A Virtual Environment-Based System for Simulating Mechanical Assembly Operations

J. E. Brough, M. Schwartz, A. Thakur, and S. K. Gupta

Motivation

- Reduce need for physical models in visualizing and analyzing assemblies
- Provide immersive experience for enhancing the understanding of the assembly process
- Provide an environment where users can safely make mistakes and learn from them
- Reduce the time needed to generate assembly instructions

Virtual Workspace module provides basic environment for the user to interact with the virtual parts
- Simulates the adequate level of realism to support training and includes dynamic animation and plan completion
- Supports 3D Animation, Video, Audio, Text, and Interactive Simulation

Virtual Author module enables the trainer to generate instructions by performing a demonstration in the virtual environment
- The system records, cleans, and generalizes the trainer’s actions automatically translating them to text
- No programming is required

Instruction Generation

- Detailed text instructions and 3D animation are automatically generated for the engine maintenance procedure by analyzing demonstration of the procedure in our system

Design for Assembly

- A designer is interested in assessing assembly difficulty of a new pulley mount
- The designer simulates the assembly steps in our system and discovers that shaft cannot be inserted into the bracket without changes in the design

Virtual Manufacturing

- An assembly operator needs to practice assembly operations for a rocket motor to pass the certification test
- User studies involving 30 users show 94% success rate in transferring the skills acquired using our system to physical assembly tasks

Sample Virtual Author Output

- Align piston assembly with engine case
- Insert piston assembly into engine case until connecting rod contacts the bottom of the engine case

Virtual Maintenance/Service

- A maintenance engineer needs to learn how to perform a specialized maintenance operation for an engine
- User studies involving 30 users show 97% success rate in transferring the skills acquired using our system to physical assembly tasks

Project Goals

- Develop a low cost virtual environment for simulating assembly operations
- Develop computational foundations to provide interactive speeds and immersive experience at low cost
- Enable generation of training instructions without any programming
- Develop features to offer interactive assistance to users and tailoring training instructions based on their skill level
- Conduct user studies to determine the effectiveness of the virtual assembly technology

VR World seen through HMD