PROSSEIA-VR: Training in Virtual Environments

Luís Grave, Cristina Escaleira and Adérito Marcos

German Abstract

Die Virtual Reality (Virtuelle Realität oder VR) wird für viele Anwendungen in der Industrie eingesetzt. Allerdings sind diese Anwendungen nur für gut geschultes Personal oder VR Experten entwickelt worden. In den letzten zwei Jahren hat das CCG bei einem Schulungsprojekt für unerfahrene Benutzer aus der Industrie mitgemacht. Der Industrie-Partner dieses Projekts operiert im Bereich elektrische Leitungszusammenbauten für die Auto-Industrie und seine unerfahrenen Mitarbeiter haben spezielle Schulungsanforderungen. Die Neueinrichtung von Produktionsbändern ist extrem zeitaufwendig, denn die Arbeiter müssen die neuen Arbeitsschritte erst einüben. Besonders während der Anlaufphase in der noch wenig Leitungen produziert werden, stellt dies ein Problem dar. Das Prosseia-VR System schafft eine immersive virtuelle Schulungsumgebung, in der die meist unerfahrenen Arbeiter ihre zukünftigen Aufgaben üben können, bevor sie am tatsächlichen Laufband arbeiten. Mit dem System können sie jeden Arbeitsschritt solange wiederholen, bis sie die Aufgaben ordentlich ausführen können.
Das Prosseia-VR System integriert verschiedene Interaktions-Metaphern für die sehr präzisen Arbeitsgriffe wie etwa das Erfassen von Leitungen und kleinen Teilen, das Zusammenbauen, die korrekte Positionierung der Teilchen, etc. Das System maximiert die Speicherung der Gestik für den jeweiligen Werkplatz, die Mitarbeiter müssen dann nur noch die verschiedenen Aufgaben wiedererkennen und die gespeicherten Gesten korrekt ausführen.

Introduction
The Virtual Reality (VR) field can provide a wide variety of industrial applications. We can find several examples in the automobile industry, where VR is used for tasks like design, wind tunnel simulators, assemble/disassemble, etc. However, all these applications are designed to be used by VR experts, or well trained personnel. This happens because the VR devices and the VR interaction metaphors are not yet well developed to fulfil the needs of an inexperienced user, like robustness, failure recovery, easiness of use. All these aspects have to be resolved before an inexperienced user can effectively use such a system.

In the last two years, CCG has been involved in an industrial project aiming to solve, at least partially, this problem, targeting the training on wire twist assembly for the automobile industry.

Motivation
The industrial partner in this project is an electric cable company, with specific training needs: they have their assembly lines changing often and is not feasible to set-up physical assembly lines just for training purposes due to time and cost constraints.

The VR system can provide this company with a solution for their training needs, by enabling the workers to train for their tasks before going to the real assembly lines. With such a system, they will be able to repeat each task separately until they are able to carry out the work properly.

The VR system helps the line operators out to memorize the sequence of operations, and to learn the exact gestures needed to find the pieces and the wires needed at each workspace. Therefore, at the real assembly line they only have to repeat at what they have learned before.

Specification
Each workspace in the assembly line integrates a panel where the pieces and wire have to be placed in the correct sequence and position, within a precise period of time. Workers at the assembly lines perform two main elementary operations: inserting pieces into the assembly panel and connecting these pieces with wires. The Prosseia-VR system has to cover the training of all the steps associated

Figure 1: Overview of the Prosseia-Virtual Training Environment

with these two elementary operations, namely:
- Recognition of pieces and wires
- Recognition of their correct positions in the buffer and in the panel
- Ability to execute the correct body movements necessary to take an object from the buffer and to insert it in the correct position in the panel
- Memorization of the correct sequence of operations to be performed.

The first requirement – recognition of pieces and wires – can be easily solved with good 3D modeling. The other requirements need a more careful analysis in order to integrate them effectively in the VR environment. We need actually metaphors that can improve and maximize gesture memorization.

Interaction devices
The interaction devices used in the Prosseia-VR system are:
- Kaiser XL50 HMD for enabling a full immersive system
- Flock of Birds tracking system for the track of head and hand of the user
- 18 sensors CyberGlove for interaction with the VR system

The choice of these devices has been dictated by previous studies taking into account factors like user-friendliness, simplicity and cost.

Figure 2: Interaction devices

Interaction metaphors
Having constraints like the ones mentioned earlier we designed a set of interaction metaphors that can be used efficiently by inexperienced users, in a short time period.

For picking one object, the developed metaphor resembles the »real« gesture: the user only needs to touch the object with the thumb and the index at the same time to grab the object. The object will be released when one of these fingers ends the contact with the object. The tests conducted with this metaphor have proved useful and the users only faced problems in picking small objects (at millimeter level), due to the calibration of the glove.

In connecting, for instance, a wire to one piece, the precision of the movement required to perform the real task has been dropped. It is not feasible, with the actual gloves and tracking systems to obtain such millimeter precision. But the main problem remains – we need to train operators to perform correctly the exact sequence of operations – so the connection is done by releasing the wire while he is colliding with the piece. To aid the user in piece identification, the target piece is highlighted when the wire is colliding with it. In this way, the users can concentrate in remembering the object positions and the operations sequence, instead of being distracted by confusing connection procedures.

Finally, in order to simplify the wire manipulation, it has been modeled as a small sphere, that can be used to establish the connection between several pieces, like a drawer draws a polygon by specifying point by point.

The most difficult physical operations to simulate in the immersive virtual environment were the beginning and the finishing processes of wire insertion between two pieces. After some effort and investigation research has been developed a metaphor that performs a zooming process every time a user introduces a wire into a small hole of the piece. When the wire is in the correct proximity, the application responds with a trigger that zooms to a large scale the size of the piece. This allows the user to pick the correct hole to connect the wire. When it is

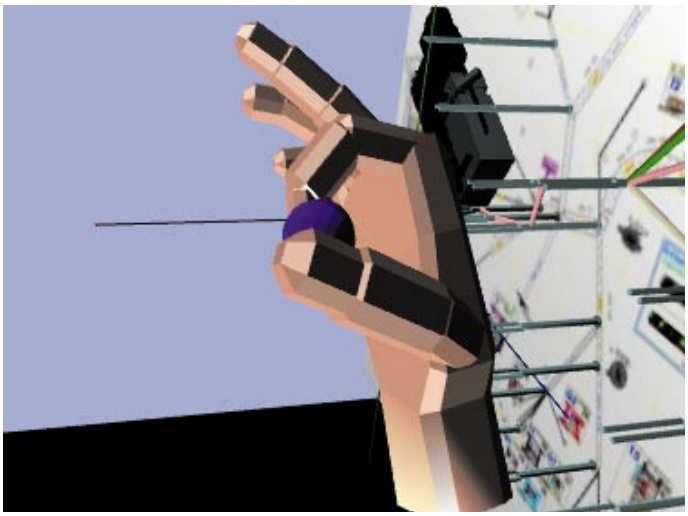

Figure 3: An aspect of the picking metaphor

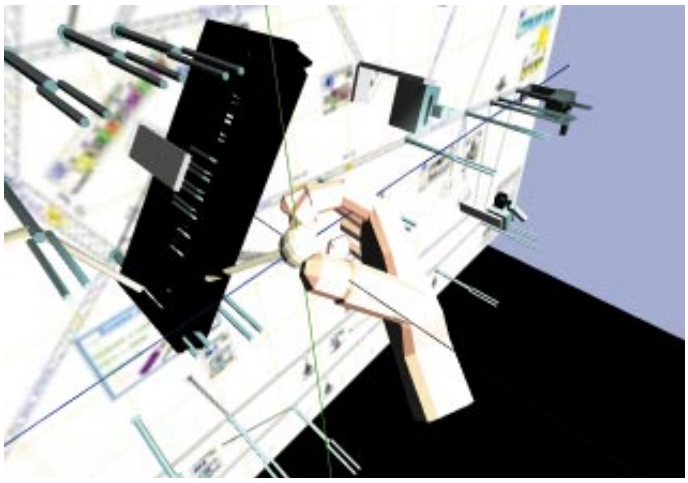

Figure 4: The sphere representing the wire

finish, the piece returns to its original size. Just to get a better idea of the complexity of the pieces, the average of holes in one small piece is about 20 holes of 0.3 cm diameter each.

For aiding the user in their tasks, a tool for indicating the next object as been developed using three color lines centered in the next object to be used in the assembly process.

Results

The tests conducted with VR experts and workers coming from the real assembly line (without VR experience) proved that is possible to train a considerable part of the assembly operations using this system. We found that assembly workers, without prior technology knowledge, can easily use the Prosseia-VR system and significantly reduce the time required to learn how to assemble a new wire. The same gestures used on the real assembly line are also used for the VR training session, for instance, when picking an object from the buffer. In the face of these results, CCG is planning, together with the industrial partner, to complete the work started by introducing more operations into the system, to obtain a fully functional training system. This opens a new relationship between VR and the industry, allowing further developments in the field.

Conclusion

If in 2D we have already a large set of interaction metaphors like the desktop metaphor, the point-and-click metaphor, the drag-and-drop metaphor, etc., that can be used by technology inexperienced users. In 3D applications there is immense scope for future developments. The researchers in this area need to solve several questions before we can have a full set of interaction metaphors that can be used effectively. The industry is primarily interested in solutions targeting profit instead of purely promotional solutions.

Points of contact

Prof. Adérito Marcos
CCG, Guimarães, Coimbra, Portugal
Email: Aderito.Marcos@ccg.pt

Luís Grave
CCG, Guimarães, Coimbra, Portugal
Email: Luis.Grave@ccg.pt

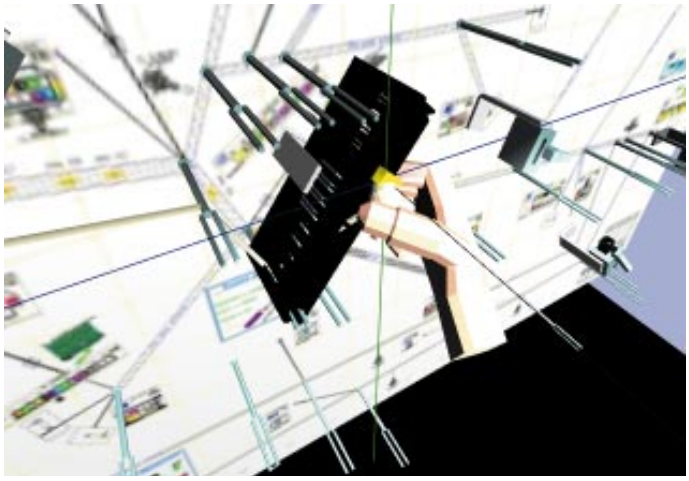

Figure 5: The zoom and help effects