Improving Accessibility: Supportive Technologies for the Hearing Impaired in a Set-Top Box

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Abstract
The authors present a conceptual set-top box specifically designed to aid people with hearing problems. All audio signals (TV, radio, telephone, acoustical notifications) are processed by supportive signal processing algorithms that filter out noise, amplify and compress the signal as it is typically done in hearing aids. A synthetic face can be displayed performing lip movements to improve the speech intelligibility. The system can be connected to home automation networks to process event notifications and present them to the user.

A PC-based prototype of the system will be demonstrated at the conference. This system is being developed in the "Hearing at Home" project funded by the EU (IST-045089).

1. Introduction

Hearing impairment is largely correlated with age. The demographic trend of ageing societies causes a significant portion of the population becoming hearing impaired. Hearing impairment affects the ability to participate in the information society. Phone calls, radio, attention signals of various household appliances, and the TV signal are difficult to understand, or do not get noticed by the hearing impaired.

Hearing aids can improve these situations, but not all hearing impaired own hearing aids, and hearing aid owners do not wear their hearing aids at all times at home.

The Hearing at Home (HaH) project focuses on the needs of hearing-impaired people in home environments. Formerly separated devices like radio, TV, telephone, PC, and services like internet access, Voice over IP (VoIP), and home automation grow together to be accessible via a TV set connected to a PC, set-top box (STB) or residential gateway(RG). The STB/RG connected to the TV is the central Home Information and Communication (HIC) platform of the household in the communication society (Meis, 2007). This STB/RG has an OSGi framework installed that enables an easy service deployment.

Six European partners joined their efforts to develop a HIC platform set-top box designed specifically for the needs of hearing impaired users.

2. Audio Processing in the HIC Platform

To address hearing-impaired users, the HIC platform processes the audio output signals to improve speech intelligibility.

The system classifies of the acoustical environment present in the TV signal, applies appropriate noise reduction algorithms, and attenuates overly loud commercial breaks. Additionally a multi-band dynamic compression as it is typically done in hearing aids is applied to ensure best audibility for the hearing impaired user. All audio processing is performed within the HörTech "Master Hearing Aid" (Grimm, 2006) software framework. The dynamic compression is configured interactively by the user who is guided through this procedure by a sophisticated software wizard.

When the output of the dynamic compression would be too loud to be presented through normal loudspeakers in a living room, a headset is used to present the output signal to the hearing impaired user. The headset used with the HIC platform contains microphones and does not shield the user from his or her surroundings. The HIC platform employs sound processing algorithms that enable the user to communicate with other people in the room effortlessly with the help of the headset when watching the TV program together.

To further support speech perception, an artificial talking head can be displayed by the integrated SynFace software (Beskow, 2004). It performs lip movements controlled by the audio signal, and has been shown to provide significant increases in intelligibility for hearing impaired users.

3. Integration with Home Automation

The HIC platform can be connected to home automation networks. Notification from household appliances, doorbell, telephone, and alarms is done in a prioritized way, configurable by the user. The user can be notified by displaying a message on the TV screen, sending an SMS, triggering an audio message, or triggering actuators in the home automation networks (like flashing lights). This functionality is provided by an easily configurable and extendable controller software implemented as a set of OSGI bundles running on top of an OSGi framework..

4. Controller and User Interface

The controller is based on Petri Nets and reads on start-up its initial configuration from an internal database. The controller itself consists of several sub-controllers which execute in parallel threads. A thread-safe generic variable functionality has therefore been developed (called "distributed properties") to ensure the deterministic concurrent processing of the system. The controller itself consists of several layers. Using these hierarchical layers enables the system to abstract from the real devices and software packages. The highest level represents the main controller, representing the system state and linking together the sub controllers. The next layer is built up from managing controllers which deal with functional grouped device clusters, e.g. Supportive Signal Processing Sub-Controller manages all video and audio supporting devices and software packages.

As an example if the fire alarm sensor detects a fire, the message is fed to the Home Event Manager. The event then is distributed to the next higher level, the home automation sub-controller, where the alarm is used to enable a Petri-net transition of the main controller. The main controller then has been configured to automatically call the fire department. This will happen again top-down from the main controller to the communication sub controller.

The user interface which is used to configure all settings of the controller described above is dedicated to be used by elderly users and therefore uses simple and consistent procedures. The interface is also used for showing messages (e.g. door bell is ringing) and interacts with the respective devices (e.g. opening the door). The visual design takes into account that the user can have a visual impairment to some degree using high contrast and large letters.

5. Demonstration activities

At the conference, the following demonstrations will be presented:

- Demonstration of effect of hearing impairment on the perception of sound and speech output of a TV program, thereby motivating the implementation of supportive technologies for the hearing impaired in a set-top box.
- Demonstration of the lip reading support for TV and telephone signals.
- Demonstration of noise reduction techniques implemented on the HIC platform.
- Demonstration of the effect of dynamic compression to compensate for hearing loss (can be combined with the hearing impairment simulation).
- Demonstration of the integration of the home automation network and user notification.
- Demonstration of the process of adapting the platform to the user's needs, including adapting the dynamic compression to the specific hearing loss of the user.

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