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Applications of visuomotor control and visual awareness

Introduction

Psychophysical user studies in the field of visuomotor control can help us design better applications interfaces. We show three examples from the medical, the multi-media and air travel industry.

Example 1: Visuo-manual tracking for robotic environments

Visuo-manual tracking tasks measure human motor control and movement performance. Psychophysical studies can be used to measure the user's adaptation to a dynamic environment. Squeri et al. performed a dual task experiment: 1) Visuo-manual tracking of a moving target on a figure eight and 2) compensation of a robot-generated, motion-dependant force-field (force-feedback) [R2].

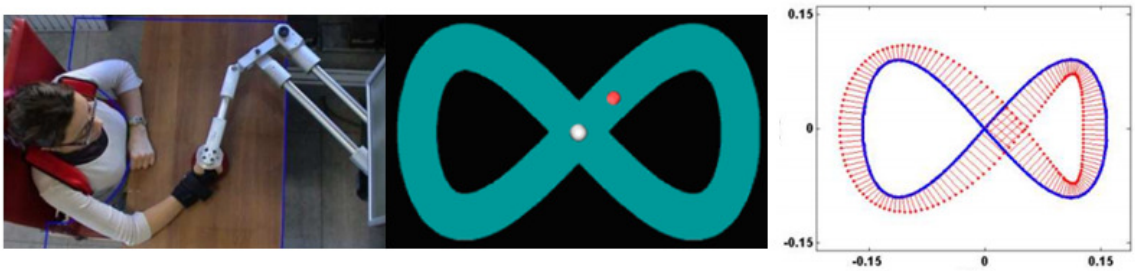

Figure 1: Experimental setup with robotic arm, visual feedback for target and position, robot-induced force-field

The target speed was dependent on the tracking error, in such a way that the task difficulty increased as tracking performance improved. Although the task is non-trivial the results indicated that the task can be learned in a coordinated way.

There are a number of potential applications making use of these results. We want to highlight on application in the medical field: the rehabilitation of neurological patients, which could be accelerated by dynamically increasing the difficulty of tasks similar to the one described in the experiment.

Example 2: Large screen spatial interaction: pointers in video conferencing

Barry et al. demonstrate in psychophysical experiments that pointing without visual feedback can be a useful interaction technique for large screen, immersive environments. [R4]. The results can be explained with the 'two-visual-systems' hypothesis, which suggests that localization and identification are tasks distinctly processed in the visual cortex [R5].

The authors found that for their experiment pointing without visual feedback might be less affected by spatial visual illusions than cognitive interactions. The theory was confirmed in a pointing experiment in which the amount of visual feedback was varied. In some conditions, such as the presence of a frame around the target display, the presence of visual feedback (e.g. laser pointer or mouse pointer) reduced the accuracy of the pointing accuracy [R4].

The results seems counter-intuitive at first, but has been confirmed independently in other studies [R6], in particular for application in which the user is close to the display.

An application that could benefit from the results is shared work spaces in video conferencing. Often a document is presented on a large screen, with video 'windows' of all participating parties in the periphery, either on separate screens or embedded into a single display. For such a system it would make sense to implement highlighting tools without visual feedback, such as gesture (pointing) recognition.

Figure 2: Pointing accuracy in shared documents might be improved by removing visual feedback, such as mouse pointers

Example 3: Visuo-manual tracking for airplane control

Several experiments have demonstrated that tracking and control tasks can be coupled with compensation tasks [R2]. An example of an application that requires an accurate coupling of visual and physical force feedback can be found in electronic airplane control

(often referred to as ‘fly-by-wire’). Military planes have used this technique since the 1950s using mechanical devices such as springs for force-feedback that estimates a physical quantity such as aerodynamic resistance [R7]. Modern passenger planes are also equipped with fly-by-wire technology. One of the biggest challenges is the coupling of data from sensors (e.g. position of the rudders) to a force-feedback control system. Svend Egenfeldt et al. developed a system to measure the force from air directly at the rudder and translate it into a proportional signal for a force-feedback system for the pilot [R8]

Conclusion

We have shown three distinct applications that make direct use of the results from user studies related to visuo-motor control.

References

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[R2] Squeri et al. “Visuo-manual tracking in a robot-generated dynamic environment.”

[R3] Knight. “Manual control and tracking”

[R4] Barry et al. “Pointing and Visual Feedback for Spatial Interaction in Large-Screen Display Environments”

[R5] Ungerleider et al. ”Two cortical visual systems.”

[R6] Poupyrev. “A Framework and Testbed for Studying Manipulation Techniques in Immersive VR”

[R7] Stengel. “Toward Intelligent Flight Control”

[R8] Svend Egenfeldt. “Fly-by-wire”