4B25 Project Report

Amy Hall (ah807)

1 Project outline

The device designed in this project should be able to detect the movements associated with someone having an epileptic seizure, time how long the seizure lasts for and be able to display this information to the user. This information is important in being able to tell the severity of the attack and could also be developed to be able to contact a carer, sound an alarm and record the length of seizures to track their development over time. The length of a seizure is important since normally, when somebody prone to seizures has one, it is not an emergency situation and there is no need for an ambulance to be called. However, if the seizure lasts over 30 minutes, or is longer than the patient's usual seizures, this could be classified as 'status epilepticus' and is considered a medical emergency. However an ambulance should be called before the seizure reaches 30 minutes in duration[1].

There are currently devices such as this on the market, however they have not been studied extensively. Four types of seizure alert devices exist currently; mattress devices, watch devices, camera devices and motor devices[2]. This design would come under the watch devices category. These tend to use accelerometers such as the one used in this design, although some work by detecting change in heart rate, and mainly focus on alerting someone that the seizure is occurring. Generally this is a feature among other features offered by the watch, which is usually connected to a phone app, and records all the data to enable it to be viewed in detail later. Examples of such devices include *SmartWatch PT*[3] and *Embrace*[4].

2 Approach

Initially the functionality of the accelerometer on board the FRDMKL03Z was explored, setting up what was required in the different registers and how this data could be extracted to produce useful data. The approach was to use the existing i2c_comm_master.c script as a working basis and write the code here to communicate with the accelerometer.

Once configured to detect data in 8g Active Mode the relevant registers for each axis are read and manipulated to form a decimal output, based on the information given in the datasheet. Since only threshold and pattern detection is important for this particular application it is not necessary to convert into m/s^2. However it is useful since this gives the potential to adapt the device to actually record data for later analysis. All the data output here is therefore in $g \times 10^4$ so and output of 4000 will be equivelent to $0.4g$. A number can therefore be output for acceleration in the x, y and z direction and a magnitude for the combination of the three as can be seen in Figure 1. These acceleration-time graphs were then produced for a mimicked seizure and for other, similar actions to determine how a seizure might be detected without other actions also triggering a response. An LED lights up to indicate when a fit has been detected, and turns off when the fit is no longer occurring. This detection process was based on both magnitude and frequency of the response, with different conditions for turn on and turn off.

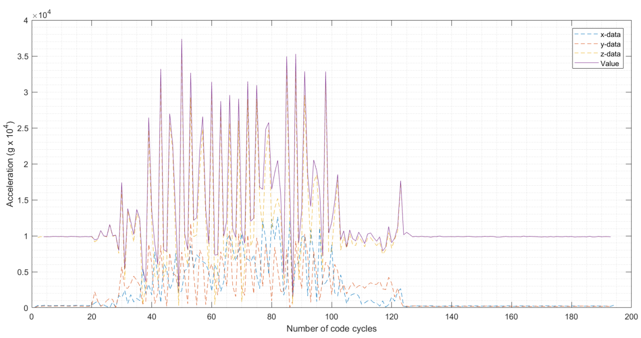


Figure 1: Output from accelerometer when the action of a seizure was produced

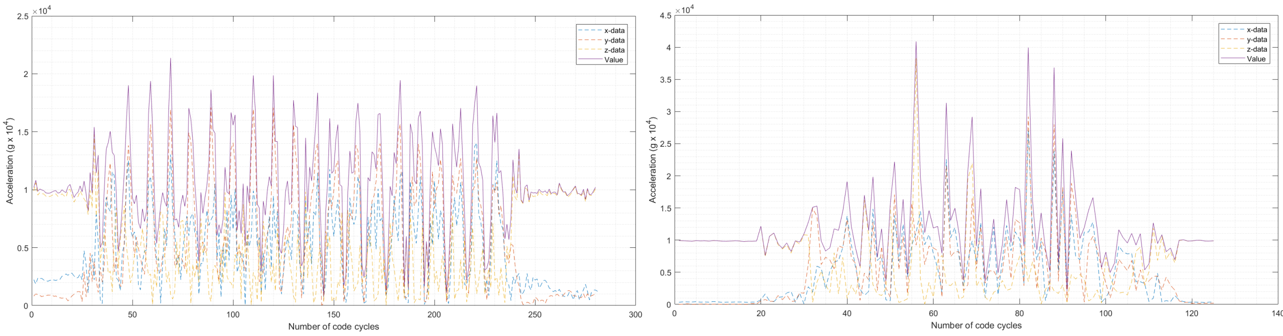
Using the code from oled.c from previous exercises, a red bar works its way across the screen, filling it at a specific value (for example 30 minutes) to indicate the fit having reached a more dangerous length in time, and flashing at this point. If the fit stops for a short period of time and then starts again the bar should continue from where it stopped. However after a set amount of time the timer will be reset. More research would be required to determine the best values for these timings. However these are made easy to edit at the start of the code. The current and voltage supplied to the device were measured to calculate power usage of the device. This was done both with and without the screen to determine what proportion of power usage was down to this.

[1]https://www.epilepsysociety.org.uk/epileptic-seizures#.WvhEi4jwbb0
[2]https://www.epilepsy.org.uk/info/daily-life/safety-aids-equipment/alarms-monitors
[3]http://epilepsysolutions.co.uk/smart-watch-pt/
[4]https://www.empatica.com/en-eu/

3 Results

Figures 2(a) and 2(b) show the output for acceleration, first for running and second as if chopping vegetables. These can be compared with the output seen earlier in Figure 1 for an imitated seizure. While the actions are very similar subtle differences can be seen in the response, there is a difference in the maximum value of acceleration reached, the consistency in reaching this value, the width of the spikes and their frequency.

Based on producing and studying many of these plots, with many iterations to find the most reliable method, the following conditions were used to make seizure start and finish decisions; (i) If the total acceleration value is above 2000 for at least 3 out of 10 cycles of code the timer would be turned on; (ii) If the total acceleration value does not exceed 2000 for all of the 10 cycles it will be turned off.



(a) (b)

Figure 2: Accelerometer output when the actions of running, (a), and cutting vegetables, (b), were produced.

Figure 3 demonstrates the point at which the seizure is detected as starting and finishing, when the timer is turned on and off. As can be seen there is a delay before it is turned on. This ensures the action is definitely that of a seizure and, relative to the length of a seizure, and given there is also a delay in turn off, should not give too high an error in the time.

The next stage of the project is to produce a timer. Figure 3 shows the increase in value of the timer (multiplied up for the image but actually counts up one at a time in seconds). As can be seen, where there is only a short gap the timer continues counting from where it left off. However after a certain amount of time being off the timer will be reset to zero ready for the next event.

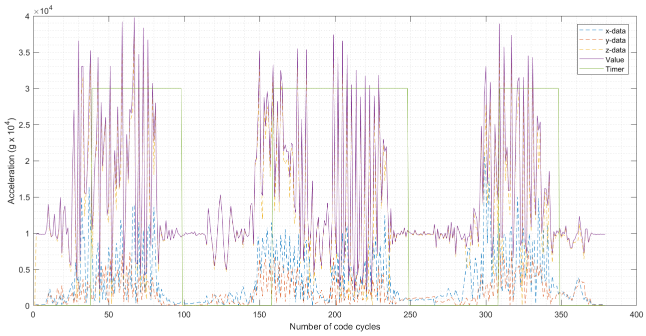


Figure 3: Output from accelerometer when the action of fitting was produced, demonstrating the points at which fitting is detected to have started and stopped

For each increment of the timer a new rectangle is drawn on the display, proportional to the time, so as to fill the screen at a specified time which might be considered dangerous, at which point it starts flashing, this time can be entered in seconds at the top of the code. Once it reaches this point, reset must be pressed to start again.

When supplied with 5V the current usage was found to be 50mA with the screen and 30mA without, giving a power usage of 250mW or 150mW. The 66% increase in power could perhaps be considered unnecessary since the limit being reached could be demonstrated with a buzzer or led, however in reality it is likely that this device would be integrated with a technology which already uses a screen. This small power usage does however demonstrate this device could easily be run off a battery.

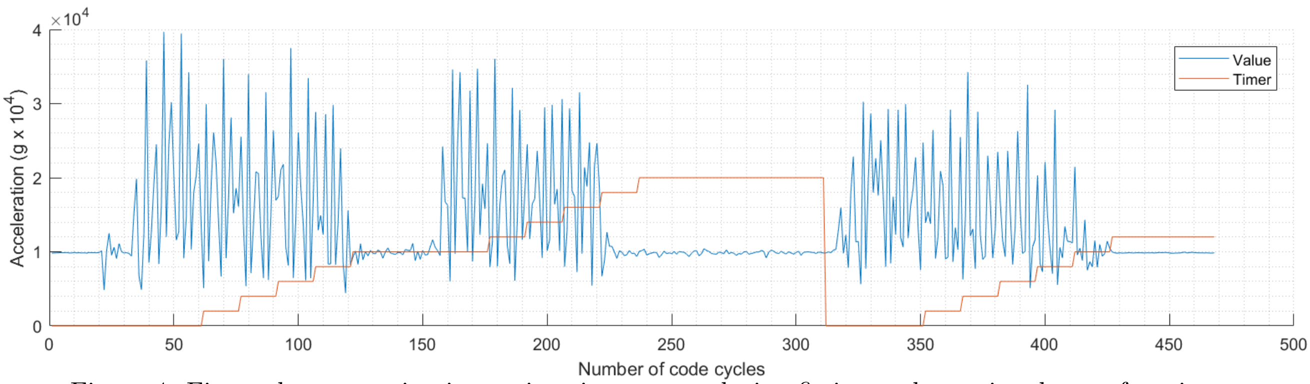


Figure 4: Figure demonstrating increasing timer count during fitting and associated reset function