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A MATLAB Based On-line Polygraph Test Using Galvanic Skin Resistance and Heart Rate Measurement

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ABSTRACT

Polygraph tests are used mainly by law enforcement agencies to detect deceptions. Many parameters such as blood pressure, pulse, respiration, skin resistance have been used as indicators. We propose to interface two simple analog circuits with MATLAB through a low cost microcontroller board- Arduino, for continuous monitoring of the parameters i.e Galvanic Skin Resistance and Heart Rate.

INTRODUCTION

Polygraph tests are an integral part of investigation strategies used by various law enforcement agencies around the globe. Since their advent they have been a topic of great dispute. Polygraph tests are claimed to be one of the most influential inventions of our time as stated by L.A. Geddes (2002). Our paper reinvents a cheap and reliable technique of making a polygraph machine wherein skin conductivity and blood flow are measured and lie detection is done through online interaction of the MATLAB computer system with the hardware. The conductivity of skin is a function of moisture and sweat glands tend to secrete more when a person is under tension or at ill-ease. This change in resistance can be detected and translated into an equivalent output voltage by the help of a Wheatstone bridge.

Similarly the heart rate of a person also increases under abnormal circumstances. Hence a heart rate measuring device has been used to detect lies.

These circuits can be interfaced with MATLAB for live monitoring as well as data storage. The interfacing can be done with the help of any data acquisition system. We have used Arduino as our data acquisition system because it offers the advantages of low cost and easy programmability.

MATERIALS AND METHODS

Measurement Of Heart Rate:

A photoplethysmographic sensor is used for the detection of volume change in the micro-vascular bed of tissue as described by Calin Corciova *et al.*(2012) . The sensor used is TCRT1000 reflective optical sensor. The change in blood volume is synchronous to the heart beat. Whenever oxygenated blood reaches the tips of the fingers there is a surge in the volume of blood and when the de-oxygenated blood leaves through the vessels the volume decreases. The sensor has a light transmitter and a light detector. The light source and the detector are placed on the same side of the body part. The light emitted from the source is focused on the tissue and the reflected light is measured by the detector. The sensor is fed through a common-emitter configuration of 2N9304 transistor and thus it senses this change in volume of blood and gives out a voltage output which is further filtered and amplified using MCP6004 IC. The circuit (shown in Figure 1) was taken from Introducing Easy Pulse (2012) and a similar circuit has also been used by M.M.A. Hashem *et al.* (2010).

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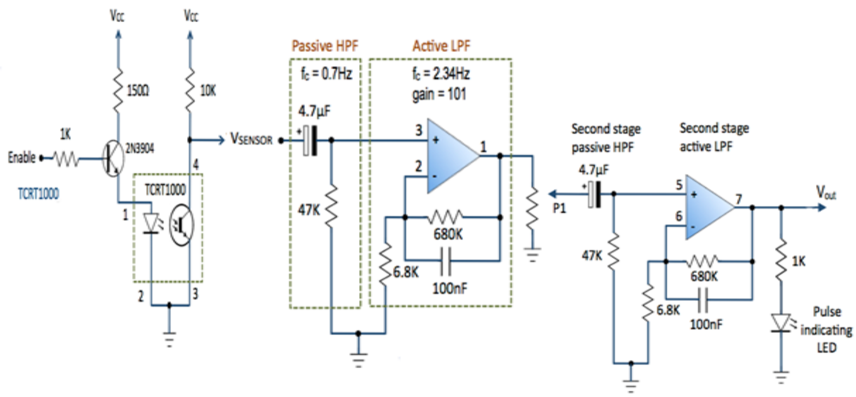

Fig. 1: Circuit Diagram for Heart-Rate Measurement

The output from the sensor is obtained and filtered to suppress the large DC component and boost the pulsating AC voltage. This is the first stage filter i.e. the High-Pass Filter. The next stage filter is a Low-Pass Filter. The two-stage filters help in removing the DC component and the high-frequency noise signals. The output from the hardware set-up (shown in Figure 2.) is a pulsating wave with amplitude of 1.8V (shown in Figure 3.). For measuring the heart-rate a counter was designed in MATLAB wherein the threshold voltage was set as 1V. Whenever the voltage rises above this value, the value stored in the counter is incremented.

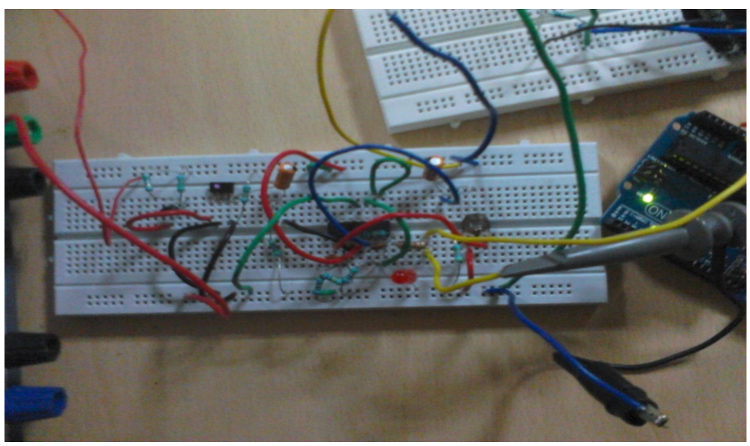

Fig. 2: Circuit Used For Measurement of Heart-Rate

Fig. 3: Output form the Heart-Rate Measuring Circuit

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Measurement of Skin-resistance:

Aluminum foil pasted onto a Velcro strip was used as the electrodes (shown in Figure 4.) for measuring the skin resistance. Two such electrodes were made and worn on two fingers when the measurement had to be made. The electrodes formed one branch of a Wheatstone bridge. Whenever a person tells a lie the fingers generally tend to sweat. This results in a decrease in the resistance and current flows through the detector arm of the bridge. This current flow was measured in terms of voltage and fed into the analog pin of the Arduino board as implemented by Edward Sazonov e*t al* (2012).

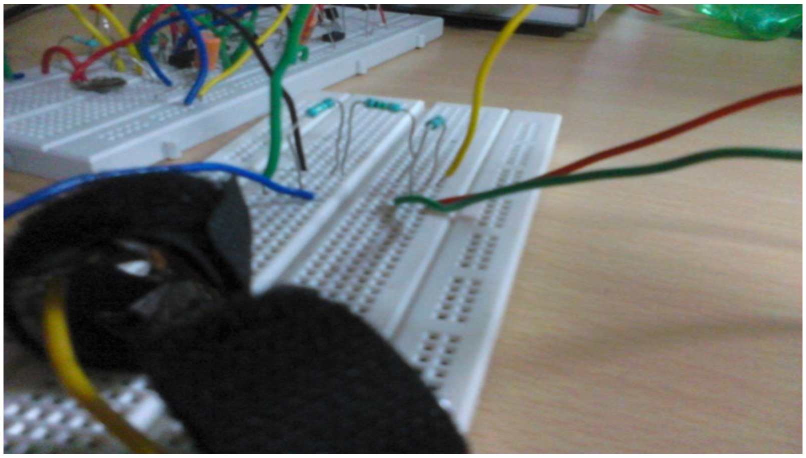

Fig. 3: Aluminum electrodes and the Wheatstone Bridge

Arduino

Arduino is a microcontroller board based on the ATmega328 microcontroller. ATmega328 is a low power 8-bit controller by AVR. It has an in-system; self-programmable, flash program memory of 32kBytes. 0.5 kB of this memory is used up by the Arduino boot loader program. It also has an in-built 10 bit ADC which makes it possible for the user to read analog inputs directly. Apart from the microcontroller the board has 14 digital input/output pins out of which 6 can be give PWM outputs (used as analog outputs), 6 analog input pins, a 16 MHz oscillator, an ICSP header, and an ATmeg16U2 chip which acts as a USB to serial converter. The board can be powered through the USB cable or an AC-to-DC adapter or a battery (6-20V). We used Arduino to take in the analog inputs from the two circuits and then send the data serially into Simulink where the necessary processing is done (shown in Figure 5.).

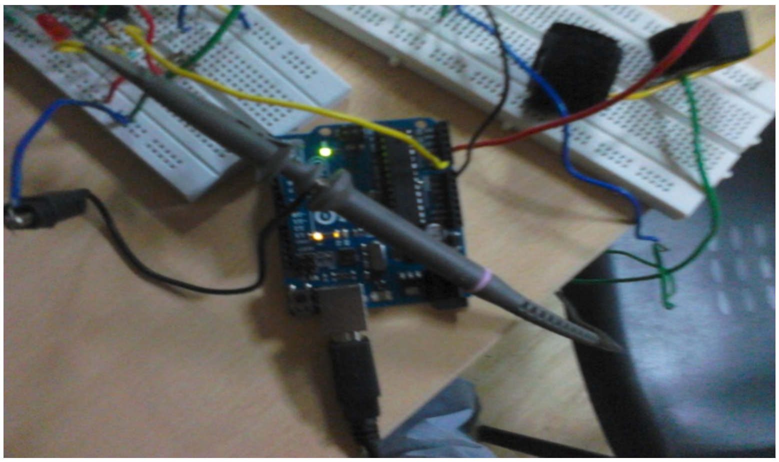

Fig. 4: Arduino Uno Micro-Controller used as the Data Acquisition System

Arduino-MATLAB interface:

We have used the Simulink Support Package for Arduino Uno Hardware (R2012a) for communicating between MATLAB and Arduino as used by Akarsh Sinha *et al.*(2013). A library of Simulink Blocks is provided by the support package which allows access to Arduino I/O pins and Serial Port. The package allows implementation of Simulink Models in Arduino board such that the board acts as stand-alone hardware.

Simulink Model:

It takes in inputs from the circuits and sends them serially to Simulink. The Simulink model (shown in Figure 6.) counts the number of incoming pulses and displays the heart rate .The counter is updated every 5 seconds to have a continuous monitoring over any changes in the heart-rate. Every person has a different normal heart rate. Before conducting a test, the model requires calibration unique to each individual. On questioning if at any point of time the subject's heart rate elevates, it implies that he has lied.

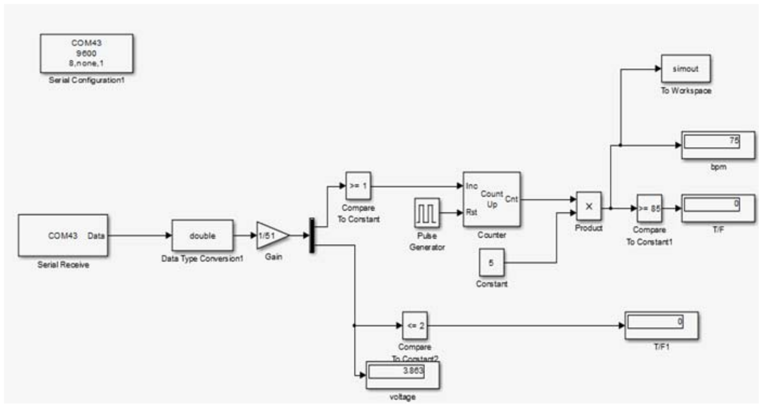

Fig. 6: Simulink Model

It also displays the voltage across the detector arm of the Wheatstone bridge. Under normal conditions the voltage is above 2V. The voltage measured through the bridge is compared with a value of 2V using a comparator block. In case the voltage is below 2V it implies that the subject has spoken a lie.

RESULTS AND DISCUSSION

The equipment (shown in Figure 7.) was tested on 5 different subjects and the values of heart rate and skin resistance were measured prior to the testing for calibration of the model parameters.

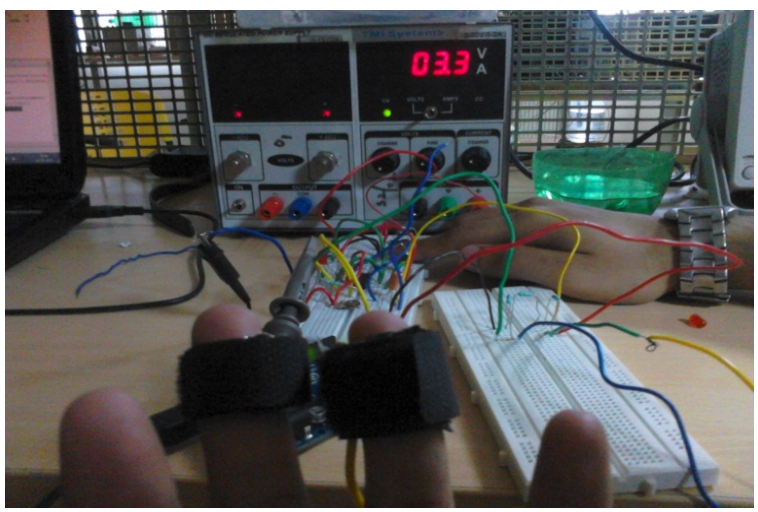

Fig. 7: Complete Hardware Setup

There was a clear shift in the values of skin resistance in all test subjects when the moisture content of their fingers was increased by an external source. The shift in heart rate was more difficult to observe. The graphs obtained for different subjects and a tabulation of their heart rates is shown in Table 1.

Table 1: Hear-Rate of 5 Subjects measured using the circuit

Subject1	Subject2	Subject3	Subject4	Subject5
80	90	65	85	70
75	85	65	85	70
65	80	60	80	70
60	80	65	80	75

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Conclusion:

The above described method provides a cheap and easy option for real-time lie detection. Calibration is required in every lie-detector; our technique boasts of a novel and simplified method of calibration. The system is fast in processing and operation. Screen Capture of a real time test on one of the subjects is shown in Figure 8.

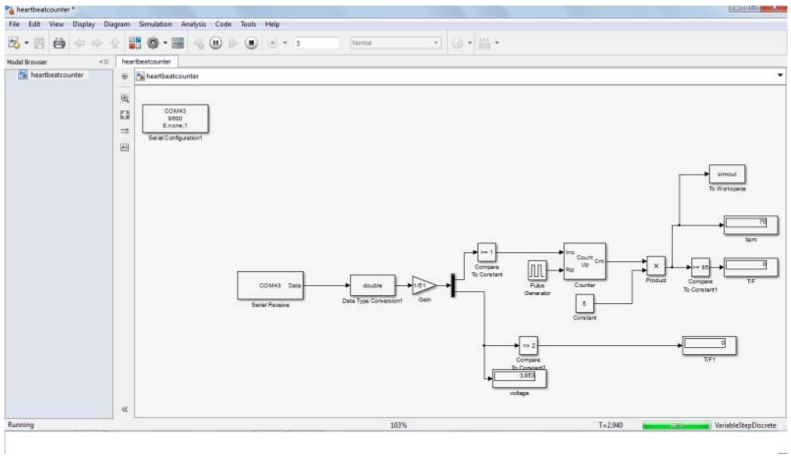

Fig. 8: Online Lie Detection

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REFERENCES

Akarsh Sinha, M. Pavithra, K.R. Sutharshan, “Arduino based pulse width modulated output voltage control of a dc-dc boost converter using PID strategy,” unpublished.

Calin Corciova, Radu Ciorap, Dan Zaharia and Daniela Matei, 2011. On Using Impedance Plethysmography for Estimation of Blood Flow, IEEE.

Edward Sazonov, Timothy Haskew, Andrew Price, Bryant Grace and Stephanie Schuckers, 2012. Electronic and Electromechanical Tester of Physiological Sensors , Sixth International Conference on Sensing Technology (ICST).

Introducing easy pulse: A diy photoplethysmographic sensor for measuring heart rate. (2012, September 12). Retrieved from http://embedded-lab.com/blog/?p=5508

Geddes, L.A., 2002. Purdue University, The truth shall set you free: Development of the Polygrapgh, IEEE Engineering In Medicine and Biology.

Hashem, M.M.A., Rushdi Shams, Md. Abdul Kader and Md. Abu Sayed, 2010. Design and Development of a Heart Rate Measuring Device using Fingertip, International Conference on Computer and Communication Engineering (ICCCE 2010), 11-13 May 2010, Kuala Lumpur, Malaysia.