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Abstract

Dengue fever is a viral illness transmitted by mosquitoes that are found in tropical and subtropical regions around the world.The monsoon seasons, characterized by warm temperatures and abundant rainfall, create ideal breeding grounds for Aedes mosquitoes. The primary vectors responsible for transmitting the Dengue virus.

This work presents a pioneering application of deep learning techniques, specifically Long Short-Term Memory (LSTM) networks, for the purpose of forecasting Dengue Fever in Bangladesh.Through a comprehensive analysis of previous data, the developed LSTM model exhibits notable accuracy in predicting future occurrences of Dengue.The successful integration of deep learning methodologies into the realm of infectious disease forecasting represents a significant step forward in bolstering public health preparedness and response strategies, not only in Bangladesh but also offering a scalable model for similar challenges globally.

Considering the greater burden of disease in larger epidemic years and the difficulty in understanding current and future needs, it is highly needed to address early warning systems to control epidemics from the earliest.

Introduction

Dengue cases are increasing dramatically worldwide, especially in counties located in tropics and subtropics like Bangladesh. This disease threatens about 50% of the global population (3.9 billion people). Dengue fever cases have risen over 15 times in the last two decades, according to the World Health Organization, from 505,430 cases in 2000 to over 2,400,138 cases in 2010 and 3,312,040 cases in 2015. Annually, an estimated 390 million dengue virus infections occur, with 67–136 million occurring clinically. Dengue fever is caused by the viral infection spread by mosquitoes that are transmitted by four distinct virus serotypes (DEN-1, DEN-2, DEN-3, and DEN-4) that are genetically related but anti-genically distinct.[1]

The geographic range of dengue is expanding, and much like in many other tropical regions of the world, dengue has become a major public health issue in Bangladesh. Until a large epidemic dengue outbreak in 2000, sporadic outbreaks have occurred in Bangladesh since 1964. After 2000, varying intensities of dengue activity were observed each year until 2018. However, in 2019, Bangladesh experienced the largest dengue epidemic in its history, with 101,354 dengue cases and 164 dengue related deaths. Notably, this outbreak occurred in many regions that were previously considered free of the disease. As of 10 December 2022, a total of 60,078 dengue cases and 266 dengue-related deaths were reported in Bangladesh, with the 2022 outbreak being the second largest since 2000. There is an increased genetic diversity of the dengue virus (DENV) in Bangladesh and all four DENV serotypes are prevalent and co-circulating, which increases the risk for severe dengue owing to the antibody-dependent enhancement effect.[8]

Machine learning approaches can be used to model and predict the risk of dengue fever outbreaks, which can inform the development of prevention and control strategies. Long short-term memory (LSTM) is a type of recurrent neural network that is well suited for modeling time series data, such as data on the incidence of dengue fever over time. LSTM networks can learn long-term dependencies in the data by using gates that control the flow of information within the network. This allows LSTM networks to effectively capture patterns that may span multiple time steps, which can be useful for predicting future outcomes.[2]

In recent 2023 Bangladesh has experienced a significant surge in Dengue fever cases.Which posing a substantial threat to public health and placing an unprecedented burden on healthcare systems.

This research stems from a deep-seated commitment to alleviating the burden of Dengue on the people of Bangladesh. I want to develop a robust forecasting model using Deep Learning techniques to predict Dengue outbreaks in Bangladesh.

Related Literature Review

Mokhalad A. Majeed et al.[2] used an LSTM model with spatial Attention to forecast Dengue fever in Malaysia. They find that the SSA-LSTM model has the best performance for predict dengue in Malaysia among the six Six different long short-term memory (LSTM) models were developed and compared for dengue prediction in Malaysia: LSTM, stacked LSTM (S-LSTM), LSTM with temporal attention (TA-LSTM), S-LSTM with temporal attention (STA-LSTM), LSTM with spatial attention (SA-LSTM), and S-LSTM with spatial attention (SSA-LSTM).

The limitation of the data-set used in this research is that it only includes dengue case data at the state level in Malaysia and does not include data at a more granular level, such as at the district or city level. This may limit the ability of the models to capture local variations in dengue prevalence and to identify specific hot-spots or areas at higher risk of outbreaks. Additionally, the data-set only includes dengue case data from 2010 to 2016, which may not be sufficient to capture longer-term trends or patterns in the disease. This could potentially limit the models' ability to accurately predict dengue cases in future years.

Doni and Sasipraba et al.[3]used an LSTM model to predict the impact of dengue cases in India. They found that the model had an 89% accuracy in forecasting dengue infection and 81% accuracy in forecasting deaths.

A limitation of this works is that they have limited evaluation of the performance of the models for long-term forecasts. They used data from a few years to train and evaluate the models, and it is unclear how well the models would perform for longer-term forecasts.

Motivation and Objective

Recent year , the individuals and communities grappling with the devastating consequences of Dengue outbreaks. Behind the numbers and statistics lie stories of resilience, but also of suffering and loss. This research stems from a deep-seated commitment to alleviating the burden of Dengue on the people of Bangladesh.

The aim is to develop a robust forecasting model using Deep Learning techniques to predict Dengue outbreaks in Bangladesh. Also to contribute to the development of more accurate and timely forecasting models and to empowering public health authorities in Bangladesh to proactively manage and mitigate the impact of Dengue Fever.

Methodology

Dengue fever first appeared in Asia, Africa, as well as North America in the years 1779–1780.5Dengue fever is prevalent in Southeast Asia and the Western Pacific, accounting for roughly three-quarters of the global burden. A massive dengue outbreak struck the Philippines and Thailand throughout Asia in the 1950s . The first episode of dengue fever in Bangladesh was officially recorded in 1964 in Dhaka.The very first dengue outbreak in this country occurred during the monsoons of 2000,resulting in 5551 officially confirmed cases and 93 deaths.[4]

The sequence of procedure followed in the proposed methodology is shown in Figure 1.The data are collected from various sources are pre-processed. From the available features the attributes that are having impact are considered by applying XGBoost algorithm. The data is split into three categories: train, test and validate.The model is built and is trained by the training data set and the correctness of the proposed model is tested using the test data-set. The model is further evaluated by the validating data set. The results are then evaluated by applying the necessary measures and a recommendation engine is generated.[3]

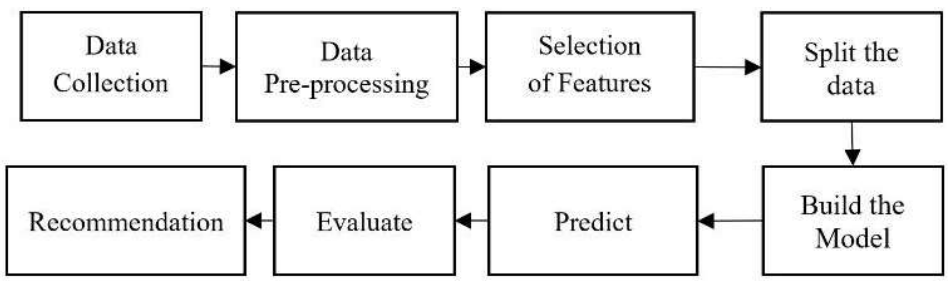

Figure 1. Flow of process for prediction of dengue fever

Data-set

A data-set consisting of daily dengue cases in Bangladesh from 2008 to 2023 was obtained from the Bangladesh health ministry Data website[5].Also the data of temperature from 2008 to 2023 from Bangladesh meteorological department. Which include min temperature, max temperature, humidity and rainfall data[6].

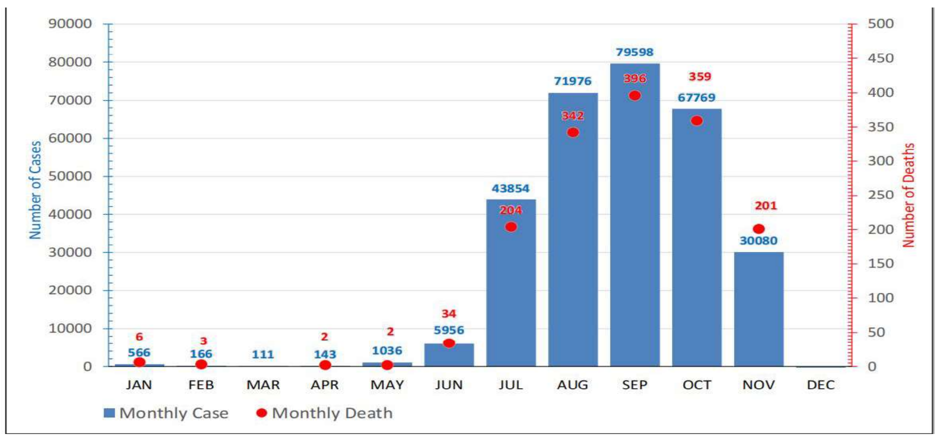

Figure 2. Month Wise case and death 2023[5]

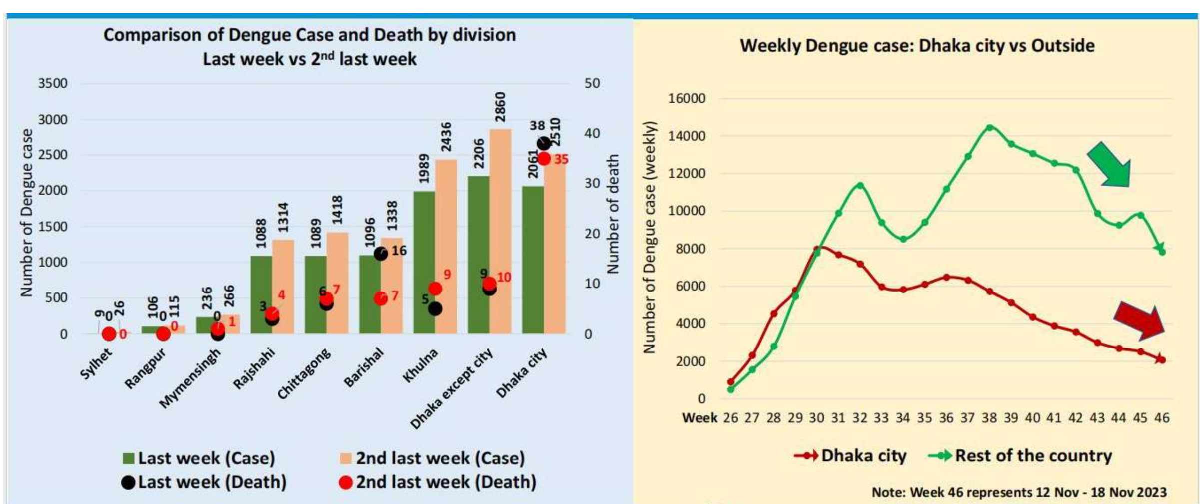

Figure 3. Weekly dengue case and death 2023[5]

RNN based model for prediction of dengue

Figure 4 represents the generic structure of the proposed model for the prediction of dengue cases using recurrent neural network (RNN).

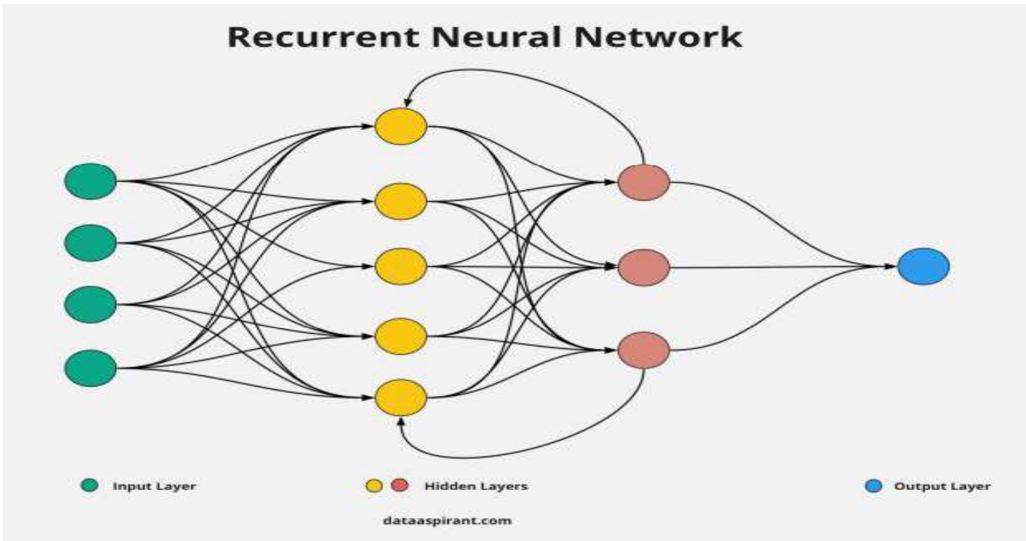

Figure 4. Structure of RNN process[7]

As per this model. The input given is population, rainfall, temperature and humidity. The history of dengue data is also being shared in line with the input and the data is processed using the hidden layers and the expected result is the prediction of number of dengue cases and the cases of death due to dengue.

Figure 5 represents the LSTM-RNN based architecture for the prediction of dengue cases and deaths consists of a hidden layer which is the LSTM. The layer includes a set of 64 memory cells for computing the intermediate results and the resulting values are transferred to the next iteration.[3]

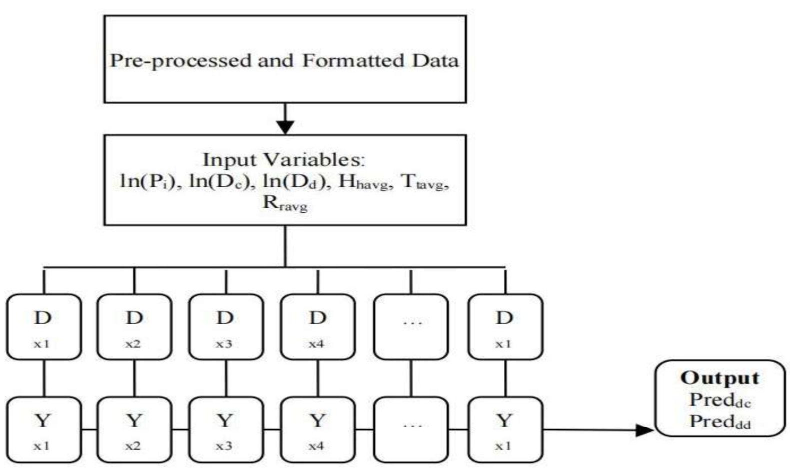

Figure 5. LSTM-RNN architecture for prediction of dengue cases and deaths

Expected Results

From my work we can predict future dengue situation .This predictions enable health authorities to implement proactive measures and allocate resources efficiently. Forecasting Dengue Fever allows for the implementation of targeted public health campaigns, including community awareness programs and mosquito control initiatives.

Conclusion

Researching Dengue Fever forecasting in Bangladesh is imperative due to the significant public health impact of the disease in the region. The research holds the potential to enhance resource allocation efficiency, optimize preventive healthcare strategies, and provide a template for other regions grappling with similar epidemiological challenges.

This Work represents a significant stride in disease prediction methodologies. Particularly the region like Bangladesh that grapples with the recurring challenge of dengue outbreaks.I believe that The proposed model contributes to the field of dengue fever prediction by providing a new approach for modeling and predicting dengue cases.

References

[1] Naher S, Rabbi F, Hossain MM, Banik R, Pervez S, Boitchi AB. Forecasting the incidence of dengue in Bangladesh-Application of time series model. Health Sci Rep. 2022 Jun 8;5(4):e666. doi: 10.1002/hsr2.666. PMID: 35702512; PMCID: PMC9178403.

[2] Majeed MA, Shafri HZM, Zulkafli Z, Wayayok A. A Deep Learning Approach for Dengue Fever Prediction in Malaysia Using LSTM with Spatial Attention. Int J Environ Res Public Health. 2023 Feb 25;20(5):4130. doi: 10.3390/ijerph20054130. PMID: 36901139; PMCID: PMC10002017.

[3] Doni, A. R., & Sasipraba, T. (2020). LSTM-RNN Based Approach for Prediction of Dengue Cases in India. Ingénierie des Systèmes d'Information, 25(3)

[4] Naher S, Rabbi F, Hossain MM, Banik R, Pervez S, Boitchi AB. Forecasting the incidence of dengue in Bangladesh-Application of time series model. Health Sci Rep. 2022 Jun 8;5(4):e666. doi: 10.1002/hsr2.666. PMID: 35702512; PMCID: PMC9178403.

[5] https://old.dghs.gov.bd/index.php/bd/home/5200-daily-dengue-status-report

[6] https://www.bmd.gov.bd/

[7] https://dataaspirant.com/how-recurrent-neural-network-rnn-works/

[8] Kayesh, M. E. H., Khalil, I., Kohara, M., & Tsukiyama-Kohara, K. (2023). Increasing dengue burden and severe dengue risk in Bangladesh: an overview. Tropical Medicine and Infectious Disease, 8(1), 32.