Portable ECG

Smart systems, HAMK

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Assignment

The idea is to create prototype device such as wearable electronics for sports or student life application area.
The solution is developed on Arduino MKR1000 and it will implement at least one local function (e.g. use of sensors and/or user interface) and at least one function using communications for web user interface or for an IoT Platform.

I decided to create portable device that will measure ECG data using Mikroe ECG 3 CLICK module. ECG data and heart beat frequency will be visualised in application.

Solution

The device measures ECG data and RR interval. It sends ECG data and heart rate counted from RR interval to the application (or to the IoT platform).

Components:

- Arduino MKR1000 (https://store.arduino.cc/arduino-mkr1000-wifi)
- Mikroe ECG 3 CLICK (https://www.mikroe.com/ecg-3-click)

Solution is at github page https://github.com/pivovard/Arduino/tree/master/ECG

- ECGard - arduino code
- ECGapp - windows application
- ECGcom - communication library for application

ECG measurement

Mikroe ECG 3 CLICK module uses MAX30003 MCU for ECG measurments (datasheet https://datasheets.maximintegrated.com/en/ds/MAX30003.pdf). I use module in setup 3.3V and internal clock. There is 5V and/or external clock option also available.
The communication with module is over SPI protocol. The connection schema with Arduino MKR1000 is at fig. 1.

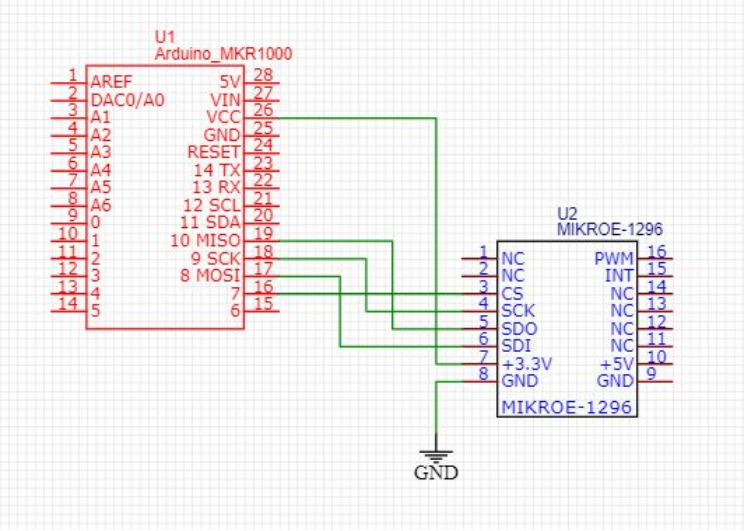

Figure 1: Connection schema

I created Arduino compatible library MAX30003.h for communication with module. Reason I don't use manufacturer official library is that it is developed for Mikroe development boards that are not compatible with Arduino.
I use same settings for ECG measurement speeds as in manufacturer library.

Data transfer

There is an option to send data to Windows application or to IBM IoT platform. Set IoT flag variable to true to send data to IoT platform.
Arduino connects to local WiFi using WiFi101 library.

To application

Arduino starts TCP server. Since new client is connected (our application) Arduino starts sending 12 bytes long messages in regular intervals. Message contains 4 bytes unsigned int time information, 4 bytes uint ECG data and 4 bytes uint heart rate value.

To IoT platform

Arduino communicate with IBM IoT platform over MQTT protocol.
Topic is *"iot-2/evt/ecg/fmt/json"*. Data are in JSON format:

```
{
  “time” : _time_value,
  “ecg”  : _ecg_data,
  “hr” : _hr_value
}
```

Data visualisation

Application

I created Windows desktop application in C# using WPF. I use OxyPlot library in graph visualisation.

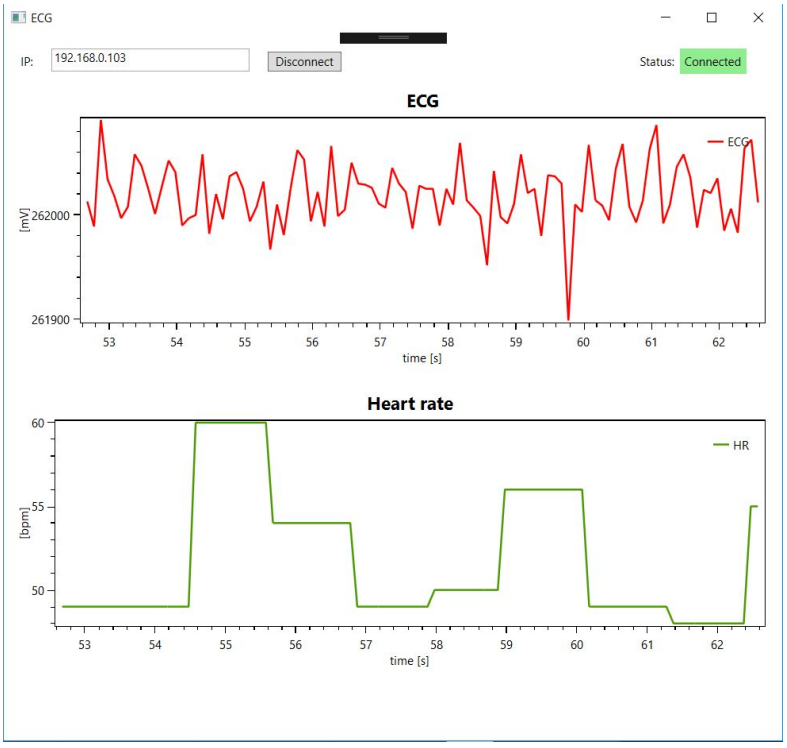

Figure 2: Windows application

IoT platform

At IBM IoT platform I created new board with two cards, first shows ecg data, second heart rate values.

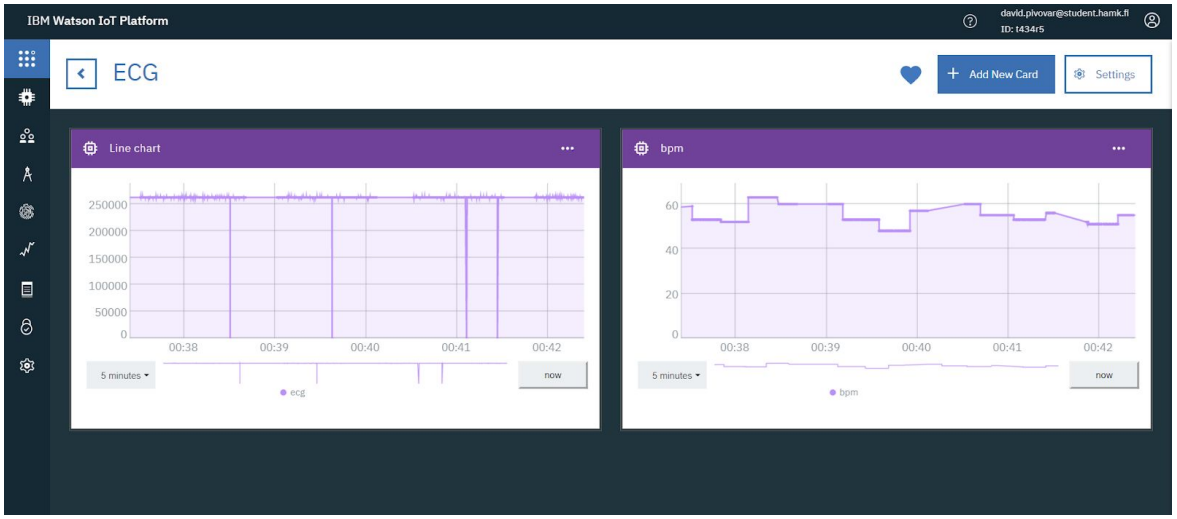

Figure 3: IBM IoT platform data visualization

Future improvements

Box
To make device usable we need to power it by battery and create box for it.

Web application
Use of Windows desktop application is restricted to PC or laptop users with Windows OS only. Creating web application makes it more available for portable devices such as Android and iOS mobile phones.

Speed measurement
Nice feature is to add speed measurement to watch ECG and heart rate changes based on speed.
I tried to use accelerometer. However, data from accelerometer are highly influenced by tilt of the sensor. Adding gyroscope sensor and subtract gyroscope value from acceleration data could be a solution. Other option is to use GPS module.

Conclusion

In my assignment I was measuring ECG data and heart rate and I visualized it.

I worked with two ECG 3 CLICK modules. I wasn’t able to communicate with first module probably because of malfunction of component on board. Communication with other module worked. However, in data I acquired is too much interference. There is no similarity with regular ECG data except visible peaks of QRS complex.
Heart rate measurement was correct, around 60 bpm.

I successfully managed sending data to both windows application and to IBM IoT platform and their visualisation.
I also managed to acquire data from accelerometer, but because of their irrelevance without gyroscope I do not use them to get speed influence to ECG.