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Editorial

Smart Healthcare

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1. Introduction

Medicine is undergoing a sector-wide transformation thanks to the advances in computing and networking technologies. Healthcare is changing from reactive and hospital-centered to preventive and personalized, from disease-focused to wellbeing-centered. In essence, the healthcare systems, as well as fundamental medicine research, are becoming smarter. We anticipate significant improvements in areas ranging from molecular genomics and proteomics to decision support for healthcare professionals through big data analytics, to support behavior changes through technology-enabled self-management, and social and motivational support. Furthermore, with smart technologies, healthcare delivery could also be made more efficient, higher quality, and lower cost. In this Special Issue, we received a total 45 submissions and accepted 19 outstanding papers that roughly span across several interesting topics on smart healthcare, including public health, health information technology (Health IT), and smart medicine. In the following sections, we highlight the primary contributions of the papers in this Special Issue in each area.

2. Public Health

Ten of the 19 papers in this Special Issue are related to public health. Lee et al. [1] reported their work on the design and implementation of a management system to help the general public to increase self-control and reduce over-dependence on smartphones. They developed an application to measure the smartphone usage, analyzed the acquired data by comparing with baseline using the Chi-square test, and recommended intervention when the actual usage was significantly higher than the baseline. The authors conducted a moderate-sized human subject test with 96 participants and showed evidence that the system was effective in diagnosing smartphone over-dependence issue, as well as in classifying smartphone usage patterns.

Liao et al. [2] presented a novel approach for detecting anomalous resident behaviors in a smart home environment based on visual analysis. This study relied on the dataset provided by the Center for Advanced Studies in Adaptive Systems (CASAS) project from Washington State University [3], which consists of pre-labeled data regarding the activities of daily living for two residents living alone. The contribution of this paper includes the anomaly detection using the local outlier factor based on activity duration, frequency, and start time of the day. To facilitate analysis and anomaly detection, the authors designed a smart home visual analysis system that is capable of constructing a variety of views, including the activity tree map view, the anomaly grading view, the data map view, the Gantt chart view, the heat Gantt chart view, the radar map view, and the space radar map view. Using the dataset, the authors showed that their visual analysis system is effective in finding behavior patterns and detecting abnormal behaviors.

Park, Park, and Lee reported an IoT system designed to facilitate remote monitoring of patients living at their own home in [4]. They introduced a protocol that converts between the ISO/IEEE 11073 protocol and the oneM2M protocol, and an algorithm to schedule biomedical data to be delivered to medical staff based on their urgency using an algorithm called multiclass Q-learning. Their experiment showed that the system worked well with the proposed multiclass Q-learning algorithm compared with the existing multiclass based dynamic priority scheduling algorithm.

In [5], Rojas et al. introduced a question-driven methodology for analyzing emergency room (ER) processes. According to the methodology, the frequently-posed questions about ER processes were classified, and a reference model was provided to guide the extraction of ER process data. The methodology was validated using a case study conducted in an ER in Chile, which showed that it can help improve the understanding of specific pathologies, triage severity, and patient discharge destinations.

In [6], Zhang et al. proposed a solution to the problem of Chinese medical question-answer matching, which could be beneficial for millions of users. They introduced a novel framework that is based on end-to-end character-level embeddings instead of word embeddings to avoid Chinese word segmentation in text pre-processing. Multi-scale convolutional neural networks were used to extract contextual information from question and answer sentences at different scales. The framework was validated with a new text corpus called cMedQA, which was collected from an online Chinese health and wellness forum.

Kuang and Davison [7] presented a method that helps monitor healthcare information and public disease from the vast tweets in twitter. They proposed to use word-embeddings to identify truly health-related tweets. They introduced two algorithms based on the continuous bag-of-words model. The weights of the words were based on the words' relative importance in the classification task. The method was validated using two healthcare-related datasets, which showed that their algorithms performed better than competing approaches by over 9%.

In [8], Modu et al. described an early warning system in the form of a mobile app for malaria outbreaks. The system depends on satellite-based meteorological data obtained from Climate Forecast System Reanalysis. Subsequently, hidden ecological factors of malaria were identified by analyzing the causal relationships among meteorological variables (such as minimum and maximum average temperature, relative humidity, etc.) using partial least squares path modeling [9]. Then, machine learning algorithms were used to find patterns that can be used to predict malaria outbreaks.

In [10], Khoie et al. presented a hospital recommendation system based on satisfaction surveys submitted by patients. They followed an unsupervised data-driven method to analyze the survey data. The key is to identify major factors by clustering individuals with similar satisfaction factors and introduce proactive measures to improve patient care. Based on actual patient survey data of a hospital, they made 19 recommendations, and among them, ten were statistically significant according to the Chi-sqaure test.

Automatic emotion recognition can play a big role in patient care and treatment of mental health patients. In [11], Li et al. reported their work on detecting human emotion from EEG signals via hybrid deep neural networks. They did so in two steps. In the first step, they integrated spatial characteristics, frequency domain, and temporal characteristics of the EEG signals, and converted the result into a two-dimensional image. This led to a series of EEG multidimensional feature image sequences that contain information regarding human emotion variations. In the second step, they performed the emotion recognition task by combining convolution neural networks and long short-term-memory recurrent neural networks. They validated their approach using a public dataset and achieved an average emotion classification accuracy of 75.2%.

In [12], Liu et al. reviewed the current state of the art and practice on technology-facilitated diagnosis and treatment of individuals with autism spectrum disorder (ASD). They conducted the review from an engineering point of view where the system used for ASD treatment was modeled as a human-machine system. This review addressed the issues such as the presentation of the treatment content, input data collection, adaptability of the system, and program assessment. They pointed out limitations in current research and outlined future research directions [13] that are needed to truly help children with ASD to generalize what they have learned during the treatment sessions to their daily lives.

3. Health IT

Five papers in this Special Issue are related to health IT. In [14], Cho, Lee, and Lee proposed to use real-time lossless EMG data to monitor pre-term delivery in a medical information system. Their main research contribution is to enable lossless efficient real-time EMG data transmission by compressing the data using a novel algorithm.

In [15], Dziak, Jachimczyk, and Kulesza reported an IoT-based information system for healthcare. The system takes the sensing data from accelerometers and magnetometers, and employs pedestrian dead reckoning, thresholding, and decision trees to localize a person within the four room-zones, and to recognize falls, lying, standing, sitting and walking activities.

In [16], Peng et al. presented a fault-tolerance mechanism in wireless body area networks for healthcare monitoring systems. The mechanism is based on network coding where a greedy grouping algorithm is used to construct a hierarchical structure of the networks. Subsequently, linearly independent coding combinations are generated based on random linear network coding.

In [17], Yuh, Chung, and Cheong introduced a reformulation-linearization technique to improve the efficiency of the kidney exchange program. In this paper, the kidney exchange problem is modeled as a maximum-weight cycle-packing problem in a directed graph. Via analysis, the authors argued that their approach may be used to allow one more patient to have a kidney transplant than the matching solutions made by existing formulations.

In [18], Mahmood et al. proposed a secure authentication and prescription safety protocol to facilitate secure communication between patients and caregivers remotely. The protocol is validated via formal modeling using Rubin logic and via simulation using NS-2.

4. Smart Medicine

Four papers in this Special Issue are related to advancing medicine research and practice using computer and information technologies. In [19], Liang et al. proposed a new method to improve the state of the art in automatically judging meibomian gland morphology. The method is based on an improved fuzzy c-means (FCM) algorithm and rough sets theory. Compared with the traditional FCM algorithm, the proposed FCM algorithm is more robust against outliers and hence increased the recognition efficiency with excellent recognition accuracy as high as 97.5%.

In [20], Zheng et al. reported their research on detecting protein complexes or function modules in protein-protein interaction networks. Their approach is based on the simplified swarm optimization (SSO) algorithm and the Gene Ontology (GO). The SSO algorithm is used to cluster proteins with similar functions. The GO is used to help identify function complexes and improve detection accuracy.

In [21], Tang, Chen, and Li presented their research on differentiating aortic and pulmonary components from the second heart sound using respiratory modulation and measurement of respiratory split. The key idea is that the aortic component does not change much in the second heart sound waveform in respiration, while the delay of the pulmonary component is modulated by respiration. Their validated their approach via simulated second heart sounds with known varying splits.

In [22], Suman et al. reported their work on medical image processing for wireless capsule endoscopy. They introduced a novel statistical approach to differentiating ulcer and non-ulcer pixels using color bands as the feature vector and the support vector machine with grid search as the classifier. They validated their approach experimentally with excellent ulcer detection accuracy, sensitivity, and specificity.

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