An IoT-based CBL Methodology to Create Real-world Clinical Cases for Medical Education

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***Abstract*— Medical education is the practice of being a medical practitioner, which varies considerably across the world. It is an active research area and has evolved tremendously in recent decades. The learning activities are commonly explored using patient cases. Among multiple medical education methodologies, *Case-Based Learning* (CBL) is considered as an effective methodology for small-group of medical students. Normally in CBL, the medical experts give the legacy fixed medical cases to students during their class for group discussions and their learning. In this practice, due to lack of beforehand practice or knowledge about that particular case, students hesitate to participate due to lack of confidence. Internet of Things (IoTs) is one of the well-known emerging technology and this hesitation can be dealt with creating real-world clinical cases using IoTs data and user-friendly environment for case-based learning. In this paper, an IoT-based CBL methodology is introduced, which records real-world patient data using IoTs, analyzes the imperative signs' data, creates the real-world clinical case for students practicing, and finally provides feedback to medical students. For case study purposes, our developed CBL tool is simulated on patient's data to realize the proposed methodology.**

***Keywords*—Internet of things, case-based learning, clinical case, medical education.**

I. INTRODUCTION

In medical education, most of the literature is describing the *Problem-Based Learning* (PBL). A large number of PBL systems have been developed to exploit the learning outcomes. The *Case-Based Learning* (CBL) is a kind of teaching in which PBL principles are followed. The CBL is a shared learning approach in which small-group is involved in the discussion to identify the solution for a given patient's problem collectively [1]. The purpose of CBL is to develop a grip on the core activities including problem solving skills and critical thinking [2]. The CBL was introduced by pedagogy experts to improve knowledge exploration, emphasized critical thinking, better teamwork, and increased opportunity for getting feedback [3].

In CBL, it is assumed that an online learning environment works well as compared to CBL in a closed class environment [4]. We have already developed an online CBL tool [5], which formulates the CBL case summaries (e.g. further history, examination, and investigations) of a virtual patient through an intervention of student as well as medical experts' knowledge. This tool provides learning services to students before attending the actual class. However, it lacks the support of IoTs for creating real-world clinical cases. Similarly, a platform for case-based learning has been developed by *Extension for Community Healthcare Outcomes* (ECHO) project [6] in which primary and specialty care providers working together to care patients using video conferences and shared electronic records. The ECHO project provides the postgraduate medical education, however, it does not allow the medical teacher to visualize vital signs, to assist in the development of each clinical case.

Internet of Things (IoTs) is one of the well-known emerging technology and has gained much attention in the recent years [7]. With the passage of time, this technology will be an integral part of every field of life. In IoTs concepts, IoT devices are used to collect data that can be used for information extraction. In healthcare, IoTivity has been exploited from wellness applications to treatment and patient care such as using sensors for monitoring and real-time status detection [8]. Normally, medical experts obtain the history of imperative signs' information through dialogue with a patient and looking at lab reports. Nowadays, vital signs can easily be obtained by IoTs. Online CBL under the umbrella of IoTs can promote learning capabilities. In education, when we link the real-world patient cases with clinical practice, then learning capability can be further enhanced. For better learning, real-world clinical cases and user-friendly environment for case-based learning can play an important role for ground level education.

The objectives of this study is to (1) provide an online learning environment to medical expert as well as ground level medical students to create clinical cases and practicing that cases before attending the actual CBL class, (2) facilitate the medical expert to visualize the imperative signs' data in user-friendly environment, and (3) provide an expert feedback to boost the learning capabilities for better clinical competence.

Keeping in view all above-mentioned facts, an IoT-based CBL methodology is introduced, in which real-world patient data is collected using IoTs, analyzed the imperative signs' data, and finally created the real-world case for students practicing before attending the actual class in an online environment. This study is the detailed description of some sections of our previous work [9], which covers some patients' vital signs data as well as IoT gadgets to collect the imperative signs' information.

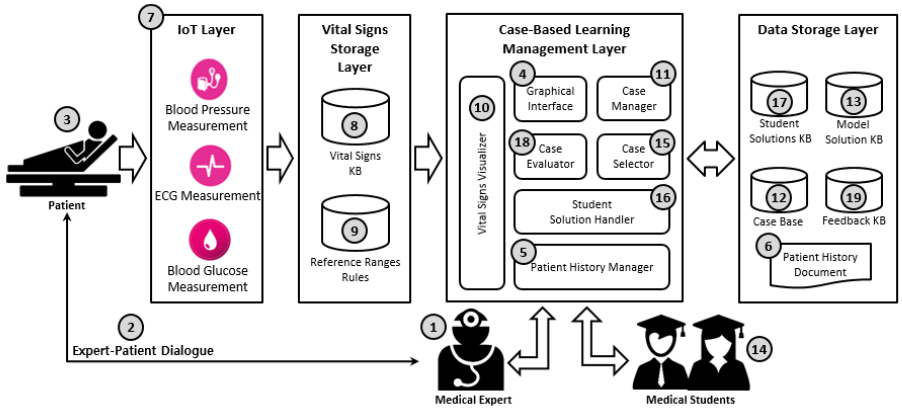

Figure 1. Functional architecture of the proposed methodology

In order to realize the real-world clinical case creation, our previous developed CBL tool, called *Interactive Case-Based Flip Learning Tool* (ICBFLT) [5] has been enhanced further to support the proposed methodology.

Using this tool, the medical expert can create cross-domain clinical case(s) for their students for better clinical competence (see Figure 4). It facilitates the medical expert to record and visualize the vital signs' data in a user-friendly environment so that it can be easily analyzed to create new online cases (see Figures 2 and 3). Similarly, this tool provides a user-friendly environment to students for solving and getting feedback from the medical expert. After solving a clinical case, it provides the model solution to the medical students so that they can understand and validate the gained knowledge of the clinical cases in a practical way. This tool has been developed based on current CBL practices by the School of Medicine at the University of Tasmania, Australia and has already achieved a success rate of over 70% [5].

II. Proposed Methodology

The functional architecture of the proposed methodology is shown in Figure 1, which consists of four layers, namely *IoT Layer*, *Vital Signs Storage Layer*, *Case-Based Learning Management Layer*, and *Data Storage Layer*. Two types of users - medical expert and medical students interact with the CBL management layer. Here in this study, the medical expert is assumed to be a medical teacher that interacts with patients either at the private clinic or at hospitals. In Figure 1, the labels (1 to 19) represents the flow of the proposed methodology. Following is the description of major steps involved in the proposed methodology.

A. Expert-Patient Dialogue

Medical expert dialogues with the patient directly to get his demographics, daily routines activities, medication history (if any), and family history information.

B. Record Patient History

A patient history is the health information of a patient, which provides information about the risk of specific health concerns and allows to take necessary steps to reduce that risk. Medical expert obtains patient initial history through dialogue and interacts with the *Graphical Interface* to record history information into the *Patient History Document* through the *Patient History Manager*.

C. Record Vital Signs

Medical expert requires the log of vital signs to understand the severity of disease so he suggests the patient to use wearable devices for observing his/her critical signs such as blood pressure, glucose level, and heart rate. With the help of RFID technology and sensors, the medical expert can capture the imperative signs' information of patients and can take samples related to patient treatment and for disease diagnosis. For real time patient data collection, multiple IoT gadgets are available that can be used to measure crucial signs. These imperative signs' measurements are stored into the *Vital Signs Knowledgebase* as shown in Figure 2.

D. Visualize Vital Signs Log

Visualization is the presentation of data in a format that can be easily and quickly understandable than the raw numbers alone. It is the strategic way to analyze and interpret the collected data. For easy interpretation, the *Vital Signs Visualizer* categorizes the collected crucial signs' data based on rules that are stored in the *Reference Ranges Rules* such as

- IF (Fasting Blood Glucose <= 69) THEN interpretation = "hypoglycemia"
- IF (70 =< Fasting Blood Glucose <= 99) THEN interpretation = "normal"

The *Vital Signs Visualizer* also displays the hidden and interesting patterns on the *Graphical Interface* as shown in Figure 3.

E. Analyze Data

The alarming conditions can be identified after exploring the data available in the knowledge base. The processing and mining of the large scale data highlighted the hidden and interesting patterns. With analysis of these patterns, the medical expert deduces the information through the *Vital Signs Visualizer*.

F. Create Real-world Clinical Case

Medical expert combines the patient history that is stored in the *Patient History Document* and his/her own analysis as described in the previous step.

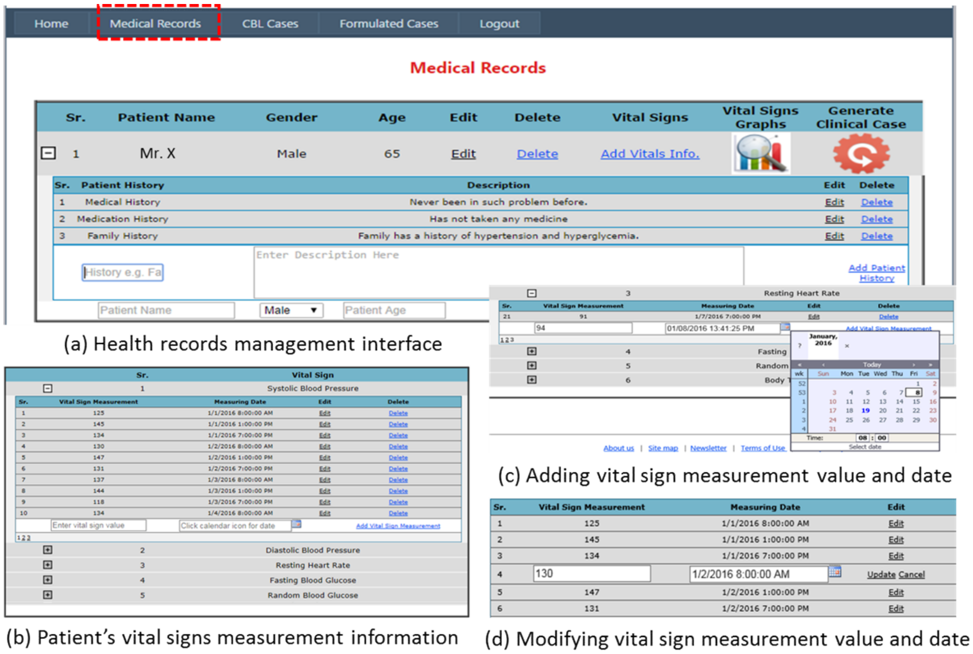

Figure 2. Health record management interface along-with *vital signs information management view of our developed CBL tool*

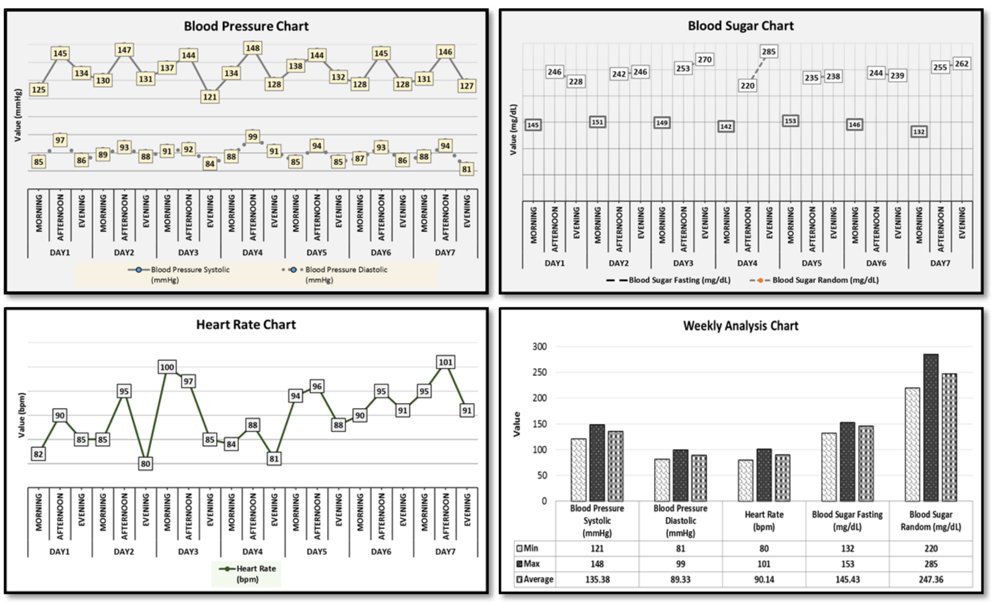

Figure 3. Weekly charts of measured patient's vital signs

After combining, the medical expert interacts with the Graphical Interface and create a real-world clinical case using the *Case Manager* for the medical students as shown in Figure 4 and then stores that case into the *Case Base*. While entering a real-world case along with its difficulty level in the *Graphical Interface*, the medical expert also adds his/her opinion considered as the model solution into the *Model Solution Knowledgebase*, which is invisible to the medical students.

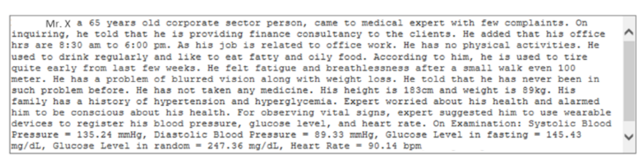
Mr. X a 65 years old corporate sector person, came to medical expert with few complaints. On inquiring, he told that he is providing finance consultancy to the clients. He added that his office hrs are 8:30 am to 6:00 pm. As his job is related to office work. He has no physical activities. He used to drink regularly and like to eat fatty and oily food. According to him, he is used to tire quite early from last few weeks. He felt fatigue and breathlessness after a small walk even 100 meter. He has a problem of blurred vision along with weight loss. He told that he has never been in such problem before. He has not taken any medicine. His height is 183cm and weight is 89kg. His family has a history of hypertension and hyperglycemia. Expert worried about his health and alarmed him to be conscious about his health. For observing vital signs, expert suggested him to use wearable devices to register his blood pressure, glucose level, and heart rate. On Examination: Systolic Blood Pressure = 135.24 mmHg, Diastolic Blood Pressure = 89.33 mmHg, Glucose Level in fasting = 145.43 mg/dL, Glucose Level in random = 247.36 mg/dL, Heart Rate = 90.14 bpm

Figure 4. *An example of a real-world clinical case created by our developed CBL tool*

G. Solve CBL Case

After a case creation, students can solve the real-world as well as evolutionary CBL cases online for their practice before attending the actual CBL class. To do this, first, the medical students interact with the *Case Selector* to select the case using the *Graphical Interface*. The medical students solve the CBL case and can modify their solution through the *Student Solution Handler*. Finally, students submit their solutions into the *Student Solutions Knowledgebase*.

H. Evaluate and Provide Feedback

Feedback contains experts' opinions and can enhance the students learning. The medical expert interacts with the *Case Evaluator* for reviewing and providing the feedbacks. The medical expert extracts all students' solutions from the *Student Solutions Knowledgebase* and reviews all solutions. The medical expert also provides feedback to students about their solutions that are stored into the *Feedback Knowledgebase*.

I. Get Feedback

Once, the medical expert provides feedback after reviewing students' solution, then students get feedback from the expert for his solved case in advance before attending the actual CBL class. Similarly, just after submission of their solutions, the *Case Evaluator* provides the model solution to students so that they can analyze their solutions with the model solution.

J. Save Medical Knowledge

Patient history documents, newly created CBL cases, model solutions provided by experts, students' solutions, and the experts' feedback all are an important medical knowledge that stored into the various knowledgebase. This knowledge will be helpful for future for computerized feedback in future.

III. Conclusion

In the medical domain, every medical student has to interact with patients and to deal with a variety of cases during their clinical practice life for better clinical competency. To achieve this goal, there is a need for real and evolutionary medical cases based on IoTs sensory data. We have introduced an IoT-based CBL methodology through which a medical expert can create real-world clinical cases for their students to rehearsal the CBL cases. As future work, we will develop a knowledge base to support our proposed CBL methodology to transfer the expertise among multidisciplinary medical experts and students.

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