



Experiment No.: 1

Title: Back propagation algorithm (VLAB)



Aim: To understand backpropagation algorithm

Resources needed: Virtual Lab

Theory:

Backpropagation, short for "backward propagation of errors," is an algorithm for supervised learning of artificial neural networks using gradient descent. Given an artificial neural network and an error function, the method calculates the gradient of the error function with respect to the neural network's weights. It is a generalization of the delta rule for perceptrons to multilayer feedforward neural networks. The "backwards" part of the name stems from the fact that calculation of the gradient proceeds backwards through the network, with the gradient of the final layer of weights being calculated first and the gradient of the first layer of weights being calculated last. Partial computations of the gradient from one layer are reused in the computation of the gradient for the previous layer. This backwards flow of the error information allows for efficient computation of the gradient at each layer versus the naive approach of calculating the gradient of each layer separately.

The algorithm

Each training iteration of NN has two main stages

- 1) Forward pass/propagation
- 2) BP

The BP stage has the following steps:

- 1) Evaluate error signals for each layer.
- 2) Use the error signal to compute error gradients.
- 3) Update layer parameters using the error gradients with an optimization algorithm such as GD.

How Backpropagation Algorithm Works?

The Back propagation algorithm in a neural network computes the gradient of the loss function for a single weight by the chain rule. It efficiently computes one layer at a time, unlike a native direct computation. It computes the gradient, but it does not define how the gradient is used. It generalizes the computation in the delta rule.

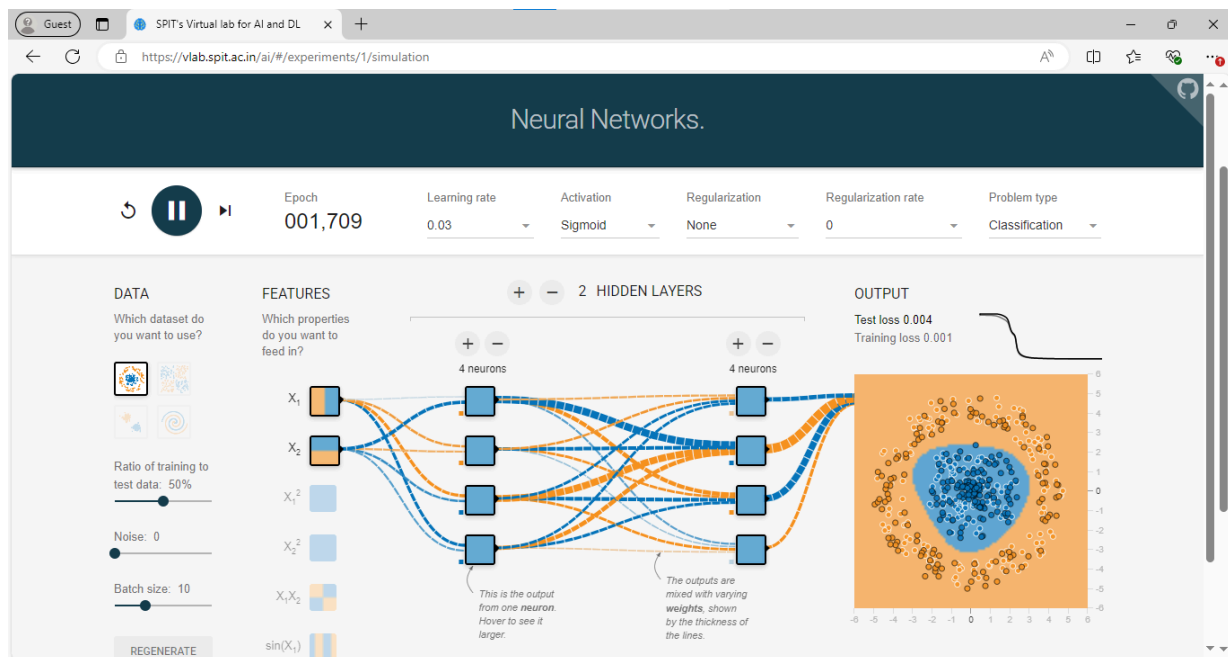
Activity:

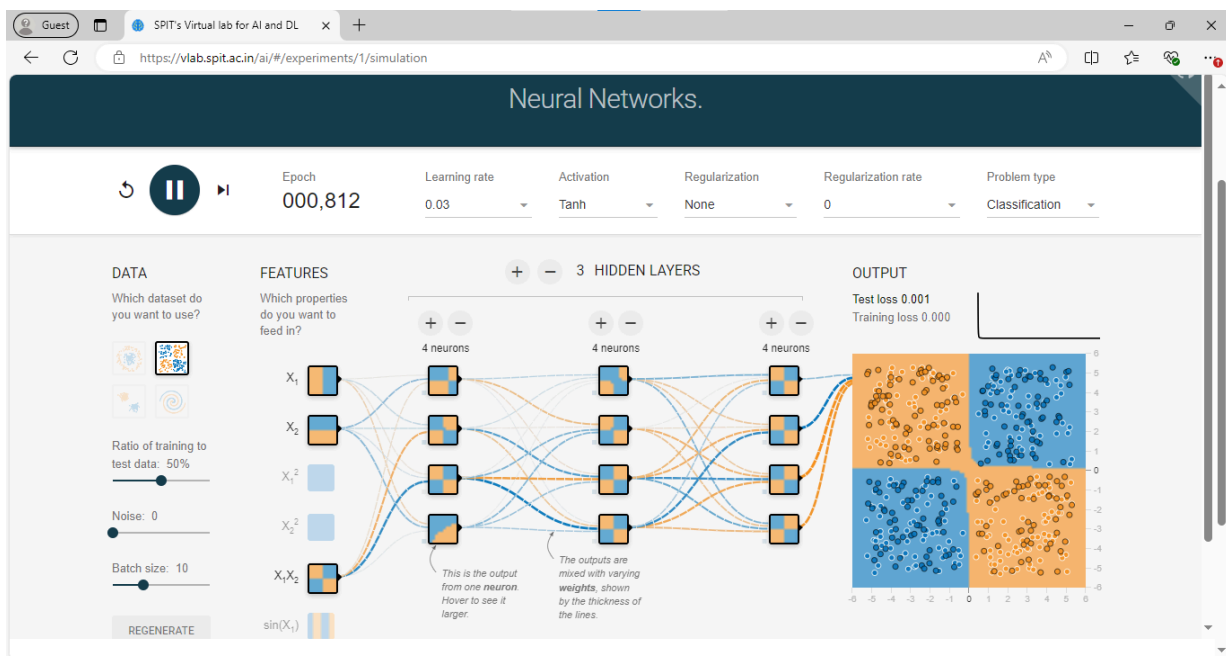
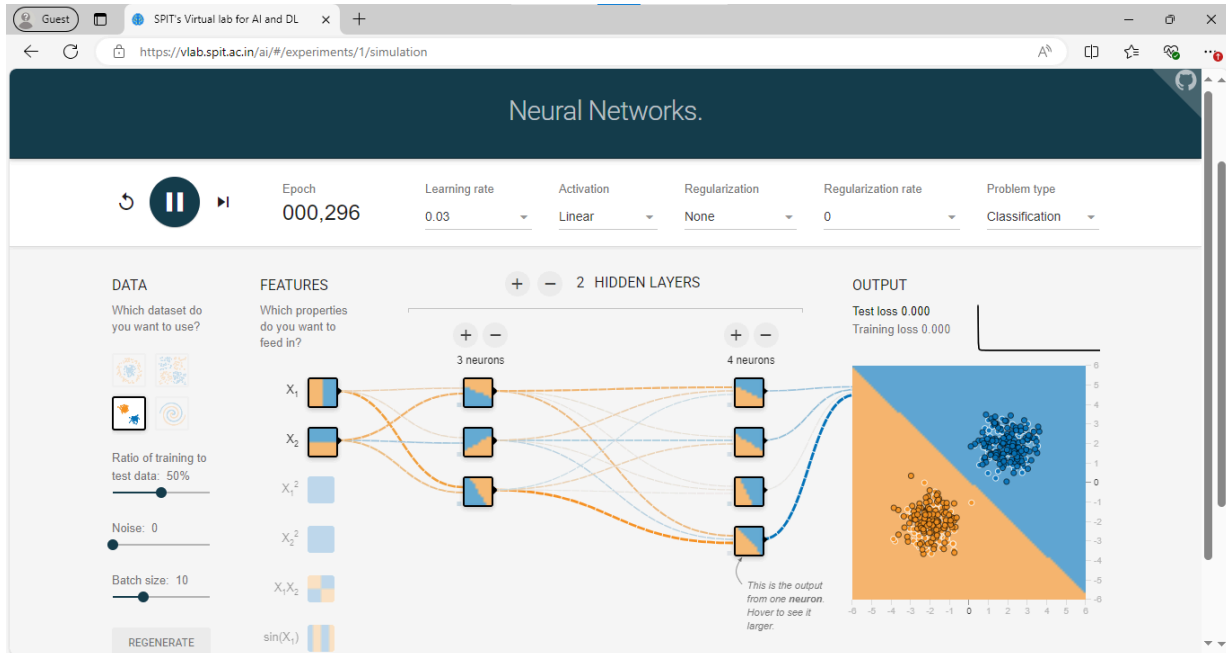
- 1) Refer the following website:
<https://vlab.spit.ac.in/ai/#/experiments/1>
- 2) Follow the steps given in the procedure.
- 3) Run the simulation for
 - a) Select any one dataset and type of problem.
 - b) Choose the input function of your choice.
 - c) Select no of hidden layers and no of hidden neurons.
 - d) Select the hyperparameters such as learning rate, epochs, activation function, etc.
 - e) Train and test the network.
- 4) Analyze the effect of regularization on network efficiency.

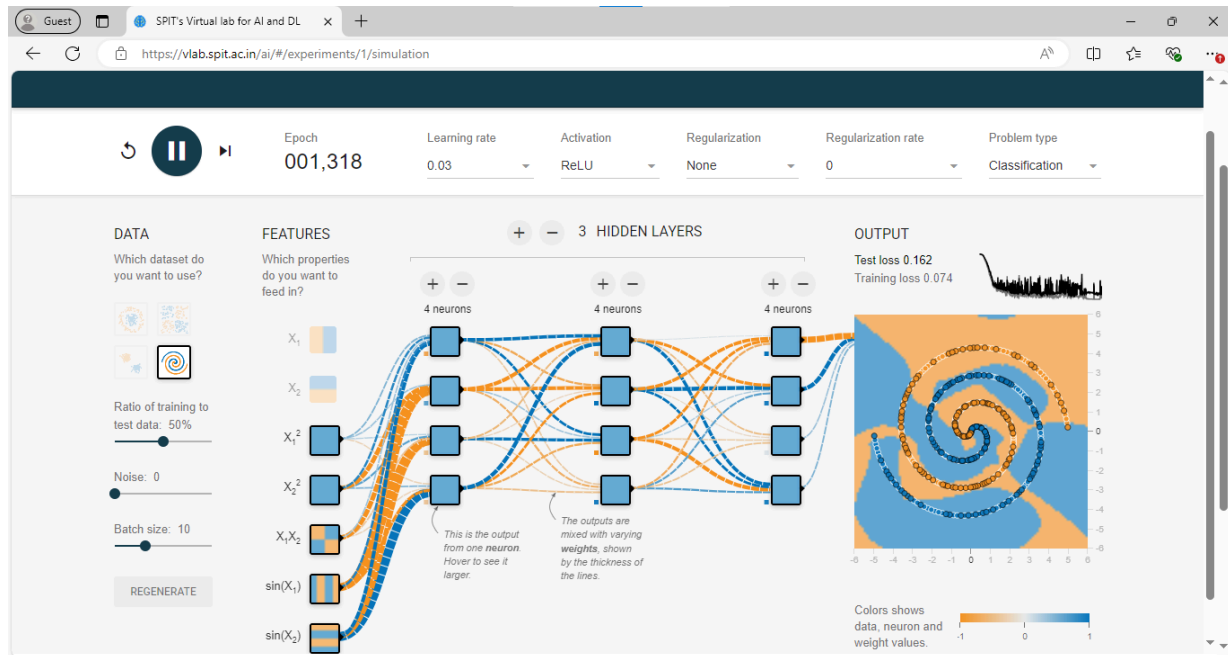
Output:

Put the screenshots of the network and output.

Attempt post-test questions and put the screenshots in this section.







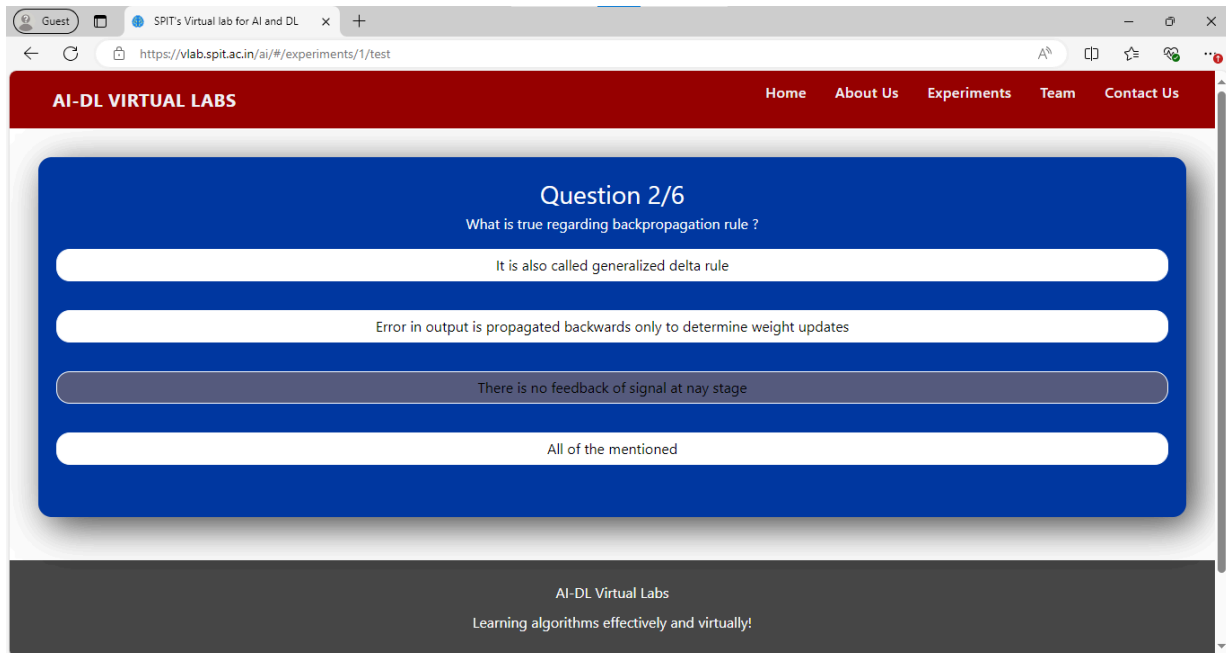
The screenshot displays the AI-DL Virtual Labs test interface. The top navigation bar shows the URL <https://vlab.spit.ac.in/ai/#/experiments/1/test>. The interface includes a header with the text "AI-DL VIRTUAL LABS" and a navigation menu with links: Home, About Us, Experiments, Team, and Contact Us.

The main area shows a question titled "Question 1/6" with the text "What is the objective of backpropagation algorithm?". There are three multiple-choice options:

- To develop learning algorithm for multilayer feedforward neural network
- To develop learning algorithm for single layer feedforward neural network
- To develop learning algorithm for multilayer feedforward neural network, so that network can be trained to capture the mapping implicitly

The third option is selected. The footer of the interface contains the text "AI-DL Virtual Labs" and "Learning algorithms effectively and virtually!"

3. To develop learning algorithm for multilayer feedforward neural network, so that network can be trained to capture the mapping implicitly



A screenshot of a web browser displaying the 'AI-DL VIRTUAL LABS' interface. The browser's address bar shows the URL 'https://vlab.spit.ac.in/ai/#/experiments/1/test'. The page has a red header with the site name and navigation links: Home, About Us, Experiments, Team, and Contact Us. The main content area is a blue box titled 'Question 2/6' with the text 'What is true regarding backpropagation rule?'. Below the question are four white input fields. The first field contains the text 'It is also called generalized delta rule'. The second field contains 'Error in output is propagated backwards only to determine weight updates'. The third field, which is highlighted with a dark blue background, contains 'There is no feedback of signal at nay stage'. The fourth field contains 'All of the mentioned'. At the bottom of the page, there is a dark grey footer with the text 'AI-DL Virtual Labs' and 'Learning algorithms effectively and virtually!'.

Question 2/6

What is true regarding backpropagation rule ?

It is also called generalized delta rule

Error in output is propagated backwards only to determine weight updates

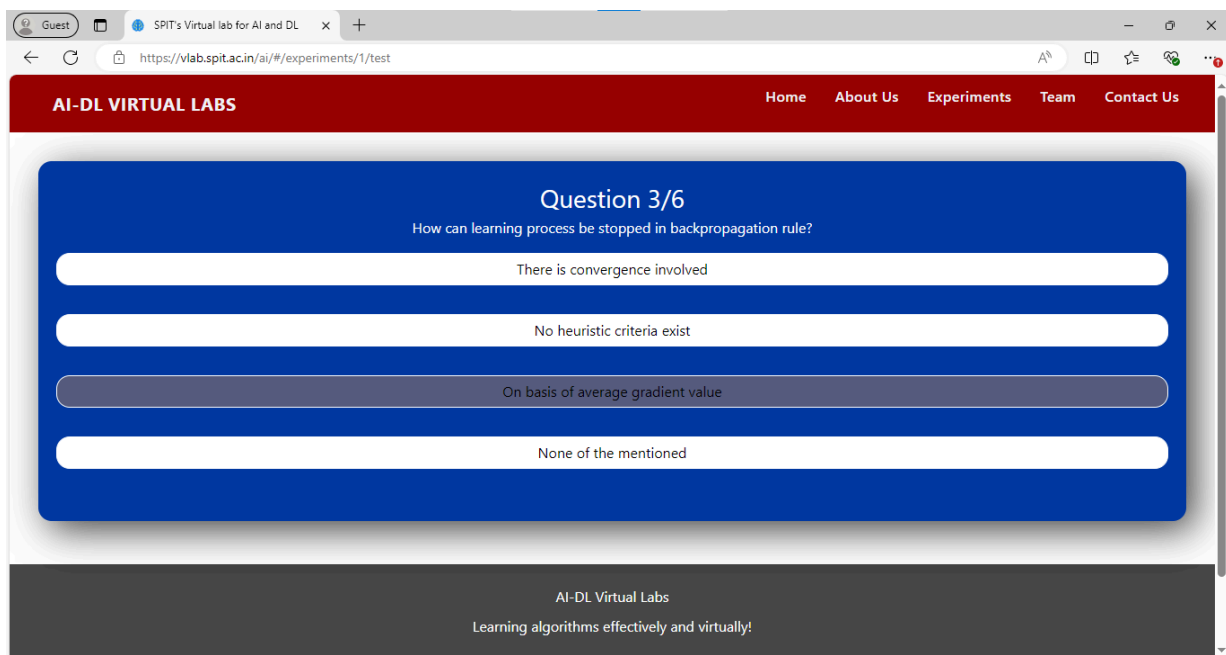
There is no feedback of signal at nay stage

All of the mentioned

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3. There is no feedback of signal at any stage



A screenshot of the same 'AI-DL VIRTUAL LABS' web interface, showing 'Question 3/6' with the text 'How can learning process be stopped in backpropagation rule?'. There are four white input fields. The first field contains 'There is convergence involved'. The second field contains 'No heuristic criteria exist'. The third field, highlighted with a dark blue background, contains 'On basis of average gradient value'. The fourth field contains 'None of the mentioned'. The footer is identical to the previous screenshot.

Question 3/6

How can learning process be stopped in backpropagation rule?

There is convergence involved

No heuristic criteria exist

On basis of average gradient value

None of the mentioned

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4. On basis of average gradient value

A screenshot of a web browser displaying the 'AI-DL VIRTUAL LABS' interface. The browser's address bar shows the URL 'https://vlab.spit.ac.in/ai/#/experiments/1/test'. The page has a red header with the site name and navigation links: Home, About Us, Experiments, Team, and Contact Us. The main content area is a blue box titled 'Question 4/6' with the text 'There is feedback in final stage of backpropagation algorithm?'. Below the question are two radio button options: 'Yes' (selected) and 'No'. At the bottom of the page is a dark grey footer with the text 'AI-DL Virtual Labs' and 'Learning algorithms effectively and virtually!'.

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Question 4/6

There is feedback in final stage of backpropagation algorithm?

Yes

No

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2. No

A screenshot of the same 'AI-DL VIRTUAL LABS' web interface, now showing 'Question 5/6'. The question text is 'What are general limitations of back propagation rule?'. There are four radio button options: 'Local minima problem', 'Slow convergence', 'Scaling' (selected), and 'All of the mentioned'. The rest of the interface, including the header, navigation links, and footer, remains the same as in the previous screenshot.

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Question 5/6

What are general limitations of back propagation rule?

Local minima problem

Slow convergence

Scaling

All of the mentioned

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3. Scaling

The screenshot shows a web browser window with the URL <https://vlab.spit.ac.in/ai/#/experiments/1/test>. The page has a red header with the text "AI-DL VIRTUAL LABS" and navigation links: Home, About Us, Experiments, Team, and Contact Us. The main content area is a blue box titled "Question 6/6" with the text "What are the general tasks that are performed with backpropagation algorithm?". Below the text are four white input fields with the following options: "Pattern mapping", "Function approximation", "Prediction", and "All of the mentioned". The "All of the mentioned" option is highlighted with a dark blue background. At the bottom of the page, there is a dark grey footer with the text "AI-DL Virtual Labs" and "Learning algorithms effectively and virtually!".

4. All of the mentioned

The screenshot shows the same web browser window as the previous one, but the main content area is now a blue box with the text "You scored 6 out of 6". Below the text is a cyan button with the text "GO TO EXPERIMENTS". The header and footer remain the same as in the previous screenshot.

Outcome: CO1 – Understand the evolution of Deep Learning.

Conclusion:

The backpropagation algorithm is a fundamental technique in training artificial neural networks, enabling efficient learning by minimizing the error through gradient descent. By propagating the error backward through the network, it updates the weights systematically, improving the model's accuracy. The experiment provided hands-on experience in implementing backpropagation, adjusting hyperparameters, and analyzing the impact of regularization on network efficiency. This reinforced the understanding of deep learning principles and the role of optimization techniques in neural network training.

Grade: AA / AB / BB / BC / CC / CD / DD

Signature of faculty in-charge with date

References:

Books/ Journals/ Websites:

- 1) Jacek M. Zurada, "Introduction to artificial neural systems", West Publishing Company
 - 2) <https://vlab.spit.ac.in/ai/#/experiments/1>
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