A Collaborative Assembly Task to Assess Worker Skills in Robot Manufacturing Environments

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ABSTRACT

In recent years robots have been replacing human workers in many industries. As robot manufacturing becomes more optimized and cost effective, the use of robots is going to evolve in various fields. Thus, it is essential to prepare workers to operate robots and work collaboratively with them side by side. In this paper, we are proposing a human-robot collaborative task to assess human performance in experimental, industrial setup. The task is designed in both virtual and physical environments.

CCS CONCEPTS

•**Human-centered computing** → **Human computer interaction (HCI); Collaborative and social computing;**

KEYWORDS

Vocational Training, Virtual Reality, Human-Robot Collaboration, Assembly Jobs.

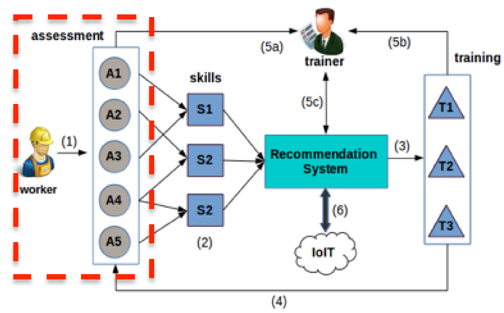

Figure 1: System Architecture.

1 BACKGROUND AND RELATED WORK

In 2017, the number of industrial robots around the world was projected to be around 1.9 million robots [9] and this number is expected to increase as the cost of robots decreases. The McKinsey Global Institute (MGI) predicts that the United States workforce by 2030 will be around 166 million, and it predicts that up to 73 million will be displaced and 48-54 million will need to change occupations due to rapid automation [3]. In recent years, there has been a revival of concerns that robots and automation are leaving many workers jobless. Workers who lack the skills and training are effected the most. A critical factor in improving manufacturing productivity is dependent on how well the workers' skills are suited for the jobs they seek. The need for personalized training and accurate job matching is particularly evident in manufacturing industries. Thus it is very crucial to prepare workers with the skills and training to be able to operate and collaborate with robots.

Virtual Reality (VR) is a promising technology for training and assessment of various vocational scenarios. VR is used for multiple vocational training areas ranging from manufacturing industries [4] to medical areas [2]. [8] uses VR as a platform to safely train mine workers whereas [5] discusses how VR is used to train mine workers fire escape. VR is also used to train workers with health issues and prepare them for job interviews [6] as well as vocational rehabilitation [7]. In manufacturing industries, assembly tasks are dominant. Hence, we chose an assembly task. The task assesses the user's ability to assemble furniture, a nightstand table in particular.

2 SYSTEM ARCHITECTURE

In this paper, we partially discuss the assessment phase of a large project on building a smart vocational assessment and intervention service system , called *iWork*, that assesses a worker's needs for training and rehabilitation in an experimental setup that simulates a factory [1]. Figure 1 shows the closed-loop architecture which consists of four phases: assessment, recommendation, training, and evaluation. This paper partially discusses the assessment phase, which is surrounded by a red dashed box. Based on the workers' assessment, their skills are measured and they are recommended specific training tasks to improve their performance. Then, the performance is evaluated and they are given new assessment tasks based on their performance evaluation.

3 ASSESSMENT FRAMEWORK

In this framework we propose two assessment tasks: Virtual Reality task and Physical World task. The main goal of the proposed tasks is to assess the user's task completion abilities in two different environments. The task is to assemble a table while collaborating with an industrial robot. To measure user performance in both tasks, the completion time, errors (e.g., dropping or failing to pick up a block, picking the wrong block, placing the block in the wrong place, etc) and the number of help requests are recorded. With these performance measurse and extensive surveys, we will be able to measure metrics (e.g physical capability, knowledge, overload, stress, morale, fatigue, competence, experience, etc.) that can be used to assess the workers.

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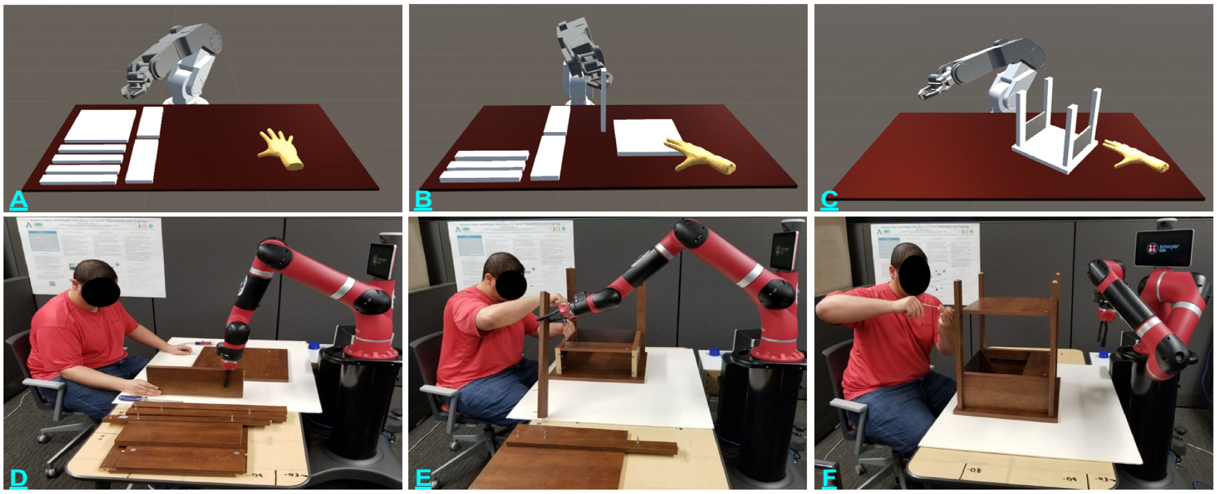

Figure 2: The first row (A, B, C) shows the virtual version of the furniture assembly task, and the second row (D, E, F) shows the physical version.

3.1 VR Task

As shown in Figure 2A-C, the user needs to assemble a table with a set of blocks. The robot gives the user one part at a time and the user then assembles it. As soon as the user completes the assembly of given parts, the user hits the *Next* button in the VR environment and the robot gives the next part. The user can also use the *Help* button to ask for instructions if stuck. An audio-visual feedback is given to the user to guide him/her on how the two parts should be assembled. VR headset HTC Vive is used along with Leap Motion to translate user's actions. The task is complete when the table is completely assembled, Figure 2C. The skills measured in this task are cognitive, collaborative and attention skills.

3.2 Physical Task

The physical task setup is very similar to the VR task setup, Figure 2D-F. The robot initially gives 2 parts to the user to be assembled. When the parts are assembled, the user presses the *Next* button and the robot gives the next part. Similarly, audio-visual instructions are given when the user presses the *Help* button. This task measures physical, cognitive, collaborative and attention skills. Both the Sawyer robot and Wizard of Oz technique are used in this task.

4 DISCUSSION AND CHALLENGES

Human-Robot collaboration (HRC) is a very challenging task that has many concerning issues. The first issue is the human safety. In manufacturing industries robots are usually caged in designated areas away from workers, and the robots automatically shut down when workers enter these areas. The large size and high speed of these robots can cause fatal injuries to workers if misused. Furthermore, making the robots detect, pick and handle objects with high accuracy, avoid collision with a collaborating worker, detect human errors, provide assistance, and adapt to user's skills and performance makes HRC more challenging. Thus, in the first stages of this project we are proposing to use the Wizard of Oz experimental technique, where a human administrator controls the movements of the robots remotely. The VR task does not have these issues, but it cannot provide the same hands-on experience as the physical task. The advantages of VR are that VR is cheaper, more convenient to the user and it does not require the presence of an administrator and expensive equipments.

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