Detection of Lounging People with a Mobile Robot Companion

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Abstract. This paper deals with the task of searching for people in home environments with a mobile robot. The robust estimation of the user’s position is an important prerequisite for human robot interaction. While detecting people in an upright pose is mainly solved, most of the user’s various poses in living environments are hard to detect. We present a visual approach for the detection of people resting at previously known seating places in arbitrary poses, e.g. lying on a sofa. The method utilizes color and gradient models of the environment and a color model of the user’s appearance. Evaluation is done on real-world experiments with the robot searching for the user at different places.

Keywords: people detection, various poses, home environment.

1 Introduction

This work is part of the CompanionAble project, which intends to develop a personal robot for assisting elderly people with mild cognitive impairments in their home. The goal of the project is to increase the independence of the user by means of a combination of a smart home and a mobile robot. Therefore, the system provides different services, like e.g. day-time management, and allows for video conferences with care-givers or friends. Furthermore, it recognizes emergency situations, like falls, and tries to prevent progression of the cognitive impairments by providing stimulation programs. To offer these service functionalities, the robot system provides several autonomous behaviors. First, observing the user in a non-intrusive way allows to facilitate services that require interaction or to react on critical situations. Second, the robot must seek for the user if a reminder has to be delivered or a video call comes in. A third behavior is following and approaching the user if interaction is desired. A prerequisite to these behaviors is the robust detection and tracking of the user in the apartment. In contrast to other interaction applications in public environments, people in

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1 www.companionable.net
home environments often do not face the robot in an up-right pose but sit on chairs or lie on sofas. Therefore, our system tries to detect the user independent of their pose at places, where he or she usually rests. In this work, we focus on a robot-only solution – not relying on any smart home sensors – to enable the robot to function autonomously in any home environment. The key idea is to learn the visual appearance of predefined resting places and the user beforehand and to compare the current visual impression to both of these models in the detection phase.

The remainder of this paper is organized as follows: Section 2 summarizes previous work carried out on the research topic. We present the innovation of detecting lounging people at places in detail in Sec. 3. Afterwards, Sect. 4 gives a description of the experiments carried out, while Sec. 5 summarizes our contribution and gives an outlook on future work.

2 Related Work

People detection and tracking are prominent and well-covered research areas, and impressive results have been accomplished in recent years. Considering the constrained hardware of mobile robots, two main fields for people detection have been established – range-finder-based and visual approaches. [1] employ AdaBoost on laser range scans to combine multiple weak classifiers to a final strong classifier that distinguishes human legs from the environment. Visual approaches mainly focus on the face or the human body shape. The most prominent up-to-date face detection method also utilizes AdaBoost, which learns and applies a cascade of simple, but very efficient image region classifiers to detect faces [2].

Histograms of Oriented Gradients (HOG) have been established as the state-of-the-art method for upright people detection. The basic idea is to compute block-wise histograms of gradient orientations, resulting in robustness to slight spatial variation of object shape, color, and image contrast. The histograms inside a detection window are concatenated into a high-dimensional feature vector and classified by a linear Support Vector Machine [3]. Further extensions to the original HOG method focus on upper body detection [4] or use deformable sub-parts, which increase detection performance given partial occlusion [5]. Detection, segmentation and pose estimation of people in images is addressed by [6] who combine HOG features with the voting scheme of the Implicit Shape Model [7]. [8] augment the HOG features with color and texture information achieving impressive results on outdoor datasets. Unfortunately, the latter two approaches are far beyond real-time capabilities.

Plenty of research has been done to develop methods for people tracking on mobile robots in real-world applications. Most of these approaches focus on pedestrian tracking and single poses [3,7,9]. Yet, few approaches handle the detection and tracking of people in home environments, especially on mobile robots. Often smart home technologies, like static cameras with background subtraction methods [10] or infrared presence sensors, are applied, which facilitate the problem of detection [11,12]. On occasion, approaches working with mobile robots