# Implementing a Prototype Diabetic Telemedicine System

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**Abstract**

Portable electrocardiogram monitoring devices for use by persons at home or work environments have long been known.

In this project a portable ECG monitoring device have been implemented that may be carried by a Diabetic for monitoring ECG data and transmitting the data through the GPRS services network to a database on the remote server in Monitoring Center for analysis. Analyzing software on the server collect, store up and analyses ECG data in the database and visualizes the actual ECG signal to the hospital side computer. This project is Biomedical Engineering MS student's Thesis with tendency Medical information technology management of Amirkabir University of Technology in Tehran, Iran.

***Keywords:*** *Telemedicine, Portable Device, Electrocardiogram, Diabetic Patient.*

## 1. Introduction

In the past, medical procedures depended on presence patient and physician at a particular time and place. But telemedicine has grown with major developments in information and communication technology and by overcoming geographical boundaries and barriers, improve the quality of health care or treatment of disease. Telemedicine can lead to better use of treated patients in golden hours; duration disease to reach treatment centers, the most important time to treat patients So that mentioned this time as the golden hour [1].

Medical services provided at each point and prevent the referral patient to the medical center. It can also monitor patient after discharge from hospital will be improving the quality of treatment.

Continuous monitoring of patients at each point, On the other hand the duration of hospitalization for patients using telemedicine are reduced in the hospital system and patients can immediately resume their normal activities.

Various medical and patient information stored in a memory and access to those in telemedicine system are provided by using a time and place for nurses and medical professionals [2].

Increase the number of people suffering from diseases that require continuous monitoring, such as heart disease, diabetes, and high blood pressure and so on, and review reports from the World Health Organization indicates that a large number of deaths in the world occur, followed by cardiovascular disease.

Studies also show that diabetes plays an essential role in the development of cardiovascular disease, and hypertension [1, 2].

ECG is an important tool in diagnosing patients presented to an emergency room with chest pain.

Portable electrocardiogram monitoring devices for use by persons at home or work environments have long been known. In this project, portable compact device have been implemented that may be carried by a Diabetic for monitoring ECG data and transmitting the data through the GPRS services network to a database on the remote server in Monitoring Center for analysis. Analyzing software on the server collects, store up and analyses ECG data in the database and visualizes the actual ECG signal to the hospital side computer [3,4].

## 2. Methodology

An ECG is a graphic tracing of the variations and the electrical potential caused by the excitation of the heart muscle as detected at the body surface by the leads of the ECG device. A normal electrocardiogram is a scale or representational that shows deflections resulting from cardiac activity as changes in the magnitude of voltage and polarity over time and includes a P-Wave, a QRS complex, a T-Wave, and a U-Wave. These waves are then analyzed using a set of rules and parameters to determine what is normal and what is not. Certain deviations are used to flag possible complications.

The portable ECG monitor and an overall system for remotely monitoring cardiac function of a Diabetic patient have two communication parts.

First is the data acquisition unit to receive patient ECG data (Fig.1),

Fig. 1 ECG signals amplifying circuit.

Second is NXP LPC1768 Processor to process the patient ECG data and transmit them through the GPRS service network module to a database on the remote server in Monitoring Center in for analysis. (Fig. 2) (Fig. 3).

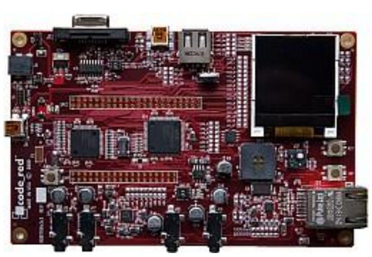

Fig. 2 NXP LPC1768 Processor.

Fig. 3 MOD-SIM900 Board.

The database on the remote server receives the ECG signals from the portable ECG monitoring device.

Designed software on the remote server is based on real time interaction between client and server application and is based on TCP/IP protocols. The ECG receiving software is implemented using Microsoft C#.

The signals are processed in the software on the remote server. The processing include processing the raw ECG signals to produce a graph of the ECG and analysis P-Wave, QRS complex, T-Wave, and U-Wave to set of rules and parameters to determine what is normal and what is not IN Diabetic patient. The database of portable ECG monitoring system is created in MySQL. This database is a collection of interrelated ECG data of Diabetic patients.

In this project Pan-Tompkins algorithm has been used to discover the location of the QRS complex. (Fig.4),

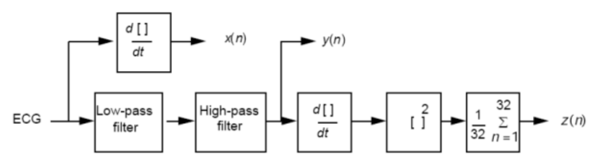


Fig. 4 Block diagram of Pan-Tompkins algorithm.

At the appendix in the DSP_ECG function, there are codes to finding and fixing the maximum of R wave, minimum of S, and minimum of Q in C# language.

## 3. Findings

There are three groups of ECG Monitoring systems: Systems that record signals and perform ECG classification off-line Systems that perform remote real-time ECG classification Systems that perform local real-time ECG classification. [5][6]

The advantage of the first group is patients can continue living a normal life, they present a serious drawback: if the patient suffers from a serious rhythm irregularity, only recording is performed and not real-time classification of ECGs: the classification is performed off-line. For example, halters.

The second group systems make use of mobile telephones and/or PDAs to capture the ECG signal and send it to a control center where the real-time classification is performed. They continually send ECGs through a wireless communication network. There is a loss of efficiency in the use of a wireless network because normal ECGs are also sent and, in case the wireless network is not available at Some moment, there might be a loss of ECG signal with the corresponding risk of not detecting some anomalies. For example, Vitaphone, MeditSense, QRS Diagnostic, Cardio Control, Active ECG and MobiHealth.

The third group systems are not mobile and intermediary computers perform some local real-time monitoring in order to detect some anomalies and send alarms to a control center or a hospital.

These systems only record the signals of heart rate but do not perform any analysis in real-time. The recorded data are downloaded on computers where the analysis is performed off-line. Therefore, they are systems that perform any classification off- line.

The purpose of this research is the use of applicable technologies in telemedicine services for the management heart signals in diabetes. We presented a model to receive ECG signals of patients with diabetes in the form of a portable device equipped with GPRS module, that also received ECG signal send them to a web-Based database system for monitoring and diagnosis of hospital doctors. The doctor also view the status of ECG signals that have been sent to the system from the patient's location, may also be seen Interpretation based on changes from hypoglycemia or diabetic ketoacidosis in the ECG. In case of any risk interventions, emergency in the patient's condition will be treated by the staff.[7][8][9][10][11][12]

The prototype of the portable ECG monitoring system in this project is in second group systems category.

Database of ECG signals of patients with diabetes have an important contribution to improving the results of scientific research in the future.

## 4. Conclusions

The portable ECG monitoring device allows 24-hour surveillance by a qualified clinician at a central facility, or hospital, of a diabetic patient without requiring costly hospitalization.

It would be advantageous if a physician, or health care provider, could supply a device with this type of patient that could expedite diagnosis and treatment by alleviating the embarrassment and time expense of showing up in an emergency department when in fact, no cardiac problem exists. This could eliminate not only the time involved in a patient going to the emergency room, but also saves hospital resources and health insurance costs.

Designed telemedicine system in this project receives and amplifier electrocardiogram signal and helps to diabetic patients at risk of heart attack will be possible to detect the risk of heart anytime and everywhere. In addition, travel costs to get ECG to the hospital are reduced. ECG signals from mobile networks by using packet radio service network is transmitted to the database that is located on telemedicine server. Then electrocardiogram signals are interpreted by a running software application on the telemedicine server. Use of this system will be used to assist physicians in clinical diagnosis. Another part of the project is the friendly user web based system that doctor can observe submitted ECG signal of their patients and interpreted system. Functionality of the running application software in telemedicine server can be increased by adding the vary algorithms that are able to detect abnormalities in the form of electrocardiogram wave signals. On the client Side computers that doctors or professionals trained to work in treatment centers only needs a desktop computer with a web browser and connect to the network. This is the features of software that install, update and manage the interface are facilitated by focusing and no need to install applications on client computers. The database this system where has been collecting the information electrocardiogram signals of diabetic patients and analyzed in real time, provides Possibility of continuous awareness and dynamic in diabetic patients under the care To doctors. Also, they help to provide statistical reports to the Ministry of Health. Patients with diabetes can do their daily activities and can be control far from. Also proposed system is possible continuously monitoring of ECG signal of diabetic patients instead provides a discrete measure. On the other hand reduces patient's stay in hospital, unnecessary and indirectly helps to save time and money. Also, by using this system reduces mortality rates due to heart disease in diabetic patients. A system already is of provides accurate results.

**Appendix**

```
DSP_ECG::~DSP_ECG()
{
```

```
}

void DSP_ECG::SetECG(double* ARECG,int lenght,double*
destMINMAX,int* qrs_count,int* qrs_ms,int* pr_ms,int*
qt_qtc_ms,int select_segment)
{
                //clear the arrays
        ZeroAll();
        //Move ARECG in to ecg
        MoveArr(arECG,ARECG,lenght);
        //calculate D1 of the ECg signal
        dsp_flf.Delta1(arD1,arECG,lenght);
        //calculate the D2 of the ECg sygnal
        dsp_flf.Delta2(arD2,arECG,lenght);
        //count QRS complex
        //the result will be set at the address that
points
        //*qrs_count so to use in after this
        dsp_flf.RFilter_Low(arECG,lenght,250,0.1);
        *qrs_count = QRS_COUNT(arECG,lenght,destMINMAX);

        *pr_ms = ms_PR(arECG,lenght,arD1,arD2);
        *qrs_ms = ms_QRS(arECG,lenght,arD1,arD2);
        *qt_qtc_ms = ms_QT_QTc(arECG,lenght,arD1,arD2);

        if(select_segment==0)
                MoveArr(destMINMAX,arQRS,lenght);
        if(select_segment==1)
                MoveArr(destMINMAX,arPR,lenght);
        if(select_segment==2)
                MoveArr(destMINMAX,arQT,lenght);
        if(select_segment==3)
        {
                ZeroAll();
                MoveArr(destMINMAX,arD1,lenght);
        }
}

int DSP_ECG::QRS_COUNT(double* ECG,int lenght,double*
destminmax)
{
        //max lenght can be 5000 samples
        if(lenght>5000)
        {
                lenght=5000;
//              MessageBox(NULL,"This ECG DSP program
can't calculate lenght>5000smpl","Error",MB_OK);
                //MSK
        }

        int D;
        int Delta[5000];
        double AR_MINMAX[5000];
//      double AR_ECG[5000];
        int Deltamin[5000];
        for(int i=0;i<lenght;i++)
        {
                AR_MINMAX[i] = 0;
                Deltamin[i]= 0;
        }
        //Calculate the standard deviation of the D1
signal
        double dev =
dsp_flf.StandardDeviation(arD1,lenght);
        dev = dev*1.2;
        for(int i=0;i<lenght-1;i++)
        {
                D = arD1[i];
                Delta[i] = D;
                if(D>dev)
                *(AR_MINMAX+i) = 2;
                if(D<-dev)
                *(AR_MINMAX+i) = -2;
        }
        D = 0;
        int d_count;
        for(int i=0;i<lenght-1;i++)
        {
                d_count=0;
                        if(*(AR_MINMAX+i)==2)
                        {       //*(AR_REV+i-1)=400;//find the
delta begining

                                do{     i++;d_count++;}
                                while(*(AR_MINMAX+i)==2);
                        if(d_count>3)
                        {
                                int max=i;
                                do{max++;}
                                while(*(AR_MINMAX+max)==2);
                                *(AR_MINMAX+max) =
*(ECG+max);//fing max after delta+

                                do{max++;}
                                while(*(AR_MINMAX+max)<0);
                                *(AR_MINMAX+max+1) =
*(ECG+max);//find min after R max

                                //Find end of S segment
                                do
                                {
                                        max++;
                                }while(arD1[max]>0);
                                arQRS[max] = -200;

                                max = i;
                                do{max--;}
                                while(Delta[max]>0);
                                *(AR_MINMAX+max+1) =
*(ECG+max+1);//find min before P d+
                                do
                                {
                                        max--;
                                }while(arD1[max]<0);
                                arQRS[max] = 200;

                                //*(AR_REV+i) = 400;//end of
the delta+
                        D++;
                        }
                        }
                }
                for(int i=0;i<lenght;i++)
                {
                        if(arQRS[i]==200)
                        {
                                do
                                {
                                        i++;
                                        arMark[i] = 200;
                                }
                                while(arQRS[i]>-200);
                                arMark[i] = -200;
                        }
                }
                //Move back the min max values
//              MoveArr(destminmax,arMark,lenght);
                //D contains QRS/10s to convert it in QRS/min
                //we must multiply it by 6, because 1 min
contains 60 seconds
                return D*6;
}

int DSP_ECG::ms_QRS(double *ECG, int lenght, double *D1,
double *D2)
{//return QRS complex deviation
        int ms;
        int mean = 0;
        int count =0;
        for(int i=0;i<lenght;i++)
        {
                if(arQRS[i]==200)
                {
                        do
                        {
                                arQRS[i]=200;
                                count++;
                                i++;
                        }
```

```
                        while((arQRS[i]>-
200)&(i<lenght-1));
                        mean++;
                }
        }
        if(mean==0)mean=1;
        ms = count/mean;
        return ms*4;
}

int DSP_ECG::ms_PR(double *ECG, int lenght, double *D1,
double *D2)
{
        //returns PR interval
        int ms;
        dsp_flf.RFilter_Low(arECG,lenght,250,0.36);
//      dsp_flf.Delta1(arD1,arECG,lenght);
        for(int i=0;i<lenght;i++)
        {
                int count=0;
                int q = 0;
                if(arQRS[i]==200)
                {
                        do
                        {
                                q++;
                        }
                        while(arD1[i+q]<=0);
                        arPR[i+q] = -100;
                        do
                        {
                                q++;
                        }
                        while(arECG[i+q]<=0);
                //      arPR[i+q] = -100;

                        do
                        {
                                count++;
                        }
                        while(arD1[i-count]<=0);
                        arPR[i-count] = 100;
                /*      do
                        {
                                count++;
                        }
                        while(arECG[i-count]>=0);
                        arPR[i-count] = 200;
        */      }
        }
        int mean = 0;
        int count =0;
        for(int i=0;i<lenght;i++)
        {
                if(arPR[i]==100)
                {
                        do
                        {
                                arPR[i]=100;
                                count++;
                                i++;
                        }
                        while((arPR[i]>-100)&(i<lenght-
1));
                        mean++;

                }
        }

        if(mean==0)mean=1;
        ms = count/mean;

        return ms*4;
}

int DSP_ECG::ms_QT_QTc(double *ECG, int lenght, double
*D1, double *D2)
{
//returns QT_QTc interval
        int ms = 0;
        int count = 0;
        for(int i=0;i<lenght;i++)
        {
                if(arQRS[i]==-200)
                {
                        arQT[i] = arECG[i];
                        count=0;
                        //Find the next QRS
                        //This count will be our
interval to search T wave
                        do
                        {
                                count++;
                        }
                        //very important check for
i+count<lenght!!!!!!!!!!!!!!!!

        while((arQRS[i+count]<200)&(i+count<lenght));
                        //After finding the next Q fix
it!
                        arQT[i+count] = 100;

                        int max = arECG[i];
                        int max_index = 0;
                        for(int j=i;j<i+count;j++)
                        {
                                //finds the maximum
value
                                //May be a T wave?
                                if(arECG[j]>=max)
                                {
                                        max =
arECG[j];
                                        max_index =
j;
                                }


                        }
                        //Finding the end of QT
interval
                        arQT[max_index] =
arECG[max_index];
                        do
                        {
                                max_index++;
                                arQT[max_index] = 100;
                        }
                //
        while((arECG[max_index+10]>=0));
                        //can use two while!

        while((arD1[max_index]<=0)&(arECG[max_index]>=0)
);
                        arQT[max_index] = -100;
                }

        }
        //calculate QT interval meav
        int mean = 0;
        count =0;
        for(int i=0;i<lenght;i++)
        {
                if(arQT[i]==100)
                {
                        do
                        {
                                arQT[i]=100;
                                count++;
                                i++;
                        }
                        while((arQT[i]>-100)&(i<lenght-
1));
                        mean++;
                }
        }
        if(mean==0)mean=1;
        ms = count/mean;
//      dsp_flf.Message(ms*4);
        return ms*4;
```

```
}

void DSP_ECG::ZeroAll()
{
        //Zero all arrays
        for(int i=0;i<5000;i++)
        {
                arD1[i] = 0;
                arD2[i] = 0;
                arECG[i] = 0;
                arQRS[i] = 0;
                arQT[i] = 0;
                arMark[i] = 0;
                arPR[i] = 0;
        }
}

void DSP_ECG::MoveArr(double *dest, double *source, int
lenght)
{
        //copy one array from source to dest array
        for(int i=0;i<lenght;i++)
        {
                *(dest+i) = *(source+i);
        }

}
```

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