SC 209

DA-IICT Dengue Outbreak and Vulnerability Mapping

What is Dengue and how it spreads

- Dengue is mosquito-borne viral disease caused by the dengue virus. It has four serotypes: **DEN-1**, **DEN-2**, **DEN-3**, **DEN-4**.
- Dengue is transmitted by the **Aedes aegypti** mosquito which bites during daylight hours. It cannot spread directly from one person to another person.
- Female mosquito takes a blood meal from person infected with dengue fever and becomes infected. When this infected mosquito bites an uninfected person, the virus enters into the human body.
- The infected mosquito can transmit the virus for the rest of its life.
- **Symptoms:** Severe headache and fever, pain behind eyes, nausea, vomiting, muscle and joint pains, rashes, etc.

Dengue Outbreak at DAIICT

- The first case of dengue was allegedly detected in DAIICT on the 5th of August, 2019.
- Then the number of cases kept on increasing during successive months.
- Mosquitoes breeding sites are the major places where the disease spread on a large scale.
- Based on parameters that affects the spread of this diseases we designed a predictive model which can give you the degree of precautions you need to take during the current day.

Support Vectors and Danger Index

- The favorability index for mosquitoes breeding is the danger index for humans.
- The breeding of dengue mosquitoes is extremely sensitive to changes in temperature and humidity while almost being independent of rainfall.
- The statistical and laboratory studies obtained the most favorable values of temperature and humidity for their sustainment are:

Temperature = 29 ℃ Humidity > 62 %

Calculation of Danger Index

- The relation for Danger Index can be modelled by **Radial Basis Function.**

$$\textbf{Danger Index} = T_f * H_f$$

Where, T_f = Temperature factor = $e^{(-\,|\textbf{current\_temperarure - 29}|\ \textbf{x 0.1})}$

H_f = Humidity Factor = 1 if humidity > 62 %

$H_f = e^{(-\,|\textbf{current\_humidity - 62}|\ \textbf{x 0.01})}$ otherwise

Predictive Models

- **Short term Model**:- Gives you the danger index by considering the weather conditions of current day only.
- **Medium term model**:- Gives you the danger index by considering the span of past few days along with the current day.
- As the weather of past days also might affect the danger index of current day, medium term model is more practical.

Result of Model

- By running the weather data of Gandhinagar for the year of 2019 through our **(MTM) Medium Term Model**, we found that the results are quite consistent with the actual data.
- During winter and summer seasons, the index lies below 0.5 while in monsoon it shows high peaks as the mosquitoes breeding is more favourable in those days.
- As our Institute observed large number of cases during the month of August, September and October, the results of our prediction model matches with the actual case.

Graphs for Last Year Outbreak

Fig.1. Medium term model results

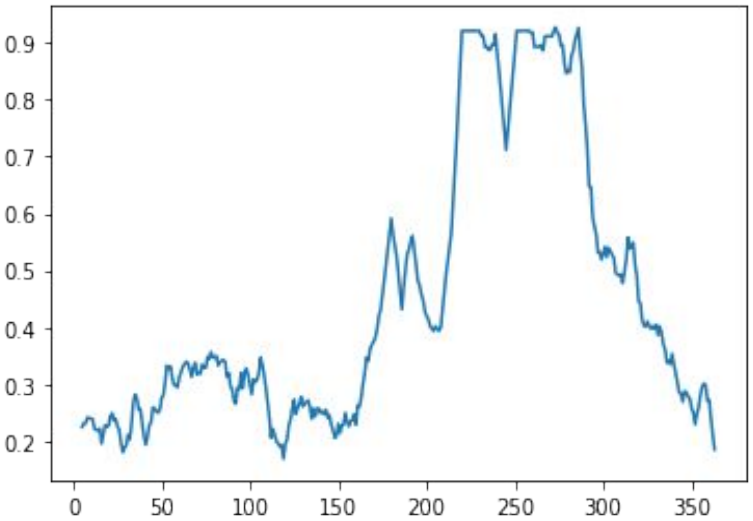
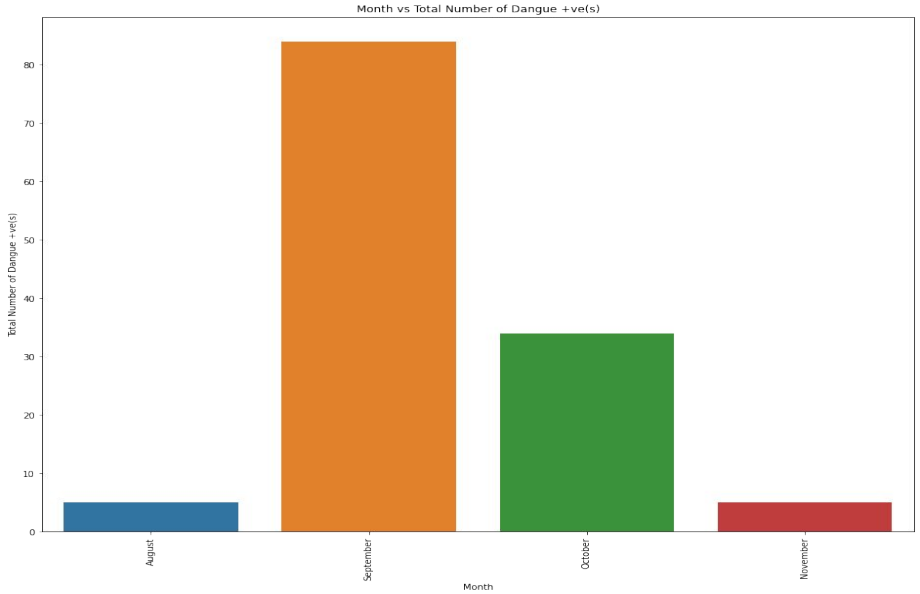


Fig.2. Graph according to actual data



Differential Model

- In this model, we have established various differential equations on the parameters causing the outbreak of dengue and affecting its spread.
- We have calculated different rates with the help of some parameters and equations.
- With this calculation by having the rate of spread of dengue we can estimate the future conditions roughly and we can take actions according to that and cease the spread of this disease.

Understanding of Model

- Here in our Differential Model, we help to calculate the rate of patients getting infected and the susceptible/exposed students on our campus.
- We have also taken the infection rate and death rate of the mosquito under consideration.
- With the help of these rates, we can calculate the currently infected and susceptible hosts and currently infected vectors.

Working of Model (Initial Values)

- **A** = Constant Recruitment Rate of Vector Population = 8
- S_{v0} = Initial No. of Susceptible Vector = 10
- S_{h0} = Initial No. of Susceptible Host = 1600
- I_{v0} = Initial No. of Infected Vector = 1
- I_{h0} = Initial No. of Infected Host = 0
- R_0 = Initial No. of Recovered Patients = 0

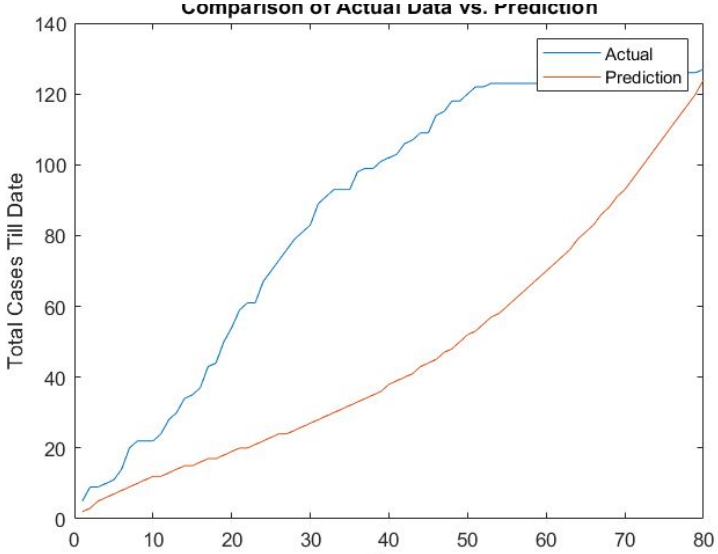
Working of Model (Rates)

- D_v = Death Rate of Vector = 1/12
- D_h = Death Rate of Host = 0
- B_v = Transmission Rate from Host to Vector = 0.000045
- B_h = Transmission Rate from Vector to Host = 0.00097
- **r** = Recovery Rate of Patients = 0.03

Working of Model (Differential Equations)

- $\mathbf{dS_v / dt} = A - B_v S_v I_h - D_v S_v$
- $\mathbf{dS_h / dt} = - B_h S_h I_v$
- $\mathbf{dI_v / dt} = B_v S_v I_h - D_v I_v$
- $\mathbf{dI_h / dt} = B_h S_h I_v - r I_h$
- $\mathbf{dR / dt} = +r I_h$

Output of Differential Model



- With the help of the above explained parameters, constants and the differential equations, our model predicts the total number of cases till date from day 1 to the end of the season.
- Thus we can take precautions and care according to that.

- The blue line shows **actual number of cases** and red line shows **predicted number of cases**.

ML Prediction Model

- We have developed the prediction model that predicts the total number of cases of a day using temperature and humidity. We have developed this model using Deep learning and specifically **ANN (Artificial Neural Networks)**. This model is completely based on previous year's data. the input of the prediction model is
  - High temperature
  - Low temperature
  - Average of Humidity

ML Prediction Model (Data Set)

- We first divided our data into two parts :
  1. 80% of the data as Training data and
  2. 20% of the data as Test data.

- This training data is used for training of the model. The testing data is to evaluate the performance of the model.

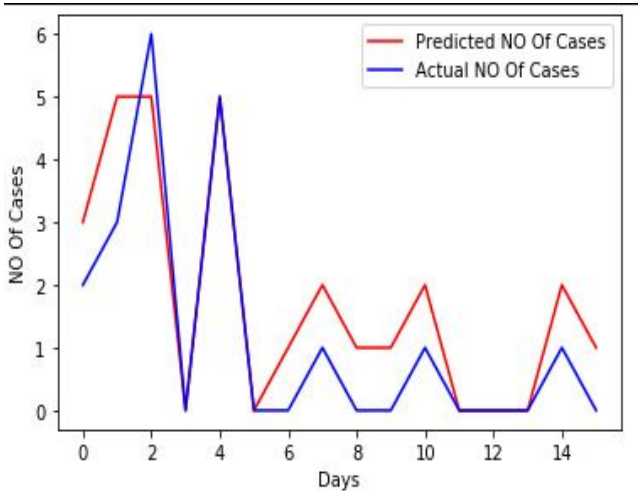
Working of the Model

- Now we created a model using Deep learning that consists of layers that are made of nodes.It has input layer,hidden layers and output layer. It tries to map input to output.
- Now in our model input layer contains 6 nodes: different combination of temperature and humidity. Then we have 3 hidden layer and one output layer consists of 1 node i.e:No of dengue cases per day.
- A node assigns significance to input by combining input with a set of coefficients, or weights and the algorithm then tries to analyze which input is helpful to classify data without error.

Working of the Model

- These input-weight products are summed and then passed to the activation function to determine whether and to what extent that signal should progress further through the network to affect the ultimate outcome.
- Now we have divided our training data sets into batches. And to get accurate results we tried to pass this data set multiple times.We used multiple epochs.
- Now error is calculated as the difference between our prediction and actual output and the function which does this is known as the loss function.

Output of Prediction Model



- From the graph we can see that the red line shows **predicted number of cases** and blue line shows **actual number of cases**. And output is much closer to the actual outcome. Maximum variation is only 1 case per day.
- It turns out that our model's accuracy is **70-75%**. So we can say that the model can predict 2019's outbreak quite accurately.

- Now with this model we can also predict future outbreak for DA-IICT, for that we only have to provide temperature and humidity data to model.

Future Improvements and Challenges

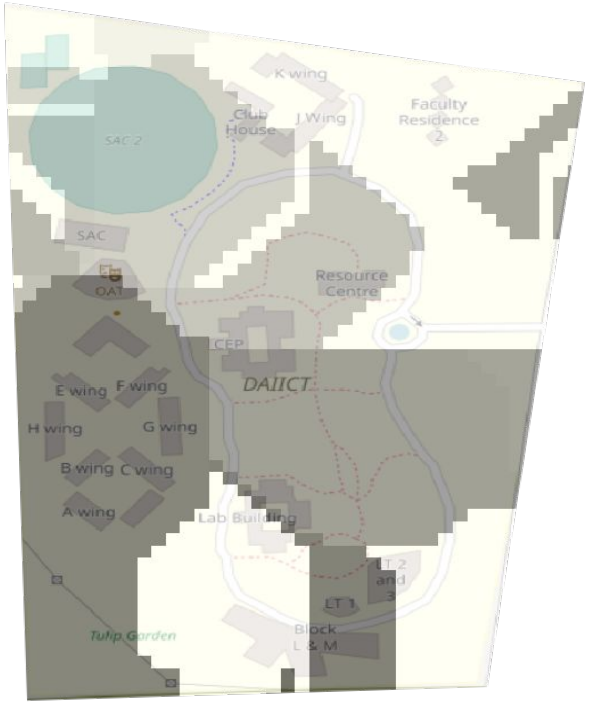
- The model can have a better prediction, and the accuracy can also be increased if the data provided to the model is large enough so by which we can train the model more efficiently and have some better results.
- The model focuses on the humidity and temperature as they are the main factors for dengue. But this also brings challenges with it. The model is trained for the last year’s data. At that time there were many construction activities going on in the campus due to which there were many small pits in the campus where the water could have been accumulated and would ultimately result in breeding of mosquitoes.

Topographical map of DA-IICT.

- Here on the map, different colors are used to represent the altitude of land.
- Meaning of colors
  Green : ~76 meter
  Orange : ~72 meter
  Red : ~71 meter
- Areas that have lower height are more vulnerable because of higher possibilities of waterlogging.
  - Residential Areas for Boys and Girls,
  - Lecture Theaters, and
  - Lab Buildings

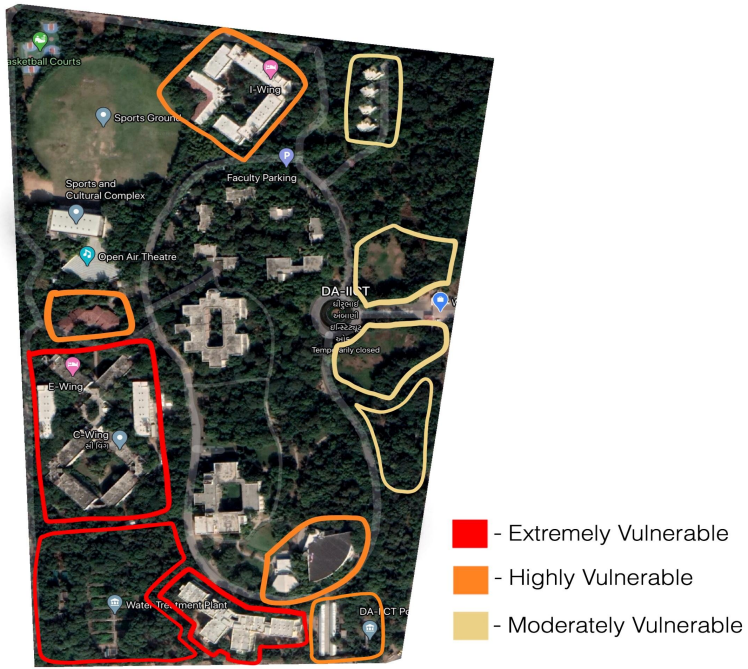
Vulnerability mapping and Drainage basin map

- Dengue Mosquitoes lay eggs into stagnant water. We have analysed basic reasons and source of stagnant water and it turns out to be water accumulation of rainwater.
- We have shown drainage basin map of DAIICT for two different threshold values of certain parameter which has some relevance to elevation angle.
- It is clear that there are more accumulation at HoRs for men and it supports last year's outbreak.



Drainage basin map for 4

Vulnerability map of DAIICT



- Here we have shown a vulnerability map of DAIICT using parameter like stagnant water.
- We have plotted this map using cumulative of both topographical and drainage basin maps.
- According to proposed vulnerability map, management can take different precautions of different degrees according to different places.

The Requirement of Technology To Defeat Dengue

- Using humidity and temperature data from the previous year's outbreak of dengue, we developed a predictive model, which predicts the number of people infected on that day and an application that predicts the vulnerability index of your surrounding environment. According to it, you can act on precautions.
- Other such predictive models are being developed at the macro scale, which can be utilized to minimize the spread, and steps can be taken. These technologies can be utilized for a better and healthy future for humankind.

The Requirement of Technology To Defeat Dengue

- Due to the rapid rate of dengue spread, particularly in tropical and subtropical areas, professionals are implementing new strategies to diagnose better, treat, and contain this disease. The mortality rate has been reduced compared to the past.
- Despite such a significant medical service, dengue has a high infection rate. Using ML algorithms, professionals are developing models to predict the outcome of dengue in various regions based on meteorological data.

Thank You