Chapter 55
Safety Issues and Infrared Light

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ABSTRACT

Infrared light is the most common choice for illumination of the eye in current eye trackers, usually produced via IR light-emitting diodes (LEDs). This chapter provides an overview of the potential hazards of over-exposure to infrared light, the safety standards currently in place, configurations and lighting conditions employed by various eye tracking systems, the basics of measurement of IR light sources in eye trackers, and special considerations associated with continuous exposure in the case of gaze control for communication and disabled users. It should be emphasised that any eye tracker intended for production should undergo testing by qualified professionals at a recognised test house, in a controlled laboratory setting. However, some knowledge of the measurement procedures and issues involved should be useful to designers and users of eye tracking systems.

INTRODUCTION: EYE TRACKERS AND INFRARED LIGHT

Infrared light is the most common choice for illumination of the eye in current eye trackers, usually produced via IR light-emitting diodes (LEDs). As we previously discussed, IR light is particularly suited to eye tracking because it is not visible to the human eye and is therefore comfortable for the user. IR light doesn't cause the pupil to contract and can also provide an image with sufficient contrast and quality for image analysis. Since levels of exposure to light can have various effects on the health of the structures of the eye, all light-emitting and eye protection products are subject to international safety standards. Infrared light levels must fall within safe exposure limits, set according to type and intended use. These levels are decided upon and continuously updated by international standardising bodies. In this chapter, we will look at how light affects the eye, potential hazards, rudimentary measurement of IR

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sources in eye trackers, and currently applicable standards. In the case of eye tracking, the usual hardware set-up involves one or more IR LEDs directed toward the eyes. These can be mounted on or beside the eye cameras but may be elsewhere or additionally mounted beside head cameras. Light source position, number, brightness, size, and distance from the eye all have a bearing on the safety calculations, so safety calculations must be made for all possible set-up variations, with worst-case scenarios assumed (e.g., the shortest possible distance between the eye and camera during normal operation) and with a single-fault criterion (i.e., assuming at least one failure or fault within the system).

This chapter provides an overview of the potential hazards of over-exposure to infrared light, the safety standards currently in place, configurations and lighting conditions employed by various eye tracking systems, the basics of measurement of IR light sources in eye trackers, and special considerations associated with continuous exposure in the case of gaze control for communication and disabled users.

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LIGHT AND THE EYE

The eye is designed by evolution to be biologically sensitive to natural light energy; indeed, this is the basis of vision. Therefore, the various structures and tissues of the eye are designed to collect and focus light on the retina. These structures and tissues are affected in various ways by light, and at intense levels, this effect may be adverse. Because of this, any light source intended for human use must be carefully tested and conform to safety regulations.

Natural Defence Mechanisms and Photobiological Effects

The eye is well adapted to protecting itself against overly intense broad-band optical radiation from the natural environment (i.e., ultraviolet, visible, and infrared radiant energy), and mankind has learned to use protective measures, such as hats and eye-protectors, to shield against the harmful effects on the eye from very intense ultraviolet radiation (UVR) and the blue light present in sunlight over snow or sand. The eye is also protected against bright light by the natural aversion response to viewing bright visible light sources. The aversion response includes blinking and/or head movements to avoid strongly perceived light. It normally protects the eye against injury from viewing bright light sources such as the sun, arc lamps, and welding arcs, since this aversion limits the duration of exposure to a fraction of a second (about 0.25 s).

The infrared LEDs employed in most infrared LED eye trackers do not, however, produce a strong aversion response, as they are barely visible to the human eye, and the spectral emission is limited to the near-infrared (IR-A, 780–1400 nm) spectral band. If a conventional incandescent lamp or discharge lamp that has been filtered to block most visible light and transmit IR-A is employed, some emissions of note are possible outside the IR-A range and must be evaluated separately.

Potential Hazards

In general, optical radiation safety guidelines identify at least five separate types of potential hazards to the eye from intense optical sources that normally must be independently evaluated to assure optical safety:

1. Ultraviolet photochemical injury to the cornea (photokeratitis) and lens (cataract) of the eye (180nm to 400nm): with separate measurements to be made in relation to each