NCIIA Proposal

Institution: Vanderbilt University

Team Members:
Sean Hill
Vanderbilt University
VU Station B 352726
Nashville, TN 37235

Dan Merritt
Vanderbilt University
VU Station B 354377
Nashville, TN 37235

Alexander Kuley
Vanderbilt University
VU Station B 354089
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Principal Investigator:
Brian Rothman
1211 Medical Center Drive
2301 VUH 37232-7614
(615) 343-9419

Administrative Contact:
Mary Judd
Vanderbilt University
VU Station B 351631
Nashville, TN 37235-1631
(615) 322-6224
Project Title: Acoustic Apnea Detector

Abstract:
Main Objectives
• Detect apnea
• Wake patient during apnea
• Lightweight to allow patient to sleep

The purpose of this project is to develop an affordable lightweight instrument that detects and alerts for sleep apnea cases. The instrument will be comfortable to the user and will be placed just above the sternum at the superternal notch with an adhesive film. The instrument will be composed of a contact microphone coupled to an amplification chamber. The chamber will be modeled after a stethoscope diaphragm and will be in direct contact with the patient’s skin. The microphone will be input to a computer via 1/8” cable. A computer program will detect and analyze breathing patterns for sleep apnea events. If a certain number of events occur (15+) in an hour, the computer will sound an alarm. The entire unit will be water and shock resistant to keep from harming the patient.

Proposal Narrative:

Introduction:
An estimated 5% of the entire human population suffers from obstructive sleep apnea (OSA) [1]. In the US alone, an estimated 18 million suffer from this condition. Many of these people are not diagnosed with the condition due to the difficulties of diagnosing a sleeping disorder. Undiagnosed OSA puts a patient at serious risk following sedative usage and/or anesthesia during a hospital visit. Monitoring these patients based on manpower alone is not feasible. This necessitates an easy to use reliable monitoring system that will detect and alert for apnea.

History and Context:
Previous methods for apnea detection have included using heart-rate analysis (ECG), blood-oxygen saturation analysis, and nasal CO₂ detection [1]. These devices are still used today and are quite reliable at detecting apnea. However, they are typically bulky and cumbersome [1]. Therefore, they lack comfort and portability. The goal of our project is to design a device that is both comfortable and portable. As mentioned before, the market for such apnea detection is on the order of millions of people. In hospital visits involving anesthesia, for example, monitoring patients (especially those who are obese) post-operation is important [2]. This is because undiagnosed apnea is common and the condition can be exacerbated by anesthetics and high body fat [2]. A fatal apnea event can occur in these patients without warning and can be fatal if nearby hospital staff are not alerted quickly. To monitor all patients who undergo anesthesia would prove to be costly and impractical with these aforementioned cumbersome devices. However, using a cheaper, smaller, and lightweight device like the one we are creating would be much easier to implement in any hospital. As a quick overview of numerical parameters, an apnea event is defined as a period where breathing ceases for 10 seconds or more [8]. Sleep apnea can then be categorized into 3 levels – mild, moderate, and severe – based on the number of events in an hour. 5-14 events/hour corresponds to mild apnea. 15-29 events/hour
corresponds to moderate apnea. 30+ events corresponds to severe apnea [5]. Our device will focus on detecting the latter 2 levels of apnea.

**Team:**
Alex Kuley and Sean Hill are both biomedical engineers and will be overseeing the biocompatibility, circuit design, and programming of the project. Dan Merritt is an electrical engineer and will be overseeing the signal analysis and circuit building. Brian Rothman, the chief investigator, will be overseeing the overall implementation and marketing of the product for hospital use.

**Work Plan and Outcomes:**
See attached schedule below

**Evaluation Plan:**
Success will be measured by:

- the accuracy of the device (i.e. does it alarm when a patient stops breathing for 15 seconds?)
- device operates in desired frequency range (400-700 Hz) [4][5]
- sufficient battery life
- sufficient shock/water resistant
- minimal number of failures in patient testing
- sufficient alert mode (i.e. is the device loud enough to wake the patient and alert the hospital staff?)
- is the cost within an acceptable range per unit
- device has similar performance to more expensive respiratory detection devices such as the Masimo Rainbow Acoustic Respiration Sensor [7]

**References**


[8] Personal communication with advisor
Appendix A: Budget

Acoustic Sleep Apnea Detector
Vanderbilt University School of Engineering
Budget Proposal

<table>
<thead>
<tr>
<th>Expense Category</th>
<th>Amount</th>
<th>Percent of Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Equipment</td>
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</tr>
<tr>
<td>(Describe briefly below in Justifications area.)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Materials &amp; Supplies</td>
<td>$50</td>
<td>100.00%</td>
</tr>
<tr>
<td>(Describe briefly below in Justifications area.)</td>
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<td></td>
</tr>
<tr>
<td>Other Expenses</td>
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<td>0.00%</td>
</tr>
<tr>
<td>(Describe very specifically below in Justifications area.)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>$50</td>
<td>100.00%</td>
</tr>
</tbody>
</table>

Justifications - Use the space below to describe expense line items above.

Estimate value of all materials that will have been purchased by the end of the project.

Appendix B: Team Member Credentials
Attached below
Daniel B. Merritt  
VU Station B 354377  
Nashville, TN 37235  
daniel.b.merritt@vanderbilt.edu

Education:  
- **Vanderbilt University**-Nashville, Tennessee  
  Bachelor of Engineering, Electrical Engineering, May 2010  
  Major Concentrations: Communications and Signal/Image Processing  
  Minor: Management of Technology

Skills and Certifications:  
- **Software Applications**: Matlab, PSpice, Advanced knowledge of Microsoft Office Suite  
- **Programming**: Java and C++  
- **Engineering Skills**: Breadboarding, Hardware and Software troubleshooting, digital design, oscilloscope, spectrum analysis, signal processing  
- **Operating Systems**: Extensive knowledge of Windows NT, 2000, XP, Vista and MAC OS

Technical Experience:  
- **Information Technology Services Technician**-Vanderbilt University (Fall 2007-Present)- Resolve student computer problems, remove viruses and spy ware, correct email, web-browser, remote access, and desktop application issues.  
- **IT Intern**, Tait Engineering, Inc. (Summer 2006) Migrated company computers from Novell to Windows domains and assisted IT Team with company security and operational issues.  
- **Audio-Video Technician**, Mariners South Coast Church. (2000-2006) Set up and operated audio-video equipment and soundboard for youth ministries.

Academic Projects:  
- **Digital Signal Processing Project** (Fall 2008)- Designed and developed voice identification software program using voice samples within specified accuracy range  
- **Audio Engineering Project** (Spring 2008)- Designed subwoofer enclosure for loudspeakers with specific physical properties to yield a flat frequency response  
- **Research and Development Report on Verizon FiOS** (Fall 2007)- Researched and prepared a detailed written report on the development and release of FiOS by Verizon, including analysis of technical, economic, and market factors. (Team Project)

Personal and Hobbies: Eagle Scout, IEEE student member, PADI Certified SCUBA diver, and digital photography
Sean Matthew Hill

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1217 Cedarwood Dr.
Flower Mound, TX  75028
(972) 355-2593

Campus Address
VU Station B #352726
2301 Vanderbilt Pl.
Nashville, TN 37235
Cell: (972) 824-9837

EDUCATION
Vanderbilt University, Nashville, TN
Bachelor of Engineering, Biomedical Engineering; May 2010

RELEVANT COURSEWORK
Biostatistics, Biomaterials, Biomechanics, Circuits (2 semesters), Bioinstrumentation, Computer Science (Matlab-based), Physiological Transport Phenomena, Systems Physiology (2 semesters), Neuromuscular Physiology, Chemistry (2 semesters), Biology (2 semesters), Calculus (2 semesters), Linear Algebra, and Differential Equations

EXPERIENCE
Vanderbilt University Medical Center, Department of Neurology, Nashville, TN  June, 2009 – Present
Research Assistant
• Worked with a team of medical doctors in an ongoing 5 year study funded by the National Parkinson’s Foundation
• Developed software to diagnose Parkinson’s tremor with a Nintendo Wii remote
• Helped test and validate software in preparation for publishing research

SKILLS
• Strong leadership, organization, problem-solving, and communication skills
• 3 semesters of persuasive/argumentative writing experience
• 3 semesters of technical/scientific writing experience
• Technical skills in programming and data analysis

LEADERSHIP
Vice President (External), Vanderbilt Biomedical Engineering Society, Fall 2009 – Present
• Coordinated meetings
• Revised and maintained society’s constitution and charter
• Working to generate new member interest and develop relationships with alumni and other organizations

Committee Chair, Vanderbilt Biomedical Engineering Society, Education Committee, Fall 2008 – Spring 2009
• Expanded Vanderbilt’s existing physician shadowing program to include more doctors
• Created a new partnership between our society and Vanderbilt’s shadowing program to allow more engineering pre-medical students to shadow doctors
• Laid the groundwork for a freshman engineer mentoring program

Team Leader, Vanderbilt Student Volunteers for Science (VSVS), 2007 – Present
• Provided hands-on science lessons to Nashville inner-city elementary school students
• Trained teams on how to teach and perform experiments
• Led experiment demonstration for students and learned valuable communication skills by teaching

AWARDS AND HONORS
Dean’s List, Fall 2006, Spring 2007, Spring 2008, Fall 2008, Spring 2009
Lotus Eaters, Sophomore Academic and Service Honor Society, 2007-2008
Alpha Lambda Delta, National Academic Honor Society, 2007-Present
Phi Eta Sigma, National Academic Honor Society, 2007-Present
ALEXANDER J. KULEY

(513) 312-7232  •  alexander.j.kuley@vanderbilt.edu

EDUCATION

Vanderbilt University, Nashville, TN
Biomedical Engineering Major, 2010
GPA: 3.69/4.00 Overall (3.73 Engineering); Dean’s List for Five Semesters

Relevant Coursework: Biomedical Materials, Biomechanics, Systems Physiology, Physiological Transport Phenomena, Circuit Analysis, Organic Chemistry, Introduction to Matlab, Biomedical Instrumentation, Analysis of Biomedical Data

EXPERIENCE

Laboratory for Bionanotechnology and Nanomedicine, Nashville, TN
Dr. Rick Haselton, Professor
Research Project (January 2009 – present)
• Optimizing a rapid antigen detection apparatus.
• Designing a component to maximize sensitivity in a minimum timeframe.
• Attempting to harness electrochemical properties of target antigen.

U. of Cincinnati College of Medicine, Ophthalmology Department, Cincinnati, OH
Dr. James Augsburger, Chairman
Research Assistant (June 2008 to August 2008)
• Researched the prognostic implications of metastatic cancer to ocular tissue.
• Documented clinical data and statistically evaluated different clinical data sets.
• Gained a practical understanding of manipulating clinical data to describe disease progression.
• Shadowed Dr. Augsburger in his Ocular Oncology practice.

Sifri Eye Center, Cincinnati, OH
Dr. Michael Sifri
Ophthalmic Technician (Summers of 2003 to August 2008)
• Ran standard tests including Visual Field Test, GDX glaucoma test, Basic Vision Test, and Schirmer’s Test.
• Administered more complicated procedures including Manifest Refractions, Intraocular Pressure Measurements, and Pachymetry, and assisted with in-office chalazion removals.

Biomaterials, Drug Delivery, & Tissue Engineering Lab, Nashville, TN
V Prasad Shastri, Ph. D, Assistant Professor
Volunteer Research Assistant (Feb. 2008 to May 2008)
• Researched the intricacies in regeneration of corneal epithelia.
• Worked to develop stimulants of epithelia regeneration at the nanoscale level.
• Techniques learned include: cell culture, cell toxicity, viability staining, and cell counting.

ACTIVITIES

• Unite for Sight, VP of Eyeglass Drive: organize eyeglasses drives for organization that provides free vision care.
• Vanderbilt Students Volunteering for Science, Site Leader: organize a team that teaches science lessons to underprivileged schools.
• Biomedical Engineering Society: serve on the newsletter committee for Vanderbilt chapter.
• Wilderness Skills: participate in an outdoor club that takes camping trips on weekends.
• WRVU DJ: host a radio show one hour per week highlighting new independent music.