A Concept for the Application of Augmented Reality in Manual Gas Metal Arc Welding[1]

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Abstract

The large problem to create manual welds of constant high quality results from missing optical information during the actual welding process. Due to the extreme brightness conditions in arc welding and the use of protective glasses, even experienced welders can hardly recognize details of the welding process and the environment. This paper describes a new research project for the development of a support system for the welder.

1. Introduction

Because of the extraordinary high brightness, infrared and ultraviolet radiation of gas metal arc welding processes an observation is only possible with a welding helmet and suitable protective glasses. These glasses darken the entire scene homogenously, so details of the welding pool, the welding seam and the environment are only insufficiently recognizable (figure 1).

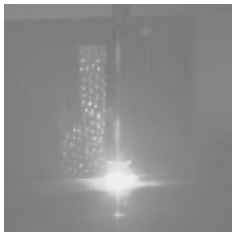

Figure 1. View of the welder, simulated with a CCD camera and standard protective glasses

Moreover, the welder has no additional information about the actual welding process and he receives no feedback about the quality of his work. Furthermore, an online-monitoring of the welding process is possible only for electrical welding parameters. To increase the manufacturing quality and economic efficiency a support system for the welder is required. This can be achieved by improving the visual information and by supplying additional information.

2. Description of the system

The system is based on a video see-through augmented reality [1]. A welding helmet is combined with a closed-view head-mounted display. Thus, the welder has no direct view on the welding process and is protected against the high radiation and light intensity. Two High-Dynamic-Range-CMOS cameras (HDRC) are integrated into the welding helmet and provide the user's stereoscopic view on the welding process. Due to the technology of the HDRC camera [2] the welder has a detailed view on the welding process and the environment. A portable computer provides further enhancement of the image quality [3] and displays the images on the head-mounted display. By methods of augmented reality, additional information is supplied to the welder. This information can be derived from the welding power supply (e.g. electrical welding parameters or wire feed), directly extracted from the images (e.g. dimensions of the arc) or transferred from a stationary computer (e.g. joint type or consumption values). Figure 2 shows a schematic sketch of the welding helmet.

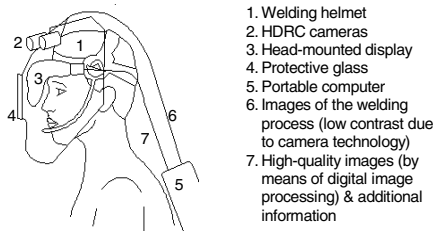

Figure 2. Welding helmet

The requirements to the portable computer are very high. Although the environment is not completely artificial, many image processing algorithms are used for image recording, enhancement of the image quality [3], extraction of relevant features for object recognition and tracking and representation of the images together with the overlaid information on the head-mounted display. Due to the stereoscopical image perception, the need for

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performance raises, because the two video channels have to be separately processed. The delay between image recording and image projection should not exceed 40 ms to achieve an ergonomical image rate of 25 frames per second and to avoid cybersickness and/or a distortion of the hand-eye coordination. To fulfil these requirements, a distributed system architecture with an evidently higher performance than conventional systems (e.g. notebooks or laptops) is used (figure 3). The portable computer is a combination of three single board Pentium III 850 computers to ensure a parallel image processing for achieving an ergonomical image rate. Each camera is connected with one single board computer, which performs the image improvement. The video outputs are connected separately to the left and right channel of the head-mounted display. Besides the image improvement for the user's view, the data extraction and placing of augmenting information still has to be done. This application is not that time-critical for the user like the image improvement, since a delayed update of textual data only uses a small area of the viewable display. The implementation of a third single board computer performs these AR-applications. It receives the images via ethernet connection from the camera computers. The amount of data is reduced by transferring only every n-th image of the camera. Additionally the welding machine data are transmitted to this computer. This data are recorded and processed by a stationary computer, which is connected via a measuring board with the welding machine [2]. This allows the measurement of electrical welding parameters and the calculation of characteristic welding process parameters.

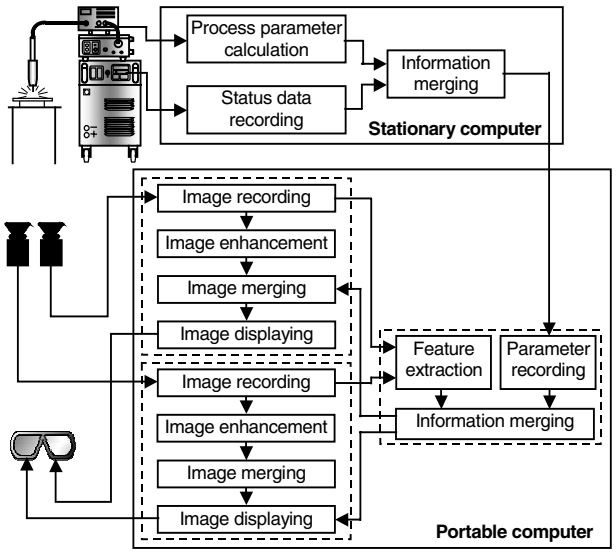

Figure 3. System architecture

3. Application areas

The system can be used for several steps of the welding process. The first application possibility is the use during welding preparation. In this phase constructional details can be displayed, e.g. material type, joint type or desired welding machine settings (figure 4a.).During the welding process, different information can be supplied to the welder, e.g. the actual data of the welding machine, like current or voltage (figure 4b.), or features directly extracted from the images, like inclination angle or welding speed. An online monitoring is possible by the continuous comparison of actual and desired values and an error message when a certain tolerance limit is exceeded (figure 4c.). For weld inspection purposes the images of the welding process can be stored together with relevant welding parameters, which can be easily assigned to each individual picture (figure 4d.).

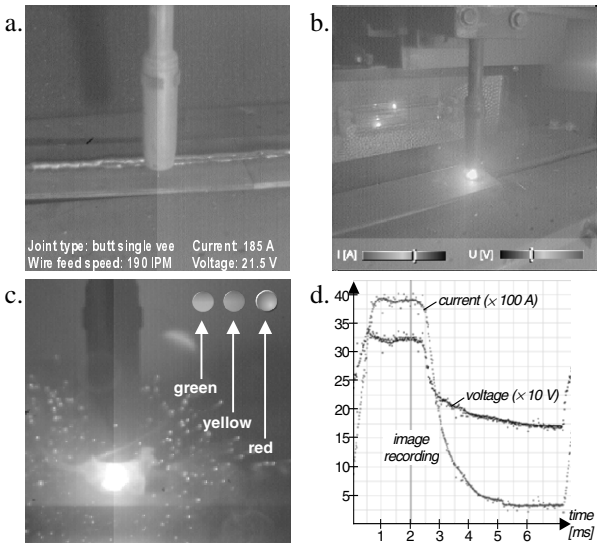

Figure 4. a. Welding preparation; b. welding process; c. online-monitoring; d. weld inspection

4. References

[1] R.T. Azuma, "A Survey of Augmented Reality", *Presence: Teleoperators and Virtual Environments 6*, August 1997, pp. 355-385.

[2] S. Nordbruch, P. Tschirner, A. Gräser, "Visual Online Monitoring of PGMAW without a Lightning Unit", *Int. Sheet Metal Welding Conf. IX*, 18.-20. Oct. 2000, Detroit, USA. Paper Nr. 4-4

[3] S. Nordbruch, P. Tschirner, A. Gräser, "Analyse HDRC-Bildern des Werkstoffübergangs des MSG-Schweissprozesses", *Mustererkennung 2000*, G. Sommer, N. Krüger, C. Perwass (Editors), Springer-Verlag, ISBN 3-540-67886-7, pp. 147-154.