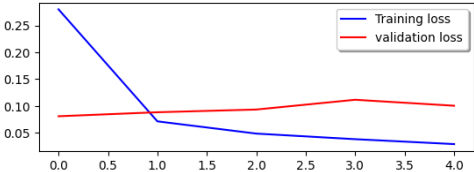
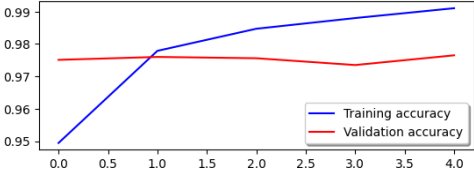


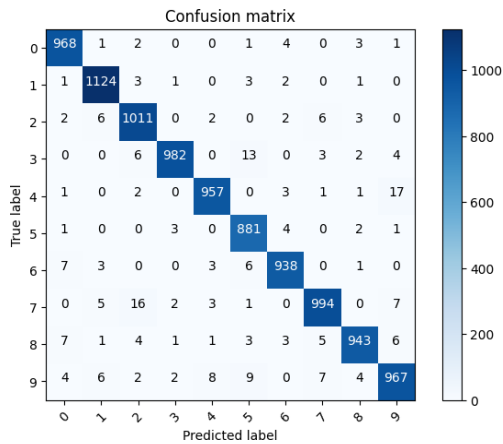
Project Development Phase Model Performance Test

| | |
|---------------|--|
| Date | 16 November 2022 |
| Team ID | IBM Project -55415-1668664168 |
| Project Name | Project - A Novel Method For Handwritten Digit Recognition System. |
| Maximum Marks | 10 Marks |

Model Performance Testing:

Project team shall fill the following information in model performance testing template.

| S.No. | Parameter | Values | Screenshot | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|-------------------|--------------------|--|--|--------------|---------------|-----------------|-----------------|--------------------|------|-------------------|--------------------|-------|-------------------|---------------|------|---------------|------------|--------|-----|------|------|-------|-------------------|---------------------|-----|------|-------|-----|------|-------|-----|-------|-------|-----|------|------|-----|------|-------|
| 1. | Model Summary | | <div>Model: "sequential"</div> <table><thead><tr><th>Layer (type)</th><th>Output Shape</th><th>Param #</th></tr></thead><tbody><tr><td>conv2d (Conv2D)</td><td>(None, 26, 26, 64)</td><td>640</td></tr><tr><td>conv2d_1 (Conv2D)</td><td>(None, 24, 24, 32)</td><td>18464</td></tr><tr><td>Flatten (Flatten)</td><td>(None, 18432)</td><td>0</td></tr><tr><td>dense (Dense)</td><td>(None, 10)</td><td>184330</td></tr></tbody></table> <div>Total params: 203,434 Trainable params: 203,434 Non-trainable params: 0</div> <div>None</div> | Layer (type) | Output Shape | Param # | conv2d (Conv2D) | (None, 26, 26, 64) | 640 | conv2d_1 (Conv2D) | (None, 24, 24, 32) | 18464 | Flatten (Flatten) | (None, 18432) | 0 | dense (Dense) | (None, 10) | 184330 | | | | | | | | | | | | | | | | | | | | | |
| Layer (type) | Output Shape | Param # | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| conv2d (Conv2D) | (None, 26, 26, 64) | 640 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| conv2d_1 (Conv2D) | (None, 24, 24, 32) | 18464 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Flatten (Flatten) | (None, 18432) | 0 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| dense (Dense) | (None, 10) | 184330 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 2. | Accuracy | Training Accuracy - 99% Validation Accuracy - 97% | <div><table><caption>Loss Metrics</caption><thead><tr><th>Epoch</th><th>Training loss</th><th>validation loss</th></tr></thead><tbody><tr><td>0.0</td><td>0.25</td><td>0.08</td></tr><tr><td>1.0</td><td>0.08</td><td>0.09</td></tr><tr><td>2.0</td><td>0.06</td><td>0.10</td></tr><tr><td>3.0</td><td>0.05</td><td>0.11</td></tr><tr><td>4.0</td><td>0.05</td><td>0.10</td></tr></tbody></table></div> <div><table><caption>Accuracy Metrics</caption><thead><tr><th>Epoch</th><th>Training accuracy</th><th>Validation accuracy</th></tr></thead><tbody><tr><td>0.0</td><td>0.95</td><td>0.975</td></tr><tr><td>1.0</td><td>0.98</td><td>0.975</td></tr><tr><td>2.0</td><td>0.985</td><td>0.975</td></tr><tr><td>3.0</td><td>0.99</td><td>0.97</td></tr><tr><td>4.0</td><td>0.99</td><td>0.975</td></tr></tbody></table></div> | Epoch | Training loss | validation loss | 0.0 | 0.25 | 0.08 | 1.0 | 0.08 | 0.09 | 2.0 | 0.06 | 0.10 | 3.0 | 0.05 | 0.11 | 4.0 | 0.05 | 0.10 | Epoch | Training accuracy | Validation accuracy | 0.0 | 0.95 | 0.975 | 1.0 | 0.98 | 0.975 | 2.0 | 0.985 | 0.975 | 3.0 | 0.99 | 0.97 | 4.0 | 0.99 | 0.975 |
| Epoch | Training loss | validation loss | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 0.0 | 0.25 | 0.08 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 1.0 | 0.08 | 0.09 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 2.0 | 0.06 | 0.10 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 3.0 | 0.05 | 0.11 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 4.0 | 0.05 | 0.10 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Epoch | Training accuracy | Validation accuracy | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 0.0 | 0.95 | 0.975 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 1.0 | 0.98 | 0.975 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 2.0 | 0.985 | 0.975 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 3.0 | 0.99 | 0.97 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 4.0 | 0.99 | 0.975 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

| 3. | Confusion Matrix |  <table><caption>Confusion matrix</caption><tr><th>True label \ Predicted label</th><th>0</th><th>1</th><th>2</th><th>3</th><th>4</th><th>5</th><th>6</th><th>7</th><th>8</th><th>9</th></tr><tr><th>0</th><td>968</td><td>1</td><td>2</td><td>0</td><td>0</td><td>1</td><td>4</td><td>0</td><td>3</td><td>1</td></tr><tr><th>1</th><td>1</td><td>1124</td><td>3</td><td>1</td><td>0</td><td>3</td><td>2</td><td>0</td><td>1</td><td>0</td></tr><tr><th>2</th><td>2</td><td>6</td><td>1011</td><td>0</td><td>2</td><td>0</td><td>2</td><td>6</td><td>3</td><td>0</td></tr><tr><th>3</th><td>0</td><td>0</td><td>6</td><td>982</td><td>0</td><td>13</td><td>0</td><td>3</td><td>2</td><td>4</td></tr><tr><th>4</th><td>1</td><td>0</td><td>2</td><td>0</td><td>957</td><td>0</td><td>3</td><td>1</td><td>1</td><td>17</td></tr><tr><th>5</th><td>1</td><td>0</td><td>0</td><td>3</td><td>0</td><td>881</td><td>4</td><td>0</td><td>2</td><td>1</td></tr><tr><th>6</th><td>7</td><td>3</td><td>0</td><td>0</td><td>3</td><td>6</td><td>938</td><td>0</td><td>1</td><td>0</td></tr><tr><th>7</th><td>0</td><td>5</td><td>16</td><td>2</td><td>3</td><td>1</td><td>0</td><td>994</td><td>0</td><td>7</td></tr><tr><th>8</th><td>7</td><td>1</td><td>4</td><td>1</td><td>1</td><td>3</td><td>3</td><td>5</td><td>943</td><td>6</td></tr><tr><th>9</th><td>4</td><td>6</td><td>2</td><td>2</td><td>8</td><td>9</td><td>0</td><td>7</td><td>4</td><td>967</td></tr></table> | True label \ Predicted label | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 0 | 968 | 1 | 2 | 0 | 0 | 1 | 4 | 0 | 3 | 1 | 1 | 1 | 1124 | 3 | 1 | 0 | 3 | 2 | 0 | 1 | 0 | 2 | 2 | 6 | 1011 | 0 | 2 | 0 | 2 | 6 | 3 | 0 | 3 | 0 | 0 | 6 | 982 | 0 | 13 | 0 | 3 | 2 | 4 | 4 | 1 | 0 | 2 | 0 | 957 | 0 | 3 | 1 | 1 | 17 | 5 | 1 | 0 | 0 | 3 | 0 | 881 | 4 | 0 | 2 | 1 | 6 | 7 | 3 | 0 | 0 | 3 | 6 | 938 | 0 | 1 | 0 | 7 | 0 | 5 | 16 | 2 | 3 | 1 | 0 | 994 | 0 | 7 | 8 | 7 | 1 | 4 | 1 | 1 | 3 | 3 | 5 | 943 | 6 | 9 | 4 | 6 | 2 | 2 | 8 | 9 | 0 | 7 | 4 | 967 |
|------------------------------|-----------------------|--|------------------------------|-----------|--------|----------|---------|-----|------|------|------|-----|---|------|------|------|------|---|------|------|------|------|---|------|------|------|------|---|------|------|------|-----|---|------|------|------|-----|---|------|------|------|-----|---|------|------|------|------|---|------|------|------|-----|----|------|------|------|------|----------|---|---|------|-------|-----------|------|------|------|-------|--------------|------|------|------|-------|---|---|-----|---|---|---|---|---|---|---|---|---|---|---|-----|---|---|---|---|---|---|----|---|---|---|---|-----|---|---|---|---|---|---|---|---|---|---|---|-----|---|---|---|---|---|---|---|---|---|---|---|-----|
| True label \ Predicted label | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 0 | 968 | 1 | 2 | 0 | 0 | 1 | 4 | 0 | 3 | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 1 | 1 | 1124 | 3 | 1 | 0 | 3 | 2 | 0 | 1 | 0 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 2 | 2 | 6 | 1011 | 0 | 2 | 0 | 2 | 6 | 3 | 0 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 3 | 0 | 0 | 6 | 982 | 0 | 13 | 0 | 3 | 2 | 4 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 4 | 1 | 0 | 2 | 0 | 957 | 0 | 3 | 1 | 1 | 17 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 5 | 1 | 0 | 0 | 3 | 0 | 881 | 4 | 0 | 2 | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 6 | 7 | 3 | 0 | 0 | 3 | 6 | 938 | 0 | 1 | 0 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 7 | 0 | 5 | 16 | 2 | 3 | 1 | 0 | 994 | 0 | 7 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 8 | 7 | 1 | 4 | 1 | 1 | 3 | 3 | 5 | 943 | 6 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 9 | 4 | 6 | 2 | 2 | 8 | 9 | 0 | 7 | 4 | 967 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 4. | Classification Report | <table><tr><th></th><th>precision</th><th>recall</th><th>f1-score</th><th>support</th></tr><tr><td>0</td><td>0.98</td><td>0.99</td><td>0.98</td><td>980</td></tr><tr><td>1</td><td>0.98</td><td>0.99</td><td>0.99</td><td>1135</td></tr><tr><td>2</td><td>0.97</td><td>0.98</td><td>0.97</td><td>1032</td></tr><tr><td>3</td><td>0.99</td><td>0.97</td><td>0.98</td><td>1010</td></tr><tr><td>4</td><td>0.98</td><td>0.97</td><td>0.98</td><td>982</td></tr><tr><td>5</td><td>0.96</td><td>0.99</td><td>0.97</td><td>892</td></tr><tr><td>6</td><td>0.98</td><td>0.98</td><td>0.98</td><td>958</td></tr><tr><td>7</td><td>0.98</td><td>0.97</td><td>0.97</td><td>1028</td></tr><tr><td>8</td><td>0.98</td><td>0.97</td><td>0.98</td><td>974</td></tr><tr><td>9</td><td>0.96</td><td>0.96</td><td>0.96</td><td>1009</td></tr><tr><td>accuracy</td><td></td><td></td><td>0.98</td><td>10000</td></tr><tr><td>macro avg</td><td>0.98</td><td>0.98</td><td>0.98</td><td>10000</td></tr><tr><td>weighted avg</td><td>0.98</td><td>0.98</td><td>0.98</td><td>10000</td></tr></table> | | precision | recall | f1-score | support | 0 | 0.98 | 0.99 | 0.98 | 980 | 1 | 0.98 | 0.99 | 0.99 | 1135 | 2 | 0.97 | 0.98 | 0.97 | 1032 | 3 | 0.99 | 0.97 | 0.98 | 1010 | 4 | 0.98 | 0.97 | 0.98 | 982 | 5 | 0.96 | 0.99 | 0.97 | 892 | 6 | 0.98 | 0.98 | 0.98 | 958 | 7 | 0.98 | 0.97 | 0.97 | 1028 | 8 | 0.98 | 0.97 | 0.98 | 974 | 9 | 0.96 | 0.96 | 0.96 | 1009 | accuracy | | | 0.98 | 10000 | macro avg | 0.98 | 0.98 | 0.98 | 10000 | weighted avg | 0.98 | 0.98 | 0.98 | 10000 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | precision | recall | f1-score | support | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 0 | 0.98 | 0.99 | 0.98 | 980 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 1 | 0.98 | 0.99 | 0.99 | 1135 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 2 | 0.97 | 0.98 | 0.97 | 1032 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 3 | 0.99 | 0.97 | 0.98 | 1010 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 4 | 0.98 | 0.97 | 0.98 | 982 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 5 | 0.96 | 0.99 | 0.97 | 892 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 6 | 0.98 | 0.98 | 0.98 | 958 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 7 | 0.98 | 0.97 | 0.97 | 1028 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 8 | 0.98 | 0.97 | 0.98 | 974 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 9 | 0.96 | 0.96 | 0.96 | 1009 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| accuracy | | | 0.98 | 10000 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| macro avg | 0.98 | 0.98 | 0.98 | 10000 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| weighted avg | 0.98 | 0.98 | 0.98 | 10000 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |