Evaluating the influence of interaction technology on procedural learning using Virtual Reality

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ABSTRACT

Within the context of industry 4.0, this paper studies the influence of interaction technology (Vive controller and Knuckles) on manufacturing assembly procedural training using Virtual Reality. To do so, an experiment with 24 volunteers have been conducted and these participants have been separated in two groups: one using Vive controller and the other using Knuckles. Our conclusions are based on two indicators: Time to realize all tasks and the number of manipulations. This study shows that, after get used to, volunteers using Knuckles are faster than the other group but for some very delicate tasks, they need more manipulations to succeed.

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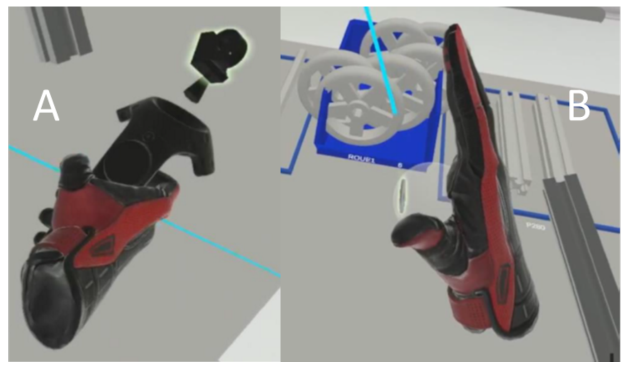

Figure 1: Visualization of manipulation with Vive controller (A) and Knuckles (B)

1 INTRODUCTION

In the context of Industry 4.0, the use of digital tools based on digital twin, augmented or virtual reality is growing. VR is used, for example, for facility layout 5, process and workstation design [2, 3] or for training operators on assembly or maintenance operations [6, 8]. VR training experiences could be impacted by numerous parameters like the training scenario, the fidelity of the simulation, the used hardware (input and display devices), . . . [4, 8]. In 7, authors study the influence of input devices (mouse, haptic, motion capture devices) on the learning of assembly procedures in VR. With the democratization and technological evolutions of VR headsets and controllers, they are more and more used for industrial VR training but there is still few study on the impact of these input devices on the assembly training experience.

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2 EXPERIMENT

2.1 Goal

The main goal of this study is to observe the influence of two controllers (HTC Vive controller and Knuckles) used with HTC Vive VR headset on virtual assembly training. To do so, we have set up an experiment, involving 24 volunteers, on a manufacturing assembly VR application 1. This application is a digital twin of 5 workstations where operators need to follow a sequence to assemble part of a bike.

In this experience, we focused our attention on 2 workstations (n°2 and n°3) of 5 in order to limit the experiment duration. There are 8 tasks on workstation n°2 and 6 tasks on workstation n°3. The 2 main studied parameters are the assembly duration and the number of manipulations that can vary due to mistakes and misread instructions.

A first difference between these two controllers is that with Knuckles, we can simulate haptic feedback. So, if the candidate wants to grab an object, he can squeeze his controller. Moreover, the candidate will see a visualization of his hand in the virtual environment without the controller like it can be seen in 1. Also, these two controllers have very different ways to grab objects so the aim of its study is to explore the influence of the controller on Virtual assembly training.

2.2 Description

In this part, we will describe the experiment process with 6 steps. The all process is during around 2 hours per participant.

The first step is the reception of the candidate and the presentation of the experiment. The most important is that all volunteers have same information. The second step is a 10 min upstream survey. The goal here is to identify if volunteers are comfortable with Virtual Reality, video games or do-it-yourself. Our predictions are that volunteers comfortable with theses will be faster than others. By identify them, we can remove this factor of our study. The third step is an initiation to VR. To do so, volunteers will learn to move in a virtual environment and grab virtual objects for 10 to 15 min. We have chosen to do this step because we want that every candidate can be a minimum comfortable with VR. Thanks to this step, we can reduce time manipulation due to the discover of VR during the main step of the experiment. The fourth step is the main step of this experiment. In this step, volunteers are asked to assembly parts of the bike. Volunteers have between 30 and 45 minutes to complete all the task. During this part, we measure the time for each task and the number of manipulations to complete each task. The fifth step is a 20 minutes downstream survey. Here, we collect data on their self-evaluation, on the simulation software and the use of the VR equipment thanks to a System Usability Scale and on their overall impression thanks to a User Experience Questionnaire. The final step is mainly an exchange of 15 minutes with candidate. This step doesn't allow us to collect data for our experiment but it is important that we take time for them to exchange.

3 RESULTS

A T-test has been run with data collect on each workstation separately. It appears that the difference of time between the two technologies on the workstation n°3 is significant (p-value = 0.035>0.05). As it can be seen on Figure 2, volunteers of the Knuckles group took lees time to realize all tasks on the workstation n°3 than the other group. However, it's not true for the workstation n°2.Our thought is that, after getting used to the virtual environment and used to manipulate, the group using Knuckles is faster to complete their tasks than the Vive group. To verify this hypothesis, on the next session, we'll exchange the order of workstation. However, differences of number of manipulations aren't significant.

Finally, we have compared task per task to define if there are significant difference on type of task for both technologies. Over the 14 tasks, 3 of the workstation n°3 are significantly done faster by the group of Knuckles.

These results are in line with our previous conclusions. Regarding the number of manipulations, there is only one task where results are significant according to T-test (p-value =0.047). This task is a very delicate one on workstation n°2. As it can be seen on Figure 3, this task as been handled more efficiently by the group using Vive controllers than the other group. It can be explained by the fact that in this task, the space between two pieces to assemble is very thin. The cone of selection on the Vive interface allows participants to grab pieces with more precision than with the haptic one on this task.

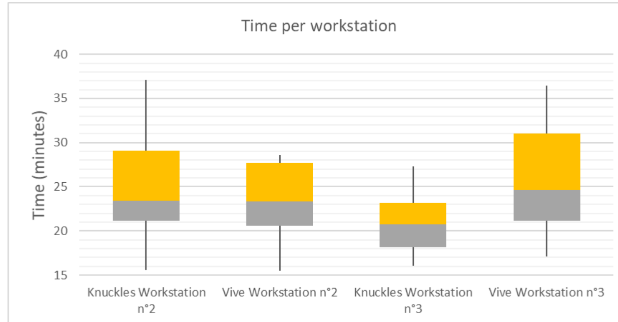

Figure 2: Boxplot of time per workstation for both technologies

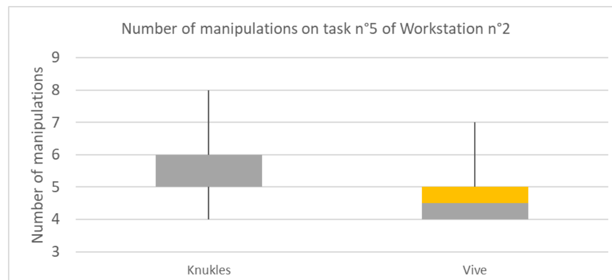

Figure 3: Boxplot of number of manipulations on task n°5 of workstation n°2 for both technologies

4 CONCLUSION

In this study, we have designed an experiment to measure the influence of controllers on time and number of manipulations when participant realize different tasks. With a total of 24 participants, we haven't measured a significant difference between the two controllers on overall time and overall number of manipulations. However, during the second part of the experiment, aka workstation n°3, spent time is significantly smaller for the group using Knuckles than the group using Vive controllers. Our hypothesis is that using Knuckles is faster and easier than Vive controllers but it can be seen only an amount of time spent on the application. To confirm it, we will switch the order between workstation n°2 and n°3. If the spent time on workstation n°2 is significantly smaller with the Knuckles group, it will confirm our hypothesis.

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