# Chapter 1
# Haptic and Gesture-Based Assistive Technologies for People with Motor Disabilities

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## ABSTRACT

*The goal of this chapter is to explain how haptic and gesture-based assistive technologies work and how people with motor disabilities can interact with computers, cell phones, power wheelchairs, and so forth. The interaction is achieved through gestures and haptic feedback interfaces using bioelectrical signals such as in surface Electromyography. The chapter also provides a literature survey on ElectroMyoGraphic (EMG) devices and their use in the design of assistive technology, while it covers typical techniques used for pattern recognition and classification of EMG signals (including Independent Component Analysis, Artificial Neural Networks, Fuzzy, Support Vector Machines, Principle Component Analysis, the use of wavelet coefficients, and time versus frequency domain features) the main point driven by this literature survey is the frequent use of multiple sensors in the design and implementation of assistive technologies. This point is contrasted with the state-of-the-art, more specifically the authors' current work, on the use of a single sensor as opposed to multiple sensors.*

## INTRODUCTION

According to Americans with Disabilities Act (ADA), a person with a disability is someone who has a physical or mental impairment that substantially limits one or more activities of daily living. A physical or mental impairment is one that prevents that person from fully utilizing their senses and/or coordinating those senses with motor skills. For example, a person suffering from paralysis, blindness or Down syndrome, or a person who is not able to walk or eat on their own, can be classified as a person with disability. According to the World Health Organization (WHO, 2011), it is estimated that more than a billion people in the world today experience some form of disability. The sources of disabilities can be broken down into several categories, depending on their causes and effects. However, one key aspect that is true for all the different forms of disabilities is

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that they all diminish the ability of that person to interact with other people and the environment.

Independence and self-sufficiency are fundamental to our everyday living and is often taken for granted. The importance of independently performing activities of daily living to human well-being cannot be overstated in terms of its physiological, social and mental impacts. According to many studies, impaired mobility and loss of independence lead to social isolation, anxiety, and depression. Technology can assist people with disabilities in achieving the much-desired independence. Assistive Technology (AT) is a field that addresses the development of methods and systems to assist people with different levels of impairments in carrying out routine activities. AT can help, for example, people: with lost limbs; who survived strokes or spinal cord injuries; with quadriplegia, muscular dystrophy and cerebral palsy; patients engaged in physical therapy, and the elderly. The range of AT that research advances have made possible is almost as wide as the range of disabilities. However, there is still a great need to find better, faster, more reliable, more adaptable, user-friendlier and less expensive solutions before people with disabilities can fully contemplate independence in their daily lives.

This chapter presents in detail the design and implementation of AT, more specifically Robotic Assistive Technology (RAT) to assist people with motor impairments. In that sense, the first contribution of the chapter is to present a survey of past researches in the area of haptic and gesture-based ATs. Through this survey, we establish taxonomy of the methods developed to date. This discussion will provide insights on "why" and "when" each approach is better suited to address a specific disability. In that sense, haptic and gesture-based technologies provide an extended advantage to ATs for motor impairments. These technologies come together as a fusion of many areas in electrical, computer and mechanical engineering, computer science, physics, biology, physiology, neurosciences, medicine, etc. For this reason, this chapter will give details concerning some of those areas, in particular, a discussion on bioelectrical signals such as EMG signals. These signals are commonly used for interfacing the impaired users with the assistive devices. Within this discussion, it will be necessary to review some of the signal processing, feature extraction and pattern recognition algorithms and methods most frequently employed to analyze and classify the bioelectrical signals that control the devices.

In addition to the methods and algorithms developed for AT, the chapter will also present a review of the most common applications, for example, the control of power wheelchairs, prosthetic limbs and Human-Computer Interfaces (HCI), covering the three main limitations imposed by most disabilities: movement, manipulation of objects, and interaction with other technologies such as cell-phones and computers. The assumption made in those cases is that a particular user may have a motor disability, but he may still be able to control some muscles and therefore produce a hand, a face or other kind of gestures with specific bioelectrical signals which can be detected and the information extracted can be analyzed and eventually be translated into a command to move a wheelchair, to grasp and lift an object with a robotic arm or to control prosthetic limb.

At the end of the chapter, we will present the state-of-the-art in haptic and gesture-based AT, including these authors' research using a single surface EMG (sEMG) sensor and a new method called Guided Under-determined Source Signal Separation (GUSSS). Finally, this presentation will lead to a discussion on the research challenges that will allow for fewer sensors, a larger variety of interfaces, the multiple modality of operation, and the recognition of user intention in the ATs of the future. Those are the advances that will bring real independence and quality of life to people with disabilities.