

# Research Proposal: Smart Infant Monitoring System

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## Background

According to US Department of Labor's report, almost three out of four women with children (72%) were in the workforce [Department of Labor 1998]. It was only 39% in 1970. As a result, majority of infants have been sent to daycare facilities.

However, it is reported by news media [CNN Aug 2000, CBS Oct. 2004] that a substantial number of crib deaths take place in day care settings. The causes were mainly due to SIDS (Sudden Infant Death Syndrome) as well as the cases of faulty crib such as Playskool Travel Lite Cribs. The side of the crib collapsed, caught a baby's neck, and suffocated the baby.

In the past, SIDS was sometimes called "crib death," even though cribs themselves do not cause SIDS. According to the NIH study ([www.nichd.nih.gov/womenshealth/sids\\_research.cfm](http://www.nichd.nih.gov/womenshealth/sids_research.cfm)), researchers estimate that SIDS is the cause of about 2,500 infant deaths each year in the USA. Although the exact cause of SIDS is unknown, researchers have discovered trends in SIDS deaths that may help them understand this mysterious fatal problem. For instance:

- SIDS is the leading cause of death in babies after one month of age.
- Most SIDS deaths occur in babies less than six months old.
- Babies placed to sleep on their backs are less likely to die from SIDS than those placed on their stomachs to sleep.
- Babies are more likely to die from SIDS when they are placed on or covered by soft bedding.
- African American babies are twice as likely to die from SIDS as white babies.
- American Indian babies are nearly three times more likely to die of SIDS than white babies.

Even though the exact cause of SIDS is unknown, researchers have identified steps that caregivers can take to reduce the risk of SIDS, including:

- Always place your baby on his or her **back to sleep**, for naptime and bedtime.
- Make sure your baby has a **safe sleeping environment**, which includes:
  - Placing the baby on a firm mattress, such as in a safety-approved crib. Research has shown that placing a baby to sleep on soft mattresses, sofas, sofa cushions, waterbeds, sheepskins, or other soft surfaces can increase the risk of SIDS; and
  - Removing soft, fluffy bedding and stuffed toys from the baby's sleep area. Make sure you keep all pillows, quilts, stuffed toys, and other soft items away from your baby's sleep area.
  - Make sure the baby's head and face stay uncovered during sleep. Keep blankets and other coverings away from your baby's mouth and nose. Dressing the baby in sleep clothing will avoid having to use any covering over the baby. If you do use a blanket or another covering, make sure that the baby's feet are at the bottom of the crib, the blanket is no higher than the baby's chest, and the blanket is tucked in around the bottom of the crib mattress.

- Don't allow your baby to get too warm during sleep. Your baby's room should be at a temperature that is comfortable for an adult. Too many layers of clothing or blankets can overheat your baby.
- Don't allow smoking around your baby.
- Make sure all of your family members, babysitters, and anyone else who cares for your child knows to put the baby on his or her back to sleep, and other ways to reduce the risk of SIDS.

### Current Technology Products

In order to solve those problems, some companies already developed some baby monitoring systems as affordable products as the following:

<p><b>BebeSounds Color &amp; Sound Video Monitor (\$178)</b></p> <p>Lets you hear and watch baby while you roam freely around the house. The receiver clips to your belt or stands on a table. The wireless camera has infrared night vision capability.</p> <p>If the person is not watching the monitor, this system is useless.</p>	 The image shows the BebeSounds Color & Sound Video Monitor system. It consists of a silver receiver unit with a small color LCD screen on top, and a silver wireless camera unit with a lens and a microphone. Both units have the BebeSounds logo on them.
<p><b>Angelcare (\$75)</b></p> <p>Angelcare Movement Sensor with Sound Monitor brings peace of mind for concerned parents. Alarm goes off if absolutely no movement is detected for 20 seconds, while the sound monitor lets you hear the slightest sound.</p>	 The image is an advertisement for the Angelcare Movement Sensor with Sound Monitor. It features a baby sleeping in a crib. The text says "BebeSounds 2 Monitors in 1 200 Foot Range". The product is described as a "Movement Sensor with Sound Monitor". It states "Alarm sounds ONLY if absolutely no movement is detected for 20 seconds". The sensor pad is shown on the crib mattress. The receiver unit is shown with "Micro." and "Power" buttons. The slogan is "Stop worrying while your baby sleeps!". The Angelcare logo is at the bottom.

<p><b>BabySense II</b> <a href="http://www.babysafetymonitor.com">www.babysafetymonitor.com</a>, \$99)</p> <p>Highly sensitive device which monitors baby's movements and breathing through the mattress during sleep. Alerts if baby stops breathing during sleep. Two sensors located under the mattress: Cover total crib area, No contact with baby Babysense alerts you with an alarm if baby's breathing becomes abnormally slow or if breathing and motion stop. These could be signs of Central Apnea, which is considered one of the causes of Infant Crib Death (S.I.D.S). Babysense can also alert when these signs indicate a cold, high fever, or other illness.</p>	 The image shows the BabySense II monitoring system. It consists of a white rectangular control unit with a digital display and several buttons. Below the control unit are two light-colored, rectangular sensors designed to fit under a crib mattress. The sensors have small circular openings and are connected to the control unit by thin wires.
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### **Suggestions to improve the current products**

Nowadays the cost of microprocessors is becoming cheaper and cheaper and they are everywhere. Pervasive (wireless, wearable, and ubiquitous) computing with blue-tooth technology could make it possible to develop economically feasible monitoring system for child day care environment, especially for the cribs. Bluetooth is a short-range radio technology aimed at simplifying communications among Internet devices and between devices and the Internet.

Accidents occur suddenly. As a backup and double checking tool, networked wirelessly with blue-tooth devices, integrated home personal computers can monitor each child's status and the system can provide early warning signals, if any abnormal activities are detected. Even it can predict possible future problems. Sudden infant death syndrome (SIDS) is the sudden and unexpected death of young baby that has no specific cause despite a detailed investigation. However, if we use the modern sensor fusion technologies effectively, the system may alert the caregiver in a timely manner. In this proposal, the following items are suggested to develop:

#### **1. Connect the monitoring systems to the personal computer through wireless network**

Current products are designed to monitor only one baby or one area. They cannot be effectively used in a place where there are many cribs such as day care facilities. Also, there is no mechanism to record data in the current products. Some product like BebeSounds Color & Sound Video Monitor is just sending video and sound data to a monitor. If a human is not keep on watching the monitor, actually the system is useless. To solve the above problems, it is suggested that the systems should be connected to a computer. Then the computer can perceives data from multiple locations and process data to reason about the perceived information so that it can react accordingly. The development of standard protocol for baby monitoring systems and the computer network is also required.

#### **2. Introduce more smart sensors**

Basic sensors such as motion, pressure, temperature, etc. have been used so far. Now we could think of adding the following smart sensors to the system:

Vision is the richest of the five sensing modalities of human being. Computer vision could be the best mechanism to detect if something goes wrong. Also, computer vision can be the only solution to identify whether the baby is back to sleep or stomach to sleep. Currently, sound was

not analyzed, but just detected. It is needed to develop more smart functions to understand the meanings of the sounds when infants are involved. Breathing sensor is to alert if no breathing for 20 seconds, for example. It will be useful large day care centers to have humidity sensors to check diapers.

The following biomedical sensors can also be considered: blood pressure, EMG (ElectroMyoGraphy - muscle), ECG (ElectroCardioGraphy – heart rate), EEG (ElectroEncephaloGraphy - Brain), EOG (ElectroOculoGraphy – eye movement) sensors and among others.

### **3. Develop intelligent software for the sensor fusion for the personal computer to give early warning signals.**

When there are multiple sensors are connected to the system, it is not easy to synthesize all the perceived information from all the input sensors to make right decision at the right time while reducing false alarms. Sensor fusion technologies will be adopted to do this mission. Considered techniques for this problem would be the fusion of evolutionary computation, recurrent artificial neural networks, and fuzzy logic system.

### **4. Develop effective mechanisms to send the warning signals to the caretaker and parents**

If the computer is connected to the Internet and/or PSTN, then we could develop effective communication interface, for example, 911 phone calls, cell phone calls, text messaging, and emails in order to deliver the warning messages and statistical reports.

### **5. Gather data to be used for SIDS research in depth**

Establish a global network to collect baby monitoring data in standard format with various attributes. Construct a large database with real-time baby monitoring data for further analysis by various research groups.

### **6. Find knowledge leading to SIDS using data-mining technologies**

Data mining techniques can extract knowledge from data, uncover hidden trends, explain known patterns and predict the future behavior. In other words, data mining means exploration and analysis of large quantities of data in order to discover meaningful patterns and rules to discover knowledge. It can be viewed as the automated extraction of hidden predictive information from large data sets. After collecting baby monitoring data from multiple locations for long period of time, we could apply data mining techniques to find real knowledge to uncover the mystery of SIDS. This will lead to the understanding of SIDS. We suggest genetic programming based methods to this data mining problem to find the smallest decision tree which minimizes the misclassification.