

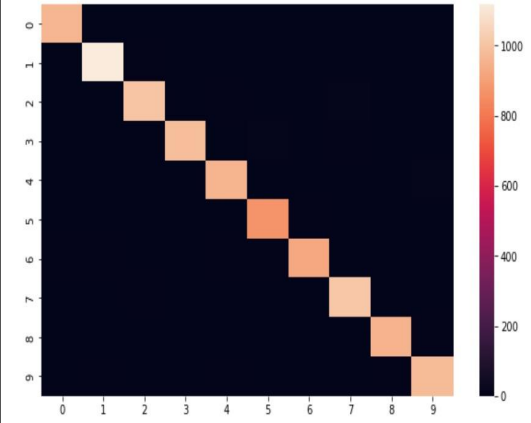
## Project Development Phase Model Performance Test

|               |   |
|---------------|---|
| Date          | 10 November 2022  |
| Team ID       | PNT2022TMID52947  |
| 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 the 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 colspan="3">=====</td></tr><tr><td>conv2d (Conv2D)</td><td>(None, 26, 26, 64)</td><td>640</td></tr><tr><td colspan="3">=====</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><tr><td colspan="3">=====</td></tr></tbody></table> <div>Total params: 203,434<br/>Trainable params: 203,434<br/>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 - 99.3%<br><br>Validation Accuracy -97.8% | <div><div>model accuracy</div><table border="1"><thead><tr><th>epoch</th><th>Train Accuracy (%)</th><th>Validation Accuracy (%)</th></tr></thead><tbody><tr><td>0.0</td><td>99.3</td><td>97.8</td></tr><tr><td>1.0</td><td>99.4</td><td>98.1</td></tr><tr><td>2.0</td><td>99.5</td><td>97.8</td></tr><tr><td>3.0</td><td>99.5</td><td>97.9</td></tr><tr><td>4.0</td><td>99.5</td><td>97.8</td></tr></tbody></table></div> <div><div>model loss</div><table border="1"><thead><tr><th>epoch</th><th>Train Loss</th><th>Validation Loss</th></tr></thead><tbody><tr><td>0.0</td><td>0.025</td><td>0.125</td></tr><tr><td>1.0</td><td>0.018</td><td>0.10</td></tr><tr><td>2.0</td><td>0.015</td><td>0.14</td></tr><tr><td>3.0</td><td>0.015</td><td>0.165</td></tr><tr><td>4.0</td><td>0.015</td><td>0.15</td></tr></tbody></table></div> | epoch        | Train Accuracy (%) | Validation Accuracy (%) | 0.0   | 99.3 | 97.8 | 1.0             | 99.4               | 98.1 | 2.0   | 99.5 | 97.8 | 3.0               | 99.5               | 97.9  | 4.0               | 99.5          | 97.8 | epoch         | Train Loss | Validation Loss | 0.0   | 0.025 | 0.125 | 1.0 | 0.018 | 0.10 | 2.0 | 0.015 | 0.14 | 3.0 | 0.015 | 0.165 | 4.0 | 0.015 | 0.15 |
| epoch             | Train Accuracy (%) | Validation Accuracy (%)                                     |  |              |                    |                         |       |      |      |                 |                    |      |       |      |      |                   |                    |       |                   |               |      |               |            |                 |       |       |       |     |       |      |     |       |      |     |       |       |     |       |      |
| 0.0               | 99.3               | 97.8  |  |              |                    |                         |       |      |      |                 |                    |      |       |      |      |                   |                    |       |                   |               |      |               |            |                 |       |       |       |     |       |      |     |       |      |     |       |       |     |       |      |
| 1.0               | 99.4               | 98.1  |  |              |                    |                         |       |      |      |                 |                    |      |       |      |      |                   |                    |       |                   |               |      |               |            |                 |       |       |       |     |       |      |     |       |      |     |       |       |     |       |      |
| 2.0               | 99.5               | 97.8  |  |              |                    |                         |       |      |      |                 |                    |      |       |      |      |                   |                    |       |                   |               |      |               |            |                 |       |       |       |     |       |      |     |       |      |     |       |       |     |       |      |
| 3.0               | 99.5               | 97.9  |  |              |                    |                         |       |      |      |                 |                    |      |       |      |      |                   |                    |       |                   |               |      |               |            |                 |       |       |       |     |       |      |     |       |      |     |       |       |     |       |      |
| 4.0               | 99.5               | 97.8  |  |              |                    |                         |       |      |      |                 |                    |      |       |      |      |                   |                    |       |                   |               |      |               |            |                 |       |       |       |     |       |      |     |       |      |     |       |       |     |       |      |
| epoch             | Train Loss         | Validation Loss   |  |              |                    |                         |       |      |      |                 |                    |      |       |      |      |                   |                    |       |                   |               |      |               |            |                 |       |       |       |     |       |      |     |       |      |     |       |       |     |       |      |
| 0.0               | 0.025              | 0.125   |  |              |                    |                         |       |      |      |                 |                    |      |       |      |      |                   |                    |       |                   |               |      |               |            |                 |       |       |       |     |       |      |     |       |      |     |       |       |     |       |      |
| 1.0               | 0.018              | 0.10  |  |              |                    |                         |       |      |      |                 |                    |      |       |      |      |                   |                    |       |                   |               |      |               |            |                 |       |       |       |     |       |      |     |       |      |     |       |       |     |       |      |
| 2.0               | 0.015              | 0.14  |  |              |                    |                         |       |      |      |                 |                    |      |       |      |      |                   |                    |       |                   |               |      |               |            |                 |       |       |       |     |       |      |     |       |      |     |       |       |     |       |      |
| 3.0               | 0.015              | 0.165   |  |              |                    |                         |       |      |      |                 |                    |      |       |      |      |                   |                    |       |                   |               |      |               |            |                 |       |       |       |     |       |      |     |       |      |     |       |       |     |       |      |
| 4.0               | 0.015              | 0.15  |  |              |                    |                         |       |      |      |                 |                    |      |       |      |      |                   |                    |       |                   |               |      |               |            |                 |       |       |       |     |       |      |     |       |      |     |       |       |     |       |      |

| 3.           | Confusion Matrix      | <pre>[[ 964  2  3  0  1  1  3  1  3  2]  [  0 1119  6  2  3  0  1  2  2  0]  [  1  2 1003  4  5  0  2 11  4  0]  [  0  0  2 987  0 10  2  5  4  0]  [  1  0  2  0 960  1  4  2  3  9]  [  1  0  0  4  0 874  7  0  4  2]  [  5  6  0  0  7  6 930  0  4  0]  [  0  4  6  3  3  0  0 1010  2  0]  [  3  0  2  3  1  1  1  2 956  5]  [  0  6  0  3  8  4  0  2  8 978]]</pre> |   |         |           |        |          |         |   |      |      |      |     |   |      |      |      |      |   |      |      |      |      |   |      |      |      |      |   |      |      |      |     |   |      |      |      |     |   |      |      |      |     |   |      |      |      |      |   |      |      |      |     |   |      |      |      |      |          |  |  |      |       |           |      |      |      |       |              |      |      |      |       |
|--------------|-----------------------|--|--|---------|-----------|--------|----------|---------|---|------|------|------|-----|---|------|------|------|------|---|------|------|------|------|---|------|------|------|------|---|------|------|------|-----|---|------|------|------|-----|---|------|------|------|-----|---|------|------|------|------|---|------|------|------|-----|---|------|------|------|------|----------|--|--|------|-------|-----------|------|------|------|-------|--------------|------|------|------|-------|
| 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>0.99</td><td>0.98</td><td>0.99</td><td>980</td></tr><tr><td>1</td><td>0.98</td><td>0.99</td><td>0.98</td><td>1135</td></tr><tr><td>2</td><td>0.98</td><td>0.97</td><td>0.98</td><td>1032</td></tr><tr><td>3</td><td>0.98</td><td>0.98</td><td>0.98</td><td>1010</td></tr><tr><td>4</td><td>0.97</td><td>0.98</td><td>0.97</td><td>982</td></tr><tr><td>5</td><td>0.97</td><td>0.98</td><td>0.98</td><td>892</td></tr><tr><td>6</td><td>0.98</td><td>0.97</td><td>0.97</td><td>958</td></tr><tr><td>7</td><td>0.98</td><td>0.98</td><td>0.98</td><td>1028</td></tr><tr><td>8</td><td>0.97</td><td>0.98</td><td>0.97</td><td>974</td></tr><tr><td>9</td><td>0.98</td><td>0.97</td><td>0.98</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 | 0.99 | 0.98 | 0.99 | 980 | 1 | 0.98 | 0.99 | 0.98 | 1135 | 2 | 0.98 | 0.97 | 0.98 | 1032 | 3 | 0.98 | 0.98 | 0.98 | 1010 | 4 | 0.97 | 0.98 | 0.97 | 982 | 5 | 0.97 | 0.98 | 0.98 | 892 | 6 | 0.98 | 0.97 | 0.97 | 958 | 7 | 0.98 | 0.98 | 0.98 | 1028 | 8 | 0.97 | 0.98 | 0.97 | 974 | 9 | 0.98 | 0.97 | 0.98 | 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            | 0.99                  | 0.98   | 0.99   | 980     |           |        |          |         |   |      |      |      |     |   |      |      |      |      |   |      |      |      |      |   |      |      |      |      |   |      |      |      |     |   |      |      |      |     |   |      |      |      |     |   |      |      |      |      |   |      |      |      |     |   |      |      |      |      |          |  |  |      |       |           |      |      |      |       |              |      |      |      |       |
| 1            | 0.98                  | 0.99   | 0.98   | 1135    |           |        |          |         |   |      |      |      |     |   |      |      |      |      |   |      |      |      |      |   |      |      |      |      |   |      |      |      |     |   |      |      |      |     |   |      |      |      |     |   |      |      |      |      |   |      |      |      |     |   |      |      |      |      |          |  |  |      |       |           |      |      |      |       |              |      |      |      |       |
| 2            | 0.98                  | 0.97   | 0.98   | 1032    |           |        |          |         |   |      |      |      |     |   |      |      |      |      |   |      |      |      |      |   |      |      |      |      |   |      |      |      |     |   |      |      |      |     |   |      |      |      |     |   |      |      |      |      |   |      |      |      |     |   |      |      |      |      |          |  |  |      |       |           |      |      |      |       |              |      |      |      |       |
| 3            | 0.98                  | 0.98   | 0.98   | 1010    |           |        |          |         |   |      |      |      |     |   |      |      |      |      |   |      |      |      |      |   |      |      |      |      |   |      |      |      |     |   |      |      |      |     |   |      |      |      |     |   |      |      |      |      |   |      |      |      |     |   |      |      |      |      |          |  |  |      |       |           |      |      |      |       |              |      |      |      |       |
| 4            | 0.97                  | 0.98   | 0.97   | 982     |           |        |          |         |   |      |      |      |     |   |      |      |      |      |   |      |      |      |      |   |      |      |      |      |   |      |      |      |     |   |      |      |      |     |   |      |      |      |     |   |      |      |      |      |   |      |      |      |     |   |      |      |      |      |          |  |  |      |       |           |      |      |      |       |              |      |      |      |       |
| 5            | 0.97                  | 0.98   | 0.98   | 892     |           |        |          |         |   |      |      |      |     |   |      |      |      |      |   |      |      |      |      |   |      |      |      |      |   |      |      |      |     |   |      |      |      |     |   |      |      |      |     |   |      |      |      |      |   |      |      |      |     |   |      |      |      |      |          |  |  |      |       |           |      |      |      |       |              |      |      |      |       |
| 6            | 0.98                  | 0.97   | 0.97   | 958     |           |        |          |         |   |      |      |      |     |   |      |      |      |      |   |      |      |      |      |   |      |      |      |      |   |      |      |      |     |   |      |      |      |     |   |      |      |      |     |   |      |      |      |      |   |      |      |      |     |   |      |      |      |      |          |  |  |      |       |           |      |      |      |       |              |      |      |      |       |
| 7            | 0.98                  | 0.98   | 0.98   | 1028    |           |        |          |         |   |      |      |      |     |   |      |      |      |      |   |      |      |      |      |   |      |      |      |      |   |      |      |      |     |   |      |      |      |     |   |      |      |      |     |   |      |      |      |      |   |      |      |      |     |   |      |      |      |      |          |  |  |      |       |           |      |      |      |       |              |      |      |      |       |
| 8            | 0.97                  | 0.98   | 0.97   | 974     |           |        |          |         |   |      |      |      |     |   |      |      |      |      |   |      |      |      |      |   |      |      |      |      |   |      |      |      |     |   |      |      |      |     |   |      |      |      |     |   |      |      |      |      |   |      |      |      |     |   |      |      |      |      |          |  |  |      |       |           |      |      |      |       |              |      |      |      |       |
| 9            | 0.98                  | 0.97   | 0.98   | 1009    |           |        |          |         |   |      |      |      |     |   |      |      |      |      |   |      |      |      |      |   |      |      |      |      |   |      |      |      |     |   |      |      |      |     |   |      |      |      |     |   |      |      |      |      |   |      |      |      |     |   |      |      |      |      |          |  |  |      |       |           |      |      |      |       |              |      |      |      |       |
| accuracy     |                       |  | 0.98   | 10000   |           |        |          |         |   |      |      |      |     |   |      |      |      |      |   |      |      |      |      |   |      |      |      |      |   |      |      |      |     |   |      |      |      |     |   |      |      |      |     |   |      |      |      |      |   |      |      |      |     |   |      |      |      |      |          |  |  |      |       |           |      |      |      |       |              |      |      |      |       |
| macro avg    | 0.98                  | 0.98   | 0.98   | 10000   |           |        |          |         |   |      |      |      |     |   |      |      |      |      |   |      |      |      |      |   |      |      |      |      |   |      |      |      |     |   |      |      |      |     |   |      |      |      |     |   |      |      |      |      |   |      |      |      |     |   |      |      |      |      |          |  |  |      |       |           |      |      |      |       |              |      |      |      |       |
| weighted avg | 0.98                  | 0.98   | 0.98   | 10000   |           |        |          |         |   |      |      |      |     |   |      |      |      |      |   |      |      |      |      |   |      |      |      |      |   |      |      |      |     |   |      |      |      |     |   |      |      |      |     |   |      |      |      |      |   |      |      |      |     |   |      |      |      |      |          |  |  |      |       |           |      |      |      |       |              |      |      |      |       |