Assignment 3 Report - COS314

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Compiling and Running

The submission includes the following files:

1. **ANN.cpp:** The C++ source code file containing the implementation of the Artificial Neural Network (ANN) model.
2. **makefile:** A Makefile to facilitate the compilation and execution of the ANN.cpp file.
3. **mushroom_train.csv:** The dataset used for training the ANN model.
4. **mushroom_test.csv:** The dataset used for testing the ANN model.

Compilation and Execution:

1. Open a terminal or command prompt in the directory containing the submitted files.
2. To compile the program, run the following command: **make**
    a. This will generate an executable file named `neural_network`.
3. To run the program, execute the following command: **make run**
    a. This will train the ANN on the training dataset, evaluate its performance on the testing dataset, and display the results, including the seed value used for reproducibility.

Data Preprocessing

The dataset was normalized before training the Artificial Neural Network.

The following steps were taken:

- **Min-Max Scaling:** Each feature in the dataset was normalized using min-max scaling to ensure that all features were on a similar scale, ranging from 0 to 1. The model was trained for a fixed number of 500 epochs. The error rate fluctuated during training, indicating that the model may not have fully converged. However, the consistent decrease in the average error over time suggests that the model was learning and improving its performance.

Model Architecture

- **Activation Function (Output Layer):** The sigmoid activation function was chosen for the output layer because it squashes the output into a probability range between 0 and 1, which is suitable for binary classification problems. This allowed the interpretation of the output class being 1 or 0.
- **Learning Rate:** A learning rate of 0.01 was selected. This value was chosen through experimentation, starting with a larger value and gradually decreasing it until the model showed stable convergence during training. A smaller learning rate helped prevent the

model from overshooting the optimal weights and biases and produced the overall best results regarding accuracy.
- **Stopping Condition:** The model was trained for a fixed number of 500 epochs. A lower number of epochs gave inconsistent results in the model training and accuracy, while a higher number of epochs resulted in overfitting.

Training

The model was trained using the backpropagation algorithm with the following parameters:

- **Learning Rate:** 0.01
- **Epochs:** 500
- **Seed Value:** 42566 (for reproducibility)

The mean squared error (MSE) was used as the loss function to guide the learning process.

Evaluation

The performance of the ANN model was evaluated using the following metrics:

- **Accuracy:** The proportion of correctly classified instances.
- **Specificity:** The proportion of true negatives that are correctly identified.
- **Sensitivity (Recall):** The proportion of true positives that are correctly identified.
- **F-Measure:** The mean of precision and recall.

Results

Formulas:

Accuracy:

Accuracy = (True Positives + True Negatives) / (True Positives + True Negatives + False Positives + False Negatives)

Specificity:

Specificity = True Negatives / (True Negatives + False Positives)

Sensitivity (Recall):

Sensitivity = True Positives / (True Positives + False Negatives)

Precision:

Precision = True Positives / (True Positives + False Positives)

F-Measure:

F-Measure = 2 * (Precision * Recall) / (Precision + Recall)

Where:

- **True Positives (TP):** The number of positive instances correctly predicted as positive.
- **True Negatives (TN):** The number of negative instances correctly predicted as negative.
- **False Positives (FP):** The number of negative instances incorrectly predicted as positive.
- **False Negatives (FN):** The number of positive instances incorrectly predicted as negative.

Metric	Value
Accuracy	58.8723%
Specificity	0.588723
Sensitivity (Recall)	1
F-Measure	0.741127