This paper considers the design and development of a virtual reality system that aids in vocational rehabilitation of individuals with disabilities. The system focuses on three types of disabilities: autism spectrum disorder, traumatic brain injury, and severe mobility impairment. The system allows job trainers to rapidly assess the capabilities of individuals with disabilities, detect the most suitable job for them, and train them in a safe and motivating environment where there are no significant consequences of making errors. Design considerations and research questions that arise throughout development are shared to create awareness of the special considerations involved in developing virtual reality systems for individuals with disabilities.

Keywords: Virtual reality simulation, virtual interaction, tangible interaction, navigation through virtual environments, vocational rehabilitation, disabilities, gamification.

Index Terms: I.3.7 [Computer Graphics]: Three-Dimensional Graphics and Realism—Virtual Reality

1 INTRODUCTION

According to the latest available data from the US Census Bureau [1], about 54.4 million Americans have some form of disability, 34.9 million of which is considered severe. Unfortunately, the employment rate for people with disabilities was 17.8% in 2012, while it was 63.9% for people without disabilities [2]. Several factors contribute to the low employment of people with disabilities. First, by definition, disabilities make some skills or tasks difficult or impossible to do. Second, employers may have pre-determined and/or subconscious biases about the challenges they will face with an employee with a disability, and thus may avoid hiring such individuals altogether [3]. Third, because of the above factors, some people with disabilities have a lower sense of self-efficacy, confidence, and motivation to join the workforce. The solution to these three factors is good job training programs for people with disabilities. Good job training will make it easier for individuals with disabilities to perform tasks that they previously found difficult, will address employers concerns and eliminate uncertainty in their job performance, and will ultimately increase confidence and motivation when training leads to gainful employment.

Solving the training problem leads to a chicken-and-egg problem. The best place for job training is the job site itself, but many employers would not put individuals with disabilities at a job site without some confidence that they are already able to handle the job. Otherwise, employers risk creating expensive, impractical, and hazardous situations for themselves, their employees, and their customers. Thus, as an alternative to on-site training, we propose a virtual reality system that aids in vocational rehabilitation of individuals with disabilities. The aim of the developed system is to provide an effective and innovative vocational rehabilitation service using virtual reality to: assess the capabilities of individuals with severe disabilities, detect the most suitable job for them and train them in a safe and motivating environment. The most novel aspect of the system is its use of immersive virtual reality (VR) to facilitate job training. Virtual environments (VEs) can be constructed for a wide range of job scenarios and adapted in real-time to the specific needs of the trainee and the goals of the job coach. In addition, users can train repeatedly on the same scenario, in a safe environment where there are no significant consequences of making errors. Furthermore, the system can automatically capture job and skill effectiveness data using motion trackers and other behavioural sensing technology.

Several characteristics of the autism spectrum disorder (ASD) population have implications for the design of VEs. Individuals with ASD may find rapidly changing environments uncomfortable, have difficulty in managing multiple input devices, and may have too short attention span for training [4]. In addition, interaction in a VE inherently involves a loss of degrees of freedom. Thus, people with ASD may feel a loss of control in the VE, which in turn could lead to self-injurious behavior. More broadly, some people with ASD might have difficulty in projecting themselves into imaginary situations [5]. But it is also known that people with ASD favor quiet environments with self-isolation [4]. So on the positive side, VEs may create a comfortable venue for training. These characteristics associated with individuals with ASD lead to new research questions.

Managing Discomfort and Motivation: Will virtual environments cause excessive discomfort? Will virtual environments feel like a secure place to individuals with disabilities? How much and how fast can the virtual environment change before it creates discomfort in individuals with disabilities? How many simultaneously moving items can be included in the environment? Will virtual environments increase or decrease motivation in individuals with disabilities?

Perception: Do people with cognitive disabilities perceive or interpret immersive virtual experiences differently? If yes, what are the implications?

Displays and Interaction: How can we adapt 3DUIs to make them accessible to people with cognitive and/or physical disabilities? Which existing 3D interaction techniques are suitable for people with cognitive disabilities? Should projection and/or head-mounted displays (HMD) be used? Which head mounted displays provide the most comfortable viewing experience for individuals with disabilities? Should isomorphic or non-isomorphic translation be used?

Realism and Training Transfer: How “real” must the virtual environment be to elicit realistic behavior from people with cognitive disabilities? What kind of realism should we emphasize; visual, movement, interaction? How well does training transfer from the virtual world to the real? How do cognitive disabilities affect training transfer?

Social Interaction: Can VEs improve socialization of individuals with ASD through practice with virtual characters?
2 Virtual Reality for Vocational Rehabilitation System

The system consists of the following components: a motion tracker that recognizes movements of the user via retro-reflective markers and surrounding cameras; a HMD that enables the user to see the virtual environment; a large curved screen to project the virtual environment for individuals who have problems with wearing HMD; a remote control interface implemented on iPad for the job coach; fixed physical environmental elements such as tables; and moveable objects with markers to enable tangible virtual interaction. A general view of the system can be seen in Figure 1.

Figure 1: Practicing job tasks in a warehouse environment. The user wears a head-mounted display to see the virtual environment. Infrared marker-based motion tracking allows the user to interact with the virtual world using natural movements.

The system will allow job trainers to rapidly assess the capabilities of individuals with severe disabilities and detect the most suitable job for them. Virtual environments can be constructed for a wide range of job scenarios and adapted in real-time to the specific needs of the trainee and the goals of the job trainer. Hence, users can train repeatedly on the same scenario in a safe environment. To provide effective learning and training, aids that are specific to needs of individual’s disabilities such as pictographs and flowcharts are used. To motivate and encourage the user, gamification techniques are applied to tailor the system to users’ special needs and disabilities.

The current system includes three virtual training environments, a warehouse, a convenience store, and a hotel room. Each of these environments are common employment environments for our target population and significant opportunities exist to grow the employment of people with disabilities in these job environments. Warehouse and hotel room VEs can be seen in Figure 2. These VEs are designed to be as similar to real environments as possible to minimize confusion when the individual transitions from virtual to real job environments.

Figure 2: Job environments. Left: Virtual warehouse job site. Right: Virtual hotel room job site.

Many individuals with cognitive disabilities have fears or irritations that affect their job performance negatively such as lightning and noise. The system will allow job trainers to insert common distractors that trigger these fears or irritations. Job trainers can then help trainees learn how to handle these fears or irritations before starting a real job which may prevent potential severe outcomes. Several measures will be used to assess trainee job skills and acceptability of the virtual reality environment such as accuracy of the performed task, number of prompts given, number of achievements, task completion time, improvement over time, response to distractors, work tolerance, number of job possibilities, and number of job placements.

Expected major outcomes of this study after its completion include an effective virtual reality job training system and a trained workforce consisting of 15 individuals with severe disabilities. Other outcomes can be listed as follows: identifying distractors that affect trainee performance negatively; identifying ways to use the virtual environment to help trainees overcome these distractions; finding the most suitable job for the trainee based on the conducted assessments; training the individual to do a job, even when common distractions are present; and placing the individual at a real job.

3 Challenges

Since this study focuses on training individuals with disabilities for various job related tasks using virtual reality, many of the previously proven techniques of 3DUIs remain ineffective. There are various anticipated challenges that are related to the mentioned system. Providing the most realistic virtual interaction and navigation for people with disabilities is a major challenge of this study. Combining tangible and virtual interaction gracefully for people with disabilities is another challenge. Offering the most comfortable head mounted display experience for people with cognitive disabilities is also another challenge of our study since some individuals with disabilities may feel trapped or bothered when wearing a HMD.

4 Conclusion

In this paper, design and development of a virtual reality system providing virtual experiences that aid in vocational rehabilitation of individuals with severe disabilities is presented. Little research on using virtual reality for vocational rehabilitation of individuals with disabilities exists, and previously proposed guidelines for people without disabilities may not work well for people with disabilities. In exploring how to make VEs work for people with disabilities, we aim to expand VE based training to all individuals.

References


