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A distributed system for computer vision quality control of clinched boards

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Abstract

Clinching technology allows to join metal sheets by using a cold press. The quality control of joint points, a type of joint buttons, is performed by experts observing the shape of the joint button on the basis of their experience. VISICON IST Research and Development project (partially funded by the European Commission) has realized algorithms and a distributed quality control system for assessing in real time the production of clinched galvanized metal boards. The solution is based on computer vision, software engineering, process modeling, and knowledge representation through object-oriented modeling. The image processing algorithm is based on the *G* Transform. The transform presents interesting properties and is computationally cheap. The VISICON solution has been validated by using a large set of data and statistical analysis for the detection of joint buttons and for their quality assessment. The paper reports a description of the distributed real-time architecture of the VISICON computer based quality control system, the main aspects of the computer vision processing for quality assessment and the results of the validation phase.

1. Introduction

Most factories which are producing *metal boards* for scaffoldings use the weld system to joint different parts of the boards. An alternative system for joining metal sheets by using a cold press joining technique is the so-called *clinching*. In these cases, the joint points are a kind of joint buttons that are grown up by the metal board for pressing it with a punch (see Figs. 1 and 2). Clinching (press joining) is a proven technique for joining metal sheets, tubes and profiles. The permanent joints are created by cold forming alone, without the use of additional parts or welds. The most significant feature of this technique, which is standardized in DIN 8593, is that the joint is formed from the metal parts, which have to be connected.

The clinching press-joining process requires machines, mobile tools or stationary machines that are driven from one side only. The set of tools required to perform a press joint consists of a punch and a die. The die is made of a fixed anvil in the centre and some laterally moving spring plates or sliding pieces. This technique allows a reduction of production and manufacturing costs, the elimination of the rust onset into the junctions and an energy saving of 60% with respect to the welding technique and avoids the use of chemical additives.

The quality of joint button has to be kept under control during the production process. There are several causes of defect that may arise during the board joining and production: defects in the metal sheets in the area of the joint, defects related to the tools for clinching (they have a limited life-time), problems in the production process machine (e.g., pressure), etc. The production process has to be stopped immediately to solve these problems in order to save time and money when recovering such found defects. At present, the typical approach for quality control is based on (i) measuring the join-button size, (ii) evaluating the join-button thickness, (iii) the observation of the joint button from both sides by an expert. Even a single joint over the total of 60 joint buttons on the board can be a reason to reject the board itself, for security reasons in the board use. The inspection has to be carried out within the production time of a board, which is about 20–30 s. Experts can detect such defects by a simple visual

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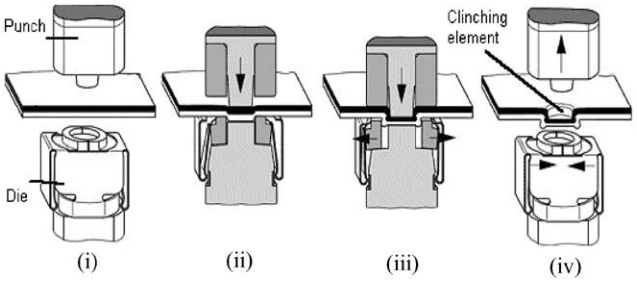

Fig. 1. Phases of joint button production: (i) metal sheets are positioned between the punch and the die; (ii) metal sheets are pressed both by the punch and the die; (iii) the pressure of the punch and an enlargement of the die produces the joint button; (iv) end of pressure and release of metal sheets with the clinching element: joint button.

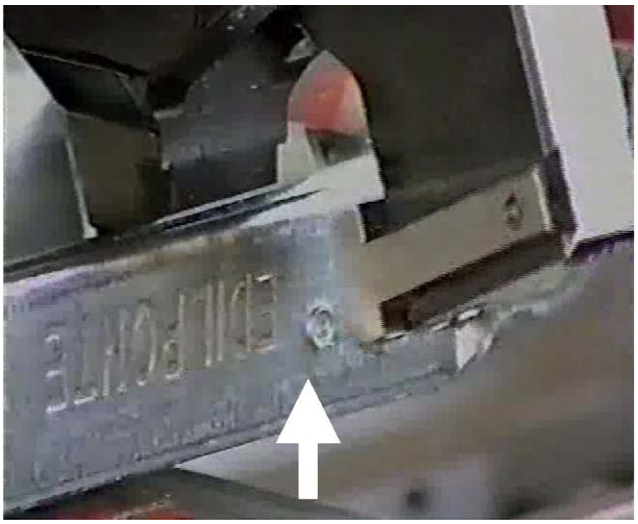

Fig. 2. A particular of the Clinching Process in metal boards production. The image shows a joint button produced by means of a press-joining robot (NUOVACETASS).

inspection on the buttons. This aspect convinced us to start researching a vision-based solution for automating this process.

In this paper, VISICON (VIsion System Inspection for CONtrol of Clinched Boards) FP5 IST Research and Development project, partially funded by the European Commission, is presented. VISICON proposes a solution for realising a distributed quality control system for the controlled production of *clinched galvanized metal boards for civil constructions, scaffolding*. They are used by carpenters to move from one place to another, when building and/or restoring walls, etc. VISICON architecture consists of a set of CCD cameras managed by industrial computers which are controlled by a quality control server for managing the whole process. The image analysis and a priori-knowledge about the joint buttons structure and their position on the board allow deciding whether the joints of metal boards are defective or not. In this manner, the quality of boards and the production efficiency is improved, thus reducing the number of defective boards. The solution integrates aspects of software engineering, process modeling, and knowledge representation and computer vision by using an object-oriented modeling [1,2]. The computer vision algorithms are based on the *G* Transform that allows the detection and the assessment of circular shapes. The realization of distributed computer vision architectures is becoming very relevant for the realization of real-time processing systems [3–7].

The paper is organized as follows. In Section 2, the VISICON architecture is reported by describing both hardware and software aspects. Section 3 describes the Object-Oriented data model used for modeling software on quality control supervisor and on local image inspectors. Furthermore, the synchronization process and model for the estimation of the overall quality are reported. In Section 4, details regarding the computer vision algorithms and process are reported. Section 5 presents the experimental results with their corresponding statistical analysis and configuration details. Conclusions are drawn in Section 6.

2. The VISICON system architecture

VISICON is a distributed image acquisition and processing system where a number of industrial computers (called Local Inspectors) simultaneously process images of different parts of a clinched board in order to evaluate the quality of the individual joints and out of such datum inferring the general quality of the board. VISICON allows a continuous on-line quality control (rather than the use of sampling or off-line techniques). Continuous automatic control improves overall quality and reduces variations in the final product caused by the subjective judgements made by human operators who may change along the process. The consequent reduction in the number of rejected boards results in substantial savings.

In this section, the hardware and software architecture of VISICON solution are presented. This part introduces a set of terms and components used throughout the paper. The main idea is focussed on building a quality control area placed at the end of the production machine for clinched boards, in order to process in real time all the produced boards with throughput which can keep up with the clinching machine.

The distributed system for quality control developed for VISICON is general enough to be applied in different contexts. The number of used Local Inspectors may vary according to the board type and the speed of the production line. This enables the system to be scaled