Non Contact Eye-tracking on Cats

Christoph Kayser, Konrad Körding, Belinda Betsch & Peter König
Institute of Neuroinformatics ETH / UNI Zürich
kayser@ini.phys.ethz.ch

Introduction
The objective of visual neuroscience has shifted over the past years from determining the receptive fields of cells towards the understanding of higher level cognition in awake animals processing natural stimuli. In experiments with awake animals it is important to control the relevant aspects of behavior. Most important for vision science is the control of eye-movements and of the direction of gaze. Here we present Dual Purkinje (DPI) eye-tracking on cats, which is one of the most accurate eye-tracking systems and as a non-contact method does not require any surgery on the subjects.

A common problem with eye-tracking on non-humans is the calibration of the system. We present an objective method, not requiring the collaboration of the subject which allows accurate measurement of gain and offset. The DPI system, together with the proposed method for calibration results in a highly accurate system for measuring the eye-movements of cats.

The Dual Purkinje (DPI) Eye-tracking System

The Dual Purkinje eye-tracking system is widely used with human subjects because of its high accuracy and the fact that it does not require any surgery on the subjects. We show that the DPI system (manufactured by Fourward Technologies Inc., Buena Vista, VA 24416) can also be used reliably with head fixed cats.

The DPI measures the orientation of the eye using the reflection of an infrared light beam at the cornea and the lens, called Purkinje images.

Advantages:
High accuracy
No surgery
Insensitive to small displacements of the subject
High temporal resolution
Use with animals and humans

Disadvantages:
Expensive
Setup changes before use on cats
Technically complicated

Accurate and Objective Calibration

Every system for eye-tracking needs calibration. In contrary to humans, which can be told to fixate given spots, calibration with animals is more difficult. For cats we propose the following objective method for measuring gain and offset. It has the advantage to rely entirely on objective criteria and not to involve the cooperation of the subject.

The DPI system measures the orientation of the eye using the lens, called Purkinje images. The light of the flash is guided through a fiber optics cable placed right in front of the eye. The light is reflected at the cornea and illuminates a tangent screen. Then a photo of the reflection is taken.

Infrared light beam
Cornea
Purkinje images
Retina
Camera
Flash
Fiber optics

Infrared light is reflected at the front- and backside of the cornea and the front- and backsize of the lens. These reflections are called Purkinje images.

The DPI uses the relative positions of the 1st and 4th Purkinje to determine the orientation of the eye. Proper functionality requires the room to be darkened since the reflections are dim. The operation range furthermore depends on the size of the pupil.

Conclusion

We showed how the DPI system, which was previously used only with primates, can be used reliably with cats. Together with the proposed method for calibration it results in a convenient system for controlling the eye-movements of cats with a precision required for the electrophysiological study of early visual areas.