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Migraine Generative Artificial Intelligence based on Mobile Personalized Healthcare

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Abstract - Migraine is a complicated genetic disorder characterized by episodes of moderate-to-severe headaches that are usually unilateral and are frequently accompanied by nausea and increased sensitivity to sound and light. A migraine attack induces intense pain, hindering an individual from engaging in daily activities and potentially persisting for hours or even days. By the growth of the Internet of Things, we have new opportunities to try to apply it to the medical field. To identify the origin of a migraine, specialists need access to a patient's medical history and a comprehensive understanding of migraine symptoms for effective treatment. Determining the true source of a migraine may take longer than expected. Nowadays, solving problems through the Internet has become very common in people's lives. Hence, the objective of this research is to create a mobile personalized healthcare mechanism that can assist migraine patients in promptly receiving optimal and precise treatment. Moreover, this research would establish a user-friendly interface that facilitates the presentation of compelling evidence regarding the repercussions of patient health issues. Additionally, machine learning training was designed to treat patients based on relevant demographic characteristics of the healthcare treatment, such as medical history and reports provided. Therefore, this paper can provide insights into the state of art in mobile based personalized healthcare system to recommend future paths, for integration and investigation to improve online migraine platforms for a wide range of migraine patients.

Keywords— Migraine, Generative Artificial Intelligence, Mobile Personalized Healthcare, Patient Health, LangChain

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1. INTRODUCTION

Nowadays, it is not surprising that everyone has different smart devices in their hands, such as smartphones, tablets, iPads, and even laptops. However, smartphones are the most common devices in people's hands [1]. This is because smartphones can support various features, such as regular text messaging, email synchronization, instant messaging, keyboard layouts, and touch screens, which are comparable to computers and are very lightweight compared to other smart gadgets. Therefore, many people use mobile phones to handle most things in their lives, until smartphones become inseparable from people's lives. Some people use smartphone apps to complete daily tasks, such as shopping and online transactions. Additionally, people can use apps on their smartphones to learn about their health status [2].

Therefore, this research develops a mobile WebApp application that combines machine learning with the medical field. As a result, WebApp can assimilate data provided by patients or specialists to obtain better responses. The application can also provide timely solutions and suggestions for patients. In addition, it learns from its mistakes and provides better responses to patients when they obtain wrong solutions based on previously absorbed data. In addition, the patient can request a WebApp anytime and in any way, if the application is installed on the phone. When a migraine attack occurs and there is no vehicle to go to a clinic or hospital to seek expert advice, the patient should know what to do in case they need migraine advice or a solution.

Moreover, this research focuses on migraines for several reasons: first, migraines are prevalent, second, their diagnosis is complex and third, treatment is challenging. Migraine was the second causative attribute of years lived with disability worldwide, affecting between 1 billion and 2 billion people worldwide, according to the Global Burden of Disease study. While conditions with more standardized management protocols, such as diabetes, are very different, migraine management is very individualized by virtue of the vast number of triggers, symptom presentations and treatment responses.

Episodic attacks with frequency, intensity and duration variables are present with migraine and is hard to anticipate and control. Environmental, hormonal, dietary, and lifestyle factors act as triggers, and do differ greatly between individuals [3]. Because of this complexity, a more tailored approach to care is required and artificial intelligence (AI) driven solutions can uniquely provide individualized treatment plans and real time insights based on the individual's symptom tracking.

In addition, migraine is frequently underdiagnosed and under treated, and many patients experience barriers to achieving specialized care. Additionally, this highlights the necessity of AI driven solutions to make patients' life easier while also allowing them in being able to handle their disease effectively. With other chronic illnesses such as diabetes or hypertension, the treatment has taken a more predictable path, whereas for migraine, a dynamic, patient specific approach to healthcare treatment dictates that it is an ideal candidate for AI interventions.

To validate if the proposed Migraine Generative AI System is feasible and if it is effective, we propose conducting a pilot study with a small but diverse population. Approximately 30 people will be carefully selected to participate in this pilot as they represent different demographic and clinical profiles (i.e. age, gender, migraine severity, and frequency). Their aim is to find out how the system is usable, how accurately they predict migraine patterns, and how users feel about the system. First feedback on the system's performance in real world settings will be provided by the pilot, before further refinement in preparation for testing or implementation in broader settings. The trends and potential areas for improvement are analyzed on data from the pilot to ensure generalizability of the system among different user groups.

As for the problem statement, this research was initiated in response to several critical deficiencies identified in the existing migraine management systems. First, there are only a few studies on online migraine management systems related to generative artificial intelligence (AI). Second, the current mobile application lacks a design for this type of migraine function. Furthermore, there are no mobile WebApp applications on the market that can manage demography and personalized features, such as approaching high-risk situations and keeping track of personalized details.

The objectives of this research are to research the workflow of online generative, as there are no mobile applications on the market that can manage demography and personalized features, such as approaching high-risk situations and keeping track of personalized details. Next, we designed a console application for managing demography and personalized features, such as approaching high-risk situations and keeping track of personalized details. Then, the console system for generative AI was developed according to the proposed design. The scope of this research is to develop a console mobile WebApp application using development and AI tools, such as Python, Semantic Kernel and LangChain.

2. BACKGROUND STUDY

2.1. Generative Artificial Intelligence Overview

In the contemporary era, artificial intelligence (AI) is gaining popularity in society, driven by technological advancements. Generative AI is a field of artificial intelligence that has been applied to many fields, such as text, images, videos, audio, and code [4]. Recently, significant strides in artificial intelligence (AI) have led to the development of large language models (LLMs) such as Chat Generative Pre-Trained Transformer (GPT) and Gemini. "Generative" indicates that the model can create text by understanding and classifying input. "Pre-trained" means the model has already undergone initial training on a large volume of text data. "Transformer" refers to the architecture used to comprehend the content of the user's input text.

Natural language processing (NLP) development is taking a positive turn owing to the advancement of LLMs that are trained on vast text datasets [5]. Generative AI provides an opportunity for the healthcare sector to make improvements. Zhang and Boulos' research [6] stated that NLP-generated AI could be a revolutionary technology in the field of healthcare. Using this type of science, we may be able to redesign healthcare, giving rise to breakthroughs and changes in the landscape of health sciences.

Over the past few years, there has been a growing interest in LLM as applications in the healthcare field. LLMs offer many opportunities in the healthcare sector, such as data processing at clinics, the creation of detailed summaries of medical records, and acting as chatbots for patients seeking information on their condition and the proposed solutions. In addition, LLMs can guide medical center workers in the diagnosis of cases [7]. Furthermore, LLM can be embraced by the healthcare industry as a bridge between migraine patients and medical records. For instance, a device may record migraine data from patients, extract them only to formulate the data, and then answer more precise migraine questions from other patients.

2.2. Generative AI System Techniques

Figure 1 shows a generative AI system with different techniques for building a generative AI system. The choice of technology to build a generative AI system is critical for satisfying a user's desire to generate migraine content. This section explains three main generative AI system techniques.

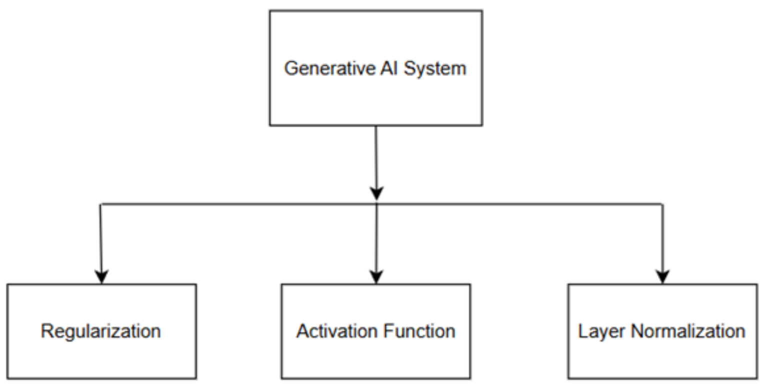

Figure 1. Techniques of Generative AI Approach

In regularization, deep learning algorithms are applied in different areas such as Natural Language Processing (NLP), computer vision, bioinformatics, and speech recognition, taking full advantage of mass-anticoding datasets. The parameters must be altered quite often during the training of these algorithms in the case of high-dimensional data, which can lead to overfitting problems of this data or when it is sufficiently large. Regular procedures were used to remove the uncertainty associated with this risk. Many regularization methods help solve this problem [8].

Overfitting may occur in supervised machine learning for reasons such as the small sectors of the training set, noise in the data, and complexity degree of the classifier. Regularization techniques work in such a way that allows the model to learn and generalize to entities, which has not been seen before and even in situations involving restricted data and epochs. In addition, regularization is used to improve the model architecture’s skills, which are also a part of the generalization. Those who have robust generalization abilities perform well in learning and are trained on new data without overfitting as well as accurate prediction [9].

There are some cases in which the algorithm, with the aim of considering every one of the few details, including noise and traits, goes too far, resulting in an overfitting. Regularization is designed to aid in optimization; it helps the model to adjust the amount of complexity to surpass the predictions of future events [10]. Regularization methods such as L1 and L2, which are known as such, keep the coefficients of a model from expanding to unnecessary lengths. Aside from dropout, is a method used to train models in which a portion of the hidden units is entirely omitted from the neural network during training. In addition, regularizations such as early stopping, data augmentation, weight decay, and elastic net regularization can be considered. Nevertheless, choosing an appropriate regularization technique for a specific application depends on the nature of the models employed and the characteristics of the data.

Data are usually the result of AI, which has issues surrounding its collection, and not all the information can be understood. Among the numerous successful solutions to this problem, deep learning is one of the most popular. It contains many parameters that are used to train the model, which is not obvious without different explanation techniques. Nothing is more important in this case is that supervising with an excess of training implied cannot be thought of as an overfitting antidote; rather, it brings forth many overfittings through complexities. This method ensures that the process proceeds smoothly with highly efficient regularization, which in turn results in a perfect generalization owing to the absence of overfitting.

2.3. Activation Function and Layer Normalization

Artificial neural network (ANN) is composed of multiple artificial neurons. Every artificial neuron has an activation function that determines the firing rate of the neurons to be activated. In addition, it provides non-linear properties to the ANN and bounds the input data to a finite value [11]. The idea of activation function is enlightened by biological neurons in the central nervous system [12][13]. Activation plays a crucial role in neural networks, particularly within hidden layers, enabling them to tackle complex problems and facilitate data analysis and transfer through deep learning algorithms. Various activation functions, including linear and non-linear variants, such as binary linear, are employed.

The function of activation in artificial neural networks mirrors the behavior of cells and neurons in the human brain. Achieving a level of computational thinking like humans requires significant effort. Activation functions ensure that algorithmic networks, such as deep learning and artificial intelligence, prioritize important tasks by segmenting inputs, thus optimizing the processing power usage. Neural networks, inspired by the structure and function of the human brain, are designed in various ways based on this inspiration. These models consist of interconnected layers of nodes that process and transmit information to form deep networks. Nodes, akin to human brain cells, are pivotal to this network. The activation functions receive specific inputs in machine learning, artificial neural networks, and deep neural networks to determine the output of a node.

Activation functions are essential components of neural networks, as they introduce non-linearity into the model, enabling the network to grasp complex patterns and relationships within the data. They significantly influence the hyperparameters of AI-based models. With numerous activation functions available, selecting the most suitable function is critical for optimal model performance [14].

In Large Language Models (LLMs), activation functions serve to determine the output of neural networks, given specific inputs. They are pivotal in the learning process of the model, aiding in comprehending the intricate language patterns and structures encountered. Activation functions enable the model to interpret data and generate outputs resembling human language based on training. Moreover, activation functions assist LLMs in regulating the information flow within the model. They discern which information holds priority for transmission, and which can be disregarded. This functionality is crucial in language processing tasks, enabling the model to grasp not only individual words, but also their contextual usage, nuanced meanings, and the overall structure of the text [15].

On the other hand, layer normalization, introduced by researchers Jimmy Lei Ba, Jamie Ryan Kiros, and Geoffrey E. Hinton [16], ensures that within a specific layer of a neural network, all neurons maintain a consistent distribution across all features for a given input. To illustrate, if each input consists of d features, forming a d-dimensional vector, and there are B elements in a batch, normalization occurs along the length of the d-dimensional vector rather than across the entire batch of size B. Normalizing all features for each input to a specific layer eliminates reliance on batches. This characteristic makes layer normalization particularly suitable for sequence models, such as transformers and recurrent neural networks (RNNs), which were prominent before the advent of transformers [17].

Layer normalization (LN) is a deep learning technique aimed at stabilizing the training process and enhancing the neural network performance. It tackles the issue of internal covariate shift (ICS), where the distribution of activations within a layer fluctuates during training, thereby hindering effective learning. Widely employed across diverse deep learning applications, including computer vision, natural language processing, speech recognition, machine translation, and reinforcement learning, layer normalization has become a fundamental tool for improving the model performance. Layer normalization is a potent technique capable of substantially enhancing the training and performance of deep neural networks. By effectively tackling the internal covariate shift problem, the training process is stabilized, rendering the network less reliant on precise initialization and hyperparameter tuning [18].

2.4. Comparing System with Existing System

There is a key difference between a general purpose ChatGPT with Migraine Generative AI System which aims to be customized and purposeful. A typical ChatGPT will be designed to answer any type of question in any domain with flexibility, but not deep in specific topics. Unlike this, this app only has specific areas which it emphasizes on, including the merging of relevant medical data to track symptoms of the users. This leads to the app being good for inchoate domain specific problems, but not really all encompassing.

The Migraine Generative AI System is equipped with one vital advantage that it can read and store personalized data and give recommended stuff that matches the type of stuff they like. This can be very helpful to the user because it will keep creating the user's medical history and will give them more relevant advice every time they ask. Although, there is a degree of privacy and security concerns with sensitive health data being so easily exposed through this. Privacy management becomes a top priority because of health-related compliance with regulations such as Health Insurance Portability and Accountability Act (HIPAA), and prevention of data breaches or misuse of personal data. A second difference is in the level of integration and decision support. A generalized model through ChatGPT models performs independently, giving basic answers and a more specialized app can be incorporated to healthcare systems to produce more actionable tendencies for patients, and specialists to use in their approach process.

There are many other existing migraine apps, like Migraine Buddy and the rest of them, that were created to educate users with respect to migraine triggers, symptoms, and patterns. They use AI and machine learning to generate insights — based on user input and historical data — to predict the occurrences of migraines and helping with managing the condition. Most of these apps offer some level of personalized predictions about users' migraine patterns, and all tend to feature data logging.

Nevertheless, these apps seem to be lacking in some areas. In many cases, however, the generalized models used limit their predictive power, as the variability in the user's unique migraine triggers and responses can sometimes be inadequately captured by these models. Also, most apps provide little personalization and the predictive models used by most apps do not adapt in real time to constantly evolving health conditions. Also, several apps act as standalone tools, having limited integration with healthcare providers, which means that further collaboration and best medical interventions are out of options.

A second fundamental limitation is the lack of health insights. Some of the apps offer valuable migraine-specific data, but few ever link this data with the user's overall health. Migraine apps, as compared to apps aimed at the management of 'chronic' conditions like diabetes or high blood pressure, rarely provide comparative or health dimension risk analysis. In fact, they often do not prescribe adaptive and real time interventions that can change dynamically with the current user's health data.

To meet these gaps, the Migraine Generative AI System brings to the table some of the most advanced features. Generative AI is used to create personalized and evolving models that work better and better the more you use them. Then, the system supplies real time feedback as to how fast one is recovering allowing users to change the way they work or the treatments they are taking based on immediate health changes. The app also stresses cooperation with healthcare providers, offering eases of better information exchange and more accurate treatment adjustments. This differs from current solutions in its implementation of comparative health insights and recommendations for intervention in a more complete and ahead-of-the game approach to migraine management.

3. RESEARCH METHODOLOGY

The AI model used in this study is the ChatGPT 3.5 model, also known as ChatGPT. ChatGPT is the creation of OpenAI. It is an advanced conversational agent. This is an instance of the ChatGPT model, and the modified version of the GPT-3 model, which are part of the family of generated pre-trained transformers. ChatGPT generates text that closely resembles human language using machine learning technology. Through this approach, it comprehends the user input and offers appropriate solutions or explanations across various fields. ChatGPT was built on the Generative Pre-trained Transformer (GPT) architecture. The transformer uses a mechanism called "attention" to weigh the impacts of different words when generating responses. For example, when generating a response to the sentence "The cat chases its tail," the model understands that "cat" is the subject and is more important than "tail." Vaswani et al. [19] presented the transformer model in their paper "Attention is All You Need," establishing it as a fundamental component of various natural language processing tasks. The GPT architecture extends to converters with a focus on generating coherent and contextually accurate texts [20].

The groundwork in the practical considerations enabled the decision to implement the migraine personalized healthcare mechanism using both generative AI and Mobile Development Life Cycle (MADLC) techniques. The primary goal is to assist migraine patients based on individual user personalization and healthcare similarity, thereby enhancing the overall migraine healthcare experience. Nevertheless, it is fruitful to explore the potential challenges to lead to more relevant migraine personalization, thereby meeting the specific users' needs. Figure 2 summarizes the research method flow for this study. The research methodology starts with a background search to provide an idea of the information we will be processing in the field. Next, while exploring and understanding the field, we define the problem and research objectives to be achieved by the end of the study. Subsequently, a literature review was conducted. This step is crucial to provide a better understanding of the methods that can be used to address the research question, and to explore the techniques used by other researchers and the problems they face when doing so. Furthermore, from then on, the design of the research methods we need to plan, will become easier. Subsequently, data collection and analysis are performed, and simulations are performed to prove the concept. Finally, conclusions were drawn based on the simulation results.

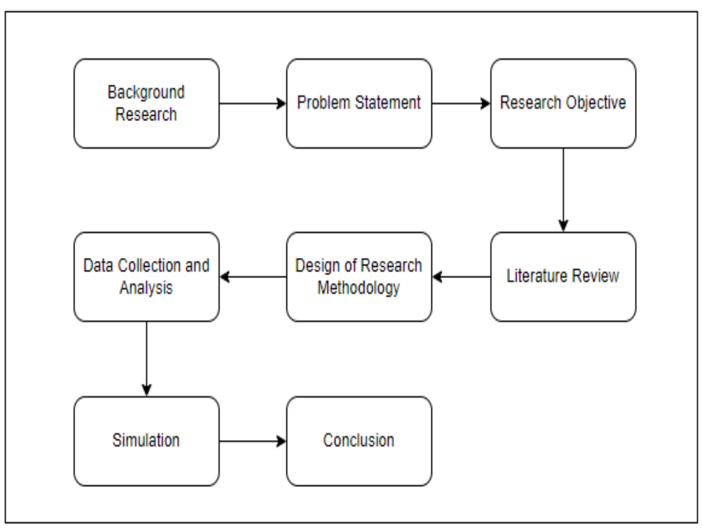

Figure 2. Research Methodology Flow

Neural network architectures, particularly transformers [19] are extensively employed in natural language processing tasks. Layer normalization plays a crucial role in the success of the transformer models. Initially, the transformer architecture implemented layer normalization between residual blocks, a configuration often termed as a transformer with Post-Layer Normalization (post-LN). This architectural design exhibits superior performance across numerous tasks such as language modelling and machine translation. Moreover, unsupervised pre-trained models built on the post-LN transformer architecture have demonstrated remarkable effectiveness in various downstream tasks. For LN, consider$(x_1, x_2, \dots, x_H)$ as the vector representation of an input of size H into the normalization layers [22]. The layer Norm operation re-centres and rescales the input x as expressed by Equation (1).

$$h = g \cdot N(x) = \frac{x-\mu}{\sigma},\ u = \frac{1}{H}\sum_{i=1}^{H} x_i,\ \sigma = \sqrt{\frac{1}{H}\sum_{i=1}^{H}(x_i-\mu)^2} \tag{1}$$

where h represents the output of LN. Subsequently, the operator of '·' denotes a dot product operation. Here, μ and σ are the mean and standard deviation of the input, respectively. Bias b and gain g are parameters of the same dimension, H.

The Rectified Linear Unit (ReLU) activation function [23] operates by applying a threshold operation to each input value. It sets any value from less than zero to zero, whereas for input values greater than or equal to zero, it behaves as an identity function. The ReLU activation function is shown in Equation (2).

$$y_i = \begin{cases} y_{a,i}\ for\ y_{a,i} \geq 0 \\ 0\ for\ y_{a,i} < 0 \end{cases} \tag{2}$$

where y_i is the output from the activation function while $y_{a,i}$ is its input.

In terms of the hardware and software requirements to develop the system, in this study, software will be developed specifically to evaluate the effectiveness of the selected generative artificial intelligence system methods. To evaluate whether a system is qualified to develop or run software, it is crucial to understand system requirements. The hardware used to build the system is described as follows.

- Laptop with operating system Windows 11
- 2.6 GHz AMD Ryzen 3
- 8GB RAM
- 475 GB SDD

Multiple software packages were used to implement this system. The software used is further described as the following.

- Python 3.12.1, LangChain, Flask: Python 3.12.1 is the latest stable version released of Python. This version of Python includes a series of changes to the language and the standard library. This Python version of the library also changes the focus to the cleanup of deprecated APIs, usability, and correctness. The filesystem support in *os* and *pathlib* has been improved, and several modules have better performance.
- VS Code: Visual Studio Code, also known as VS Code, was created by Microsoft. It is available on Windows, Linux, and MacOS. This supports the use of the most common programming language. Additionally, it includes various features, such as support for debugging, syntax highlighting, smart code completion, code snippets, code refactoring, and embedded Git. Users can also change the VS Code's themes, keyboard shortcuts, and preferences. They can even go to the VS Code Marketplace to install extensions to support additional languages or additional features.

One of the primary challenges in developing a mobile web application for migraine management is to ensure privacy and security of patient data. With the integration of IoT devices and machine learning algorithms, sensitive medical information, such as medical history and symptom data, can be collected and processed. It is imperative to implement robust data encryption techniques, access controls, and compliance with regulatory standards, such as the Health Insurance Portability and Accountability Act (HIPAA), to safeguard patient privacy and prevent unauthorized access or data breaches. To maintain focus on clinical and medical standards as well as on the real patient needs, collaboration with healthcare providers, headache specialists, and patients are prerequisite. Developing a medical app without healthcare professionals in the development process will give rise to medical insights that will not be useful since their validation may not be done. Future iterations will be more than just variations on the original theme and will need to be shaped continuously in response to regular feedback from these stakeholders to serve the diverse and specific needs of both patients and medical professionals.

Furthermore, integration of the application with currently existing health care workflows is of special importance for this collaboration. Control of Migraine is often a multidisciplinary approach involving a primary care physician, neurologist and headache specialist working together to provide comprehensive care. To support this, the mobile web application must work with Electronic Health Record (EHR) systems in a seamless manner and must be interoperable with other medical software platforms. This will be a very handy form of compatibility that will help in sharing data among patients in various health care settings to continue with care and in making decisions. The successful collaboration between developers and healthcare providers is created by the development of an app that is responsive to the needs of patients, and yet also interoperable to the technological systems of the healthcare infrastructure. This means that patient data is moving across care teams securely and efficiently for providers to see the data and make data driven decisions and improve patient outcomes. More importantly, collaborating with healthcare providers can address potential risks of diagnosis misdiagnosis or incorrect suggestions since the app needs to interface with healthcare providers core functionalities. And in the end, these partnerships mean that the innovation and technology gap get bridged between those ideas and the real, practical, useful healthcare solutions.

To ensuring user acceptance, the adoption of mobile web applications among patients with migraine is essential for success. User-friendly design, intuitive interfaces, and personalized features tailored to individual patient needs can enhance the user experience and engagement. Additionally, educating patients about the benefits of the application, addressing their concerns regarding data privacy and security, providing ongoing support and training will promote the acceptance and sustained use of the application. In addition, ethical considerations regarding the use of AI-driven technologies in healthcare should be carefully addressed. This includes ensuring transparency in data collection and processing, obtaining informed consent from patients for data usage, and maintaining accountability and fairness in algorithmic decision making. Ethical guidelines and frameworks, such as the Belmont Report and the IEEE Global Initiative on Ethics of Autonomous and Intelligent Systems can provide valuable guidance in navigating these complex ethical considerations.

It must also consider what ethical and legal considerations attend the liability issue. And if a patient decides incorrectly, bad outcome and then questions of responsibility, was the fault of the app developers, the healthcare providers involved, or the patient? The outlines of accountability should be clear by law and the healthcare providers should be involved in the validation process and make the medical accuracy of the app. By working together, we will be able to reduce risk and support a tool that offers more benefits than the potential downsides of an app for migraine management, a safer and more reliable tool for migraine management.

With this, a migraine management system has the potential to provide many benefits, such as personalized symptom tracking, real time navigation, and predictive analysis through AI, but needs to overcome several key hurdles to achieve success when deploying such an app. Data privacy and security is paramount so we need strong cryptography, careful access controls, and stick to data sensitive regulations like HIPAA. For the app to be developed properly, healthcare professionals must be working on it to ensure medical accuracy and medical compliance standards that will reduce a risk of misdiagnosis or incorrect advice. It’s also important for integration with existing medical systems, like Electronic Health Record (EHR) platforms, to have the data shared seamlessly across care teams and for full patient care. To win over user acceptance of the app, the app design should be user friendly, have strong privacy and provide continuous patient support. Rigorous adherence must be made, however, to ethical considerations including, transparency in data usage, informed consent and accountability in decision making. In case of adverse outcomes, then liability frameworks should be clear regarding who is to blame.

Lastly, this is all about the partnership between developers, patients, and healthcare providers to alleviate the breach between technology progression and actually viable, dependable healthcare solutions. This allows the app to be a useful and reliable instrument for handling migraines while weighing up the pros with the ethical and legal responsibilities that come with it.

4. RESULTS AND DISCUSSIONS

The system is built using GPT Turbo, a high-performance model known for its procedural language capabilities. The system relies on core artificial intelligence technology to create a migraine chatbot application. A dataset that included a custom text file with migraine information was compiled. In other words, it contains a PDF document with various types of information about migraines. This diverse dataset was designed to fine-tune the model's learning and demonstrate its ability to handle migraine-specific data. Figure 3 shows the flow diagram of the system. The dataset consisted of two different data sources. Migraine Generative Artificial Intelligence responds with its own AI after scanning the local data set. It searches for a text file named data.txt that contains a dataset. The first text file, data.txt contains unique custom data that will be used by the chatbot.

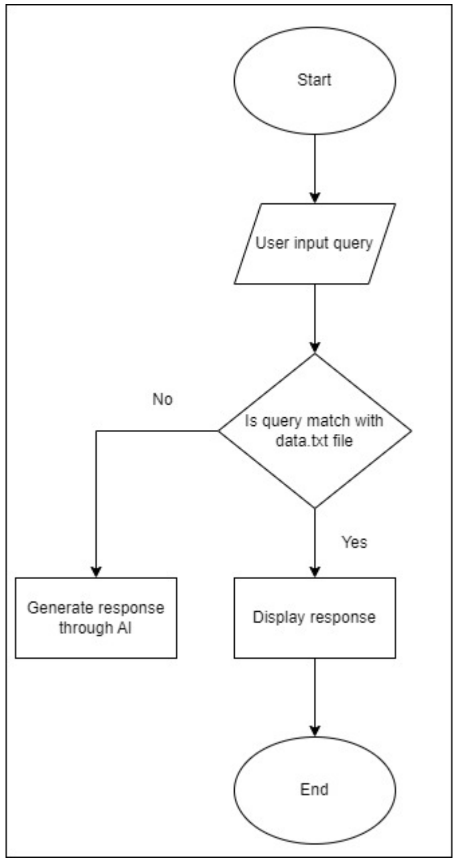

Figure 3. Flowchart of the Migraine Generative AI system

Figure 4 shows the icon design of the Migraine Generative Artificial Intelligence system. The name "MiGA" in the logo is an abbreviation of the system. The head sign represents someone suffering from migraines. In addition, the logo colours are a mix of green, blue, and yellow. Users can choose to log in or register as a new user. Figure 5 shows the MiGA registration screen. Users need to enter their username, email address, password and confirm the password in the designated text fields and click the "Register" button to register an account. Furthermore, this Figure 5 shows the sign-up screen of the application. Users must enter their username, email, password and confirm password text fields before clicking the “Sign Up” button to create a new account to login into this application.

Upon preparing the Generative AI chatbot for migraine and fine-tuning the GPT-Turbo model, these data were used in the proposed system. The Migraine-Generative AI (MiGA) system is displayed on the local host webpage powered by Flask technology. In addition, LangChain is used to develop Migraine Generative AI chatbots that enable users to create AI applications using LLM and a wide range of data sources. First, the migraine generative AI chatbot provides text boxes for users to enter queries. The system then uses its dataset to filter questions about migraines to provide a more personalized solution for migraines. Additionally, if the query is not focused on migraine, the chatbot will also provide a response using data already available in GPT.

Figure 4. Welcome Screen of MiGA System

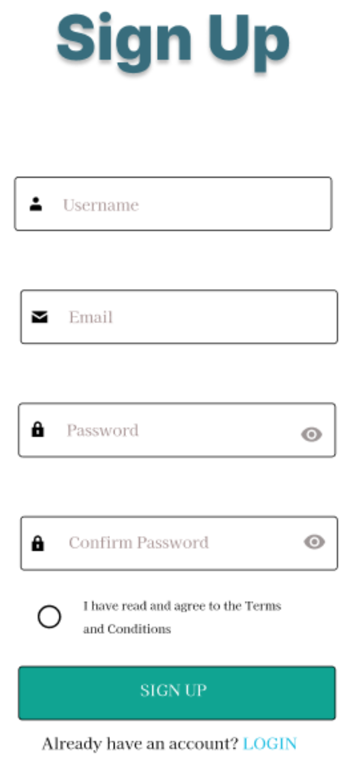

Figure 5. Sign Up Screen of MiGA System

Figure 6 shows the login screen of the application. Users must enter their email address and password in the designated text fields and click the "Login" button to access their account. After providing valid credentials, the user is directed to the home page. If a user forgets their password, they can click on the "Forgot Password" link to launch the password reset process. For new users, there is a "Sign up" link below the login button. Clicking on this link redirected them to the registration screen. If the user forgets their password, they can click the forget password, which will lead to the page shown in Figure 7, where the user can request a reset code to create a new password.

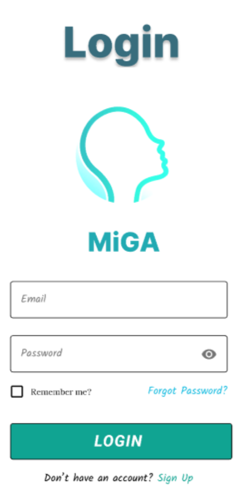

Figure 6. Login Screen of MiGA System

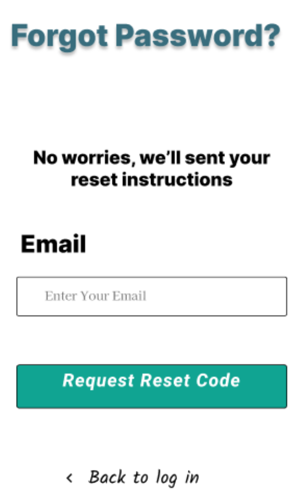

Figure 7. Forget Password Screen of MiGA System

After the user clicks the Request Reset Code button on the Forgot Password screen, the user is directed to the screen shown in Figure 8, which verifies the code entered by the user. After verifying that the password entered by the user is correct, the user will be directed to the page shown in Figure 9, where the user can enter the new password, and want to confirm the entered password again. Then, the user clicks on the Create Password button, which is directed to the subsequent login page.

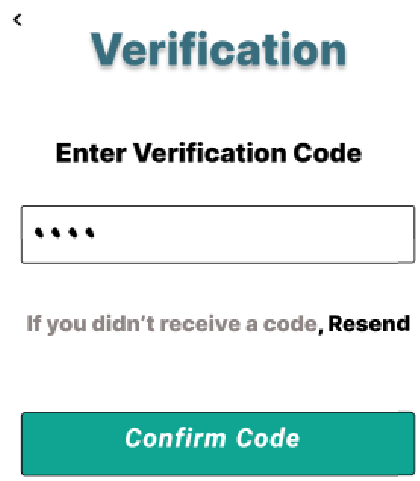

Figure 8. Verification Code Screen of MiGA System

Figure 9. Create New Password Screen

The MiGA homepage screen is shown in Figure 10. The title section contains the welcome user and application full name. The footer section contains a chat box in which users can enter their requirements. The chat content typed by the user in the chat box floats above the chat box with a system-generated output, which is capable to enhance features such supported by diagnostic support found in Migraine Buddy, HeadApp Migraine Trainer, and Migraine Monitor.

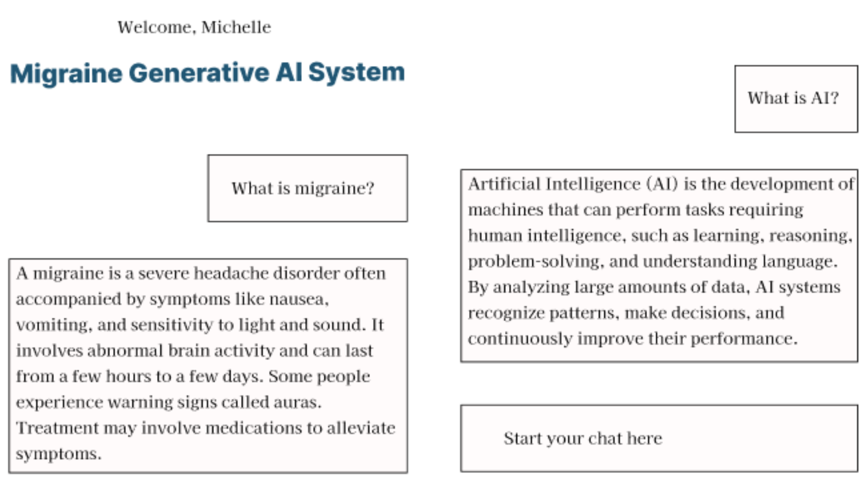

Figure 10. Home Page Screen of MiGA System

To gauge the proposed method works well, the algorithm and model is measured using the evaluation metric of ROUGE (Recall-Oriented Understudy for Gisting Evaluation) scores. ROUGE assesses the similarity between generated text and reference text by analysing overlap in n-grams, word sequences, or word usage [24]. In the realm of Large Language Models (LLMs), researchers have recognised the significance of ROUGE scores in evaluating models fine-tune for specific domains or tasks. Table 1 presents the evaluation of the MiGA system using ROUGE scores. The authors include two queries along with their respective expected answers and the system generated responses. For each query, the accuracy percentage, ROUGE-1 score, and ROUGE-L are provided.

Table 1. Evaluation of Queries Using ROUGE Scores

Query	**Expected Answer**	**MiGA Generated Text**	**Accuracy (%)**	**ROUGE-1 Score**	**ROUGE-L Score**
Q1: What do migraine specialists recommend?	Acute treatments, stress management, and balanced lifestyle. Acute treatments relieve pain during a migraine attack.	A combination of medication, lifestyle changes, and stress management. Include acute treatments to relieve pain during a migraine attack.	63%	0.632	0.53
Q2: How to prevent migraine attack due to weather?	Ensure a consistent sleep schedule, track stress levels, and keeping hydrated to minimize migraine impacts.	Maintain a consistent sleep schedule, tracking stress levels. Stay hydrated to minimize migraine impacts.	86%	0.857	0.86

In the first query, the expected answer emphasizes the importance of acute treatments, managing stress, and maintaining healthy balanced lifestyle. The system response aligns around the expected answer, achieving both a ROUGE-1 and ROUGE-L scores of 0.632, indicating a 63% similarity. In the second query, which specifically asks about the preventive measures to reduce migraine attacks due to weather, the system response – "Maintain a consistent sleep schedule, tracking stress levels. Stay hydrated to minimize migraine impacts" – closely matches the expected answer. This results in a ROUGE-1 score of 0.857 and a ROUGE-L score of 0.86, demonstrating a sound degree of relevance and accuracy. Figure 11 shows the pseudocode fragment deployable with the light philosophy in obtaining ROUGE scores. One can walk with a good-hearted light side of heart despite the LLM pathways darkness or dimmed light. The important thing is the good light in our heart for this score can guide us navigate through darkness of LLM complexities by observing the output footsteps one takes or prompts.

```
## Perform "!pip install rouge-score". Next, deploy after adjusting candidate_summary, and reference_summary
from rouge_score import rouge_scorer
scorer = rouge_scorer.RougeScorer(['rouge1', 'rouge2', 'rougeL'], use_stemmer=True)
# Single reference
candidate_summary = "MiGA Generated Text"
reference_summary = "Expected Answer"
scores = scorer.score(reference_summary, candidate_summary)
for key in scores:
  print(f'{key}: {scores[key]}')
```

Figure 11. Pseudocode in Python Context for The ROUGE Scores

This light philosophy helps one to check heavy non-relevant things and burdens the LLMs carry from the past and dispose them away. Using oneself evaluations on the generated suggestions or recommendations with the guided

ROUGE scores, one can be more sensible and respectful to others for improving relationships with them, which include the community, users, and system. The current implementation of the system provides essential core functionalities for migraine patient management. However, several other features would significantly enhance the patient–doctor interaction and system overall effectiveness. The goal is to bring improvements to migraine management and having elements that are often ignored in existing solutions. The system would become more effective and patient centric on endeavouring these improvements on potential deployment with previous diagnosis, remote therapy management, recording of adverse events, triggers and measures that are useful in the complex interaction between patient and doctor.

5. CONCLUSION

In conclusion, generative AI systems have the potential to revolutionize migraine research and management by analysing vast amounts of data to identify patterns and correlations that might be invisible to human researchers. These systems use diverse data sources, such as electronic health records, patient-reported outcomes [24][25], wearable device data, and genetic information [26]. Ensuring data accuracy and consistency through cleaning and normalization is crucial for a reliable analysis. Machine learning models, such as decision trees, random forests, and support vector machines, can predict migraine triggers and healthcare treatment responses, whereas deep learning models, such as convolutional neural networks (CNNs) and recurrent neural networks (RNNs), are useful for analysing time-series and imaging data. By leveraging these techniques, generative AI can offer personalized recommendations, early prediction models, and deeper insights into migraine triggers, symptoms, and healthcare treatments, potentially improving care and providing relief to patients. However, addressing ethical considerations, data privacy issues, and collaboration with healthcare professionals are essential to ensure the accuracy and effectiveness of these systems in real-world scenarios.

For future work, the MiGA system has the potential to add some additional features to its existing functionality. For instance, it could enhance remote therapy management to enable continuous communication between patients and healthcare providers, allowing real time changes in therapy and ongoing care without the need for in person visits. Additionally, it could record adverse events such found in [27],[28] to allow patients to register side effects that they have encountered working with or utilizing their medication or therapy. Once this is established, healthcare providers have access to important information to modify healthcare treatment plans [29],[30] on the fly. With this, one can document and monitor potential triggers (e.g., diet, sleep, stress), among other things [31],[32]. This provides visual reports [33],[34] to help both patients and doctors see patterns when looking at data over time. Furthermore, the symptom diary feature would let users to record migraine episodes [35],[36], providing data including symptom onset [37], severity [38], and duration [39]. Such data might be useful to clinicians for measuring progress and changing care.

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Michelle Ting-Ting Yong: Conceptualization, Formal Analysis, Investigation, Methodology, Validation, Visualization, Writing – Original Draft Preparation;
Sin-Ban Ho: Conceptualization, Data Curation, Formal Analysis, Investigation, Methodology, Validation, Visualization, Resources, Supervision, Writing – Original Draft Preparation;
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CONFLICT OF INTERESTS

No conflict of interests were disclosed.

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The paper follows The Committee of Publication Ethics (COPE) guideline.

REFERENCES

[1] G., Tsaramirsis, A., Kantaros, I., Al-Darraji, D., Piromalis, C., Apostolopoulos, A., Pavlopoulou, M., Alrammal, Z., Ismail, S. M., Buhari, M., Stojmenovic, & H., Tamimi, "A modern approach towards an industry 4.0 model: From driving technologies to management", Journal of Sensors, 2022 (1), p. 5023011, DOI: https://doi.org/10.1155/2022/5023011

[2] T. C. L., Chow, & W. W., Ma, "A Longitudinal Study on Smartphone Use in Hong Kong", In New Media for Educational Change: Selected Papers from HKAECT 2018 International Conference, pp. 203-216, 2018, Springer Singapore, DOI: https://doi.org/10.1007/978-981-10-8896-4_17

[3] M. A., Pescador Ruschel, & O., De Jesus, (2020). Migraine Headache. StatPearls. NIH (National Institutes of Health), National Library of Medicine. Retrieved December 12, 2024, from https://www.ncbi.nlm.nih.gov/books/NBK560787

[4] D., Kim, S., Oh, & T., Shon, "Digital forensic approaches for metaverse ecosystems", Forensic Science International: Digital Investigation, 46, p. 301608, 2023, DOI: https://doi.org/10.1016/j.fsidi.2023.301608

[5] R., Yang, T. F., Tan, W., Lu, A. J., Thirunavukarasu, D. S. W., Ting, & N., Liu, "Large language models in health care: Development, applications, and challenges", Health Care Science, 2(4), pp.255-263, 2023, DOI: https://doi.org/10.1002/hcs2.61

[6] P., Zhang, & M. N., Kamel Boulos, "Generative AI in medicine and healthcare: promises, opportunities and challenges", Future Internet, 15(9), p. 286, 2023, DOI: https://doi.org/10.3390/fi15090286

[7] B., Meskó, & E. J., Topol, "The imperative for regulatory oversight of large language models (or generative AI) in healthcare", NPJ digital medicine, 6(1), p. 120, 2023, DOI: https://doi.org/10.1038/s41746-023-00873-0

[8] H., Soumare, A., Benkahla, & N., Gmati, "Deep learning regularization techniques to genomics data", Array, 11, p.100068, 2021, DOI: https://doi.org/10.1016/j.array.2021.100068

[9] Y., Tian, & Y., Zhang, "A comprehensive survey on regularization strategies in machine learning", Information Fusion, 80, pp. 146-166, 2022, DOI: https://doi.org/10.1016/j.inffus.2021.11.005

[10] R., Moradi, R., Berangi, & B., Minaei, "A survey of regularization strategies for deep models", Artificial Intelligence Review, 53(6), pp. 3947-3986, 2020, DOI: https://doi.org/10.1007/s10462-019-09784-7

[11] D. A., Clevert, T., Unterthiner, G., Povysil, & S., Hochreiter, "Rectified factor networks for biclustering of omics data", Bioinformatics, 33(14), pp. i59-i66, 2017, DOI: https://doi.org/10.1093/bioinformatics/btx226

[12] A., Urooj, & A., Nasir, "Neural network-based self-tuning control for hybrid electric vehicle engines", Engineering Applications of Artificial Intelligence, 138, p. 109275, 2024, DOI: https://doi.org/10.1016/j.engappai.2024.109275

[13] B. F., Wee, S., Sivakumar, K.H., Lim, W. K., Wong, & F. H., Juwono, "Diabetes detection based on machine learning and deep learning approaches", Multimedia Tools and Applications, 83(8), pp. 24153-24185, 2024, DOI: https://doi.org/10.1007/s11042-023-16407-5

[14] A., Apicella, F., Donnarumma, F., Isgrò, & R., Prevete, "A survey on modern trainable activation functions. Neural Networks", 138, pp. 14-32, 2021, DOI: https://doi.org/10.1016/j.neunet.2021.01.026

[15] J., Yang, H., Jin, R., Tang, X., Han, Q., Feng, H., Jiang, S., Zhong, B., Yin, & X., Hu, "Harnessing the power of llms in practice: A survey on chatgpt and beyond", ACM Transactions on Knowledge Discovery from Data, 18(6), pp. 1-32, 2024, DOI: https://doi.org/10.1145/3649506

[16] J. L., Ba, J. R., Kiros, & G. E., Hinton, (2016). Layer normalization. arXiv: 1607.06450. Retrieved December 12, 2024, from https://arxiv.org/abs/1607.06450

[17] A., Ziaee, & E., Çano, "Batch Layer Normalization A new normalization layer for CNNs and RNNs", In Proceedings of the 6th International Conference on Advances in Artificial Intelligence (pp. 40-49), 2022, October, DOI: https://doi.org/10.1145/3571560.3571566

[18] S., Naseem, "Advancing Health Literacy Through Generative AI: The Utilization of Open-Source Large Language Models (LLMS) for Text Simplification and Readability", Master thesis, Michigan Technological University, 2024, DOI: https://doi.org/10.37099/mtu.dc.etdr/1762

[19] A., Vaswani, N., Shazeer, N., Parmar, J., Uszkoreit, L., Jones, A. N., Gomez, L., Kaiser, & I., Polosukhin, (2017). Attention is All you Need. Advances in Neural Information Processing Systems, arXiv (Cornell University), 30, pp. 5998–6008. Retrieved December 12, 2024, from https://arxiv.org/pdf/1706.03762v5

[20] B., Lutkevich, & E., Burns, (2021). Natural language processing (NLP). TechTarget: Newton, MA, USA. Retrieved December 12, 2024, from https://www.techtarget.com/searchenterpriseai/definition/natural-language-processing-NLP

[21] T., Webb, K. J., Holyoak, & H., Lu, "Emergent analogical reasoning in large language models", Nature Human Behaviour, 7(9), pp. 1526-1541, 2023, DOI: https://doi.org/10.1038/s41562-023-01659-w

[22] W., Zhou, H., Wu, J., Xu, M., Zeineldeen, C., Lüscher, R., Schlüter, & H., Ney, "Enhancing and adversarial: Improve ASR with speaker labels", In ICASSP 2023-2023 IEEE International Conference on Acoustics, Speech and Signal Processing (ICASSP) (pp. 1-5), IEEE, 2023, June, DOI: https://doi.org/10.1109/ICASSP49357.2023.10096722

[23] Y., Yang, S., Xinyang, Q., Wang, & C., Fang, "Enhancement of electromagnetic scattering computation acceleration using LSTM neural networks", Electronics, 12(18), p. 3900, 2023, DOI: https://doi.org/10.3390/electronics12183900

[24] C., Yin, K., Du, Q., Nong, H., Zhang, L., Yang, B., Yan, X., Huang, X., Wang, & X., Zhang, "PowerPulse: Power energy chat model with LLaMA model fine-tuned on Chinese and power sector domain knowledge", Expert Systems, 41(3), p.e13513, 2024, DOI: https://doi.org/10.1111/exsy.13513

[25] S.-B., Ho, E.-Y., Chew, & C.-H., Tan, "Streamlining Dental Clinic Management for Effective Digitisation Productivity and Usability", Journal of Informatics and Web Engineering (JIWE), 3(2), pp. 70-85, 2024, DOI: https://doi.org/10.33093/jiwe.2023.3.2.5

[26] J.-L., Goh, S.-B., Ho, & C.-H., Tan, "Weather-Based Arthritis Tracking: A Mobile Mechanism for Preventive Strategies", Journal of Informatics and Web Engineering (JIWE), 3(1), pp. 210-225, 2024, DOI: https://doi.org/10.33093/jiwe.2024.3.1.14

[27] S. N., Kalid, S.-B., Ho, A., Ibrahim, J. H. N., Azman, S.-J., Tan, & J.-E., Cheong, "Enhancing personalized healthcare with an effective E-Healthcare Management System", Journal of System and Management Sciences (JSMS), 14(2), pp. 482–497, 2024, DOI: https://doi.org/10.33168/JSMS.2024.0230

[28] X.-X., Cho, S.-B., Ho, & C.-H., Tan, "Improving asthma treatment adherence by integrating weather information with responsive web technique", AIP Conference Proceedings, vol. 3153, 030005, 2024, DOI: https://doi.org/10.1063/5.0216655

[29] G. A., Makho, S.-B., Ho, & I., Chai, "Exploring the potential of artificial intelligence in the medical sector for patient well-being: A review technique", AIP Conference Proceedings, vol. 3153, 030003, 2024, DOI: https://doi.org/10.1063/5.0216651

[30] R. J. Y., Kok, S.-B., Ho, & C.-H., Tan, “Improving the prediction resolution time for mobile eczema support system”, AIP Conference Proceedings, vol. 3153, 030007, 2024, DOI: https://doi.org/10.1063/5.0216658

[31] J., Jayapradha, Y., Kulkarni, P., Naveen, & E.A., Anaam, “Treatment recommendation using BERT personalization”, Journal of Informatics and Web Engineering (JIWE), 3(3), pp. 41-62, 2024, DOI: https://doi.org/10.33093/jiwe.2024.3.3.3

[32] C. M., Chituru, S.-B., Ho, & I., Chai, “Integrating spatial computing with clinical pathology for enhanced diagnosis and treatment informatics in healthcare”, International Journal on Informatics Visualization (JOIV), 8(3-2), pp. 1762-1771, 2024, DOI: https://doi.org/10.62527/joiv.8.3-2.2951

[33] I. Ibriwesh, S.-B. Ho, I. Chai, & C. H. Tan, “A controlled experiment on comparison of data perspectives for software requirements documentation,” Arabian Journal for Science and Engineering, 42, pp. 3175-3189, 2017, DOI: https://doi.org/10.1007/s13369-017-2425-2

[34] S.-B. Ho, I. Chai, & C. H. Tan, “An empirical investigation of methods for teaching design patterns within object-oriented frameworks,” International Journal of Information Technology & Decision Making, 6(4), pp. 701-722, 2007, DOI: https://doi.org/10.1142/S021962200700271X

[35] W.-X., Ong, S.-B., Ho, & C.-H., Tan, “Enhancing Migraine Management System through Weather Forecasting for a Better Daily Life”, Journal of Informatics and Web Engineering (JIWE), 2(2), pp. 201-217, 2023, DOI: https://doi.org/10.33093/jiwe.2023.2.2.15

[36] S.-B. Ho, S.-L Chean, I. Chai, & C.-H. Tan, “Engineering meaningful computing education: programming learning experience model,” In 2019 IEEE International Conference on Industrial Engineering and Engineering Management (IEEM), (pp. 925-929), IEEE, 2019. DOI: https://doi.org/10.1109/IEEM44572.2019.8978920

[37] S.-B. Ho, I. Chai, & C. H. Tan, “Leveraging framework documentation solutions for intermediate users in knowledge acquisition,” International Journal of Information Science, 3(1), pp. 13-23, 2013

[38] R. Haque, S.-B. Ho, I. Chai, C.-W. Teoh, A. Abdullah, C.-H. Tan, & K. S. Dollmat, “Intelligent health informatics with personalisation in weather-based healthcare using machine learning,” In International Conference of Reliable Information and Communication Technology (pp. 29–40), Springer International Publishing, Cham, 2020, December, DOI: https://doi.org/10.1007/978-3-030-70713-2_4

[39] C.-W. Teoh, S.-B. Ho, K. S. Dollmat, & I. Chai, “An evolutionary algorithm-based optimization ensemble learning model for predicting academic performance,” In Proceedings of the 2022 11th International Conference on Software and Computer Applications (pp. 102-107), ACM, 2022, February, DOI: https://doi.org/10.1145/3524304.3524320

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