School of Engineering and Applied Science (SEAS), Ahmedabad University

B.Tech(ICT) Semester V: Wireless Communication (CSE 311)

- **Group No :** BTS13
- **Group Members :**

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  3) Priyank Sangani (AU1841136)

- **Base Article Title:**

  1) X. Qian, M. Di Renzo, and A. Eckford, "Molecular communications: Model-based and data-driven receiver design and optimization," IEEE Access, vol. 7, pp. 53555–53565, 2019.

  2) Include the new title based on your contributions.

1 New Performance Analysis

- List of symbols and their description

Symbol	**Description**
P_d	Probability of detection
P_{fa}	Probability of false alarm
P_{md}	Probability of mis-detection
M	Number of sensing events

- Introduction/overview

  Long short-term memory (LSTM) is an artificial recurrent neural network (RNN) architecture. Unlike standard feedforward neural networks, LSTM has feedback connections. LSTM networks are well-suited to classifying, processing and making predictions based on time series data LSTMs were developed to deal with the vanishing gradient problem A problem with using gradient descent for standard RNNs is that error gradients vanish exponentially quickly with the size of the time lag between important events. This is due to lim n → W n = 0 $\lim_{n\to\infty} W^n = 0$ $\lim_{n\to\infty} W^n = 0$ if the spectral radius of WWW is smaller than 1 where W is the weight matrix The advantage of an LSTM cell compared to a common recurrent unit is its cell memory unit The cell vector has the ability to encapsulate the notion of forgetting part of its previously stored memory, as well as to add part of the new information.

RNNs using LSTM units partially solve the vanishing gradient problem, because LSTM units allow gradients to also flow unchanged

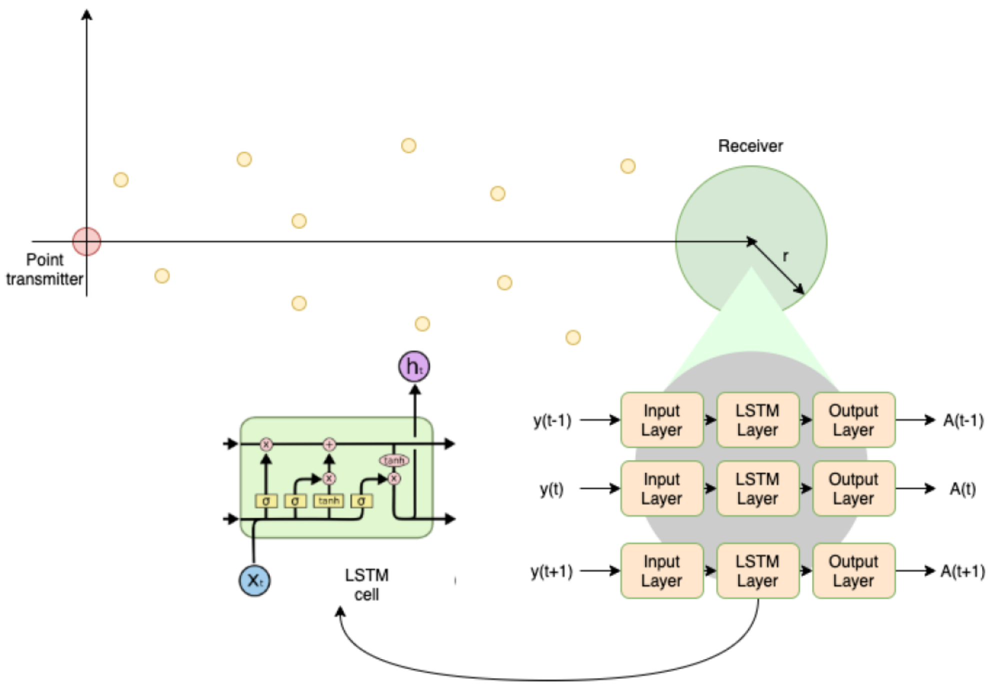
- **System Model/Network Model** :

  Insert the image of system model used in your innovation and clearly describe the channel model, the transmitted signal (e.g BPSK,QAM etc.,) and the nature of noise if applicable.

  There are several architectures of LSTM units. A common architecture is composed of a cell (the memory part of the LSTM unit) and three "regulators", usually called gates, of the flow of information inside the LSTM unit: an input gate, an output gate and a forget gate. Intuitively, the cell is responsible for keeping track of the dependencies between the elements in the input sequence. The input gate controls the extent to which a new value flows into the cell, the forget gate controls the extent to which a value remains in the cell and the output gate controls the extent to which the value in the cell is used to compute the output activation of the LSTM unit. The activation function of the LSTM gates is often the logistic sigmoid function.

- **LSTM Training/Algorithm And Model Selection**

  A RNN using LSTM units can be trained in a supervised fashion, on a set of training sequences, using an optimization algorithm, like gradient descent, combined with backpropagation through time to compute the gradients needed during the optimization process, in order to change each weight of the LSTM network in proportion to the derivative of the error (at the output layer of the LSTM network) with respect to corresponding weight. However, with LSTM units, when error values are back-propagated from the output layer, the error remains in the LSTM unit's cell. This "error carousel" continuously feeds error back to each of the LSTM unit's gates, until they learn to cut off the value.



- **ANN Training And Model Selection**
  The ANN code uses tensor floow and python libraries in order to derive and train the system model. It divides into the testing and training components.The training comprises of 80 percentage of data and testing comprises of remaining 20 percentage of it. here, each dataset corresponds to one SNR and has 100 data items in both input and output which depicts the number of time slots. Also, since our system here uses only one input and one output, the neural network model is meant to be specified with the following parameters. We took the network that has 6 hidden layers comprising of 10 neurons each. Specifically, we use the Bayesian regularization back-propagation technique, which updates the biases and weights by using the Levenberg- Marquardt (LM) optimization algorithm which is as mentioned in the base article as the future prospects and improvements. The data inputted here in the model for training is in the form of batches whose length is decided by the batch size parameter specified in order to reach the maximum accuracy. The batch size specified is 10. Furthermore, We calculate the output of the test data using this ANN model and compare it with actual output to compute the error rate.

2 New Numerical Results

2.1 Simulation Framework

For Data Generation, the parameters used are,

- $SNRRange = -5 : 85$
- $\lambda = 100$
- $r = 45nm$
- $d = 500nm$
- $D = 4.265 * 10^{-10}$
- $\Delta T = 9 * 10^{-6}$
- $T = 30 * \Delta T$
- $L = 5$

For ANN part,

- $Epochs = 100$
- Batch-size = 10
- $Layer = 2$

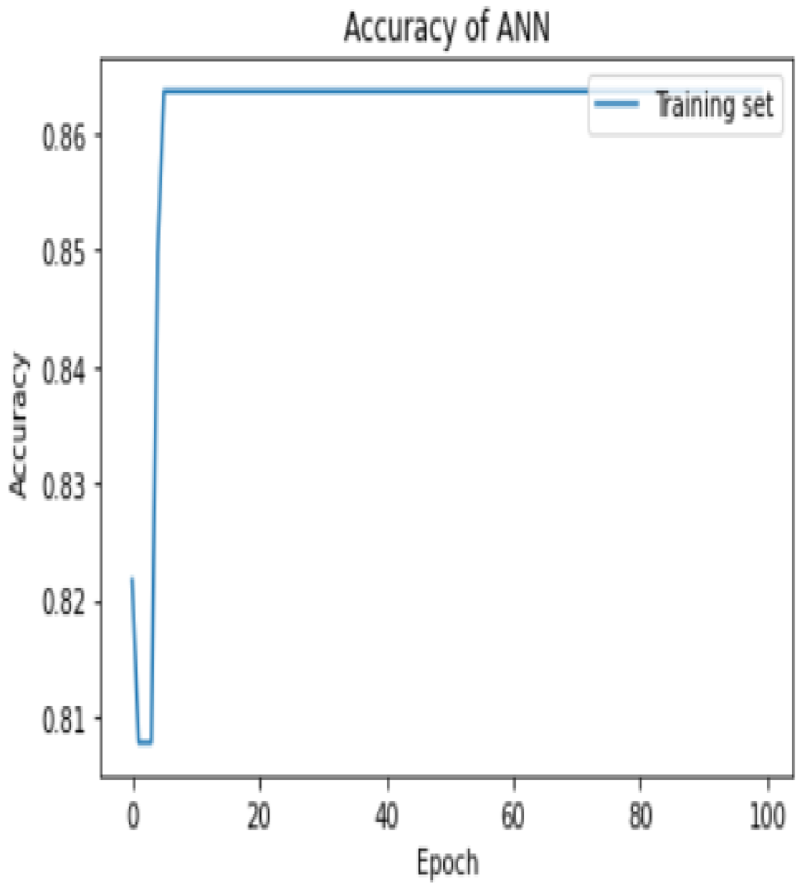
- Activation = tanh and sigmoid
- X-train, Y-train = 80% of data
- X-test, Y-test = 20% of data

For LSTM part,

- $Epochs = 100$
- Batch-size = 150
- input-shape= $(2, 1)$
- $Layer = 2$
- Activation = sigmoid
- X-train, Y-train = 80% of data
- X-test, Y-test = 20% of data

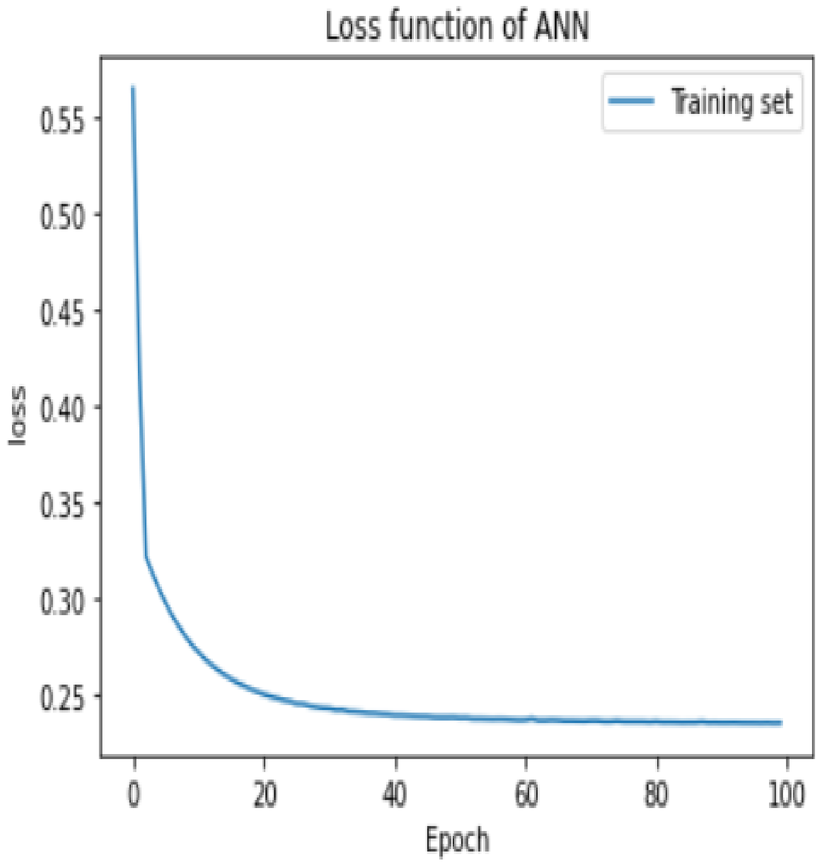
2.2 Description of Figures

- New Figure-1



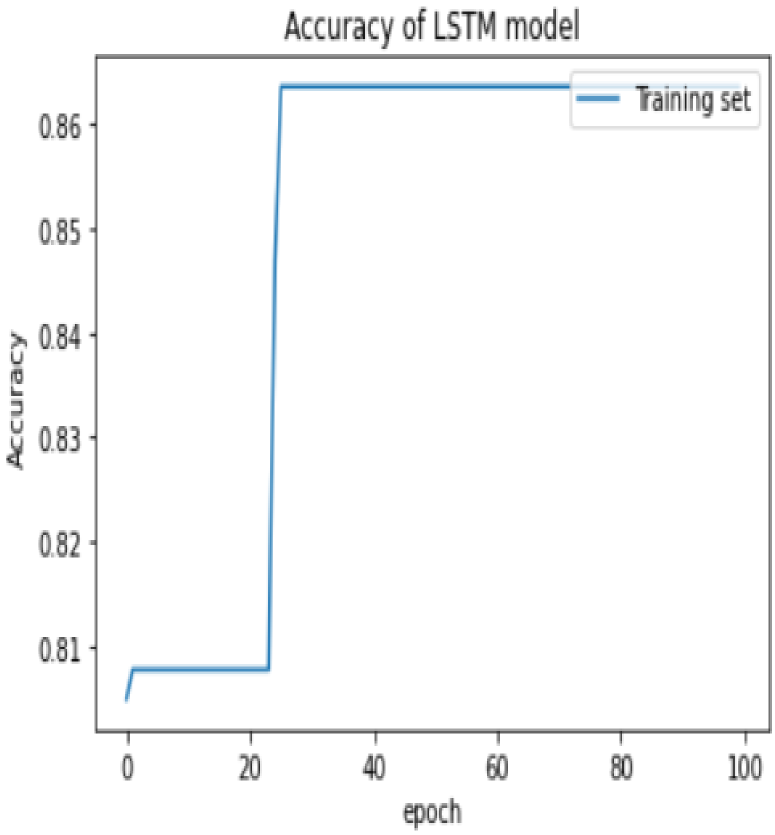
Description: We generated the plot for accuracy of ANN model. Initially, as the data is still training the accuracy turns to be a little low but as it progresses, the accuracy increases.

- New Figure-2



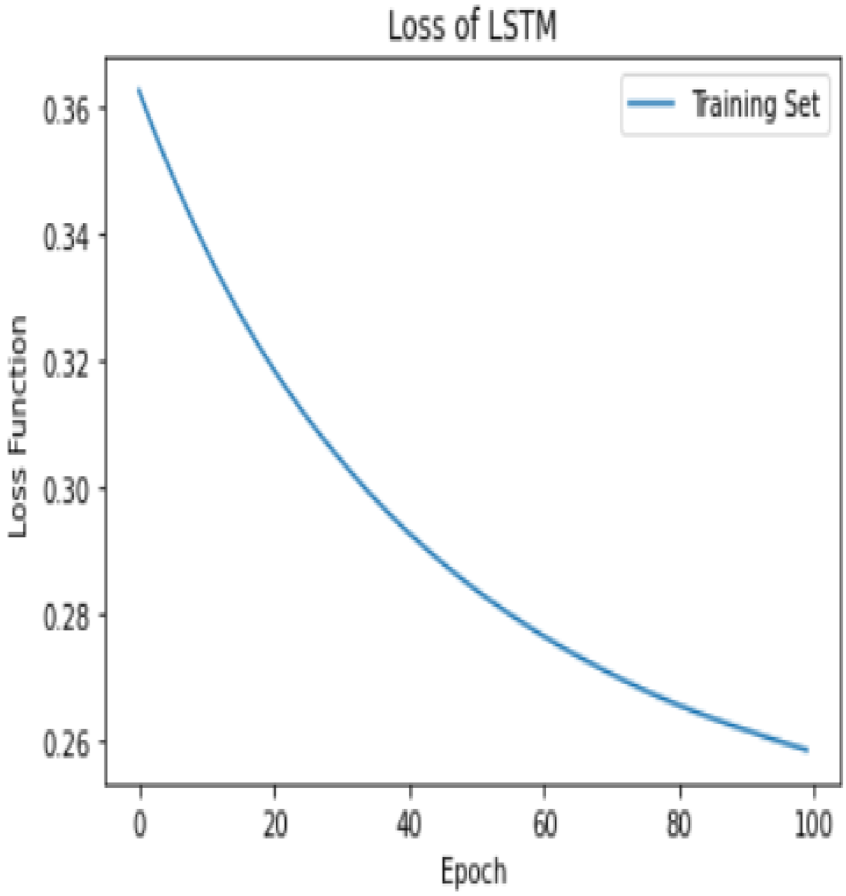
Description: Loss generated is shown in the figure. Initially it is high but it reduces as the iterations increase.

- New Figure-3



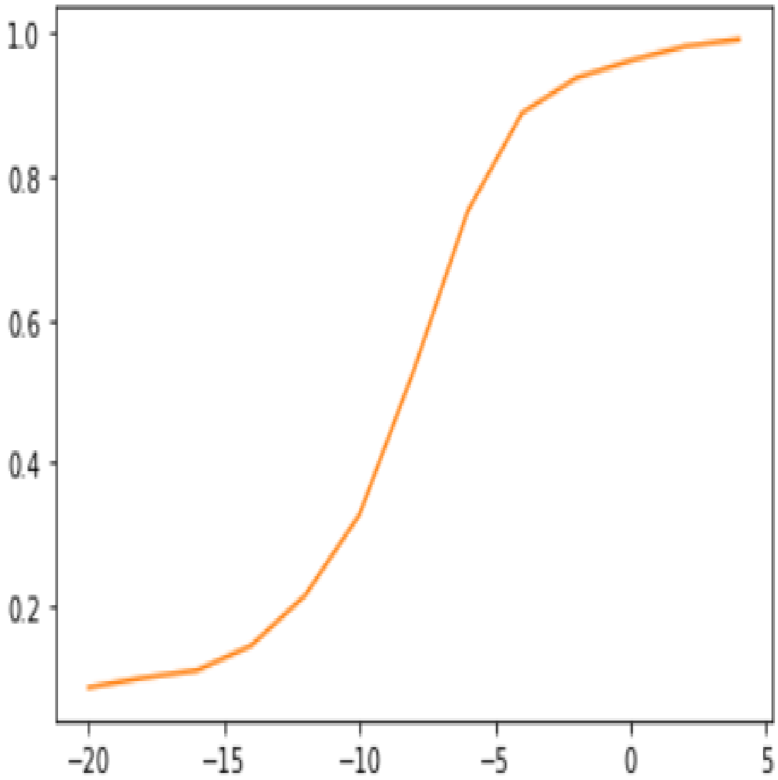
Description: We generated the plot for accuracy of LSTM model. Initially, as the data is still training the accuracy turns to be a little low but as it progresses, the accuracy increases.

- New Figure-4



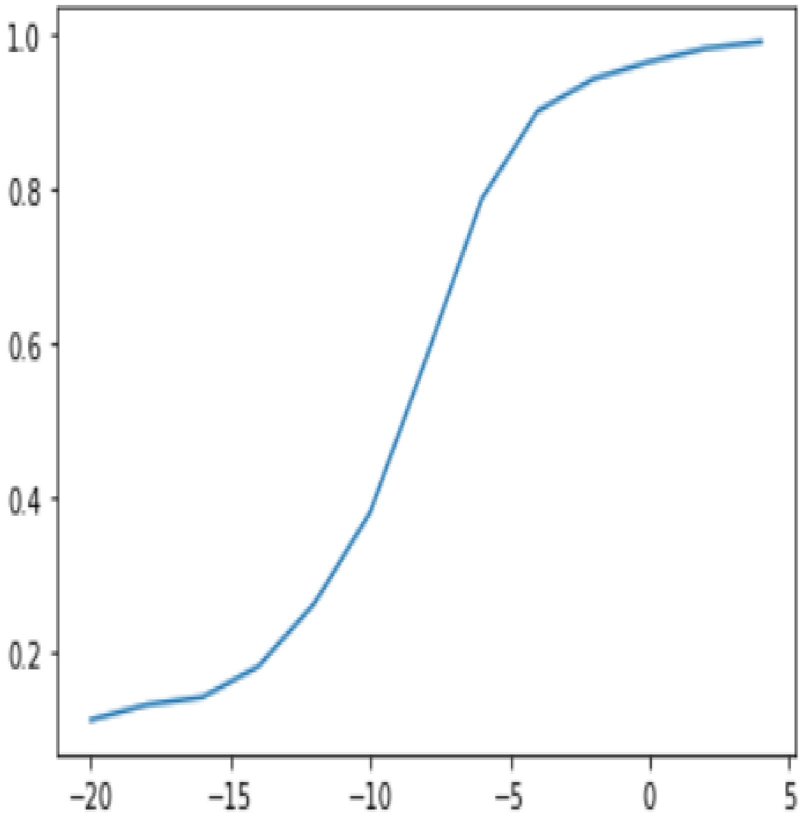
Description: Loss generated is shown in the figure. Initially it is high but it reduces as the iterations increase.

- New Figure-5



Description: BER vs SNR for LSTM

- New Figure-6



Description: BER vs SNR for ANN

3 Contribution of team members

3.1 Technical contribution of all team members

Tasks	Dhruv Shah	Yash R Patel	Priyank Sangani
Mathematical Analysis of base article	✓	✓	✓
Analytical Graphs of base article	✓	✓	✓
Performance analysis of base article	✓	✓	✓
System model research	✓		
Flow Diagram and Conclusion	✓		✓
Simulation of Matlab Codes		✓	
Simulation of Data-driven Codes	✓	✓	✓
Latex Coding		✓	✓

3.2 Non-Technical contribution of all team members

Tasks	Dhruv Shah	Yash R Patel	Priyank Sangani
Introduction and Motivation		✓	✓
Overview and Background	✓	✓	
Leadership and Co-ordination of team	✓	✓	✓
Report Writing and Reviewing	✓		✓
Presentation Slide	✓	✓	✓
Presentation Video	✓	✓	✓
Miro Framework	✓		✓
Report Writing and Reviewing	✓	✓	✓
Inference for reproduced results	✓	✓	✓