Mobile Medical Assistant and Analytical System for Dengue Patients

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*Abstract*—Dengue fever is a viral vector-borne disease spread by the mosquito Aedes Aegypti. Dengue fever is a public health problem, with an estimated 500 million infections each year and no effective vaccination. It is very common in Southeast Asia. Due to people's hectic schedules, they may not have enough time to see a doctor every time they have a fever. They may overlook their disease, believing it to be a common ailment. In those circumstances, their situation may deteriorate. The majority of individuals who develop critical circumstances (Dengue Hemorrhagic Fever – DHF) do so as a result of a lack of early identification. As a result, in this research, we offer a method for detecting Dengue sickness early on and gaining a thorough understanding of their present health status by assessing their medical factors and symptoms. The main research areas that we have considered are analyzing the skin condition of the patients, through the report, identifying the severity of the Dengue infection, and providing awareness through the dynamic map, which will predict the users about infection areas by using Real-time data processing, and the users will also be advised to take necessary steps after the diagnosis is complete. A mobile application prototype is created and tested, with the possibility of future testing and implementation.

Keywords—Dengue fever, Aedes Aegypti, DHF, infection, symptoms

# Introduction

Dengue hemorrhagic fever (DHF) and dengue fever (DF) cases have risen rapidly in recent decades, posing a global danger. The World Health Organization estimates that 500 million cases of DF and 250,000–500,000 cases of DHF occur each year. Dengue fever has become a deadly disease in recent years. Detecting Dengue fever in its early stages and gaining a thorough understanding of its present health status by studying its medical variables and symptoms is a huge challenge. Dengue fever has become a fatal disease in Sri Lanka in recent years. In total, 30802 suspected dengue cases were reported to the Epidemiology Unit from all across the island in 2020, and 1999 suspected dengue cases were reported to the Epidemiology Unit from January 2021 to the present. Dengue fever cases were reported in the Western province at a rate of 15.0 percent. In 2017, Sri Lanka faced the worst dengue outbreak [1]. During the 29th week of 2017, the maximum number of dengue cases was reported. Figure 1 shows the reported dengue cases in the past 6 years in Sri Lanka. It is critical to seek medical assistance if you have a fever and to have necessary laboratory tests done by day three of your sickness.

1. Reported dengue cases from 2015 to 2020

Dengue fever (40°C/104°F) is accompanied by two or more of the following symptoms: severe headache, discomfort behind the eyes, muscle and joint pains, nausea and vomiting, and a skin rash. Symptoms often emerge 4-10 days after an infected mosquito bite and last 2-7 days. People suffering from dengue fever are recommended to relax, drink plenty of water, and take paracetamol to reduce their fever. It is critical to get admitted to a hospital as soon as possible if the situation worsens. Due to significant bleeding, plasma leakage, fluid accumulation, or organ dysfunction, severe dengue, or dengue hemorrhagic fever (DHF), can be fatal. Severe abdominal pain, persistent vomiting, quick breathing, bleeding gums, exhaustion, restlessness, and blood in vomit appear 3–7 days after the first symptoms, coupled with a drop in temperature (below 38°C/100°F). Dengue fever and DHF complications can be avoided with early detection and adequate medical treatment [2]. There is no suitable system in place to identify Dengue patients early on, provide them with information about their current health, and lead them toward appropriate treatment options.

Early detection and treatment of Dengue fever can help to reduce morbidity and mortality. Dengue illness (Dengue Fever - DF/Dengue Hemorrhagic Fever - DHF) is being considered in the differential diagnosis of patients presenting with acute onset of fever, headache, retro-orbital pain, myalgia, arthralgia, and rash hemorrhagic manifestation in the current hyper-endemic setting in Sri Lanka. Complications can be avoided if the signs are detected early on. Dengue patients are suffering from major health problems as a result of a lack of effective health monitoring in the settings they must endure [3].

Remote diagnostic systems are becoming more common and precise as technology advances, offering various benefits such as cost-effectiveness and speedy and reliable support for medical diagnostic judgments. The project's goal is to create a chatbot system that can be easily accessed by users to identify Dengue patients early on and provide them with information about their present state without wasting time. As medical technology becomes more creative, medical expert systems that oversee and govern diagnosing procedures will be required. Medical diagnostic processes using technology to properly identify ailments when evaluating patient data in order to make effective judgments, as well as Chabot, have shown promise in improving people's health. In today's world, mobile chats are becoming the norm. As a result, a chatbot can be successful if it mimics the simplicity of instant messaging services. Chatbots are typically text-based, with graphics and uniform widgets, making it simple to begin communicating with one.

The rest of the paper is ordered as follows. The second section discusses the existing systems related to Dengue Patients. The third sections represent the proposed system methodology with its main features. The fourth section evaluated the obtained system results and discuss the further improvements in development. The last section concludes the research works of the system.

# Literature Review

Over the years, no one has attempted to detect Dengue Virus using skin photos utilizing Image Processing and Machine Learning approaches; only systems that similarly detect other skin illnesses have been developed. Yasir, R., Rahman, A., & Ahmed, N. (2014) [4] have proposed without the requirement for expert mediation, a framework for analyzing skin diseases utilizing shading photographs has been developed. The framework is separated into two phases: the first is the identification of infected skin using shading image processing procedures, such as k-implies bunching and shading slope approaches, and the second is infection type categorization using fake neural organizations. The detection of the system was designed with the use of the Alexa Net convolutional neural network model and Support Vector Machine. The system was implemented using MATLAB software. The framework was put to the test on six different skin conditions, with the first-stage precision of 95.99 percent and a second-stage precision of 94.016 percent. Zeljkovic, V., Druzgalski, C., Bojic-Minic, S., Tameze, C., & Mayorga, P proposed the development of a Melanoma detection device for brown complexions based on specialized computation data sets that included photographs from a variety of Melanoma assets are a type of skin cancer [5]. A variety of skin cancer images were used in the system to develop an algorithm. The system implementation was carried out in three steps as a colour image to grayscale conversion, applying edge detections and image enhancing. The system acquired more than 5% accuracy in the image classifications. The tool applies to the initial pre-screening of the broader population tool by general medical staff.

Anno, S., Hara, T., Kai, H., Lee, M., Chang, Y., Oyoshi, K., Mizukami, Y. and Tadono, T., 2021 proposed Early warning systems (EWS) to determine how to control and prevent dengue fever outbreaks in Taiwan The search for parameters with a spatiotemporal link with dengue fever epidemics was aided by machine learning [6]. The town-level emerging dengue fever hotspots were examined by conducting an analysis. Machine Learning techniques and a Convolutional Neural Network model were trained for the proposed system. The hotspots analysis was conducted via ArcGIS 10.4.1. Through this analysis, the dengue fever spreading patterns and outbreak projections were examined. According to the results, the analysis showed a direct connection between rainfall and dengue outbreak. The test data represented 100% accuracy in the evaluated system performances. The Extreme Learning Machine Method for Dengue Hemorrhagic Fever Outbreak Risk Level Prediction project was implemented by Najar and others [7]. The system creates ELM architecture with weather variables as input nodes and DHF outbreak risk level as a target. They employ a bipolar sigmoid with several hidden neurons ranging from 5 to 200 nodes and a binary sigmoid activation function. The system consists of three main processes as acquisition and pre-processing of data, training and testing. Monthly weather and dengue hemorrhagic fever data have been used for the system. The system performances showed that the system model is suitable for the DHF predictions. Kassim and others designed and developed a mobile application to analyze dengue attacks [8]. The application is developed for both patients and hospital users. The registered users can check their conditions through the App. The user needs to enter the blood test and temperature level data tested using a dengue kit to the application. Microsoft Azure is used as the data storage tool and the hospital can monitor the patient’s data through a web page. After entering the data if the condition is critical, the application issues a warning alert and gives advice. If the condition is not critical then the application provides advice. The system has been tested and evaluated for 20 patients in Malaysia.

Reddy, S. Kumar, N. Rollings and Rohitash proposed a fever monitoring and tracking mobile application [9]. The proposed system is designed for Fiji Island with the help of mobile phone technology. The system supports a dengue-infected area map that helps authorities to take quick actions. The proposed application consists of four main features, user authentication, dengue symptom checking, confirmed case reporting and feedback support. The feedbacks are based on traditional medication which is giving papaya leaves extracts. All the user data is directed to the database and presented through a map on a website. Technologies such as Android, Java LAMP Server, PHP have been used for the developments. The system tested with 10 mobile phone users and a dengue map is generated with collected data. A chatbot, also known as a conversational agent, is a computer program that engages in natural language interaction with a user and delivers some type of service [10]. Chabot provides intuitive and accessible human-computer contact and is thus widely utilized in areas such as customer service, e-commerce, education and learning, information retrieval, and more. Healthcare (Section 2.2.1) is a common topic in scientific writing. Chatbots are often goal-oriented, meaning they are trained to fulfill requests related to a single area (closed domain). Other chatbots, such as Mitsuku [11] and Cleverbot [12], are intended for recreational communication, meaning they react to inquiries from any domain in a smart and entertaining manner (open domain). Weizenbaum's Eliza, who simulates a chat with a psychiatrist, was the first conversational agent to garner widespread notice [13]. Eliza was limited in her ability to recognize and preserve contexts within a discourse because she was based on simple keyword matching. The terms expressed by the user were combined into basic follow-up questions using a simple set of rules. If no keyword was detected, a generic response (such as "tell me more about it!") was put together. It also relied on user feedback to keep the conversation going.

Divya and others introduced a medical chatbot that gives the patient a sickness diagnosis and then gives them complete information about the disease [14]. The user's input is matched for symptoms, and the system generates a shortlist of possible diseases based on these symptoms. The chatbot then asks further questions to validate the diagnosis and presents a shortened list until a definitive diagnosis is reached. In the event of a major ailment, the symptoms' data will be submitted to a professional. For lesser illnesses, the bot recommends first aid and a trip to the doctor. Riech et al. discussed the challenges in the dengue infection prediction system with the Thailand case study [15]. A model was developed for the real-time forecasting of dengue hemorrhagic fever. The system involves methods such as real-time data management, delay accounting, time predictions, etc. The disease model was implemented as a statistical model for the result estimation. The real-time model data was compared with manual report data and evaluated the system challenges.

# Methodology

The mobile application is designed with four main functions. Figure 2 represents the high-level architecture of the system. All the registered users can receive the medical assistant through the App. The implementation of the system was carried out via techniques such as Image processing, Machine learning and Data analysis.

1. Overall system architecture.

## Patient Identifying and Classifying Chatbot

Chatbot gives the symptom information and identifies the condition of the user. It helps to reduce the patient’s complications by identifying the disease at an early stage. At first, the chatbot gathers the user's symptom information via a questionnaire. Then the collected data will be stored in the database and analyzed to give the output. The results will present in terms of the dengue stage as normal dengue fever, dengue hemorrhagic fever or dengue shock syndrome. Figure 3 shows the overview of the chatbot system.

1. Overview of the chatbot system

The chatbot can be divide into three main functional modules as pre-processing, feature extraction and classification. The questions that gather user inputs include via a pilot survey. To get an affirmative response, the questions are in yes or no format. The noise of the dataset will be removed and create as labeled 2D arrays. The phase optimization is achieved at the pre-processing stage. The text pre-processing is accomplished by using Natural Language Processing (NLP) techniques. The NLP module extracts the texts from the user inputs. In this process, the Natural Language Tool Kit (NLTK) is used to generate a token list from the dataset [18]. The procedure is called tokenization. The word embedding techniques are used to transform keywords into feature vectors. The feature vectors are later applied together with the machine learning algorithms. The pre-processed text inputs can be distinguished as feature vectors. In the classification module, the classifier is selected based on the system requirements such as complexity and phase testing. The text input category predictions are developed through machine learning and relevant accurate classifiers. The data processed by the NLP module is used to train the classifier. At last, the classifier model receives the feature vectors and the chatbot will send the results to the user by completing word classification.

Unlike Other chatbots, this system gives immediate and accurate responses to the user. The dengue stage classification is acquired through a trained Artificial Neural Network based model. The NLP model is an important component in the chatbot [16]. NLP and Natural Language Understanding techniques are embedded in the system for efficient response. Haman languages can be read, decode and interpret with the use of NLP. The NLP module comprises a knowledge base recognized as the main source of symptom data and medical ontology. The model is trained with the Naive Bayes classifier in NLTK. Apart from the above techniques. the chatbot development included python technology stack, Keras, TensorFlow, Sklearn NumPy and Pandas machine learning libraries and node JS software technologies.

## Analyzing and Identifying Dengue Infected Areas

Through dengue infected area analysis, the user can get to know the infected locations via a dynamic map. The module is implemented with the past and real-time weather forecast data. Figure 4 shows the module architecture with its functions. This module provides three services to the user such as analysis of infected areas, visualization of infected areas and sending notifications to the user. With the support of the Medical Officer of Health (MOH), the weather forecast data is used for the analysis. After analysis, the users can view those analyzed infected risk areas in an inbuilt map. The application requires the user location permission to enable the notifications. Using the GPS of the mobile, the application sends a notification if the user is in a risk area or if the user entered a risk area. And also, if a registered user is identified as a dengue patient, all the user details together with the location will be added to the application database. Then the application infected area map will be updated with the information.

1. Overview of infected area prediction

The model development procedure follows problem identification, data collection and pre-processing, feature extraction and risk map construction. Data is collected from the meteorological department and the regional epidemiological nits in districts. The data parameters are monthly rainfall information, rainy days and monthly dengue cases. In the pre-processing stage, data is subjected to selection, cleaning, reduction and discretization. Data selection and reduction take more time than the other two operations. Artificial Neural Network is used for feature extraction since it has high accuracy in time series prediction [17]. The system has been implemented with the regression-based neural network. The development techniques include Neural networks and software technologies such as Android, Flutter, Python, Machine Learning Libraries and Node JS.

## Analyzing Skin Conditions

Diagram

Description automatically generatedThrough skin condition analysis, the system identifies whether the patient is dengue infected or not. The users can easily upload their skin images to the mobile application and get the output. Figure 5 shows the overview of the skin analyzing module. The module was developed with trained machine learning algorithms and image processing. The input images are analyzed through the developed model. The analysis is conducted in terms of allergies, rashes and abnormalities in the skin. The system is trained with the above conditions to identify the user condition. The user is identified as a dengue patient if the input image matches with the system identification process.

1. Skin condition analyzing system overview

The system comprises three main operational functions namely pre-processing, feature extraction and classification. Image resizing is used as a pre-processing technique to generate high performance in the module. Different image sizes in the database can cause a lot of problems. So the images are resized to a static resolution. In this system, all images are set to 350 x 350-pixel size. Thus, it gives high system performance, less processing time and the same no of image features. This image size can be improved with a high-performance system environment. The features of input images are extracted through Convolutional Neural Network (CNN). CNN is known for good feature extraction. The efficiency of CNN is when compared with other neural networks. And also, CNN supports feature learning and weight sharing. After feature extraction, the images are classified as infected and non-infected.

Multi-Layer Sequential Architecture is used for the CNN model that develops and trained in the Keras Machine Learning library. The training of the model is done through RGB images. The image data sets are generated using the “ImageDataGenerator” method in Keras and saved in ".h5" format. By referring to the distinct characteristic data the model classifies the user input as “Dengue Infected” or “Not Infected” and provides the output via mobile application.

## Analyzing Blood Reports and Severity Identification

Diagram

Description automatically generatedThis module supports application users to check whether he/she is dengue infected person with their blood report analysis. When the user uploads their full blood count report, the system analyzes it based on the patient's platelet count, white blood cells count and some other necessary parameters. The report is analyzed through image processing and machine learning techniques. The user receives the final output of the blood report in the present dengue stage from the four fever categories. Figure 6 shows the architecture of the blood report analysis module.

1. Blood report analysis architecture

The operation of this module can be divide into three steps. At first, the uploaded blood report image is pre-processed for optimization. The image is cropped and resized to remove unnecessary parts. Then a white mask will be applied to the blood report to remove the background of the report. The procedure consists of dilation and erosion. The edges of the report are increased with the canny threshold technique. Vector autoregression (VAR) is applied to train and build the system model. The pre-processed image is then moved to the Google Optical Character Recognizer (OCR). Google OCR is technology that works through google cloud vision API [19]. Google OCR The report features are isolated under the feature extraction stage. Then a keyword search algorithm is applied to detect some specific words like Red Blood Count(RGB), Platelet count (PLT) and hemoglobin (HGB) vale in the report. At last, the dengue stage is presented to the user from one of the three categories below

* Normal dengue fever.
* Dengue hemorrhagic fever.
* Dengue shock syndrome condition.

. The machine learning module of the system is trained with a training dataset of blood reports. The development was carried out via a location-based machine learning approach. Software technologies and libraries such as Numpy, Open CV, Cloud Vision API, Mathlab and node Js have been used for the implementation of this module.

# Results and Discussion

In the chatbot, first, the system gets the user input through the questionnaire. Figure 7 shows the prototype interface of the questionnaire that collects ser symptoms. The model consists of training and testing data, altogether 14000 data records. The accuracy of the user condition is delivered as a certain percentage. If the accuracy is relatively low, then the system gets more user inputs related to the symptoms and generates the response. The evaluated system performances depicted a low value for the model loss. Thus, providing efficient outcomes from the chatbot.

1. Prototype of symptoms questionnaire

Chart

Description automatically generatedIn infected area analysis, the model has been trained and acquired the regression output. In the training model, the results show a decrease in model loss parameters. Figure 8 shows the deviation of model loss in terms of testing & training data.

1. Model loss in infected area prediction

Model loss depicts the quality of the model prediction and zero model loss represents the perfect predictions. The model showed an overall accuracy of 71.84% as the output. The dengue patients who check their dengue condition with other application functions will also add to the database for the use of this prediction model. In the skin condition analysis module, the accuracy is evaluated in training data and testing data. First, the training data accuracy is evaluated and then predicted the results from test data. Then the validation accuracy is obtained by comparing the prediction and test data results. The output is classified with the SoftMax activation function. According to the input, the system provides whether the user is dengue infected or not. The model testing has shown an efficient and accurate system performance. The blood report analysis module operates the location-based machine learning approach and the testing records the system accuracy. The Google OCR identifies the text list from the reports with the location. The evaluated system performances showed an increasing accuracy rate with more testing phases.

Overall the application supports identifying dengue-infected areas, analyze skin conditions, identify user conditions and analyze blood reports. The mobile medical assistant and analytical system for dengue patients are developed by allowing users to enter their blood reports, skin conditions, symptoms, locations and to receive an immediate response. The application helps as a medical assistant not a substitute for a doctor's treatment. The relevant authorities like MOH can get great use from the infected area map. The ability to use a smartphone or tablet to check the dengue conditions provides a great advantage for the users. The system platform is one of the limitations in the application as it is developed for Android devices.

# Conclusion

In this paper, we present an analytical mobile medical assistant for dengue patients. The proposed mobile application provides more convenient services for dengue patients to identify their condition. A dengue patient can upload their blood report and find their dengue stage, a person with normal fever or some related symptoms can add their symptom information and check the condition, a patient can use their skin images to identify the condition and last but not least user can get informed with dengue infected areas through a dynamic map.

The application can be improved for higher performances with more utilization of system requirements. The system compatibility can be improved by developing the application for the iOS platform for future development. The application features can be enhanced by allowing users to upload videos, doctor prescriptions, etc. Further testing and large-scale implementations of the mobile application can achieve to verify the system performance with thousands of user accesses. And also, system validation and improvements can perform with user feedbacks and surveys.

##### Acknowledgment

##### References

1. Severe Dengue Epidemic, Sri Lanka, 2017 - Volume 26, Number 4—April 2020 - Emerging Infectious Diseases journal - CDC’. https://wwwnc.cdc.gov/eid/article/26/4/19-0435\_article (accessed Aug. 17, 2021)
2. Preventing Dengue in Sri Lanka’. https://www.who.int/srilanka/news/ detail/08-07-2019-preventive-action-is-vital-to-curtail-dengue-outbreaks-in-sri-lanka (accessed Feb. 15, 2021).
3. ‘NDCU Dengue Illness’. http://www.dengue.health.gov.lk/web/ index.php/en/information/ dengue-illness (accessed Feb. 15, 2021).
4. N. S. ALKolifi ALEnezi, ‘A Method Of Skin Disease Detection Using Image Processing And Machine Learning’, Procedia Comput. Sci., vol. 163, pp. 85–92, 2019, doi: 10.1016/j.procs.2019.12.090
5. V. Zeljkovic, C. Druzgalski, S. Bojic-Minic, C. Tameze, and P. Mayorga, ‘Supplemental melanoma diagnosis for darker skin complexion gradients’, in 2015 Pan American Health Care Exchanges (PAHCE), Santiago, Vina del Mar, Chile, Mar. 2015, pp. 1–8. doi: 10.1109/PAHCE.2015.7173338.
6. S. Anno et al., ‘Spatiotemporal dengue fever hotspots associated with climatic factors in Taiwan including outbreak predictions based on machine-learning’, Geospatial Health, vol. 14, no. 2, Nov. 2019, doi: 10.4081/gh.2019.771.
7. A. M. Najar, M. I. Irawan, and D. Adzkiya, ‘Extreme Learning Machine Method for Dengue Hemorrhagic Fever Outbreak Risk Level Prediction’, in *2018 International Conference on Smart Computing and Electronic Enterprise (ICSCEE)*, Shah Alam, Jul. 2018, pp. 1–5. doi: 10.1109/ICSCEE.2018.8538409.
8. M. Kassim, N. A. N. Ali, A. Idris, S. Shahbudin, and R. Ab. Rahman, ‘Dengue Attack Analysis System on Mobile Application’, in *2018 IEEE 8th International Conference on System Engineering and Technology (ICSET)*, Bandung, Oct. 2018, pp. 151–156. doi: 10.1109/ICSEngT.2018.8606397.
9. [9] E. Reddy, S. Kumar, N. Rollings, and R. Chandra, ‘Mobile Application for Dengue Fever Monitoring and Tracking via GPS: Case Study for Fiji’, *ArXiv150300814 Cs*, Mar. 2015, Accessed: Aug. 17, 2021. [Online]. Available: http://arxiv.org/abs/1503.00814
10. dengue-diagnosis.pdf’. Accessed: Aug. 18, 2021. [Online]. Available: https://www.who.int/tdr/publications/documents/dengue-diagnosis.pdf
11. Chatbot Mitsuku, Square Bear | Virtual Assistant Mitsuku | Virtual agent Mitsuku | Chat bot Mitsuku | Conversational agent Mitsuku | (4146)’. https://www.chatbots.org/chatbot/mitsuku/ (accessed Aug. 18, 2021).
12. ‘Cleverbot.com - a clever bot - speak to an AI with some Actual Intelligence?’ https://www.cleverbot.com/ (accessed Aug. 18, 2021).
13. J. Weizenbaum, ‘ELIZA—a computer program for the study of natural language communication between man and machine’, Commun. ACM, vol. 9, no. 1, pp. 36–45, Jan. 1966, doi: 10.1145/365153.365168.
14. S. Divya, Indumathi, S. Ishwarya, M. Priyasankari, and S. Kalpanadevi, ‘A Self-Diagnosis Medical Chatbot Using Artificial Intelligence’, *undefined*, 2018, Accessed: Aug. 17, 2021. [Online]. Available: https://www.semanticscholar.org/paper/A-Self-Diagnosis-Medical-Chatbot-Using-Artificial-Divya-Indumathi/7eec7477ddaa673a65c355dea479e63dd3e36e8f
15. N. G. Reich *et al.*, ‘Challenges in Real-Time Prediction of Infectious Disease: A Case Study of Dengue in Thailand’, *PLoS Negl. Trop. Dis.*, vol. 10, no. 6, p. e0004761, Jun. 2016, doi: 10.1371/journal.pntd.0004761.
16. Why Natural Language Processing (NLP) is a core AI Technology’.https://witanworld.com/article/2018/10/28/naturallangua- ge processing-nlp/ (accessed Aug. 18, 2021).
17. Feature Extraction Network - an overview | ScienceDirect Topics’. https://www.sciencedirect.com/ topics/ computer-science/ feature-extraction -network (accessed Aug. 08, 2021).
18. Natural Language Toolkit — NLTK 3.6.2 documentation. https://www.nltk.org/ (accessed Aug. 14, 2021).
19. ‘Detect text in images | Cloud Vision API | Google Cloud’. https://cloud.google.com/vision/ docs/ocr (accessed Aug. 21, 2021).