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September 24, 2007

Dr. Andrew Rawicz
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Re: Functional Specification for an Anti-Snore Pillow (ASP)

Dear Dr. Rawicz:

Attached is the functional specification for LifeX's most recent innovation, the *Anti-Snore Pillow*. LifeX's goal is to design an ANC-enabled *Anti-Snore Pillow* that will lower the background snoring noise, so that everyone can enjoy peaceful and quality sleep every night, even with a noisy snorer.

The functional specification is a set of detailed requirements regarding Anti-Snore Pillow's functionality. The functional specification will be used as a guide by LifeX's members during the research and development phase of the project.

LifeX is comprised of four highly motivated undergraduate engineering science students from SFU: Camillia Lee, Stanley Yang, Simon Wong and Raymond Lee. If you have any questions or comments, please do not hesitate to contact us by phone at (604) 594-6816, or email us at *lifex-ensc440@sfu.ca*.

Sincerely,

Raymond Lee

Chief Executive Officer
LifeX

Enclosed: Functional Specification for an Anti-Snore Pillow (ASP)

LIFEX

FUNCTIONAL SPECIFICATION:
ANTI-SNORE PILLOW (ASP)

PROJECT MEMBERS:

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ISSUED DATE:

OCTOBER 15, 2007

VERSION

1.0

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Glossary

CSA – Canadian Standards Association
ANC – Active Noise Control/Cancellation
APTA – American Physical Therapy Association

1 Introduction

The Anti-Snore Pillow is the first innovation from LifeX Technology. It uses Active Noise Cancellation technology to reduce the noise level of snoring at the non-snorer's pillow. Using microphones, speakers and a DSP controller, an adaptive noise prediction system will produce an anti-noise which will suppress the unwanted noise. The requirements of the Anti-Snore pillow are described in this functional specification.

1.1 Scope

The functional specification will describe the functional requirements of the Anti-Snore Pillow. It will also show the proof-of-concept device, which will drive the actual design of the Anti-Snore pillow in the future.

1.2 Intended Audience

The functional specification will be used by all members of the Anti-Snoring Pillow team in LifeX Technology. During the development phase, the team leader should use this document as a measurement of development progress. In addition, this document will help design engineers with the overall design during the design and implementation phase. Finally, test engineers will use this document as a reference during verification and validation processes.

1.3 Classification

The following convention will be used to denote functional requirements in the functional specification document:

[Rn-p] A functional requirement

where n is the functional requirement number, and p is the priority of the functional requirement as denoted by one of three values:

I The requirement applies to the proof-of-concept system only.
II The requirement applies to both the proof-of-concept system and the final production system.
III The requirement applies to the final production system only.

2. Executive Summary

Studies have shown that forty-five percent of normal adults snore at lease occasionally, and twenty-five percent are habitual snorers. And these statistics increases with age as well. LifeX knows that sleeping with someone who habitually snores can sometimes be difficult, but some snorers might be scared of getting surgical treatments done or might find it too expensive. This is why LifeX is committed on producing a product that will allow everyone to enjoy quality sleeps every night.

Our latest innovation is to design an anti-snore pillow, which consists of a pillow with embedded speakers, very sensitive microphones and a digital signal processor (DSP). The whole development of the product can be broken down into to two phases: research phase and design & development phase. Upon completion of the first phase we will have completed the following:

- Research and select required components.
- Have adequate knowledge of the physics of sound.
- Have adequate knowledge of adaptive filter and control algorithm.
- Have adequate knowledge on programming the DSP.
- Theoretical knowledge of the actual design of the system.

We are currently in the late stages of the research phase and will soon proceed to the design & development phase of the project. The second phase of the project consists of hardware design, and software development. Upon completion of the two, we will proceed to integration, testing and optimization. The four month R&D cycle of the ASP prototype is expected to be completed by the December 15, 2007, upon which the prototype is expected to conform to this proposed functional specification.

3 System Requirements

High level requirements for the Anti-Snore Pillow are presented in this section.

3.1 System Overview

Figure 1 below shows the high lever block diagram of the system.

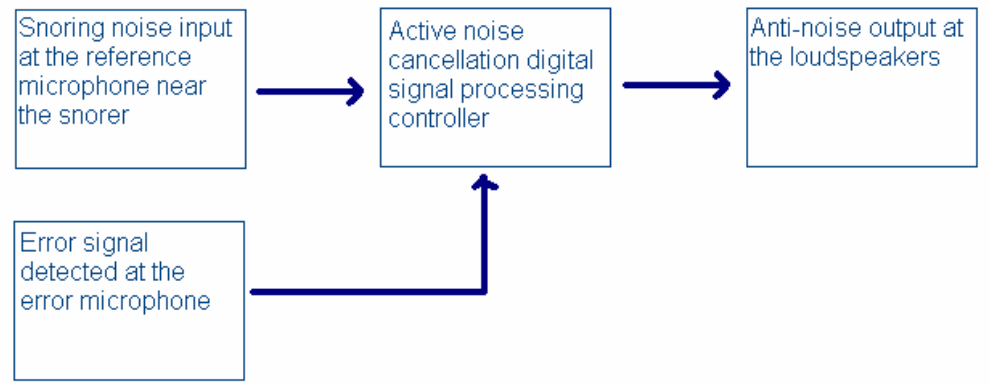

Figure 1: High level block diagram of the system.

In the first stage of development, a system with two loudspeaker outputs, single reference input and single error input will be developed. A multi-channel system with multiple inputs and multiple outputs like shown in figure 2 will have a better system performance. However, the complexity of a multi-channel system is much higher due to the interactions between multiple inputs and outputs, the acoustic feedback effect, multiple primary and secondary paths estimation and other various advanced issues. Due to time and budget constraints, a multi-channel system would only be considered in future versions of the product.

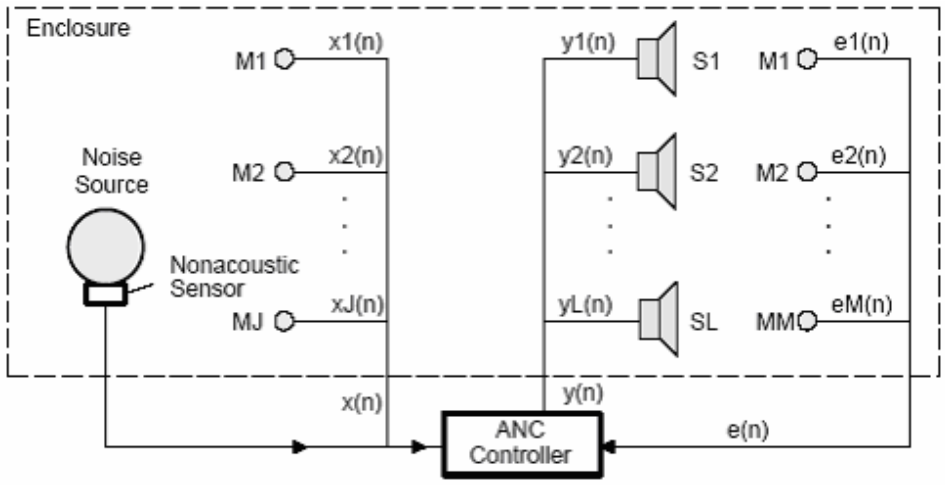

Figure 2: Multi-channel ANC system.[5]

The anti-snore pillow will have two loudspeakers attached to the two sides of the pillow. They will be pointing in the direction such that maximum attenuation of the unwanted noise is achieved within the “quiet zone” of the user. The directions will be determined by various experiments during development. A microphone will be placed inside the “quiet zone” to detect the error signal. A microphone will be placed near the snorer to detect the snoring noise input. All the above components will then be connected to an ANC controller, which would be placed in a location not immediately observable by the user. A start button on the ANC controller will start the system. The system should be embedded into a standard size pillow.

One important restriction of the system is that the locations of the input microphones and output loudspeakers should be fixed. The reason is that the primary path from the reference microphone to the loud speaker and the secondary path from the loudspeaker to the error microphone are the main factors in determining the characteristic and performance of the ANC system. The ANC controller will also be optimized for the fixed locations of the inputs and outputs.

The anti-snore pillow will be optimized based on the assumption that the user will sleep in the proper sleeping position. Figure 3 shows the proper sleeping position suggested by the American Physical Therapy Association.

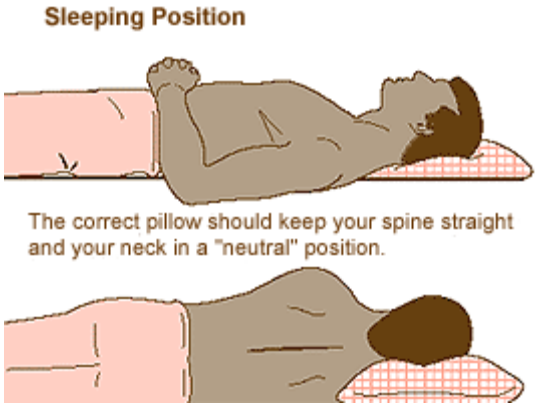

Figure 3: Proper sleeping position. [6]

3.2 General Requirements

[R1 – III] Speakers, microphones, ANC controller and wires shall be minimally intrusive to the user.

[R2 – III] Final product should retail for less than $500CDN.

[R3 – II] System should decrease unwanted noise and not generate extra unwanted noise.

3.3 Physical Requirements

[R4 – II] Speakers and ANC controller should be integrated with a standard size pillow (20"x26”).

[R5 – III] Pillow should be comfortable.

[R6 – II] System should fit on at least a standard double full size bed (54”x 75”)

[R7 – III] Wires/cables should not be too long such that users might get tangle up.

3.4 Electrical Requirements

[R8 – III] The power adapter is compatible with the standard 110/120V at 60 Hz wall supply within North America.

[R9 – III] The power supply should be enough to power the signal processing unit and at the same time up to 10 Watts within the speakers

[R10 – II] Device should never encounter rapid change in electricity demand

[R11 – II] Cables shall be insulated and sheathed and installed in a heavy duty non-metallic enclosure

[R12– II] The power supply shall be operational for 5 years before requiring maintenance

[R13– II] The power cord can stay plugged in and not cause any breakdowns

3.5 Environmental requirements

[R14 – III] This pillow will function properly at sea level to approximately 2200m above sea level.

[R15 – III] This pillow will be able to function properly at normal room temperatures which will range from 15**°C** to 30**°C.**

[R16 – III] This pillow will function properly at comfortable humidity conditions which will range from 30% to 60% [1].

[R17 – III] This pillow can only be used indoors.

3.6 Safety Requirements

[R18 – II] The speakers on the side of the pillow should not contain any hard and sharp objects that may potential harm the user

[R19 – II] All electronic components should be fully enclosed

[R20 – II] The connection between the microphones and the wall should be extremely secured

[R21 – II] Microphones cannot be heavy, in case they fall down and hit the user

[R22 – II] The signal processing unit should have no sharp edges

[R23 – II] Upon startup, the device will run through a routine check to make sure all electronic components are functional, otherwise an error message would be displayed

[R24 – II] The electronics of the device will not conflict with other household electronic devices

[R25 – II] No small (small enough for a child to swallow) loose parts should come off of the device

3.7 Performance Requirements

[R26 – III] The ASP shall complete all calculations within 1ms.

[R27 – III] The ASP shall be able to be able to continually operate for at least 12 hours each time.

3.8 Usability Requirements

[R28 – II] Device should have a user-friendly interface that does simple operations such as on/off and sleep mode

[R29 – II] The signal processing unit should be unexposed to user to avoid confusion

[R30 – III] The speakers should come out of only one side of the pillow to distinguish between the top and bottom of the pillow

[R31 – II] The device can be connected to the computer via USB cable for potential firmware updates

4. Standards

- The ASP shall conform to CAN/CSA-C22.2 NO. 60065-03 (R2007).
- The ASP shall conform to ANSI standards.
- The ASP shall conform to CAN/CSA-CEI/IEC CISPR 22-02 (R2006).

5. Reliability and durability

[R32 – II] This pillow will be able to function continuously throughout one night of sleep.

[R33 – II] This pillow will be able to be serviced by trained technicians.

[R34 – II] The minimal MTBF (mean time between failures) for this pillow will be 6144 hours which is approximately 768 nights.

[R35 – II] The pillow will be resistant to any damage caused during normal sleep movement.

[R36 – II] The pillow's comfort and structure will last up to 6144 hours and can replace easily.

6. Luxury functions

[R37 – III] The pillow will reduce the sounds of the user's partner for a peaceful sleep.

[R38 – II] The ergomically designed pillow will position the users head for optimal comfort.

7. Microphone

- The microphone shall be low cost, specifically below $15.
- The microphone shall have low impedance.
- The microphone shall have large signal-to-noise ratio.
- The microphone shall be non-directive.
- The microphone shall have high sensitivity.

8. Speaker

- The speaker shall be able to generate sound pressure level higher than the source.

- The speaker shall have good low frequency response.
- The speaker shall have good humidity resistance.
- The speaker shall be low cost, specifically below $50.
- The speaker shall be light and compact.

9. Signal Processing Unit

A “computer-on-a-chip” will be needed to execute small control programs in the real time environment. The main functionality of this unit will be executing algorithms of a LMS feed-forward system in order to minimize error. This unit will be responsible for communicating the reference microphone, error microphone, and the two output speakers.

9.1 General Requirements

[R39 – III]	The unit should have at least 2 input audio jacks
[R40 – III]	The unit should have at least 2 output audio jacks
[R41 – II]	The unit should include at least 256K words of flash memory and 64K words RAM
[R42 – II]	The unit should have an embedded audio codec
[R43 – III]	The power supply of the unit should be the +5V universal power supply
[R44 – III]	The unit should be compatible with a compiler/debugger

9.2 Physical Requirements

[R45 – II]	The input and output audio jacks should be the standard 3.5mm
[R46 – II]	The total area of the unit should be no larger than 18cm x 25cm
[R47– II]	The thickness of the unit should be no more than 4cm

10. Pillow

10.1 General Requirement

[R48 – II] Pillow should consist of a mineral fiber core

[R49 – II] Pillow should be washable

[R50 – II] Material on the outside of the pillow should not be corrosive and conductive

[R51 – II] Material on the outside of the pillow should be strong and durable

10.2 Physical Requirement

[R52 – II] The area of the pillow should be no less than 13 inch x 26 inch

11. User interface

The interface of the system will have a on and off switch. The system should be turned off when it is not needed to conserve power and life cycle of the product.

12. User documentation

[R53 – III] The user documentation will include a user manual written in English.

[R54 – III] The user manual will include detailed and simplistic instructions on the technology used.

[R55 – III] The user manual will also contain functional aspects of the pillow.

13. System Test Plan

The test plan will be separated in a few categories:

- *Functional Testing*
- *Interface Testing*
- *Performance Testing*
- *Acceptance Testing*

13.1 Functional Testing

The objective of this test is to ensure that each element of the application meets the functional requirements of the design specification. A series of simple tests will be executed to make sure our device is functional. Low-level tests will be executed, aiming to test the individual process and data flows. This is to make sure all the different parts are functional after being assembled,

13.2 Interface Testing

The Interface Testing measures the device's potential to accomplish the goals of the user through the UI. Friends and family will be invited to judge the user-friendliness of our product's interface

13.3 Performance Testing

Performance is one of the most important aspects of our product. Intense and repetitive tests will be executed to measure the amount of snoring noise that our product has lowered. Our goal currently is to achieve a noise reduction of at least 10 dB.

13.4 Acceptance Testing

A suite of tests will be executed on the completed system. Friends are family are invited to grade our product based on the product's appearance, usability, performance and safety. The test procedures are as the following:

1. Place the microphone beside our demo snorer.
2. Switch on the product
3. Lay down on the Anti-Snoring Pillow
4. Switch off the Anti-Snoring Pillow.

14 Conclusion

The functional requirements and capabilities of the Anti-Snore pillow are described in this document. All members of the team shall reference this document closely during development phase. The requirements that apply for the proof-of-concept model are expected to be achieved by the target date of December 15h, 2007.

15 References

[1] Wikipedia.org, “Humidity”, October 2007, http://en.wikipedia.org/wiki/Humidity#Effects_on_electronics,

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[4] Work Safe BC, “General Electrical Requirements”, October 2003, http://www2.worksafebc.com/Publications/OHSRegulation/Part19.asp?ReportID=18566

[5] Texas Instruments, “Design of Active Noise Control Systemwith the TMS320 Family, June 1996, http://focus.ti.com/lit/an/spra042/spra042.pdf

[6] American Physical Therapy Association, “Physical Therapy Patient Satisfaction Questionnaire Research Grants”, 2007, http://www.apta.org//AM/Template.cfm?Section=Home