Development of Audio Sensing Technology for Ambient Assisted Living: Applications and Challenges

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ABSTRACT

One of the greatest challenges in Ambient Assisted Living is to design health smart homes that anticipate the needs of its inhabitant while maintaining their safety and comfort. It is thus essential to ease the interaction with the smart home through systems that naturally react to voice command using microphones rather than tactile interfaces. However, efficient audio analysis in such noisy environment is a challenging task. In this paper, a real-time audio analysis system, the AuditHIS system, devoted to audio analysis in smart home environment is presented. AuditHIS has been tested thought three experiments carried out in a smart home that are detailed. The results show the difficulty of the task and serve as basis to discuss the stakes and the challenges of this promising technology in the domain of AAL.

Keywords: Ambient Assisted Living (AAL), Audio Analysis, AuditHIS System, Health Smart Homes, Safety and Comfort

INTRODUCTION

The goal of the Ambient Assisted Living (AAL) domain is to enhance the quality of life of older and disabled people through the use of ICT. Health smart homes were designed more than ten years ago as a way to fulfil this goal and they constitute nowadays a very active research area (Chan, Estève, Escriba, & Campo, 2008). Three major applications are targeted. The first one is to monitor how a person copes with her loss of autonomy through sensor measurements. The second one is to ease daily living by compensating one’s disabilities through home automation. The third one is to ensure security by detecting distress situations such as fall that is a prevalent fear of the elderly.

Smart homes are typically equipped with many sensors perceiving different aspects of...
the home environment (e.g., location, furniture usage, temperature...). However, a rarely employed sensor is the microphone whereas it can deliver highly informative data. Indeed, audio sensors can capture information about sounds in the home (e.g., object falling, washing machine spinning...) and about sentences that have been uttered. Speaking being the most natural way of communicating, it is thus of particular interest in distress situations (e.g., call for help) and for home automation (e.g., voice commands). More generally, voice interfaces are much more adapted to people who have difficulties in moving or seeing than tactile interfaces (e.g., remote control) which require physical and visual interaction.

Despite all these advantages, audio analysis in smart home has rarely been deployed in real settings mostly because it is a difficult task with numerous challenges (Vacher, Portet, Fleury, & Noury, 2010). In this paper, we present the stakes and the difficulties of this task through experiments carried out in realistic settings concerning sound and speech processing for activity monitoring and distress situations recognition. The remaining of the paper is organized as follow. The general context of the AAL domain is introduced in the first section. The second section is related to the state of the art of audio analysis. The third section describes the system developed in the GETALP team for real-time multi-source sound and speech processing. In the fourth section, the results of three experiments in a Smart Home environment, concerning distress call recognition, noise cancellation and activity of daily living classification, are summarized. Based on the results and our experience, we discuss, in the last section, some major promising applications of audio processing technologies in health smart homes and the most challenging technical issues that need to be addressed for their successful development.

**APPLICATION CONTEXT**

Health smart homes aim at assisting disabled and the growing number of elderly people which, according to the World Health Organization (WHO), is forecasted to reach 2 billion by 2050. Of course, one of the first wishes of this population is to be able to live independently as long as possible for a better comfort and to age well. Independent living also reduces the cost to society of supporting people who have lost some autonomy. Nowadays, when somebody is loosing autonomy, according to the health system of her country, she is transferred to a care institution which will provide all the necessary supports.

Autonomy assessment is usually performed by geriatricians, using the index of independence in Activities of Daily Living (ADL) (Katz & Akpom, 1976), which evaluates the person’s ability to realize different tasks (e.g., doing a meal, washing, going to the toilets...) either alone, or with a little or total assistance. For example, the AGGIR grid (Autonomie Gérontologie Groupes Iso-Ressources) is used by the French health system. In this grid, seventeen activities including ten discriminative (e.g., talking coherently, find one’s bearings, dressing, going to the toilets...) and seven illustrative (e.g., transports, money management, ...) are graded with an A (the task can be achieved alone, completely and correctly), a B (the task has not been totally performed without assistance or not completely or not correctly) or a C (the task has not been achieved). Using these grades, a score is computed and, according to the scale, a geriatrician can deduce the person’s level of autonomy to evaluate the need for medical or financial support.

Health Smart Home has been designed to provide daily living support to compensate some disabilities (e.g., memory help), to provide training (e.g., guided muscular exercise) or to detect potentially harmful situations (e.g., fall, gas...).
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