Efficient Multi-Pass Welding Training with Haptic Guide

Yongwan Kim[*+] Ungyeon Yang[*] Dongsik Jo[*] Gun Lee[*] Jinseong Choi[*] Jinah Park[+]
[*]Electronics and Telecommunications Research Institute (ETRI) [+]Korea Advanced Institute of Science and Technology (KAIST)

1 Introduction

Recent progress in computer graphics and interaction technologies has brought virtual training in many applications. Virtual training is very effective at dangerous or costly works. A represetative example is a welding training in automobile, shipbuilding, and construction equipment. Welding is define as a joining process that produces coalescence of metallic materials by heating them. Key factors for effective welding training are realistic welding modeling and trainig method with respect to users' torch motions. Several weld training systems, such as CS WAVE, ARC+ of 123Certification, and SimWelder of VRSim, support either only single-pass or inaccurate multi-pass simulation, since multi-pass welding process requires complicate complexity or enormous bead DB sets. In addition, these welding simulators utilize only some graphical metaphors to teach welding motions. However, welding training using graphical metaphors is still insufficient for training precise welding motions, because users can not fully perceive graphical guide information in 3D space under even stereoscopic environment.

In this paper, we present a real-time efficient multi-pass welding process with appropriate accuracy and a haptic welding teaching interaction scheme to enhance the training effectiveness.

2 Proposed System

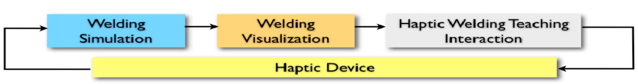

Figure 1: Overall System Flow

Our system consists of three parts – welding simulation, welding visualization, and haptic welding teaching interactions. Tracking values from a haptic device, such as PHANTOM Omni, are reflected to a virtual torch. Based on the motion parameters of virtual torch, such as motion straightness, work/travel angle and tip distance, an appropriate bead is simulated and visualized. In the basic/advanced teaching mode, users can also feel force and vibration feedbacks according to their welding motions.

2.1 Welding Simulation and Visualization

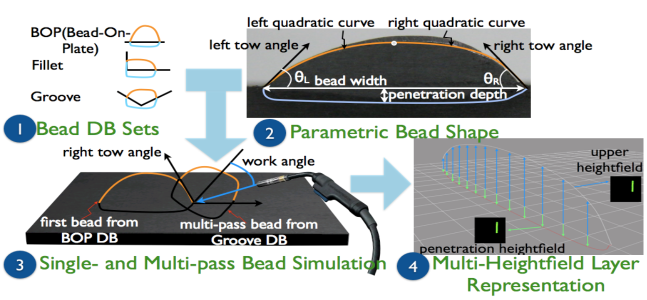

Figure 2: Single/Multi-Pass of Bead Simulation

The bead data was collected by cutting and measuring the cross section of real beads. We recorded bead parameters including bead sizes, weld penetrations, and tow angles. In our virtual training system, we reconstruct a parametric bead shape (using piecewise quadratic polynomial curve) from these bead parameters. The reconstruction process is simple in single-pass case, but a multi-pass case is a challenging problem. Traditionally, we should analyze a heat distribution from a welding arc and perform a FEM (Finite Element Method) over a single-pass bead to get a multi-pass bead shape. However, this approach is impossible to solve in real-time. Therefore, we present an efficient multi-pass scheme with appropriate accuracy. Using the tow angle of the single-pass bead below, we approximate a subsequential multi-pass bead into a groove bead, tilted to the orientation that matches to the edge of the bead below. In our case, we ignore the gravity effect caused from tilting the groove bead.

From the reconstructed parametric curve, we effectively construct a bead mesh model through multi-heightfield layer as shown in Figure 2. We adopt the multi-heightfield structure because of its simplicity in representing multi-pass process.

2.2 Haptic Welding Teaching Interaction

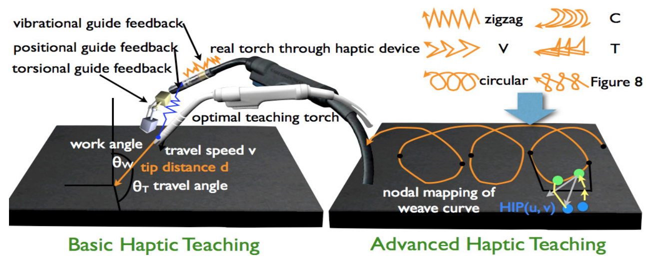

Figure 3: Basic/Advanced Haptic Welding Teaching Interaction

To train basic welding motion control parameters - straightness, work angle, travel angle and tip distance - we generate positional/torsional/vibrational guide feedback through a haptic device. Positional guide force is related to the tip distance and damping factor to the travel speed. Torsional guide force also changes as the work/travel angle and speed. Vibrational guide feedback increases as smaller tip distance. The stick-out phenomenon, which occurs when a torch comes to a contact with a base metal, is simulated as a sticking force of a haptic device.

For guiding weave patterns, we construct a haptic feedback with spline model. First, we break down the weave pattern into multiple piecewise spline curves according to trajectory directions. Then, we apply nodal mapping scheme as shown Figure 3.

3 Conclusion

In this paper, we proposed virtual welding training system with haptic teaching interaction. The proposed method helps users to efficiently learn complicate weld operations, including single- and multi-pass welding processes with appropriate accuracy.

References

JEFFUS, L. 2007. Welding: principles and applications. *Delmar Learning*.

[1]e-mail: ywkim@etri.re.kr [2]e-mail: uyyang@etri.re.kr
[3]e-mail: dongsik@etri.re.kr [4]e-mail: endovert@etri.re.kr
[5]e-mail: jin1025@etri.re.kr [6]e-mail: jinah@cs.kaist.ac.kr

SIGGRAPH Asia 2009, Yokohama, Japan, December 16–19, 2009.
ISBN 978-1-60558-858-2/09/0012