# Chapter 85
# Rehabilitation Systems in Ambient Assisted Living Environments

**A. M. Middleton**
*National University of Ireland Maynooth, Ireland*

**R. P. Harte**
*National University of Ireland Galway, Ireland*

**T. E. Ward**
*National University of Ireland Maynooth, Ireland*

## ABSTRACT

*This chapter reviews Ambient Assisted Living (AAL) in the context of movement-based rehabilitation. The authors analyse the need for AAL solutions and how they can overcome many of the drawbacks associated with traditional rehabilitation. They discuss the benefits and challenges of rehabilitation within the AAL paradigm and the well-known benefits that the telerehabilitation and telemedicine models have already established. The authors review the top ambient technologies in use today, detailing their advantages and shortcomings. The review focuses primarily on areas such as motion capture, serious games, and robotic rehabilitation. The authors carry out a structured search of two well-known databases to find the most recent advances and present the most interesting lines of research and development. Finally, the authors discuss the review findings and draw conclusions on the future of personalised rehabilitation within an AAL paradigm.*

## INTRODUCTION

By the year 2020, it is estimated that 29,000 people per year in Ireland will suffer a stroke (Institute of Public Health Ireland, 2012). Across the European Union 2.11 per 1,000 children will be born with cerebral palsy (Oskoui et al., 2013). These figures, coupled with the multitude of people who acquire brain and spinal injuries every year, suggest a need for quality rehabilitation therapy that can be delivered where the patient needs it when they need it, without placing burdensome

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costs on the healthcare system. In this paper we present and discuss an approach that couples the pervasive computing elements of ambient assisted living with movement-based rehabilitation.

Ambient Assisted Living (AAL) is a technology framework designed to unobtrusively assist the user and allow them to accomplish goals in their day-to-day activities. These technologies come in many forms. AAL typically involves the use of sensor networks (Cavallo et al., 2009), smart fabrics (Harms et al., 2009), monitoring equipment (Fleck and Straßer, 2008) and robotic agents (Linder et al., 2013a) all operating within a home environment. AAL systems have been used for activity monitoring (Adami et al., 2010), fall detection (Lombardi et al., 2009) (Leone et al., 2011), medication management (Pollack et al., 2003) and surveillance systems (Fleck and Straßer, 2008). The data from these systems can be collected and transmitted remotely where it can be reviewed and analysed. The reviewer may be a therapist, caregiver or clinician, checking the user's data and deciding on an appropriate action. Agents are being developed which can process and act upon the data generated by these systems in much the same way as a human expert would. These agent approaches allow more efficient utilisation of increasingly expensive human intervention and are becoming integrated into the ambient living environment and smart homes.

One such smart home is the Intelligent Sweet Home, developed at the Korea Advanced Institute of Science and Technology (KAIST), Korea. It focuses on human-friendly technical solutions for motion/mobility assistance, health monitoring, and advanced human–machine interfaces that provide easy control of both assistive devices and home-installed appliances (Lee et al., 2007). The smart house behaves in accordance with the user's commands, their intentions, and current health status. This environment and others like it (Chen et al., 2012) (Wan et al., 2013), represents a classic example of the implementation of ambient smart technology within a living environment. The CASALA project in Dundalk IT, Ireland (http://www.casala.ie/) exhibits the investment which is now taking place in AAL research within the European Union.

AAL is a user-centred paradigm with sharp focus on the primary user. It is also a framework in which medical professionals, therapists, caregivers and other stakeholders can monitor and assess the living quality of the user in order to maintain or improve it (Cook et al., 2009). This approach promotes independence in otherwise potentially dependent user groups such as older adults, disabled people and those with injuries or chronic diseases. Provided the sensors are suitably discrete, the user will be generally unaware of their presence. Sensors can collect data on many aspects of the person's activities. Accelerometers embedded in clothing, switches embedded in beds, walls and seats and video monitoring can gather data. This data can then be transmitted remotely to a computer in order to extract meaningful information. Based on this data, remote algorithms can create a model of the patient's movement, compare this against a database of risk situations, calculate if the patient is at risk and then recommend appropriate intervention. This means the patient can live safely independently in their own home for longer, a model closely related to that of connected health, telehealth and telemedicine (O'Neill et al., 2012) (Bogan et al., 2010).

## REHABILITATION IN AAL ENVIRONMENTS

AAL is extending beyond the monitoring applications listed above into the area of personalised rehabilitation. Telerehabilitation, or e-rehabilitation, is a well-established method whereby therapy is applied to a patient over a communication network,

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