DSP 425 Final Project

Overview:

Your final project in Digital Signal Processing has three parts. First you must build a system to monitor breathing rate. Second you must demonstrate in a video that your system works and meets the project specifications. Third, you must document the monitoring system in an IEEE journal format paper. Your IEEE journal format paper must stand on its own in that it must prove to a reader that your system was successful. It must include appropriate graphs and data to describe a successful system. Your video demonstration is separate from your paper and demonstrates proper system operation.

Description of the system you must build

Using your Arduino and the LM61 temperature sensor, you are to build a breathing rate monitor to warn of a potential acute respiratory infection (pneumonia) in a child age 11 months to 5 years.

System Specifications:

Your breathing rate monitor must detect if the breathing rate is greater than 40 breaths per minute and sound an audible warning. If the breathing rate is normal (12-39 breaths per minute), do not sound a warning. If the breathing rate is well below normal (0 to <12 breaths per minute), this might indicate that the sensor is disconnected, in which case a warning should be sounded. The warning signal for a disconnected sensor, should be different than the signal for below normal breathing rate and the high breathing rate warning. The monitor should operate continuously and reliably. The warning should be sounded within 2 minutes of the breathing rate entering into either warning zone. The monitor should not produce either false positives or false negatives. The final system must stand alone and not require being connected to a PC to operate.

Suggested warning tones are:

System not working – 200 Hz continuous tone
Low rate breathing – 400 Hz continuous tone
Normal breathing – No tone
High rate breathing – Intermittent 1000 Hz tone 1 sec on, 1 sec off

Description of the demonstration/video

You will produce a video presentation of no more than 10 minutes of your operating system. The video will include a fully functional demonstration of high breathing rate, low breathing rate and normal breathing rate. This may be recorded using ZOOM or other video recording software.

Good videos tend to have:

- an introduction that sets context for the problem
- a description of the approach
- evidence/proof that the method works

Description of the final project paper documenting your work

You will write a technical paper in the IEEE Transactions journal paper format on the subject of respiration rate monitoring based on measurement of nasal or oral air temperature. The paper must be illustrated with code examples, figures, illustrations, test results, simulations, and so forth. In preparing these, you will develop a deeper understanding of the subject.

You should expect to put significant effort into the write-up so that it is a polished piece of work that you would be proud of providing to a current or prospective employer.

Good papers tend to have these components:

- A clear statement of what problem is being solved or investigated
- An introduction to why the topic is relevant, significant, where it applies
- A review of what is already known and what is not known.
- A description of how the problem is being approached
- A description of key system characteristics (e.g. temperature sensor specifications, ADC specifications, quantification of system noise, etc.
- A description of the design goals
- A description of the design approach (filter options, filter choice)
- A description of design implementation (key issues, data types, etc).
- A description of design performance (impulse response, frequency response, execution time, memory usage, comparison to alternative implementation options and explanation of why you chose one design versus another.)
- Several well labeled figures with clear descriptive captions.
- Tables to summarize data.
- Relevant equations with descriptive text

What your paper should discuss

1) Your introduction should provide motivation for the problem – Why is monitoring of respiration rate useful? To whom? Who will benefit? Why not just use other methods for detecting pneumonia? What is the advantage of respiration rate monitoring for detecting pneumonia?

2) Your introduction should also provide context for the specific implementation of respiration rate monitor. For example, state that you are given a fixed configuration of a system - a low cost 8-bit microprocessor with only a 10 bit A/D converter and only 2k of RAM memory. The sensor (LM61) and input analog path are constrained by cost to having no op-amp, no gain, no other analog components (e.g. you can't use an analog filter).

a) Include photographs, schematics, etc. as appropriate so that your reader understands the system you are working with.

3) Your paper should describe how you performed the signal processing. Include a block diagram of the signal flow: Show the signal coming from the temperature senor, into the A/D, averaging, initial filtering, scaling, additional filtering, decision making, and light/sound alarm setting/clearing.

a) Where appropriate in the signal flow diagram, indicate what the signal level is, in appropriate units. For example, possible units might include: degrees C, millivolts, A/D converter counts, integer value, floating point value, etc.

4) Your paper should include results that demonstrate how well your system works. Your paper must stand on its own showing that your project works. It is independent of the video. Include:

a) Labeled plots of the time domain signal plus noise for significant points in the signalflow. Record/print data as needed to do this. Note that this will show how the signal changes as it progresses through your system.

b) Labeled plots of the frequency spectrum of the signal plus noise at key points in signal flow diagram. (Where possible). Do this for both low frequency breathing and high frequency breathing.

5) Your paper should have a thesis. It should make a statement. An example thesis statement might be: "Despite having a very low amplitude of variation in the temperature signal with breathing to work with and high quantization noise (SNR < ?? dB at A/D converter output), we were able to apply signal processing to get a reliably detectable difference between normal breathing rates and abnormal breathing rates (> 40 breaths/min) using low cost hardware."

Your final write-up will be judged on how well it presents you as an engineer who is knowledgeable about applying and evaluating digital signal processing techniques and your ability to communicate clearly, supported by key graphs, figures, data, comparisons, diagrams, and code details. You may also find it helpful to read the handout "reproducible research" posted on myCourses.

Objectives: The objectives of this assignment are:

1) To solidify your understanding of digital signal processing from analog to digital conversion through noise reduction and filtering.

2) Practice conveying your newly gained knowledge to others so that they may benefit from what you've learned

3) Provide a polished written document that you can add to your portfolio for job interviews in the next few years.

**Deliverable / **	**Date / **	**Grade**
Final Paper	Last day of Class	70% of the final project grade
Demonstration/Video	Last day of Class	30% of the final project grade

The primary measure of success for this project will be how clearly and thoroughly you convey to others the technical issues encountered and the solutions you employed.

Final Project Rubric	
Result Description	**Points Available**
Video	
Introduction setting the context of the problem	5
Description of the approach	5
Demonstration of proper operation of the system for each breathing rate. (Lo-Mid-Hi and broken)	20
Report Paper	
Correct IEEE format used	10
Introduction -- Describing motivation for the problem. Why is this useful, to whom? Why not other methods. Advantage to this approach	5
Context for the specific implementation of the system -- Low cost, minimal hardware, minimal RAM and inexpensive sensor	5
Description of the signal processing, block diagram with the signal flow. Sensor, ADC averaging, equalizer, filtering, warring logic and alarm setting and clearing. Describe signal units and levels, data types	20
Results (graphs and or data tables) that demonstrate proper operation of the system. Time domain and frequency domain plots as needed. SNR at key points in the system.	20
Strong conclusion stating how the project objectives were met with the hardware and software system that was implemented.	10