Haptics-Based Systems Characteristics, Classification, and Applications

Abeer Bayousuf
King Saud University, Saudi Arabia

Hend S. Al-Khalifa
King Saud University, Saudi Arabia

Abdulmalik Al-Salman
King Saud University, Saudi Arabia

INTRODUCTION

With advances in technology, individuals today can interact with computer technology, not only through their visual and auditory senses, but also through touch. The sense of touch is unlike other senses such as vision and hearing; its uniqueness lies in the fact that it enables a bi-directional exchange of information between users and the virtual or real environment, whereas the other senses, such as sight and hearing, are uni-directional forms of interaction, taking place from the computer application to the user.

A haptics-based system utilizes the tactile sense of touch, the kinesthetic sense, or both types to enable human–computer interaction. The source of the touch under investigation could be animate (e.g. humans), inanimate (e.g. machines), or a combination of both. The items or environments being touched could be real, virtual, or a combination of both (M. Eid, Orozco, & Saddik, 2007), (Saddik, 2007). In addition, a haptics-based system may complement other sensory information such as vision, audition, or both, to make an environment appear more realistic.

Nowadays, haptics-based systems have had a significant impact in a variety of fields, such as surgical simulation, rehabilitation, technology designed to help the blind and visually impaired, education and training, entertainment and leisure activities such as video games, art and design, online consumer activity, security, and mobile phones. A survey of haptic-based applications can be found in (M. Eid et al., 2007), (Saddik, 2007), (Abdulmotaleb El Saddik, Mauricio Orozco, Mohamad Eid, & Jongeun Cha, 2011) and (Escobar-Castillejos, Noguez, Neri, Magana, & Benes, 2016). Despite this, haptics-based applications are still in their infancy (Saddik, 2007), and their development is ongoing.

In this chapter we present the concept of haptics, its characteristics, classification and applications. Thus, the outline of the chapter is as follows: Section 2 defines the concept of haptics. Section 3 presents the components of haptics-based system architecture in a virtual environment. Section 4 provides the characteristics and classification of haptic devices. Section 5 presents examples of haptics-based systems in different areas. Finally, section 6 concludes the chapter with future research directions.

BACKGROUND: THE CONCEPT OF HAPTICS

The concept of haptics is derived from the Greek verb haptesthai which means 'to touch'. It refers to the science of sensation and manipulation by touch for the purpose of perception or modification of the environment (Abdulmotaleb El Saddik et al., 2011), (M. Eid et al., 2007), (Mihelj, Novak, &

DOI: 10.4018/978-1-5225-2255-3.ch404

Begus, 2014). Touch is divided into two forms: the tactile (also called cutaneous) sense, and the kinesthetic (also called proprioceptive or force) sense (Abdulmotaleb El Saddik et al., 2011), (Benali-khoudja, Hafez, Alex, & Kheddar, 2004). The tactile sense refers to the registering of physical contact with a real object through skin receptors. It provides the individual with information about an object; this includes texture, pressure, temperature, wetness, softness, friction, vibration, and shape. Conversely, the kinesthetic sense of touch means feeling motion through awareness of position and movement of body parts as well as muscular efforts that are conveyed to the individual by sensory receptors in joints, tendons, and muscles when touching and manipulating items. The kinesthetic sense tells the individual about the movement of joints, velocity, muscle control, and weight. The human hand features both types of touch (Abdulmotaleb El Saddik et al., 2011), (Mihelj et al., 2014).

The term haptics was introduced in the field of psychology in the early 20th century to provide an explanation of the human perception of objects by touch. In the 1970s and 1980s, robotics researchers redefined the term to refer to the remote control of robots and their environment by touch (Abdulmotaleb El Saddik et al., 2011), (M. Eid et al., 2007). The early 1990s were the 'golden age' of haptics, due to the widespread appearance on the consumer market of different haptic devices such as the tactile mouse and the joystick. The field of computer haptics, introduced to integrate haptic devices with computers (Abdulmotaleb El Saddik et al., 2011), (M. Eid et al., 2007), is associated with the design and development of algorithms and software to generate and display forces and tactile sensations to the user (Abdulmotaleb El Saddik et al., 2011).

HAPTICS-BASED SYSTEM ARCHITECTURE

The components of haptics-based system architecture in a virtual environment consist of the human operator, the haptic device, haptic rendering, the simulation engine, and audio-visual rendering, as shown in Figure 1.

The interaction between a human and a virtual environment in a haptics-based system is easy to understand. It is best described as follows:

Human Operator

The human operator manipulates the haptic device via the touch sense in either a tactile or kinesthetic manner, or both. Most haptics-based systems in a virtual environment interact with individual users through their hands, including fingertips and palms (see Figure 2), or through both hands (see Figure 13). However, the touch sense is distributed all over the body. As a result, Boian et al. have developed haptics-based systems that interact with an individual's foot (Boian, Deutsch, Lee, Burdea, & Lewis, 2003).

Figure 1. Haptics-based system architecture in virtual environments (Salisbury, Conti, & Barbagli, 2004)