

Chapter 31

Fusion Physiological Sensing System for Healthcare

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ABSTRACT

In the super-aging society, daily healthcare monitoring has become increasingly emphasized as a possible approach for the early diagnosis and timely treatment of lifestyle-related diseases. A wide variety of information transfers and platforms have been developed for daily healthcare monitoring. Using these techniques, the commercially available devices for home healthcare are also networked. However, techniques for obtaining physiological information are unfocused, and in such a case, even useful data cannot be obtained even if the network system is applied. Given these considerations, the authors have investigated a new network system combined with new bioinstrumentation techniques, i.e., the fusion physiological sensing system and its applicability for the daily healthcare monitoring. In particular, as contributions towards the development of healthcare technology, two promising monitoring techniques, ambulatory and non-conscious physiological monitoring, have been developed. These methods can contribute to the fields of the personal healthcare, medical care, and rehabilitation through their fusion with information and communications technology. The utility of these systems are reported according to the results of practical use, in addition to the outline of the sensing techniques in this chapter.

INTRODUCTION

In the super-aging society, daily healthcare monitoring is well recognized as important for the early diagnosis and timely treatment of lifestyle-related diseases, especially for inpatients and/or

outpatients living with the chronic disorders that require acute life support or chronic therapies. Moreover, medical care and rehabilitation efforts at home are also increasingly important. Some platforms and methods of information transfer (Continua Health Alliance, 2006) have been developed for daily healthcare monitoring, and there are commercially available devices for the

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home healthcare that are networked. However, the sensing techniques for obtaining physiological information are not focused. For example, cumbersome devices may obstruct continuous monitoring, and, consequently, useful data for checking health condition cannot be obtained, even if information and communications technology (ICT) such as the network technology or the platform mentioned above are used to the information transfer. Thus, in this paper, we have focused on new bioinstrumentation techniques and their applicability for the daily healthcare monitoring by fusion with the ICT.

First, non-invasive monitoring is necessary for daily healthcare and many commercially available devices, such as blood pressure (BP) monitors, electrocardiogram monitors, etc., are used conventionally as a medical use. However, the demands for new technologies with which to carry out the long-term and continuous monitoring of health conditions have been increasing. In particular, as contributions towards the development of the most desirable healthcare monitoring, two promising systems, ambulatory and non-conscious physiological measurement, have recently been developed through modern technological advances.

Regarding ambulatory physiological measurement, the Holter-type electrocardiogram (ECG) recorder (Holter, 1961) and the portable sphygmomanometer, called the ambulatory BP monitor (ABPM), which is based on the auscultation and/or the cuff-oscillometric method (Mauck, Smith, Geddes, & Bourland, 1980; Yamakoshi, K., 1991), are also widely used in clinical medicine to obtain continuous vital signs. However, the conventional methods can only measure intermittent BP. Moreover, modern microelectronics and mechanical technologies have enabled the production of more convenient devices capable of monitoring BP, ECG, respiration, etc. For example, some wearable instruments that monitor ECG or respiration using textile electrodes or woven sensors made of smart material with conductive and piezoresistive

properties were reported (Bourdon, et al., 2005; Paradiso, Loriga, Taccini, Gemignani, & Ghelarducci, 2005; Rantanen, et al., 2002). Additionally, for ambulatory monitoring, we developed some systems capable of measuring BP both at a specified interval (Yamakoshi, K., Kawarada, Kamiya, Shimazu, & Ito, 1985) and on a beat-by-beat basis (Tanaka & Yamakoshi, K., 1996; Yamakoshi, K., 2004) using volume-oscillometric and volume-compensation methods, respectively (Yamakoshi, K., Shimazu, & Togawa, 1980; Yamakoshi, K., Shimazu, Shibata, & Kamiya, 1982). They can also combine these measurements of BP with other hemodynamic variables, including the cardiac output (CO), using electrical admittance methods (Ikarashi, Nogawa, Tanaka, & Yamakoshi, K., 2007; Ito, Yamakoshi, K., & Togawa, 1976; Yamakoshi, K., Nakagawara, & Tanaka, 1997). It is apparent that the concurrent acquisition of BP and CO data on a beat-by-beat basis enables the detailed analysis of hemodynamic responses and the autonomic regulation of the cardiovascular system in response to various kinds of daily activities.

Furthermore, the importance of ambulatory activity monitoring is well recognized in the fields of gerontology, rehabilitation, and general healthcare. For example, in the field of gerontology, one of the key aims in the care of the elderly is to maintain their daily activities at appropriately high levels, especially to avoid their becoming bedridden. Therefore, the objective measurement of activity levels is essential. Furthermore, to evaluate the efficacy of rehabilitation, a therapist must evaluate motion characteristics during various activities, including standing up, walking, etc. However, the therapist must usually make these assessments subjectively, using direct observation. Therefore, the quantitative assessment of activities is desirable. One method employed is to make recordings using a 3D motion-capture system; however, the range over which such recording is possible is usually limited, and data analysis is complicated. Therefore, these methods

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