ACOUSTIC APPLICATIONS AND TECHNOLOGIES FOR AMBIENT ASSISTED LIVING SCENARIOS

Danilo Hollosi[1], Stefan Goetze, Jens Appell, Frank Wallhoff

Abstract

The support of people in care is connected with enormous temporal as well as personal efforts. Awareness of increasing the efficiency of today's care by using assistive technologies has arisen in recent years. Thus, the focus of this contribution is on the application of acoustic technologies to support users and care givers in ambient assisted living (AAL) scenarios. One of these applications is an intelligent autonomous system for acoustic monitoring of older persons developed within the project SonicSentinel. This system detects and identifies potential emergencies, with a significantly reduced false alarm rate compared to existing approaches. Furthermore, we investigated acoustic user interfaces for service robots in health care environments and retirement homes in the project ALIAS. Here, novel approaches for user–machine interaction using speech recognition techniques as a very natural user-interface will be investigated and evaluated.

Keywords: Acoustic Event Detection, Reasoning, Monitoring, Automatic Speech Recognition (ASR), Ambient Assisted Living (AAL)

1. Introduction

Demographic change has led to a continuous growth of the percentage of older people in today's society [1, 2] and, consequently, to higher costs for the social and medical care systems. One possibility to tackle this problem is to prolong the time for which persons live in their own homes independently and to use assistive technologies, such as reminder systems [3], medical assistance and tele-healthcare systems [4], personal emergency response systems, social robotics and safe human–robot collaboration [5], accessible computer-input strategies [3] and, more recently, mobile devices and smartphones. Such systems usually rely on application-dependent sensors, such as vital sensors, cameras or microphones. It has been shown that microphones can be integrated easily into existing living environments, are perceived as non-obtrusive sensors by the users, and can serve multiple purposes related to AAL [6, 7]. In addition to monitoring applications, acoustic signal processing strategies can also be

[1] Fraunhofer Institute for Digital Media Technology IDMT Project Group Hearing, Speech and Audio Technology HSA Marie-Curie-Straße 2, 26129 Oldenburg, Germany, {Danilo.Hollosi,S.Goetze,Jens.Appell,Frank.Wallhoff}@idmt.fraunhofer.de http://www.idmt.fraunhofer.de

used for interaction with technical systems [3, 8]. Due to the natural and ambient character of these approaches, they are preferred by older users if the recognition rate is sufficiently high [6].

In the following paper we therefore describe novel methods and concepts for human–machine interaction [9], i.e. acoustic event detection, reasoning [10, 11, 12] and speech recognition, addressing stakeholders from the sectors of health, transportation, multimedia, telecommunication and security. Sections 2 and 3 of this contribution briefly describe the work of the research projects "SonicSentinel - An Intelligent Autonomous System for Acoustic Monitoring" and "ALIAS – Acoustic User Interfaces for Service Robots in Health Care Environments", respectively. More detailed information about the overall system design and the methodology is also described. Preliminary outcomes and results of the projects are given in Section 4, and Section 5 concludes the paper.

2. SonicSentinel – An Intelligent Autonomous System for Acoustic Monitoring

The possibility of raising alarms in care environments in the case of an emergency is of great importance. Unfortunately, existing approaches are mainly based only on the continuous surveillance of sound level. Their inability to distinguish between various acoustic events leads to a significant false alarm rate. Within the project SonicSentinel, a novel intelligent embedded acoustic monitoring system for care institutions is being developed, aimed at automatic analysis of audio signals to detect potentially dangerous situations and to initiate emergency calls when necessary. One of the main challenges is the varying acoustic backgrounds, i.e. noise sources, which are considered to be the main reason for the imperfection of acoustic event detectors. We apply noise-robust model-based algorithms for emergency detection to reduce the false alarm rate to a minimum. Pre-filtering of the audio signal when speech is detected is also supported for the protection of privacy rights.

2.1 System Overview

As announced in one of our last works [11], we reuse the system proposed there in encountering the problem here. Basically, the system consists of three major modules: a preprocessing module for audio segmentation, pre-filtering and feature extraction; the actual event classification module for the specified events (cf. also Section 2.2); as well as an event modelling module which generates semantic information from the event data to model more complex events that cannot be detected directly from the audio signal. An overview of the system is given in Fig. 1. Please note that we do not address the event notification module in this contribution, since its implementation heavily depends on the desired application.

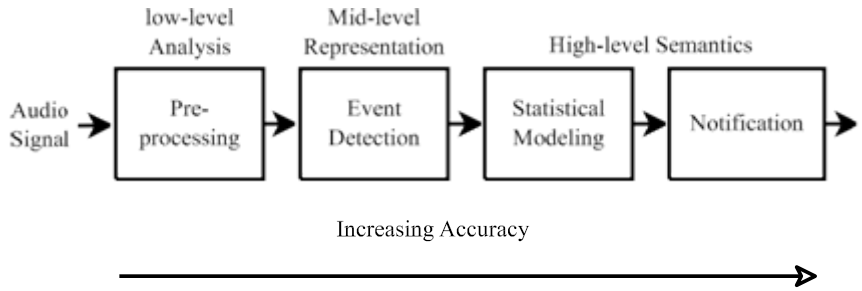

Figure 1. System overview in SonicSentinel

2.2 Data Gathering

The datasets used in this study consist of 17 acoustic events. We asked employees of retirement homes what kind of events it is important to detect and which of them should lead to an emergency notification. Additionally, we asked them to rank the events according to their importance, ranging from 0 (unimportant) to 5 (very important). In total, 15 different events were identified to be important: these are summarised in Table 1, together with the respective importance score.

Table 1. Acoustic events and their relative importance for automatic detection.

Acoustic Event	Score	Acoustic Event	Score	Acoustic Event	Score
shout out for help	4.67	shout out for nurse	4	fast breathing sounds	1.67
breaking glass	4.67	coughing	4	water tap	1.33
groaning	4.67	whining	3.67	speech	1.33
screaming	4.67	stertorousness	3.33	door	1.33
asphyxiation	4.67	moving furniture	3	singing	1.33
falling down	4.67	moaning	2.67		

Recordings were collected over a period of six months using six recording devices at six different retirement homes and care institutions, i.e. the project partners' locations. The recorded data was then analysed for ground-truth annotation and training of the acoustic event classifiers.

3. LIAS – Acoustic User Interfaces for Service Robots in Health Care Environments

It is the goal of the ALIAS project to develop a mobile robot platform to sup- port older persons in their daily life as well as to enhance communication and social interaction. Thereby, ALIAS will not make human-to-human communication obsolete, but will ensure the maintenance of existing contacts to prevent social isolation. Additionally, the user is stimulated to perform cognitive activities in order to preserve

quality of life. A touch display and a robust speech recognition and synthesis system enable the ALIAS robot platform to interact with the user via speech or using the mounted touch display (see Fig. 2). In addition to communication with the robot by speech input and output, a central goal is communication with relatives and acquaintances via telephone channels, mobile phone channels and the internet. An automatic reminder system motivating the user to participate actively in social interaction has been developed.

Figure 2. ALIAS robot platform

Approaches for user–machine interaction using speech input and output as a very natural user-interface have been developed and evaluated in a user-centred design approach, as visualised in Fig. 3. Providing additional information to the users, supporting them in their daily lives, reminding them of appointments, keeping them company or simply motivating them to stay active throughout the day, are only a few examples of what service robots may be capable of achieving to prolong independent living using audio technology.

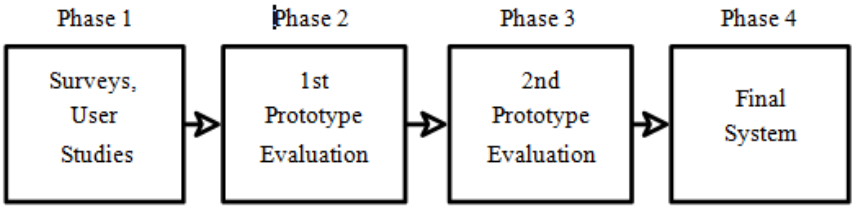

Figure 3. Design concept of the ALIAS platform

4. Preliminary Results and Work Progress

Within the SonicSentinel project, a database of audio recordings has been gathered by the project partners. First ground truth annotations are already available and allowed for the first AED experiments for algorithm development, i.e. acoustic feature extraction, feature selection and machine learning algorithms, and deeper investigations regarding expected acoustic backgrounds and privacy issues. The acoustic events of interest were ranked by experts according to their importance in the final application scenario (cf. Table 1). Additionally, a suitable hardware platform was selected for the embedded implementation of SonicSentinel.

Within the ALIAS project, a speech input and reasoning system, as well as a speech output system (text-to-speech), has been integrated with an easy-to-use graphical user interface specifically designed for older users. The needs and preferences of older users regarding human–machine interactions are constantly evaluated in a user-centred design process to optimise the human–machine interfaces of the ALIAS robot platform.

5. Conclusion

As exemplarily shown in this contribution, acoustic technologies have a broad range of applications in AAL scenarios. These range from acoustic monitoring, acoustic events and emergency detection, acoustic localisation, to signal enhancement and individual hearing support for communication applications. In particular, if the acoustic modality is combined with traditional input and output modalities such as touch panels, mouse and keyboard, an increased user satisfaction can be observed.

Acknowledgements

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