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A VIRTUAL LEARNING FACTORY FOR ADVANCED MANUFACTURING

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ABSTRACT

Virtual reality (VR) technology allows for the creation of fully immersive environments that enable personalized manufacturing learning. This case study discusses the development of a virtual learning factory that integrates manual and automated manufacturing processes such as welding, fastening, 3D printing, painting, and automated assembly. Two versions of the virtual factory are developed: (1) a multiplayer VR environment for the design and assembly of car toys; which allows for the collaboration of multiple users in the same VR environment, and (2) a virtual plant that utilizes heavy machinery and automated assembly lines for car manufacturing. The virtual factory also includes an intelligent avatar that can interact with the users and guide them to the different sections of the plant. The virtual factory enhances the learning of advanced manufacturing concepts by combining virtual objects with hands-on activities and providing students with an engaging learning experience.

1 INTRODUCTION

Virtual reality (VR) is a computer generated experience for humans (Seibel and Chatelier 1997). The history of VR technology goes back to 1838 when Charles Wheatstone created his stereoscope that was able to impose an image over the user eyes, thus creating a distant 3D image (Schroeder 1996). Over the years, VR technology has faced multiple challenges due to the extremely high development costs. In the last two decades, development costs were reduced dramatically and VR devices became more affordable. VR has received an enormous amount of publicity over the past few years and many applications, from education to training and therapy, have been developed that were not previously viable. VR allows users to experience a simulation of real-world events and, hence, many useful applications can be developed. In education, VR can be used to improve learning and enhance student engagement. Without physical restrictions, students can utilize VR simulations to perform laboratory experiments and gain immersive and immediate learning experiences that better prepare them for real-world scenarios in their prospective careers. For manufacturing applications, VR can improve learning of manufacturing concepts while providing a safe and comfortable environment for learning. VR applications are expected to enhance data-driven, experiential training that can significantly benefit education as well as manufacturing industry. In this case study, we discuss a virtual learning factory for advanced manufacturing. The virtual factory integrates manual and automated processes and includes hands-on activities that represent the five manufacturing paradigms: craft production, mass production, lean manufacturing, mass customization and personalized production. Both single-player and multi-player virtual environments are developed. We use artificial intelligence (AI) and

eye tracking for data collection and modeling of user's behavior. Gamification of manufacturing activities, which aims to make learning process more enjoyable, is performed through serious games in which users are challenged with creation of a car product that meets customer requirements and functional constraints.

2 VIRTUAL FACTORY

Sample snapshots from the virtual factory are shown in Figure 1. The snapshots A-C are from the single-player factory, which combines manual and automated assembly processes of virtual car products. The manufacturing processes include welding, fastening, 3D printing, machine painting, supply and demand, and six sigma defect checking. In the manual assembly, users are instructed to assemble five different components of a car (engine, frame, body, axles, and wheels). These components are then transported using conveyor belts to the automated assembly line, in which the final cars get assembled and inspected. Snapshots D-F are from the multiplayer virtual factory, which is used to make virtual car toys that meet specific customer requirements. The factory consists of five rooms, one for each manufacturing paradigm, and a sixth room for finished product inventory.

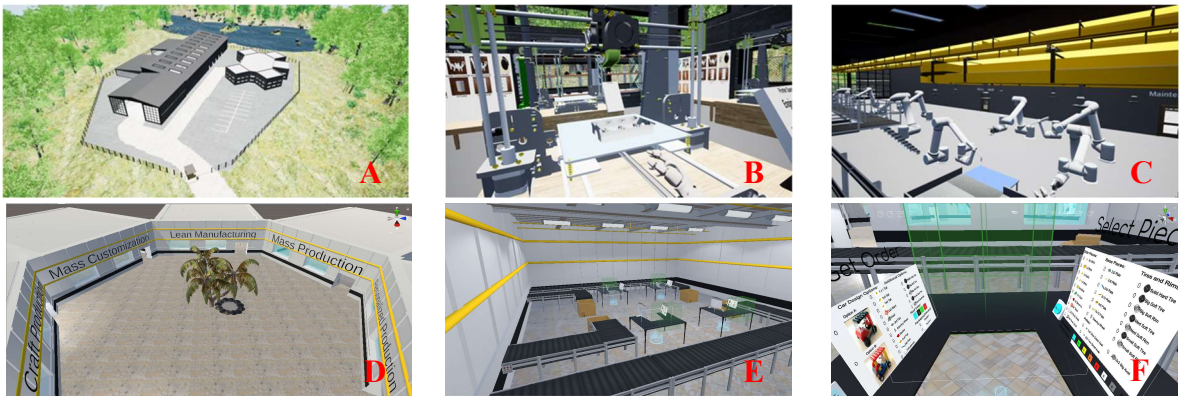

Figure 1: Snapshots from the virtual learning factory for advanced manufacturing.

3 BENEFITS

The virtual learning factory is used to enhance advanced manufacturing training. It utilizes gamification for teaching manufacturing process and integrates AI and eye tracking with the VR games to enhance the learning process. The utility of the virtual simulation is gauged through user testing in order to assure that it preforms adequately for its pedagogical intention. The use of game engine technology, together with game design principles, provide students with a more immersive and immediate learning experience that can better prepare them for real-world scenarios in their prospective careers. The virtual simulations provide an incredible resource for education and training and will only continue to improve in the future. Future work will focus on enhancing the virtual factories and incorporating different supply chain activities such as order planning and inventory management.

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