Fraunhofer IAO

Test Report: Ergonomic Evaluation of 3D Mice

Introduction

3D mice provide support for manipulating and navigating in CAD applications. Fraunhofer Institute for Industrial Engineering IAO was asked by 3Dconnexion GmbH to conduct a scientific study assessing the ergonomic benefits of working with a SpaceMouse Enterprise. Health related issues such as the strain of the hand-arm-system and the impact on the sitting posture as well as the usability and user experience were examined. Finally, the effect on the productivity was analyzed under laboratory conditions.

Methodology

The study was split into a laboratory study and a field study. The goal of the *laboratory study* was to measure and observe human factors issues, health-related issues as well as productivity. This part of the study was conducted with 14 engineering students of an advanced CAD course at the University of Stuttgart. The participants were on average 23 years old, 2 female, 12 male, all used the mouse with the right hand, although only 12 were right-handed, Ø 2 years of CAD experience, and none used a 3D mouse for more than testing purposes before.

The participants received a standardized and randomized CAD task to be solved under observation with a traditional setup of keyboard and mouse in NX 10. After a training period of one week with a provided 3D mouse, a second, similar task was given to be solved with a 3D mouse. The two tasks were of similar difficulty but required a different set of tools to solve. During the tasks all mouse movements and clicks were logged as well as the body posture monitored (see Figures 1 and 2).

Figure 1 Two participants working on a CAD task while the postures are being monitored

The *field study* was aimed towards professionals working with CAD software on a daily basis. The participants were on average 38 years old, 2 female, 8 male, all were right-handed, Ø 14 years of CAD experience (0.5–30 years), Ø 6 hours of CAD per day, 4 already used a 3D mouse by 3Dconnexion, the participants work as either engineers, designers, or consultants.

This part of the study relied on semi-structured interviews as well as the standardized and validated questionnaires SUS[i] and AttrakDiff[ii]. Similar to the laboratory study the two conditions of working with and without a 3D mouse were examined. The four participants already using a 3D mouse stopped working with it for three weeks. To the six participants not using a 3D mouse before, a SpaceMouse Enterprise was provided. The interviews were conducted before and after this three-week change of devices.

Results

Health

There is strong evidence that using a 3D mouse leads to healthier sitting posture—upright and supported by the chair—caused by having both arms on the desk while working in a CAD application (shown in Figure 2 as an example for one test subject). The positive effect in posture is supported by answers given in the field interviews.

As the 3D mouse takes over tasks traditionally done with the right-hand mouse, the load on the right hand-arm-

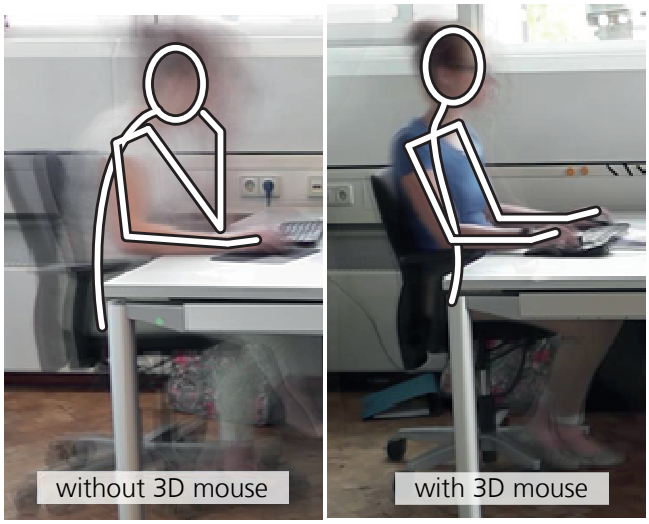

Figure 2 Change in sitting posture

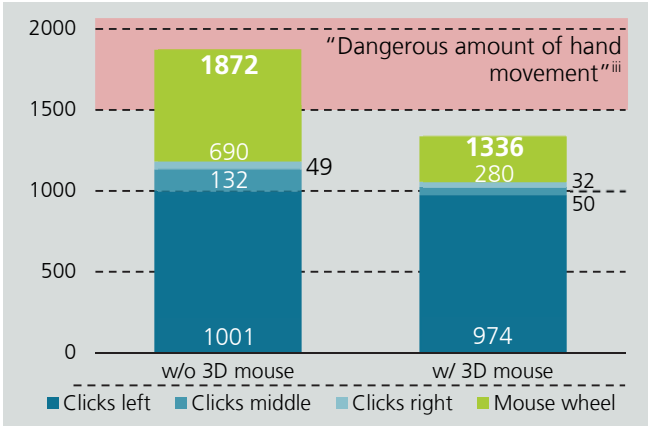

Figure 3 Finger movements per hour t(13)=2.52, p=0.028

system is reduced significantly. The number of mouse wheel movements (used in NX to zoom in and out of the model) is reduced significantly (t(13)=2.52, p=0.028), leading to a total reduction of finger movements by 28.6% (see Figure 3). This reduces the amount of finger movements from a "dangerous" level (over 1500 movements/hour[iii]) to an acceptable level.

The amount of mouse clicks and distance covered by the mouse was not reduced significantly during the laboratory study. However, it is expected that the amount and distance is reduced in a professional setting as the function keys are used more frequently and the traditional mouse is used less for navigating inside of the CAD application's menus. This hypothesis was confirmed during the field study by all participants, stating that the load is distributed more evenly on both hands. Three participants who had a tenosynovitis in the right arm reported decreased strain by using a 3D mouse.

Productivity

The productivity could be increased significantly under the condition of using the 3D mouse. The time necessary to solve the randomized task went down by 28% (from 96 minutes to 68 minutes to solve each task; t(13)=5.28, p<0.001) using a 3D mouse in the laboratory study. Two confounding factors may have influenced this result in both directions: the test subjects may have gotten faster using the CAD application due to more training. On the other hand, one week of part-time training is not enough to take full advantage of the 3D mouse and its functions, slowing the participants down.

In a professional setting the productivity between multiple workstations can be raised by providing a more efficient way of transferring the personal settings between multiple work spaces. For beginners the tutorial should be advertised more prominently and should go into greater detail to make the first steps easier.

Usability and User Experience

The workflow of using the SpaceMouse Enterprise in a professional setting shows an excellent level of usability with a SUS score of 86.3 compared to an only OK level of usability (SUS: 62.3) for the traditional workflow with keyboard and normal mouse.

The AttrakDiff questionnaire shows a very high level of user experience, with a high hedonic ("Is the product appealing?") and pragmatic ("Does the user achieve his goals?") quality as well as a high level of attractiveness for the end user.

After 1.5 weeks, five out of six participants described working with the 3D mouse as moderately difficult; after three weeks, five out of six participants described it as easy or very easy. The CAD experience was described as more "fluid" and more "harmonic" using the 3D mouse.

Participants using a 3D mouse for the first time (both in the laboratory and the field study) reported that the direction of the controller cap axes was not intuitive at first use. These users could benefit from better instructions on how to use the controller cap of the 3D mouse. Furthermore, the allocation of function keys to the explaining pictograms of the ondevice screen could be optimized by reducing the space between the two areas.

Summary

Overall the SpaceMouse Enterprise leads to a healthier posture and reduces the workload for the dominant hand-arm-system. It shows a high level of usability and makes working with CAD applications demonstrably more productive.

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[ii] Hassenzahl, M., Platz, A., Burmester, M. & Lehner, K. (2000). Hedonic and ergonomic quality aspects determine a software's appeal. *Proceedings of the CHI 2000 Conference on Human Factors in Computing.* The Hague, NL

[iii] Salvendy, G. (2012). *Handbook of human factors and ergonomics* (pp. 828-836). New York, USA: John Wiley & Sons, Inc.