**Department of Artificial Intelligence**

**College of Computer and Cyber Sciences**

**Introduction to Deep Learning**

***Debugging Common Issues in Neural Network Implementation***

1. **Learning Objectives**

By the end of this lab, students will:

* Understand **LeNet-5**, its architecture, and its implementation in PyTorch.
* Identify and **debug** common errors in neural network architectures.
* Learn **debugging techniques** to fix issues in deep learning models.

1. **Explanation of Key Concepts**

* **LeNet-5:**

LeNet-5 is a CNN architecture developed by Yann LeCun in 1998 for digit recognition. It consists of two convolutional layers, subsampling layers, fully connected layers, and an output layer, and it was a key milestone in the development of deep learning for image classification.

A diagram of a diagram

Description automatically generated

* **Debugging:**

Debugging is the process of identifying, analyzing, and fixing errors or bugs in software code. It involves systematically testing and inspecting the code to find the source of problems, such as incorrect outputs or crashes, and making corrections to ensure the program runs as intended.

In the context of AI, debugging refers to the process of identifying, analyzing, and resolving issues in machine learning models, algorithms, or AI systems. It involves examining data, model performance, and code to detect errors, improve accuracy, and ensure the AI system functions as expected.

* **Some Debugging Techniques in Deep Learning:**
  1. Verify Input Data Consistency: Ensure that the input data has the correct shape, format, and type expected by the model.
  2. Check Layer Configuration: Review the architecture's layer configurations, such as input/output dimensions and activation functions.
  3. Tune Hyperparameters: Experiment with different hyperparameters such as learning rate, batch size, and optimizer settings.
  4. Analyze Loss Function Behavior: Examine the behavior of the loss function during training.
  5. Monitor Training and Validation Curves: Track the training and validation loss curves to identify issues like overfitting or underfitting.

1. **Activities**

* **Exercise 1: Building a LeNet-5 Model for MNIST Classification.**

In this exercise, we will build a LeNet-5 model for classifying handwritten digits from the MNIST dataset using PyTorch.

|  |
| --- |
| # Code provided in the notebook |

Screenshot of the result:

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1. **Tasks**

* **Task 1:**

In this task, you will debug and optimize the LeNet-5 model we built in Exercise 1. You will identify common errors in the model architecture, defined functions, training loop, and validation loop.

Submit your jupyter notebook & Add a screenshot of the result:

|  |
| --- |
| Jupyter notebook submitted |

* **Task 2:**

Use the table below to document the issue in the model, how to fix it, and the reason why it needs to be fixed.

(Using ChatGPT or any other Chatbot is completely prohibited).

|  |  |  |
| --- | --- | --- |
| **Bug** | **How to Fix it** | **Why Should It Be Fixed** |
| Learning rate is 0 | Set learning rate to 0.01 | In gradient descent formula, learning rate is multiplied by the gradient, if learning rate is 0, it will make the gradient 0 as well, so the weights will not update |

1. **References**

[Neural Networks — PyTorch Tutorials 2.6.0+cu124 documentation](https://pytorch.org/tutorials/beginner/blitz/neural_networks_tutorial.html)

[Gradient-Based Learning Applied to Document Recognition](http://vision.stanford.edu/cs598_spring07/papers/Lecun98.pdf)

[Lenet-5 | Lenet-5 Architecture | Introduction to Lenet-5](https://www.analyticsvidhya.com/blog/2021/03/the-architecture-of-lenet-5/)

[LeNet 5 Architecture Explained. In the 1990s, Yann LeCun, Leon Bottou… | by Siddhesh Bangar | Medium](https://medium.com/@siddheshb008/lenet-5-architecture-explained-3b559cb2d52b)

[What is Debugging in Software Engineering? - GeeksforGeeks](https://www.geeksforgeeks.org/software-engineering-debugging/)

[What Is Debugging? | IBM](https://www.ibm.com/think/topics/debugging)

[9 Steps of Debugging Deep Learning Model Training](https://neptune.ai/blog/debugging-deep-learning-model-training)