Apnea Monitor for Sudden Infant Death Syndrome
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Abstract

According to the US Bureau of Census in 2000, 2151 infant deaths were attributed to Sudden Infant Death Syndrome or SIDS. By monitoring infant chest movement, immediate warning can be given to alert parents and caregivers that the child is experiencing apnea, the cessation of breathing which has been linked to SIDS. The design of current apnea monitors are non-mobile and expensive, costing upwards of $5000. Our design challenge is to create an Infant Respiratory Monitor that is both portable and inexpensive. The purpose of the Infant Respiratory Monitor is to provide a direct reading of the child's chest movement. If movement falls below threshold limits, an alarm is sounded. Feasibility of concept was preformed for the monitoring of a baby's chest with a cost analysis review for the proposed design.

Research

- Literature Review
- Patent Review
- Physician Interviews
- Competition (see Figure 2)

<table>
<thead>
<tr>
<th>Product</th>
<th>Price</th>
<th>Performance</th>
<th>Portability</th>
<th>Picture</th>
</tr>
</thead>
<tbody>
<tr>
<td>AngelCare</td>
<td>Good</td>
<td>Fail</td>
<td>Fail</td>
<td></td>
</tr>
<tr>
<td>Babysense 5</td>
<td>Fail</td>
<td>Fail</td>
<td>Poor</td>
<td></td>
</tr>
<tr>
<td>SmartMonitor 2</td>
<td>Poor</td>
<td>Good</td>
<td>Fail</td>
<td></td>
</tr>
</tbody>
</table>

Benchmarking

Our product was benchmarked against all three competitors for portability; against SmartMonitor 2 for performance; and against AngelCare and Babysense 5 for price.

Design Evolution

- Conceptual Design: Created in Solid Works (See Figure 3)
- Considered Accelerometers, Strain Gages, and Solenoids for sensor
- Considered Nylon and Neoprene for strap material
- Analysis indicated that strain gages were not appropriate for measuring strain on fabric
- After preliminary testing, accelerometer proved more effective for sensing motion when compared to solenoids
- Neoprene chosen as material due to its water resistant qualities and elasticity.

Testing

- Testing apparatus designed to model infant breathing- linked water bottles filled with air
- Apparatus tested accelerometers and solenoid attached to chest bands
- Tests documented voltage changes for simulated apnea – (constant voltage) and simulated breathing – (voltage fluctuation) See Figure 4

Results

After researching and testing the various sensors, we found that a baby's chest motion can be detected with readily available, inexpensive sensors. The ADXL330[1] accelerometer was attached to the neoprene chest band and was tested and compared to the performance benchmark of the SmartMonitor 2 (See Figure 5) [2]. Based on preliminary testing, lab results showed 100% success rate in detecting apnea with the ADXL330. These results are promising, but SmartMonitor 2 tested with actual babies in a clinical setting while we simulated baby breathing. Cost analysis showed that using the ADXL330 accelerometer and a neoprene chest band could be manufactured and sold at a lower price than the competitors we benchmarked.

<table>
<thead>
<tr>
<th>Monitor Tested</th>
<th>Apnea Detected</th>
<th>Apnea Not Detected</th>
<th>False Alarms</th>
<th>Success (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SmartMonitor 2</td>
<td>73</td>
<td>69</td>
<td>85</td>
<td>51.4%</td>
</tr>
<tr>
<td>Our Design</td>
<td>14</td>
<td>0</td>
<td>0</td>
<td>100%</td>
</tr>
</tbody>
</table>

Figure 5. Results and Benchmark Comparison

Proposed Design

- ADXL330 accelerometer on a printed circuit board
- Powered by CR3032 Lithium Battery
- Electronics in sealed container inside Neoprene Pouch
- Pouch is attached to chest band via Velcro
- Chest band is 250mm to 600mm X 25mm X 1mm
- Material cost (chest band, transmitter, and monitor): $50

Future Design Recommendations

- Reduce Size of printed circuit board
- Integrate Wireless Signal Transmitter and Receiver
- Optimize Power Consumption for Extended Battery Life

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References


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