VISION SYSTEM FOR PRODUCT QUALITY CONTROL

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Abstract. The article presents an algorithm of comparison of shots of a current video to a given template. The identity is represented by the coefficient of correlation. The practical realization of the given algorithm was performed in the Simulink package of the program Matlab. This algorithm can be used to perform tasks such as checking the availability of the necessary components, reading the text and barcodes, size measurement, alignment check, as well as detection of defects.

Keywords: vision system, correlation, algorithm.

Introduction

Today systems of technical vision are demanded in different areas of sciences, industry, and technology. They are mainly used for detecting objects of different shapes and sizes, control of the state of objects, and reception of data about their location.

In the production process, one of the main factors is control of quality of produced goods. Modern automated enterprises use the system of technical vision to control the quality of the production. The system of technical vision has high speed, affordability, low cost and is contactless. The high resolution cameras provide a detailed image of products. But the quality analysis of these images, identification of the contained objects, as well as the control of the quality of products need a special a algorithm of comparison to a template, able to produce the operations mentioned above. Thus, the algorithm of comparison is one of the major components in the system of technical vision for quality control.

Statement of the problem and the object of study

The object of research is the algorithm of comparison of shots of a current video to a given template. The measure of identity is the correlation. The correlation is the interconnection of two random variables. The mathematical measure of correlation of two occasional variables is the correlation ratio, or the coefficient of correlation. The practical realization of the given algorithm was performed in the Simulink package of the Matlab program.

Matlab is a well-known environment for numerical calculations, widely used in the scientific community. It works both with Windows and Mac systems. The language of Matlab is optimized to work with matrixes and multi-dimensional arrays. In addition to that, there are many extensions (Toolboxes) to solve the problems of optimization, statistical calculation, processing of images and signals and so on (Perelmuter 2012).

Simulink package is an interactive environment for modeling and analysis of a wide range of dynamical system and devices, represented by the functional block diagram, named S-model. The block diagram of comparing to a template is presented in Fig. 1.

In order to build the functional block diagram of modeled devices, Simulink has a wide library of block components and an editor of block schemes. It is based on a user's graphical interface and is a typical means of visual and orientation programming. There exists a possibility of parameters setting for virtually all blocks. The parameters of settings are located on the margins of the settings window of a chosen block. The Help button in the settings opens detailed information about the block and the parameters of its settings.

The conversion of information in systems of technical vision is usually represented as a sequence of five basic steps (Dyakonov 2005):

1. Perception that is producing a visual image with a video camera;
2. Image pre-processing which involves the use of methods of noise reduction and image enhancement;
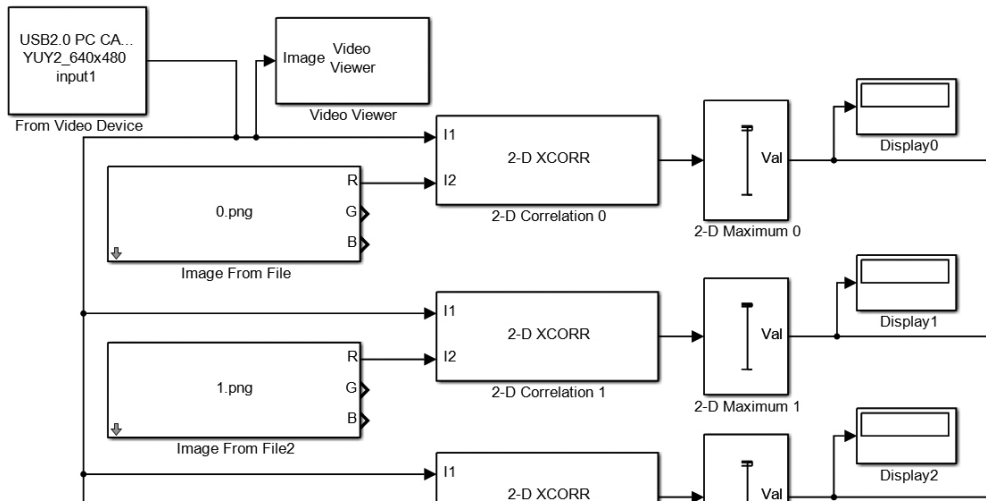
Fig. 1. Block diagram, part 1

3. Allocating an image of one or more objects of interest;

4. Determining the object characteristic parameters: size, shape, etc.;

5. Identification.

In the beginning we need to set up a connection between the video camera and the program. The video camera is connected to a computer through a USB 2.0 port. Next we are using block «From Video Device» to capture the video current from the camera in real time. The resolution of the video current from the camera is set in the settings of this block. The settings of the parameters of this block can be seen in Fig. 2.

These parameters are:

1. Choice of the device of video capture;

2. Video format;

3. Resolution;

4. Type of output data;

5. Block sample time.

The block «Image from file» is used for introducing a particular template to the given model. In our case there are 10 templates, consequesntly, there is the same number of blocks. Every shot of the video current will be compared to a template. The major parameter of the block is the way to the graphic file of the format .png, as well as port of output one of three colors. The settings of this block can be seen in Fig. 3.

The block «2-D Correlation» measures the coefficient of correlation between the template image and the current shot of video current. Correlation is the biggest in case of coincidence between the shot and the template, or if they are closes enough. Correlation is a method for establishing the degree of probability that a linear relationship exists between two measured quantities (Dyakonov 2005). For digital images, the coefficient of correlation is defined as:

$$r = \frac{\sum_i (x_i - x_m)(y_i - y_m)}{\sqrt{\sum_i (x_i - x_m)^2}\sqrt{\sum_i (y_i - y_m)^2}} \, ,$$

here: x_i and y_i are intensity values of ith pixel in 1st and 2nd image respectively. Also, x_m and y_m are mean intensity values of 1st and 2nd image respectively. Consequently,
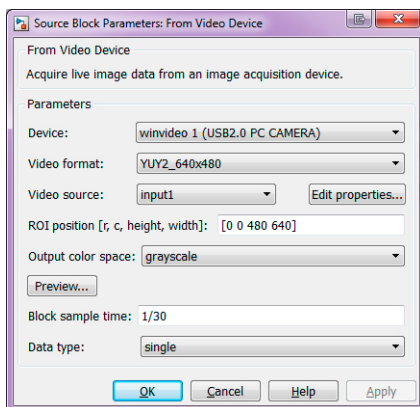

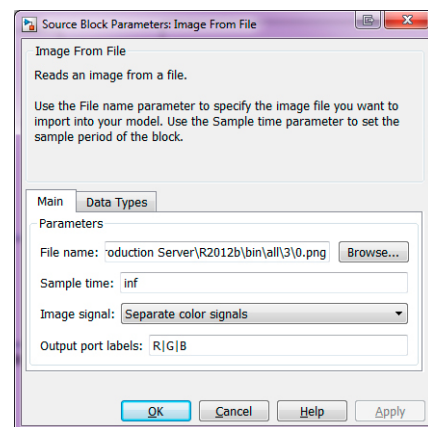Fig. 2. Block «From Video Device»
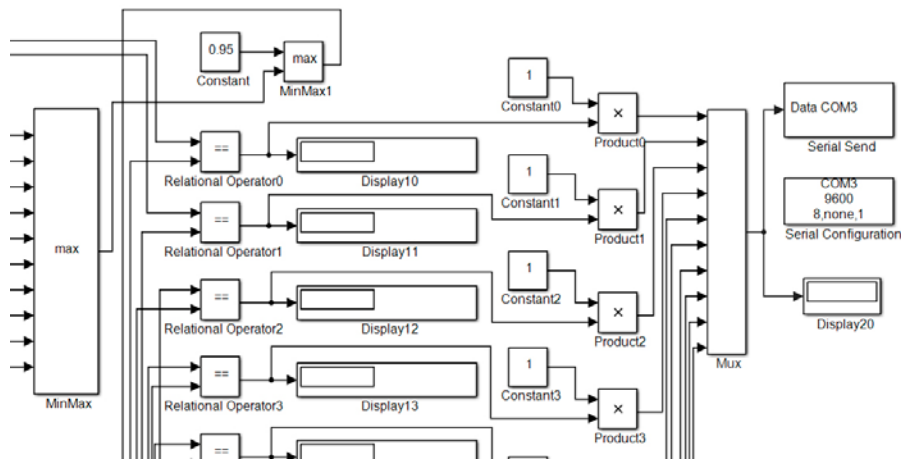

Fig. 3. Block «Image From File»

Fig. 4. Block diagram, part 2

the bigger is the resolution of the video current and the template, the longer is the calculation of the correlation coefficient. The correlation coefficient has the value $r = 1$ if the two images are absolutely identical, $r = 0$ if they are completely uncorrelated.

The block «2-D Maximum» is used for selecting the maximal measure that is transformed to the single type – the same type as one for the data of the video current. These blocks can be seen in Fig. 1.

To view the video current and to see other graphical files of templates the «Video Viewer» block is used. It enables to see double, RGB and intensity images.

After the «2-D Maximum» block there is a dynamically changing coefficient of correlation, which tends to 1, if the shots of a video current are very close to the image of a template.

We have 10 images of templates; correspondingly, we have 10 dynamically changing coefficients of correlation. We must choose the maximal one, the one that is closest to 1. To do that, we use the «MinMax» block that gives only one maximal value in the output. This block can be seen in Fig. 4.

After that we need to define the maximal value of coefficient of correlation, when one of the templates is compared to the video current. We need it for the system to recognize the signal, in which the shots from the video current could be similar to our templates. Introduce a constant equal to 0.95, called a «Constant» block. If the signal after the «MinMax» block is less than this value, correspondingly, the system will not consider that we are comparing the image simialr to the current.

After sorting and transforming the output variable we need to connect the Simulink package to the Arduino microcontroller using the COM-port.
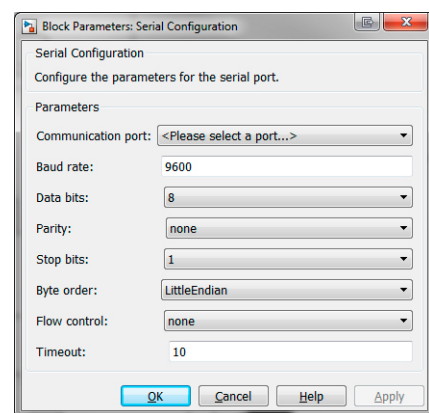

Fig. 5. Block «Serial Configuration»

For the settings of the COM-port we need the «Serial Configuration» block. There the speed of data transformation is given, and the choice of a port is provided. We need «Serial Send» block for the transmittion to the COM-port. We also need to set the dimension of the matrice that will be transmitted to the port, in our case it is [10 1]. The setting of these parameters can be seen in Fig. 5.

In the output we have an array with dimension [10 1], the value of which will be "0" only in case when there is no image similar to the template, or nine "0" and one "1" in case when one of the 10 matches the template (White 2015).

After that the array is transformed to the COM-port and Arduino microcontroller, having processed the signal, forms a command that lights up a particular diode (Monk 2011).

Conclusions

This algorithm can be used to perform tasks such as checking the availability of the necessary components, reading the text and barcodes, size measurement, alignment check, as well as detection of defects.
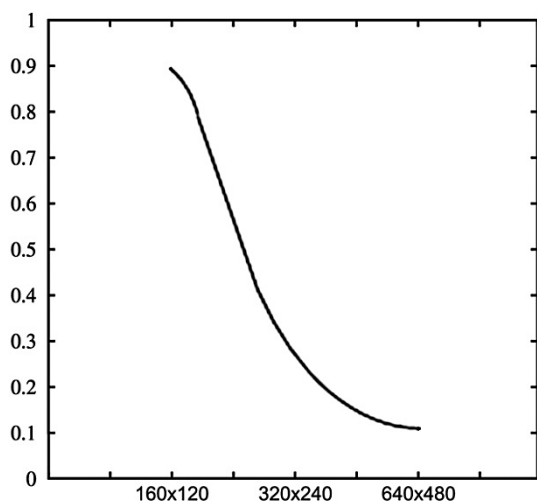
Fig. 6. Graph of *P*(*A*) versus resolution of the video

Matlab compared with traditional programming languages (C / C ++, Java, Pascal, Fortran) allows an order to reduce the time for solving typical tasks and greatly simplifies the development of new algorithms. Matlab provides low calculation times. The calculation time at a given resolution of the video current is 0.1 seconds. The time of calculation varies depending on the resolution of video current through, as well as the number of uploaded templates and the entered correlation coefficient in the «Constant» block.

The given algorithm of comparison to a template, based on the correlation method, is probabilistic. We use the probability theory to determine the misidentification depending on the resolution of the video current and the template. We mark the event A = {misidentification}. We plot the graph of *P*(*A*) versus resolution of the current video, where *P*(*A*) is a probability of misidentification. The given graph can be seen in Fig. 6.

According to the data and the graph, we get a normal distribution on the interval of resolution of the video current from 160×120 to 640×480.

The advantages of the given algorithm:

1. The speed of comparison of the current video to a template.

2. The possibility of setting a particular coefficient of similarity of a template and production.
3. Creation of a big base of templates, i.e. the storage of a big number of templates of production in order to compare to the current video.
4. The device of video capture is connected directly to a computer through USB-port.
5. Compliance of the scale of production with the scale of a template.

Disadvantages of the given algorithm:

1. A sufficient illumination is needed.
2. At the moment of comparison the images should be stationary.

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VAIZDO SISTEMA, SKIRTA PRODUKTO KOKYBEI KONTROLIUOTI

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Santrauka

Pristatomas vaizdo kadrų palyginimo su nustatytu pavyzdžiu algoritmas, skirtas produkto kokybės kontrolės sistemai. Vaizdo atitiktis įvertinama koreliacijos koeficientu. Algoritmas realizuotas *Matlab* terpėje *Simulink* paketu, gali būti taikomas nustatytiems komponentams aptikti, tekstui ir brūkšniniams kodams skaityti, dydžiui matuoti, lygiavimo patikrai atlikti, defektams aptikti ir kt.

Reikšminiai žodžiai: vaizdo sistema, koreliacija, algoritmas.