Future Healthcare: Will Digital Data Lead to Better Care?

Evgin Goceri [a][*],Akdeniz University, Dumlupinar Boulevard, Antalya 07058, Turkey.
Melih Gunay [b], Akdeniz University, Dumlupinar Boulevard, Antalya 07058, Turkey.

Selection and peer review under responsibility of Prof. Dr. Afsun Ezel Esatoglu, Faculty of Health Sciences, Ankara University, Turkey.

Abstract

Currently, datasets used in bioinformatics and computational biology are high-dimensional, complex and multivariate. Analysis and processing of data is vital in medicine; however, manual analysis and pattern recognition with big data is difficult, and processing of large and weakly connected datasets is challenging. The increasing complexity of healthcare systems causes high health cost. To provide better healthcare services at reduced prices, computer-aided tools using smart approaches and context-aware computations are of great importance. Advancements in wireless network technology, mobile devices and pattern recognition applications help solve the cost problem of healthcare systems. In the future, patients will be able to participate in healthcare as their own health manager and observe important parameters like body fat amount and blood pressure. However, open issues related to this topic exist. In this paper, we present a survey of smart healthcare environments and smart hospitals and discuss some questions and challenges in this area.

Keywords: Future healthcare, healthcare system, smart hospitals, smart environments.

* ADDRESS FOR CORRESPONDENCE: **Evgin Goceri** , Akdeniz University, Dumlupinar Boulevard, Antalya 07058, Turkey.
E-mail address: evgin@akdeniz.edu.tr / Tel.: +90-242-310-4393

1. Introduction

Health costs are increasing because of the increasing complexity of healthcare systems. These systems produce high- dimensional, multivariate, large and weakly integrated datasets [1, 5]. Biomedical experts are not capable of dealing with these datasets. Analysis and processing of big data is of great importance [6, 11]. However, making manual analysis is time consuming and nearly impossible [12], requiring the use of computer-based tools [13, 14]. Therefore, smart approaches and context-aware computations to manage big data have been vital [6, 7, 15, 17]. Advancements in wireless network technology, mobile devices (e.g., smart phones, smart sensors) and pattern recognition applications help to solve the cost problem of healthcare systems and to provide better healthcare.

Smart hospitals [18] present highly interactive environments that are related to context-aware health systems [19], which are predictive, preventive and personalised. Recently, several companies (such as Siemens, IBM and Google) have been focused on smart hospitals in order to reduce costs of healthcare systems. In smart hospital approaches, medical doctors are supported with mobile assistants to manage floods of data. Also, patients are supported for their wellness and healthier life by health assistants.

It seems that our health will be tracked automatically by smart environments in the future. Also, patients will be able to participate in healthcare as their own health manager and observe important parameters (e.g., body fat amount and blood pressure value).

However, there are some open issues related to this topic. In this paper, we present a short survey of smart healthcare environments and smart hospitals. Also, we discuss some questions and challenges on this topic.

1.1. Smart Healthcare Environments

The idea that computers should be invisible and integrated into physical environments instead of as a device on the desktop [20] is used in the concept of smart health. Artificial intelligence and desired properties of healthcare systems (predictive, preventive and personalised) are applied [21] to produce smart healthcare environments in order to improve patients' conditions. Novel interactive technologies and sensors are integrated into these environments and medical support systems are developed. These systems include several services/abilities such as monitoring personal health conditions, assistance for daily activities or accessing to emergency or medical systems.

Currently, the main application areas of healthcare systems are heart failures and falls [22]. However, people usually don't take care of mobile devices and don't carry them, or these devices may not be able to use in case of falls or other medical problems such as heart failure. Therefore, various projects have been developed for monitoring of patients and managing of their diseases, which can be in different categories. For example, a smart monitoring and controlling approach for an airborne disease (Pandemic influenza A), which spreads easily and has a high death rate, has been proposed [23].

In [24] is discussed a monitoring system for patients who are at end-stage of heart failure. Figure 1 shows the monitoring system that uses an infrared camera (that is behind an interactive display) and devices (that are integrated in a coffee table) for coagulation monitoring and blood pressure and weight sensors (that are located under the floor).

The objective in another healthcare system [25] is to determine whether adding cognitive impairment to frailty improves its predictive validity for adverse health outcomes. Similar approaches have been developed for memory loss in [26] and [27].

A multimodal user interface has been developed for people with motor and mobility impairment [28]. Also, similar approaches for physical impairments have been proposed [29, 30].

Web-based and mobile systems for diabetes controlling have been discussed and proposed in many studies [31, 36].
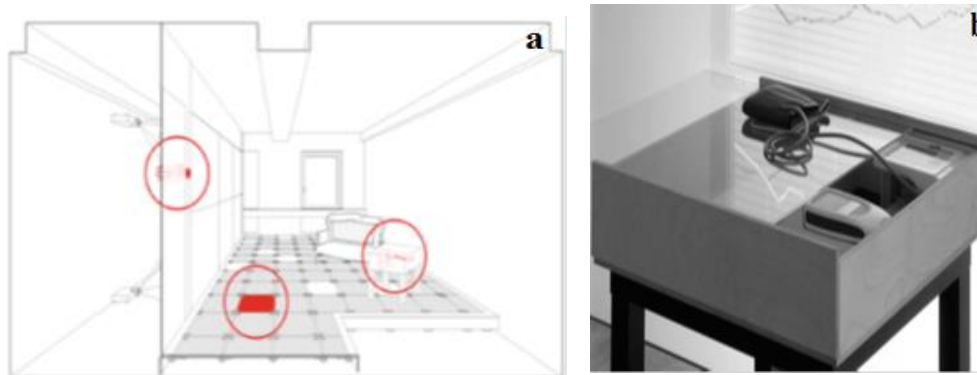

Figure 1. A monitoring system (smart home (a), devices for blood pressure and coagulation monitoring (b) for patients who are at the end-stage of heart failure [24]

In general, usage of smart medical services can be categorised under three main groups:

- Long-term treatment of diseases;
- Prevention and detection of an emergency case;
- Early detection and prevention of diseases.

In a recently published work [37], several applications in these categories and prototype systems have been discussed. In addition to [37], there is a new study [38] that discusses bulk metallic glasses for healthcare.

In [39], principles and attitudes have been observed as beneficial for successful implementation of several healthcare systems with integration of various electronic healthcare environments and platforms between 1993 and 2016, illustrating four different projects.

Smart hospitals have been important to deal with problems in medicine, particularly related to management of complex, large and high-dimensional datasets and high cost of healthcare. Smart hospitals integrate systems, people and processes to work together. These hospitals aim to improve the quality of patient care while reducing the cost of services by connecting everything (people, system and process). There are some open issues related to building a smart hospital and smart health systems. For instance:

- Multi-agent based systems are becoming important [40, 41], since smart agents and humans can have a relationship to achieve common and individual aims. However, a scientific foundation on humans and agents is not available. Therefore, fundamental research is required in incentive engineering and agile teaming to provide infrastructures and applications for machine learning to network metrics.
- Smart health environments have the potential to enable a large number of people to control their health. However, some questions should be taken care of such as where the new health data streams end or who wants to share their own datasets.
- An important factor for smart hospitals is accuracy of contextual information. If definition of context is not correct or not clear, then users can get inaccurate results. Therefore, a well-defined, clear architecture and explicit relationship is required between environment and adaptation to achieve the desired context-aware computation [42, 44].

2. Conclusion

Smart hospitals can be effective to reduce costs of health systems and to provide a high quality of patient care. Therefore, although the importance of smart hospitals and smart health systems is increasing, there are still some open issues that should be considered while building a smart hospital or healthcare system.

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