QR Codes and Java Applied to Physiological Data Acquisition in Biomedical Engineering Education

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Abstract. A remote laboratory should meet the students' pedagogical needs, and should be accessible anytime and anywhere. This work briefly describes a remote laboratory directed to biomedical engineering education, developed using LabVIEW software. The most apparent limitationin the use of LabVIEW is the inability to access from some technological platforms. Therefore, the present paper provides an overview of the workin progress and new developments, in a new remote laboratory, using an independent platform programming language – Java. Moreover, it is also presented new additional functionalities. For instance, the development of remote experiments supporting applications making use of augmented reality tools.

Keywords: Engineering Education; Physiological Systems; Remote Laboratories

INTRODUCTION

The medical problems involve fundamental aspects of the systems and devices analysis, and of the practical conception and application, forming the core engineering practice process. Thedata acquisition from experimental procedures in real physiological situations is very difficult and expensive[1]. New pedagogical tools have to be developed in order to overcome this challenge and allow students and researchers to understand the human body functioning.

Under this assumption, a remote laboratory for biomedical engineeringeducation wasdeveloped, thereby facilitating physiologicalconcepts understanding, through physiological data acquisition from human body. The RePhyS(Remote Physiological Systems) laboratory aims to achieve the pedagogical needs and to be suitable for the biomedical engineering undergraduate students. This remote laboratory development was based on biotelemetry with pedagogical goals, engaging the signals recognition, the remote control and configuration of the physical devices and the observation of cause-effect relationship with parameters changing. Most of all, it enables the interaction with real physiological data.

The present workdepicts the LabVIEW-based remote laboratory developed, presenting its functionalities and showing the results of a study conducted for its validation. In addition, to report the importance of this tool for the biomedical engineering education, building on the positive results achieved, this work also mentions some of the limitations encountered. In order to enhance the remote laboratory as a learning tool, a conceptual vision of a Java-based remote laboratory is defined. This new approach is an undergoing work, whichintends to have more functionalities than the legacy one, providing more flexibility and more adaptability to the target public.

THE REMOTE LABORATORY

The remote laboratory is based on the remote physiological data acquisition for the physiological systems study and research. RePhyS is available on the Internet and it allows the remote access to the real experiments [2]. These experiments define a complementing learning paradigm centered in student interaction and experimentation. Students can acquire, visualize and analyze, in real-time, results of practical experiences and they are able to interact with the measurement's parameters and control them [2]. The aim of the development of this remote lab is the improvement of student's learning on data acquisition and further processing.

The initial phase of the RePhyS development aimed the implementation of the remote physiological data acquisition experiment in the real laboratory. For that purpose, it was employed the Shimmer Research™ Bio Starter Kit®, which consists of four sensor modules: ECG (electrocardiogram), EMG (electromyography), GSR (galvanic skin response) and Strain Gauge [3]. The device has also an accelerometer in order to detect the movement of human body. The experiments performance using each one of the sensor modules demands the electrodes placing on a subject, who undergoes the experience in the real laboratory. The experiences are undertaken voluntarily by the

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subjects, without taking risks and being watched by the responsible researcher, following the code of ethical conduct of the educational institution [4].

The LabVIEW software was used to develop applications for the data acquisition from Shimmer™ device and for the implementation of the experiments. Making use of the LabVIEW Web Publishing Tool, it was possible for the user to view and remotely control the experiment from the webpage, in real time [3]. Fig. 1 illustrates the LabVIEW-based user interface of RePhyS laboratory.

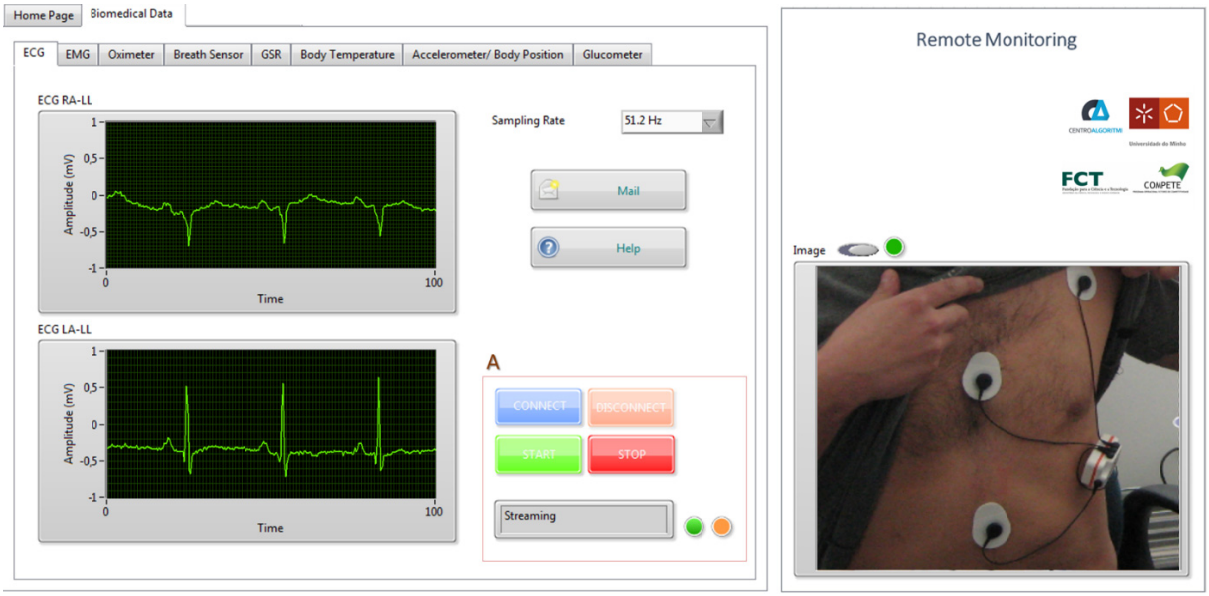

FIGURE 1. LabVIEW-based user interface of RePhyS laboratory, currently available on the Internet.

The validation of the platform and the evaluation of some educational and technical features was possible as a result of a study conducted on the RePhyS experiments. This study showed the importance of the remote laboratory developed for physiological data acquisition and it allowed evaluating issues such as the utility, the usability, the students' perceptions, and the efficiency and effectiveness as a new learning tool. The participants in the study were biomedical engineering students, who performed an ECG and accelerometer values remote acquisition. The main information to retain from the study is that all experiments and the designed and implemented protocol achieved the educational goals of the remote laboratory. Most importantly, the students considered it a useful tool and their receptiveness to this new educational platform is remarkable and is a great motivation for the development of new remote applications in this area of knowledge and learning.The positive results achieved are very encouraging and they proved that this innovative tool provides enriching experiences for biomedical engineering students, able to engage them and fulfil the remote laboratory pedagogical goals [5].

THE NEW APPROACH

Even though the platform works correctly at a distance, this remote lab has some limitations with respect to the user-side. LabVIEW is a useful tool for both the device handling (control and configuration) and the platform's deployment on the web. However, the use of this software has a caveat that could be incompatible with. The required LabVIEW Runtime plug-in installation, from the user-side, is not available for all operating systems besides its incompatibility with some web browsers. To overcome this limitation, the team explores new user-side solutions.The objective is to develop a program that runs in the majority of the web browsers and technological platforms currently available [2].

Considering the results achieved in the assessment study conducted on the remote laboratory, a new solution is being built using the platform independent Java programming language. The introduction of the Java programming language extends the capability of HTML documents by allowing developers to integrate platform (computer hardware and operating system) and browser-independent features into Web documents. Java provides programmers with the freedom to create interactive content for the Web by developing new data types and the methods to operate

on them. The major strength of Java is that most software developers are no longer forced to choose between computer platforms, or expend great resources porting code from one platform to another [6].

The Java application in development is based on a client/server architecture, which the typical scenariois presented in Fig. 2. The server application runs on the local PC, and TCP/IP protocol makes the interaction between client (client socket) and networking equipment (server socket) through Internet [7, 8]. The local Web browser is the only user interface to the experiment. The browser loads the client software as Java applets from the server and starts them.

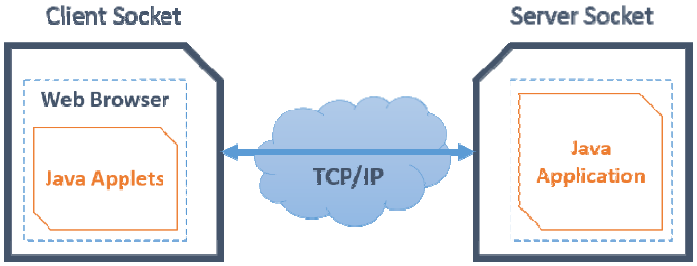

FIGURE 2. Typical scenario of Java client/server application, with TCP/IP communication between client and server sockets.

This new approach should satisfy some requirements to improve the legacy remote laboratory. One is to overcome the limitations of the legacy tool. Aside from the platform dependency tool, the access to the platform by more than one user at the same time is a highly sensitive issue. The LabVIEW application developed and the Web Publishing Tool used do not allow this facility. The new approach should allow the access up to four users at a time. To achieve this goal in the short term, the experiments available in the new platform will be restricted to ECG and EMG acquisition with Shimmer™ devices. Considering these experiments, to develop the server Java application it will be used the Shimmer Java/Android Instrument Driver Library, a development tool provided with the equipment.An access management system should also be implemented, associated to a database with students' usernames and passwords. The real-time experiment monitoring by the video streaming should be improved with the Java Media Framework (JMF). The general remote laboratory architecture proposed for the new approach is presented in Fig. 3.

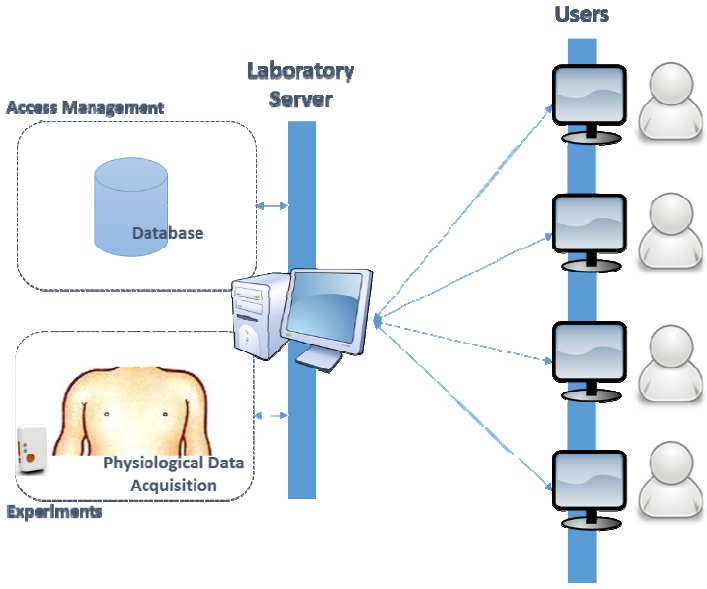

FIGURE 3. General architecture of the RePhyS laboratory proposed for the Java-based approach.

Another requirement is promoting active ways of learning. The survey carried out allowed to conclude about the students learning styles. It is vital to ensure that activities are designed and conducted to offer each learner the opportunity to engage appropriately. Indeed, the outcomes of the students' preferences analysis showed a clear trend to process information in an active way [5]. Therefore, it is intended to deliver information through videos, images and to test the students' knowledge providing short written exercises. With the purpose of motivate, stimulate and

help the students, use will be made of augmented reality. This kindof applications have been used in remote laboratories development [9, 10].An interesting one is the use of QR codes enabling the direct access to different content. In this undergoing work, it is intended to take advantage of this application for pedagogical purposes: in the user side, scanning the QR code using tablets, iPad or smartphones, to allow students to access the different and essential theoretical support during each remote experiment performance.Moreover, it will be possible to see support videos and images in order to improve the students learning process.The QR codes will be provided with the guide of each remote experiment. A schematic of this application to complement the RePhyS is presented in Fig. 4.

FIGURE 4. Schematic of the use of QR codes applications to complement the students' learning during the remote experiments, with access to support theoretical content.

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