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Use of Delta Robot as an Active Touch Device in Immersive Case Scenarios

Damian Grajewski[a,*], Filip Gorski[a], Dominik Rybarczyk[a], Piotr Owczarek[a], Andrzej Milecki[a], Pawel Bun[a]

[a]*Poznań University of Technology, Faculty of Mechanical Engineering and Management, Piotrowo Str. 3, PL-60-965 Poznan, Poland*

Abstract

The paper presents a new approach to creating interactive simulations for testing tactile interaction with the user, which involves use of a low-cost device. The role of the haptic (touch) device and its functionality is achieved by using a manipulator with a parallel kinematic structure (Delta robot). This required the development of methods of integrating a robot with the selected Virtual Reality (VR) systems. Therefore, a new element was introduced into the virtual environment - a device to simulate real objects. In the Virtual Environment (VE), user interacted with a simulated object, and the task of the Delta robot was moving into a position which enabled the interaction. In this way, VE has become more responsive because it corresponded to the behavior of the user, who can move and interact with digital objects and directly experience their physical properties (e.g. size, shape). According to the authors, this type of application will be able in the future to support the effectiveness of virtual training, with particular emphasis on educational simulation (e.g. to perform procedural tasks).

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Keywords: Virtual reality; Delta robot; Immersive simulations; Virtual training

1. Introduction

Nowadays, virtual and haptic technologies are solutions that are used in supportive role in many branches of industry, starting from the military industry, through the e-entertainment industry, medicine, education, to

* Corresponding author. Tel.: +48 61 665 2718; fax: +48 61 665 2774.
*E-mail address:*damian.grajewski@put.poznan.pl

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engineering. One can observe the use of Virtual Reality (VR) as a set of techniques to prototyping new devices (military vehicles, weapons). Virtual Environments (VE) are also used to build interactive simulations (including the conditions of combat)[1]. When it comes to e-entertainment industry, it is mainly about the use of interactive devices for computer games, so the level of interaction in the virtual world of games, from the perspective of the user reached a value that was previously unseen. In the medical industry, Virtual Reality solutions found their application in medical engineering (prototyping of medical devices, medical infrastructure aided design)[2]. For several years virtual technologies have been used to create interactive educational applications for medical environments[3,4,5,6] to build specialized surgical simulators and virtual simulations of treatment procedures[7,8,9,10,11] as well as to create applications for rehabilitation of patients[12,13].

In the field of mechanical engineering and production engineering, VR solutions effectively support primary processes of designing products and processes. Virtual environments enable real-sized, realistic visualization of CAD data of the product, among other things to optimize the entire design before manufacture, and enable diagnosis of environments in which the products will be used. When it comes to support of the process design, virtual reality provides tools for simulation, analysis and optimization of manufacturing and assembly processes. These technologies are also increasingly used to conduct research in the field of design of ergonomic workplaces[14]. This is possible thanks to the large possibilities of intuitive, realistic interaction with VR environments, which can contribute to broadening the scope of research on the one hand, and to reduce the costs associated with the production of physical prototypes of workplaces on the other hand.

One of the most developing areas of the use of Virtual Reality in production engineering, are interactive systems for industrial training. Until recently, a major constraint on development of virtual training applications was the cost of such a device. A significant increase of interest in VR solutions (mainly from the e – entertainment industry), led to development of many new low-cost VR devices (for example low-cost Head Mounted Displays – trend started by the Oculus Rift device). As a result, the VR technology became more widely available, which also has its impact on solutions for virtual training applications[15,16].

Virtual simulation as a training tool, is used more and more in cases where traditional training may compromise the health and life of the trainee, or in situations where implementation of the training requires large investments. Modern IT tools can help generate virtual environments, which are complex both visually and logically. Therefore, interactive VR systems allow the user to interact with elements of the created three-dimensional world.

VR solutions can support traditional methods of training procedural tasks[17,18,19,20,21,22,23,24]. VR systems can be successfully used to improve efficiency, quality and productivity of a trainee. The user can interact with virtual object, feel the collisions, and, what is the most important, consistently practice tasks and “learn by doing”. In this way it is possible to obtain a ready-made solution, so that a trainee can practice until a satisfactory level of efficiency at a given task is reached.

Analysis of potential of VR systems as environments dedicated to interactive simulations, with particular emphasis on user interaction with the virtual environment, leads to the identification of different approaches in the creation of virtual applications and training systems. There are two main approaches – an immersive one, where user is free to walk around and is using immersive gear (e.g. a Head Mounted Device) and a haptic one, where user remains stationary as he is manipulating with a force feedback device. These approaches will be presented in detail in the next part of the paper.

This paper presents a new approach to build training VR applications, focused on touch-based interactions in immersive environment. Usually building solutions that integrate haptic and immersive approaches requires very high investments, especially in hardware, and is very rarely practiced. The authors present a new approach, with use of low-cost robot as an active haptic device.

2. Basic approaches to VR training simulations

2.1. Immersive approach

Immersive approach involves use of advanced systems for stereoscopic visualization, which are integrated with tracking systems. In the case of interactive training for industry, it is an immersive simulation of the selected workplace, prepared on the basis of the CAD model. The scenario of such a simulation takes into account the