The Efficiency of Medical Volume Data Processing Using Virtual Reality

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Abstract: The paper shows pilot studies aimed at examining the effectiveness of volumetric data processing in a virtual environment compared to standard solution. The speed and accuracy of the users' actions in the environments were analyzed.

INTRODUCTION

Medical volumetric data (e.g. MRI, CT, PET) are problematic for intuitive visualization on two-dimensional monitors [1,2]. Therefore, the search for innovative solutions, which would allow for more intuitive processing of this type of data, is continued [3]. One of them is the virtual reality (VR) on which the research presented in this paper is focused [4]. Modern methods of interaction available for these solutions enable more intuitive influencing volumetric objects and operating them in a way that is inaccessible to conventional solutions [5]. VR imaging technology is based on the Head-mounted display (HMD), which displays images for both eyes of the user [6,7]. Based on a set of sensors, the current position and orientation of the HMD (and thus the human head) are passed on to the system, which in turn updates the image displayed to the user [8]. Using the HMD tool, the user moves to the virtual world where he perceives objects in an analogous way as in reality [9,10].

MATERIALS AND METHODS

A virtual environment has been created for the study. The hardware configuration included HMD HTC Vive and the entire SteamVR Lighthouse Tracking System. Leap Motion was used as a manual positioning system for the user. This device was permanently mounted on the front of the HMD. The created software made it possible to initial examine the ergonomics of using this type of solution in comparison with conventional monitor applications. The interaction possibilities of a virtual center with volumetric data are presented in Figure 1.

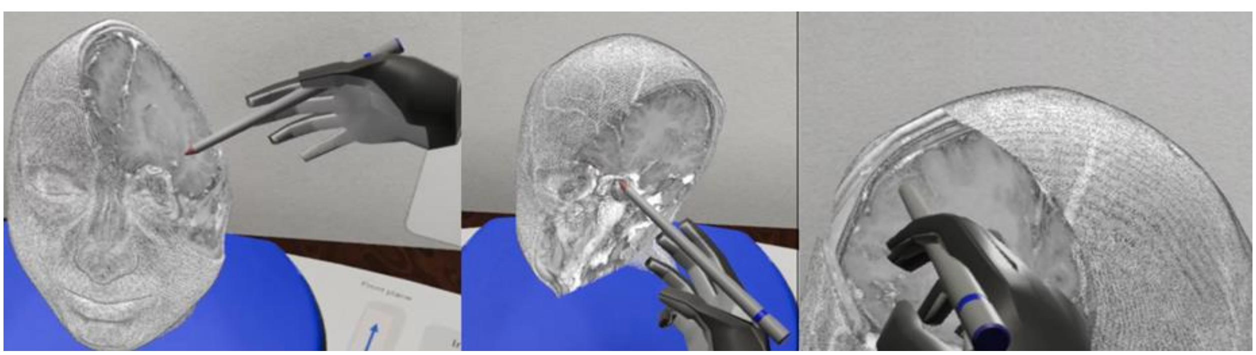

Fig.1. The interaction possibilities of a virtual environment with volumetric data

During the study, volunteers familiarized themselves with both environments and then determined the position of the defects previously applied to individual volumetric data (same data for all participants) in five consecutive tests. Each test consisted of medical imaging data and a defect marked on it. Participants were instructed to try in the shortest possible time and with the greatest accuracy to determine the position of the found defect. The supervisor of the study conducted time measurements and noted down the observations provided by the participants. The group one (n=5) first performed detection using conventional method and then in the virtual environment. The second group (n=5) in reverse order. Thanks to the division into groups and conducting tests in reverse order, the sequence of tests (2D and VR) and was shown not to affect the results in particular groups. The lack of influence of the sequence on the results in both groups made it possible to take into account all the tests carried out by the participants - 10 tests in conventional systems and 10 in VR. In both environments, the participants were searching for defects in the image data and then they were determining its exact position in relation to the proposed coordinate system. For each user, the following were measured: the time of mastering the environment to the degree allowing for the detection of the defect, the time of determining the position of the defect on the projection of three planes, and the error in determining the position of the defect by the user was determined. These variables were collected using the built-in timer.

The tests were carried out based on the head's MRI data. The spatial resolution of the image was 526 microns per voxel in 304 slices. Used image acquisition protocol was based on a standard spin-echo sequence. All statistical analyses were performed by using software (StatSoft Statistica for Windows, version 13.3; TIBCO Software Inc, Palo Alto, CA). Statistical significance equal to 0.05 was used in the analysis.

RESULTS

The research carried out was a small-scale pilot study in which we proved sufficient statistical significance to draw the early conclusions. Studies have shown that the average duration of volunteer training was 48% (P =.07) faster for VR software. In the event of further tests, the volunteers needed less and less time to determine the location of the defect. This trend was noticed in both environments. The average time needed to detect a defect was 25.43% (P=.04) faster for VR software. However, the analysis of defect determination errors showed that users made an average of 26.5% (P=.05) fewer errors in 2D applications. Based on the initial results, it is possible to plan larger-scale research to study the abovementioned dependencies more precisely.

DISCUSSION

The analysis of research results in the aspect of training time indicates that the intuitiveness of a VR solution close to human perception makes it possible to significantly shorten the time of training employees in the use of software. Research in the aspect of time needed to determine the position of the defect showed that the tool placed in 3D space is more effective, which translated into shorter search time and determination of the position of the defect. More significant errors in identifying the position of a defect in a VR application compared to a classic 2D solution indicate the imperfections of current VR technology solutions. Another limitation of the study was a small number of participants. In the future, it would be recommended to conduct research with a large group (n > 100), as well as to propose tests dedicated to medical personnel working on such data on a daily basis. Assuming that with the development of virtual reality technology the parameters of available HMD (resolution, fields of view, positioning precision and intuitive perception of VR technology) will be refined, it can be safely stated that these solutions will certainly be applied not only in visualization and interaction of volumetric data but also in many other fields of medicine. In the future, they will be a compliment or maybe a substitute for current solutions and will become a permanent part of medical imaging systems.

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