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EDITORIAL

Ubiquitous healthcare monitoring

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Technologies for healthcare are rapidly progressing. Recent years, we are facing surprisingly successful application of artificial intelligence (AI) in medicine and healthcare as well as in many other areas. In addition to AI, big data, internet of medical things (IoMT), telemedicine, predictive analytics, augmented/virtual reality (AR/VR), 5G wireless communication, Chatbot, and smart biosensor technologies are technologies mostly focused as key technologies for future healthcare [1]. These technologies are closely related each other and basically based on intelligent computing technology for massive data and fast communication technologies without noticeable delay. To be successful with this technology, we should be able to collect large amount of healthcare data so that the final decisions can be provided with accurate enough results. Sporadically collected healthcare data within hospitals or medical clinics are not much enough for this applications. This requirement has smoothly extends the realm of healthcare data monitoring from hospitals into our ordinary living and working environments. To predictively analyze and make treatment in the earliest time, we need routine data collected before subjects notice any symptoms of their diseases. This requirement need the extension of healthcare monitoring time through our whole lives of days and nights [2]. So, the ubiquitous healthcare monitoring, which makes monitoring of healthcare data without constraints of time of place, are required for seamless healthcare data collection and following applications of AI and progressed healthcare technologies [3].

Then, what kind of data should be monitored? In hospital, we are using many kinds of diagnostic devices and equipment and they produce information for the detection of problem and diagnosis of specific diseases. Some are too large to carry and some are so invasive and not enough to use frequently. So they cannot be used in out of hospitals. The healthcare data collected in ubiquitous monitoring should have specific characteristics. Firstly they should provide valuable information to be applicable to large portion of population. If the occurrence of events to detect is too rare and prevalence of targeted disease is too low, effectiveness of the ubiquitous monitoring decreases. Secondly, the monitoring should be done easily and comfortably and unnoticeably as possible. That is, the monitoring should not cause any pain or inconvenience in related activities and easy enough to be used by non-experts of general population. If the monitoring is done automatically without recognition of subject, it is much more acceptable by users for longer time use. Vital signs are most appropriate candidate for this purpose. EEG signal for brain activity monitoring and blood glucose level for diabetes management also can belong to this category. In this issue, we selected five topics which take the major roles in seamless healthcare monitoring.

Vital signs are a group of most important biological signals which indicate the status of the body's life-sustaining functions. Body temperature, blood pressure, pulse rate by electrocardiogram (ECG) or photoplethysmogram (PPG), respiration rate, and oxygen saturation level (SpO_2) are most representative and generally included in patient monitoring units. These signals basically evaluate the general physical health of a subject and give clues to possible diseases. Since these signals are also using to evaluate the recovery progress, it can be widely used in ubiquitous health monitoring applications. In the first article, Chen reviewed on the thermometry and interpretation of body temperature (BT). Since, BT indicates a human body's average thermal energy generated by metabolism, deviations from the normal are certainly to be regarded as there is a significant cause. The

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abnormal temperatures implies the existence of latent disease [4]. Also temperature status can alter metabolic activities, perturb organic function, cause tissue damage, and lead to a strong decrease in mental and physical performance. So the easy and convenient BT monitoring is required. Tamura has reviewed current progress of PPG and SpO_2 for healthcare monitoring in the second article. Since PPG is most widely accepted for pulse rate monitoring in many weable units, there has been large progress in its technology. Respiration rate can be derived from PPG. SpO_2 also be monitored with same unit using multiple light sources and detectors [5]. Measured data has wide applications including cardiac function evaluation. The review includes the principles, signal processing methods, practical issues, standards, and clinical applications of PPG and oxygen saturation level monitoring. In the third article Ding and Zhang reviewed the pulse transit time (PTT) technique for cuffless unobtrusive blood pressure (BP) measurement. While BP is measured noninvasively with cuff, its application is limited by inconvenience of using cuff. So, cuffless technique holds great promise to measure BP in an unobtrusive way, extending the range of monitoring hypertension and cardiovascular diseases, with the maximal independence of subjects [6]. PTT has been the most employed techniques for cuffless BP estimation and many studies have been conducted. This review investigated the understanding and development of the PTT technique in depth, from theory to algorithm.

In the fourth article, Casson reviewed the wearable technology for electroencephalogram (EEG). While the EEG is most representative signal as a non-invasive method for monitoring the brain, its use is strongly restricted by electrode type using paste. Recently, much effort has been put into the creation of wearable EEG which overcomes these limitations and allows the long term non-invasive recording of brain signals while people are out of the lab and moving about [7]. This review article covers from the recent progress in electrode design and units to the considerations for the creation of next generation wearable EEG units. Park and Choi reviewed smart technologies toward sleep monitoring at home in the fifth article. Monitoring of sleep used to be done with polysomnography (PSG) using multiple biological signals only within hospitals. Since sleep take about one-third of our lives, its monitoring at home provide integrative information of subject's health status [8]. Recently, there were many studies evaluating sleep with minimal number of biological signals measured unobtrusively. They reviewed smarter technologies for sleep monitoring at home by comparing their performances in reference to the in-lab PSG.

Even though, we have already many wearable healthcare monitoring methods and devices, we believe that we are still in the early stage of rapidly progressing digital and ubiquitous healthcare era. Healthcare environment will change dramatically within near future based on new technologies. Ubiquitous healthcare monitoring will take major role in this progress. We hope these review articles provide informative basis for the readers to participate actively toward smarter and intelligent healthcare world.

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Compliance with ethical standards

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