# GliaX Status Report

Progress report since Mon 9. 7. 2018 up to Fri 20. 7. 2018.

## PULSE OXIMETER

Features added:

1. finger presence detection implementation
2. automatic LED brightness adjustment algorithm implemented

## 1. FINGER PRESENCE DETECTION

Finger presence algorithm serves both as a user experience feature as well as trigger for other actions, loops and processes that happen in firmware. It takes the level of `raw_red` signal as a reference to detect the finger presence. As soon as detected level falls below the specified threshold, that means the finger was inserted and device calibration is initialized. Before that, the device is at standby and “`FINGER OUT`” sign is seen on the display. If the finger is removed during measurement, the device displays the same sign however the brightness level remains the same once the finger is re-inserted and the measurement reappears in a few seconds again.

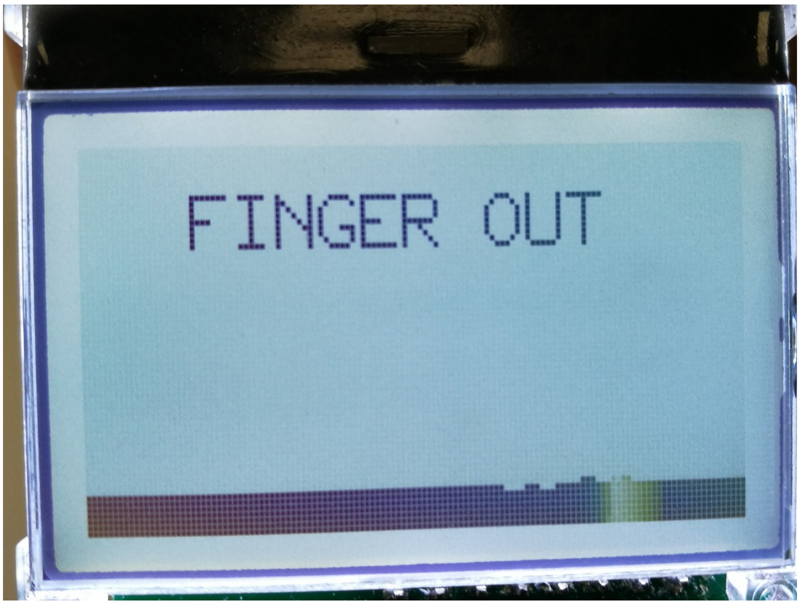


**Figure 1: Finger out message displayed when the finger is not present.**

# 2. AUTOMATIC LED BRIGHTNESS ADJUSTMENT ALGORITHM

## Device Calibration

Automatic LED brightness algorithm is necessary to compensate for finger light absorption. Light absorption at different wavelengths varies with skin thickness, pigmentation etc. of the person therefore each specimen will have a different optimal light intensity necessary to have the finger illuminated at the right intensity to get the optimal reading.

The calibration process is divided up into **setup loop** and **test loop**. The setup loop is initiated right after the finger presence is detected. When pulse is detected, a test loop is initiated which runs the fine optimization. The user sees a message "**`CALIBRATING...`**" displayed on the screen[1] until brightness levels of IR and RED LEDs are successfully adjusted. Afterwards, the device switches to normal operational mode.

**1 NOTE: The function for message display is already implemented in the firmware but is not yet turned on due to chip memory issues. The code will first be optimized to increase available ROM, then the function will be enabled. Visually it is similar to what is shown in the Figure Figure.**

## 2.1 SETUP LOOP

Setup loop is initiated upon the presence of the finger. It begins at initial brightness level[2] and changes it stepwise until pulse is detected. Brightness level change is executed in a fixed time window of 3 seconds, ensuring enough time for detection of at least 2 heart beats when brightness is close to satisfactory level. Once heart beat is detected, the setup loop is terminated and test loop starts instantaneously. This change is still unseen to the user.

**2 NOTE: The initial brightness levels need to be tested locally to achieve the time-optimized solution. The current solution will work best with light-skinned people, but could take a little more time to settle when used on a patient with more pigment.**

## 2.2 TEST LOOP

The test loop starts as soon as heart beat is detected and is there to achieve the best signal-to-noise ratio after we already have a useful signal. It is based upon an invented variable that describes ratio between noise and useful signal in the measurement. The variable is named Signal Quality Index (SQI) and is calculated as

$$\mathrm{SQI} = 1 - \mathrm{STD}/\mathrm{AMP} \qquad (1)$$

where STD is the signal standard deviation of the signal noise and AMP is signal amplitude when noise is filtered out (see Block diagram in the Figure 2).

Upon successful stabilization of IR and RED brightness levels, the device switches into normal operating mode. At this point the best possible signal quality is achieved.

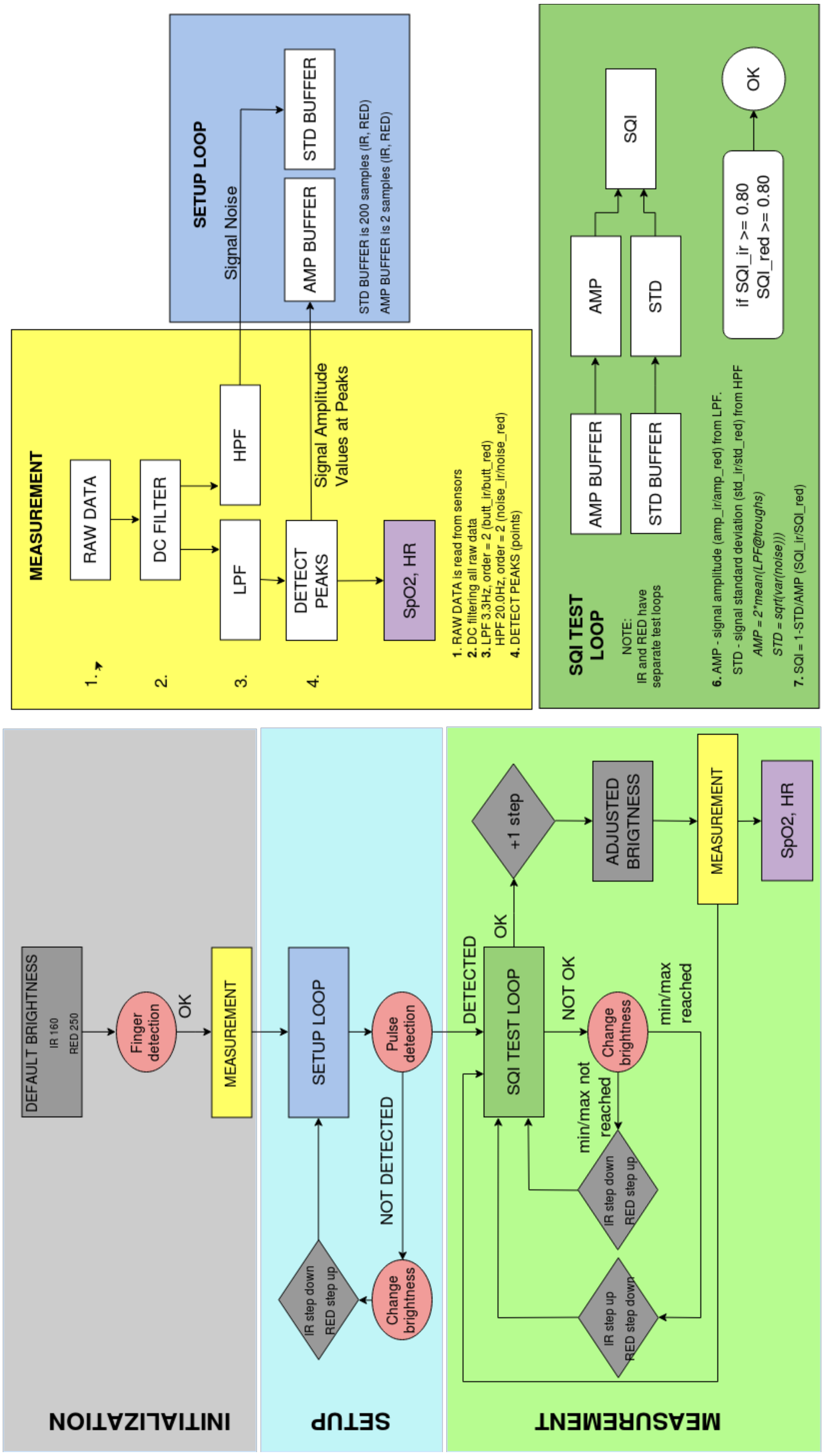


Figure 2: Code block diagram.

## Safety Measures

### AVOIDING CONTINUOUS CALCULATIONS

To avoid continuous calculations, we first check for presence of finger in the sensor, and only then brightness adjustment function starts. Brightness adjustment is happening in predefined steps (which can be adjusted) between max and min possible value (also predefined). To make sure the process takes the least possible time, we change brightness in both directions, up and down. This way we ensure that we reach optimal brightness as soon as possible.

### REMOVAL OF FALSE-POSITIVES IN PEAK DETECTION

When detecting a pulse from signal peaks, we need to avoid detecting false positives. For that purpose a threshold value was empirically derived and introduced as a safety parameter.

### BUFFER MANAGEMENT

When calculating SQI values we need to ensure that all data used is time-aligned. This is done by emptying all used buffers after each test loop iteration. The test loop runs on IR and RED signal completely separately.

### VALUE THRESHOLDS

Signal minimum and maximum threshold values were introduced ensuring that too noisy or too weak signals are ignored.

## Next Steps

- retesting of the automatic brightness adjustment algorithm
- Finalization of project documentation
- Release debug version of firmware to Tarek Loubani for testing

**To be completed by: 27. 7. 2018**