IoT-Based Patient Monitoring Device

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OPERATOR'S MANUAL

IoT Health Monitoring Device

TEAM # 14

Tyler Dieter, Matthew Lowe, Matthew Baldwin

Project for: Northern Illinois University

Faculty Contact: Dr. Ji-Chul Ryu (jryu@niu.edu) And Dr. Pradip Majumdar
(pmajumdar1@niu.edu)
IMPORTANT SAFETY INSTRUCTIONS

• The device is designed for use on adults only, and is not intended for operation by children.
• Do not self-diagnose or self-medicate on the basis of this device without consulting a doctor. In particular do not start taking any new medication or change the type and/or dosage of any existing medication without prior approval from a doctor.
• Used equipment, parts and batteries are not treated as ordinary household waste, and must be disposed of according to the applicable local regulations.
• Do not let children use the device by themselves and do not leave the device within the reach of children.
• There are small parts that my cause a choking hazard if swallowed by mistake by infants.
• Do not open the housing while the device is powered on.
• Precision components are used in the construction of this device. Extremes in temperature, humidity, direct sunlight, shock or dust should be avoided.
• Don’t use any part of the device together with MRI or CT equipment.
• Measurements from the device may be distorted if the device is used close to televisions, microwave ovens, X-ray or other devices with strong electrical fields.
• When measuring for a long time, please check whether there an allergic reaction with skin around the area the sensors are placed. If there is an allergic reaction, you should stop using the sensor immediately.
• Skin preparation in advance is strongly advised for skin contact sensors. Please make sure that skin is clean and dry.
• Do not add or replace sensor modules without proper training in circuitry and software development.
• Avoid handling the circuit boards whenever possible and never handle them while they are being powered.
• Do not stretch, over bend, or otherwise cause undue strain within the exposed cables and wires.
• Avoid running the device while charging the battery as this may impact the lifespan and charging abilities of the battery.
• Keep the device clear of any weights being used during a measurement session.
• When turning the device on and off, do not flip the switch from a single side to avoid damaging the internal structure. Always use two fingers to slide the switch over.
• Always ensure that any sweat or moisture has been removed and that clean, dry hands are used to plug in the charging cable.
• Avoid jostling, shaking, or dropping the case

If there are any issues with the device that cannot be solve using the troubleshooting guide, please contact the company and do not try and solve these on your own.
PARTS AND ACCESSORIES

- Raspberry Pi 4 model B
- Miuzei 4-inch touchscreen display
- Elegoo Uno R3
- Quimat Battery Expansion Board
- Case
- Tragoods Heart Rate Monitor Sensor
10000 mAh Lipo Battery

FEATURES

- 4-inch touch screen interface.
- Screen resolution of 800X480p. With a refresh rate of 60 hz.
- Simple 2 button interface and desktop launcher
- Intuitive user interface with minimalist layout to avoid distraction
- Minimal buttons and switches allow anyone to use the device, regardless of comfort level when using technology
- Versatility outside the GUI and written program allows the device to be used for other things if needed
- No assembly required.
- Continuous sensing of health properties with modular replacement
- 10,000mAh lithium polymer battery for main device.
- All devices rechargeable or do not need to be charged at all.
- Devices equipped to be capable of running for up to 8 hours without stopping.
- Medically accurate device sensing capabilities. (see technical description for more information.
- Main computational device (Raspberry Pi 4 B) runs on Broadcom BCM2711 high-performance 64-bit quad-core processor
- Device also has 2 GB of ram, and is Bluetooth 5.0 and dual-band 2.4/5.0 GHz wireless LAN compatible.
- Baud rate of 115200
- Real time readouts for pulse, oxygen level and temperature that can be modified to match the health module being used
- Data stored in a local database each update cycle
- Data saved to device as backup, for later reference, or for use in your records.
- Ending the workout session will generate an email containing the health metrics from the session for long term storage/analysis
- Automatically generated email is sent from a special health sensor email address to any specified address.
- Health detection devices can be modified and replaced by a skilled individual
- Contains the ability to record and display the collected data
- Stores a session of data for review, but will overwrite it to ensure memory availability
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1 INTRODUCTION

1.1 General Overview

When in use, the device will display on the screen the health metrics that are being measured by the health sensor array. In this version, the sensor array only contains a pulse measurement device. To begin this graphical user interface (GUI) display and the sensor’s data collection, turn the device on and launch the “Health Metrics” program that should be located on the desktop. This should bring up the GUI with all of the data displays and buttons ready to begin at any time. The GUI being displayed with include a “start” and a “stop” button in addition to a number of labeled numerical displays as shown in Figure [A]. These displays will be updated once per update cycle which is set to be one each second in the current version of the product. The update cycles begin when the “Start” button is pressed and end when the “Stop” button is pressed. When the Start button is pressed, the update cycles will initialize meaning that pressing the start button will ensure that the data will all be reset for the new session which can begin immediately after the stop button is pressed. A byproduct of this versatility is that accidentally pressing the start button will cause the data for the session to be overwritten. This is due to the fact that in the current prototype version, there can only be a single database file active at a single time, although this can easily be refined in the future. Figure [b] illustrates why there will only be
a single file at a time for the database for the current version of the device.

```python
if os.path.exists('BPMdata.db'):
    os.remove('BPMdata.db')

conn = sqlite3.connect('BPMdata.db')
```

*Figure 2: Sample Code*

As such it is advised to place the device in a location or position that will minimize the possibility of the data being overwritten. While the device is running and the sensors are collecting data, the user is free to perform any workout routine they intend to. If the freedom of movement needs to be increased, consider obtaining a longer connector cable that has the desired length. The program will automatically generate an email to a specified email address whenever the stop button is pressed. In the current prototype version, this cannot be prevented and will send to a pre-specified email address that is predefined in the code. If the user were to want to alter this location, a knowledge of python coding is required for the current version of the device. Search for the address line in the “stop” subroutine and alter the string for the variable “receiver” to match the desired email address.

```python
receiver= "1234@example.com"
body = "Hello there from Yagmail"
```
1.2 Step-by-Step Instructions

To begin, ensure that the sensor is plugged into the external board, and the external board is plugged into the device. Figure 3 shows the sensor plugged into the external board and Figure 4 shows where this plugs in on the primary device. Note: it is highly advised that the user does not unplug the sensor from the remote board, however the remote board may be unplugged from the primary device to improve storage.

*Figure 3: Primary Device and External Processor*
When connecting the remote processor to the main device, the cable should plug into the device as shown in Figure 4. Either port shown in the circle will work for the connection type. Ensure that this connection is firm. The connector will not fit if inserted upside-down, so using the correct orientation may require a second try.
Toggle the switch from the “off” position to the “on” position. Be sure to keep the switch oriented in the same direction: this is not a switch like a light switch and will slide the entire switch to the side rather than rotate like a lever. Use two fingers to slide the switch over as shown below. **WARNING:** rotating the switch by applying force from one side may cause the part to break which would make the device unable to be turned on.

Once the device has powered up, launch the desktop icon titled “Health Metrics” and wait for the widow to appear.
When the window has appeared, ensure that the sensor is applied to the user properly before pressing the start button. This will begin to show updates on the screen shown below.

![Sample GUI Display](image)

*Figure 6: Sample GUI Display*

Once the session is complete, press the stop button. This will stop the updates on the screen and send an email to the pre-defined email address. This may be the user or the user’s medical professional.
If the battery runs out, plug the wall outlet into the extended wire for charging shown below. For battery longevity, it is advised not to use the device while it is charging.

![Figure 7: Device with Charging Cable Visible](image)

2 MAINTENANCE

2.1 Mechanical Maintenance

- Due to the product being mainly software based, all physical maintenance should be light. The case can be opened and cleaned out as much as needed. If the Raspberry Pi starts to heat up, removing dust from the case and the surrounding hardware should improve circulation flow within the device.
- The screen may become dirty from extended use. Using a soft cloth moistened with water or alcohol to clean all the device’s surfaces before first use and after each use should mitigate any screen cleanliness issues.
- The battery will need to be replaced after continual use. A new battery can be purchased or received from the user's doctor. This replacing process should be simple. To replace the battery simply unscrew the case and remove the lower half of the device. Carefully unplug the depleted battery from the battery expansion board. Plug in the new Lipo battery into the same place that
the old battery was removed. Turn on the Raspberry Pi to confirm the new battery works properly.

2.2 Software Maintenance

- Other than technical software issues, which will be covered in the troubleshooting section, all other possible maintenance could be only periodic updates to the codes via python updates and specific library updates. However, do not update the libraries or python versions as this could cause incompatibility issues within the codes and cause the device to not function as usual.
- Using the Raspberry Pi for functions outside of the health monitoring system code is restricted and could result in more technical issues arising if continual tampering.

2.3 Electrical Maintenance

- Due to the amount of circuitry and electrical components within the device, it is strongly advised that the user do not alter the boards for the safety of the user and the integrity of the product. If an issue needs immediate attention, please contact the company or organization that provided the device.
- If any substance or item meets any electrical component let the company that provided the device know immediately so that they can take care of it properly.
### 3.1 Raspberry Pi Technical Specifications

<table>
<thead>
<tr>
<th>Spec Table 1: Raspberry Pi 4 Model B Specifications</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Processor</strong></td>
</tr>
<tr>
<td><strong>Memory</strong></td>
</tr>
<tr>
<td><strong>Connectivity</strong></td>
</tr>
<tr>
<td><strong>GPIO</strong></td>
</tr>
<tr>
<td><strong>Video &amp; sound</strong></td>
</tr>
<tr>
<td><strong>Multimedia</strong></td>
</tr>
<tr>
<td><strong>SD card support</strong></td>
</tr>
<tr>
<td><strong>Input power</strong></td>
</tr>
<tr>
<td><strong>Environment</strong></td>
</tr>
<tr>
<td><strong>Production lifetime</strong></td>
</tr>
</tbody>
</table>
Schematic 1: Raspberry Pi 4 Model B Circuit Diagrams and Connections
Schematic 2: Raspberry Pi 4 Model B Dimensions
3.2 Elegoo Technical Specifications

Spec Table 2: Elegoo Uno R3 Specifications
Schematic 3: Arduino/Elegoo Uno R3 Circuit Diagrams and Connections
Schematic 4: Elegoo Uno R3 Dimensions
3.3 LCD Screen Technical Specifications

<table>
<thead>
<tr>
<th>SKU</th>
<th>MPI4008</th>
</tr>
</thead>
<tbody>
<tr>
<td>Screen Size</td>
<td>4.0inch</td>
</tr>
<tr>
<td>LCD Type</td>
<td>TFT</td>
</tr>
<tr>
<td>Module Interface</td>
<td>HDMI</td>
</tr>
<tr>
<td>Resolution</td>
<td>800*480 (Pixel)</td>
</tr>
<tr>
<td>Active Area</td>
<td>51.84x86.40(mm)</td>
</tr>
<tr>
<td>Touch Screen Controller</td>
<td>XPT2046</td>
</tr>
<tr>
<td>LCD Driver IC</td>
<td>NT35510</td>
</tr>
<tr>
<td>Backlight</td>
<td>LED</td>
</tr>
<tr>
<td>Power consumption</td>
<td>0.16A*5V</td>
</tr>
<tr>
<td>Working temperature</td>
<td>-20~60</td>
</tr>
<tr>
<td>Module PCB Size</td>
<td>98.60*58.05 (mm)</td>
</tr>
</tbody>
</table>

Spec Table 3: Miuzei Display Specifications

Figure: Miuzei Display Back side

1. 3.5mm Headphone Jack
2. Interface: HDMI signal input interface
3. Micro USB: Get 5V Power from USB, if ⑤-13"2 Pin Socket has been connected, that USB interface can be No Connect.
4. Backlight button: backlight brightness adjustment button, short press backlight changes by 10%, long press 3 seconds to close backlight.
5. 13"2 Pin Socket: gets power and return touch from this area when used as a raspberry pie monitor
3.4 Battery Expansion Board Technical Specifications

<table>
<thead>
<tr>
<th>Specification</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Battery capacity</td>
<td>7500 mAh Maximum</td>
</tr>
<tr>
<td>Maximum output current</td>
<td>1.8 A</td>
</tr>
<tr>
<td>Output voltage</td>
<td>5.1 V ±0.1 V</td>
</tr>
<tr>
<td>Standard charging current</td>
<td>1.0 A</td>
</tr>
<tr>
<td>Standard charging voltage</td>
<td>5.0 V</td>
</tr>
<tr>
<td>Cut-off voltage of fully charging</td>
<td>4.18 V - 4.2 V</td>
</tr>
</tbody>
</table>

Spec Table 4: Quimat Battery Expansion Board Specifications

Figure: Quimat Battery Expansion Board
3.5 Tragoods Heart Rate Monitor Sensor Technical Specifications

**Specification:**
Input Voltage (Vin): 3V - 5V (5V recommended)
Operating current: <10mA
Output signal type: analog signal
Interface Type: 3p DuPont line
LED Wavelength: 609nm
material: ABS plastic

Spec Table 5: Tragoods Heart Rate Monitor Sensor Specifications

![Tragoods Heart Rate Monitor Sensor](image)

Figure: Tragoods Heart Rate Monitor Sensor
Schematic 5: Tragood Heart Rate Monitor Sensor Circuit Diagrams and Connections
### 3.6 10000 mAh Lipo Battery Technical Specifications

<table>
<thead>
<tr>
<th>Item</th>
<th>Specifications</th>
<th>Remark</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nominal Capacity</td>
<td>11500 mAh</td>
<td>0.2C₃A discharge</td>
</tr>
<tr>
<td>Typical Capacity</td>
<td>10000 mAh</td>
<td>0.2C₃A discharge</td>
</tr>
<tr>
<td>Nominal Voltage</td>
<td>3.7V</td>
<td>Average Voltage at 0.2C₃A discharge</td>
</tr>
<tr>
<td>Charge Current</td>
<td>Standard: 0.2 C₃A; Max: 1C₃A</td>
<td>Working temperature: 0~40°C</td>
</tr>
<tr>
<td>Charge cut-off Voltage</td>
<td>4.20±0.03V</td>
<td></td>
</tr>
<tr>
<td>Standard Discharge Current</td>
<td>0.2C₃A</td>
<td>Working temperature: -20~60°C</td>
</tr>
<tr>
<td>Max Discharge Current</td>
<td>2.0C₃A</td>
<td>Working temperature: 0~60°C</td>
</tr>
<tr>
<td>Discharge cut-off Voltage</td>
<td>2.75V</td>
<td></td>
</tr>
<tr>
<td>Cell Voltage</td>
<td>3.7~3.9 V</td>
<td>When leave factory</td>
</tr>
<tr>
<td>Impedance</td>
<td>≤15mΩ</td>
<td>AC 1KHz after 50% charge</td>
</tr>
<tr>
<td>Weight</td>
<td>Approx: 196g</td>
<td></td>
</tr>
<tr>
<td>Storage temperature</td>
<td></td>
<td>Best 20±5°C for long-time storage</td>
</tr>
<tr>
<td></td>
<td>≤1month -20~45°C</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≤3month 0~30°C</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≤6month 20±5°C</td>
<td></td>
</tr>
<tr>
<td>Storage humidity</td>
<td>65±20% RH</td>
<td></td>
</tr>
</tbody>
</table>

Spec Table 6: 10000 mAh Lipo Battery Specifications

Figure: Diagram displaying different components of the Lipo Battery
<table>
<thead>
<tr>
<th>Item</th>
<th>Test Methods</th>
<th>Performance</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.1</td>
<td>After standard charging, laying the battery 0.5h, then discharging at 0.2C\textsubscript{5}A to voltage 2.75V, recording the discharging time.</td>
<td>≥300min</td>
</tr>
<tr>
<td>4.2</td>
<td>After standard charging, laying the battery 0.5h, then discharging at 1C\textsubscript{5}A to voltage 2.75V, recording the discharging time.</td>
<td>≥54min</td>
</tr>
<tr>
<td>4.3</td>
<td>Constant current 1C\textsubscript{5}A charge to 4.2V, then constant voltage charge to current declines to 0.05C\textsubscript{5}A, stay 5min, constant current 1C\textsubscript{5}A discharge to 2.75V, stay 5min. Repeat above steps till continuously discharging time less than 36min.</td>
<td>≥300times</td>
</tr>
<tr>
<td>4.4</td>
<td>20±5℃, After standard charging, laying the battery 28days, discharging at 0.2C\textsubscript{5}A to voltage 2.75V, recording the discharging time.</td>
<td>≥240min</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Item</th>
<th>Test Methods</th>
<th>Performance</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.1</td>
<td>After standard charging, laying the battery 4h at 60℃, then discharging at 0.2C\textsubscript{5}A to voltage 2.75V, recording the discharging time.</td>
<td>≥270min</td>
</tr>
<tr>
<td>5.2</td>
<td>After standard charging, laying the battery 4h at -20℃, then discharging at 0.2C\textsubscript{5}A to voltage 2.75V, recording the discharging time.</td>
<td>≥210min</td>
</tr>
<tr>
<td>5.3</td>
<td>After standard charging, laying the battery 48h at 40±2℃, RH 93±2%. Recording 0.2C\textsubscript{5}A discharging time No distortion No electrolytes leakage</td>
<td>&gt;270 min</td>
</tr>
<tr>
<td>5.4</td>
<td>After standard charging, battery stored at -20℃ for 2 hours, then stored at 50℃ for 2 hours. Repeat 10 times.</td>
<td>No electrolytes leakage</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Item</th>
<th>Test Methods</th>
<th>Performance</th>
</tr>
</thead>
<tbody>
<tr>
<td>6.1</td>
<td>After standard charging, put battery on the vibration table, 30 min experiment from X,Y,Z axis. Scan rate: 1 oct/min; Frequency 10-30Hz, Swing 0.38mm; Frequency 30-55Hz, Swing 0.19mm.</td>
<td>No influence to batteries' electrical performance and appearance.</td>
</tr>
<tr>
<td>6.2</td>
<td>After vibration test, batteries were laying on the vibration table about X, Y, Z axis. Max frequency acceleration: 100m/s\textsuperscript{2}; collision times per minutes: 40–80; frequency keeping time 16ms; all collision times 1000±10.</td>
<td>No influence to batteries' electrical performance and appearance.</td>
</tr>
<tr>
<td>6.3</td>
<td>Random drop the battery from 10m height onto concrete one times.</td>
<td>No explosion or fire</td>
</tr>
</tbody>
</table>

Spec Tables 6, 7, & 8: General, Environmental, and Mechanical Performance of the Lipo Battery
4 TROUBLESHOOTING

4.1 Common Problems

**Problem: Device will not turn on at all**

Make sure that the device is either charged or in the process of being charged. Also, check if all the wired connections are established. If none of those solutions fix the problem, then the issue could lie with either a dead or defective battery. Please reach out to the organization or company that provided the product.

**Problem: Device is not charging**

Check to make sure all the of the wires are plugged in properly. Another solution might be to unplug and plug back in the charging cord. However, if the problem persists reach out to the organization or company that provided the product.

**Problem: GUI will not launch**

Restarting the Raspberry Pi may fix this issue. Try clicking the launcher multiple times as the device may have frozen. If the launcher is gone entirely, see the “Uncommon Problems: The launcher/icon does not appear on the desktop” section below.

**Problem: The graphic user interface isn’t functioning as expected**

The most typical solution will be to restart the Raspberry Pi. If this doesn’t fix the issue, then the next step would be to check all the wire connections. Unplugging and then plugging them back in should resolve most issues.

**Problem: The heart rate data is very incorrect or oscillating dramatically**

Rerunning the program should fix the issue in most cases. Trying to minimize shaking and not press on the sensor too harshly. Attempting to placing the heart rate sensor on another part of the body may also fix the issue.

**Problem: The time elapsed is functioning but the BPM values aren’t changing.**

Try to restart the GUI launcher. If the issue persists, see “Uncommon Problems: the sensors were disconnected from the external processor” section below.

**Problem: The program isn’t displaying any data at all**

On occasion the start button on the GUI will not register when the user clicks it. Pushing the button a second time should fix this error. Another solution may be to simply restart the GUI launcher and allowed the system to reset itself.
4.2 Uncommon Problems

Problem: The launcher/icon does not appear on the desktop

Open the file explorer on the primary device. Go to “Tools” on the ribbon on the top. Drop down the menu and click on “Find Files…” Alternatively, if a keyboard is plugged into the device, pressing Shift+Ctrl+F will also work within the file explorer.

A window will pop up. Type “Health Metrics” into the search bar and then click “Find”

If the file is found, simply create a shortcut of the file to the desktop. It is recommended to use a mouse to right-click the file (hover the cursor arrow over the file and press the right button on the mouse) and select “create shortcut” from the menu that appears. This should have created a desktop shortcut that can be launched to show the GUI.
Problem: The sensor was disconnected from the external processor

The position of the wiring is important. The sensor will have three wires: a red, blue and green wire as shown in the image below. Insert the green wire into the port labeled A1, the blue wire into the
port labeled **GND**, and the red wire into the port labeled **5V**. Run the program and use the sensor. The numbers should work as expected. If problems persist, try placing the green wire into different *numbered* ports. Do not insert the green wire into any port labeled 3V, 5V, or GND. Start by plugging the green wire in at **A0** and run the program. Repeat this step for **A1**, **A2**, **A3**, **A4**, and **A5**. If problems continue to persist, contact the company or doctor who gave the device to you and request a replacement pulse sensor.

**Problem: the battery won’t charge even when it’s plugged in**

Unscrew the four corners screws located on the bottom of the case and carefully take the two halves apart. Locate the charging cable that sticks out from the case and is used to charge the battery. Ensure that it is plugged into the port as shown below. Firmly insert the cable into the port and

![Figure 11: The Internal Port where the Charging Cable Attaches](image)

reassemble the case. Charge the device using the wall outlet adapter for an hour. If the screen does
not turn on after an hour, contact the distributor and inform them that the battery is no longer able to hold a charge.

**Problem: the database is not being received**

Open the file explorer on the primary device. Go to “Tools” on the ribbon on the top. Drop down the menu and click on “Find Files…” Alternatively, if a keyboard is plugged into the device, pressing Shift+Ctrl+F will also work within the file explorer.

A window will pop up. Type “GUI_SD2020.py” into the search bar and then click “Find”

Open the file for viewing. If asked to select a program to open with, select “Thonny”. There should be a line at the very top of the document that looks something like shown below:

```
receiver = "1234@example.com"
```

*Figure 14: Example Email Address*
Make sure that the email address matches where you intend for the email to go. Change the email address to the correct address, save the document, and re-launch the program. If the problem persists or the address was already correct and did not need to be changed, open the file explorer again and search for the file “BPMdata.db”. The database may have generated in the incorrect folder. To solve this, simply delete the file and run the program again. This will prompt the program to re-generate the file in the correct location.
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