ECE1778 – Creative Apps. for Mobile Devices
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Final Project Report for:

WhIMPeR
WORLD NOISE MAPPING PROJECT

This report explains in detail the World Noise Mapping Project designed and developed by our team for the final project assignment of Creative Applications for Mobile Devices.

1. Introduction

The sound we hear is due to mechanical waves of oscillatory pressure traveling through any medium such as air. Sound can be broken down into two categories: Noise and Acoustic Sound. Noise, by definition is any unwanted sound. Acoustic sound, or sound, refers to favourable types of oscillatory pressure waves such as conversation or a good song.

From musical instruments to sonar noise sources are all around us. Urbanization and the increasing human population have contributed a significant amount to the degradation of our environment. However, not until recently has attention been given to the growing problem of noise pollution. Matter of fact, Noise pollution as it stands today is the most predominant type of pollution yet it remains a “silent” topic with very little research being conducted [1].

The effects of high noise exposure however are not new. It has long been understood that long exposures to high noise is detrimental to the hearing of a human. The former has motivated government agencies such as the Ministry of Environment (MoE), to impose workplace noise exposure limitations with stringent guidelines [2]. However, workplace noise exposures are required by the Ministry of Environment only if a random inspection is performed at a workplace. Furthermore, the workplace noise exposure

2. Overall Design

The WhIMPeR application provides three main functionalities; a noise measurement component, a daily noise exposure graph and a visualization of the noise data. The noise measurement component of the application takes digital output from the microphone and outputs dB readings. The noise exposure graph is a form of visualization of the day’s noise exposures with the x axis being time of the day (24 Hours) and the y axis being the dB reading. Finally, the noise map shows an overlay of noise signals and measurements on top of a Google map.

With the aim of separating the presentation layer from the processing and data management we have divided the implementation into five modules. The implementation of the modules was carried out such that they can be developed and tested separately based on the defined interaction schemes between them. Figure 1 illustrates the five modules and the major interactions between them.

2.1 User Interface (UI) Manager Module

Different program screens (activities) were implemented in this module. This module acted as the intermediate layer between users and internal components. By concentrating all of the user interaction in this component, the remaining components were independent, enabling us to easily develop versions for different mobiles which may have different user interaction features such as screen resolutions or special UI interface APIs.

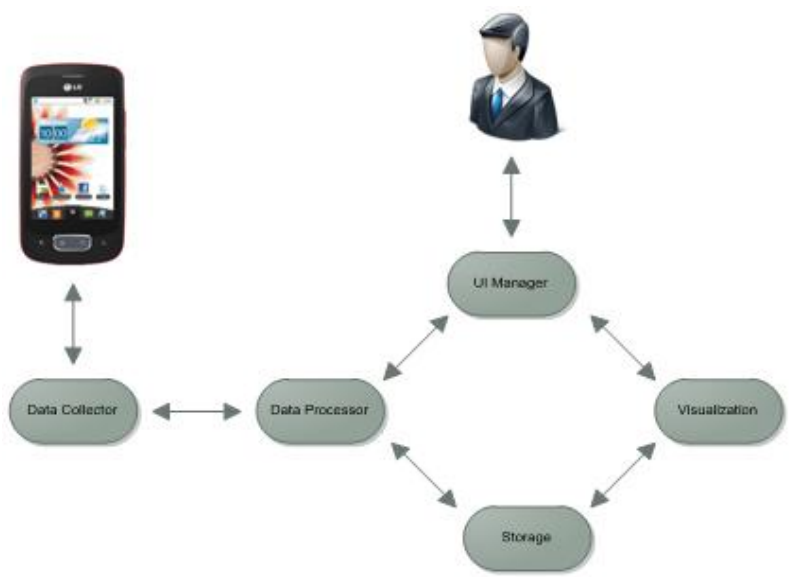


Figure 1. The five major modules of the application with the interaction between them

2.2 Data Collection Module

This module collects raw data act as a connection between the components that require them. This module will contain two main components, the GPS and Microphone Manager.

2.3 Data Processor Module

The data processor is the core of our system. This module uses the data that is collected buy the Data Collector and performs the required algorithms in order to generate accurate noise levels. This module is only responsible for calculating the noise level from the raw audio.

2.4 Storage Module

This module is responsible for storing and restoring the data. The data gathering and data visualization are performed separately. While the program is running in the data gathering mode, it records the noise level data. Whenever the user requests to see the data, it is formatted before visualization. To accomplish its functions, the output of each of the *Data Processor* module was stored. This module saves the data into the phone, so that the user can consult it later.

2.5 Visualization Module

This module is used to prepare and present the data to the user. For example, it is responsible for combining the results of different days for each location to provide an average noise level for the noise map.

By separating the data processing and visualization, we were able to speed up data processing, due to being able to run in real-time. Visualization is only performed when the user requests it and using the data that was selected.

3. Statement of Functionality

3.1 Noise Measurement Component

As previously mentioned, the sounds and noise we hear are due to pressure fluctuation in the air around us. We can hear and perceive these pressures though our ears by interaction of these pressure waves with our ear drums.

Pressure is usually expressed in units called Pascals (Pa). A young human with no hearing loss can sense sound pressure charges as low as 0.00002 Pa. A human ear can hear from 0.00002-20 Pa

Is it rather difficult and non-intuitive to use pressure measurements to quantify the loudness of noise and hence why we often convert pressure readings to Decibels. In order to obtain dB reading from a pressure measurement we convert the pressures using the following formula:

$$dB = 20log\frac{Sound\ Pressure}{Reference\ Pressure} \tag{1}$$

The sound reference in equation (1) refers to the lowest pressure that a human hear can detect, also known as the reference pressure and is a constant for air at room temperature and is equal to 0.00002 Pa.

Microphones traditionally are highly sensitive pressure sensors which convert pressure values into voltage differentials. The correlation between pressure and voltage differential depends on the microphone and is a constant provided from the manufacturer. The microphone with the LG phone that was used as a test for this project outputted a digital signal with readings that were easy to convert to a relative dB level (un-calibrated).

The un-calibrated noise reading that were first obtained from the phone were used inside an anechoic chamber with a calibrated noise level meter to find a relationship between the two. As seen in Figure 2 the relationship between the values is linear with a slope close to 1 and a static offset of 93.945. The slope was assumed to be one and a value of 93.945 was added to the un-calibrated values to yield relatively accurate and calibrated results.

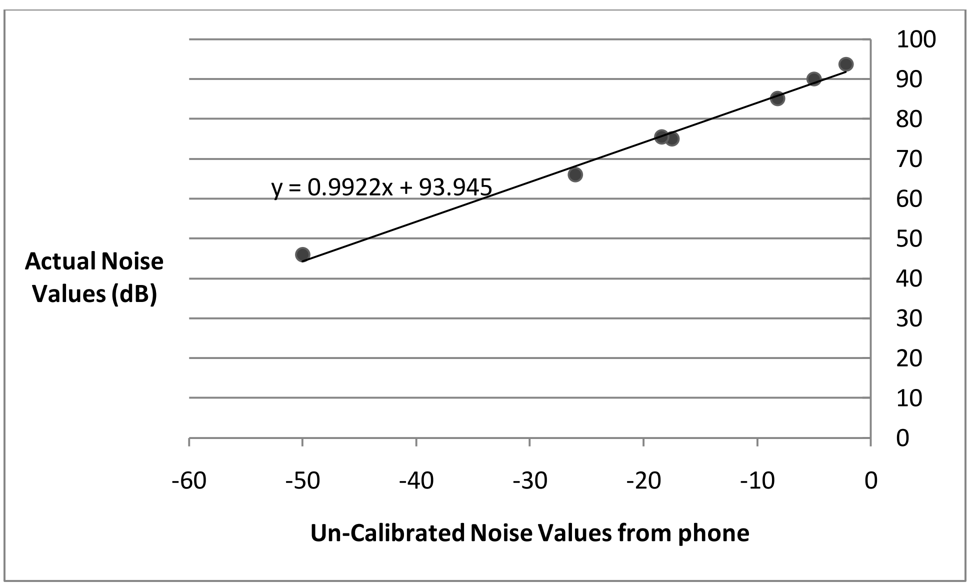


Figure 2. Linear relationship between un-calibrated measurements obtained from the phone and a calibrated noise level meter

This component of the application showed a current, average and smoothed sound level (Figure 3). The current sound level is a direct calculation of the current state of the microphone. The averaged value was of the last 1 seconds of acquisition. Finally the smoothed value was implemented to average out around 2 seconds of data in order to obtain "slow response" measurements. Slow response measurements are favourable since they ignore large peaks in noise that occurs in durations of miliseconds which are usually associated with signal noise or dropping an object etc. This is traditionally done in commercially available noise level meters.

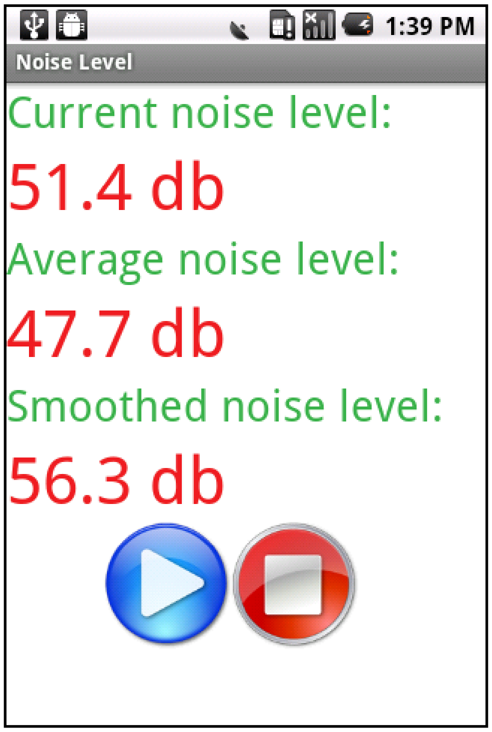


Figure 3. The sound level meter feature of the application which shows three important noise readings.

3.2 Daily Noise Exposure Graph Component

The daily noise exposure graphs works by taking the data collected from the noise measurement component and plotting it over a span of 24 hours with the y axis being noise values. This component allows the user to select different dates for which to plot the data (Figure 4). This information can be used by to perform pulmonary workplace noise exposure by looking at the noise levels during working hours relative to other activities during the day.

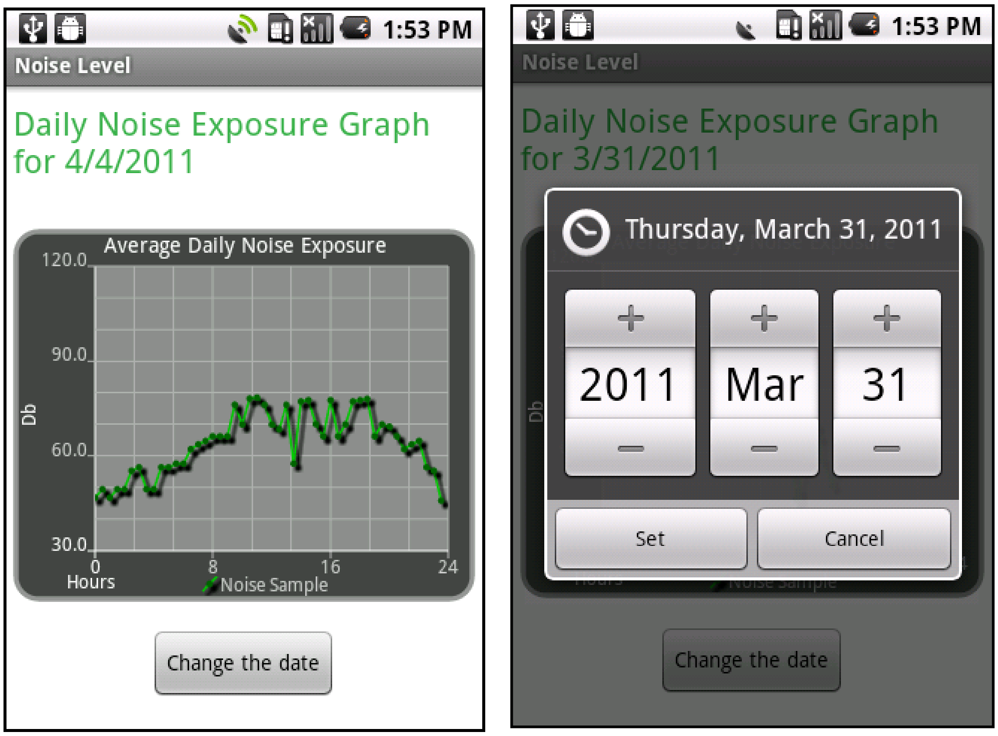


Figure 4. Noise exposure feature of the WhIMPeR application. The figure on the rights shows the ability to change the date for which the data is displayed

3.3 Noise Map Component

The noise map constitutes the main motivation behind this work is shown in Figure 5. The captured noise values from the measurement component coupled with the geographical location of the data is plotted on a Google map with a noise overlay. Markers were used to place small circular markers in selected locations based on the measured noise levels. The points were averaged and a square was denoted with a colour based on Figure 6 to illustrate the severity of the noise level. Furthermore, the noise map within WhIMPeR was fitted with the ability to map noise within selected time frames. For example a noise map is shown for 12pm-6pm in Figure 5(right). The user will user this feature to better understand the noise situations during relevant times, like at night, in decision making situations such as purchasing or renting an apartment.

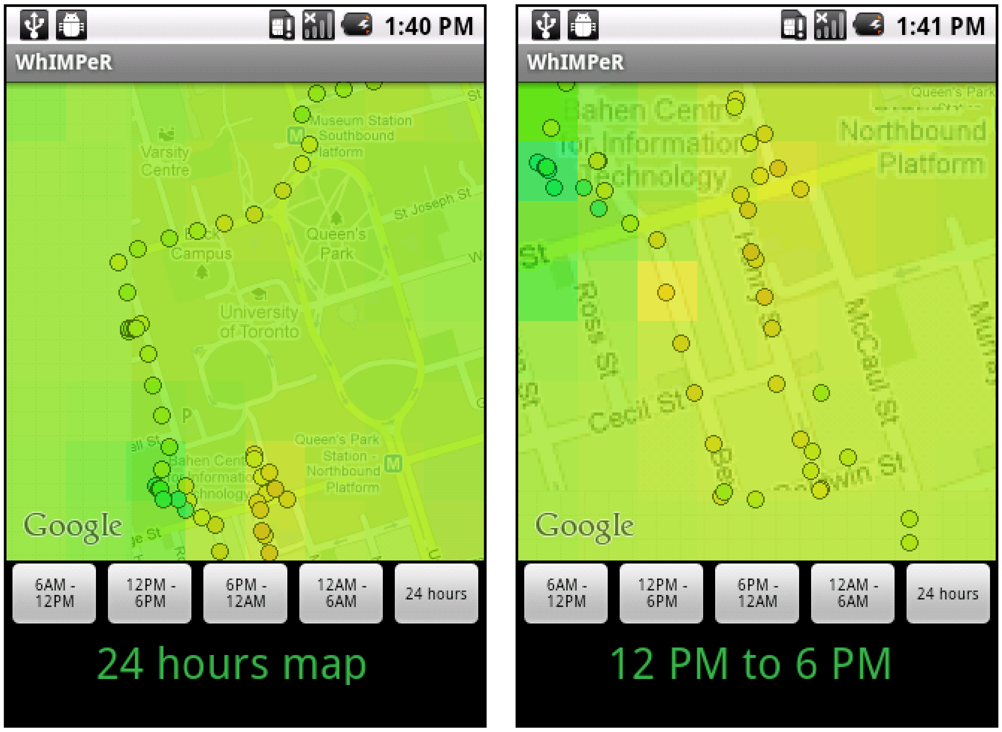


Figure 5. Noise map showing selected points of the noise data as well as a noise intensity overlay. The figure on the right shows the feature of time interval selection.

VERY LOUD		
Dangerous over 30 minutes	110	• Concerts (any genre of music) • Car horns • Sporting events
	100	• Snowmobiles • MP3 players (at full volume)
	90	• Lawnmowers • Power tools • Blenders • Hair dryers
Over 85 dB for extended periods can cause permanent hearing loss.		
LOUD		
	80	• Alarm clocks
	70	• Traffic • Vacuums
MODERATE		
	60	• Normal conversation • Dishwashers
	50	• Moderate rainfall
SOFT		
	40	• Quiet library
	30	• Whisper

Figure 6. Colour coding for different levels of noise (Courtesy of the American Academy of Audiology - audiology.org)

4. Discussion of Project

Overall results, collaboration and implementation of the project went extremely well. We believe that this was largely due to setting realistic goals and good collaborative work. However, the overall project outcome could have been improved if complications such as obtaining an API license for Google maps were foreseen and planned for.

Other areas of improvement for the overall project could have included collaboration with noise testing laboratories to enable more noise testing to ensure the quality of the collected data versus actual results. The measurements that are obtained from the phone were calibrated to the best of our abilities however no verification of the noise map or the daily noise exposure outputs were conducted due to lack of availability of comparative data.

5. Group Member Contribution

5.1 Programmer #1 (Yeleiny Bonilla):

Implemented most of the code related to the UI interface and was in charge of the application design, icon selection, themes, and all the general UI functionalities. Yeleiny also designed all 5 screens which were implemented as a separate activity.

Yeleiny implemented the functionalities of the Storage module by designing the SQLite DB and programming all the functionalities in the DBAdapter.java and DBManager.java classes. Furthermore, she created the Classes “MapOverlay.java” and “MapItemizedOverlay.jav” which were used to create the map overlay. Also, introduction of the Android Plot library which was used to plot. In addition to that above mentioned, she implemented multiple general object classes, including, “MyLocation.java”, “NoiseSample.java”, “Range.java”, and “Utils.java”

5.2 Programmer #2 (Sajad Shirali-Shahrenza):

Sajad created the infrastructure for sharing the project code using subversion in Google Code, https://whimper.googlecode.com/svn/trunk/WhIMPeR. He was in charge of the DataCollector and the DataProcessor modules. He implemented all the functionalities to capture noise samples, by using the capabilities of the microphone. Implemented the algorithms to transform and calibrate the noise obtaining the desired decibels measurements. He implemented classes “AudioReader.java” and “NoiseMeter.java”.

The integration of the GPS location was also a part of his accomplishments. He implemented the final version of the NoiseMap, by putting markers (small circles) in the map with different colors depending on the amount of decibels recorded in the area and the noise cloud over the map. Modified some classes and introduce others.

5.3 Apper (Ali Sabti):

Ali provided insight, knowledge and experience in the noise aspects of the project. He ensured that the calculations that were being performed were accurate and conformed to classical noise analysis methods. Furthermore, he conducted a literature review on the topic and found no similar topics of research. The noise calibration of the phone was performed by him. He creating and set up a test using an anechoic test scenario with conformance to ASTM standards.

Furthermore, he was responsible for all initial sketches of the design and layout of the application (Appendix II). Finally, the project outline, reports and presentations were completed by him.

6. Apper Statement

Noise mapping is one study that is commonly performed in order to better understand the propagation and the effects of noise. Noise mapping is traditionally performed by placing microphones in designated areas to measure the noise levels while logging the time stamp. The software needed to create a noise map which would take the measurements from the noise level meters and the time stamp are expensive due to the nature of the numerical computations that needs to be performed. The creation of noise maps is both a time consuming and an expensive ordeal. An example of the complexity of such a project is the Windsor Environmental Noise Mapping Initiative (WENMI) which set out to establish noise emission contours of North America's Windsor-Detroit border crossing. The project was aimed at eliminating transport noise affecting Canada's largest border crossing, the Ambassador Bridge and more precisely Huron Church Rd. which spans approximately 5 km. The project used the acoustic specialty software as well as multiple sound level meters. The project costs in the upwards of tens of thousands of dollars, 12 students and was completed in a year. The

WhIMPeR projects hopes to perform these kinds of measurements and replicate the results in a more economical and for broader locations.

The project would also aid in workplace noise exposure ratings. In today's industry, Ministry of the Environment employees perform random noise exposure checks. The checks are to ensure that the employees at the given establishment are not being exposed to more than 85 dB (8 hour equivalent). Currently, the ministry employees will ask the company, if they deem appropriate, to contract a noise consulting firm to perform a comprehensive noise analysis. The workplace noise exposure measurements can cost between $3000-$10000 depending on the number of employees and the size of the facility. Not only does the high cost of equipment prevent workplaces from conducting their own noise measurements if a complaint is filed but it forces facilities to only perform these measurements if a random inspection calls for it. By the aid of the daily noise exposure feature of the WhIMPeR project, we hope to aid employees in taking safety into their own hands. The project will provide a crude estimate which can act as a baseline for further action.

The results of this project will be able to aid private, public and individual users as well. The individual advantage will be the ability for the user to pinpoint quite spots for residence location and also for vacation or entertainment purposes. In the public sector, municipalities interested in noise source identification and improving the standards of living will also benefit a great deal. The WhIMPeR project will place in the hand of the user what is otherwise inaccessible only to a select few of noise consulting businesses, a sound level meter and the ability to measure equivalent sound levels.

7. Future Work

Although we met all the requirements that were set out to accomplish at the beginning of the course, we believe that there are numerous improvements that can be implemented to enhance functionality. Firstly, the application would benefit a great deal from the ability capture noise data while the user is one the phone either through access to the noise cancelling microphone or by other signal processing means. Furthermore, global calibration of phones is of vital importance. Currently, for this application to be used on different models of cell phones, separate calibrations would need to be performed for the models. This is due to the inability of obtaining the voltage differentials from the microphone as well as the voltage to pressure constant.

Finally in order for the successful commercialization of this application we would need to develop a website based interface. The interface would allow users to view the data and enable them to print, plot and visualize it in accordance to their needs.

8. Conclusions

We set out to create an application that is interesting and can raise awareness about the ever growing problem of noise pollution. We believe that we have made monumental steps in creating an application that is both interesting and functional for the user. The creation of the device will now enable any user to obtain sound level measurements with reasonable accuracy without the need for expensive noise level meters. Furthermore, we now enable users to perform their own workplace noise exposures by utilizing our daily noise exposure graphs. Finally, the noise map that was an output of this project shows noise reading in an interactive and informative fashion.

References

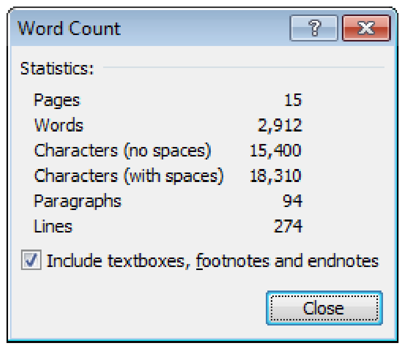
[1] V. Pathak, B.D. Tripathi, and V. kumar Mishra, “Evaluation of traffic noise pollution and attitudes of exposed individuals in working place,” *Atmospheric Environment*, vol. 42, May. 2008, pp. 3892-3898.

[2] M. Picard, S.A. Girard, M. Simard, R. Larocque, T. Leroux, and F. Turcotte, “Association of work-related accidents with noise exposure in the workplace and noise-induced hearing loss based on the experience of some 240,000 person-years of observation.,” *Accident; analysis and prevention*, vol. 40, Sep. 2008, pp. 1644-52.

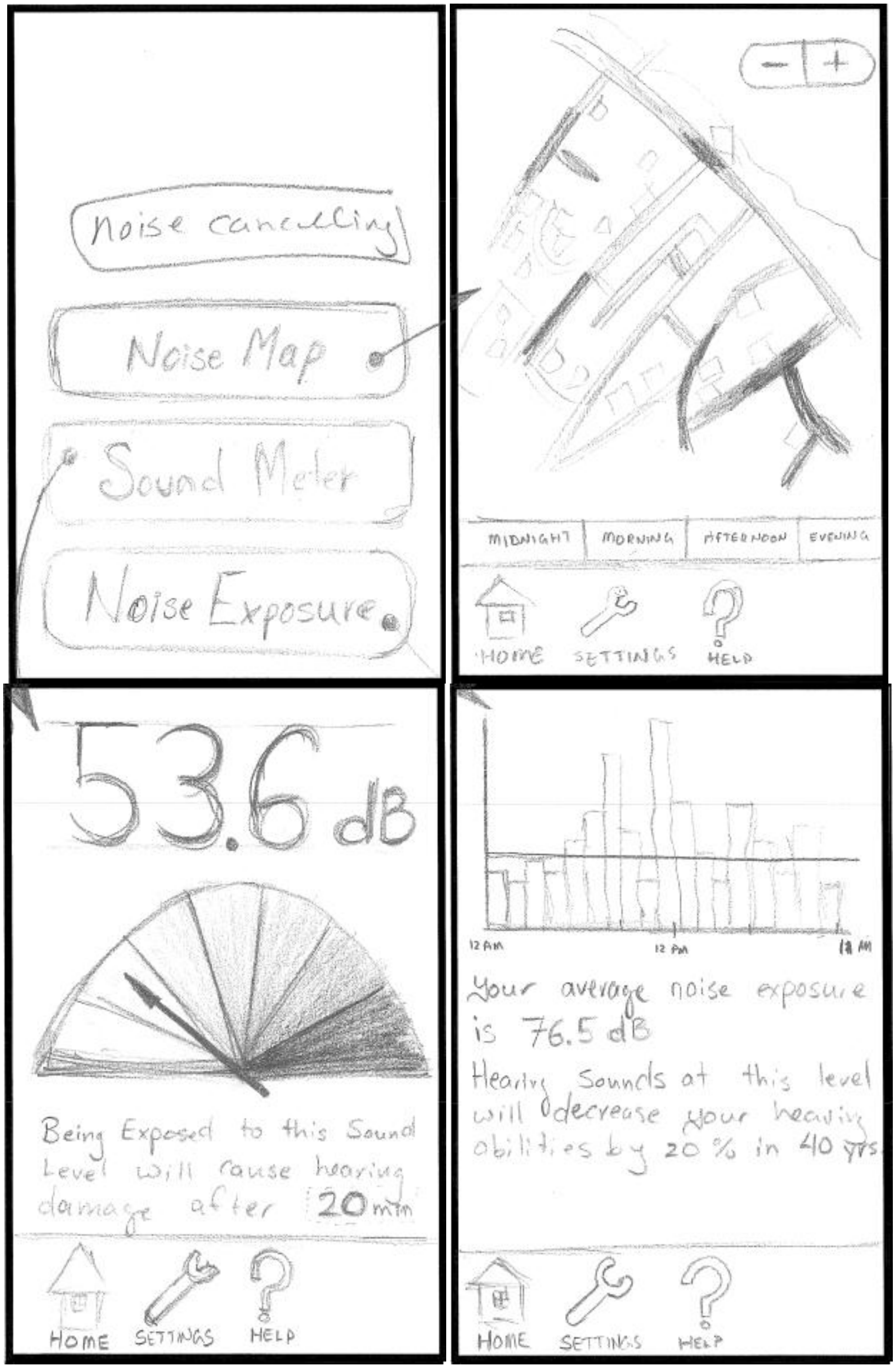
Appendix I (Word Count)

The apper statement is **476** Words

The entire document is **2912** words long including all the content, titles, references, captions, table of contents, and even this appendix.



Appendix II



Noise cancelling
Noise Map
Sound Meter
Noise Exposure
MIDNIGHT
MORNING
AFTERNOON
EVENING
HOME
SETTINGS
HELP
53.6 dB
Being Exposed to this Sound Level will cause hearing damage after 20 min
HOME
SETTINGS
HELP
12 AM
12 PM
12 AM
Your average noise exposure is 76.5 dB
Hearing Sounds at this level will decrease your hearing abilities by 20 % in 40 yrs.
HOME
SETTINGS
HELP