Smart Pillow

By Trusha, Karan and Aniketh

Team 50
The Team

Trusha Vernekar  
Senior in Computer Engineering

Karan Samat  
Senior in Computer Engineering

Aniketh Aangiras  
Senior in Electrical Engineering
Problem Statement

- Recent deterioration in sleep quality
- Increasing fatigue
- Signs - Snoring, moving
- Inadequate current solutions
Proposed Solution

“SMART PILLOW”

Aims to detect:

- Position
- Motion
- Snoring
High-Level Requirements

1. The pillow should be **able to detect motion when the person is in contact** with the surface of the pillow.
2. There should be **no interference in the data** collected by the sensors from other components of the pillow.
3. The pillow **should be comfortable**, which means that the user should not be able to feel the sensors when they touch their head to the top of the pillow.
4. The **front and back of the pillow should be clearly differentiated** so the data from the pillow is actually usable.
Subsystem Overview
Pressure Subsystem

- Used to detect high head pressure indicating poor sleep/change in position

- Consists of 2 thin film pressure sensors and a DC to DC step down Buck converter

- Step down converter to convert 3.7V to 3V
## Requirement and Verification

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Verification</th>
</tr>
</thead>
<tbody>
<tr>
<td>The thickness of the sensor should not exceed more than 7.62mm to ensure comfort while sleeping</td>
<td>Thin film pressure sensors were used</td>
</tr>
<tr>
<td>The distance between each pressure sensor should be 120.11 mm to ensure accurate reading of the head position</td>
<td>Distance between the pressure sensor was recorded and placed accordingly</td>
</tr>
</tbody>
</table>
Power Subsystem

- Consists of a Lithium Polymer battery
- Supplies 3.7V to the remaining subsystems
- LiPo batteries are commonly used in medical devices due to their lightweight and safety

Lithium Polymer Battery
# Requirement and Verification

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Verification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Must supply 3.7 Volts</td>
<td>Measure the output voltage of the DC power using Multimeter</td>
</tr>
<tr>
<td>To ensure comfort, the dimensions should be 35x100x15 mm and should weigh less than 80g.</td>
<td>Lithium Polymer battery pack was used after looking at the dimensions and the weight: 33.5x96x10.3 mm and weighs 74g.</td>
</tr>
</tbody>
</table>
Audio Subsystem

- Made up of two high sensitivity audio sensors and a DC-DC voltage step up converter.
- Used to detect sounds such as snoring from the user.
- Step up converter is used to step up 3.7V to 5V.
## Requirements and verification

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Verification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dimensions of each sensor should be within the following: 5x5x1 inches and weigh less than 1 ounce.</td>
<td>2 High Sensitivity Sound Microphone Sensor which have the following dimensions: 4 x 4 x 0.5 inches and weighs 0.63 Ounces</td>
</tr>
<tr>
<td>Speaker doesn’t interfere with the audio sensor</td>
<td>10 s delay between noise and next data collection</td>
</tr>
</tbody>
</table>
Touch Subsystem

- Consists of six HiLetgo touch sensors and a DC to DC step down Buck converter
- Used to determine the various head positions of the user
- Step down converter to convert 3.7V to 3V
# Requirements and Verification

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Verification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dimensions of each sensor should be within the following: 24x24x7.2 mm</td>
<td>To ensure the size of the sensors, we compared the thickness and dimensions of different types of touch sensors available and decided to go with the touch sensors that match our requirements.</td>
</tr>
<tr>
<td>Must be at equal distance from a pressure sensor on either side: must at 60 mm from a pressure sensor</td>
<td>Distance was measured and sensor was placed accordingly</td>
</tr>
<tr>
<td>The 6 sensors should detect sleeping positions</td>
<td>Determined by checking how many and which sensors are turned on depending on the head position</td>
</tr>
</tbody>
</table>
Speaker and Bluetooth Subsystem

- Consists of the bluetooth board, speaker and a DC-DC voltage step up converter

- The speaker is used to play white noise
## Requirements and verification

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Verification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Limited to the sum of size dimensions 45x45x40mm</td>
<td>The speaker is just 36x17x14mm, the VHM-314 is 3x3cm</td>
</tr>
<tr>
<td>Ability to work with the audio sensor, switching it off within 1 minute of the audio sensors being used</td>
<td>We were able to ensure this was the case through our code</td>
</tr>
<tr>
<td>Cross device connectivity enabled by Bluetooth 5.0</td>
<td>VHM-314 offers Bluetooth 5.0 connectivity</td>
</tr>
</tbody>
</table>
Control Subsystem

- ATmega328P microprocessor: Responsible for collecting data regarding head positions, head pressure, and snoring.

- Data processed to determine bad sleep

- Triggers bluetooth speaker
## Requirements and verification

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Verification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Must be able to determine if the user is snoring</td>
<td>If the sensor value is 1 or more then the user is determined to be snoring.</td>
</tr>
<tr>
<td>Must be able to determine if the user is changing positions every 30 seconds</td>
<td>If we receive data from all touch sensors, the person is determined to be changing positions.</td>
</tr>
<tr>
<td>Must be able to determine if the user is applying high pressure on the pillow</td>
<td>If the pressure detected is above 1100, this implies high pressure on the pillow.</td>
</tr>
</tbody>
</table>
```python
current_time = datetime.now()
print("The current date and time is:", current_time)

arduino_port = "COM3" #serial port of Arduino
baud = 9600 #arduino uno runs at 9600 baud
fileName="analog-data3.csv" #name of the CSV file generated

ser = serial.Serial(arduino_port, baud)
print("Connected to Arduino port:" + arduino_port)
file = open(fileName, "a")
print("Created file")

#display the data to the terminal
getData=ser.readline()
dataString = getData.decode('utf-8')
data=dataString[0:][:-2]
print(data)
```
Obtaining Real Time Value

```java
long currentTime = millis(); // Get current time

while line <= samples:
    getData = ser.readline()
    dataString = getData.decode('utf-8')
    data = dataString[0:][:-2]
    print(data)

    readings = data.split("","")
    print(readings)

    readings[0] = currentTime + timedelta(milliseconds=int(readings[0]))
```
Pressure Data Collection Process

- Pressure data is used to determine when to play white noise

```python
if ((int(readings[9])+int(readings[10]))>1300):
winsound.PlaySound('white_noise.wav', winsound.SND_FILENAME)
```
Audio Data Analysis

Sensor Data vs Real Time

Sensor Types
- Audio
- Pressure

Sensor Values

<table>
<thead>
<tr>
<th>Time</th>
<th>Sensor Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>12:46:02</td>
<td>2</td>
</tr>
<tr>
<td>12:46:04</td>
<td>1</td>
</tr>
<tr>
<td>12:46:06</td>
<td>1</td>
</tr>
<tr>
<td>12:46:08</td>
<td>1</td>
</tr>
<tr>
<td>12:46:10</td>
<td>1</td>
</tr>
<tr>
<td>12:46:12</td>
<td>1</td>
</tr>
<tr>
<td>12:46:14</td>
<td>1</td>
</tr>
<tr>
<td>12:46:16</td>
<td>1</td>
</tr>
</tbody>
</table>

2023-04-25 12:46:00.799431
Positioning Readings

- Utilizes data from the touch sensor to determine the head position

[Position vs Time Scatter Plot]

- Motion
- Head to Pillow Right
- Side Sleep/Head to Pillow Right
- Head to Pillow Centre
- Head not on Enough Sensors
Conclusion
Ethics and Safety

- Used LiPo battery
  - Biologically better

- Low voltage system
  - Less hazardous

- Open wiring
  - Solution: Foam Casing
Problems faced

- PCB soldering and parts delay
- Budget issues - lesser and cheaper sensors
- No wifi access for real time
Summary

- We were able to get real time data from all the sensors which allowed the microcontroller to trigger the bluetooth subsystem when required

- All the sensors gave us reliable and accurate data

- The project met all the high level requirements
Future Plans

- Add a thick foam layer on top of the wires on the breadboard
- Cover the pillow with a thick pillow case with a foam lining
- Move the breadboard to the PCB to avoid large chunks of wires
THANK YOU