

Design And Implementation of Experimental Setup For Neural Data Based Stimulator By Using Labview

Savaş Şahin^a, Mutlu Bayraktar^b, Kübra Evren Şahin^c

^a İzmir Katip Celebi University, Faculty of Engineering and Architecture, Department of Electrical-Electronics Engineering, Balatçık Campus 35620 Çigli, İzmir/Turkey _ sahin.savas@yahoo.com

^b İzmir Katip Celebi University, Graduate School of Natural and Applied Sciences, Department of Biomedical Technology, Balatçık Campus 35620 Çigli, İzmir/Turkey bayraktar.mutlu@windowslive.com

^c Dr. Behçet Uz Children's Hospital, 35210 Konak, İzmir/Turkey kubraevren@gmail.com

Abstract. Recently, the requirements of biomedical technologies have forced to bring up appropriately educated employees. That member staffs are to understand the relations of the multidiscipline, to assimilate theory and application. Hence, they could reach their knowledge of human body system and biomedical systems so as to proceed and contribute to education technologies. In this study, a neuron output data based stimulator experimental setup is designed and implemented via virtual instruments (VIs) in LabVIEW. The neuron output data is generated with Hodgkin–Huxley model. The setup is eligible example to show how the fundamentals of biomedical systems build to the students and how a dc motor can be controlled with neuron output data via VIs on PC. In future direction, a muscle nerve cell will be used with invasive methods to stimulate a real dc motor setup. So, this application might be an initial stage of the designing prosthetic hand applications for students.

Keywords: Biomedical laboratory setup, neuron output data, LabVIEW, biomedical technologies.

1 INTRODUCTION

Recently, the requirements of biomedical technologies have forced to bring up appropriately educated employees. They should make out both theory and application of biomedical system. Thus, they could reach desired knowledge of biomedical technologies. In other words, the design of a biomedical system application needs the knowledge of the human body system and its operating conditions. Such a biomedical system application can be designed to be solved as understanding the human body's biological system and treating on human in terms of simulations and implementations (Cakır et al., 2011; Ozer et al., 2004; Zarghami et al., 2012). LabVIEW program can be used for simulation and implementations for biomedical educational setup (Kumar & Kashyap, 2015). In 2013, Şahin & İşler proposed a robotic arm educational setup via LabVIEW based supervisory control and data acquisition (SCADA) system.

Biomedical system applications are theoretically and technically important biomedical education, this need to follow the latest developments many countries improve their medical and biomedical education tools because biomedical systems have attracted a great deal of attention in recent rapidly (Çakır et al., 2011; Zarghami et al., 2012). Therefore, this paper presents a microcontroller based dc motor experimental setup which is developed for a neuron output data based stimulator. The peripheral units of the experimental setup provide the observation and the control of the dc motor behaviors driven by a neuron output data on LabVIEW graphical user interface (GUI). The neuron output data based stimulator experimental setup is designed and implemented via virtual instruments (VIs) in LabVIEW

widely used for engineering applications (<http://www.ni.com/labview/>, 2012; Şahin et al., 2010). As for the neuron output data, it is generated with Hodgkin–Huxley (H-H) mathematical model (Hodgkin & Huxley, 1952). The setup is eligible example to show that how w a dc motor can be controlled with neuron output data via VIs.

The rest of the paper is organized as follows: in the following section, brief descriptions of the biological and artificial nerve cell made H-H model are given. In Section 3, software and hardware of the neural data based stimulator with LabVIEW are explained. In Section 4, the conclusions and possible future directions for further development are given.

2 BACKGROUND OF NEURON

A neural data based stimulator experimental setup is designed and implemented for driving a dc motor by using a neuron (i.e. nerve cell) output data. In this study, skeletal muscle neuron output data is considered as an example for reference neuron output data.

Neuron ending makes a connection with neuromuscular junctions via skeleton muscle fiber in shown Fig.1 (a). Emitted axon potential throughout neuron moves along the nerve fiber. This event releases calcium ions from sarcoplasmic reticulum in the muscle fiber. The interaction between calcium ions and muscle fiber composed myosin and actin filaments activates muscle contraction. If the muscle contraction occurs continuously, this is called as tetanization shown in the Fig.1 (b) (Guyton & Hall, 2006).

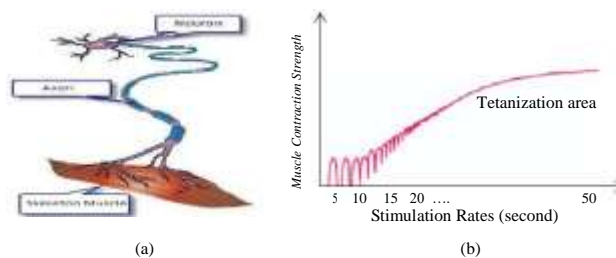


Fig. 1. (a) Neuron and skeleton muscle (<http://www.healthline.com>) (b) Muscle tetanization (Guyton & Hall, 2006)

Any neuron output data in human body can be observed with two measurements methods such as EMG and EEG. Axon potentials in each muscle can be recorded via EMG, when a muscle activates contraction and relaxation. This EMG data, which points out differences between time and amplitude of the recorded axon potentials, can be used for diagnosing in neurology and algology fields. EEG is a data record directly or indirectly about axon potentials generated brain cortex neurons. EEG is used for observing anesthesia depth, following up epilepsy patients, and diagnosing some brain disasters.

In this study, a skeleton muscle neuron output data was generated by H-H model. The H-H mathematical model is determined for voltage-gated ion channels (Hodgkin & Huxley, 1952). Current balance equation of the single-compartmental model is given by

$$C_m \frac{dV_m}{dt} + I_{ion} = I_{inject} \quad (1)$$

$$I_{ion} = \sum_k G_k (V_m - E_k) \quad (2)$$

$$\frac{dV_m}{dt} = \frac{1}{C_m} (I_{inject} - I_{ion}) \quad (3)$$

where C_m , V_m , and I_{ion} stand for membrane capacitance, membrane potential, sum of ion currents, and injected current, respectively. Sum of the ion currents is given in Eq. 2 in which is conductance of an ion channel through a population of identical ion channels and the Nernst equilibrium potential (i.e. reversal potential). The change in membrane potential is determined in Eq. 3 and presented as sample data in Fig.2.

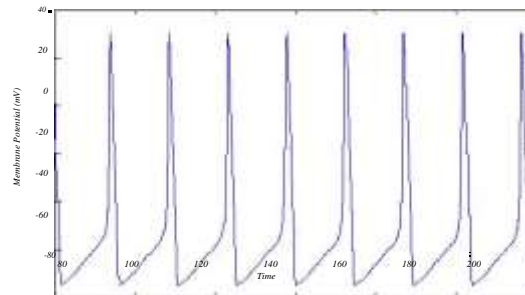


Fig. 2. Simulated data via H-H model

3 EXPERIMENTAL SETUP

The software and the hardware of the neural data based stimulator experimental setup by using LabVIEW are briefly described in this Section. The software of the experimental setup is to provide engineering tools so the software package LabVIEW is chosen for engineering and education applications (Ertugrul, 2000, Sahin et al., 2010). The LabVIEW evaluation copy was used because of its free. Muscle neuron output data that was generated by H-H mathematical model was simulated with Matlab software. Matlab is a high performance language for technical computing. The software have many features such as scientific and engineering graphics, algorithm development, data visualization, data analysis, numerical computation and including GUI .

As for hardware, microcontroller, which is probably one of the most popular control devices for the engineering applications, which is single-chip computers with limited digital and analog input interfaces (Dinçer, 2006). In this study, the Arduino MEGA 2560(ATmega2560) microcontroller has 54 digital input/output pins (of which 15 can be used as PWM output), 16 analog input, 4 hardware serial port, a 16MHz crystal oscillator, a USB connection, a power jack and a reset button. ATmega2560 includes 256 kb of which 8 kb used by bootloader of flash program memory, 8 kb SRAM area and 4 kb EEPROM. Generating Matlab data that is used as muscle neuron output is communicated with serial port of ATmega2560 microcontroller. The neural data based stimulator experimental setup has been realized via the ATmega2560 microcontroller based setup with a dc motor presented in Fig.3. The biomedical application setup is equipped with a PC has Intel(R) Core(TM) i5 processor running with Windows 7 Home Basic and LabVIEW 2014 Evaluation software and Matlab R2013 Simulation software.



Fig. 3. Implementation of the neural data based stimulator experimental setup

The designed experimental setup and the ATmega2560 unit were supplied to the students, who are interested such a biomedical system application, in the BMT506-Data Acquisition and Programming Course in Department of Biomedical Technologies, İzmir Katip Çelebi University. Then, they were requested to develop their front panel GUI with VI programs in LabVIEW. Students are expected to actuate the dc motor and observe the dc motor via neuron output data generated H-H model. Herein, Fig.4 (a) shows the GUI developed with VIs; (b) shows the graphical program with its functions.

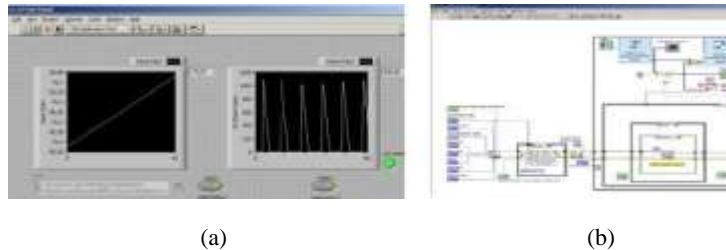


Fig. 4. (a) The GUI developed with Vis, (b) the graphical program with its functions.

4 CONCLUSIONS AND FUTURE DIRECTIONS

The experimental setup of the neuron output data based stimulator has been developed with a microcontroller based dc motor card and LabVIEW GUI for an educational biomedical system setup. The neuron output data based stimulator setup might be commonly used by using artificial EEG generated by H-H model for biomedical engineering applications because possible extensions of the presented study might be prosthetic hand and rehabilitation robot design in Fig.5. Future directions might be determined as two directions such as theoretical and of practical. One can develop EEC, EEG and EMG correlation methods which might be stimulator sign for prosthetic hand and rehabilitation robot design and one can enhance the experimental setup by adding novel features in order to meet some specifications.

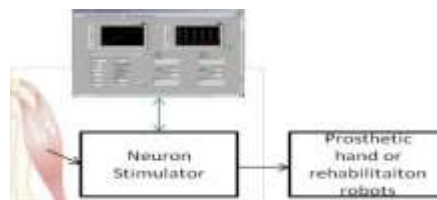


Fig. 5. Future applications of the neural data based stimulator

Acknowledgment

This work was supported by the Scientific Research Projects Office of İzmir Katip Çelebi University under Grant 2015-ÖDL-MÜMF-0004. The authors would like to thank to Dr. Yalçın İşler for his encouragement to write the paper.

References

- Cakır, M. P., Ayaz, H. İzzetoğlu, M., Shewokis P. A., İzzetoğlu, K. & Onaral B. (2011), Bridging Brain and Educational Sciences: An Optical Brain Imaging Study of Visuospatial Reasoning, *Procedia - Social and Behavioral Sciences*, 29, 300-309.

- Dinçer, I. (2006). *Microcontroller Based Applied Digital Control*, John Wiley & Sons, Ltd., West Sussex.
- Ertugrul, N. (2000). Towards virtual laboratories: A survey of LabVIEWbased teaching/learning tools and future trends, *Int. J. Eng. Educ.*, 16(3), 171–180.
- Guyton, A. C. & Hall, J. E. (2006). *Textbook of Medical Physiology*, 11th Edition, W.B. Saunders Company.
- Hodgkin, A.L. & Huxley, A.F. (1952). A quantitative description of membrane current and its application to conduction and excitation in nerve, *J. Physiol.*, 117, 500-544.
- http://www.healthline.com/galeimage?contentId=gegd_0002_0001_0_00036&id=gegd_0002_0001_0_img0022/, Online available (11.21st.2012).
- Kumar, V. & Kashyap, V. (2015). ECG Acquisition Under Incorrect Electrode Positions, 12th International Conference on Remote Engineering and Virtual Instrumentation (REV), 63-68.
- LabVIEW Software From National Instruments, Austin, TX, <http://www.ni.com/labview/>, Online available (11.21st.2012).
- Ozer, M., Isler, Y. & Ozer, H. (2004). A computer software for simulating single-compartmental model of neurons, *Comput. Meth. Prog. Biomed.*, 75, 51–57.
- Şahin, S., Ölmez, M. & İşler, Y. (2010). Microcontroller-Based Experimental Setup and Experiments for SCADA Education, *IEEE Transactions on Education*, 53(3), 437-444.
- Şahin, S. & İşler, Y. (2013). Microcontroller-Based Robotics and SCADA Experiment, *IEEE Transactions on Education*, Vol. 56, No. 4.
- Zarghami, M., Haghali, E., Nikbakht, M. & Valizadeh, R. (2012). The Effect of Eight Weeks Hydrotherapy Exercises on the Mental Health of Men Staffs of Bid Boland Gas Purge Company of Omidyeh City, *Procedia - Social and Behavioral Sciences*, 46, 5392-5396.