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A MOBILE-BASED APPLICATION FOR COVID-19 DIAGNOSIS AND RECOMMENDATION

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ABSTRACT

In 2019, a new coronavirus outbreak emerged, identified in December 2019. The disease exhibits an average incubation period of 5.2 days, with flu-like symptoms, accompanied by cough and fever. COVID-19 affects various organs and tissues in the human body. While expert systems exist for disease diagnosis, they require experts to operate due to their specific platforms. This paper proposes the development of an efficient, rapid, and precise COVID-19 diagnostic system using mobile phone technology, leveraging the widespread availability of mobile devices. Unlike existing applications, this system's focus is to offer a diagnostic tool accessible to any individual without requiring expert intervention. The framework was implemented using Android Studio and the Dart platform. The resulting mobile application demonstrated user-friendliness and ease of use, ensuring a seamless and intuitive experience for The COVID-19 APP has the potential to reduce disease transmission and enable early treatment initiation, thus mitigating the risk of severe illness. This proactive approach contributes to better overall health outcomes, enhancing individuals' quality of life The mobile phone-based diagnostic system offers an accessible and reliable means for diagnosing COVID-19 without expert involvement. By leveraging mobile technology, this solution can positively impact disease management and foster a healthier population

Keywords: coronavirus, COVID-19, accuracy, diagnostic-system, mobile-devices, disease-management

1. INTRODUCTION

In 2019, there was an outbreak of the new coronavirus which was realized in December, 2019 (Wang et al., 2020). The disease has a mean infection incubation period of 5.2 days with symptoms that are flu-like coupled with cough and fever. This disease has an immense effect on different organs and tissues of the human body. This viral disease is known as COVID-19. Many affected patients develop pneumonia (called novel coronavirus pneumonia, NCP) and move on progress speedily into serious failure of their respiratory organs with a very poor diagnosis and high mortality (Guan et al., 2020). The disease has been seen to be more transmitted more often through personal contacts (Zhu et al., 2020; Rothe et al., 2020). This ended up making the World Health Organization declare Covid-19 a global pandemic. The diagnosis of COVID-19 confirmation is carried out through a positive molecular polymerase chain reaction (PCR) test (Zhang et al., 2020). The tool used for diagnosing lung diseases is a Chest computed tomography (CT) radiography. Considering all of the tests and diagnosis steps that would be essential for

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carrying out this for each of the symptoms, a faster and efficient approach for ensuring an accurate diagnosis before treatment is then essential. (Huang et al., 2020). Recent and exciting advances in the applications of Artificial Intelligence in many healthcare areas (Esteva et al., 2019; Gulshan et al., 2016; Norgeot et al., 2019; Ting et al., 2017; Topol, 2019) have inspired innovations. It is urgently crucial to provide a faster approach that makes suspect patients who may be having the disease aware and recommend measures that can foster their early recovery. This research work hereby would be employing a mobile technology system in the diagnosis of suspected Covid-19 patients and recommend actions that could be taken. This will foster a first step toward individual awareness of the disease before physicians' intervention and separate between assumption and perception. This research aims to develop a mobile-based application to diagnose Covid-19 disease using a decision support system technique.

1.1. RELATED WORKS

Cascella *et al*. (2020) considered COVID-19 to be a public risk looking at its growth daily. This is coupled with the statement of the WHO that CoV epidemic is risky on a "very high" level, on February 28, 2020. World governments are actively engaged in implementing countermeasures to address the potential devastating effects of the threat. Health organizations play a vital role in coordinating information dissemination and issuing directives and guidelines to mitigate the impact of the threat effectively. The authors of the study recognize that the current therapeutic strategies for treating the infection are primarily supportive in nature. Therefore, prevention measures aimed at reducing transmission within the community are considered the most effective weapon in combating the threat. Hence, the authors decided to utilize the "StatPearls" platform due to its distinct capability within the PubMed environment, which enables real-time updates. Their objective is to gather information and scientific evidence to create an ongoing, up-to-date overview of the topic. It is important to note that their focus was not on developing a system specifically for diagnosing the presence of the disease in individuals. Wu *et al*., 2020 were motivated by the massive increase of COVID-19 diseases across the world and a means of reducing the spread. The authors stated that to control the infection, the first and key step is to identify and separate the infected people. But due to the lack of Reverse Transcription Polymerase Chain Reaction (RT-PCR) tests, it is essential to discover suspected COVID-19 patients via CT scan analysis by radiologists. However, CT scan analysis is usually time-consuming, requiring at least 15 minutes per case. The authors of the study developed a novel system called Joint Classification and Segmentation (JCS) to enable real-time and explainable COVID-19 diagnosis. To train this system, they created a large-scale COVID-19 Classification and Segmentation (COVID-CS) dataset. This dataset comprised 144,167 CT images obtained from 400 COVID-19 patients and 350 uninfected cases. Among these, 3,855 CT images from 200 patients

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were annotated with detailed pixel-level labels, including lesion counts, infected areas, and locations. These annotations provided valuable information for various aspects of the diagnosis process, enhancing the system's performance. The extensive experiments conducted on the proposed Joint Classification and Segmentation (JCS) diagnosis system have demonstrated its high efficiency in COVID-19 classification and segmentation tasks. The system achieved impressive results, with an average sensitivity of 95.0% and specificity of 93.0% on the classification test set. Additionally, it achieved a dice score of 78.3% on the segmentation test set of the COVID-CS dataset. These performance metrics indicate the system's ability to accurately classify COVID-19 cases and effectively segment the relevant areas in CT images. Yet the system was web-based and not mobile-enabled.

Song *et al*., 2020 developed an accurate computer-aided method to support clinicians in identifying COVID-19-infected patients by CT images. The authors collected chest CT scans of 88 patients diagnosed with COVID-19 from hospitals of two provinces in China, 101 patients infected with bacteria pneumonia, and 86 healthy persons for comparison and modeling. Based on the dataset collected, the researchers developed Deep Pneumonia, a deep learning-based CT diagnosis system aimed at identifying patients with COVID-19. The experimental results demonstrated the model's high accuracy in distinguishing COVID-19 patients from others. It achieved an excellent Area Under the Curve (AUC) value of 0.99, indicating strong discriminatory power. The model also exhibited a high recall (sensitivity) of 0.93, suggesting its ability to correctly identify positive cases. Moreover, the model successfully localized the main lesion features, particularly ground-glass opacity (GGO), which is valuable for doctors in making accurate diagnoses. This feature provides significant assistance to medical professionals during the diagnostic process. The diagnosis for a patient could be finished in 30 seconds. Yet, the model is not mobile based and does not allow self-diagnosis. Jin et al. (2020) proposed an artificial intelligence (AI) system for fast COVID-19 detection and performed extensive statistical analysis of CTs of COVID-19 based on the AI system. The system was developed and evaluated using a large dataset consisting of over 10,000 CT volumes from various categories, including COVID-19, influenza A/B, non-viral community-acquired pneumonia (CAP), and non-pneumonia subjects. Despite the challenges of performing multi-class diagnosis, the deep convolutional neural network-based system achieved impressive performance metrics. On an internal test cohort of 3,203 scans, the system achieved an area under the receiver operating characteristic curve (AUC) of 97.17%, a sensitivity of 90.19%, and a specificity of 95.76% specifically for COVID-19 detection. Furthermore, on the publicly available CC-CCII database with 1,943 test samples, the system achieved an AUC of 97.77%. These results demonstrate the system's high accuracy and effectiveness in diagnosing COVID-19, even in the presence of other similar respiratory conditions. In a reader study involving five radiologists, the AI system outperforms all of

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radiologists in more challenging tasks at a speed of two orders of magnitude above them. Diagnosis performance of chest x-ray (CXR) is compared.

It can be deduced from all the related literature that none of the approaches considered a mobile -based approach using mobile applications and would require physician interaction before carrying out the diagnosis. There is no initial diagnosis approach that maximizes physician intervention and saves more time. This is the consideration in this project work.

2. METHODOLOGY

The study work incorporated the utilization of expert systems, mobile phone technologies, and SQL-based database administration to facilitate the diagnosis of Covid-19. The objective behind employing these methods is to enable efficient and user-friendly diagnosis of the illness using widely accessible devices such as smartphones, without the need for consulting a specialist. By using this strategy, fewer people visit designated isolation centers for diagnosis even though they are not sure they have the disease. This is especially helpful in situations where there is a high demand for testing but a shortage of doctors. People can undergo preliminary screening and receive potential diagnoses remotely by using Android mobile technology, reducing the danger of illness spread or potential mortality. The methodology, architecture, and algorithms used in the development of the COVID-APP mobile application will be explained. The application, referred to as COVID-APP in this research, utilizes data gathered through observations and interactions with medical experts. This knowledge base obtained from medical experts serves as a valuable resource for the development of the application, helping to minimize ambiguity and incompleteness throughout the entire process.

2.1 Architectural Framework for the COVID-APP

The framework depicted in Figure 1 provides an overview of the essential entities involved in developing the mobile application for diagnosing and recommending treatment for Covid-19. Figure 2 illustrates the architectural integration of the mobile application technology, demonstrating how the various components and systems come together to create a cohesive and functional application. The interaction between each component is demonstrated in the diagrams, showcasing how they communicate and collaborate with each other. During the design stage, the system architecture was developed, taking into account the user requirements and the available technology. The architecture was designed to accommodate the constraints and limitations imposed by these factors, ensuring the successful integration and functionality of the system. The following components are involved in the development:

i. **Mobile devices:** component serves as a means to access the application, as the mobile application is launched and utilized on these devices. The selection of observable symptoms that contribute to the diagnosis is performed through this medium. The components can vary

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in form and size, although these aspects are not the primary focus of this research. Instead, the emphasis lies on the requirement for the mobile devices to have an Android operating system, driven by the higher prevalence and usage of Android devices in the intended test environment.

ii. **The interface layer**: plays a crucial role in facilitating interaction between the system and the application. It enables the system to provide results through the mobile interface. This layer grants users access to the necessary information stored in the knowledge base by utilizing the selections made in the interface. The inference engine processes the inputs and arrives at a final diagnosis, which is then displayed to the user through the user interface.

iii. **The functional description** layer is responsible for describing and specifying the conditions that need to be met before a diagnosis can be performed. It projects the existing problem as a set of conditions that must be satisfied. These necessary conditions must be fulfilled before the system proceeds with the diagnosis. For instance, if an insufficient number of symptoms are selected, the system will issue a signal to notify the user about the inadequacy and prompt them to provide additional symptoms or information.

iv. **The knowledge base:** serves as a repository for the domain-specific expertise of the system. It contains encoded information in various forms such as semantic nets, procedural representations, production rules, or frames. These rules are examined by the inference engine in a sequential manner. If the information provided by the user satisfies the conditions specified in the rules, corresponding actions are executed. The knowledge base acts as a valuable resource for the system, enabling it to make informed decisions and provide accurate diagnoses based on the available information.

vi. **The inference engine:** serves as the dialogue mediator between the user and the system within the user interface. The user provides information or inputs regarding the problem to be solved, and the system's inference engine utilizes this information to derive or infer insights from the knowledge base. After examining the knowledge base, the inference engine generates and provides relevant insights or recommendations to the user. It plays a critical role in processing user inputs and utilizing the knowledge base to generate meaningful outputs for the user.

vii. The database: server is a crucial component of the system, also known as the working storage. It collaborates with both the knowledge base and the inference engine, serving as a means of data storage. The database server stores essential details such as the required consultations or medications for the diagnosed disease. It ensures that the system can efficiently access and retrieve the necessary information to provide accurate recommendations or actions based on the diagnosis made by the system.

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2.2 Algorithm for the COVID-APP Operation

INPUT: Selected symptoms S[]

OUTPUT: Diagnosed disease DG,
Recommended medication RM

PROCESS:

1: Start
2: for i = 1 to N of all available symptoms
3: if symptoms is observed
4: S[i] = select observed symptom
5: else
6: leave symptom unselected
7: end if
8: return diagnosed disease got from knowledge base
9: return necessary recommendation
10: end for
11: end process

3.3 Algorithm to perform inference update on knowledge base

INPUT: symptoms S[], disease D[], recommendation R[]

OUTPUT: Upload report

PROCESS:

1: start
2: open update icon
3: for i = 1 to N of all symptoms
4: if symptoms scenario exist
5: check S[i]
6: else
7: uncheck S[i]
8: end if
9: input recommendation

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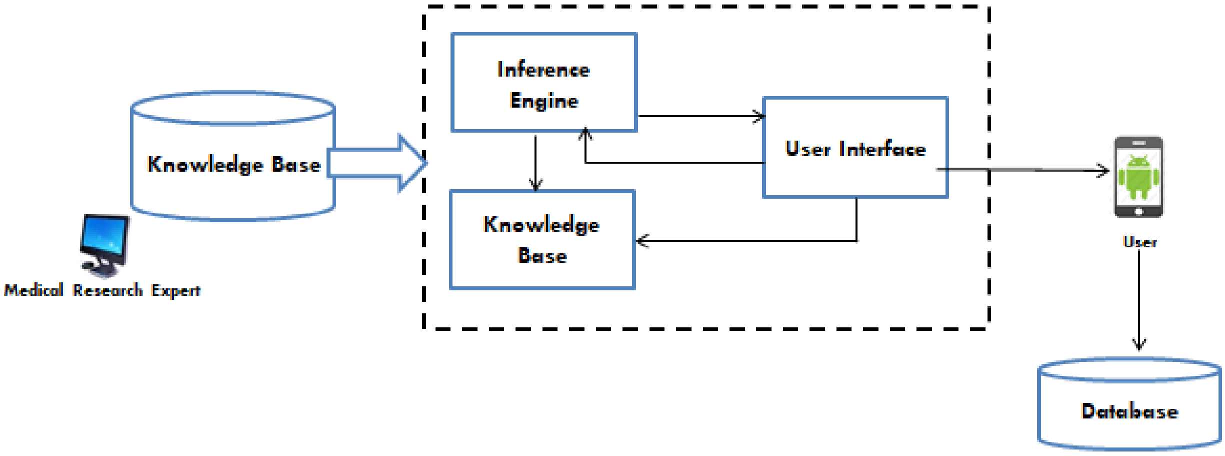

Figure 1: Architectural Framework for the COVID-APP.

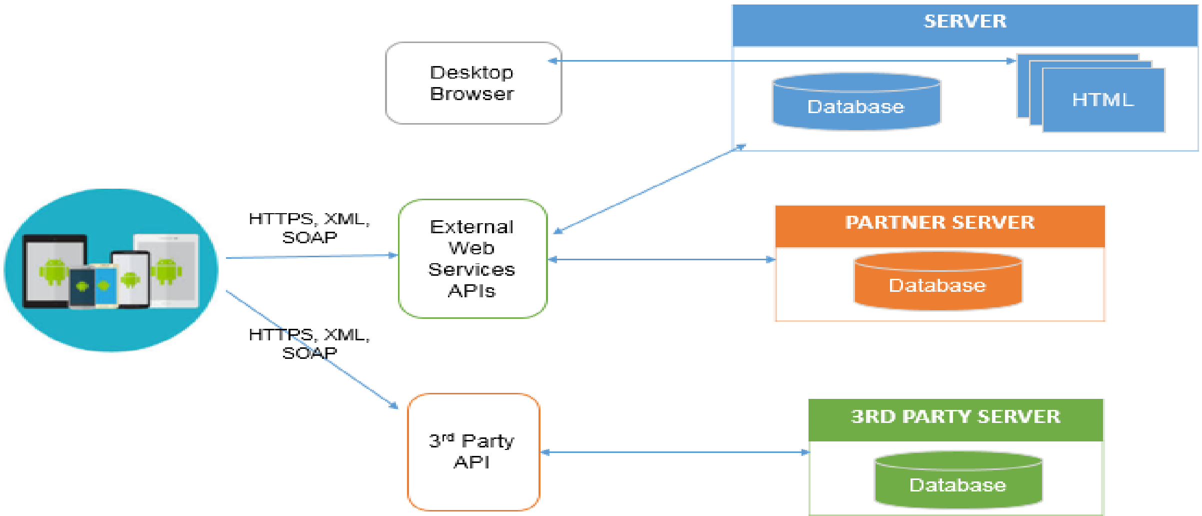

Figure 2: Integration Architecture of COVID-APP

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3.4 Process Flow for COVID-APP

Figure 3 displays the process flow diagram of COVID-APP, illustrating how the mobile application operates. It highlights the sequence of steps that the user follows to utilize the application's functionalities. Upon launching the application, the user is prompted to login using their registered credentials, or if not registered, they are given the option to complete the registration process. Upon selecting various symptoms on the diagnosis page, the user is presented with the corresponding result. Along with the outcome, a recommendation is provided. However, in critical cases, it is strongly advised that the user consults a medical expert instead of relying on self-medication.

3.5 Sequence Diagram of COVID-APP

Figure 4 shows the sequence diagram of COVID-APP.The sequence diagram presents the interactions between the user, the mobile application, and the diagnosis page, providing a visual representation of how these components communicate and collaborate with each other.

4. RESULTS

The main objective of this research is to show and identify a fully documented operating system that is implementable on a smartphone system. By carrying out this, the following activities were conducted: the development of mobile-based software, testing the program by capturing data to ensure efficient execution, and the preparation of the documentation. To develop the mobile application, the data was collected by gathering recommendations from medical experts. These recommendations were obtained through consultations and personal interviews conducted with the experts in the areas where they reside. Furthermore, their suggestions regarding nutrition, medications, and activities can be received to assist individuals in their recovery from any type of illness. The symptoms and recommendations collected for the mobile diagnosis system were stored in the database. The representation of each symptom that was used is shown below:

S_1 = Running nose, S_2 = Coughing, S_3 = Vomiting, S_4 = Sore throat, S_5 = Loss of appetite, ... ,S_n = Sneezing

The login form of the mobile application is available to all users; however, it requires the user's email and password for authentication. Upon successful login, users will be directed to their dashboard, where they can access the features and activities of the mobile application. Figure 5 displays the dashboard page, which consists of various navigation options that allow users to navigate to different sections of the application. This page provides users with the ability to navigate and access all the features available on the mobile application. Users can check for general statistics, submit survey applications and so on. The diagnosis section where the User has access to self-diagnosis has pre-set questions available to ask the user which will be used to get a result as seen in Figure 6. In the diagnosis result page, the user sees the output of the diagnosis based on the selection of symptoms selected from the diagnosis page as seen in Figure 7. The application has a newsfeed section where the user gets an update on countries that are likely to suffer

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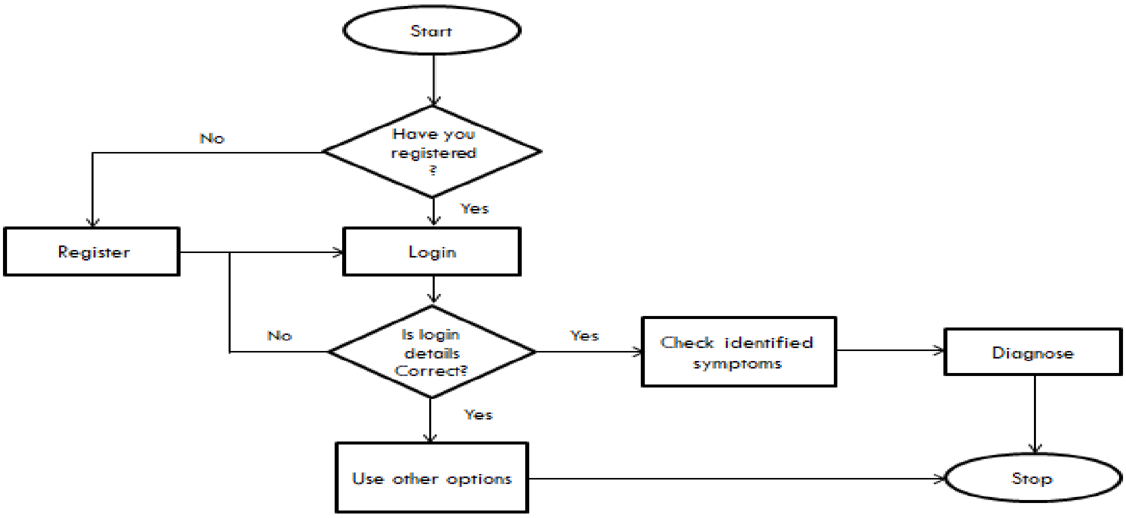

Figure 3 : The process flow diagram of COVID-APP.

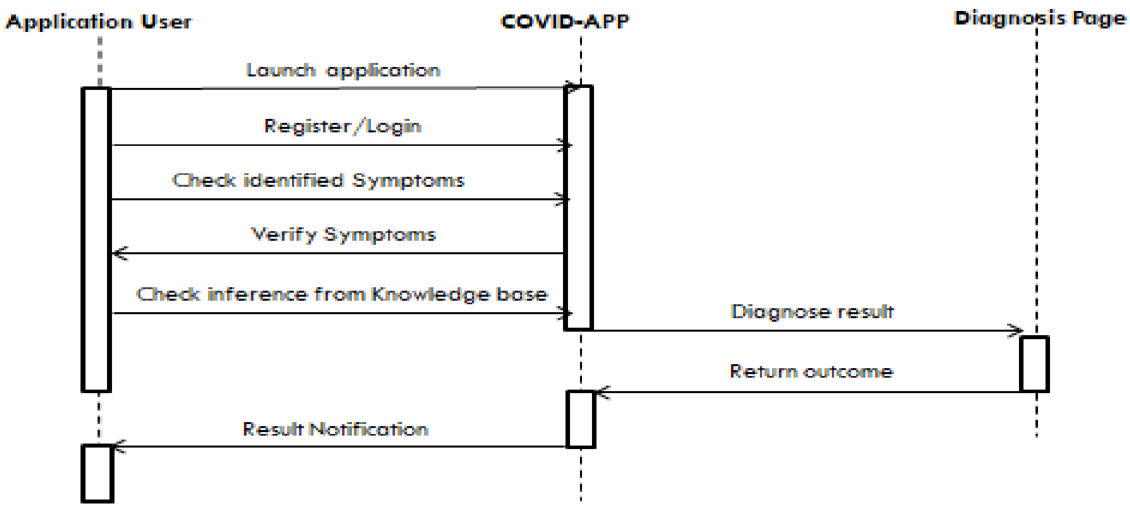

Figure 4: The sequence diagram of COVID-APP operation.

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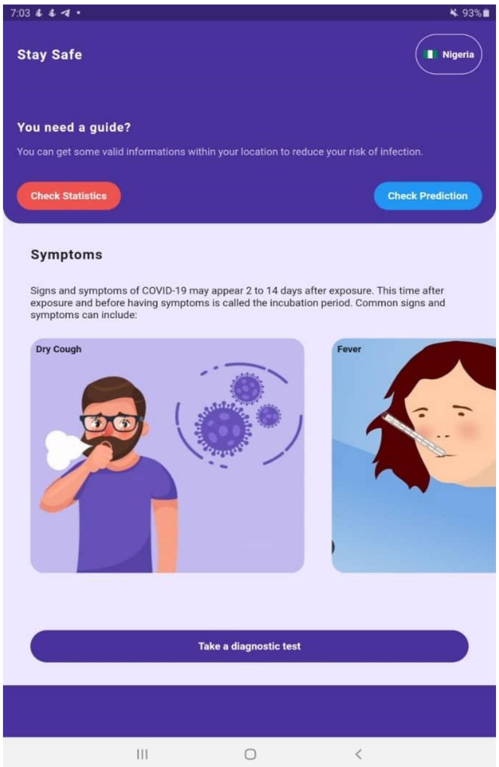

Figure 5: The Dashboard page

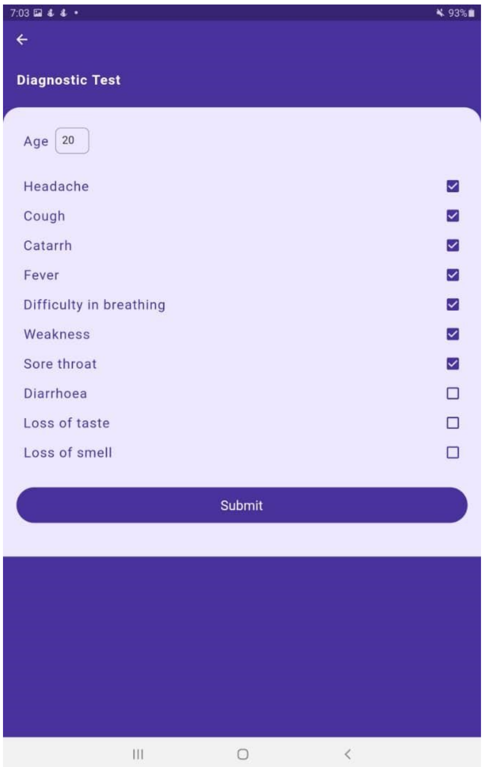

Figure 6: The Diagnosis Page

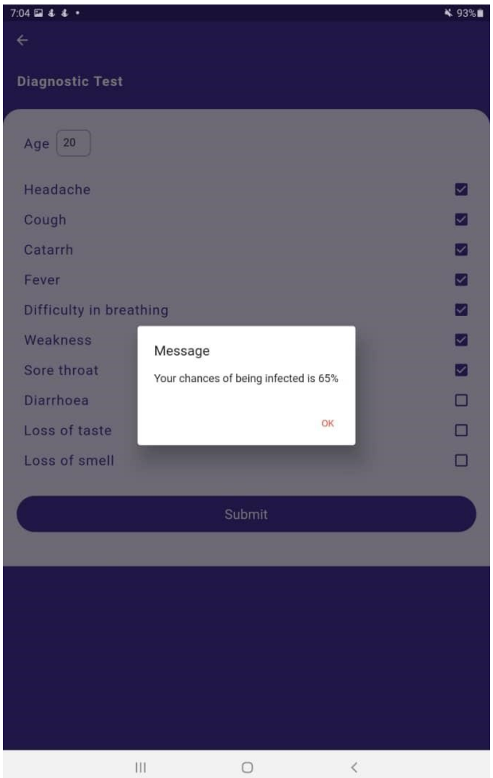

Figure 7: Diagnosis output page

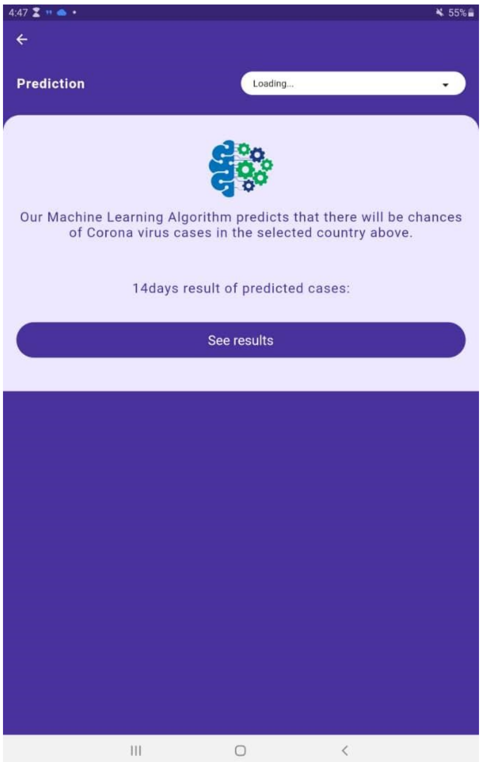

Figure 8: Newsfeed page stating likely

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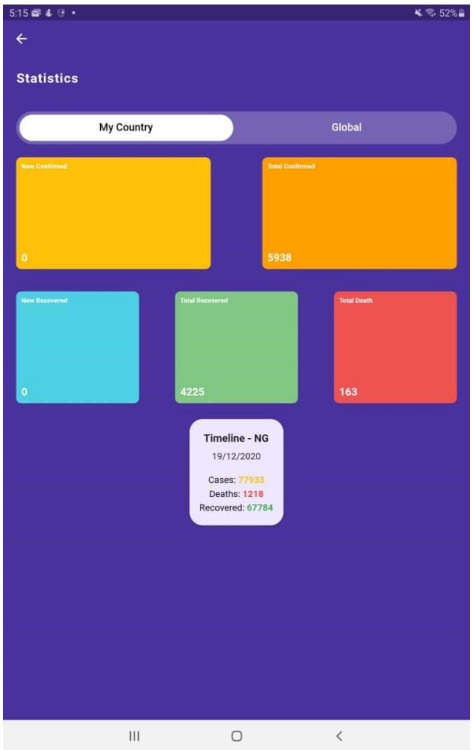

Figure 9: COVID-19 Update Newsfeed

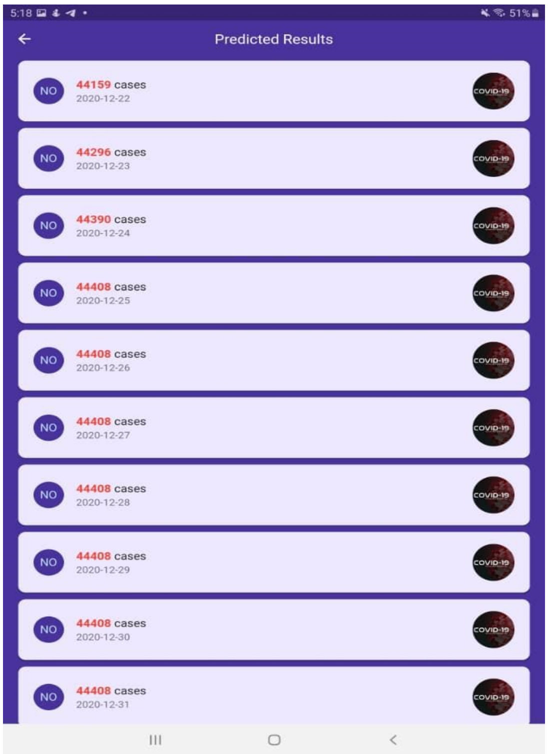

Figure 10: COVID-19 Update Newsfeed by Date

from the increase of the disease based on the several diagnoses obtained. This can be seen in Figures 8 and 9 . Figure 10 shows the update of infected, recovered and death update of the disease.

5. CONCLUSION

COVID-19 was declared a global pandemic that affected every continent of the world with about150 countries (Nigeria inclusive) affected. This happened as a result of the fast spread of the virus through personal contact in several places. Many times, those who carried the virus were unaware of it and had to take care of other illnesses on their own. The disease's late diagnosis and treatment led to the loss of a number of lives. Additionally, there is currently no effective COVID-19 mobile technology self-diagnosis application. Mobile technology is a major contribution to effective daily operation which can be employed in medical diagnosis. In order to diagnose COVID-19 disease, this study uses mobile technologies and expert system approach. Benefits include a decrease in malpractice cases due to less physician errors, more medical specialist proficiency, lower training resource costs, and physician time. The experience from using the application showed that it is high beneficial and can minimize the spread of the disease as those who have the disease would take personal isolation and treatment. For the purpose of to diagnose COVID-19 disease, this study uses mobile technologies and expert system approach. Benefits include a decrease in malpractice cases due to less physician error

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errors, more medical specialist proficiency, lower training resource costs, and physician time. The suggested method can also be utilized to diagnose and suggest treatments for various other illnesses. We anticipate validating the mobile application and gathering a significant number of user feedback to assess perception and make enhancements to the current version.

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