Karaelmas Fen ve Mühendislik Dergisi
Journal home page: http://fbd.beun.edu.tr

Research Article
Received / Geliş tarihi : 15.12.2016
Accepted / Kabul tarihi : 10.02.2017

Data Collection from Blood Glucose Meter and Anomaly Detection

Kan Şekeri Sayacından Veri Toplama ve Anomali Tespiti

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Abstract

Blood glucose concentration is accepted as a pandemic disease because every day the patient count increases. There are many reasons for blood glucose disease and millions of people are affected. Some people living in big cities and near hospitals can have a continuous treatment, but most people are lack of regular doctor checking which is very important for the health. There some instruments to keep track of the daily blood glucose measurements but they are personal use only. In this project, a personal use only data collector used to collect data for multi patients. Data are stored in a database then doctor or the patient himself can reach and see the trend of the measurement in a meaningful graph. So, regular checking could be minimized in hospitals and also doctors can advise patients about treatment. With this study, blood glucose data are transferred from the measuring device to a recording medium. Although individual use of many devices, with this project a system designed for individual use is employed for more than one patient.

Keywords: Computerized instrumentation, Data collection, Diabetes, Medical information systems

Öz

Kan şekeri hastalığı pandemik bir hastalık olarak kabul edilir; çünkü hasta sayısı her geçen gün artmaktadır. Kan şekeri hastalığının birçok nedeni vardır ve milyonlarca insan etkilenmektedir. Büyük şehirlerde ve hastanelerin yakınında yaşayan bazı insanlar sürekli olarak tedaviye sahip olabilir, ancak çoğu insan sağlık için çok önemli olan düzenli doktor kontrolünden yoksundur. Günlük kan şekeri ölçümlerini takip etmek için bazı araçlar vardır, ancak yalnızca kişisel kullanım içindir. Bu projede, çoklu hastalar için veri toplamak amacıyla kullanılan kişisel bir veri toplayıcı kullanılmıştır. Veriler bir veritabanında saklanır, daha sonra doktor veya hasta kendisi anlamlı bir grafikte ölçüm trendine ulaşabilir ve onu görebilir. Bu nedenle hastanelerde düzenli kontroller en aza indirilebilir ve ayrıca doktorlar hastalara tedaviden bahsedebilir. Bu çalışma ile kan şekeri verileri ölçüm cihazından bir kayıt ortamına aktarılır. Birçok cihazın bireysel kullanımı olmasına rağmen, bu proje ile bireysel kullanım için tasarlanmış bir sistem birden fazla hasta için kullanılır.

Anahtar Kelimeler: Bilgisayarla ölçme, Veri toplama, Diabet, Medikal bilgi sistemleri

1. Introduction

Hormones play an important role in the regular functioning of our body in the form of a system. Insulin is a peptide hormone is responsible for the regulation of blood sugar in our bodies. When insulin secretion is not provided, glucose cannot penetrate into the cell to provide the energy of the cell. This type of glucose that cannot penetrate into the cells is accumulated in blood in the process of time. The sugar that accumulates in the blood damages the cells and therefore the organs. This damage causes blood sugar disorder, also known as diabetes.

Diabetes is a chronic metabolism disease that requires continuous medical care. Diabetes mellitus, which results in insulin deficiency, prevents efficient use of the organism. The inability to control diabetes can lead to reduced quality of life, prolonged complications, and even death (Satman et al. 2009). According to the World Health Organization, 220 million of people have diabetes on the world in 2011 and respectable number people died from diabetes (WHO 2015). Many of the systems have developed for the practical management of data collection for the patient, sharing data and improve the patients' lifestyle management (Schiffrin, Belmonte 1982, Control, Group 1993, Strowig, Raskin

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1998, Franciosi et al. 2001, Norris et al. 2001, Izquierdo et al. 2003). Therefore blood glucose value needs to be measured periodically (Association 2010).

Blood glucose disease is spreading every day. The number of patients is increasing continuously in this direction. Regular doctor control plays an important role in the treatment of this disease.

In recent years various studies are done in order to ensure a regular medical examination of blood glucose patients remotely (Bunescu et al. 2013, Ferenci et al. 2013, Wang and Paranjape 2013, Buda and Addi 2014). Early work by David L. Duke et al (Duke et al. 2008) was concerned intelligent diabetes assistant system. In this system, patients enter blood glucose data manually into the mobile system. Subsequently, the collected data are evaluated by the doctors using the styles defined in this document. In another study F. Miele et al (Miele et al. 2015) using amobile application to manage patients' blood glucose. In this android based mobile system blood glucose values is recorded to the system manually by patients. Brian K. Smith et al developed an experience capture system (Smith et al. 2007). In this developed system, the monitoring of blood sugar is evaluated with a different perspective. Patients were taking photos of their meals and uploaded these photos to the system. Experts analyse the relation between patients' meals and differences in blood glucose. Zhanle Wang developed a Diabetic-Patient Software Agent (Wang and Paranjape 2013). In this software system, optimum measurement frequency of blood glucose has tried to determine. In these studies, blood glucose values usually are entered to the system manually. Many studies are trying to make inferences from blood glucose values with the help of computer aided systems.

In this project, Roche branded instruments are used. For data collection Accu-ChekSmartPix and blood glucose meters Accu-Chek Active, Go or Nano products which are compatible with SmartPix can be used. The summarized of the study is shown in figure 1. The SmartPix instrument has its own embedded software to use personally but it keeps the imported data in XML format. In the first stage of this project, the system gets this XML document, processes it, and collects the glucose data from this document. In the second stage, the patient is selected via the web platform. The data of the selected patient is assigned to the patient and moved to the database. After these operations, the results can be displayed graphically to determine the trend of blood glucose data. The system supports data transfer for multiple patients simultaneously. Establishing the device system at specific locations is beneficial to many patients and the physicians. On this way, many patients' data can be recorded in the system. Thus, this data can be also used for statistical purposes.

Keeping a record of blood sugar measurements, providing effective support in reducing health spending. The irregular dipstick should remove from the system with the help of controlled measurements.

2. Materials and Method

Blood glucose measuring devices basically consists of a measurement device, piercing needle used to take blood from a finger and measuring stick that are used to transfer drop of blood to device. In this study Accu-Check Active measurement device and needles are used. SmartPix device is used to provide storing measurement data. Principle diagram of the study is shown in figure 2. Accu-ChekSmartPix is a small device that imports and displays results from Accu-Chek blood glucose meters in an instant. There is an embedded software in the device and the program works in web browser (Manual 2008). It communicates with the

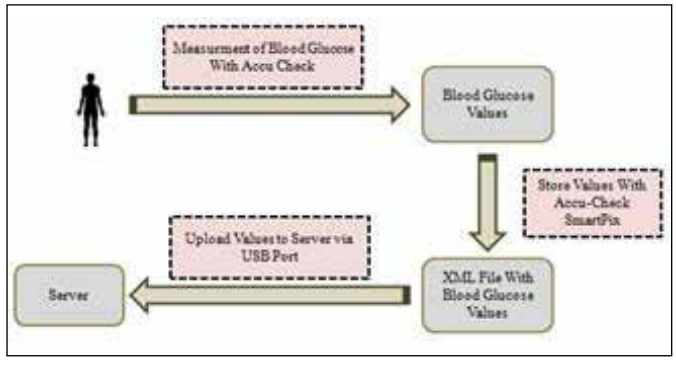

Figure 1. Summary of the study.

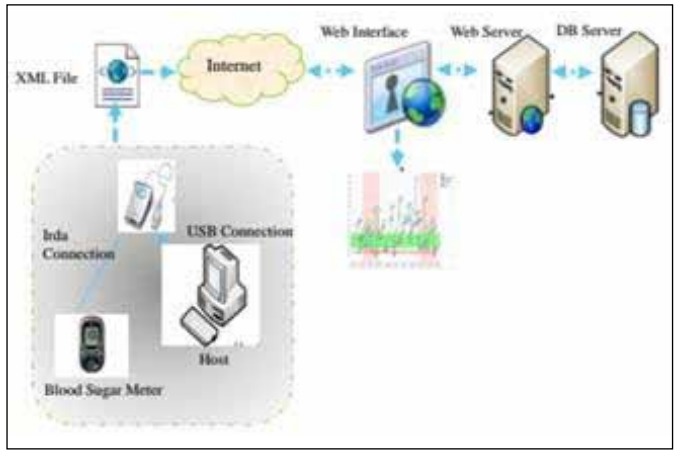

Figure 2. Principle diagram of the study.

blood glucose devices via build-in infrared. And the device is connected to a computer via USB. After connection, it automatically runs the embedded software. From the screen via Read Device link, the data stored in blood glucose meter is transported into SmartPix device (Manual 2008).

After data transportation is completed, we can use our software to transform data and store database. The software is designed with asp.net and uses SQL Server 2008 database (Lisin et al. 2009) in background. After login the software, a patient list and a tool to upload the XML file comes up figure 3. If the patient is not available in the list, he/she can be added. After selection of the patient, the next step is uploading XML file. With Browse button, XML file is found from the SmartPix device drive and Uploaded to server. After upload is completed, with double clicking of the XML file, the process is started and data is processed then recorded into database. In order, for more than one patient these process steps can be applied.

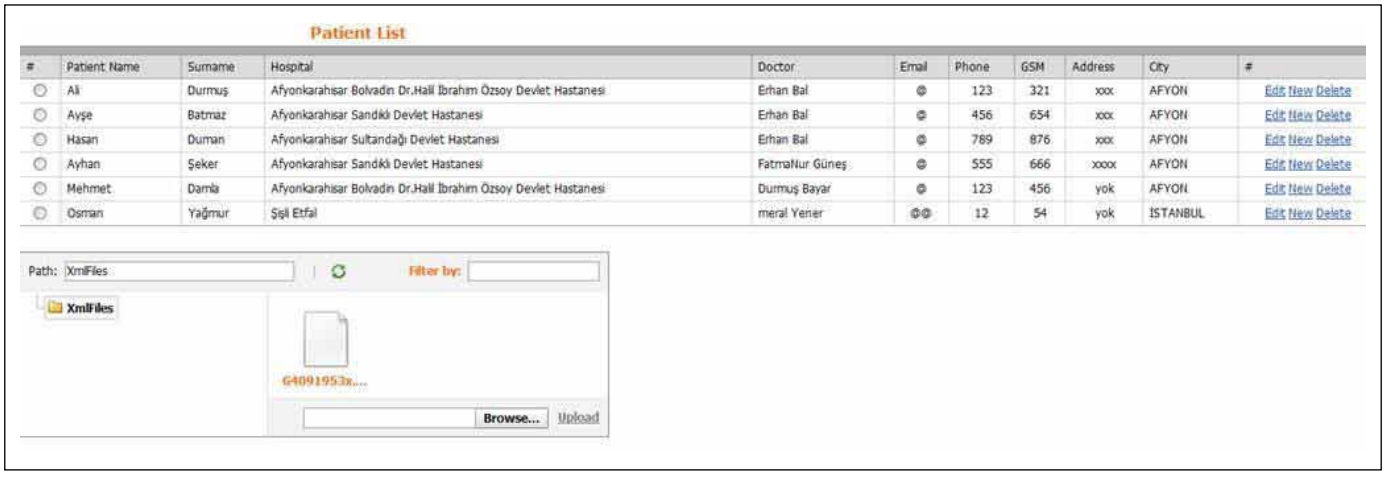

Figure 3. Patient list and the upload tool.

Figure 4. Graph interface.

After finishing data import, we can see the data in the meaningful graph format. From the Report – Graph menu we can reach a new page shown in figure 4. For all patient's doctor can see meaningful parameters. Also patients can reach information for their case regularly.

Here we select the dates range and the patient. Then to show the graph Calculate Graph button is clicked. Data are processed and graph is prepared. The flow chart for these steps is shown below in figure 5.

3. Software Interface

As declared before, the software is developed in Visual Studio 2010 with Asp.Net C# (MacDonald and Freeman 2010).Usernames and passwords are predefined. The user needs to enter the username and password, then clicking the Login button, the first interface comes up like in figure 6. To add new patient New link in the table should be clicked. Similarly, to edit a patient info Edit link and to delete a patient Delete link button are used. Selection is done with the radio buttons.

To upload a XML file first, the file is found with Browse button then it is uploaded to the system. Uploaded XML file is shown in the upload pane. After selecting a patient and double clicking the file process is started.In this interface the following features are used: XmlReader: It is a class to read xml files. It has filename and settings parameter. Settings are defined with XmlReaderSettings. XMLReader reads XmlNodeType.Element from the file. And for each element attributes are checked and the value is assigned to existing variables. Reading values from XML File process is shown in Figure 7. Firstly, an object is created to read XML file. Then all attributes are read from the file. Value parameter is referred to blood glucose value. Date and time variables are used to record measurement date and time.Type variable has three different value. These values are m1, m2 and m3. M1 is corresponded to pre-prandial blood glucose, m^2 is used to record normal blood glucose and m3 is equal to post-prandial blood glucose.

FileManager: This object itself contains upload component and a pane showing files. Its method SelectedFileOpen is used to process XML file. This method comes with parameter collection of FileManagerFileOpenedEventArgs. So with the FileManagerFile-OpenedEventArgs.Folder.Name and File. Name properties we can access the XML file.

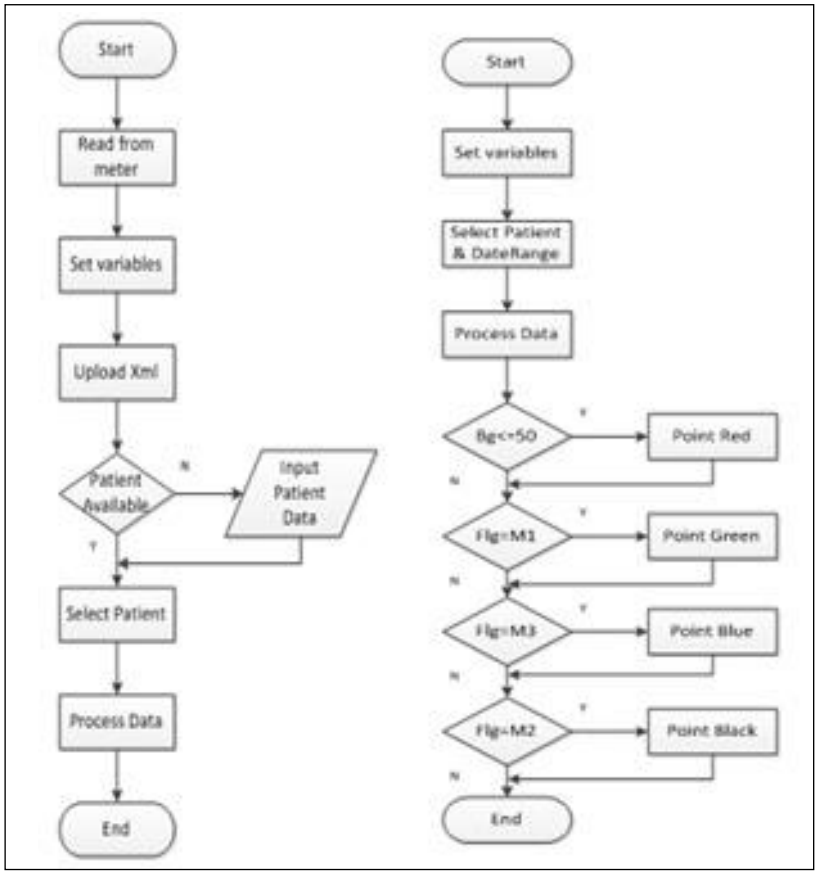

Figure 5. Data import and graph flow chart.

Figure 6. User interface.

```
//Reading values are uploaded to XML File
//Firstly we create File Reader object
create Rd object reader
//Data that store in XML File assign to Rd object
Rd <-- XML File (Data)
//XML File is read to end of it
   while(Rd.isRead)
   begin
       if(Rd.type==XmlFile.type)
       begin
/*BG is name of XML File that includes
patients blood glucose(BD) values*/
         if(Rd.name=='BG')
         begin
           if(Rd.HasAttributes)
           begin
               for i=1 to Rd.AttributeCount
               begin
                   switch(Rd.name.ToString())
                   begin
                       case "value"
                       Rd.value <-- value; break;
                       case "Date"
                       Rd.Date <-- Date; break;
                       case "time"
                       Rd.time <-- time; break;
                       case "type"
                       Rd.type <-- type; break;
                   end
               end
           end
         end
       end
   end
```

Figure 7. Pseudo code of XML file.

SetUserInfo: It is a class to setup current user info. These are current username, fullname and UserId.

GetSelectedPatientID: This procedure uses grids GetSelectedFieldValues method to get the selected patient ID.

Figure 4 shows the graph interface. In this page, there are two date fields to select the date period and the patient list to apply. After selecting patient and the report dates graph is prepared by Calculate Graph button.

SqlDataSource: As it can be understood from its name, sqldatasource create a connection to database and gets data as a view depending on selection parameters.

WebChartControl: It is a complex tool having many properties. Here we used main features.

Series class defines the series kind drawn on the graph. For multi coloring point, first weused a line graph with black points. Then to distinguish values depending on the flag and blood glucose value, we added series for each legend value. For example, for pre-prandial a lime colored point series having data filter of flag value equals to "M1". Similarly, post-prandial series is a point series having blue color and data filter of flag value equals to "M3" and hipo series is also point series having red color and data filter of value equal or less than 50.

Stripes generally used to shows target areas, and here a strip is defined as a green area to show values are in normal range. The target values are between 70 and 140. And also another stripe is defined for weekend on x axis and it is calculated depending on the date value. This process is done during DrawAxisLabel event. This event has DrawAxisLabelEventArgs class having axis item values.

4. Results and Discussion

Most of blood glucose meters are used personally and almost all of them just keep data in itself and they do not generate patient/user friendly reports. Some third instruments like Smartpix which is used in this project collect data from the meter and show the values in understandable format. But the missing point is that these kinds of instruments are only personal use.

A negative side of the personal usage of instruments keeping measurement data is that they can easily lost the values for example changing batteries, instrument malfunction and changing instrument. And Smartpix is also shows only last 2 weeks' data. The main advantage of our system is that all data are kept and whenever or wherever it can be reached.

This project makes use of this personal usage data collector instruments for multi users. Thus, many patients especially having difficulty to travel or patients far from his/her doctor location can transport their blood glucose data into this system and their doctors can check the trend and give them advices or emergency treatment. This system can also be used as mobile teams to get values from patients. With this study doctors and patients can monitor blood glucose values easily. Doctors can keep track of their patients' blood glucose weekly or monthly. This process makes easier to monitor the course of disease. In addition, this study creates a huge database of blood glucose. This database can be used for data mining or machine learning applications. Also, it can be improved as messaging SMS and/or email to warn doctor, patient and patient's relatives.

5. Acknowledgements

The instruments used in project are supplied by Roche Diagnostics Turkey Diabetes Care

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