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Wireless Intelligent Systems for Biosignals Monitoring Using Low Cost Devices

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Abstract- In this paper we propose a system able to monitor biosignals, to record information on SD card or to send relevant data remotely. This application demonstrates how to develop new wireless intelligent system, to be future used in processing, analyzing and extracting necessary features from biosignals, easily and conveniently. Artificial intelligence improves the biosignals monitoring efficiency and help critical caretakers to speed up a prior diagnose. With LabVIEW and related toolkits, such as the Advanced Signal Processing Toolkit (ASPT) and the Digital Filter Design Toolkit (DFDT), we can conveniently build signal processing applications for both stages(preprocessing and filtering), including baseline wandering removing, noise cancellation, QRS complexes detection, fetal heart rate extraction and etc. We also discuss typical ECG signal processing methods based on LabVIEW and we present the developed improvements for preprocessing and processing ECG signals for QRS complexes, using different function from LabVIEW.

I. Introduction

There are three directions that influence the development of medical instruments and establish an early position in a very competitive market: producing safe, high-quality devices for patient care; reduced development time and low cost system.

Designing a medical product that has features and capabilities necessary to use a particular customer, it is very difficult. To overcome this challenge, we need a new approach that allows increased modularity of design complexity, while allowing the implementation of innovative ideas from non-technical experts. By tightly integrating hardware, software, validation, and reporting tools, the LabVIEW platform provides the best solution for rapidly developing and testing medical devices. Graphical System Design allows an expert in designing integrated systems, to accelerate the development of medical devices.

Designers need an evaluation board to design a prototype system. However, this board often does not include all components necessary for an application signals. Most of the time is needed an extra conditioning circuit, to adapt the bioelectric signals to data acquisition system. We used an instrumentation amplifier TL048CN and Arduino Uno USB experiment interface board. By combining the power of LabVIEW and this system can be accelerate the production and completion of the desired products.

In this paper we propose a low cost fast ECG monitoring system based on silver chloride (Ag / AgCl) electrodes, EKG-V2 amplifier module for ECG signal, USB experiment interface board Arduino Uno designed for computer peripherals and the developed software running on the Laptop or tablet.

II. Experimental setup

Electrodes can be made by metal pellets with 15-25 mm diameter to be applied to the body through a conductive cream or tap water (not distilled). We used three electrodes (Ag / AgCl) connected to a low power amplifier of high gain which was easily run with batteries. The electrodes was fixed with patches through a conductive greases.

The amplification module (EKG-V2) allows viewing of ECG signals on the oscilloscope or Laptop screen and it schematic diagram is showed in Figure 1. Instrumentation amplifier (IC1A and B) amplify the signals from left and right arm with a 180 gain and the third operational circuit apply the signal on the right leg with a 31gain. As a result the patient's body is passed by a well-defined common mode level in the allowable range of instrumentation amplifiers. Common mode rejection can be reduced by P1. Calibration can be made by applying a 100mV signal at 50Hz. The output signal is about 200mV. The continuous ECG signal component is eliminated by amplifying circuit IC1 D and C1 R15 filter. Consumption of the entire circuit is maximum 2mA and batteries will operate for long time. We used autonomous source energy for the body security reasons and to avoid noise introduced by the supply network.

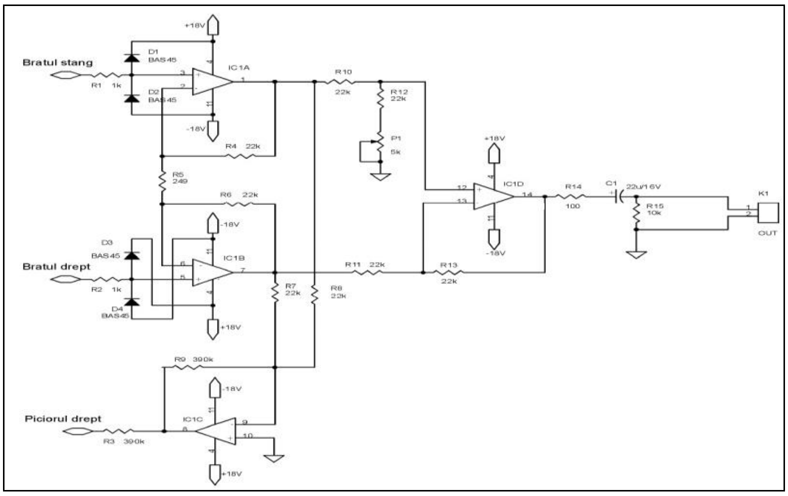

Figure 1. Circuit diagram of EKG-V2 amplification module.

The EKG-V2 output signal is connected to the analog input A0 of Arduino board.
Arduino from Figure 2, is an open-source electronics prototyping platform based on flexible, easy-to-use hardware and software. It's intended for anyone interested in creating interactive objects or environments.
Arduino can sense the environment by receiving input from a variety of sensors and can affect its surroundings by controlling lights, motors, and other actuators. The microcontroller on the board is programmed using a programming language (based on Wiring) and a development environment (based on Processing). Arduino projects can be stand-alone or they can communicate with software running on a computer (e.g. Flash, Processing, MaxMSP).

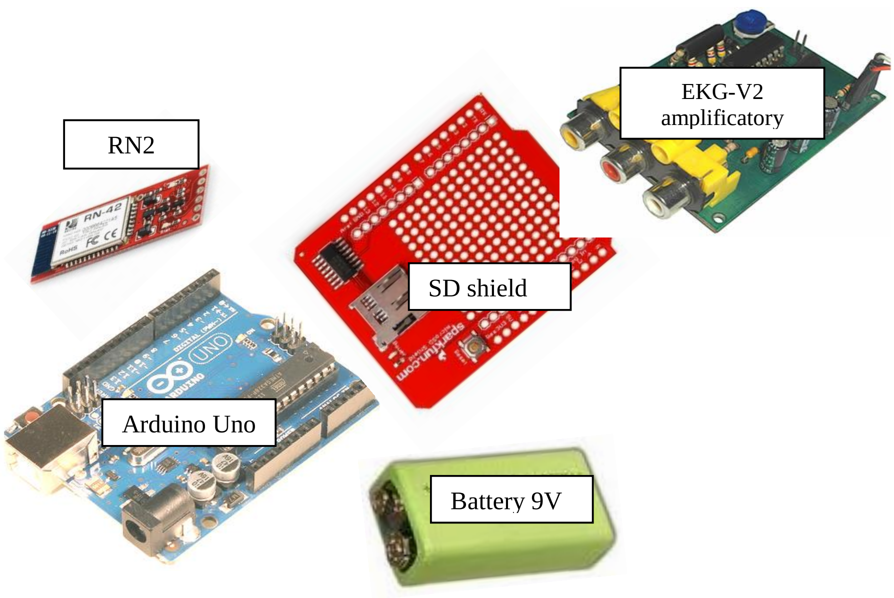

Figure 2. Hardware devices used for ECG monitoring.

The RN42 is a small form factor, low power, highly economic Bluetooth radio for OEM's adding wireless capability to Arduino. The RN42 supports multiple interface protocols, is simple to design in and fully certified, making it a complete embedded Bluetooth solution for different applications: cable replacement, measurement and monitoring systems, industrial sensors and controls, medical devices and intelligent home. In our application

it make the connection between the user smart devices or Laptop and Arduino in order to transmit data from ECG module to be visualized and to be transmitted to currant in emergency cases.
We developed LabVIEW program for the Arduino Uno board. This allows configuration and data reading/writing from analog / digital input / output board channels. In order achieve the virtual instrument for fast ECG monitoring, we used different processing tools.
The software component had a great share in that controlled the hardware system for collecting and preprocessing machine of biological signals from different subjects and storage. At the same time allowed the development of algorithms for selection at a time, processing methods used, depending on how desirable acquisition or analysis.
Using virtual instruments made in LabVIEW and following LabVIEW toolkits: Adaptive Filter, Advanced Signal Processing, PID and Fuzzy Logic, algorithms were checked through several processes:

- On-line and of-line
- Simulation and experiment
- Real time

Correlation of signals acquired was useful in order to extract new features and system check done. Methods were used to extract biological ECG signal from noise using especially wavelet and Wigner as pointed in Figure 3.

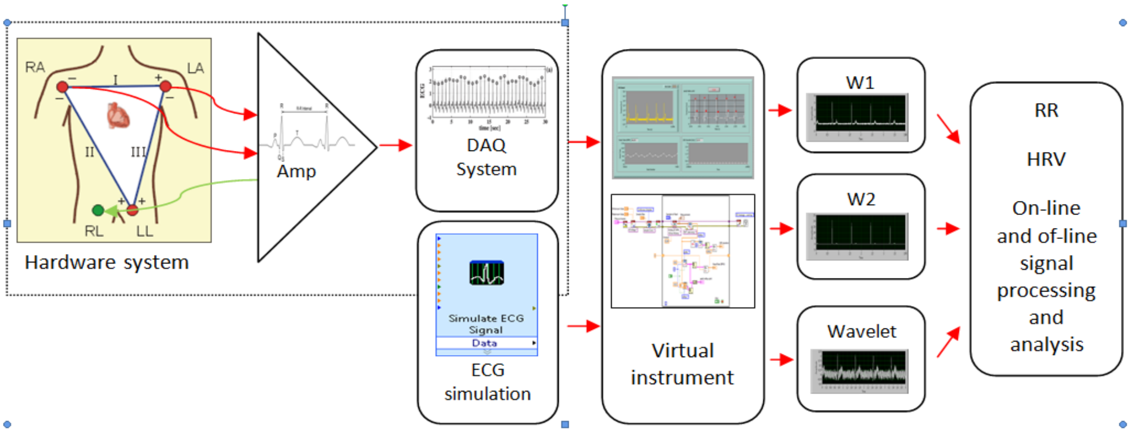

Figure 3. Block diagram for biological signals acquisition, subject to exposure conditions, the stimuli and external perturbations

Next we present the description of virtual instrument in a few steps: Open device; Creating a voltage analog input channel and start acquisition; Continue reading and displaying of ECG raw signal; Use filtering tools: wavelet denoise and wavelet detrend; Subset of ECG filtered signal extraction to detect peaks with Multiscale Peak Detection instrument, and to compute QRS complex duration using Compute QRS duration instrument; After peaks detection the RR interval is determined by the Extract Heart Rate instrument for displaying.

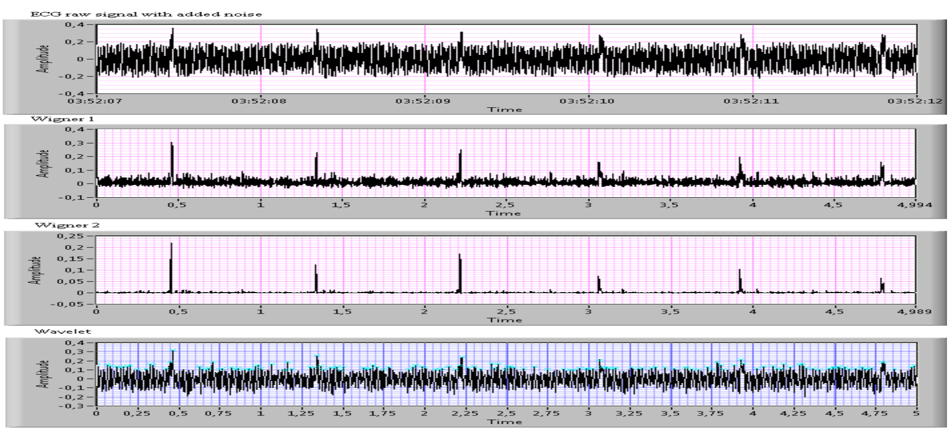

Figure 4. ECG signal collected and processed in the presence of stimuli author wavelet and Wigner functions

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III. Conclusions

The work presented is part of this trend to use virtual instrumentation, in a sense of reducing the costs, flexibility and biological signal processing systems modularization. Using a Laptop and low cost hardware to process and measure signals, our solution allows rapid product development, resulting in quicker deployment to first responders and fast patient heart diseases assessment diagnoses. The LabVIEW software that we developed stands to serve as important tools by helping critical caretakers speed up diagnoses and save lives.

ACKNOWLEDGMENT

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