Application to Generate an Optimized Sleep Schedule Using Artificial Neural Network Technique

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Abstract

Sleep is an essential state that all living things must naturally come to do. It is when the body and mind take time to recuperate from daily activities. A good night's sleep can improve overall mental and physical health. In this modern age, the number of people with sleeping disorders has arisen over the century. Irregular sleeping schedules can attribute to staying up late at night, overworking, etc. This research aims to create an intelligent application that generates an optimized sleeping schedule using an Artificial Neural Network (ANN). On the surface, it is essentially a smart alarm clock powered by Artificial Intelligence. Unlike a standard alarm clock, users will not have to worry about forgetting to set their alarm before going to sleep. This research heavily leverages the well-known fact that people these days own at least one smartphone. First, we train the neural network using existing datasets that consist of sleep data analysis. The next step is to incorporate the trained neural network into the application to recognize the user's sleep-wake patterns and automatically create an optimized sleep schedule based on that info. A smart alarm built into the application will dynamically adjust according to the generated sleep schedule.

Keywords: Mobile Apps, Sleep Schedule, Artificial Neural Network (ANN), Artificial Intelligence, Mobile Application Development.

I.INTRODUCTION

The goal of this research is to record the sleeping pattern of a person as input, analyse the pattern, and train a model using Artificial Neural Network (ANN) so it can be used to produce

personalized sleep schedules. Those personalized sleep schedules would be fed into a smart alarm application that would automatically work for the user. The smart alarm will alert the user when they should go to bed and wake up from their bed [1].

Artificial neural networks, or only neural networks, are a branch of machine learning based on biological neural networks in animal brains. Due to its ability to function like a brain, ANN can learn by themselves and produce an output not restricted by their input. It is very adaptive and will evolve accordingly to real-time data [2]. This approach can be applied to help people with sleeping problems.

This application is mostly a self-therapy, meaning the user would have to follow the application's neural network's specified scheduling. However, the application will adapt accordingly should the users deviate from their personalized schedules.

The research has recognized several vital problems or concerns such as certain people have always had trouble keeping track of time when they are invested in an activity, especially late at night. People who have disrupted circadian rhythm due to abnormal sleep schedules and desire to fix those issues [3]. People who could not afford the time to meet psychologists who can assess and help with their sleep problems.

There may be several limiting factors that would occur for this application, as the application's effectiveness depends on the user's willingness to follow the recommended sleep schedule generated by the application. The application cannot work as intended if the device's clock is not synchronized with real-time.

Based on the objectives of the development, the application will function based on the Android platform. This application will help users to create an optimal sleeping schedule to benefit their health. This application will support the autonomous smart alarm feature.

II.METHODOLOGY

A neural network is a composition of neurons that functions in a network. There are two types of neural networks, biological and artificial. Biological neural networks are the ones that exists within the brain of living things, such as us humans. They allow us to think, make decisions, and solve problems. So, in a similar vein, artificial neural networks are simply computerized model of a brain. Artificial neural network is literally the brain of an Artificial Intelligence, or AI [4]. It is a powerhouse of machine learning in this current day.

The primary objective of developing ANN system is creating a system that can work and think with human-like precision whilst outperforming the existing traditional systems. It is a computing technique that solve problems in parallel that are normally unachievable via linear computing. ANNs have three key components such as artificial neurons, connections and its associated weights, and propagation functions. Artificial neurons are nodes that have inputs and produce singular output which is then sent to other neurons. The neural network has connections that links the neurons together, with a connection providing the output of a neuron as input to the other neurons [5]. Those connections also have weights associated to them to signify their relative importance. The propagation function is a transport mechanism used to

bring values throughout the neurons. This is done by adding up the input values thus creating a weighted sum, and then passing it to the activation function which produces an output.

ANN consist of at least two layers, the input layer, and the output layer. However, occasionally a third hidden layer is added as a summation layer, responsible for adding up the outputs of the previous layer and weighed by the weight factor. During the design process, only the input and output layers are known while the hidden layer is calculated by the neural network itself. This hidden layer is what gives neural network its adaptive and self-learning trait.

III.LITERATURE REVIEW

The practical use of artificial neural network is becoming more prevalent as technology advances. Some of the applications of ANN are listed below [6]:

- Spam Mail Filter – Various email service providers utilized ANNs to detect and remove unwanted or even dangerous emails that might reach the
- recipient.
- Pattern Recognition – Automated recognition can use ANNs to increase the overall accuracy level. An example of pattern recognition using ANN is recognizing the trends and patterns of the stock market.
- Sequence Recognition – ANNs can be used to identify sequential actions such as speech, handwriting, and gesture.
- Machine Translation – Language translation can be greatly improved with use of ANNs. Google Translate for example uses ANN called Google Neural Machine Translation (GNMT), therefore allowing for better fluency and accuracy while also maintaining a natural translation.

Sleep is a basic psychological need and it is an important function for most critical processes in our body, such as immunity. As we adapt with the rapidly advancing modern lifestyle, our overall quality of sleep becomes influenced in a way or another. It is crucial that diagnostics of sleep disorders and its adverse effects are properly studied and understood.

Sleep disorders are one of the serious problems that plagues the modern world. The rise of unhealthy lifestyles and the pressure of work cause an impact in sleep quality, which can later present variety of mental illnesses. Furthermore, the existence of sleep disorders can become probable causes for diseases such as obesity. There are several sleep disorders, most well-known ones are insomnia, hypersomnia, narcolepsy, and sleep Apnea [7].

When a human goes to sleep, they will go through three primary sleep stages: W (wakefulness), Rapid Eye Movement (REM), and Non-Rapid Eye Movement (NREM) [8]. Each of these stages are further subdivided into three more stages: N1, N2, and N3. About four to five times the NREM-REM sleep occurs during a night's sleep, lasting from about 1 hour and 30 minutes, all the way up to 1 hour and 50 minutes.

Statistical data is recorded using polysomnography (PSG), also known as sleep study. PSG records EEG, ECG, EOG, and EMG. EEG is electroencephalography, which

records the activity of the brain in real time. ECG is electrocardiography and it records the electrical impulses that keeps the heart beating in correct sequence. EOG is electrooculography, which is responsible for recording the eye movements. Finally, EMG is electromyography which records muscular activity [9].

However, PSG tools are normally laboratory equipment thus not readily available within everyone's reach. Fortunately, in this modern day, more accessible consumer grade solutions are available to gain access to sleep study data. Variety of sleep monitoring tools called sleep trackers can be bought off the online marketplace, ranging from contactless devices that sit underneath the mattress to wearable armbands. Most of these devices possess sensors that allows them to gather polysomnography data. Typically, these devices can only make estimation based on the amount of time you are asleep. In a way, they are not as accurate as true sleep study although they are still definitely useful.

Given the data that is collected by the wearable's sensors, we can utilize ANN's sensor fusion, which interprets the values from multiple different sensors, and allow the neural network to learn and model the given individual's sleeping pattern. The model is then used to feed the intended smart alarm which will automatically notify the individual about their sleep times and wake-up times [11]. The sleeping pattern model may also be used to analyse for any possible abnormalities in the pattern that might develop into sleeping disorders. This proactive strategy can serve as an effective prevention of disorders from developing.

Since artificial neural networks are analogous to a brain, they can be trained and used to model human psychological behaviour. Unlike physiology, also called physical health, psychology is mental health and is much harder to diagnose than in comparison. An individual can be diagnosed by building its mental model and then comparing to the psychological metrics taken in real-time. Typically, most mental illnesses are incurable, yet they are treatable by minimizing the symptoms [12]. However, early detection allows for the prevention of the disease from occurring in the first place.

Theoretically, an individual's mental model would account for various factors that actively influence the individual's mental state [13]. This mental model would include mimicking the psychological variables such as positive and negative emotions. A simulated mental state of the individual can accurately predict if an unusual or abnormal pattern would precipitate [14]. Since not all individuals are willing to divulge their psychological problems, an unaided system without an expert's supervision would make an artificial neural network a strong choice.

The list of articles, journals, and research papers used in this Literature Review is summarized as shown in Table 1.

Table 1: Summary of Literature Review

Authors	Title	Method	Advantages	Disadvantages
R. K. Price E. L. Spitznagel,	Applying Artificial Neural	Multi-Layer perceptron ANN, Linear modelling	Artificial neural networks are capable of	Linear models and ANNs are both sensitive to

T. J. Downey, D. J. Meyer, N. K. Risk, O. G. elGhazzawy (2000) [15]	Network Models to Clinical Decision Making		outperforming most if not all the conventional statistical methods available.	low prevalence. Small sample sizes can result in a small number of false negative results.
Marina Ronzhina, Oto Janoušek, Jana Kolářová, Marie Nováková, Petr Honzík, Ivo Provazník (2011) [16]	Sleep Scoring using Artificial Neural Networks.	Single-Layer perceptron ANN Multi-Layer perceptron ANN Genetic Algorithms	An automatic scoring system powered by artificial neural networks can entirely and theoretically substitute human scoring.	No practical automatic scoring systems exist during the publication of the article.
F. Ebrahimi M. Mikaeli E. Estrada H. Nazeran (2008) [17]	Automatic Sleep Stage Classification Based on EGG Signals by Using Neural Networks and Wavelet Packet Coefficients	Tree-layer Feed Forward Perceptron ANN LevenbergMarquardt backpropagation (trainlm), Gradient descent with momentum and adaptive learning rate backpropagation (traingdx)	It was noted that increasing the number of neurons effectively increases the mean of accuracy and decreases the standard deviation.	There was a difference in performance when comparing the trainlm and traingdx training functions.
A. Malafeev D. Laptev S. Bauer X. Omlin A. Wierzbicka A. Wichniak W. Jernajczyk [18]	Automatic Human Sleep Stage Scoring Using Deep Neural Networks	Classification based on features using Random Forest and ANNs. Classification based on raw data using ANNs	A noticeable improvement in the quality of the classification.	Research only utilized two datasets retrieved from laboratories. The networks are expected to perform better if trained with more datasets.

IV.SMART NEURAL NET ALARM MOBILE APPLICATION DESIGN AND IMPLEMENTATION

Smart Neural Net Alarm is primarily developed using Java language in Android Studio environment, and as such, the application uses multiple features provided by the Android SDK. Java is an easy to learn, object-oriented programming language thus it is easy to write, compile, and debug. Its object-oriented nature also allows for highly modular and reusable code.

The application's backend makes use of Firebase for CRUD database functions. Firebase is a mobile application development platform provided by Google that serves multiple modules. The Firebase modules used in this implementation are Authentication and Real-time Database. The Authentication module allows an easier method to implement user registration and login features into the application, while the Real-time Database module provides a cloud database for data storage. The application also uses the Realm mobile database, an open source and developer friendly alternative to SQLite. Realm is lightweight and efficiently uses memory, disk space, and battery life. About the system implementation frame work as shows in Figure 1 [19]:

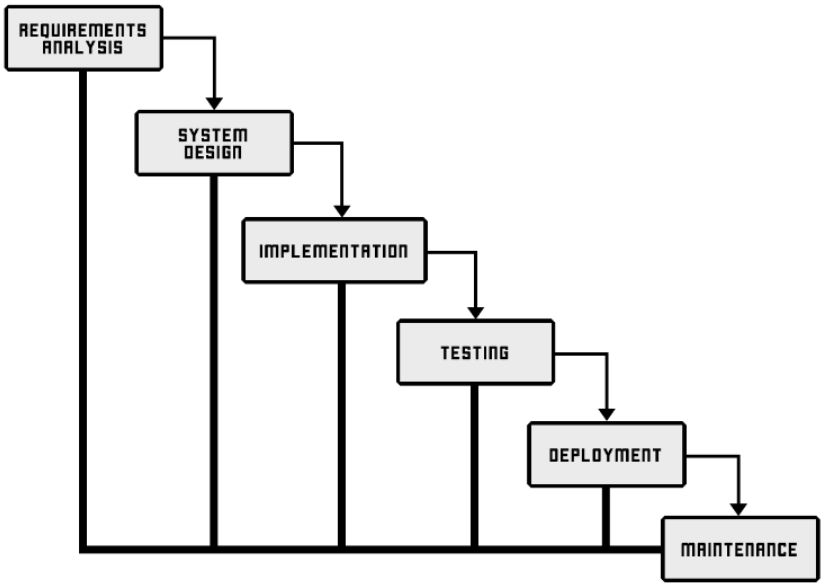

Figure 1: Smart Neural Net Alarm Development Framework

The design of the application was following the GUI and user friendly concepts to be match with all kind of users. Will show all the interfaces available in the Smart Neural Net Alarm mobile application.

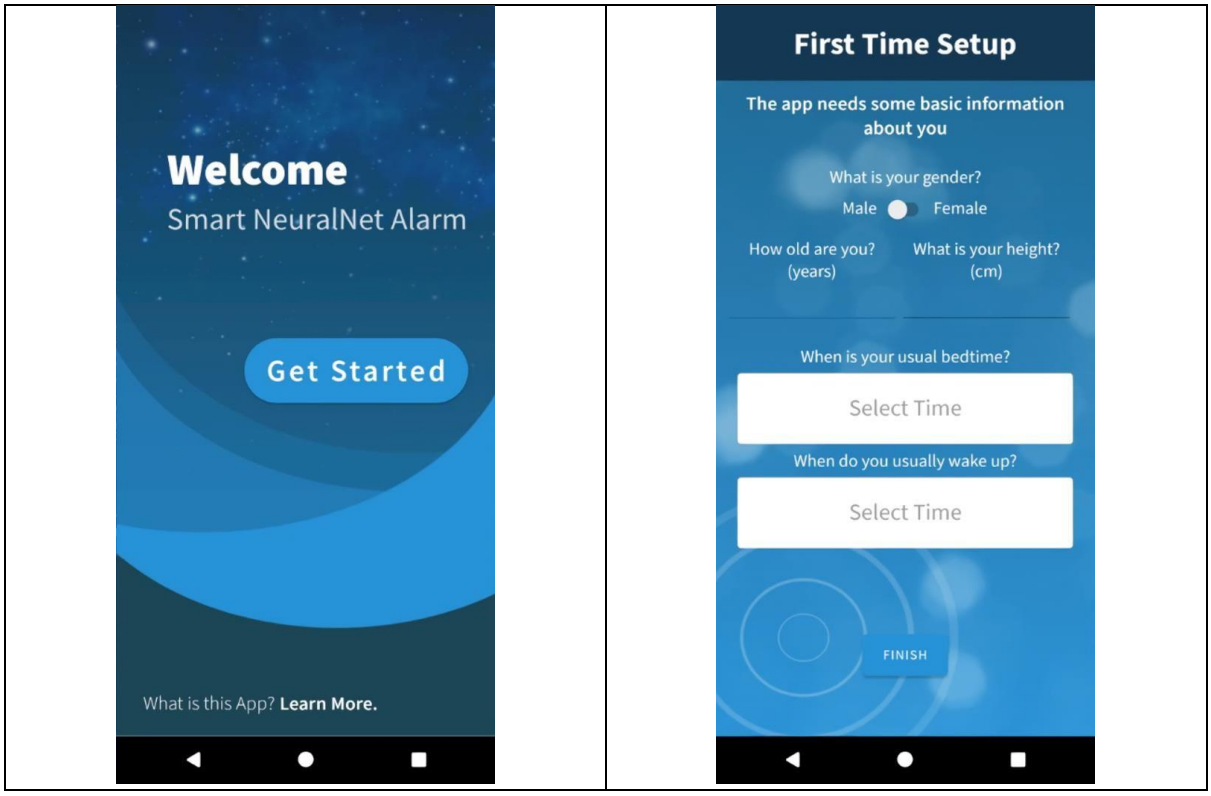

Figure 2: First Launch and First Time Setup Interface

Figure 2 as shown above is the interface the user will see when they launch the application for the first time. The user will have to go through the First Time Setup procedure by tapping on the "Get Started" button, which will take them to the interface where they must input some basic information for the application to start functioning. They are also required to configure their preferred bedtime and wake-up time.

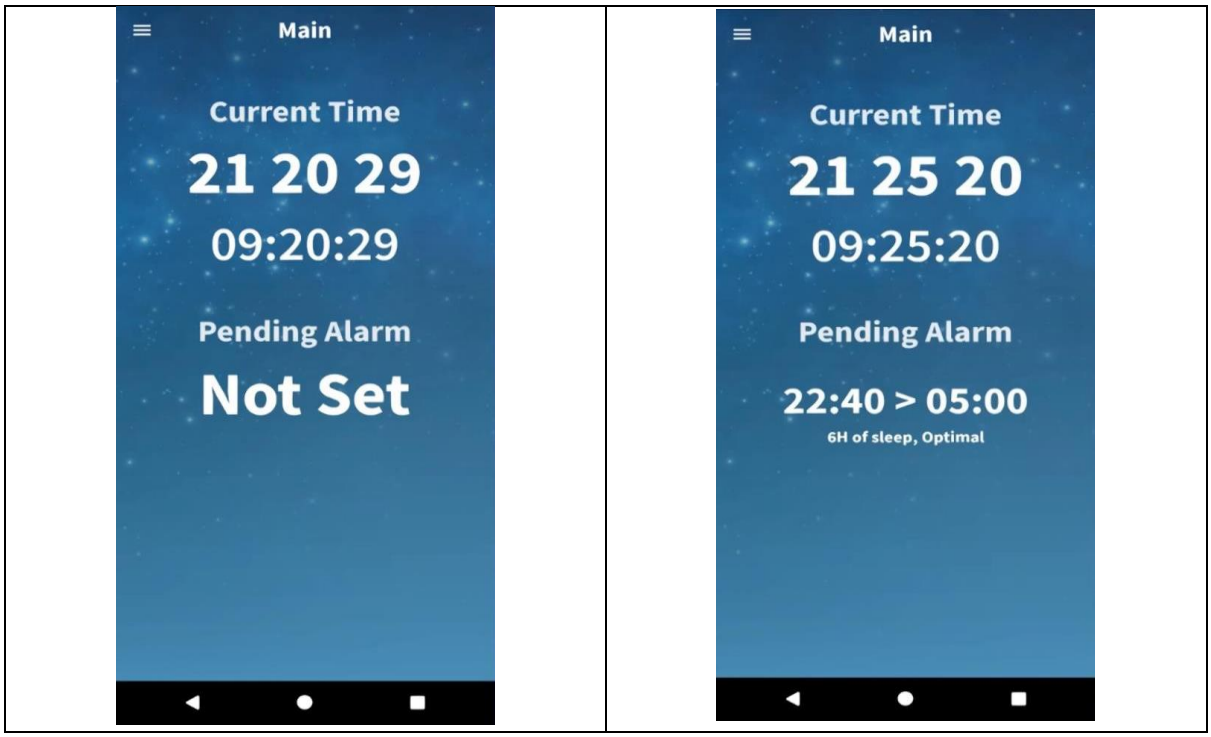

Figure 3: Home Interface and Home Interface with Alarm

Figure 3 as shown above is the interface that is displayed after the First Time Setup. It is also the same screen that is shown whenever the user launches the application. In this interface, the current time is shown as well as any pending alarm.

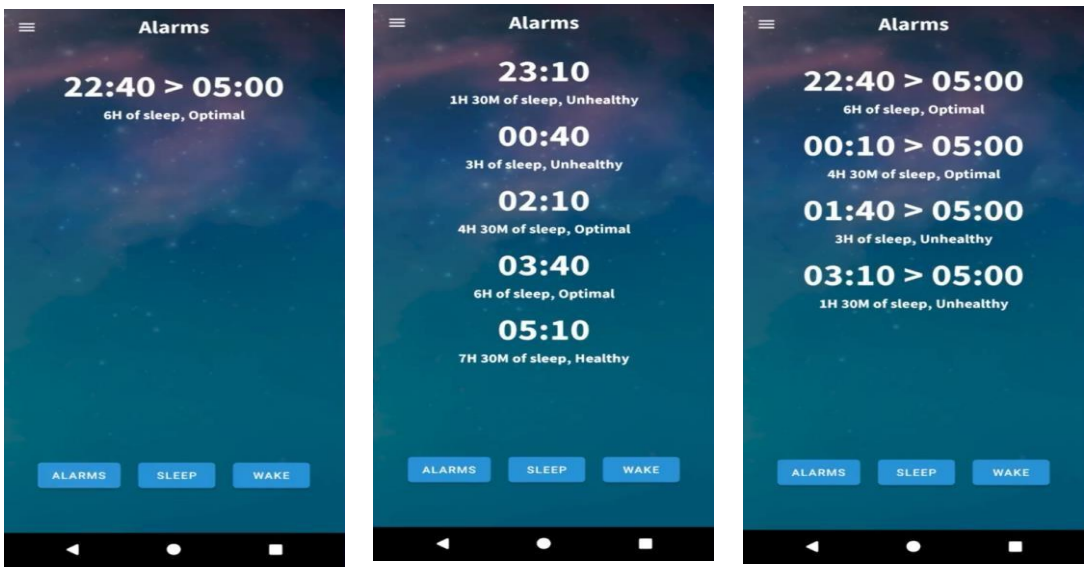

Figure 4: Active Alarms, Suggested Sleep and Suggested Alarm based on Wake-Up Time

Figures 4 shows the Alarm interface, accessed through the navigation menu. In this interface, the user can view the active alarms, suggested sleep alarm based on current time, and suggested alarms based on user's preferred wake-up time. The suggestions are also given the information of how healthy the sleep duration is as result.

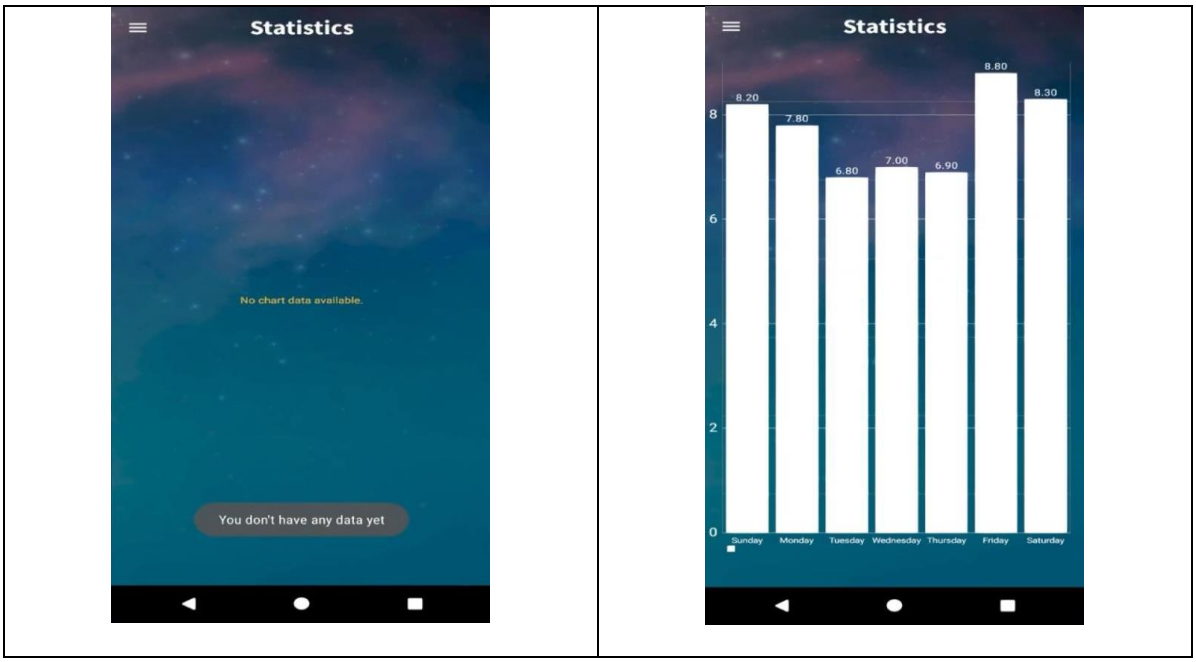

Figure 5: Statistics (No Data) and Statistics (with Data)

Figures 5 as shown above are the Statistics menu where user can view and analyze their overall sleep statistics. The statistics shown are on weekly basis and displays the time user spent sleeping each day.

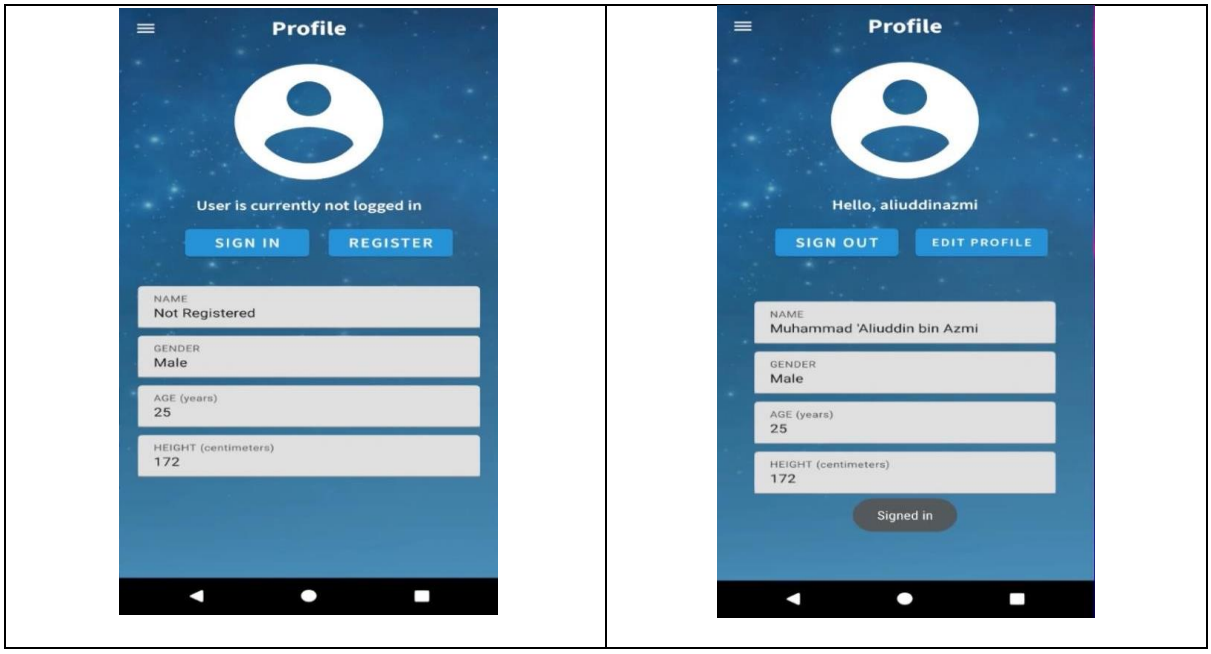

Figure 6: User Profile (before Sign And User Profile (after Sign-In) In)

Figures 6 shown above are the User Profile interface, both in signed-out and signed-in state. In the signed-out state, the user will see their basic profile information as entered earlier in the First-Time Setup as well as buttons to register and sign in. Tapping the Register button will take them to the Registration interface while the Sign in button takes them to the Sign-In interface. When they are signed in, the two buttons are replaced with Sign Out and Edit Profile. Tapping the Edit Profile button will take them to the Edit Profile interface.

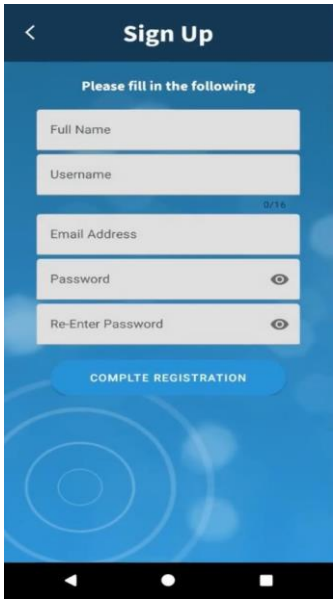

Figure 7: Registration/Sign-Up

Figure 7 as shown above is the Registration interface where user can register an account. In this form, the user can enter their full name, username, email address, and password. They must fill the form properly, otherwise the user will be met with prompts such as invalid email address, or password does not match. Tapping on the Complete Registration button will proceed to the Sign-In interface.

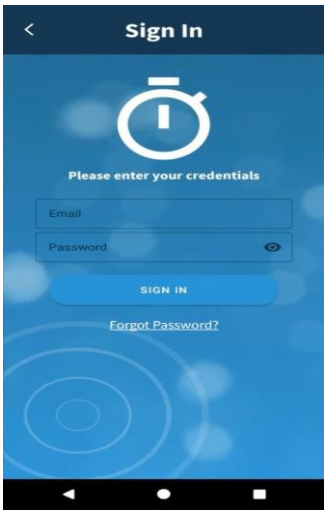

Figure 8: Sign-In Interface

Figure 8 is the Sign-In interface, which is accessed from the Profile interface via the Sign-In button or redirected from the Registration interface after a successful registration. In this interface, user can input their credentials as registered. They also have the option to reset their password by tapping the "Forgot Password?" link if they happen to forget their password. Afterward they can tap the "Sign in" button to proceed with the signing in.

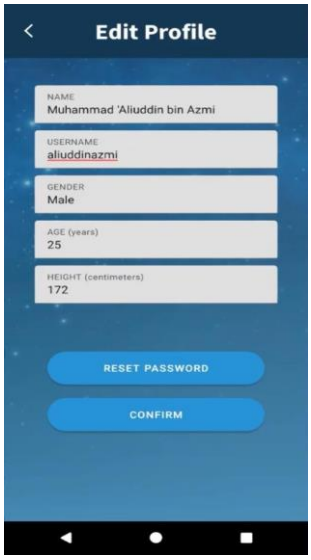

Figure 9: Edit Profile interface

Figure 9 shows the Edit Profile interface, accessed by tapping the Edit Profile button in the User Profile interface only when the user is signed in. In this interface, the user can modify their information as needed. They can also change their password by tapping the "Reset

Password" button. Finally, tapping the Confirm button will save their changes. However, if no changes are detected then tapping the Confirm button will do nothing.

V.SMART NEURAL NET ALARM MOBILE APPLICATION TESTING ANALYSIS

Testing analysis is one of the crucial parts of software development process. It is intended to reduce the possibility of errors and bugs occurring in the software before its deployment. Software testing depends on the testing methodology used and can be implemented during at stages of the development process.

A test case is a set of conditions in which a tester is required to perform to determine whether the system is working as intended and accordingly to the original specifications. The process of performing test cases can aid in finding out issues with inputs, actions, and/or events as well as expected outcome. All of these are used to determine whether the system is functioning properly. The section below shows all the test cases performed on several processes of the application.

- **Register/Sign-Up**

Table 2: Registration Test Case

Test Case Name	Expected Test Result	Test Result	Comment (if any)
Enter all information correctly in the required fields (full name, username, email address, password, re-enter password) and click Complete Registration.	Sign Up will be successful and user is redirected to the Sign-Up interface	Successful	none
Leave the fields blank and click Complete Registration button.	User will be prompted to enter details in the remaining fields and registration does not proceed.	Successful	The required fields are highlighted with red texts.
Enter a password shorter than eight characters.	User will be prompted to enter a password of at least eight characters or longer.	Successful	The password field is highlighted red and displayed an alert.
Enter an invalid email address	User will be prompted to enter the correct email address with the correct format	Successful	The email field is highlighted red and displayed an alert.

- **Sign In**

Table 3: Sign-In Test Case

Test Case Name	Expected Test Result	Test Result	Comment (if any)
Enter a registered credential in the Username and Password fields then click Sign In.	User will be logged in and redirected to the Profile interface.	Successful	none
Enter an unregistered credential in the Username and Password fields then click Sign In.	A system prompt will be displayed stating that the credentials are incorrect.		none
Enter only in the Username field and leave the Password field empty, then click Sign In.	User is prompted to enter a correct password.		none

- **Edit Profile**

Table 4: Edit Profile Test Case

Test Case Name	Expected Test Result	Test Result	Comment (if any)
Do not change any fields, only click Confirm.	A system prompt will be displayed stating "No changes are saved"	Successful	none
Change the username and click Confirm.	The change is saved, and the user is redirected back to the Profile interface. The updated username is shown accordingly.	Successful	none

The idea of implementation is the process of turning the design into an actual, usable system. This phase also dictates whether the developed system can operate without any major problems

that could impair the system's overall functionality and hurt the user's experience. This chapter also focuses upon the system testing where test cases are performed to validate the system functionality as intended.

VI.CONCLUSION

Sleep Assistance Using Artificial Neural Network, also known as Smart Neural-Net Alarm, is a mobile application developed for Android. It is created to improve people's sleeping health. The application takes input of their preferred bedtime and wake-up time to create a suggestion of alarms that can improve their overall sleep health. It has achieved some of the objectives and scopes that were stated in this application.

Sleep Assistance Using Artificial Neural Network is an Android mobile application designed to automatically suggest sleep schedules based on the user's preferred settings. Based on the discussion with the supervisor, artificial neural network is implemented in this application however severely limited. This application generates a set of suggested alarms with sleep durations and their overall healthiness ranging from not recommended to optimal. Hopefully, this application can help people sleep more healthily.

Here are some suggestions to improve the application's overall effectiveness and efficiency in the future, such as: Allow the user data to be stored in the database so it can be restored whenever the user signs in. The application needs to add a method that can take account of the user's existing conditions that might affect their overall sleep.

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