Habilitation Thesis

Computational and experimental aspects of rotatory eye movements in three dimensions

Author(s):
Haslwanter, Thomas

Publication Date:
2000

Permanent Link:
https://doi.org/10.3929/ethz-a-004418038

1 SUMMARY

Ey7e-, head-, and limb-movements in space have many degrees of freedom, and investigations of such movements are correspondingly complex. To simplify experiments and analysis, researchers initially restricted paradigms and recording devices to one-dimensional movements, for example purely horizontal eye movements. This has led to a remarkable understanding of one-dimensional movements, from the muscle mechanics to the underlying neural control system. However, many questions cannot be answered with one-dimensional investigations. Natural movements are executed in 3-dimensional (3D) space, and the control of such movements has to account for the resulting complexities and asymmetries. For example, horizontal and vertical eye movements change the direction of gaze, whereas rotations about the third axis, i.e. the line of sight, leave it unaffected. While the technological foundations for recording 3D movements were already laid in the 60s and 70s, it was not until 1985 that a convenient way to record 3D eye movements was available. At about the same time this technique was extended to animal experiments.

In my research I have built on this recent progress, and tried to turn the basic research findings into useful medical tools. The studies leading to my PhD involved early experiments on the control of 3D eye movements in monkeys. Our group also extended this technique to the recording of combined eye-, head- and arm-movements in humans. My post-doctoral research continued along the same lines: it aimed at improving the underlying technology and methodology for recording 3D eye movements, and extending the techniques to investigations of clinical problems. On the analysis side, I wrote some introductory and overview articles on the underlying questions and principles of 3D movement control and the mathematical tools required for the corresponding data analysis. In collaboration with an engineer I developed the basic algorithms that allow video-based systems to measure 3D eye position by tracking iral patterns. This line of work recently culminated in an international conference on video systems for 3D eye movement recording. In the more medical area of vestibulo-oculomotor physiology of healthy subjects, I have worked on teams concentrating on a better understanding of the peripheral stimulation of the vestibular system, and the control principles that underlie the processing of vestibular signals. The efforts to apply this improved understanding to the medical diagnosis of dizzy patients focused on the development of new tests for vestibulo-ocular pathologies, and on the effects of these pathologies on eye movement control.

The articles presented in this manuscript give a representative overview of the results of these efforts. They include nine reviewed and published articles, two newly written chapters (on eye position recording systems and on vestibular stimulators), as well as a short introduction to the field of vestibulo-ocular research.