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Video component of a computer system to supervise of charge position by induction heating

Abstract. *The article presents the project and ways to implement video component of a computer system designed to supervise position of induction heating charges.*

Streszczenie*. W artykule przedstawiony został projekt oraz metody implementacji komponentu wizyjnego systemu komputerowego przeznaczonego do nadzoru pracy stanowiska do nagrzewania indukcyjnego (**Komponent wizyjny system komputerowego do nadzorowania pracy stanowiska nagrzewania indukcyjnego**).*

Keywords: induction heating, video inspection.
Słowa kluczowe: nagrzewanie indukcyjne, inspekcja wizyjna.

Introduction

Production positions are today very often associated with computer systems performing management, control, protection or monitoring functions. The study considered now being built at the Institute of Applied Informatics Technical University of Lodz, as part of the Applied Research Program of the National Research and Development Centre, the computer system supervising the work stations for induction heating, shown schematically in figure 1.

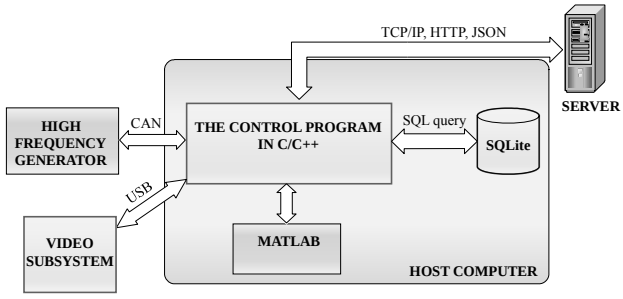

Fig.1. The computer system supervising the work stations for induction heating

The article discusses a fragment of a computerized system for supervising the operation of the system to video control of the batch loading process. From the hardware system is based on visible light camera monitoring the inductor area. These cameras can be used to control the relative position of the inductor and the batch, or to control the loading of the batch, but can also be used for other control purposes, for example inductor type or batch size. It was assumed that the work will concern the study of the static states. Cases of controlling the relative position of the inductor and the batch being in motion will not be considered. Control of loading process has to deal with cases where there is a break in the batch movement. It may refer both cases to the loading of so-called periodic heating, and the step heating in movement. Obtaining the assumed relative positions of the inductor and the batch results in a supervisory signal authorizing the execution of the heating process.

The article focuses mainly on the software part of the system, presented details of the project and the implementation of a video component in the computer system monitoring a position of induction heating. Use of developed component is not an element necessary to conduct the surveillance system over the work bench, but used can significantly improve the quality and safety of its operation.

If the station is equipped with at least one camera supported by DirectShow interface from DirectX package, developed video component allows you to check the correct selection, loading and positioning of batch on the basis of the reference data stored in the supervisory system database. For more cameras, it is possible to increase the effectiveness of supervision by using all channels independently, provided you have the reference images for each camera view.

Visual component tasks

For proper operation of the video component it is necessary to have a master image of the inductor-batch, used in the heating process and stored in the database of computer supervisory system. Master image has been further enriched by data defining the part of the reference image in which to conduct video surveillance, as shown in figure 2.

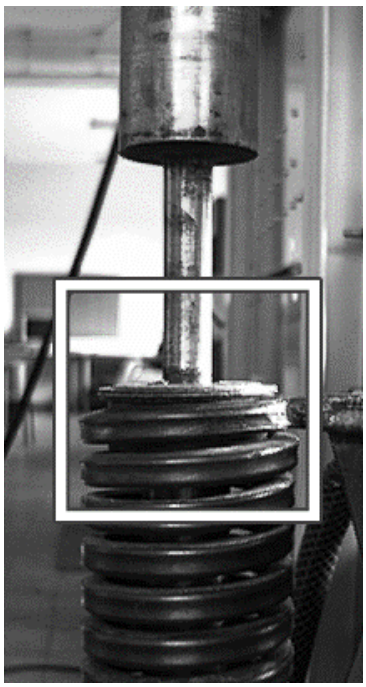

Fig.2. An example of a master image with the indicated area of observation

The basic function of the component are:

- the ability to use all of the cameras detected by the Windows operating system and configure them independently of each other;
- making (or modifying existing) the reference image and defined areas of interest;
- defining a new (or modifying existing) inductor-batch scheme, together with an indication of their mutual spatial relationships;
- easy management of the reference images and data stored in the database;
- the ability to modify allowable threshold value of similarity of recorded image to the reference image;
- the ability to modify threshold value of sensitivity for detection of loading system movement;
- conducting automatic supervision of inductor-batch system.

Automatic supervision carried out by developed and implemented video component, uses two separate algorithms for processing and analyzing video information, based on a modified method of measuring similarity between two digital images. Each of the algorithms analyzes your own fragment of the captured image, defined by the operator and stored in the database as a strictly defined part of the reference image of given inductor-batch system. Examples of fragments of the reference image are presented in figure 3.

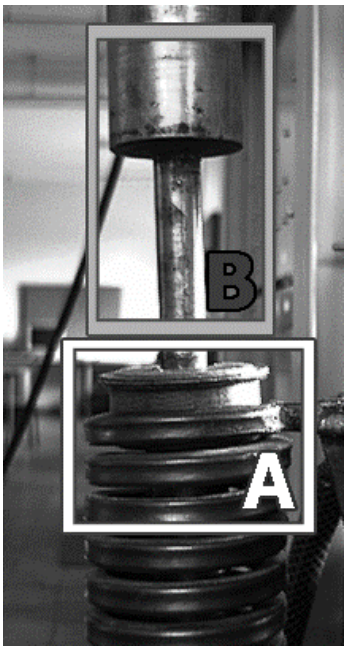

Fig.3. The analyzed areas of the frame for: validation of the relative positions of the inductor-batch system (A), loading system motion detection (B)

The area marked in figure 3 letter B tells the system about which part of the camera frame includes work of loading mechanism. This treatment is very effective in reducing the risk of detection of changes in the image are not due to the ongoing loading. When motion is detected in the loading area, motion detection algorithm stops on its duration, the algorithm validating batch in relation to the location of the inductor.

The area marked in figure 3 with the letter A, is a fragment of the reference image of the inductor-batch, in which the examination of the relative position of picture elements is performed. The algorithm validating batch in relation to the location of inductor, compares this fragment of captured image with the same fragment of reference image. If the value of the coefficient, determining the degree of similarity between these images falls below a particular threshold, the component reports a loading error and the corresponding signal in surveillance system is set to prevent the implementation of the heating process by heating generator until a satisfactory degree of similarity between images is achieved.

Digital image processing and analysis algorithms

The basic adopted functional requirements of designed video component were:

- the need for real-time operation;
- using image processing and analysis algorithms with the lowest possible computational complexity due to the additional, but not necessary for operation, the nature of the component, which activity can-not decrease the efficiency of the other more important features of the computer system supervision.

A major hurdle in the development of appropriate algorithms that would meet the above requirements, it appeared difficult to take into account, real work conditions of the position. Their diversity and unpredictability ruled out the possibility of using algorithms commonly used to verify the measure of similarity of images recorded by a camera with master images. Reference Images can be created in different lighting conditions and from a different distance, even from a different angle than the one from which camera "sees" analyzed areas.

To measure the degree of similarity between the two digital images, a measure of structural similarity in the field of the image where used, which is an index SSIM [1]. It is one of the most accurate measure of the quality of model-independent color in the image. In addition to the structural similarity SSIM also takes into account changes in the brightness and contrast [2]. As a measure of the brightness variation is assumed differences in average brightness values in the window, while a measure of standard deviation is variable contrast of the image. The structure of the image is deter-mined by the measure of linear correlation between pixels in the window. SSIM index value between the two windows X and Y of size n * n is given by the formula (1) [3]:

$$S(x,y) = l(x,y)\cdot c(x,y)\cdot s(x,y) = \\ = \left(\frac{2\mu_X\mu_Y + C_1}{\mu_X^2 + \mu_Y^2 + C_1}\right)\cdot\left(\frac{2\sigma_X\sigma_Y + C_2}{\sigma_X^2 + \sigma_Y^2 + C_2}\right)\cdot\left(\frac{\sigma_{XY} + C_3}{\sigma_X\sigma_Y + C_3}\right) \quad (1)$$

where: μ_X – the average brightness in the window X, μ_Y – the average brightness in the window Y, σ_X^2 – variance in the window X, σ_Y^2 – variance in the window Y, σ_{XY} – pixels covariance in the window X and Y, C_1, C_2, C_3 – constant factors.

For the calculation of the SSIM is generally used sliding window of size 8 * 8 or greater. The resulting value of SSIM index is the sum of the ratio of all the windows in the image. Depending on the sliding window in the image and scales adopted by counting the statistical value, SSIM accepts decimal values in the range <-1, 1>. A value of 1 is achievable only with two identical images.

Video component and system of supervising the work station for induction heating

Figure 4 shows the graphical user interface of the video subsystem host computer software positions for induction heating.

The main part of the dialog a tab containing an image obtained from the camera observing inductor and batch. On its left side has an interface allowing the user to:

1) switching on and off camera, and setting the parameters;
2) the acquire reference images for each of the inductor-batch;
3) define the areas of interest for motion detection and control system validation;
4) download stored reference images from database;
5) define the parameters and start-up vision inspection of inductor-batch system.

In the case of equipment of the inductive heating position in a greater number of cameras these interface elements are duplicated on tabs for each of them.

The upper part of the interface allows the user to define the inductor-batch for which video inspection will be carried out. This definition includes:

1) selection of the batch stored in the database;
2) selection of the inductor stored in the database;
3) determine the geometric relationships that describe the relative position of inductor and batch.

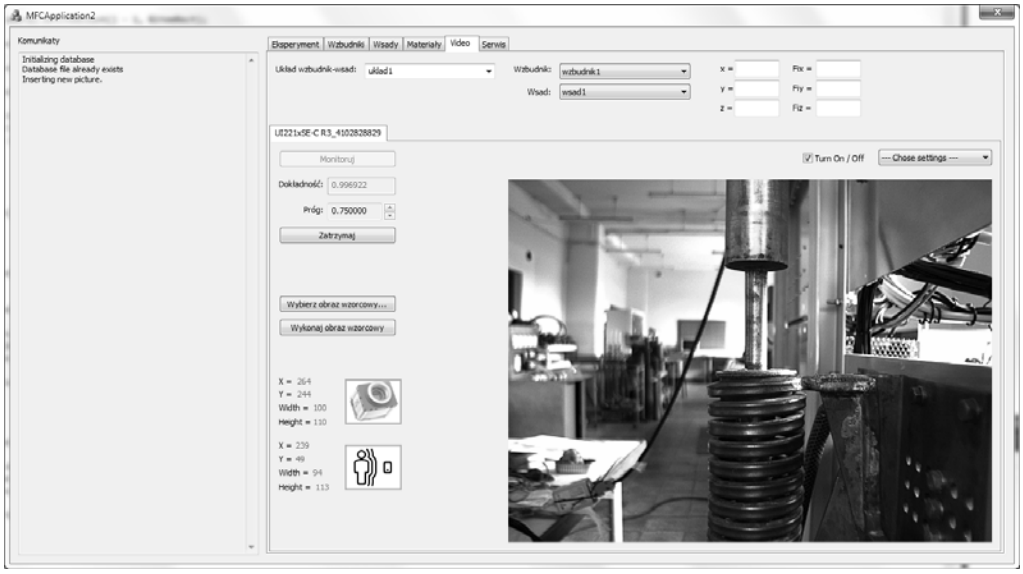

Fig. 4. Graphical User Interface of video component

Summary

Tests carried out so far have confirmed the effectiveness of the developed component, but a fair assessment of its effectiveness are required to perform tests in more differentiated working conditions.

Element, which in the future may require improvement, it is a matter of reducing, rather strong, dependence of running time of the algorithm defining the degree of similarity between the two images, on the size of the frame of the camera and the size of the defined area of interest in the reference image.

The problem that also needs to be developed, relates to the use of batches that relative to the reference image are rotated by a certain angle, but still remain in the correct position. Although the method used for determining similarity of two images take into account the rotation of the object at any angle, it requires it to designate a reference image area of interest containing no other elements than fragments of the inductor and batch.

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