Chapter 62
Learning Robot Vision for Assisted Living

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ABSTRACT

This chapter presents an overview of a typical scenario of Ambient Assisted Living (AAL) in which a robot navigates to a person for conveying information. Indoor robot navigation is a challenging task due to the complexity of real-home environments and the need of online learning abilities to adjust for dynamic conditions. A comparison between systems with different sensor typologies shows that vision-based systems promise to provide good performance and a wide scope of usage at reasonable cost. Moreover, vision-based systems can perform different tasks simultaneously by applying different algorithms to the input data stream thus enhancing the flexibility of the system. The authors introduce the state of the art of several computer vision methods for realizing indoor robotic navigation to a person and human-robot interaction. A case study has been conducted in which a robot, which is part of an AAL system, navigates to a person and interacts with her. The authors evaluate this test case and give an outlook on the potential of learning robot vision in ambient homes.

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INTRODUCTION

The phenomenon of population ageing is becoming a serious problem of this century. According to the estimate of the U.S. Census Bureau, the American population aged over 65 will grow from 13% to 20% until 2030 (Hootman & Helmick, 2006). In Europe, more than 20% of the population will be beyond 60 by 2020 (Steg, Strese, Loroff, Hull, & Schmidt, 2006) and by 2050 this group will even exceed 37% (OECD, 2007). Ageing societies would benefit from the design of "intelligent" homes that provide assistance to the elderly (Steg et al., 2006). In this context the research field of robotics is focusing attention on AAL systems which refer to a set of technological solutions that permit the elderly population to maintain their independence at home for a longer time than would otherwise be possible (O'Grady, Muldoon, Dragone, Tynan, & O'Hare, 2010). Ambient homes will not only react passively, like turning on lights when the lighting condition changes, but they will also provide active help via home electronics, motorized actuators or - in the future - socially assistive robots. They can assist the elderly effectively in everyday tasks such as communication with the external world or the ambient system and can provide medicine and health check reminders in a proactive fashion.

A number of research topics are involved in the design of the functionalities of a socially assistive robot. Among them, robotic navigation and human-robot interaction are particularly relevant. Robotic navigation in ambient homes, in particular mutual positioning between the robot and a person, is an important task for a robot that strongly influences the quality of human-robot interaction. A robot should find a way to approach a target person after localization and go to the person without colliding with any obstacles, which is very challenging due to the complexity of real-home environments and the possible dynamical changes. A vision-based system is a potential way to tackle those challenges. Compared with other kinds of sensors, a vision system can provide far more information, good performance and a wide scope of usage at reasonable cost. A robot can perform different tasks and adapt its behavior by learning new features if equipped with sophisticated vision algorithms.

Human-robot interaction is a very broad research field. Therefore, in the context of this book chapter, we understand it as the study of how robots can communicate interactively with users. Computer vision algorithms are essentials for achieving this because they can be used to acquire feedback related to the user state during interaction. Unlike an industrial robot, that, in most cases, runs preprogrammed behaviors without being interactive, service robots should be able to adapt their behavior in real time for the purpose of achieving natural and easy interaction with the user. This requires the generation of appropriate verbal and non-verbal behaviors that allow the robot to participate effectively in communication. Vision algorithms can gather information about the user's attention, emotion and activity, and allow the robot to evaluate non-verbal communication cues of the user. The benefits of non-verbal communication cues become apparent when the conversation is embedded in a context, or when more than two persons are taking part in a conversation. Particularly, head gestures are important for a smooth conversation, because cues signaled by head gestures are used for turn taking. But head gestures serve many more purposes; they influence the likability of the observer, communicate the focus of attention or the subject of conversation, and they can influence the recollection of the content of conversation (Kleinke, 1986).

In this chapter we aim at introducing the reader to the computer vision techniques used in a robotics scenario for Ambient Assisted Living (AAL) in the context of the European project KSERA: Knowledgeable SErvice Robots for Aging. Our project develops the functionalities of a socially

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