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Signal Processing for Assisted Living: Developments and Open Problems

The old-age dependency ratio, which is defined as the ratio of the population age 65 and over to the population age between 15 and 64, has been rising in many countries all over the world. According to the United Nations estimates for the "more developed regions," this ratio is anticipated to exceed 30% in 2020 and reach 40% by 2030, largely as a result of an accelerating increase in the aged population. This implies that those of working age, and, subsequently, the overall economy, will face a greater burden in supporting the aging population. In addition, the demand and trend are upward for continued independent living, in both more and less developed regions. As such, there is a growing interest in assisted living technologies that enable self-dependent living within homes and residences for the elderly, in particular those homes that will ensure an elderly person more years of life in good health.

Remote monitoring capabilities, such as fall risk assessment, fall detection, and detection of small changes from predefined baselines in health conditions and motor functional abilities of the elderly, will address the challenges associated with self-dependent living. All of the aforementioned capabilities are rooted in fundamental signal processing problems related to signal capturing, analysis, and interpretation. More specifically, these entail signal detection and enhancement in the presence of noise and interference; signal representation in a domain that is conducive to capturing a rich set of features for vital signs estimation, human activity detection, localization, and health and well-being classification; the use of single and multiple sensors; centralized and distributed data fusion; and change or anomaly detection for risk assessments; to name but a few. Contributions in signal processing for assisted living technologies have not only been driven by recent developments in signal analysis and interpretation but also important revisits to "classical" approaches for exploiting the underlying phenomenology and the specificities of the problem at hand.

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In this issue

This special issue of *IEEE Signal Processing Magazine* (*SPM*) provides a synopsis of the emerging area of signal processing for assisted living, including the most recent developments as well as interesting open problems at the forefront of the current research. The six articles demonstrate the role of signal processing in addressing key challenges and solving pressing problems encountered in assisted living applications related to various sensing modalities.

The first article by Bennett et al. provides an overview of wearable inertial measurement unit-based sensors for ubiquitous monitoring of movements and physical activities. It discusses associated signal processing techniques with a focus on enhancing accuracy, lowering computational complexity, reducing power consumption, and improving the unobtrusiveness of the wearable computers.

Erden et al. present a survey of signal processing methods employed with different types of sensors, including pyroelectric infrared and vibration sensors, accelerometers, cameras, depth sensors, and microphones. Their article demonstrates the need for a sensor network covering multiple modalities to achieve an intelligent home design that enables the elderly to live independently.

The article by Savazzi et al. investigates signal models and processing methodologies for exploiting the multitude of available wireless communication links to achieve device-free radio vision systems to address key challenges in assisted living applications.

Witrisal et al. provide insights into the potential of high-accuracy localization systems as a key component of assisted living technology, and their article demonstrates the ability of exploiting multipath and propagation environment knowledge to reduce the required infrastructure and enable robust localization.

Amin et al.'s contribution focuses on radar technology and discusses the nonstationary signal processing techniques that play a fundamental role in fall detection for elderly assisted living applications. It also reports on some of the challenges facing radar technology development for fall detection.

Finally, the article by Debes et al. covers state-of-the-art methods for monitoring activities of daily living to provide detection of deviations from previous patterns that can be crucial in identifying the early onset of geriatric dysfunctions.

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