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Insomnia Audio Therapy Mobile Application with Music Recommender System

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ABSTRACT

With the quick advancement of Internet and artificial intelligence technologies, development of a robust and accurate music recommendation system has become an important issue in the field of music information retrieval. Music recommendation system has been widely used in many real-life applications, including in the health domain as an alternative of therapies. This paper presents the research design and implementation of music recommendation system that possible to be used as an insomnia audio therapy in a mobile application platform. The research focused on investigating the performances of three machine learning algorithms namely Random Forest, Decision Tree and Support Vector Machine to be selected as the music recommendation tool. For the machine learning training and testing purposes, data was collected based on the simulated run of the proposed insomnia audio therapy mobile application. The results indicated that Random Forest performed as the best machine learning algorithm in predicting the relevant music. The proposed mobile application with machine learning music recommender system will provide a basis for the realization of intelligent music therapy in treating insomnia disorder patients as well as in other music applications.

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1. Introduction

Music therapy has been widely used traditionally and clinically to relieve insomnia disorder patients. The peoples with insomnia disorder would face a trouble of failing or staying asleep, or even both. They are often found worn out when they wake up from their sleep, which shows that insomnia would sap their energy off and this may lead them to fatigue, daytime sleepiness, decreasing their life performances and other serious effects as well. However, people are often found to have a zero realization on the presence of this disease in their life due to lack of knowledge [1].

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Integrity and privacy of information can be measured with many kinds of security mechanism. Throughout the years, the amount of adults who suffer from insomnia is increasing to millions[2] . With that, various strategies are made, which can be delivered broadly to the community in order to improve health outcomes and to address sleep disturbance issue. As we move in time, the attempt has been made to be more exposed to technology advancements for helping to resolve the issue of insomnia problem.

Cognitive behavioral therapy via mobile technologies become one of the most effective treatments for sleep disturbance. Mobile apps seems appealing to the consumer as it allows participants to engage in the comfort and privacy of their home without needing them to participate in face-to-face interventions and maintaining necessary social distancing guidelines [2]. However, the availability of meditation mobile apps has grown exponentially over the past decade but only to help in improving sleep quality.

In this project, a mobile application for insomnia audio therapy has been developed with the design aspects that focused on improving sleep and health quality by becoming an audio mediator. The focus of this project would be young adults, who are most likely would face this health complication considering them who start to carry their own burden. Therefore, the Graphical User Interfaces (GUI) and the machine learning music prediction model were designed based on the attributes of young adults. Other than just being an audio therapy, the mobile application was designed to help the users' figuring out their insomnia severity by providing information through a collection of insomnia health articles that may help the user to deal with their sleeping problems.

2. Literature Review

Sleep deficiency or clinically known as Insomnia is categorized as disproportion between the amount of sleep acquired by an individual and the ideal amount of sleep required, essential for balance life performance. According to most professionals, young generations who are considered as legal adults must have at least 7 to 9 hours of optimal sleep daily for maximum relaxation and energy restoration, and an adequate sleep must occur at night time [3]. However, a good sleep duration is depending on few factors such as age and heredity [4]. In addition, insomnia has a connection with emotional dysregulation. Once an individual starts to go through this sleeping complication, personal worries from real life events may shift to the night time, causing the person to have troubles of keeping the sleeping schedule in a good manner and may cause major energy draining throughout the next day [5]. Music is known as one of the tools which brings excitement to people. Besides, music listening is considered as a good practice that acts as a sleeping aid[6]. Based on Chen, Florence Nightingale explained that live music helps to calm the patients back in 1800s, which proved the importance of it. A lot of music therapists have been implementing music therapy for medical purposes as it is therapeutical and calming [7].

Nowadays, people are still using self-treatment, as it is more flexible following a person's willingness. During the early days, therapist will usually held meet ups with individuals who are facing insomnia for post-session assignments and feedbacks [8]. As the technology is advancing forward, a new ideal alternative for the self-treatment was introduced. This continuous process helps an individual to investigate their own problems, but still require medical advices from health care providers [9]. This method is called as Cognitive Behavioral Therapy for Insomnia (CBT-I), recommended as an effective treatment for insomnia and also the first-line treatment for chronic insomnia [10]. Moreover, research has been done on past writings related with existing applications, which helps to treat insomnia. Throughout the reading, there are few important features and limitations identified, which will be beneficial in order to improve for the better.

One example mobile application is *mHealth*, which would help those individuals to understand better about their own body and for them to conduct a self-monitoring on their diet, physical activities and sleeping schedule. Through self-monitoring, those devices can be used to monitor the users health data in order to achieve the goal of changing a person's habits [4]. *Actimeter* is the most regular and simplest sensor used in any wearable devices, which it helps to detect and record the body movements. However, *Actimeter* was proven to be less affective according to countless trials, as the sensor failed to detect sleepiness and some other conditions [4]. *KANOPEE* is another mobile application made by professionals acts as virtual agents to the individuals who are seeking for help, which can communicate with the users verbally or through actions. This application provides a digital sleep diary for the user to record their sleeping log [11]. *Calm* was proven to be potent enough in diminish tiredness and daytime sleepiness in adults with this health complication.

However, this application is lacking where it does not allow the user to edit their sleeping log. Hence, this application will produce inaccurate result and will ineffectively help an individual to achieve their aims and goals [2].

Using machine learning for insomnia has been concerned by researchers in [12], but the prediction was used to cater white noise recommendation. Furthermore, insomnia was considered to have a big relation with mood disorders like depression and anxiety, which encouraged emotion-based music recommendation system to be developed by the researchers in [13]. In a more advanced work, *SleepEEG* is an automated sleep stage scoring application that used machine learning techniques and utilized dual-channel brain electroencephalogram (EEG) signals to provide a more accurate classification of the sleeping levels of the users. By accurately classifying the insomnia level can help the patients and doctors to prepare the appropriate health strategies and medical solutions. Artificial Neural Network (ANN) with combination of Internet of Things (IoT) and Body Area Networks (BAN) have been used for providing immediate assistance to insomnia patients by automating the process of music therapy[14]. The music recommendation of this application was developed based on the mood of the patents. Predicting therapeutic songs to reduce anxiety was the main concerned of researchers in [15]. The researchers found that high-frequency spectrums are highly important to influence the therapeutic score predicted by the quadratic programming method. Given with the existing growing research in machine learning music recommender system for helping the mental health and sleeping disorder problem, it is expected that a more research that explore more deeper on techniques of machine learning for the problem remain important to be studied. This research filling the gap by looking at the potential of using Random Forest and Decision Tree in the music recommender system for insomnia patient.

3. Research Method

3.1 Development Tools

By using CANVA, the developers construct a storyboard for the mobile application as seen inf Figure 1.

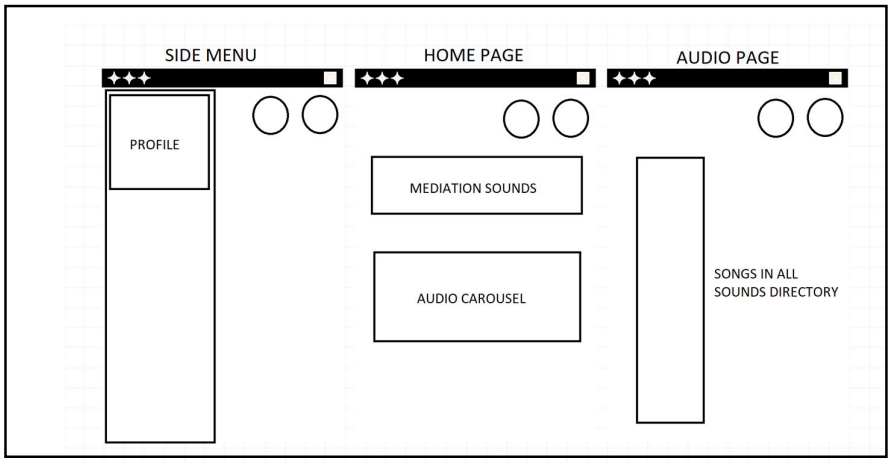


Figure 1. The mobile application storyboards

The application has a ‘Login Page’, which requires the user to login using their existing Google account to be stored as the user profile. ‘Home Page’ will be the first page shown right after the logging process has been successfully done. The meditation sounds will be appeared on this main page, along with few audios’ carousel based on artists. This application has a side menu, which directing the user to various pages. The second page would be the ‘Audio Page’, which has all the audio database in this application and will be located with the suitable machine learning algorithm for the music recommender system. The third page will be directing the user to a survey platform in order for them to figure on their Insomnia severity level. The last tab in the directory is planned to be articles’ tab, which has various articles based on the insomnia level. Based on the designed and storyboard, Android Studio software was used to develop the mobile application. To support the

database system, Firebase MySQL has been utilized. Figure 2 is the login page of the mobile application that has been named *beauty sleep.*

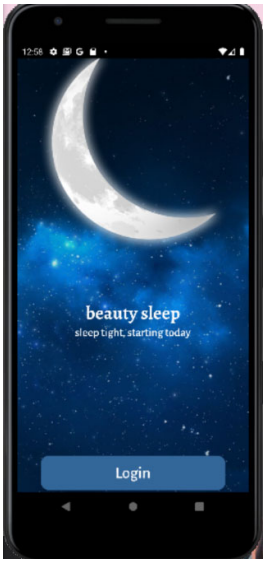


Figure 2. The mobile application login page

While the users are logging in to their Google Account, the application would send a request user authentication, and Firebase would identify and provided establishment to the account as depicted in Figure 3.

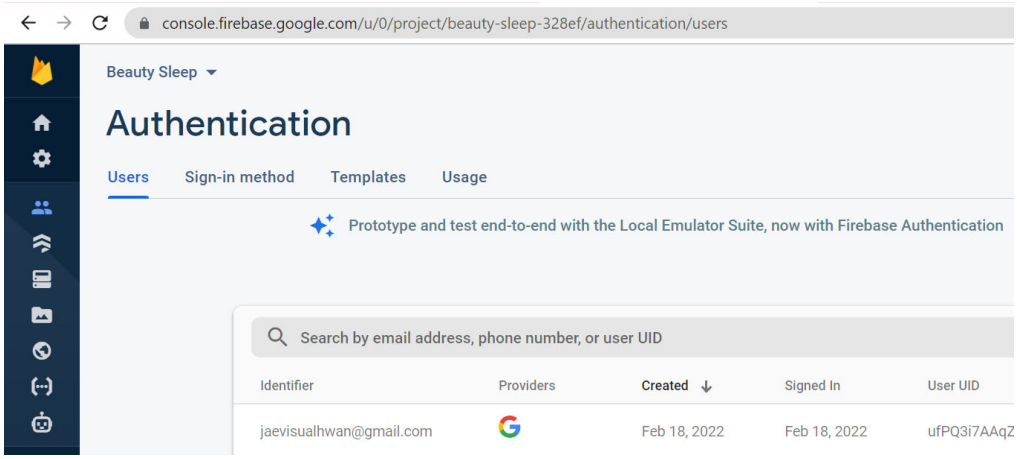


Figure 3. The user's authentication and log

Once successful login, the main page of the application will be displayed. It has a set of meditation audio files, which can be play just in one click on the type of meditation techniques. Aside from that, there are few set of songs displayed on the main page, such as the most Popular songs and songs based on its artists. There are three buttons on the top of the applications, which the first one would lead to the side bar, the next one with headphone will lead to the current music played, and another button for logging out. Figure 4 shows the main page.

Figure 4. The mobile application main page

From the side navigation bar, user can click the side navigation icon and see the brief profile of the users and directory of the system. Refer to Figure 5, there are five tabs built in the system. First tab would lead the user to the Home Page, which is the main page as well. The next tab will lead the user to another page with all the sounds provided in this system. The next tab will lead the user to log out from the system. The fourth one will lead the user to another external page for users to take a brief survey in order to roughly calculate their Insomnia severity level. Finally, the last tab will be a dropdown of medical articles provided for the users.

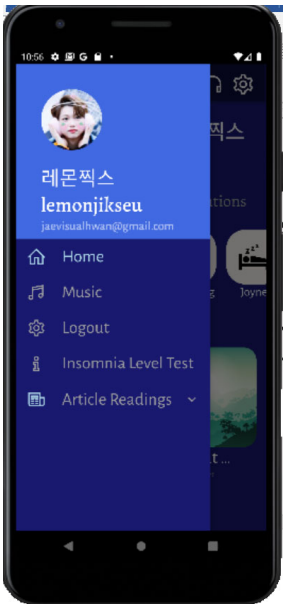
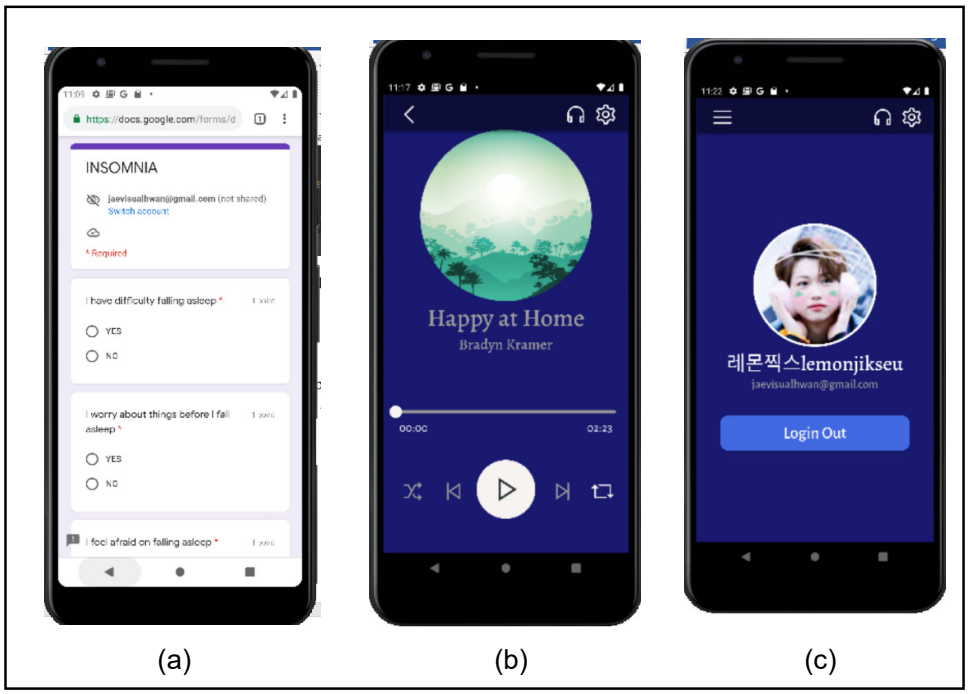


Figure 5. The side navigation bar

The music tab is where music recommender system can be located for the mobile application. The machine learning will predict the suitable music for the user based on the user's profile entered on the survey form that run the insomnia level test (Refer to Figure 6 (a)). Figure 6(b) presents the page of music player page while Figure 6 (c) shows the logout page.



(a) (b) (c)

Figure 6. Additional pages of the mobile application

The results of the insomnia level test will be shown after the user completing the survey. Besides questioning the sleepy conditions, it collects data on the users demography including age, gender, family background and their academic achievements. The data collected from this survey and the selected music will be used as the dataset in the machine learning experimental stage. Based on the marks given, user can read the suggestion articles that recommended based on their severity level (Insomnia, Sleep Anpea, Narcolepsy). The suggestion of articles has not been designed with machine learning prediction, but manually matched based on the topic contents that pre-sorted in the database of the mobile application.

3.2 Machine Learning

The predictive model is to predict the rating music that has been collected based on the mobile application simulated study after completed the development stages. The data was collected from the insomnia level test entered by the users (students of computer sciences in Universiti Teknologi MARA, Perak). The selected algorithms were Random Forest and Decision Tree. Based on 100 records and 70:30 split ratio, 70 records of data were used for training and the rest 30 were used in the testing of machine learning. Based on the auto hyper-parameters tuning of RapidMiner Auto-Model, the optimal configurations of Decision Tree and Random Forest are given in the following Table 1 and Table 2 respectively.

Table 1. Hyper-parameters and error rate in Decision Tree

Maximal depth	**Error rate**
8	8.9
4	**7.8**
7	8
10	8
15	8
25	8

Table 2. Hyper-parameters and error rate in Random Forest

Number of Trees	**Maximal depth**	**Error rate**
20	2	7.1
60	2	7.4
100	2	7.6
140	2	7.7
20	4	6.2
60	4	6.3
100	**4**	**6.0**
140	4	6.2
20	7	6.3
60	7	6.2
100	7	6.3
140	7	6.2

Besides *maximal depth,* Random Forest has one more parameter named *number of trees.* As seen in Table 1, the preliminary result shows that the optimal setting for Random Forest is 100 for the *number of trees* and 4 for the *maximal depth* that produced 6.0 percent of error rate. The same *maximal depth* in Decision Tree generated slightly higher rate at 7.8 percent.

3.3 Application evaluation

For finding the best machine learning algorithm for the music recommender system, this research compared the performances of the machine learning predictive models with R squared (R^) and Root Mean Square Error (RMSE) to present the accuracy of the music recommender module. R squared presents the proportion of the variance in the prediction model that was explained by the independent variables of the prediction model namely the users' demography and their insomnia attributes collected from the insomnia survey test. The dependent variable is the selected music that has been converted into a series of numerical value, which will be assigned based on the prediction probability towards the assigned music. For an example, if the prediction probability is between 0 to 1, the music that has been assigned with numerical value between the ranges will be selected. To be unique, only one music was assigned with a numerical value in a one interval range.

4. Results and Discussion

Table 3 presents the results of accuracy that measured based on R squared and RMSE for the two machine learning algorithms.

Table 3. The accuracy results of the machine learning algorithms

Algorithm	R^(+-std.dev)	RMSE (+-std.dev)	Total time to complete (ms)
Random Forest	0.70(0.15)	0.35(0.10)	745
Decision Tree	0.66(0.16)	0.39(0.10)	391

Random Forest as listed in the preliminary results in Table 1 and Table 2 has been slightly outperformed Decision Tree in predicting the music therapy for insomnia users. Due to more complex structure of Random Forest than Decision Tree, the completing is longer by Random Forest but still less than a second. Considering the slightly different, it will be interesting to include both machine learning algorithms in the mobile application of music recommendation modules and allows the system to randomly choose the techniques. Figure 7 illustrates the small performances difference between the two algorithms.

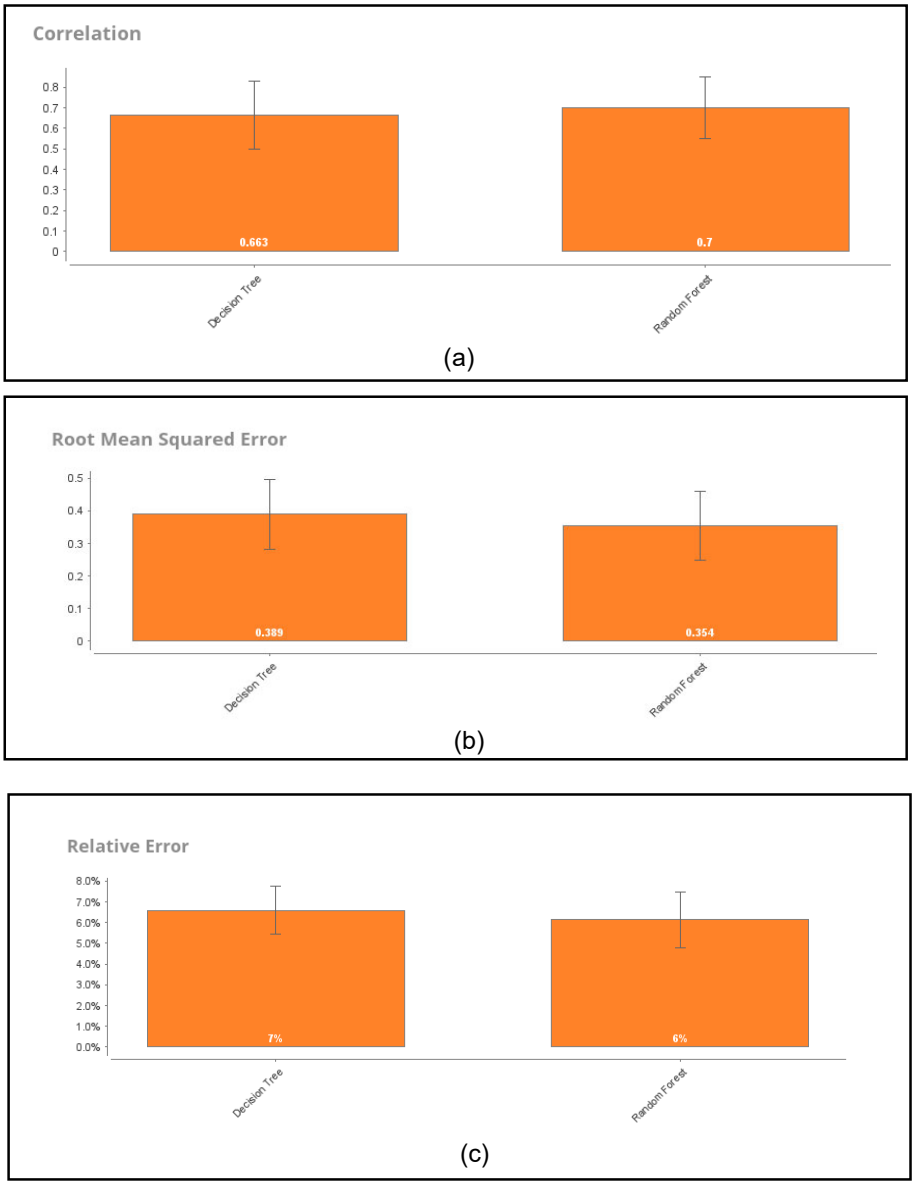


Figure 7. Machine learning comparison of R squared (a), RMSE (b), Relative error (c)

Correlation is the R squared of the models. Other than R squared and RMSE, the relative error that is defined as the ratio of the absolute error to the actual measurement has been presented lower (less than 10%) by the two algorithms.

5. Conclusion

This research extends the state-of-the-art of studies that used machine learning prediction model in music recommendation systems for the case of insomnia problem. In this research, two machine learning algorithms have been proposed namely Random Forest and Decision Tree. Random Forest has more complex structure than Decision Tree thus time to complete the prediction process is longer but it generated more accurate result. The research presented in this paper has some limitations that needs more works to be done in the future such as by looking into more machine learning algorithms to be observed and more data to be tested.

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Conflict of Interest

The authors declare no conflict of interest in the subject matter or materials discussed in this manuscript.

References

[1] M. M. Islam, A. K. M. Masum, S. Abujar, and S. A. Hossain, “Prediction of chronic Insomnia using Machine Learning Techniques,” *2020 11th Int. Conf. Comput. Commun. Netw. Technol. ICCCNT 2020*, no. July, 2020, doi: 10.1109/ICCCNT49239.2020.9225570.

[2] J. L. Huberty *et al.*, “Testing a mindfulness meditation mobile app for the treatment of sleep-related symptoms in adults with sleep disturbance: A randomized controlled trial,” *PLoS One*, vol. 16, no. 1 January, pp. 1–17, 2021, doi: 10.1371/journal.pone.0244717.

[3] J. R. Prichard, “Sleep Predicts Collegiate Academic Performance: Implications for Equity in Student Retention and Success,” *Sleep Med. Clin.*, vol. 15, no. 1, pp. 59–69, 2020, doi: 10.1016/j.jsmc.2019.10.003.

[4] E. Guillodo *et al.*, “Clinical applications of mobile health wearable–based sleep monitoring: Systematic review,” *JMIR mHealth uHealth*, vol. 8, no. 4, pp. 1–10, 2020, doi: 10.2196/10733.

[5] T. Roth, “Insomnia: Definition, Prevalence, Etiology, and Consequences,” vol. 3, no. 5, pp. 3–6, 2007.

[6] H. N. Lund *et al.*, “Music to improve sleep quality in adults with depression-related insomnia (MUSTAFI): Study protocol for a randomized controlled trial,” *Trials*, vol. 21, no. 1, pp. 1–10, 2020, doi: 10.1186/s13063-020-04247-9.

[7] L. Chen *et al.*, “Use of music to enhance sleep and psychological outcomes in critically ill patients : a protocol for a systematic analysis review and meta- -,” pp. 1–7, 2021, doi: 10.1136/bmjopen-2020-037561.

[8] B. E. Uyumaz, L. Feijs, and J. Hu, “A review of digital cognitive behavioral therapy for insomnia (Cbt-i apps): Are they designed for engagement?,” *Int. J. Environ. Res. Public Health*, vol. 18, no. 6, pp. 1–16, 2021, doi: 10.3390/ijerph18062929.

[9] Y. K. Choi *et al.*, “Smartphone applications to support sleep self-management: Review and evaluation,” *J. Clin. Sleep Med.*, vol. 14, no. 10, pp. 1783–1790, 2018, doi: 10.5664/jcsm.7396.

[10] S. G. Kang *et al.*, “Cognitive behavioral therapy using a mobile application synchronizable with wearable devices for insomnia treatment: A pilot study,” *J. Clin. Sleep Med.*, vol. 13, no. 4, pp. 633–640, 2017, doi: 10.5664/jcsm.6564.

[11] P. Philip *et al.*, “Smartphone-based virtual agents to help individuals with sleep concerns during COVID-19 confinement: Feasibility study,” *J. Med. Internet Res.*, vol. 22, no. 12, pp. 1–14, 2020, doi: 10.2196/24268.

[12] N.-W. Jhang, Y.-H. Hung, Y.-C. Lin, and Y.-H. Wu, “Applying Machine Learning to Design and Evaluate White Noise Recommendation System for Insomniacs,” in *2020 IEEE Eurasia*

Conference on IOT, Communication and Engineering (ECICE), 2020, pp. 183–186.
[13] P. Ulleri, S. H. Prakash, K. B. Zenith, G. S. Nair, and J. M. Kannimoola, "Music Recommendation System Based on Emotion," in *2021 12th International Conference on Computing Communication and Networking Technologies (ICCCNT)*, 2021, pp. 1–7.
[14] S. Siddiqui *et al.*, "Artificial neural network (ann) enabled internet of things (iot) architecture for music therapy," *Electronics*, vol. 9, no. 12, p. 2019, 2020.
[15] G. Chen, Z. Hu, N. Guan, and X. Wang, "Finding therapeutic music for anxiety using scoring model," *Int. J. Intell. Syst.*, vol. 36, no. 8, pp. 4298–4320, 2021.

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