Journal of Critical Reviews

ISSN- 2394-5125 Vol 7, Issue 8, 2020

EARTHQUAKE IMPACT ASSESSMENT USING NAÏVE BAYESIAN AND LONG SHORT TERM MEMORY MODELS

Tanmoy Das[1], Tamali Halder[2], S.S. Sridhar[3]

[1]B.Tech, Computer Science and Engineering, SRM Institute of Science and Technology, Kattankulathur Guwahati, Assam, India
[2]B.Tech, Computer Science and Engineering, SRM Institute of Science and Technology, Kattankulathur Kolkata, West Bengal, India
[3]Professor, SRM Institute of Science and Technology, Kattankulathur Chennai, Tamil Nadu, India
E-mail: [1]tammydaxx2015@gmail.com, [2]tamali.halder25@gmail.com, [3]sridhars@srmist.edu.in

Received: 08.05.2020 *Revised: 06.06.2020* *Accepted: 30.06.2020*

Abstract
This research work highlights the use of Deep learning Techniques to assess the impact of earthquakes in a place. This research concentrates on studying the impacts of earthquakes on various situations using the Deep Neural Network and the output of the prediction in terms of the impact will be used to appropriately alert the people in earthquake prone areas, so that the damage or loss of resources could be reduced. We used the historical information from various sources with data on earthquakes which have happened as well as the satellite remote sensing data. The data is used to train a deep neural network, after preprocessing of data, and adjusting the weight connections. The model was tested and the desired classes in terms of damage level, whether it is high, moderate or low were predicted. Using the Naïve Bayesian model we achieved an accuracy of 97% and using LSTM we got 98% accuracy.

Keywords--- Deep learning techniques, Recurrent Neural Network, Earthquake impact assessment, satellite image data, remote sensing, LSTM , Naïve Bayesian.

DOI: http://dx.doi.org/10.31838/jcr.07.08.216

INTRODUCTION

Earthquakes are considered to be the important occurrence of all natural calamities. The impact and damage an earthquake can make are very much, in terms of destruction and loss of lives as well as property on a large scale. Researchers have studied the Earthquake impact assessment for many reasons like the emergency planning and mitigation, and the subsequent response and recovery mechanisms. The outcome of these studies directly in the predicting the effect on the infrastructure systems, effect on damage to economy as well as social activities has made these assessments very important ingredients in developing plans which will be used to protect vulnerable communities at the right time.

Predicting earthquakes well in advance can alert the public in saving lives as well as resources at the right time. In this research project we will be studying the impact of earthquakes which have happened in the past through the historical data, using Deep Neural Network. The impact analysis through this network will be used in in alerting the earthquake prone areas in order to reduce the damages to resources. In addition to historical data, remote sensing image data also will be used for the deep neural network. The traditional processes like preprocessing of data, training the neural network, weight adjustments, testing on test data are done. The desired output are the parameters like high, moderate or low damages, based on which appropriate alert messages shall be given.

Deep Learning Techniques are the process applied in data mining using the models, which are certain types of AI and ML algorithms that have become increasingly important over the last few years. Other strategies are as follows. Fully Connected Feed Forward Neural networks are the most common network structures used in the most of the basic network applications. Convolutional Neural Networks (CNN) is a type of special deep network architecture designed for tasks performed using images. The rotating neural network (RNN), in contrast to the neural networks at the front of the feed, can work in a sequence of data with variable input length. The Generative Adversarial Networks (GANs) are very popular because it is an architecture which combines two deep learning neural networks: namely the Generator network, along with a Discriminator Network. The Generator Network generates synthetic data, which is taken by the Discriminator Network which tries to determine whether the data you are viewing is real or generated. Deep learning reinforcement is the use of reinforcement learning to train deep NNs

Recurrent Neural Networks (RNN) are a type of artificial neural network (ANN) in which connections between locations form a linearly directed graph. This allows it to display dynamic temporary performance. Based on neural feed-forward networks, RNNs can use their internal state of memory (memory) to process dynamic evolutionary sequences. This enables them to use tasks such as random, linked handwriting or speech recognition. The term "neural neural network" is used to refer to two broad categories of networks with the same general structure, minimal impact and infinite potential. Both categories of networks show strong short-term performance.

An endogenous pressure recovery network that overcomes an acyclic directed graph is also known as a DAG that can be recruited and replaced by a network that tightens the neural feed, while the nonlinear network is a directed cyclic graph that cannot be registered. RNNs are popular network structures with neuron-like regions which are organized as sequential layers. Each node of a layer is connected by a direct connection (one way) to the remaining node in the next logical layer. Each node (neuron) has real-time limited activation. Each connection (synapse) has a weight whose value can be changed. Nodes are input nodes (receives data from outside the network), output nodes (output results) or hidden nodes (converts data routing paths from output inputs). Monitor monitors in less time settings, the order of priority comes with the original installation tool. Installation sites, one veteran at a time. At any point, each incorporated entity incorporates its functionality into a function

(as a result) that does not reach the sum of all units. The performance of the objective that the management provides is assigned to specific exit units at specific time steps. For example, if speech signal is the input sequence which corresponds to a spoken digit, then the label shall be considered as the target at the end of the sequence which corresponds to the class of the output digit. In the context of reinforcement learning, there won't be any teacher signal which provides objective instruction. Instead the reward function is sometimes used to evaluate the performance of the RNN, termed as affecting the input stream through the output units which is associated with the actuators responsible for environmental disturbances. It can be used for playing games which measures the progress in terms of the points won during a round. Each sequence generates an error in the sum of all target signal deviations from the corresponding activation calculated by the network.

Friction Dampers are components that slip over each other during a strong earthquake. When the components stack on top of one another, they create friction that uses energy that goes into the building, which are actually created by earthquakes. The holes are made of a set of sponge steel plates. Tie them up. With enough force, the plates slip into themselves creating friction. These plates are treated to increase the friction between themselves.

Structural Dynamic Reactions- The response which is dynamical in nature of any system always gives us some idea on how the system behaves due to which dynamic force types. This is essential when designing buildings to prevent earthquakes. If we are designing a building where the earth is vibrating frequently, we can develop the design of the building by knowing how the building reacts to the dynamic energy of specific frequency environments. Therefore, studying dynamic response can prevent building collapse under dynamic load.

Model Calibration – It has been a process used for fine tuning model parameters which force the margin of uncertainty (model parameters and / or model forcing) with a model representation in order satisfy the pre-agreed criteria.

Impact Assessment - Impact Assessment (IA) is another well-defined process for studying the effect and proposed actions for the public and their environment. It is also used in all popular decision making processes, specifically on policies to specific projects.

STATE OF THE ART

[1] created a visual picture (3-D) of the 1906 earthquake with ground shaking. They also demonstrated through animated tools, the various options for extending scientific observations. Their work on simulation also provided a good modeling tool along with texturing feature, lighting and rendering features.

[2] The authors studied the feasibility in using the parameter energy as a criteria to assess the friction dampers' control performances on the multi-story buildings which are under more earthquake prone areas. It is also noted that the responses in the form of structural dynamic output is important in reducing the damages through their method.

Nisraf [3] developed a graphical user interface software package to visualize the impact assessment with more efficient and reliable manner. The process is shown in Fig 1.The objective was to extend the simulation outputs to other fields like hazard characterization, in model calibration, to some extent in instrumentation, then into advanced hazard characterization, more into model updating with feature for building impact assessment tools.

The work was tested on real earthquake prone area countries like Iran. The results thus obtained were used to prepare more dat to be imported into the NetLogo software in order to develop a mathematical model for earthquakes using energy at a place[4]

In this work the model estimates the seismic intensity, time and depth, longitude, latitude, and obtains the necessary results that represent the current model that actually captures some of the trends in the given seismic data. The basic structure is shown in Fig. 2. The current model that can be improved in this work by combining various deep learning models[5]

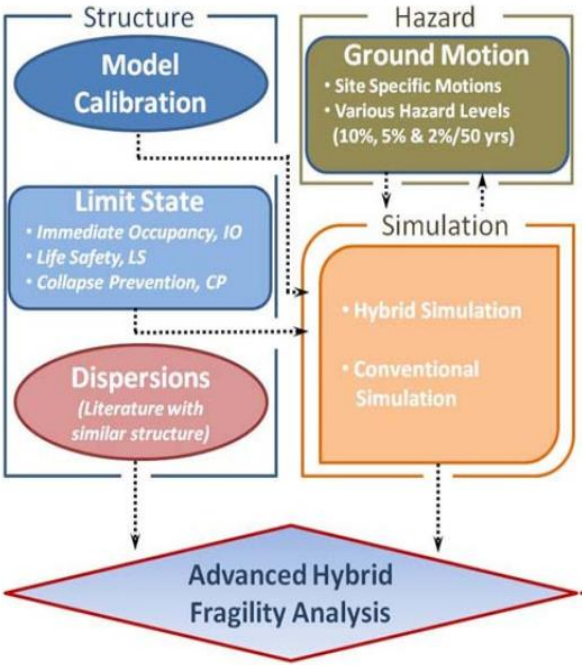

Figure 1. NISRAF Architecture

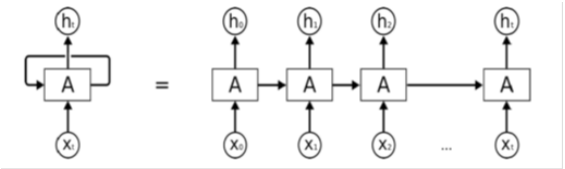

Figure 2. Architecture of RNN

Earthquakes are defined as a natural catastrophic event, where a sudden distortion is induced by the movement of the earth's crust creating a deviance or a fracture along its surface. This sort of an event has an upheaval to the properties and life. In general disasters are beyond the control of human existence and can possibly not be wiped off. There are certain factors, where the control can be taken over with the help of certain technologies and methods to predict the events at an earlier stage. The paper proposes a python model based Customized toolbox is made as an extension tool to ArcGIS that helps to understand the spatial subsurface events through the development of Seismic Information System.[6]

PROPOSED WORK

In this research we will create a deep neural network which will take the parameters as features and from that we will try to classify the damage made by the earthquake in a particular region .At initial we will have six nodes and they will be Remote Sensing data ,Seismic Data ,Geo-Physical data ,Geological data, Pedological data and Historical data. We will have k hidden nodes and h hidden layers as study is still on the process to find the exact value of k and h. We will have three nodes as output

Low damage, Moderate damage and High damage .The flowchart of the proposed model is shown in Fig 3 and general model architecture is given below in Fig 4.

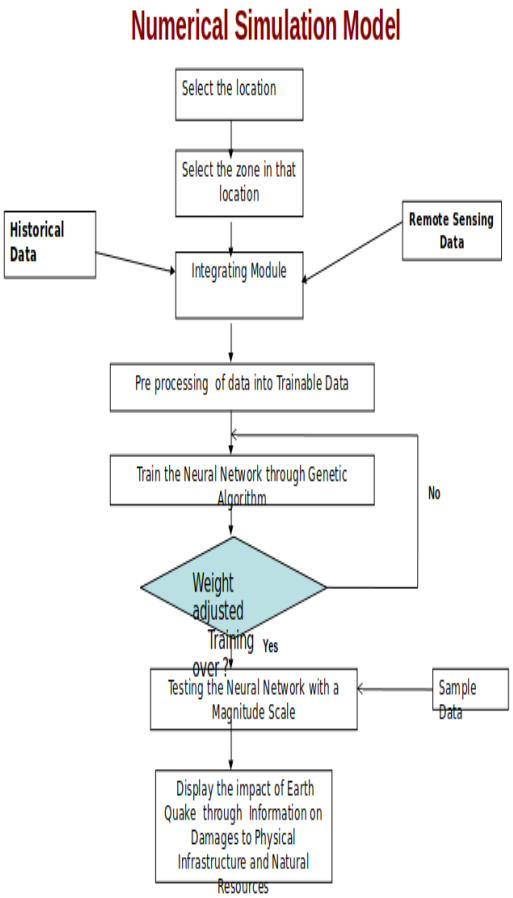

Figure 3. Proposed Model

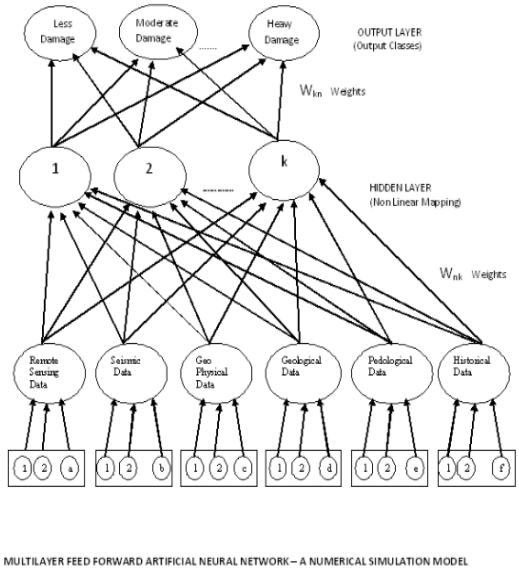

Figure 4. Architecture of Proposed Model

SAMPLE DATA

The data was taken from the NGDC (National Geophysical Data Center) government website. The digital database contains information about Epic Coordinates, Magnitude, Focal Depth, Reporting Cities Names and Coordinates, Severity of Reports and Seismic Center Distance from the City. Earthquakes listed in the digital dataset from 1638 to 1985 in the USA Figure 5 is a picture of the digital dataset we have.

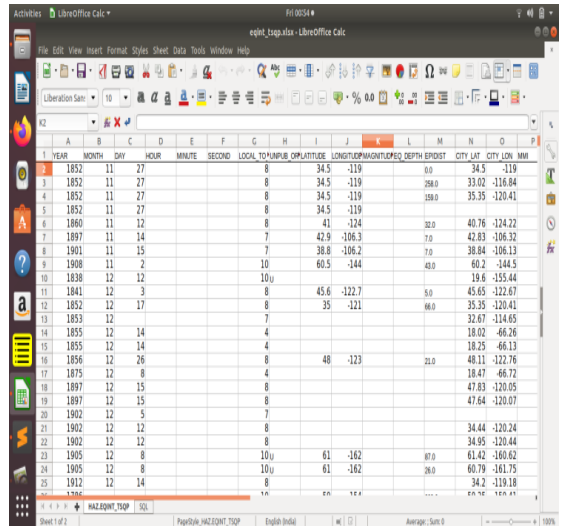

Figure 5. Sample Dataset

Graphs

Study of graphs in Fig 6,7,8 has been done by taking various important parameters as consideration with one redundant feature which is MMI(Modified Mercalli Intensity) that is the basic intensity scale of the earthquakes.

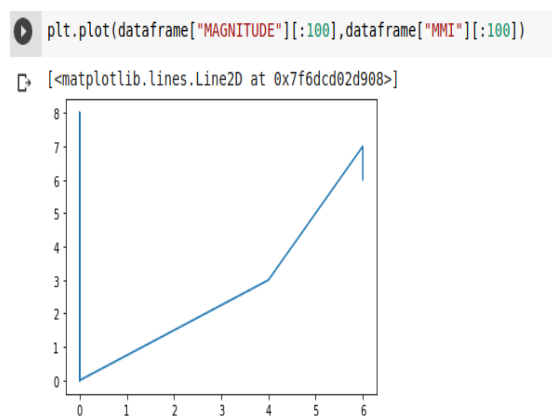

Figure 6. MMI vs Magnitude

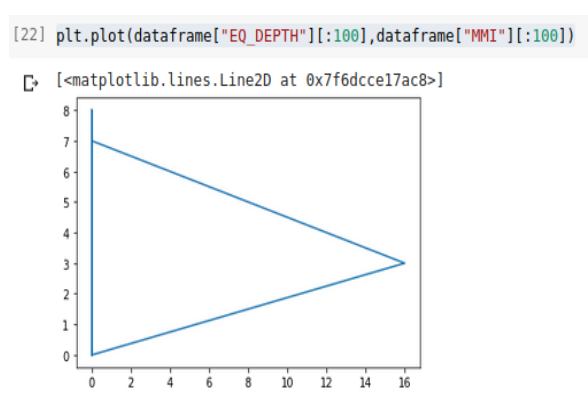

Figure 7. MMI vs EQ_DEPTH (Earthquake Depth)

```
plt.plot(dataframe["EPIDIST"][:100],dataframe["MMI"][:100])
```

```
[<matplotlib.lines.Line2D at 0x7f6dcd1579b0>]
```

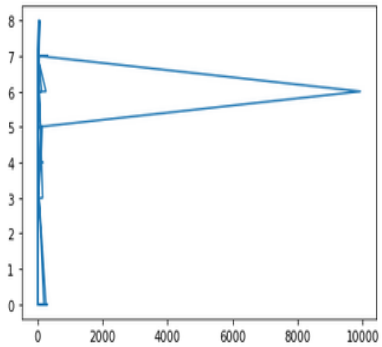

Figure 8. MMI vs EPIDIST(Distance from the epicentre)

Equations

The Deep Learning model we are trying to use is RNN and more specifically LSTM model(Long Short Term Memory). It is better than other types of models because it has memory gates which are used to store weights of previous inputs.

$i_t = \sigma*(w_i*[h_{t-1},x_t]+b_i)$

$f_t = \sigma*(w_f*[h_{t-1},x_t]+b_f)$

$o_t = \sigma*(w_o*[h_{t-1},x_t]+b_o)$

gates : i_t→input ; f_t→forget ; o_t→ output

σsigmoid function

w_x→weight connections between neurons.

h_{t-1}→output of the block in lstm (at time-1).

x_t→input at the current time.

b_x→bias for the neuron(x).

Fig 9 will show the architecture of the LSTM model.

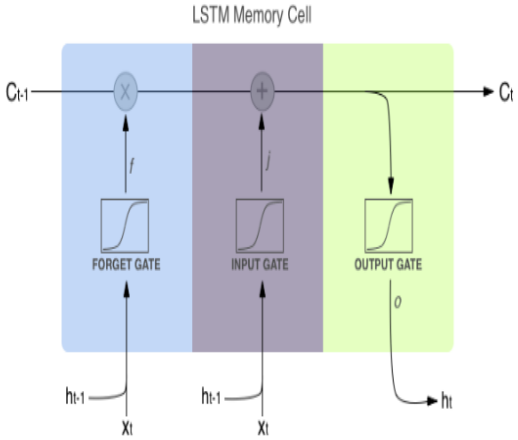

Figure 9. LSTM Model

ADAM Optimizer

ADAM is a flexible learning rate optimization algorithm developed specifically for training deep neural networks. First published in 2014, Adam performed at a very prestigious conference for Intensive Education Practitioners - ICLR 2015. This paper presents some good diagrams, with great performance support in terms of training speed. However, after some time people have found that in some cases Adam actually has a worse solution than the lineage. There has been a lot of research to tackle Adam's problems. Adam uses a fast moving average, calculating the gradients in the existing mini-batch.

$$m_t = \beta_1 m_{t-1} + (1-\beta_1) g_t$$
$$v_t = \beta_2 v_{t-1} + (1-\beta_2) g_t^2$$

MAE Loss Function

Mean absolute error (MAE) is a popular loss calculation function predominantly used in regression models. MAE is average of the sum of the absolute differences of the target and actual outputs. It is a measurement for the average errors present in a set of instructions, excluding their cues. It is called Mean Bias Error (MBE) If the directions are also considered with a range of 0 to ∞.

$$MAE = \frac{\sum_{i=1}^{n} |y_i - y_i^p|}{n}$$

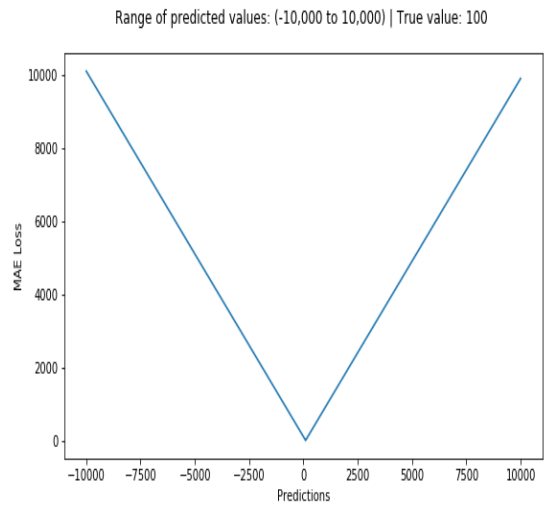

Figure 10. Graph of MAE loss function

RESULTS AND DISCUSSION

The result of our work is to find the impact of earthquakes using MMI, Earthquake depth, distance from the epicenter and richter scale magnitude as in Fig.6,7,8,10. We have successfully completed our research and are able to find out the impact of the earthquake. We have achieved accuracy of 97.1185% by using naive bayes algorithm and got 98.1004% accuracy using LSTM network. The fig.11 depicts the predicted and actual values on naïve Bayesian model, and Fig.12 explains the loss graph of train and test data.

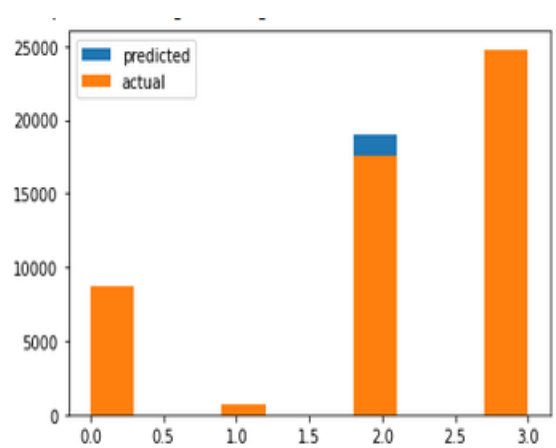

Figure 11. Results from naive bayes algorithm

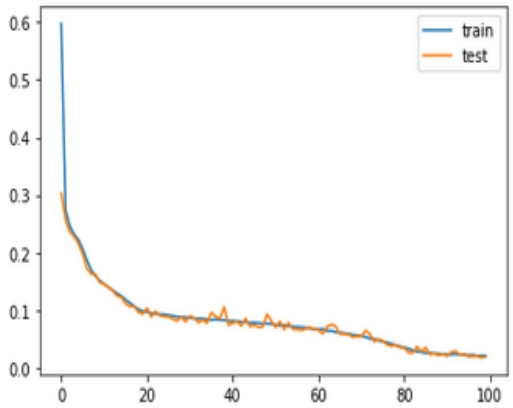

Figure 12. Train and test loss graph

CONCLUSION

In our work, the detection of earthquakes and their assessments are studied. It also presented the ways of minimizing the damages loss using various parameters and techniques. After applying the parameters on naïve Bayesian model we achieved accuracy of 97.1185% and also got 98.1004% accuracy using LSTM network. These results could pave way for more such assessments with other related parameters in future.

REFERENCES

1. Amit Chourasia, Steve Cutchin and Brad Aagaard "Visualizing the ground motions of 1906 San Francisco earthquake "Computers & Geosciences Volume 34, Issue 12, December 2008, Pages 1798-1805
2. Li Pengyun, Lin Jiedong, Nie Ming, Zhong Wanli, Huang Anguo "Vibration Energy of Earthquake-Excited Building Structures based on Computer Simulation" Energy Procedia Volume 17, Part B, 2012, Pages 1116-1123
3. S.L. Lin, A.S. Elnashai, J.Li and B.F. Spencer" Integrated System for earthquake impact assessment" COMPDYN 2011 III ECCOMAS Thematic Conference on Computational Methods in Structural Dynamics and Earthquake Engineering M. Papadrakakis, M. Fragiadakis, V. Plevris (eds.) Corfu, Greece, 25–28 May 2011
4. Mahdi Hashemi, Ali Asghar Alesheikh "Developing an agent based simulation model for earthquakes" International Journal of Geo-Information(SPRS Int. J. Geo-Inf)2018,7, 27
5. Vardaan K, Tanvi Bhandarkar, Nikhil Satish, S. Sridhar, R. Sivakumar, Snehasish Ghosh "Earthquake trend prediction using long short-term memory Recurrent Neural Network" International Journal of Electrical and Computer Engineering (IJECE), Vol.9,No.2, pp.1304-1312, 2019
6. Sreenivasan Narayanan, S.S. Sridhar, R. Sivakumar, "Development of ArcPy Based Customized Tool in GIS for Seismic Information System" , International Journal of Pure and Applied Mathematics, Volume 118 No. 22 , pp. 377-382, 2018
7. P. Shearer, "Introduction to Seismology," Cambridge University Press, 1999.
8. Masashi Hayakawa, "Earthquakes and EQ Prediction," John Wiley Sons, Singapore Pte. Ltd, pp. 1–17, 2015.
9. R. J. Geller, "Earthquake Prediction: A Critical Review, "Geophysical Journal International, vol. 131, pp. 425–450, December 1997.

AUTHOR'S PROFILE

Tanmoy Das, is a senior student in the Computer Science department at SRM institute of Science and Technology, Kattankulathur, Chennai, Faculty of Science, to be completed in the year 2020. His research interest is in machine learning, deep learning ,computer vision, data science and artificial intelligence. He recently focuses on Long Short Term Memory cells using deep learning. He is also a student member of IET (The Institution of Engineering and Technology).

Tamali Halder, is a senior student in the Computer Science department at SRM institute of Science and Technology, Kattankulathur, Chennai, Faculty of Science, to be completed in the year 2020. Her research interest is in machine learning, deep learning, computer vision, data science and artificial intelligence. She recently focuses on Long Short Term Memory cells using deep learning. She is also a student member of IET (The Institution of Engineering and Technology).

Dr. S.S. Sridhar, PhD, is a professor in the Computer Science department at SRM institute of Science and Technology, Kattankulathur, Chennai, Faculty of Science. His research interest is in Artificial Neural Networks, Pattern Recognition and Image Processing. He completed his PhD in Artificial Neural Networks in the year 2015. Master's degree in Software Systems from Birla Institute of Technology in the year 1995. Bachelor's Degree in Computer Engineering from Madurai Kamaraj University in 1990.