qquad (1)$$

where:

    p, q – respectively the x-order, the y-order

    I(x,y) – matching methods used by cvMatchShapes() [d].

After an initiation of the calibration process, the control program activates two windows. The first (called Video_Original, Fig. 2a) displays the original image from the camera, and the window (called Video_Processed, Figure 2b) shows the picture of the camera processed on an appropriate level of filtration.
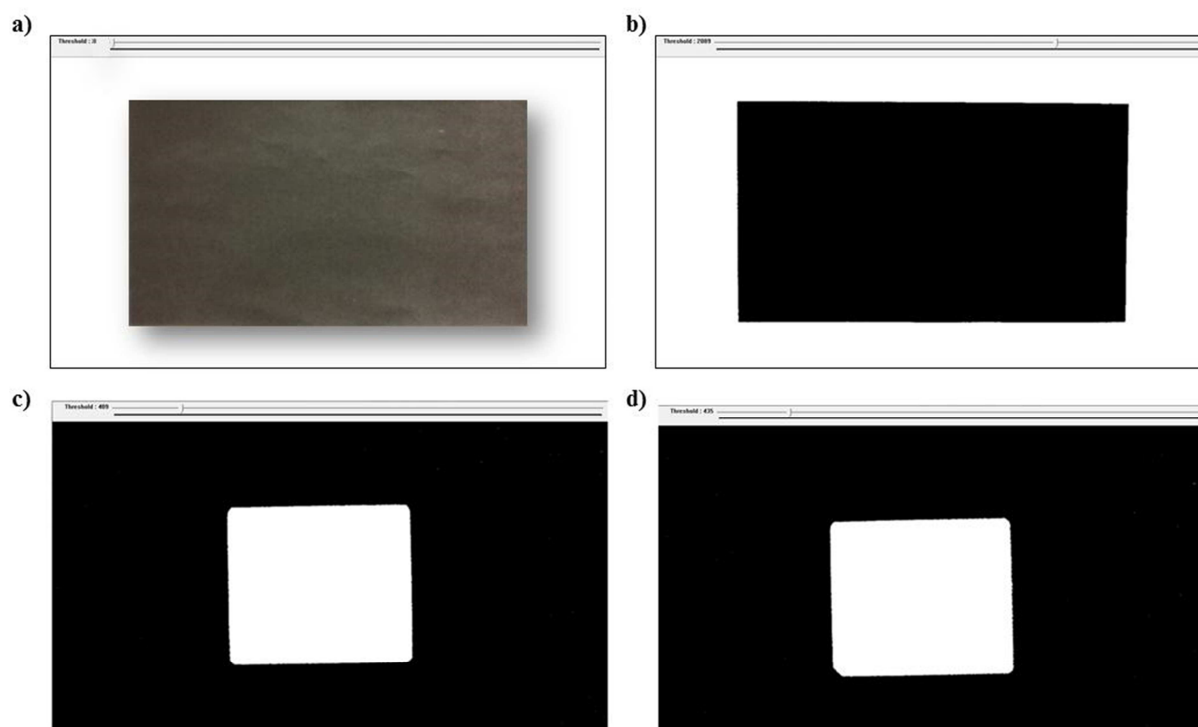
Fig.2. Views of: a) the original image capture from camera, b) the image after filtration, c) the object identified by the camera (without significant irregularities), d) the object identified by the camera (visible shape errors, irregularities in shape of corner)

Parameters that specify the method of comparing contours can take values [1,2]:

- CV_CONTOURS_MATCH_I1:

$$I_1(A,B) = \sum_{i=1}^{7} \left| \frac{1}{m_1^A} - \frac{1}{m_1^B} \right| \tag{2}$$

- CV_CONTOURS_MATCH_I2:

$$I_2(A,B) = \sum_{i=1}^{7} \left| m_1^A - m_1^B \right| \tag{3}$$

- CV_CONTOURS_MATCH_I3:

$$I_3(A,B) = \sum_{i=1}^{7} \max_{1...7} \left| \frac{m_1^A - m_1^B}{\left| m_1^A \right|} \right| \tag{4}$$

Parameters content in equations 2÷4 take values:

$$m_1^A = \text{sign}(h_i^A)\log\left|h_i^A\right| \tag{5}$$

$$m_1^B = \text{sign}(h_i^B)\text{og}\left|h_i^B\right| \tag{6}$$

where:

$$h_i^A, \quad h_i^B \text{ - respectively Hu moments of A and B.}$$

The analysis of identified image is realized by the BrokerGI subprogram (dedicated set of functional codes developed by the authors). The BrokerGI module was written in C++. Graphical arrangement of the window servicing the BrokerGI module is shown in Figure 3.

Image processing functions are performed in an OpenCV library. Described library contains many software modules divided in accordance with areas of their applications. This solution makes that application uses only selected modules, which greatly reduces the size and improves performance. In the context of this solution the authors used the functions contained in the libraries: Core, Imgproc and HighGui.

In the process of contours detection were used sequences that can be defined as the combined list of structures. In addition, it was necessary to use functions related to image capturing, displaying of graphical objects and filtration.

Error checking is performed using the graphical user interface made in the form of windows. Functions of the window being arranged in several groups, each of which contains elements related to the concrete type of operation (Fig. 3):

- **the field of remarks** – used to communication with the user program (displaying errors or messages that are related to user activities),

- **settings of resolution** – allows for selection of the resolution of the captured image (drop down menu), and then saving the settings to a file (myBrokerGI_data.txt); the resolution should be selected before starting the analysis, otherwise the settings will be applied after restarting the analysis,

- **field related to the analysis** - using pushbuttons it is possible to control the myAnalizator subprogram, the Status button provides information to the user about the current state of the analysis,

- **the field associated with the detected error –** contains information about the type of the detected error in case of analysed object,

- **field related with analog outputs** - contains the drop down menu allowing setting of the communication speed, the number of the COM port to which the device is attached and current status indicator (not connected/connected),

- **voltage outputs** – service of voltage outputs, field named Value allows to selection of the voltage value which is to appear on the corresponding output upon detection of the desired type of error (numerical range $0 \div 10$),

- **current outputs** - service of current outputs, field named Value allows to selection of the current intensity value which is to appear on the corresponding output upon detection of the desired type of error (numerical range 4÷20).

Fig.3. View of the main window: a) measurement with no noticeable deviations in shape, b) indications of exemplary errors in case of outputs maintenance, c) indications of exemplary errors in case of image analysis

Image analysis using a vision system and tests (carried out on parts with similar geometrical shapes), led to a few conclusions relevant to the accuracy of contours recognition and disorders connected with described process:

- important role in the analysis of the use of digital cameras plays adequate lighting (factor that determines the correctness of the results),

- it is very important (in phases of a calibration and an analysis) to ensure identical lighting conditions, otherwise it is highly probable to obtain spurious results (in the form of reflections, abnormal light intensity or colour resulting in a bad representation of geometric form),
- also very important are the quality of the controlled area and the contrast achieved between the element forming the base (plate measuring) and tested element.

Some of the described disadvantages can be removed by filtration process allowing reduction of the impact of interference in the phase of image analysis. In presented case, were used thresholding and anti-aliasing functions.

Identification of errors contains a number of items related to the study of geometry of the analyzed object, but not the corresponding functions developed for the quantitative determination of parameters that identified deviations in shape.

3. Conclusions

The article presents the issues related to the identification of geometric errors of simple elements. The tests show the usefulness of the developed concept and directions for further development. Applied camera gives satisfactory effect; however, in industrial conditions it is necessary to use the appropriate lighting of the recorder.

Elaborated structure of control code processing can be implemented in more complicated applications after the development of the errors database (the specific geometric distortion of tested structures).

The present example is one of several approaches dedicated for detection of faulty components. The problem of the usage of quality control methods is widely developed issue in industry, but in the next few years, the introduction of automatic error detection will become a necessity [3,4,5].

References

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