

A new 3D Interaction Concept for Radiological Image Analysis

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Abstract

In radiology, the interaction with medical image data is limited due to restricted degrees of freedom (DOF) provided by the common user interfaces that are based on the conventional computer mouse as main input device. This work presents an approach with additional DOF for the navigation through three-dimensional image data sets. The initial results show that more DOF can improve learnability and stimulation by providing a more direct interaction, but the developed prototype needs improvement with regard to input precision.

1 Introduction & Related Work

The diagnostic analysis of radiological images is currently mainly done using a conventional computer mouse as input device. While this approach might be sufficient for working on single two-dimensional images, it has limits with regard to navigating through the increasing amount of three-dimensional image data (Andriole, et al., 2011). An important visualization technique in medical 3D imaging is the creation of so-called oblique multiplanar reformations (*oblique MPR*) which allows the radiologist to freely define position and orientation of a sectional plane within the acquired three-dimensional image volume. Defining an *oblique MPR* plane can only be achieved with multiple separate interaction steps when using a computer mouse that only provides two degrees of freedom interaction. We present an approach that adopts the 2D approach of the computer mouse but features three additional degrees of freedom for the rotation of the MPR plane.

2 Methods & Materials

2.1 Interaction Concept

With our prototype, the user examines an image dataset with a pen-like device and a tablet as input devices to create *oblique MPRs* that are displayed on a normal computer screen (Figure 1). On the tablet, a 3D model is displayed for reference. Two modes are provided. In the first, “absolute” mode (T_{Abs}), the pen works like a sonographic probe (Figure 1, left). While it touches the tablet, the plane’s top follows the touched position and the plane’s orientation is determined by the pen’s orientation. In the second, “relative” mode (T_{Rel}), the changes of the pen’s position and orientation are added to the current plane’s position and orientation once the pen starts touching the tablet. It is also possible to move the plane in a parallel way with a slider on the tablet. In both modes it is possible to rotate the image volume to three different pre-set orientations. The pen was built using a normal touch pen, the Tinkerforge IMU Brick 2.0 orientation sensor (Tinkerforge GmbH, 2017) and a 3D-printed casing.



Figure 1: Basic interaction concept (left) and setup of the prototype (right).

For comparison purposes, we also implemented a common mouse-based interaction mode. Using the scroll wheel or pressing the left mouse button in combination with a drag motion scrolls the sectional plane in a parallel way. Pressing the right mouse button in combination with a drag motion rotates the sectional plane.

2.2 User tests

In an initial usability evaluation, the application was tested by 18 laypersons that had to perform three different tasks with each interaction mode. The tasks represent typical radiological tasks in a simplified manner to avoid the necessity of medical knowledge. To achieve this, several artificial objects were placed in an MRI data set of a head. In the first task, the participant had to align three spheres on a sectional plane that were randomly placed in the test data set (*Spheres on a Plane, SoaP*). In the second task, five spheres and two

ellipsoids were randomly placed in the test data set. The participant had to identify the correct number of ellipsoids (*Count Ellipsoids, CEI*). In the third task, five ellipsoids were randomly placed in the test data set. Two of them were distinct and had to be identified by the participant (*Count Extremes, CEx*). Before each task, each participant could briefly train with a neutral data set. For each task, the time needed was measured. After each interaction method, the participant filled out a standardised User Experience Questionnaire (UEQ) (Laugwitz et al., 2008).

3 Results

The participants appreciated the mouse control for its precision. Few participants used the full extent of the offered rotational options. Most of the participants described our absolute tablet mode (T_{Abs}) as intuitive and called it the most effective among the tested options. While lifting the pen from the tablet, the sectional plane moved unintentionally which led to some participants' opinion that this mode is too sensitive. It was, however, especially appreciated for a fast examination of a three-dimensional data set. In the relative tablet mode (T_{Rel}), the participants rarely used the slider for parallel scrolling. They often used the pen like in the absolute mode, i.e., without lifting the pen from the tablet. Many participants described the relative tablet mode as complicated, but also thought it could be the most effective mode, given enough practice, because of the ability to readjust the sectional plane. In both tablet modes, the participants mainly used the main monitor for orientation. The tablet screen received visual attention only when it was used to reset the scene. We also received some criticism regarding the size and weight of the pen.

The average time needed to complete the different tasks (Table 1, left) with the different input methods could not prove a significant difference with a t-test with an α of 0.05. The average error rate (Table 1, right) could not prove a significant difference either. The UEQ results (Table 2) show significant differences (t-test with an α of 0.05) between the mouse and absolute tablet mode in all categories except dependability. The mouse and the relative tablet mode do only have significant differences in the stimulation and the novelty, while the absolute and relative tablet modes have significant differences in the attractiveness, perspicuity and the efficiency.

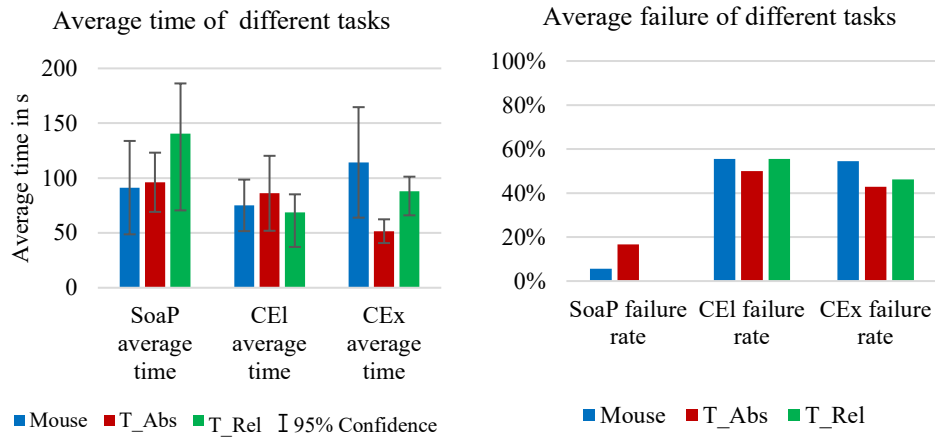


Table 1: Average time (left) and error rate (right) on different tasks

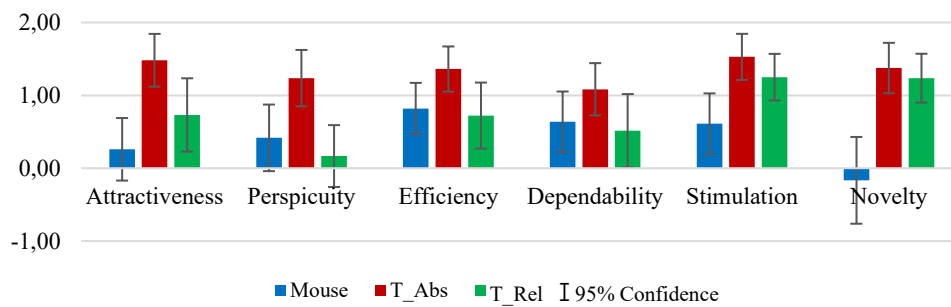


Table 2: UEQ results: Interaction method comparison (all tasks)

4 Discussion

While there was no statistically significant advantage of the presented approach with regard to efficiency or accuracy as compared to a conventional mouse-based user interface, our UEQ results show that the absolute tablet mode was deemed more effective and more satisfactory by our participant group. It was also the fastest and most accurate mode for the *Count Extremes* task. As our pen device was only a first prototype, we assume that the presented user interface approach can be a useful alternative to the common mouse-based approach for certain radiological tasks if the design and the accuracy of the pen are improved.

References

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