Chapter 6
Virtual Reality Technologies (Visual, Haptics, and Audio) in Large Datasets Analysis

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ABSTRACT

With the latest developments in technology, several researchers have integrated other sensorymotor channels in the analysis of scientific datasets. In addition to vision, auditory feedbacks and haptic interactions have been exploited. In this chapter we study how these modalities can contribute to effective analysis processes. Based on psychophysical characteristics of humans the author argues that haptics should be used in order to improve interactions of the user with the dataset to analyze. The author describes a classification that highlights four tasks for which haptics seems to present advantages over vision and audio. Proposed taxonomy is divided into four categories: Select, Locate, Connect and Arrange. Moreover, this work provides a complete view on the contribution of haptics in analysis of scientific datasets.

INTRODUCTION

Analysis of scientific datasets typically involves a set of techniques that aims to transform the raw data into representations understandable by a human user. Following the acquisition of the data starts the analysis process that spans into two distinct stages: transformation and representation.

Raw data are generally defined by a set of points that samples the physical space of the studied phenomenon. Mainly two types of transformations, geometric or topological, can occur on these raw data. They aim to change the sampling or to extract a subset in order to take advantages of algorithms that may offer adequate representations. For example, translations, rota-

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tions, or zooming can change the structure of the sampling grid. Other transformations can *a contrario* change the topology of the grid. This can result in converting an irregular grid into a regular grid. Other topological transformations may only affect the sampling of a regular grid (for instance, changing a 3D rectilinear grid to a 3D hexagonal one). Following the data transformation, rendering algorithms are applied in order to provide representations interpretable by a user.

It has been demonstrated that human beings carry remarkable capacities for detection and recognition of patterns by the mean of the visual channel. Based on this, the first works concerning analysis of numerical data triggered interest for exploitation of our visual abilities. Consequently, the process was called visualization. Gershon et al. (1998) and later Zhu et al. (2004) define visualization as a link between the human eye and computers; it helps to identify patterns and extract knowledge from large datasets. Therefore, data should be presented in a way to be easily understandable. According to Ware (2000), visualization aims to build a mental representation, an intellectual understanding of analyzed process or data. Generally, visualization refers to all the resources aiming at reducing the cognitive effort in acquiring knowledge via the visual channel.

Since vision cannot be considered as a predominant sense for human, it is justified to ask whether other modalities, mainly haptic or audio, may play an important role in analysis of large datasets. In fact in the everyday life, humans do not only rely on vision to analyze their surrounding environment since they are rather multimodal. The purpose of this chapter is to discuss the role of not only visual but also haptic and audio in the analysis of scientific datasets. Therefore, this chapter will focus on the use of different sensorimotor modalities in the analysis of scientific datasets.

POTENTIAL OF VR TECHNOLOGIES FOR ANALYSIS OF LARGE DATASETS

First, visualization applications range from non-interactive to command-driven systems. In such systems, commands are sent, processed and then comes the result. However, the need to interact with the system has emerged quickly. For example, one would like to zoom, rotate or filter the data. At this point starts the fusion, the interleaving between the query and the result via an iterative process. From there, data analysis is not only guided by the need for effective presentation of data: there are two main components that are the *presentation* and *interaction*.

At this point, Shneiderman (1996) identifies four main steps for the implementation of effective interaction process: *Overview first, zoom, filter, then details-on-demand*. Recently, Yi et al. (2007) have suggested that the interaction process can be supported through seven types of interaction based on users' intent while interacting with the system. For several researchers of the field, as part of the Human Computer Interaction (HCI) domain, interactive visualization aims at offering a direct and bidirectional communication between people (users) and the visualization system. Bryson (1996) stated *that the goal is to create the effect of interacting with things, not with pictures of things*. This approach establishes a clear difference between the user and the system: "the user interacts with the system".

Virtual Reality (VR) based-processes adopt a completely different approach in trying to go beyond a simple process of communication between a user and a computer system. The aim is rather to bring the user at the center of the analysis process. In fact, this issue plays a major role in VR technologies that aim at the immersion and presence of the user in a virtual environment. *Immersion* refers to a state of consciousness where the perception of physical reality surrounding the subject is reduced or lost