Pumping Station: One

Ouch! Sensing Galvanic Skin Response (GSR)

Gepostet von Drew Fustini in Pumping Station: One am 08.05.2011 18:02:20

Howdy,

The primary sensor I've been prototyping for the Pumping Station: One Biosensor Array is the galvanic skin response, or GSR, sensor. GSR is a measurement of the electrical conductance of the skin. Sweating causes changes in the conductance, which offers an indication of emotional excitement, because the sweat glands are controlled by the sympathetic nervous system. GSR does not offer a fine grained indication of emotion, since it does not distinguish between the many different emotions which elicit a change in skin conductance.
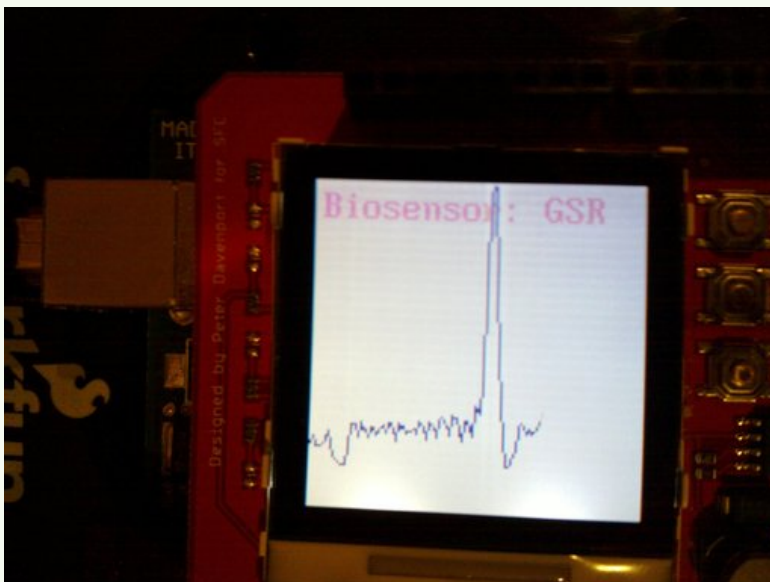
GSR graphed on SparkFun LCD shield

If you have a multimeter on hand, then you can measure the resistance between two fingers by pressing one probe against each finger. The range for the resistance of skin is typically 50k to 10M Ohm (per Sean Montgomery). Skin conductance is the reciprocal of that resistance. Thus 50k Ohm is 20 uS (micro Siemens, not Seconds) and 10M Ohm is 0.1 uS. To summarize, skin conductance is inversely proportional to skin resistance.

However, if one just looks at their skin resistance on a DMM, then it will be very difficult to determine when their skin is responding to emotional changes. Thus, a circuit is required which produces an output voltage proportional to the change in skin resistance. The circuit needs to filter out noise and amplify the GSR signal. This output voltage can then read by any microcontroller (an Arduino for this project) and graphed over time in software.

I tried many different approaches when prototyping GSR, but I found a modified version of the Truth Meter circuit by Sean Montgomery worked the best for our application:

Sidebar

Blog filtern

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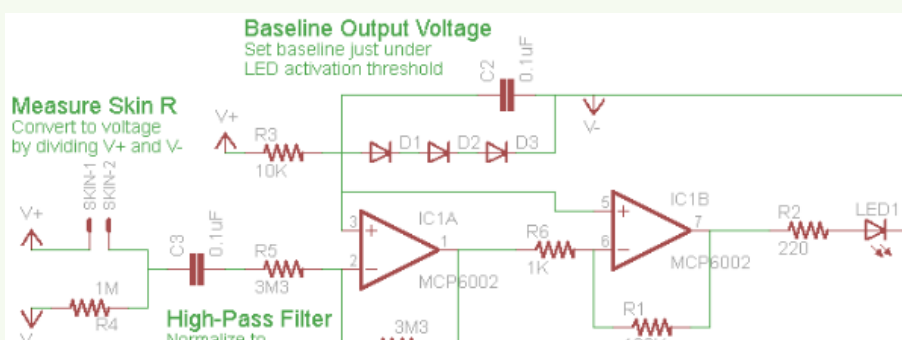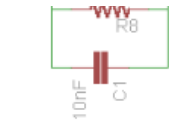
Ouch! Sensing Galvanic Skin Response (GSR)

Down to the wire - GGHC Biosensor Array build recap

Biosensor crunch time

Biosensor Array Update

Eingehende Links

Re: Have a question about Arduino? Ask me!

Re: Simple project for 10-11 year old.

Arduino sensing galvanic skin response

baseline Rskin
~0.48Hz cut

R8

Amplification
Increase signal range
to light up LED
(100x)

10nF   C1

Low-Pass Filter
Filter out high freq noise
~4.8Hz cut

Sean built this circuit so that no microcontroller is needed as it employs both a low & high pass filter to create a 0.5 Hz to 5 Hz band pass which works well for GSR since it is a slow 1 to 2 Hz signal. The low-pass filter cuts off high frequency noise above 5 Hz such as 60 Hz noise from AC power. The high-pass filter cuts off frequencies below 0.5 Hz, or 2 seconds.
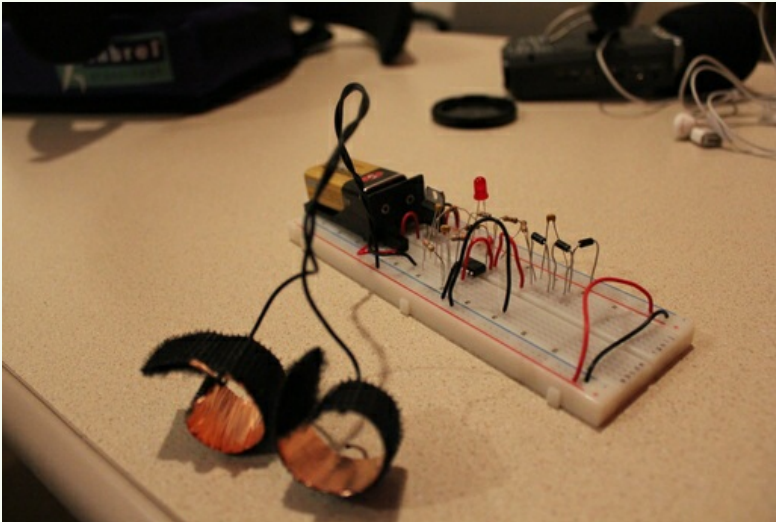

Truth Meter uses a 9V for power and an LED for output. The brightness correlates to the GSR magnitude. (Photo by Jordan Bunker)

In effect, the high-pass filtering subtracts the baseline average skin resistance leaving the only change in skin resistance within the 1-2 second range of GSR. The result is that the GSR sensor is able to auto-calibrate for each user regardless of the the baseline skin resistance. Essentially, the Truth Meter circuit produces just the GSR events, or spikes, where an emotional response occurred which is illustrated by this graph on Sean's website:
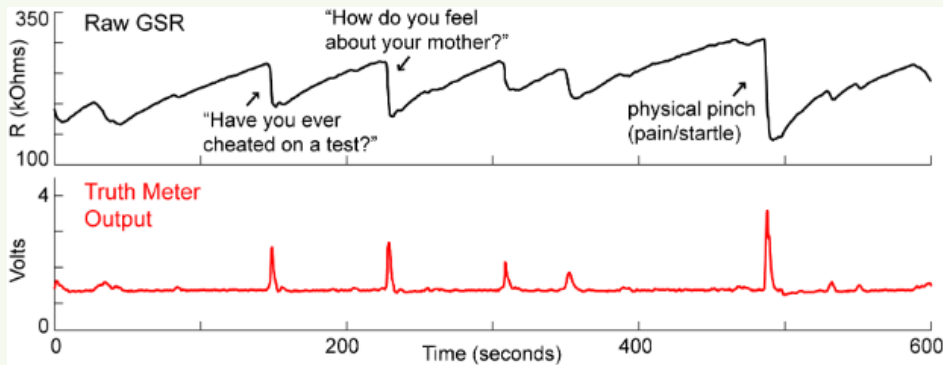
Sean's Truth Meter circuit worked really well for our project as the voltage output of the circuit is already filtered and can be simply read by disconnecting the LED and instead connecting the output resistor to the Arduino via an analog input. The complexity of the Arduino code is reduced as no additional filtering needs to be done in software.
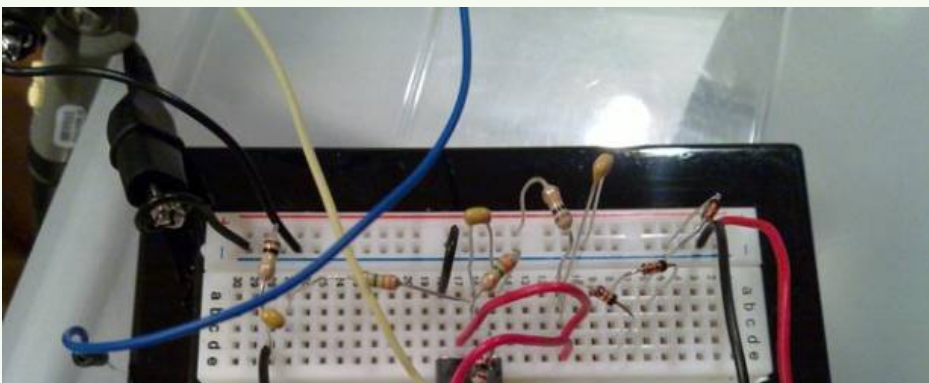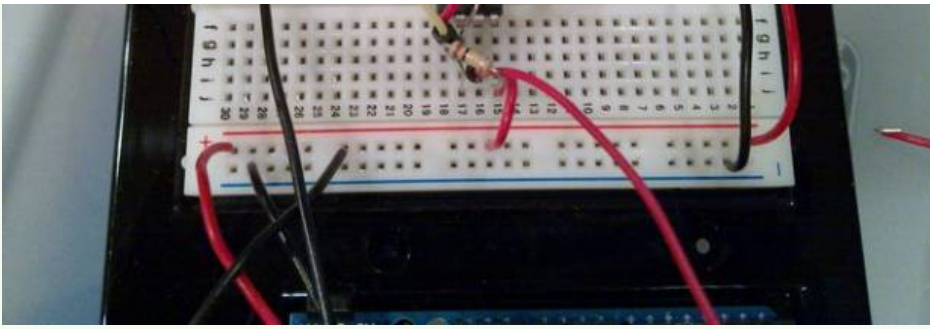
Biosensor GSR circuit prototype based on the Truth Meter connected to Arduino analog input.

[Arduinoscope](), a Processing sketch, is running and graphing the output the Arduino is sending via serial link over USB. The spike pictured below is the result of me poking myself in the leg with the leads of an LED to illicit pain:
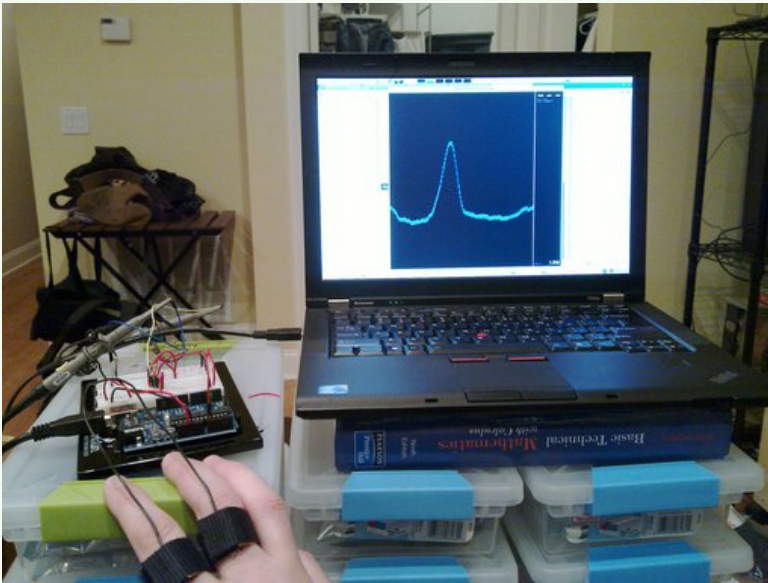
I found slapping myself also worked well too:

As an aside, always have your laptop unplugged from AC power when doing biosensing prototyping. First and most important reason is safety. Second reason is that the analog inputs will have 60 Hz noise imp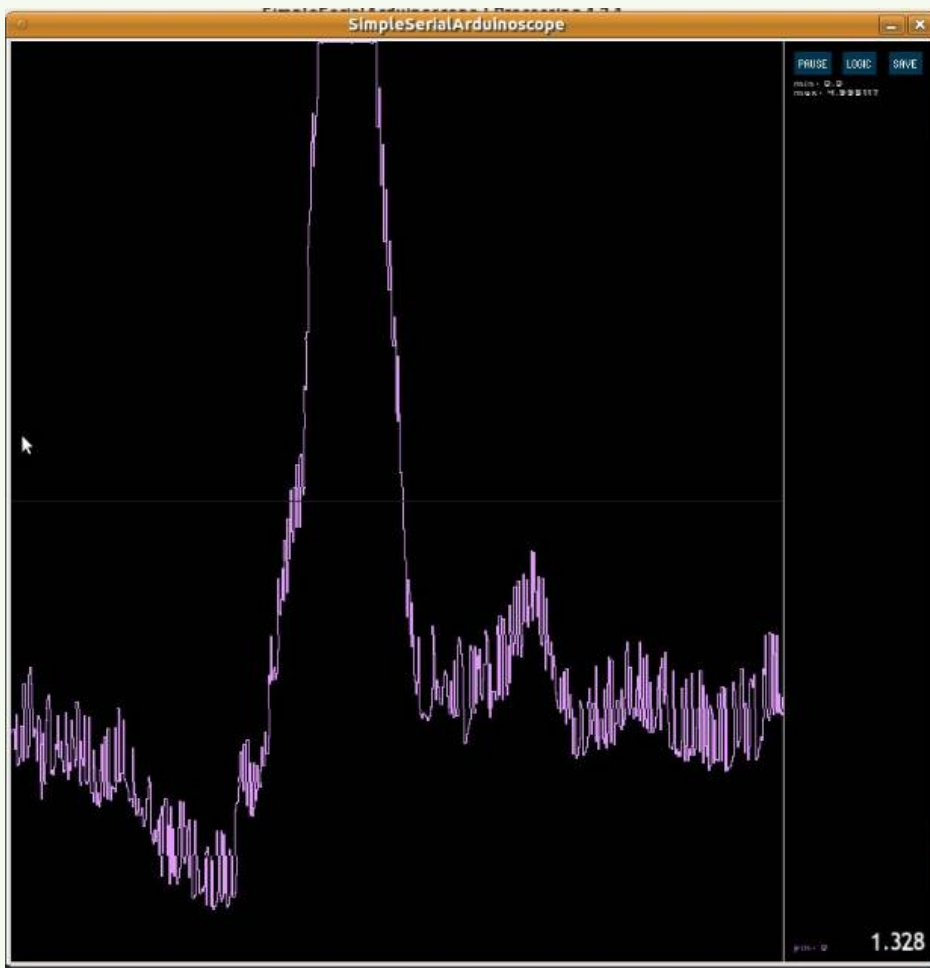osed on their waveforms. I found this to to be the case even with the bandpass filter in the GSR circuit. The above screenshot was taken when the laptop was plugged in AC and the waveform looked much smoother when laptop is running off battery. For our actual biosensor array, a Bluetooth module & 6xAA batteries are used so that there is no connection to laptop or AC power.

After prototyping on breadboard with good results, I made the Biosensor Array GSR shield which is pictured below. It is stackable with the ECG shield and has header for the BlueSMiRF bluetooth module. It is essentially the Truth Meter circuit but with pots for the important resistors to enable maximum calibration by the user: 1MOhm (skin voltage divider), 10kOhm (non-inverting reference voltage divider, substituted for the diodes) and 100kOhm (gain of final op-amp):
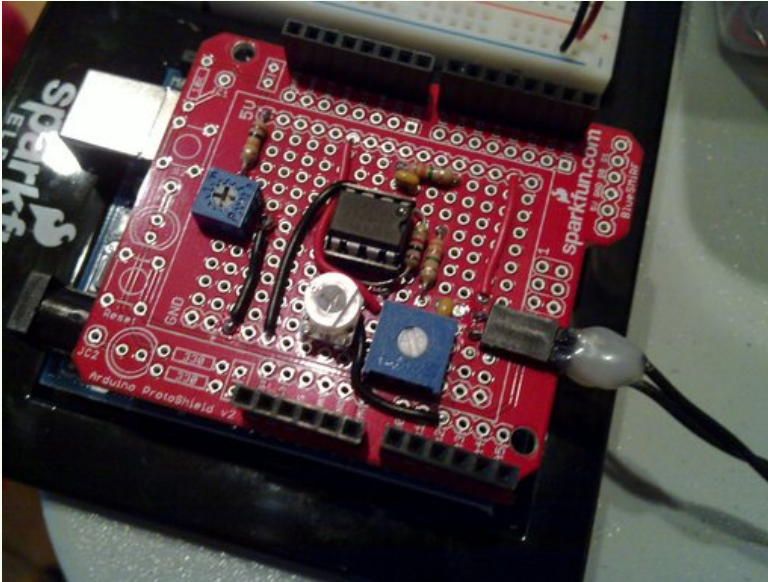

These simple finger straps below connect to header on the GSR shield and are extended for actual usage by our biosensor array cabling system. Based on the Truth Meter instructions, I built the straps from copper foil & velcro tape I got at Jo-Ann Fabrics. After building several pairs, I went out and got some stranded wire as it makes a much better solder joint than solid core wire on the copper foil. Also, I made sure to use lead-free solder as the solder joints are in direct contact with fingers during usage.

And finally, if your interested in building your own Truth Meter, the circuit is featured in Make Magazine Vol 26 (Spring 2011) in the "Biosensing" article by Ira M. Laefsky & Sean M. Montgomery:

- Make Magazine: The Truth Meter
  - http://makeprojects.com/Project/The-Truth-Meter/703/1

- MakerShed Truth Meter kit:
  - http://blog.makezine.com/archive/2011/04/new-in-the-maker-shed-galvanic-skin-response-kit.html

- Truth Meter kit assembly & usage video by Make:

In my next blog post, I will share the other circuits I prototyped and challenges encountered along with how I plan to improve the GSR sensor in the future, like refining the LCD display:
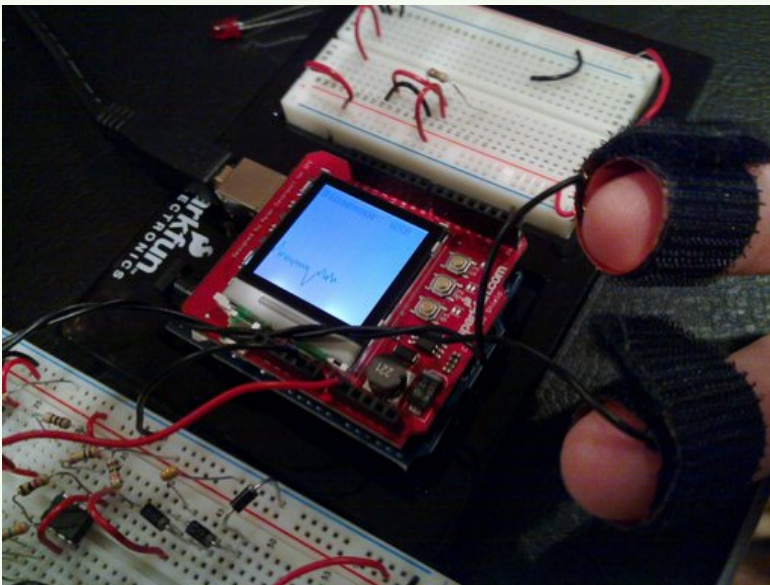
Cheers,
Drew
http://twitter.com/pdp7

6 Kommentare

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DAB 08.05.2011 22:51

Very interesting.

Thanks,
DAB

Gefällt mir (0)

paulzee 09.05.2011 05:08

Great stuff - nicely done Drew!

I'm thinking I'd love to see the OpenLab incorporate some of your sensor work as add-on experimenters kits. I'd love to kick some ideas on that - once the dust has settled 🙂

Gefällt mir (0)

Drew Fustini 10.05.2011 19:15 (als Antwort auf paulzee)

Thanks all.

@Paul, that would be great. I really liked the professional design of the OpenLab. I used NI's expensive, proprietary, Windows-only ELVIS in a couple classes and it was terrible. I think the the OpenLab would do much, much better job.

I remember from the Signal interview that ya guys got your PCB quickturned by piggybacking on a local business. Any plans to do kits of the OpenLab?

And, yeah, that would be great to try to interface the biosensors with it once things have calmed down a bit. I think everyone has been catching up on their day jobs after crunchtime 🙂

Cheers,
Drew

Gefällt mir (0)

Drew Fustini 29.11.2013 19:39

fyi - I believe the code we used is here: https://github.com/pdp7/ps1biosensor/tree/master/ps1biosensor_arduino

Gefällt mir (0)

kat1171 29.03.2015 16:57

On the Make site it's just a circuit. On here you use an Arduino board. I want to stream the data live (kind of like processing)- how should I do that?

Gefällt mir (0)

satrio_priyono 30.03.2015 16:56

Mr drew, is it possible using gsr for measuring human skin moisture ? based on your schematic above, how to connect it to arduino?

Gefällt mir (0)

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