



POSSIBILITIES OF THE APPLICATION OF THE SOFTWARE FOR WELDING IN VIRTUAL REALITY ON THE WELDERS TRAINING

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Abstract:

Welding in virtual reality is an artificial, computer generated, environment where the welder is located with a goal of the successful realization of the welding process. This process should be ended with a best derived welded joint for the given conditions. The main idea of the following type of software is to focus on the training of future welders. During the training, a great amount of energy is consumed, and hazardous radiation, fumes and gasses have an effect on the health of the welder. Therefore, the application of the software for welding in virtual reality allows a great saving in material and energy, moreover, it reduces or eliminates all harmful effects of the welding process. This paper elucidates all the possibilities of the application of one software for welding in virtual reality called "Hyperwelder". The focus is the analysis of the two parts of this software that refers to the welding training, and the simulation in workshop conditions. It is indicated on the possibilities of the software, its advantages and disadvantages, and further development in the way of welding in more real working conditions. Summarizing all the benefits that welding in virtual reality brings, this way of training will most certainly become obligatory in every training process.

Keywords:

virtual reality, welding, simulation, welders training.

1. INTRODUCTION

Welding is a procedure of joining two or more materials using the mechanical energy, heat, or using both the mechanical energy and heat. The result of this process is to obtain one solid piece with a minimum of imperfections [1]. Finally, in the last century, the welding process has spread throughout many branches of industry, and therefore, it became unavoidable.

With this acknowledgement, whole engineering world must be aware of the paramount value of the safety, risks and health of welders. A workplace of the welder can be the hull of the ship, over the tall bridge foundation, and, for instance, inside the long, dark, pipeline. Having said this, intrinsic job of the engineers is to make their job as easier as possible, and to try to reduce an impact on their life. With the development of the information technologies came the opportunity.

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The large welding companies embraced the chance of the development of VR (virtual reality) software focused on welding procedure. The goal of the virtual reality is the accomplishment of the total immersion of the user [2]. Therefore, the experience that user is exposed to, has to be tantamount convincing that the user forgets that he is in an artificial environment. Not only that he has to forget, but also, he has to start acting naturally, as in the real world. The environment where user is located is an artificially made environment [3]. If the goal is the complete virtual experience, the user will use additional equipment such as: headsets, gloves, tracking system, etc. Last but not least, their connection and synchronized work is the final step in this experience.

2. VIRTUAL REALITY WELDING

Welding in virtual reality is an artificial, computer generated, environment where the welder is located with a goal of the successful realization of the welding process. This technology is the ideal solution for the welders training, as he or she develops a feeling of affiliation to the artificial environment. Moreover, this environment can be diverse, from the workshop and the welding of the simple sheets, to the welding simulations of the real, field jobs. The separation and the connection of the real and virtual world is presented on the Fig.1.

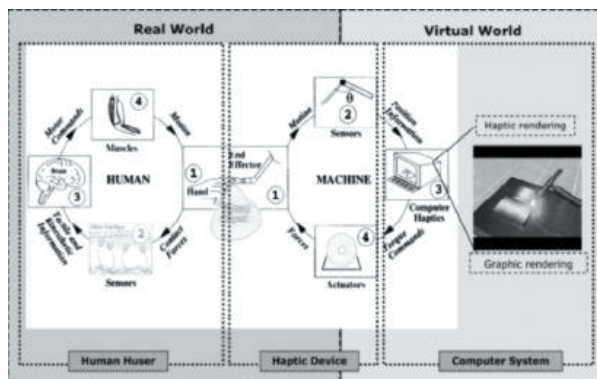


Fig. 1. Functional scheme of one VR software [4]

The terminology of the real world defines the human user with its receptors and actuators [5]. On the other hand, the virtual world includes the whole computer system. The essential part of this complex system is the one that connects both of these two worlds, and this part is named a "Heptic device". Accordingly, it can also be called a kinesthetic communication part of the system [4].

The welder, while he works in a simulator, holds a real, physical welding gun, and next to him is situated a real welding machine. The welder can use this machine for the adjustment of the welding parameters.

The application of this system of education and evaluation of the welders is significantly present in the great, international, manufacturing companies. These companies have their training centers, with the adequate training spots, and competent personnel.

Furthermore, the paramount part is the storage warehouses for the base and filler materials. For the identical training spots, the welding in virtual reality provides astonishingly more welding spots. This kind of the training procedure presents a simple and safe type of the welding procedure, where welders are not exposed to toxic vapors and gases [4].

Fig. 2 presents comparison of the real welding training workshop, and one classroom for training in virtual reality.



Fig. 2. Comparison of the real-life welding workshop and the VR welding classroom

The advantages of the use of this virtual reality softer are numerous. The great monetary savings, savings in the material and energy, the absence of the fumes, gases and vapors, the absence of the possible injuries, ergonomic workspace, simple storage of the welder's data that refers to working hours and results.

3. APPLICATION OF THE HYPERWELDER SOFTWARE

The experimental part of this text will present the application of the "Hyperwelder" software for welding in virtual reality.



The idea of this software is one simple, user friendly, software model, and the presentation of the welding process to the people that have a dearth of information on this topic [6].

The application of this software is potentially wide. It can be used by any novice, but also it can be used for the certification of the welders, and last but not least, for the presentation in the schools and universities.

As a working place, any room equipped with the computer, software, and hardware (headset, controllers, tracking system) can be used. The working place must be defined with the dimensions that are integrated in the software. The tracking system is the simple arrangement of two or more infrared cameras that are easily tracking the position of the user in space [6].

4. EXPERIMENTAL PART

Software structure

Generating of the software allows the user to access the home screen, which is presented on the Fig. 3.

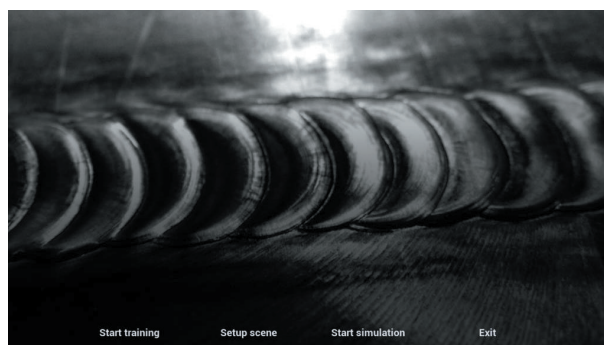


Fig. 3. Home screen [6]

The home screen sets three options that user can choose. Following entities are the main components that software is composed of. They are:

a) Welding training – This part is designed for the users that are, for the first time, connected with the welding process. By selecting this part of the software, the user is introduced to the main welding positions, gun movement, and the whole idea is based on the gamification of the welding process. At the end of the process, welders are focused on the final accomplishment that can be upgraded later on.

b) Setup scene – This part of the “Hyperwelder” software positions the user in one virtual workshop.

The scene requires from the welder to complete one fillet welded joint, on one part made of constructional steel. The welder is situated in the workshop environment, and he holds in his hand one GMAW (Gas Metal Arc Welding) gun. At the end of every completed joint, user can examine his work, moreover, the user can understand the quality of the job.

c) Welding simulation – This is the third, and the most complex part of this software. The user is situated in one realistic welding environment like pipeline welding, reservoir welding, etc. This part of the software is not fully functional; however, it presents the final phase of the welding process in virtual reality. The user can approach to this part of the software after the successful realization of the first two parts.

Welding training

After the decision to participate in this part of the software, the user finds himself in one abstract environment. In front of him appears the structure that has to be “welded”. On the structure, users can locate the weld that is presented with a red coloured line. If the user intends to complete this job, it is obligatory to follow that line, as it is presented on the Fig. 4.

The quintessence of the whole software structure is one gaming platform, moreover, accomplishment of the levels with successful production of one welded joint [6].

Depending from the welding position, the user collects points, and passes several levels. At the end of the process, the user can have a full insight of the achieved result.



Fig. 4. Slide selection with the control of welding pistole [6]

After the introduction with the software, in front of the user reveals the ghost. The user has to approach to the ghost for the kick off of the welding process. After the suitable positioning of the gun, the user presses the button on the controller, and the welding process starts.



The user follows a blue circle that leads the welding process. This circle follows the improvised joint, with the adequate speed, during the welding process.

Material selected for the selected job is the structural steel. Accordingly, thickness of the material is 5mm, and the welding speed is 28 cm/min [6]. If the colour of the welded joint turns to be green, welding process is regular. On the other hand, various shades of yellow and red are suggesting that the welder is making some mistakes and imperfections are occurring, which is presented on the Fig. 5. This is caused by the inadequate gun position, or the exceptions in the welding speed. The user can stop the welding process at any moment he desires. The user can analyze his score, and the only requirement for the advance of this process is to approach the spot where the welding process is stopped. The preview of the welding process after the break is presented on the Fig. 6.

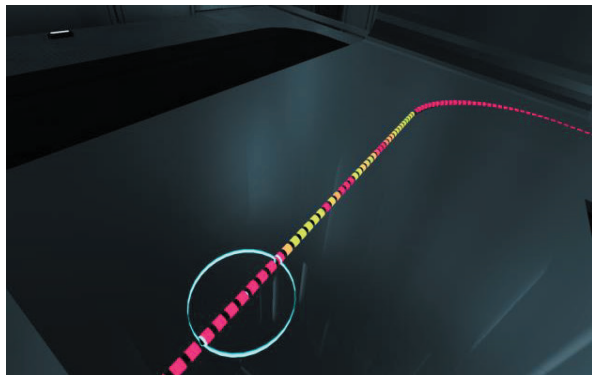


Fig. 5. Close look at one joint with the mistakes (imperfection)



Fig. 6. Stopped welding process with a look on the overall score and welded joint [6]

After the successful accomplishment of the first level, the horizontal welding position, software's marks the beginning of the second level. The complete result is presented in front of the user, and the new ghost is generated, Fig. 7.

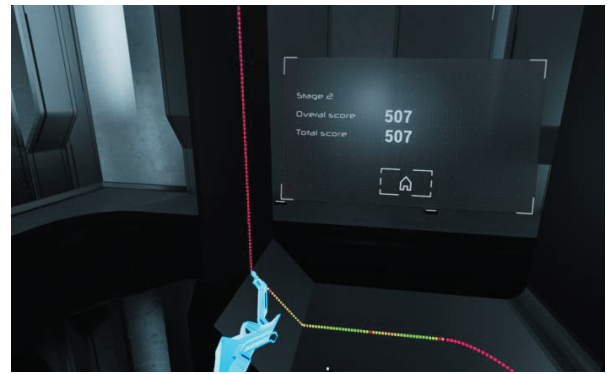


Fig. 7. The end of the first stage with the overall and total score [6]

The second level leads the user through the vertical welding position, which is inherently more complicated. After this level, the user has an insight on the welded joint made in the both levels. The screen in front of the user provides him the information that refers to the achieved result, and the cumulative result made on both levels.

Superseeded level is the most demanding part of the training. That is the overhead welding position. This level leads the user through the overhead contour of this joint. The welding directions are also imported as variables, so the user can be introduced to all the difficulties that this position dictates. The Fig. 8 presents the part of the overhead welding process.

At the accomplishment of this part, in front of the user is presented his complete work. Along with that, the user is introduced with the result he achieved, and the best result ever made in the training, Fig. 9. At the end, the user can decide his future steps between the homescreen and one more training simulation.

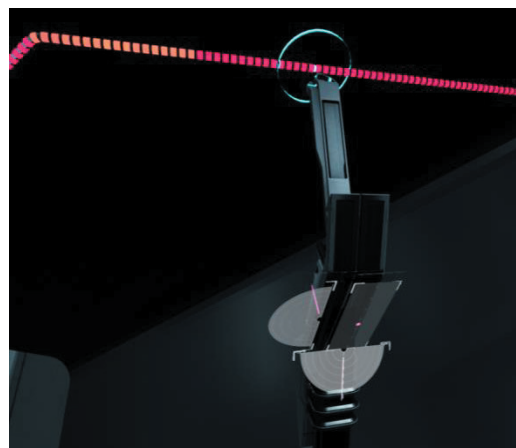


Fig. 8. Example of an overhead welding process [6]

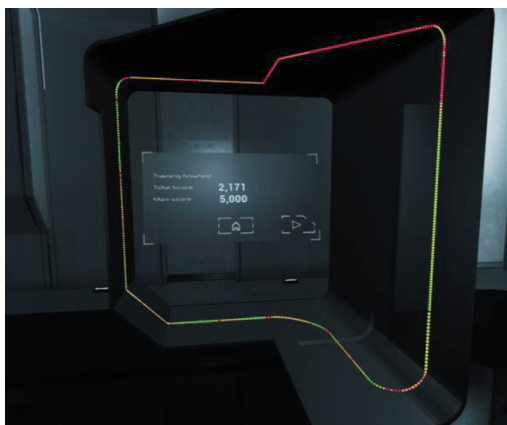


Fig. 9. One completed welding training with the information about total and best score [6]

Welding simulation in a workshop environment

After the selection of this part of the software, on the main screen the user finds himself in one workshop environment. In front of the user is one work desk, on which one two metal sheets are located. These sheets are forming one fillet joint. Depending on the real room, in the real world, the movement is correspondingly limited [6]. The essential factor is the movement of the user around the work desk; therefore, the other components are there just for the cosmetic purpose. The greater immersion is possible with the combination of the different sensory entities, such as lathe, radial drill, etc. This environment is presented on the Fig. 10.

In this simulation, the user holds the GMAW gun, and the spot where welding needs to start is marked with a pointer. This pointer is a green arrow; moreover, the user can see a message that says “Please start here”, as the Fig. 11 prominently present.



Fig. 10. Workshop environment [6]



Fig. 11. Welding gun with the marked beginning point [6]

As the user approaches the starting point, he can notice the main disadvantage of this part of the software. The welding process starts with the pressing on the button of the controller/gun. However, in the realistic world, in front of the welder there is no table, nor work-piece. Therefore, the sense of touch is excluded, and one human sensor response is excluded. The user is relying on the eyesight and his personal feeling where the work-piece actually is. This can lead to the loss of the most intrinsic part - immersion, because the users feeling of the welding position is lost. While leading the gun, it can move far away from the joint, further more, the user can penetrate, physically, through the joint.

Designers can overcome this problem, with the positioning of the realistic table in front of the user. Furthermore, a sample of the real fillet joint is an interesting solution for this problem. If this can sort the problem with the loss of the immersion, it will be the perfect solution. One more disadvantage about this part of the software is the visual aspect of the virtual experience. When the welding process initiates, there is no blackout, which presents the effect of the welding mask. The user is exposed to the welding arc, which is in the real world strictly forbidden [7]. This problem is presented on the Fig. 12., and the most reasonable solution for this problem is the initiation of the blackout as soon as the welding process starts.



Fig. 12. Initiation of welding process with no blackout

After the realization of the one joint, the user can see how one welded joint looks like. The finish of the process orders to the software to comprehend all the data collected. The data is considering the position of the gun, and the welding speed, the factors that the user learnt in the training part. The results are presented on the diagram, which is constituted from the two variables – joint length and the penetration. An example of the diagram can be seen on the Fig. 13. For the previous example, the red line presents maximum values of variables, and the green one the minimum values. At the end of the welding process, the goal of the user is to be in the middle between these two lines [6]. If the yellow line, the process line, is under the minimum line, the welding speed was too fast, and it is more than participated. On the other hand, if the line is over the red, maximum line, the speed is under participated. So, the yellow line between these two lines presents the job well done.

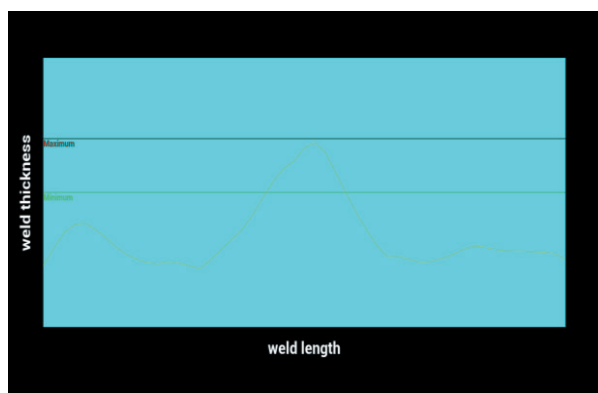


Fig. 13. Welding simulation - graphical feedback [6]

5. CONCLUSIONS

All the softwares for welding in virtual reality have only one goal, and that is the improvement of the working conditions during the training for the future welders. This training requires a significant number of training hours, within which the welder must be provided with the: qualified instructor, safe welding equipment, and material supplies. During the training process, a great amount of energy is consumed. Indubitably, not only this will occur during the real training, what follows the welding process is: the hazardous radiation, vapors, and gases which have a huge effect on the health of the welder. The training facilities, that are conducting the training process exclusively with the conventional welding technique have a worryingly big amount of waste material. The usage of the welding simulators reduces this waste, and with that comes the eco-friendly effect on the human environment and resources. The presented prototype lacks many features, but the constructed platform is more than well starting point for the further development. The initial improvements will be focused on the first two parts of the software – training and the workshop environment simulation. The goal will be the improvement in the field of the immersion of the user. Understanding all the needs and fastidious work will most certainly lead to the construction of the software with the solved problems. The sense of touch must be involved, and the blackout of the mask is an imperative. The full immersion of the user is the aspect that must not be lost. With the perfect realization of these two parts comes the opportunity to start the development of the last part, and that is the welding simulation. Summarizing all the benefits that welding in virtual reality brings, this way of training will, surely, become obligatory in every training process.

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