Chapter 14
Methods and Measures: an Introduction

John Paulin Hansen
IT University of Copenhagen, Denmark

Hirotaka Aoki
Tokyo Institute of Technology, Japan

ABSTRACT
Understanding users’ behaviour is one of the most crucial aspects in successful design of human–computer interaction. Experiments with prototypes of gaze interaction systems provide valuable quantitative measurement of performances in terms of such factors as speed, error, and accuracy, in addition to the comments and suggestions we may get from users. We will introduce some of the research methods, metrics, and measures that have emerged within the field associated with the design of gaze interactive systems. Many of the methods and measures are inherited from an engineering approach to system design that can be found within the human factors tradition. Others are unique to gaze interaction, taking advantage of the extra information that can be gained when one knows where the user is looking. In this chapter, our focus will mainly be on efficiency measures for gaze performance.

INTRODUCTION
Understanding users’ behaviour is one of the most crucial aspects in successful design of human–computer interaction (e.g., Nielsen, 1993). Experiments with prototypes of gaze interaction systems provide valuable quantitative measurement of performances in terms of such factors as speed, error, and accuracy, in addition to the comments and suggestions we may get from users. This contributes to deeper understanding of the potential and challenges of gaze interaction, and experiments may guide developers to better designs.

Gaze interaction is a new technology. In this part of the book, we will introduce some of the
Methods and Measures

research methods, metrics, and measures that have emerged within the field associated with the design of gaze interactive systems. Many of the methods and measures are inherited from an engineering approach to system design that can be found within the human factors tradition. Others are unique to gaze interaction, taking advantage of the extra information that can be gained when one knows where the user is looking.

Within the next few years, gaze interactive systems are expected to become commodity hardware and not just for use in labs or by a few people with special needs (Hansen, Hansen, & Johansen, 2001). Introducing gaze interaction to a mass market may be quite a challenge, since the majority of people have no previous experience with gaze interaction that they can relate to. This is somewhat different from introducing other physical pointing devices – e.g., for a game console – that utilise well-established motor-control schemes for the hands, fingers, and arms; even head-pose pointing seems to be a natural human capacity that people readily pick up (Hansen, Johansen, Torming, Itoh, & Aoki, 2004). Gaze interaction is quite different from conventional interaction devices, because the motor control of the human eye is all geared toward acquiring information, not to manipulating the outside world. Consequently, the use of eyes for interaction activities such as typing, clicking, and entering commands may be rather confusing, at least in the very beginning. Many experiments have been focusing on the first encounter with gaze interaction, and some studies have been conducted as learning experiments to follow the effect of familiarisation (e.g., Tuisku, Majaranta, Isokoski, & Räihä, 2008).

The most basic gaze data formats are just raw co-ordinates \((x, y)\) on the plane – for instance, the monitor – that people are looking at. The co-ordinates are then analysed in time series as fixations and saccades. The co-ordinate data can be recorded through continuous logging, and several of the professional gaze tracking systems have facilities for this. The body of data generated can be quite massive, dependent on the sampling rate. Most systems sample eye co-ordinates more than 25 times per second, and some do so more than 250 times a second. Now, how do we elicit meaningful information from this large quantity of data to address the design questions we might like to ask?

Some of the questions that we may wish to ask could be:

- **How efficient** is the application of different gaze interaction principles? What design elements will have significant impact on efficiency? For instance, there is a major impact on typing speed if users of dwell time selection are given the ability to adjust the dwell time directly via the typing interface and not just in the general settings of the system (Majaranta, Ahola, & Špakov, 2009).
- **How difficult** is it to use gaze interaction for a prolonged time? What kinds of problems are transient, and which problems are persistent? Do people feel comfortable when using gaze as input – once they have become familiar with it?
- **How hard** (strenuous) is it to use gaze interaction as compared to, for example, mouse or head pointing? Although eye movements are natural and fast, there are indications that it can be hard to stare at an object to make it respond if the activation time is too slow (Aoki, Itoh, Sumitomo, & Hansen, 2003).
- **What is the accuracy** of different gaze tracking systems, and how does accuracy affect interaction performance? Even the most accurate gaze tracking systems seems to be less precise than the mouse pointer, making it difficult to hit the smallest targets in a windowing environment (Skovsgaard, Hansen, & Mateo, 2008).
- **What are the most enjoyable parts of gaze interaction?** Can we facilitate user experiences that will make gaze interaction fun to use in, for instance, a computer game?