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Automatic Generation of Virtual Work Guide for Complex Procedures: A Case

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ABSTRACT

Practical work guides for complex procedures are significant and highly affect the efficiency and accuracy of on-site users. This paper presents a technique to generate virtual work guides automatically for complex procedures. Firstly, the procedure information is extracted from the electronic manual in PDF format. And then, the extracted procedure steps are mapped to the virtual model parts in preparation for animation between adjacent steps. Next, smooth animations of the procedure are generated based on a 3D natural cubic spline curve to improve the spatial ability of the work guide. In addition, each step's annotation is automatically adjusted to improve the visual effect of the work guide. A troubleshooting procedure example of the M16A4 Rifle shows that the generated work guide is well instructive, which provides the interactive simulation of the procedure and process-based display of technical annotation.

Keywords: Work guide, virtual environment, procedure animation, procedure annotation

INTRODUCTION

Instruction is a critical aspect of manufacturing, maintenance, and repair for complex procedures, which is significantly related to the efficiency and accuracy of operation technicians. However, traditional printed operation manuals are difficult to follow, and users are often frustrated by the need for more clarity in the manual. Virtual environments with equipment operation models and the related manuals can intuitively and vividly guide each step of work on-site and provide much information for operation personnel in real-time, greatly simplifying the difficulty of operation personnel and improving performance. The virtual work guide for complex procedures can utilize the accuracy, intuitiveness, and unambiguity of 3D models to express the operation intents and requirements and then provide practical assistance for on-site users. This paper aims to present a fully automatic technique to generate virtual work guides for complex procedures.

GENERATION OF VIRTUAL WORK GUIDE

Complex procedures are usually performed in a particular order that contains many steps, and each step may involve different operating objects. Therefore, each procedure is a continuous transfer process of related operating objects. The technique for generating work guides consists of three phases. First, the procedure information is extracted from the traditional electronic manual in PDF format and managed as text data. In the second, the extracted step information in the procedure is mapped to a group of parts of the virtual model, which provides vital frame information for subsequent animation generation, shown in Figure 1. At last, the animation between adjacent steps in the procedure is generated based on the extracted and processed procedure information. The trajectory of the camera movement in the animation follows the path generated based on the 3D natural spline cure and the related parts' positions.

The position of each step's annotation is adjusted to be close to the related model part without causing occlusion based on the Axis Aligned Bounding Box collision detection algorithm to improve the visual effect of the work guide, which also avoids the users unnecessarily taking more time to interact visually with the annotation. In addition, each step's annotation size is designed to a ratio to the screen's size to make the work guide suitable for devices of different sizes.

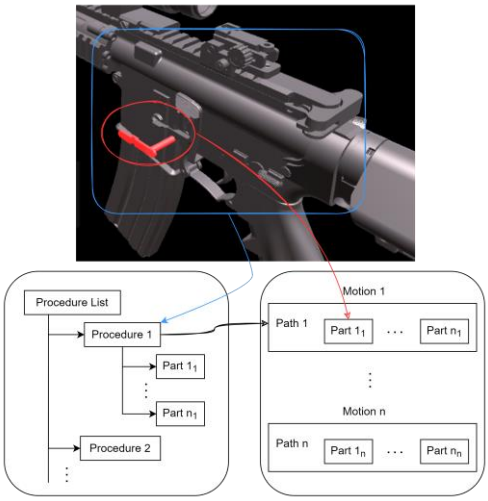
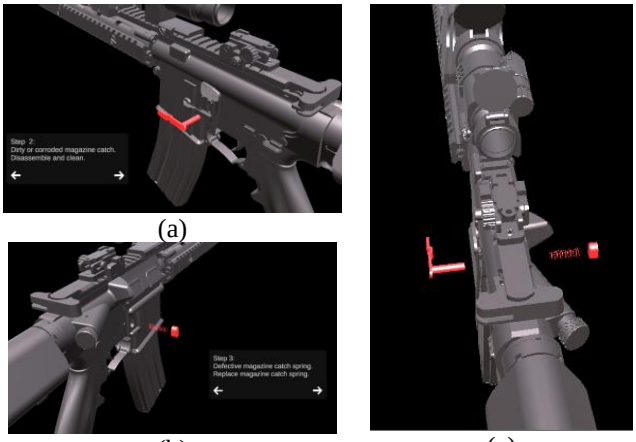


Figure 1. Mapping relations of operation procedure and virtual model

CASE STUDY

The work guide is developed upon Unity 3D and achieved by C#. The experiment object is the M16A4 Rifle model. The animation's screenshots between step 2 and step 3 of the failure of the magazine-to-lock procedure are shown in Figure 2.



(a)

(b) (c)

Figure 2. (a) Screenshot of step 2 of the failure of the magazine to lock procedure. (b) Screenshot of step 3 of the failure of the magazine to lock procedure. (c) Screenshots of the transition from step 2 to step 3.

CONCLUSION

In this paper, a technique has been presented to generate virtual work guides for complex procedures. The technique contained extraction of procedure information, data-to-model mapping, animation generation, and adaptive design of procedure annotation position and size. The work guide applies precisely registered animation and instruction texts to assist users in manual operations. The development and application process of the failure of the magazine to lock procedure of the Rifle M16 is given.