Chapter 53
Depth Cameras in AAL Environments:
Technology and Real-World Applications

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ABSTRACT

Automatic and privacy-preserving systems to monitor elderly people in their home environment are one of the basic targets addressed by the wide research area of Ambient Assisted Living. Thanks to the low-cost Microsoft Kinect® device, high-resolution depth and visual sensing is now not limited to experimental and prototype implementations and is ready to address marketable solutions. This chapter emphasizes the advantages provided by Kinect in the field of automatic monitoring, discussing its performance in human subject detection and tracking. Two sample use cases are discussed in detail: the former deals with generating a numerical representation of the Get Up and Go Test outcome, the latter implements an automatic fall detection algorithm based on depth frames analysis, with the sensor in a top configuration. The chapter ends suggesting issues that need to be addressed to further extend the range of applications for the Kinect device and enhance the obtainable performance.

INTRODUCTION

The goal of Ambient Assisted Living (AAL) is to extend ageing people autonomy as long as possible, using Information and Communication Technologies (ICT) devices and services. AAL solutions enable autonomous and active ageing by tools to support people in their own home premises, also when physical or cognitive impairments occur. Since several years, international studies revealed that population ageing is a planetary phenomenon, and, by 2050, the number of elderly people in the world is expected to hit 1 billion (United Nations, 2014). In (Chiriac & Rosales, 2012) and (Prince, Prina & Guerchet, 2013) it is highlighted that the growing number of elderly people will determine an increasing cost of resources dedicated to health care, for higher incidence of chronic diseases and

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comorbidity, thus remarking the importance of developing automatic assistive systems. By technological innovations, such as sensor networks, wearable devices, advanced computer vision and pattern recognition techniques, AAL and smart environments may contribute to autonomy and well-being of these people, enhancing safety at home, and maintaining mental and physical stimulation (Sun, H., De Florio, V., Gui, N., & Blondia, 2009). Most research initiatives aim at developing pervasive devices, using ambient intelligence to unobtrusively integrate them, and establish a safe environment to provide sensitive and responsive services to the presence of people (Zijlstra, Becker & Pfeiffer, 2011).

Monitoring and surveillance based on computer vision and pattern recognition techniques applied to images and videos are developed and implemented since a long time (Cucchiara, Grana, Prati & Vezzani, 2005; Pham, Dhome, Gond & Sayd, 2008). In AAL applications, it is of interest to integrate vision-based systems and other technologies, such as sensor networks, to either reduce the complexity of each processing element, and improve reliability of the outcome provided. This point is particularly important when considering the final target of any AAL solutions, i.e. to create a safe home environment that is able to automatically react to the user's behaviors, and to anticipate his needs. Surveillance systems based on computer vision and pattern recognition shall identify subjects moving in the field of observation, classify them into different groups, and track moving targets during time, according to the *who is where is*, or the *what is where is* paradigm. As a further evolution, these systems should be able to interpret the scene captured, and provide a description of the activities performed by the subjects in the scene. These functionalities are complex to implement; above all, the main difficulty is to obtain the desired performance when no constraints are imposed on the system, i.e. the system shall work properly under any circumstances and environmental conditions (Hu, Tan, Wang & Maybank, 2004; Rourke & Bell, 1994).

A large field of research in AAL relates to monitoring Activities of Daily Livings (ADL) and distinguishing them from hazardous situations. For example, a fall detection solution has to discriminate an accidental and dangerous fall from a lying on the floor condition, or the action of picking up an object. These monitoring solutions are realized by means of sensors that acquire data, and algorithms that process them. Usually, there are two main approaches to monitor a person and they can be used singularly or together. The former is based on wearable sensors; they can acquire and process, for example, vital data, like heart or respiratory rates, or evaluate people's activities. The latter relies on the use of vision-based systems, where fixed sensors located in the environment collect data, and send them to a processing unit. Since a few years ago, these sensors were basically cameras to capture videos, and the elaboration steps were composed of video or image processing algorithms running on a computer.

Nowadays, the availability of new vision-based solutions has enabled the development of a new branch of image processing research: the depth map processing. Engineers and researchers can now process frames where the data do not represent the color intensity values, like in classic Red Green Blue (RGB) images, but each pixel stores a distance (depth) value. The main advantage of a depth camera is the possibility of providing distance values without the need of multiple calibrated RGB cameras, by means of one single sensor. Initially, some of these devices, such as the Time Of Flight (TOF) cameras, exhibited prohibitive costs, that made them suitable for research and development purposes, but not for a mass market adoption. However, thanks to exceptional progresses in micro-scale electronics, and explosive diffusion of new sensors for gaming in the consumer market, nowadays depth-based sensors are available, at very reasonable costs, and

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