

# Analysis of images recorded during welding processes

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## Abstract

In the paper the application of some elements of a system of assessment of a welding process and welded joints were presented. The analysis of thermal images and their comparison with images recorded by CCD cameras is discussed.

## 1. Introduction

Nowadays vision systems are commonly applied to automatic quality control in wide range of industrial assembly lines and processes. The main problem concerning such vision systems seems to be a proper image analysis. In welding industry these methods were used for seam tracking [7][5], control of weld pool size [1][6], control of weld geometry and assessment of weld quality [3] as well as for adaptive control of welding process [8].

An experiment described in the paper is a part of investigations aimed at development of a system of controlling automatic welding processes. According to this approach, the vision system consists of three cameras. A crucial role is played by an infrared camera, which observes the welding arc and pool and the joint that is getting cold. Observation of the process is aided by two CCD cameras, which record correspondingly images presenting the arc and the joint. There are two goals of image analysis. The first one is to assess stability of welding process, which is performed by means of determination of geometrical parameters of the arc. Secondly, some common defects of joints are supposed to be detected. It should be stressed that the application of infrared camera lets us to detect not only surface defects but also defects that are invisible on the surface. Presented experiments were carried out with the use of series of samples divided into some groups characterized by: well prepared surface, surface covered with rust, and parts covered with some impurities [2]. Concept of a general approach applied in the system has been presented in [4]. In the paper elements of image analysis were discussed.

## 2. Image recording and pre-processing

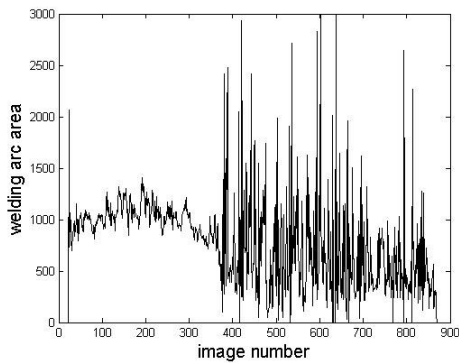
During the experiment series of images of 120x160 pixels (infrared camera) and 486x642 (CCD cameras) were recorded. In order to minimize the time of processing for further analysis some regions of interest (ROI) are selected. It is required to indicate them in images recorded by each of three enumerated cameras. These regions involve respectively welding arc and joint (infrared camera), welding arc (the first CCD camera) and joint (the second CCD camera).

Pre-processing procedures of images recorded by CCD cameras as well as infrared camera are similar and consists of converting color scale into gray, filtration and binarization. The main difference between these procedures are some parameters, especially values of binarization threshold. These values have been subjects of very detailed experiments and they depend on different factors, e.g.: welding conditions and type of image.

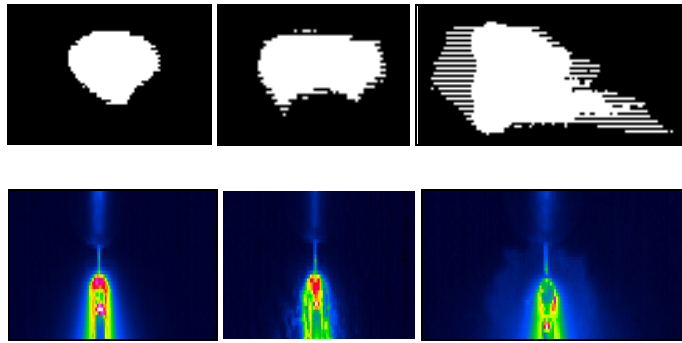
Despite all images are recorded synchronically two procedures, which goal is to adjust corresponding ROIs were required. The first one let us to find corresponding images (presenting the same welded areas) within series of images. The second procedure allows us to find details of corresponding ROIs. Since CCD cameras observe at the same time different welded areas, a single thermal image corresponds to two different images recorded by these cameras. Analysis of such selected images is based on comparison of parameters estimated on the basis of details visible in ROIs.

## 3. Image analysis

As it was mentioned above, the goal of the application of the system is to control the welding process and to detect selected defects of joints. Stability of a welding process is being estimated on analysis of images recorded by CCD cameras and thermal images representing welding arc. On the basis of performed experiments it came out that the size as well as shape of welding arc should be determined. Among other things, the stability of the welding arc depends on quality of surfaces being welded as well as welding parameters. In case of well prepared surfaces the process is smooth and deviations of arc dimension and shape are small. In the area where the condition of welding were rough the process was violent. In order to estimate instability of the welding process some pattern shapes of arcs were determined. The results of measuring the arc regions on the basis of images recorded during the welding process are presented in Fig 1. In the figure two distinct areas are visible. The first one corresponds to well prepared surface, and the second one shows changes of arc observed in cases of different impurity presence. Exemplary images presenting stable and instable arcs are presented in Fig 2. The second goal of the application of the system is to determine quality of joints. It is important that this assessment is being performed during the welding process. One distinguished a few commonly appearing defects.

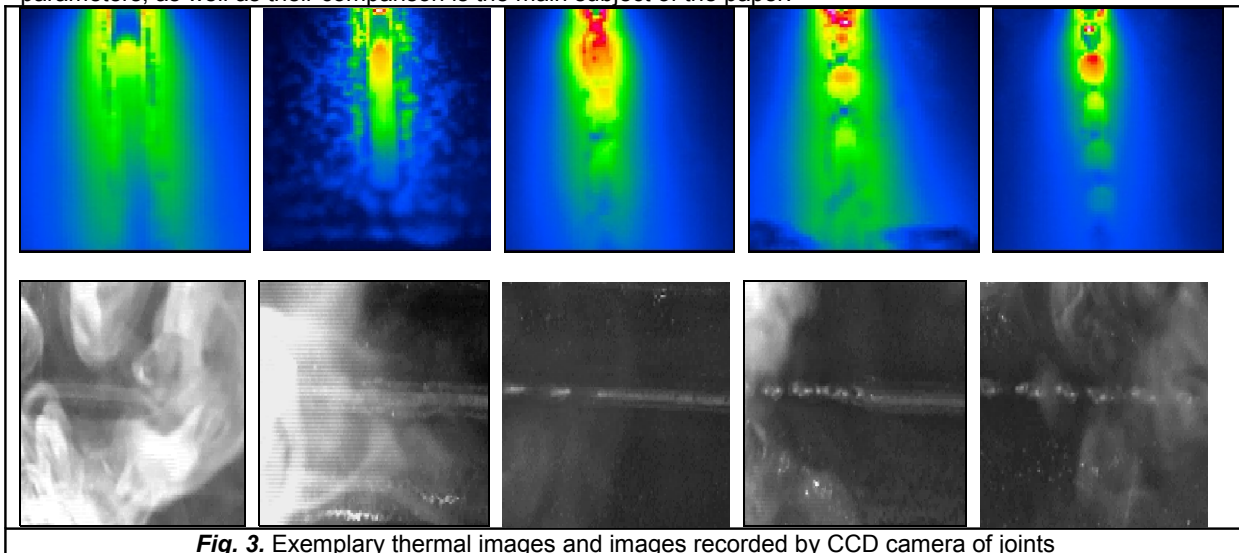


**Fig. 1.** The results of measuring the arc area during the welding process



**Fig. 2.** Exemplary images of welding arc

In order to provide their detection and recognition a library of pattern images was gathered. It is assumed that the application of the final version of the system will enable us to determine kinds of defects, their sizes and placement. These data is possible to be established on the basis of thermal images that show cooling down process of welded joint (upper row in Fig.3). Results of analysis of these images are parameters characterizing joints. These parameters in combination with results of images recorded by one of CCD cameras (lower row in Fig.3) let us to estimate joints and detect their defects. Analysis of thermal images and estimation of these parameters, as well as their comparison is the main subject of the paper.



**Fig. 3.** Exemplary thermal images and images recorded by CCD camera of joints

#### 4. Conclusions

In the paper elements of an approach to automatic control of welding process and welded joints were presented. Particular attention was paid to image analysis and comparison of results of analysis of thermal images and images recorded with the use of CCD cameras.

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