

# LAPORAN TUGAS BESAR

## **“Klasifikasi Tumor Otak Menggunakan Model *Lavenberg-Marquardt* dan *Scaled Conjugate Gradient* Berbasis *Multilayer Perceptron*”**



**Disusun Oleh :**

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## A. METHODOLOGY

Penelitian ini menggunakan dataset Brain Tumour, yang terdiri dari 3438 citra X-ray otak. Dataset ini dibagi menjadi tiga bagian utama, yaitu 90% untuk data training, 5% untuk data validasi, dan 5% untuk data testing. Setiap citra diproses untuk menghasilkan 16 fitur yang diperoleh melalui metode Gray Level Co-occurrence Matrix (GLCM). Fitur-fitur tersebut digunakan dalam pengklasifikasian menggunakan jaringan saraf tiruan Multilayer Perceptron (MLP).

Dataset diklasifikasikan ke dalam empat kelas, yang masing-masing diwakili dalam format one-hot encoding sebagai berikut:

- Kelas 1 : (0 0 0 1)
- Kelas 2 : (0 0 1 0)
- Kelas 3 : (0 1 0 0)
- Kelas 4 : (1 0 0 0)

Model jaringan saraf memiliki 20 hidden nodes dan menggunakan dua algoritma pelatihan, yaitu Levenberg-Marquardt (LM) dan Scaled Conjugate Gradient (SCG). Untuk menjalankan proses ini, digunakan spesifikasi komputer sebagai berikut:

- Prosesor : AMD Ryzen 5 7540U dengan GPU Radeon (TM) 740M, 3.20 GHz
- RAM : 16 GB
- Sistem Operasi : Windows 11 Home Single Language 64-bit

### 1. Nama Dataset yang di training: Brain Tumour

- **Berapa jumlah citra training dan citra testing yang digunakan : 90% training dari data sejumlah 3092, 5% validation sejumlah 172, 5% data testing sejumlah 172.**
- **Berapa jumlah fitur (variable): 12 fitur.**
- **Apa nama fitur-fitur yang digunakan: Contrast, Homogeneity, Energy, Correlation**

- **Berapa kelas jenis data yang digunakan: 4 (Glioma, Healthy, Meningioma, dan Pituitary)**
- **Apa jenis kelas dari data yang digunakan setelah dikonversi agar sesuai untuk MLP Matlab: Glioma [0 0 0 1], Healthy [0 0 1 0], Meningioma [0 1 0 0], Pituitary [1 0 0 0]**
- **Berapa hidden node yang digunakan? Hidden Node 15 dan 20.**
- **Apakah 2 model yang digunakan untuk training kelompok anda? LM dan SCG.**
- **Bagaimana spesifikasi computer yang digunakan untuk proses training and testing? Processor : AMD Ryzen 5 7540U w/Radeon(TM) 740M Graphics 3.20 GHz, Memori : 16384MB RAM, Sistem Operasi : Windows 11 Home Single Language 64-bit**

**Copy paste script coding yang anda ekstrak dan digunakan untuk run hingga 10x di Matlab?**

#### **EKSTRAKSI FITUR :**

```
clc;

clear all;
% PROSES MEMBACA CITRA

folder = cd('D:\Pengolahan Citra\DATASET UTS - Copy\Semua');
images = dir([folder, '\*.JPG']);
nimages = length(images);

    for i = 1:nimages
        currentimagename = images(i).name;
        imagenames(i,:) = {currentimagename};
        currentimage=imread(fullfile(folder, currentimagename), 'JPG');
% PROSES PRE-PROCESSING
R = rgb2gray (currentimage);
A = histeq(R);
F = imresize(A, [512 512]);
figure(1), imshow(R);
%% EKSTRAKSI FITUR
    offsets = [0 30; -30 30; -30 0; -30 -30];
    [glcm,S1] = graycomatrix(F, 'Offset', offsets);
    stats =
graycoprops(glcm,{'Contrast', 'Homogeneity', 'Energy', 'Correlation'});
    FiturA=stats.Contrast;
    FiturB=stats.Homogeneity;
    FiturC=stats.Energy;
```

```

        FiturD=stats.Correlation;
        Fitur = [FiturA FiturB FiturC FiturD];
        e(i, :)=Fitur;
    end
%eksport ke excel
sheet = 1;
filename = 'Data GLCM2.xlsx';%tukar nama untuk level
xlswrite(filename,e,sheet,'A1:P3436');%tukar sesuai jml data image
xlswrite(filename,imagenames,sheet,'Q1:Q3436');%tukar sesuai jml data
image

```

## KLASIFIKASI (run 10) :

```

% Solve a Pattern Recognition Problem with a Neural Network
% Script generated by Neural Pattern Recognition app
% Created 24-Mar-2023 09:39:38
%
% This script assumes these variables are defined:

%%membaca data fitur dari excel

T = readtable('Data GLCM2.xlsx');
A=T(:,1:16);
inputtotak=table2array(A);
outputtotak=table2array(T(:,18:21));

%%

% load cancer_dataset.MAT;
x = inputtotak';
t = outputtotak';

% Choose a Training Function
% For a list of all training functions type: help nntrain
% 'trainlm' is usually fastest.
% 'trainbr' takes longer but may be better for challenging problems.
% 'trainscg' uses less memory. Suitable in low memory situations.
trainFcn = 'trainlm'; % Scaled conjugate gradient backpropagation.
trainbfg | traincgb | traincgf | traincgp | traingda | traingdm |
traingdx | trainlm | trainoss | trainrp | trainscg

% Create a Pattern Recognition Network
hiddenLayerSize = 20;% 5 10 15 20
net = patternnet(hiddenLayerSize, trainFcn);

% Choose Input and Output Pre/Post-Processing Functions
% For a list of all processing functions type: help nnprocess
net.input.processFcns = {'removeconstantrows','mapminmax'};

% Setup Division of Data for Training, Validation, Testing
% For a list of all data division functions type: help nndivision
net.divideFcn = 'dividerand'; % Divide data randomly
net.divideMode = 'sample'; % Divide up every sample

```

```

net.divideParam.trainRatio = 90/100;
net.divideParam.valRatio = 5/100;
net.divideParam.testRatio = 5/100;

% Choose a Performance Function
% For a list of all performance functions type: help nnperformance
net.performFcn = 'crossentropy'; % Cross-Entropy

% Choose Plot Functions
% For a list of all plot functions type: help nnplot
net.plotFcns = {'plotperform','plottrainstate','ploterrhist', ...
    'plotconfusion', 'plotroc'};

% Train the Network
[net,tr] = train(net,x,t);

% Test the Network
y = net(x);
e = gsubtract(t,y);
performance = perform(net,t,y);
tind = vec2ind(t);
yind = vec2ind(y);
percentErrors = sum(tind ~= yind)/numel(tind);

% Recalculate Training, Validation and Test Performance
trainTargets = t .* tr.trainMask{1};
valTargets = t .* tr.valMask{1};
testTargets = t .* tr.testMask{1};
trainPerformance = perform(net,trainTargets,y);
valPerformance = perform(net,valTargets,y);
testPerformance = perform(net,testTargets,y);

% View the Network
view(net)

% Plots
% Uncomment these lines to enable various plots.
%figure, plotperform(tr)
%figure, plottrainstate(tr)
%figure, ploterrhist(e)
%figure, plotconfusion(t,y)
%figure, plotroc(t,y)

% Deployment
% Change the (false) values to (true) to enable the following code
blocks.
% See the help for each generation function for more information.
if (false)
    % Generate MATLAB function for neural network for application
    % deployment in MATLAB scripts or with MATLAB Compiler and Builder
    % tools, or simply to examine the calculations your trained neural
    % network performs.
    genFunction(net,'myNeuralNetworkFunction');
    y = myNeuralNetworkFunction(x);

```

```

end
if (false)
    % Generate a matrix-only MATLAB function for neural network code
    % generation with MATLAB Coder tools.
    genFunction(net, 'myNeuralNetworkFunction', 'MatrixOnly', 'yes');
    y = myNeuralNetworkFunction(x);
end
if (false)
    % Generate a Simulink diagram for simulation or deployment with.
    % Simulink Coder tools.
    gensim(net);
end

```

## B. TAHAPAN PENELITIAN

### 1. Ekstraksi Fitur

Setiap citra diubah menjadi skala abu-abu, kemudian ditingkatkan kualitasnya menggunakan histogram equalization, dan diubah ukurannya menjadi 512x512 piksel. Fitur diperoleh melalui analisis GLCM dengan parameter Contrast, Homogeneity, Energy, dan Correlation. Hasil ekstraksi ini disimpan dalam format Excel untuk mempermudah pengolahan selanjutnya.

### 2. Klasifikasi Menggunakan MLP

Fitur-fitur yang diekstraksi dimasukkan sebagai input ke jaringan saraf tiruan. Jaringan ini memiliki arsitektur yang terdiri dari satu hidden layer dengan 20 node, serta menggunakan fungsi pelatihan trainlm atau trainscg. Data dibagi secara acak ke dalam tiga subset: 90% untuk training, 5% untuk validasi, dan 5% untuk testing. Kinerja model diukur menggunakan fungsi cross-entropy.

### 3. Pengujian Model

Setelah model dilatih, performa diuji berdasarkan tingkat akurasi pada data training, validasi, dan testing. Selain itu, dilakukan analisis kesalahan dan pembuatan visualisasi, seperti grafik performa, histogram error, confusion matrix, dan receiver operating characteristic (ROC). Melalui tahapan ini, penelitian bertujuan untuk menghasilkan model yang mampu mengklasifikasikan citra X-ray otak ke dalam

kategori yang sesuai secara akurat dan efisien. Metodologi ini dirancang agar mudah direplikasi dan memberikan hasil yang konsisten.

## B. HASIL TRAINING UNTUK MODEL 1 (Hidden Node 15)

### 1. Hasil berupa akurasi Training, Validasi, Testing di dalam Table Model SCG HN 15.

Tabel 1.1 Hasil Best All Epoch, Akurasi Training, Validasi dan Testing

Training	All	Best	Acc Training (%)	Acc Validation (%)	Acc Testing (%)	Time
Run 1	106	112	87,0	88,4	86,0	0:00:01
Run 2	79	85	85,3	83,7	84,3	0:00:01
Run 3	116	122	88,3	92,4	92,4	0:00:01
Run 4	79	85	86,6	86,0	89,5	0:00:01
Run 5	39	45	80,3	83,1	84,3	0:00:00
Run 6	69	75	84,1	88,4	86,6	0:00:01
Run 7	57	63	83,3	82,6	80,2	0:00:00
Run 8	55	61	80,4	79,7	82,0	0:00:00
Run 9	87	93	86,5	83,1	84,9	0:00:00
Run 10	65	71	83,0	79,7	76,2	0:00:00
Rata-rata			84,48	84,71	84,64	
±			±	±	±	
Standar Deviasi			2,749	4,067	4,567	

Berdasarkan Tabel 1.1, bahwa hasil pelatihan dari sepuluh kali percobaan dengan model klasifikasi SCG dan HN 15 diperoleh dari nilai *epoch* tertinggi sebesar 122 dan nilai terendah sebesar 45 Sementara itu, nilai *best epoch* tertinggi adalah 116 dan nilai terendahnya adalah 39. Akurasi *training* memiliki rata-rata sebesar 84,48%, dengan nilai pelatihan tertinggi mencapai 88,3% pada percobaan

ketiga. Untuk *validation*, nilai rata-ratanya adalah 84,71%, dengan nilai tertinggi mencapai 92,4% pada percobaan ketiga. Sedangkan untuk testing, nilai rata-ratanya adalah 84,64%, dengan nilai tertinggi mencapai 92,4% pada percobaan ketiga. Data *best epoch validation* diperoleh dari grafik *training performance*, sementara data *training*, *validation* dan *testing* berasal dari *confusion matrix*.

## 2. Confusion Matrix dan ROC Curve Model SCG HN 15.

Training	Confision Matrix (standard) untuk Training, Validasi, Testing and All																																																																																																																																																																
Run 1	<div><div><div>Training Confusion Matrix</div><table><tr><td>427</td><td>63</td><td>38</td><td>9</td></tr><tr><td>13.6%</td><td>2.0%</td><td>1.2%</td><td>0.3%</td></tr><tr><td>0.4%</td><td>8.8%</td><td>0.7%</td><td>1.7%</td></tr><tr><td>27</td><td>73</td><td>193</td><td>10</td></tr><tr><td>0.9%</td><td>2.4%</td><td>61.5%</td><td>0.3%</td></tr><tr><td>8</td><td>71</td><td>15</td><td>397</td></tr><tr><td>0.3%</td><td>2.4%</td><td>0.5%</td><td>12.8%</td></tr><tr><td>50.1%</td><td>50.5%</td><td>95.5%</td><td>84.6%</td></tr><tr><td>9.0%</td><td>40.5%</td><td>4.9%</td><td>15.1%</td></tr></table></div><div><div>Validation Confusion Matrix</div><table><tr><td>22</td><td>4</td><td>3</td><td>1</td></tr><tr><td>18.6%</td><td>2.3%</td><td>1.1%</td><td>0.8%</td></tr><tr><td>0</td><td>10</td><td>0</td><td>2</td></tr><tr><td>0.0%</td><td>8.0%</td><td>0.0%</td><td>1.2%</td></tr><tr><td>1</td><td>1</td><td>84</td><td>1</td></tr><tr><td>0.8%</td><td>0.8%</td><td>48.8%</td><td>0.8%</td></tr><tr><td>0</td><td>6</td><td>1</td><td>26</td></tr><tr><td>0.0%</td><td>3.0%</td><td>0.8%</td><td>15.1%</td></tr><tr><td>97.0%</td><td>47.6%</td><td>95.0%</td><td>86.7%</td></tr><tr><td>3.0%</td><td>52.4%</td><td>4.9%</td><td>13.3%</td></tr></table></div><div><div>Test Confusion Matrix</div><table><tr><td>23</td><td>2</td><td>1</td><td>9</td></tr><tr><td>13.4%</td><td>1.2%</td><td>0.0%</td><td>0.0%</td></tr><tr><td>2</td><td>1</td><td>1</td><td>2</td></tr><tr><td>1.2%</td><td>5.2%</td><td>0.6%</td><td>1.2%</td></tr><tr><td>1</td><td>9</td><td>92</td><td>9</td></tr><tr><td>0.6%</td><td>5.2%</td><td>63.0%</td><td>0.0%</td></tr><tr><td>0</td><td>0</td><td>0</td><td>34</td></tr><tr><td>0.0%</td><td>3.9%</td><td>0.0%</td><td>14.0%</td></tr><tr><td>88.6%</td><td>24.8%</td><td>97.0%</td><td>82.3%</td></tr><tr><td>11.5%</td><td>50.4%</td><td>2.1%</td><td>7.7%</td></tr></table></div><div><div>All Confusion Matrix</div><table><tr><td>482</td><td>69</td><td>42</td><td>19</td></tr><tr><td>14.0%</td><td>2.0%</td><td>1.2%</td><td>0.3%</td></tr><tr><td>14</td><td>201</td><td>23</td><td>57</td></tr><tr><td>0.4%</td><td>8.5%</td><td>0.7%</td><td>1.7%</td></tr><tr><td>29</td><td>83</td><td>1769</td><td>11</td></tr><tr><td>0.8%</td><td>2.4%</td><td>51.5%</td><td>0.3%</td></tr><tr><td>8</td><td>95</td><td>16</td><td>447</td></tr><tr><td>0.2%</td><td>2.8%</td><td>0.5%</td><td>13.0%</td></tr><tr><td>60.4%</td><td>55.1%</td><td>95.0%</td><td>85.1%</td></tr><tr><td>9.6%</td><td>44.9%</td><td>4.4%</td><td>14.9%</td></tr></table></div></div>	427	63	38	9	13.6%	2.0%	1.2%	0.3%	0.4%	8.8%	0.7%	1.7%	27	73	193	10	0.9%	2.4%	61.5%	0.3%	8	71	15	397	0.3%	2.4%	0.5%	12.8%	50.1%	50.5%	95.5%	84.6%	9.0%	40.5%	4.9%	15.1%	22	4	3	1	18.6%	2.3%	1.1%	0.8%	0	10	0	2	0.0%	8.0%	0.0%	1.2%	1	1	84	1	0.8%	0.8%	48.8%	0.8%	0	6	1	26	0.0%	3.0%	0.8%	15.1%	97.0%	47.6%	95.0%	86.7%	3.0%	52.4%	4.9%	13.3%	23	2	1	9	13.4%	1.2%	0.0%	0.0%	2	1	1	2	1.2%	5.2%	0.6%	1.2%	1	9	92	9	0.6%	5.2%	63.0%	0.0%	0	0	0	34	0.0%	3.9%	0.0%	14.0%	88.6%	24.8%	97.0%	82.3%	11.5%	50.4%	2.1%	7.7%	482	69	42	19	14.0%	2.0%	1.2%	0.3%	14	201	23	57	0.4%	8.5%	0.7%	1.7%	29	83	1769	11	0.8%	2.4%	51.5%	0.3%	8	95	16	447	0.2%	2.8%	0.5%	13.0%	60.4%	55.1%	95.0%	85.1%	9.6%	44.9%	4.4%	14.9%				
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Run 2	<div><div><div>Training Confusion Matrix</div><table><tr><td>438</td><td>66</td><td>35</td><td>12</td></tr><tr><td>14.2%</td><td>2.1%</td><td>1.1%</td><td>0.4%</td></tr><tr><td>7</td><td>213</td><td>34</td><td>61</td></tr><tr><td>0.2%</td><td>7.5%</td><td>1.1%</td><td>2.2%</td></tr><tr><td>38</td><td>89</td><td>1587</td><td>10</td></tr><tr><td>1.2%</td><td>2.9%</td><td>51.3%</td><td>0.3%</td></tr><tr><td>6</td><td>88</td><td>2</td><td>379</td></tr><tr><td>0.2%</td><td>2.8%</td><td>0.1%</td><td>12.3%</td></tr><tr><td>88.6%</td><td>48.9%</td><td>95.7%</td><td>85.6%</td></tr><tr><td>10.2%</td><td>51.1%</td><td>4.3%</td><td>14.7%</td></tr></table></div><div><div>Validation Confusion Matrix</div><table><tr><td>22</td><td>4</td><td>3</td><td>2</td></tr><tr><td>12.8%</td><td>2.3%</td><td>1.1%</td><td>1.2%</td></tr><tr><td>0</td><td>10</td><td>2</td><td>3</td></tr><tr><td>0.0%</td><td>8.0%</td><td>1.2%</td><td>3.3%</td></tr><tr><td>4</td><td>4</td><td>91</td><td>1</td></tr><tr><td>2.3%</td><td>2.0%</td><td>52.9%</td><td>0.6%</td></tr><tr><td>1</td><td>4</td><td>0</td><td>21</td></tr><tr><td>0.6%</td><td>2.0%</td><td>0.0%</td><td>12.2%</td></tr><tr><td>81.5%</td><td>45.5%</td><td>94.0%</td><td>77.8%</td></tr><tr><td>18.5%</td><td>54.5%</td><td>5.2%</td><td>22.2%</td></tr></table></div><div><div>Test Confusion Matrix</div><table><tr><td>14</td><td>3</td><td>4</td><td>2</td></tr><tr><td>8.1%</td><td>1.7%</td><td>2.3%</td><td>1.2%</td></tr><tr><td>1</td><td>21</td><td>2</td><td>1</td></tr><tr><td>0.6%</td><td>12.2%</td><td>1.2%</td><td>3.0%</td></tr><tr><td>3</td><td>3</td><td>90</td><td>9</td></tr><tr><td>1.7%</td><td>1.7%</td><td>62.3%</td><td>0.0%</td></tr><tr><td>0</td><td>3</td><td>0</td><td>20</td></tr><tr><td>0.0%</td><td>1.7%</td><td>0.0%</td><td>13.0%</td></tr><tr><td>77.8%</td><td>70.0%</td><td>93.8%</td><td>71.4%</td></tr><tr><td>22.2%</td><td>30.0%</td><td>6.2%</td><td>28.6%</td></tr></table></div><div><div>All Confusion Matrix</div><table><tr><td>474</td><td>73</td><td>42</td><td>15</td></tr><tr><td>13.8%</td><td>2.1%</td><td>1.2%</td><td>0.5%</td></tr><tr><td>8</td><td>264</td><td>36</td><td>78</td></tr><tr><td>0.2%</td><td>7.7%</td><td>1.1%</td><td>2.3%</td></tr><tr><td>45</td><td>96</td><td>1768</td><td>11</td></tr><tr><td>1.3%</td><td>2.8%</td><td>51.5%</td><td>0.3%</td></tr><tr><td>6</td><td>95</td><td>2</td><td>430</td></tr><tr><td>0.2%</td><td>2.8%</td><td>0.1%</td><td>12.2%</td></tr><tr><td>68.5%</td><td>50.0%</td><td>95.8%</td><td>80.7%</td></tr><tr><td>11.1%</td><td>50.0%</td><td>4.4%</td><td>20.0%</td></tr></table></div></div>	438	66	35	12	14.2%	2.1%	1.1%	0.4%	7	213	34	61	0.2%	7.5%	1.1%	2.2%	38	89	1587	10	1.2%	2.9%	51.3%	0.3%	6	88	2	379	0.2%	2.8%	0.1%	12.3%	88.6%	48.9%	95.7%	85.6%	10.2%	51.1%	4.3%	14.7%	22	4	3	2	12.8%	2.3%	1.1%	1.2%	0	10	2	3	0.0%	8.0%	1.2%	3.3%	4	4	91	1	2.3%	2.0%	52.9%	0.6%	1	4	0	21	0.6%	2.0%	0.0%	12.2%	81.5%	45.5%	94.0%	77.8%	18.5%	54.5%	5.2%	22.2%	14	3	4	2	8.1%	1.7%	2.3%	1.2%	1	21	2	1	0.6%	12.2%	1.2%	3.0%	3	3	90	9	1.7%	1.7%	62.3%	0.0%	0	3	0	20	0.0%	1.7%	0.0%	13.0%	77.8%	70.0%	93.8%	71.4%	22.2%	30.0%	6.2%	28.6%	474	73	42	15	13.8%	2.1%	1.2%	0.5%	8	264	36	78	0.2%	7.7%	1.1%	2.3%	45	96	1768	11	1.3%	2.8%	51.5%	0.3%	6	95	2	430	0.2%	2.8%	0.1%	12.2%	68.5%	50.0%	95.8%	80.7%	11.1%	50.0%	4.4%	20.0%
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Run 3	<div><div><div>Training Confusion Matrix</div><table><tr><td>439</td><td>50</td><td>36</td><td>5</td></tr><tr><td>14.2%</td><td>1.6%</td><td>1.2%</td><td>0.2%</td></tr><tr><td>17</td><td>310</td><td>18</td><td>50</td></tr><tr><td>0.6%</td><td>10.0%</td><td>0.6%</td><td>1.6%</td></tr><tr><td>31</td><td>69</td><td>1587</td><td>11</td></tr><tr><td>1.0%</td><td>2.2%</td><td>51.3%</td><td>0.4%</td></tr><tr><td>6</td><td>91</td><td>9</td><td>393</td></tr><tr><td>0.2%</td><td>1.8%</td><td>0.3%</td><td>12.7%</td></tr><tr><td>88.0%</td><td>44.4%</td><td>96.2%</td><td>83.0%</td></tr><tr><td>11.0%</td><td>55.6%</td><td>3.8%</td><td>16.2%</td></tr></table></div><div><div>Validation Confusion Matrix</div><table><tr><td>11</td><td>3</td><td>1</td><td>0</td></tr><tr><td>6.4%</td><td>1.7%</td><td>0.8%</td><td>0.0%</td></tr><tr><td>0</td><td>10</td><td>1</td><td>1</td></tr><tr><td>0.0%</td><td>8.0%</td><td>0.8%</td><td>0.8%</td></tr><tr><td>1</td><td>3</td><td>99</td><td>0</td></tr><tr><td>0.6%</td><td>1.7%</td><td>57.8%</td><td>0.0%</td></tr><tr><td>1</td><td>0</td><td>2</td><td>31</td></tr><tr><td>0.6%</td><td>0.0%</td><td>1.2%</td><td>10.0%</td></tr><tr><td>64.0%</td><td>75.0%</td><td>96.1%</td><td>95.9%</td></tr><tr><td>15.4%</td><td>25.0%</td><td>3.9%</td><td>3.1%</td></tr></table></div><div><div>Test Confusion Matrix</div><table><tr><td>25</td><td>2</td><td>1</td><td>9</td></tr><tr><td>14.0%</td><td>1.2%</td><td>0.6%</td><td>0.0%</td></tr><tr><td>1</td><td>17</td><td>1</td><td>1</td></tr><tr><td>0.6%</td><td>9.9%</td><td>0.6%</td><td>0.0%</td></tr><tr><td>1</td><td>1</td><td>94</td><td>9</td></tr><tr><td>0.6%</td><td>1.2%</td><td>56.7%</td><td>0.0%</td></tr><tr><td>0</td><td>3</td><td>1</td><td>23</td></tr><tr><td>0.0%</td><td>1.7%</td><td>0.6%</td><td>13.4%</td></tr><tr><td>82.8%</td><td>70.0%</td><td>96.0%</td><td>85.2%</td></tr><tr><td>7.4%</td><td>29.2%</td><td>5.1%</td><td>4.2%</td></tr></table></div><div><div>All Confusion Matrix</div><table><tr><td>475</td><td>95</td><td>38</td><td>5</td></tr><tr><td>13.8%</td><td>1.6%</td><td>1.1%</td><td>0.1%</td></tr><tr><td>18</td><td>345</td><td>20</td><td>62</td></tr><tr><td>0.5%</td><td>10.0%</td><td>0.6%</td><td>1.9%</td></tr><tr><td>33</td><td>74</td><td>1768</td><td>11</td></tr><tr><td>1.0%</td><td>2.2%</td><td>51.8%</td><td>0.3%</td></tr><tr><td>7</td><td>54</td><td>12</td><td>447</td></tr><tr><td>0.2%</td><td>1.6%</td><td>0.3%</td><td>13.0%</td></tr><tr><td>66.1%</td><td>65.2%</td><td>96.2%</td><td>85.1%</td></tr><tr><td>10.9%</td><td>34.7%</td><td>3.3%</td><td>14.9%</td></tr></table></div></div>	439	50	36	5	14.2%	1.6%	1.2%	0.2%	17	310	18	50	0.6%	10.0%	0.6%	1.6%	31	69	1587	11	1.0%	2.2%	51.3%	0.4%	6	91	9	393	0.2%	1.8%	0.3%	12.7%	88.0%	44.4%	96.2%	83.0%	11.0%	55.6%	3.8%	16.2%	11	3	1	0	6.4%	1.7%	0.8%	0.0%	0	10	1	1	0.0%	8.0%	0.8%	0.8%	1	3	99	0	0.6%	1.7%	57.8%	0.0%	1	0	2	31	0.6%	0.0%	1.2%	10.0%	64.0%	75.0%	96.1%	95.9%	15.4%	25.0%	3.9%	3.1%	25	2	1	9	14.0%	1.2%	0.6%	0.0%	1	17	1	1	0.6%	9.9%	0.6%	0.0%	1	1	94	9	0.6%	1.2%	56.7%	0.0%	0	3	1	23	0.0%	1.7%	0.6%	13.4%	82.8%	70.0%	96.0%	85.2%	7.4%	29.2%	5.1%	4.2%	475	95	38	5	13.8%	1.6%	1.1%	0.1%	18	345	20	62	0.5%	10.0%	0.6%	1.9%	33	74	1768	11	1.0%	2.2%	51.8%	0.3%	7	54	12	447	0.2%	1.6%	0.3%	13.0%	66.1%	65.2%	96.2%	85.1%	10.9%	34.7%	3.3%	14.9%
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10.9%	34.7%	3.3%	14.9%																																																																																																																																																														



Run 4

Training Confusion Matrix

423	10	34	8	80.7%
13.1%	1.5%	1.1%	0.3%	19.3%
14	250	26	52	71.1%
0.5%	8.4%	0.8%	2.0%	20.5%
29	77	1002	9	53.3%
0.9%	2.5%	51.8%	0.3%	6.7%
7	07	2	394	60.4%
0.2%	2.3%	0.1%	12.7%	19.4%
85.4%	53.1%	96.3%	83.3%	86.6%
10.6%	46.3%	3.7%	16.7%	13.4%
Output Class	Target Class			

Validation Confusion Matrix

21	3	5	1	70.0%
12.2%	1.7%	2.9%	0.6%	10.0%
1	18	1	2	7.4%
0.8%	5.8%	0.8%	1.2%	26.6%
2	4	53	1	93.0%
1.2%	2.3%	54.1%	0.6%	7.0%
0	4	0	24	85.7%
0.0%	2.3%	0.0%	14.3%	14.3%
87.5%	47.6%	53.2%	85.7%	86.6%
12.5%	52.4%	6.1%	14.3%	14.0%
Output Class	Target Class			

Test Confusion Matrix

32	2	1	1	88.0%
18.0%	1.2%	0.6%	0.6%	11.1%
1	17	2	1	81.0%
0.6%	9.8%	1.2%	0.6%	19.0%
2	4	84	1	92.3%
1.2%	2.3%	48.8%	0.6%	7.7%
1	2	0	21	87.5%
0.6%	1.2%	0.0%	12.2%	12.5%
88.9%	88.2%	96.6%	87.5%	88.9%
11.1%	12.0%	3.4%	12.5%	10.9%
Output Class	Target Class			

All Confusion Matrix

476	64	40	10	80.7%
13.9%	1.9%	1.2%	0.3%	19.3%
18	288	29	65	72.2%
0.5%	9.5%	0.8%	1.9%	20.5%
33	85	1779	11	93.2%
1.0%	2.8%	51.8%	0.3%	6.8%
8	93	2	439	91.0%
0.2%	2.7%	0.1%	12.8%	19.0%
86.3%	54.2%	96.2%	83.3%	86.7%
10.7%	45.8%	3.8%	16.4%	13.2%
Output Class	Target Class			

Run 5

Training Confusion Matrix

289	57	79	3	73.7%
12.6%	1.8%	2.6%	0.1%	26.3%
21	129	29	39	69.2%
0.7%	4.2%	0.9%	1.3%	40.8%
58	106	1547	8	90.0%
1.9%	3.4%	50.0%	0.3%	10.0%
10	192	8	447	69.5%
0.3%	5.2%	0.3%	13.5%	13.4%
81.4%	26.7%	53.0%	85.2%	80.3%
18.6%	73.3%	7.0%	10.7%	19.7%
Output Class	Target Class			

Validation Confusion Matrix

19	0	6	1	73.1%
11.0%	0.0%	3.5%	0.6%	26.9%
0	3	1	1	60.0%
0.0%	1.7%	0.8%	0.6%	45.0%
3	13	88	0	94.6%
1.7%	7.6%	51.2%	0.0%	15.4%
0	4	0	33	88.2%
0.0%	2.3%	0.0%	12.8%	19.0%
86.4%	15.0%	32.2%	94.3%	83.1%
13.6%	85.0%	7.4%	5.7%	16.9%
Output Class	Target Class			

Test Confusion Matrix

27	3	6	9	79.2%
15.7%	1.7%	3.6%	0.9%	25.0%
1	10	1	9	83.3%
0.6%	5.5%	0.6%	0.9%	16.7%
4	3	85	9	92.4%
2.3%	1.7%	48.4%	0.9%	7.8%
1	8	0	23	71.9%
0.6%	4.7%	0.0%	13.4%	28.1%
81.8%	41.7%	62.4%	100%	84.3%
18.2%	58.3%	7.6%	0.0%	15.7%
Output Class	Target Class			

All Confusion Matrix

435	63	91	4	73.7%
12.7%	1.7%	2.6%	0.1%	26.3%
22	142	31	49	69.4%
0.8%	4.1%	0.9%	1.2%	39.6%
65	122	1728	8	90.9%
1.9%	3.6%	50.1%	0.2%	10.2%
11	204	8	473	69.0%
0.3%	6.9%	0.2%	13.8%	12.0%
81.8%	26.9%	93.5%	90.1%	86.6%
18.4%	73.1%	7.0%	9.8%	19.4%
Output Class	Target Class			

Run 6

Training Confusion Matrix

436	64	95	3	79.1%
14.1%	2.1%	1.6%	0.3%	21.9%
12	196	27	77	62.8%
0.4%	6.3%	0.9%	2.5%	37.2%
23	89	1584	5	93.1%
0.7%	2.9%	51.2%	0.2%	8.9%
9	127	2	383	73.5%
0.3%	4.1%	0.1%	12.4%	26.5%
90.6%	41.2%	65.2%	81.0%	84.4%
9.4%	58.8%	6.8%	19.0%	15.6%
Output Class	Target Class			

Validation Confusion Matrix

20	5	1	0	70.0%
11.6%	2.9%	0.6%	0.0%	23.1%
0	16	1	3	80.0%
0.0%	9.2%	0.2%	1.7%	20.0%
2	3	97	6	95.1%
1.2%	1.7%	56.4%	0.9%	4.9%
1	4	0	19	79.2%
0.6%	2.3%	0.0%	11.0%	25.8%
87.5%	57.1%	98.0%	85.4%	88.4%
13.5%	42.8%	2.0%	14.6%	14.6%
Output Class	Target Class			

Test Confusion Matrix

29	3	1	9	87.5%
16.9%	1.7%	0.6%	0.9%	12.1%
0	9	1	4	64.3%
0.0%	5.2%	0.6%	2.3%	35.7%
1	7	86	1	91.5%
0.6%	4.1%	92.0%	0.6%	8.9%
0	5	0	25	63.3%
0.0%	2.9%	0.0%	14.9%	19.7%
96.7%	37.5%	97.7%	83.3%	86.6%
3.3%	62.5%	2.3%	16.7%	13.4%
Output Class	Target Class			

All Confusion Matrix

469	72	32	8	74.6%
14.1%	2.1%	1.5%	0.2%	21.4%
12	221	29	84	63.9%
0.3%	6.4%	0.8%	2.4%	36.1%
26	99	1767	6	91.1%
0.8%	3.9%	51.4%	0.2%	4.9%
10	136	2	427	74.3%
0.3%	4.0%	0.1%	12.4%	28.7%
91.0%	41.9%	95.5%	81.3%	88.4%
8.0%	58.1%	4.5%	18.7%	15.6%
Output Class	Target Class			

Run 7

Training Confusion Matrix

299	63	41	7	78.2%
12.9%	2.0%	1.3%	0.2%	21.8%
33	211	34	96	96.4%
1.1%	8.8%	1.1%	3.1%	43.6%
37	94	1600	7	92.1%
1.2%	3.3%	51.7%	0.2%	7.8%
4	93	6	387	78.1%
0.1%	3.5%	0.2%	11.9%	21.9%
84.4%	45.8%	95.2%	78.9%	83.3%
15.6%	54.2%	4.8%	23.1%	16.7%
Output Class	Target Class			

Validation Confusion Matrix

22	8	3	1	71.0%
12.8%	2.9%	1.7%	0.6%	25.0%
2	17	1	2	77.3%
1.2%	9.9%	0.5%	1.2%	22.7%
5	5	85	0	88.5%
2.9%	2.9%	49.4%	0.0%	10.8%
0	6	0	18	75.0%
0.0%	3.8%	0.0%	10.5%	25.0%
75.9%	51.5%	95.5%	85.7%	83.6%
24.1%	48.5%	4.5%	14.3%	17.4%
Output Class	Target Class			

Test Confusion Matrix

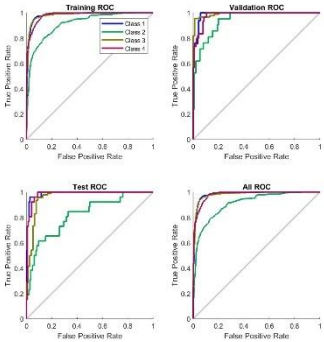
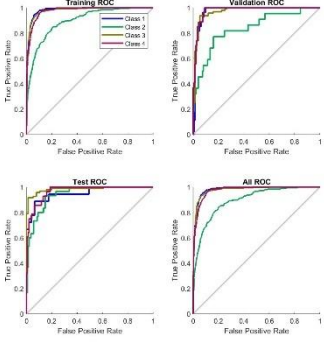
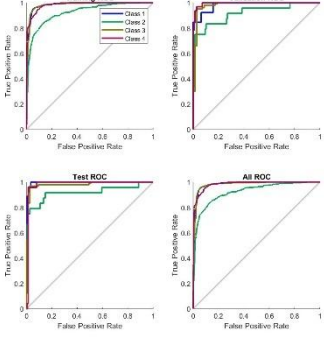
24	3	3	0	80.0%
14.0%	1.7%	1.7%	0.0%	20.0%
4	17	1	5	63.0%
2.3%	9.9%	0.6%	2.9%	37.0%
2	8	76	0	91.4%
1.2%	3.5%	43.8%	0.0%	9.4%
1	8	1	32	68.8%
0.6%	4.7%	0.6%	12.8%	31.2%
77.4%	50.0%	93.8%	81.0%	80.2%
22.6%	50.0%	6.2%	19.0%	19.8%
Output Class	Target Class			

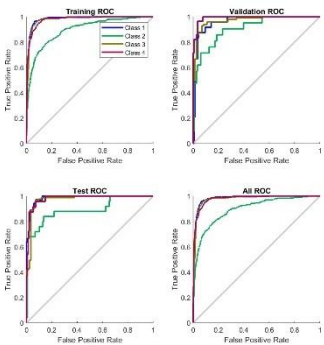
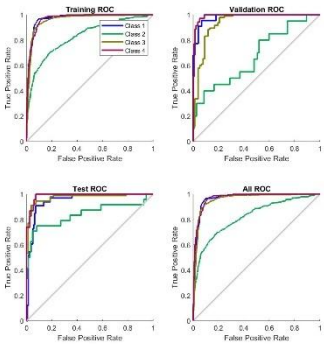
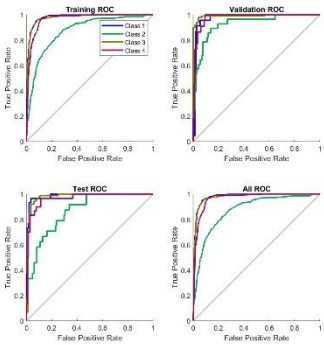
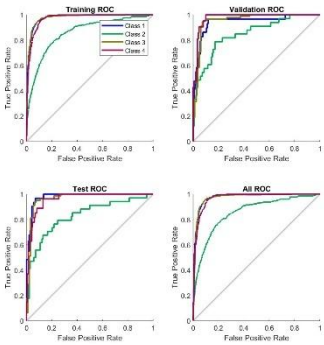
All Confusion Matrix

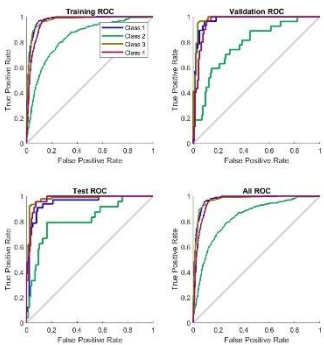
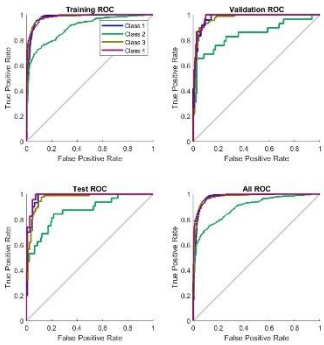
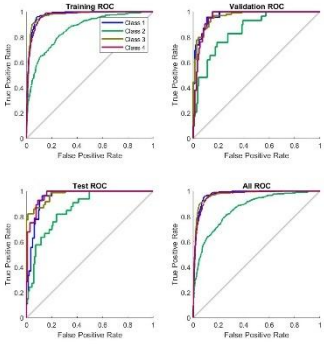
445	71	47	8	77.9%
13.0%	2.1%	1.4%	0.2%	22.1%
39	245	36	103	59.9%
1.1%	7.1%	1.0%	3.0%	41.1%
44	105	1760	7	91.0%
1.2%	3.1%	51.2%	0.2%	8.1%
5	107	7	407	77.4%
0.1%	3.1%	0.2%	11.8%	22.6%
83.5%	48.4%	95.1%	77.9%	83.1%
16.5%	51.6%	4.9%	22.0%	16.9%
Output Class	Target Class			

[illegible]

3. ROC Curve Model LM.

Training	ROC Curve untuk Training, Validasi, Testing and All
Run 1	 <p>The figure displays four ROC curves for Run 1. The top-left plot is the Training ROC, the top-right is the Validation ROC, the bottom-left is the Test ROC, and the bottom-right is the All ROC. Each plot shows the True Positive Rate (Y-axis) against the False Positive Rate (X-axis) for four classes: Class 1 (blue), Class 2 (green), Class 3 (yellow), and Class 4 (purple). The curves are generally close to the top-left corner, indicating good model performance. The legend in the Training ROC plot shows Class 1 as blue, Class 2 as green, Class 3 as yellow, and Class 4 as purple.</p>
Run 2	 <p>The figure displays four ROC curves for Run 2. The top-left plot is the Training ROC, the top-right is the Validation ROC, the bottom-left is the Test ROC, and the bottom-right is the All ROC. Each plot shows the True Positive Rate (Y-axis) against the False Positive Rate (X-axis) for four classes: Class 1 (blue), Class 2 (green), Class 3 (yellow), and Class 4 (purple). The curves are generally close to the top-left corner, indicating good model performance. The legend in the Training ROC plot shows Class 1 as blue, Class 2 as green, Class 3 as yellow, and Class 4 as purple.</p>
Run 3	 <p>The figure displays four ROC curves for Run 3. The top-left plot is the Training ROC, the top-right is the Validation ROC, the bottom-left is the Test ROC, and the bottom-right is the All ROC. Each plot shows the True Positive Rate (Y-axis) against the False Positive Rate (X-axis) for four classes: Class 1 (blue), Class 2 (green), Class 3 (yellow), and Class 4 (purple). The curves are generally close to the top-left corner, indicating good model performance. The legend in the Training ROC plot shows Class 1 as blue, Class 2 as green, Class 3 as yellow, and Class 4 as purple.</p>

<b>Run 4</b>	 <p>ROC curves for Run 4. The figure contains four subplots: Training ROC, Validation ROC, Test ROC, and All ROC. Each plot shows True Positive Rate (Y-axis) versus False Positive Rate (X-axis) for four classes (Class 1, Class 2, Class 3, Class 4). The curves are generally high, indicating good performance, with the All ROC curve being the highest.</p>
<b>Run 5</b>	 <p>ROC curves for Run 5. The figure contains four subplots: Training ROC, Validation ROC, Test ROC, and All ROC. Each plot shows True Positive Rate (Y-axis) versus False Positive Rate (X-axis) for four classes (Class 1, Class 2, Class 3, Class 4). The curves are generally high, indicating good performance, with the All ROC curve being the highest.</p>
<b>Run 6</b>	 <p>ROC curves for Run 6. The figure contains four subplots: Training ROC, Validation ROC, Test ROC, and All ROC. Each plot shows True Positive Rate (Y-axis) versus False Positive Rate (X-axis) for four classes (Class 1, Class 2, Class 3, Class 4). The curves are generally high, indicating good performance, with the All ROC curve being the highest.</p>
<b>Run 7</b>	 <p>ROC curves for Run 7. The figure contains four subplots: Training ROC, Validation ROC, Test ROC, and All ROC. Each plot shows True Positive Rate (Y-axis) versus False Positive Rate (X-axis) for four classes (Class 1, Class 2, Class 3, Class 4). The curves are generally high, indicating good performance, with the All ROC curve being the highest.</p>

<p><b>Run 8</b></p>	
<p><b>Run 9</b></p>	
<p><b>Run 10</b></p>	

Dari hasil penggunaan model *Scaled Conjugate Gradient* (SCG) dengan Hidden Neuron 15, terbentuk grafik performa yang menampilkan tiga baris berbeda. Garis biru mencerminkan nilai train, garis hijau menggambarkan nilai validation, sementara garis merah menunjukkan nilai test. Dilihat dari gambar dengan 10 grafik performance baik dari grafik *train*, *validation* dan *test*. Terlihat bahwa grafik menunjukkan penurunan error yang signifikan pada rentang epoch 0 hingga 10.

Sedangkan performa grafik menurun errornya menlandai dari sekitar epoch 10 hingga epoch maksimal terlihat pada run 1 hingga run 10.

Berdasarkan 10 fold cross validation, data training adalah 90% dari data total (3092), validation 5% dari total (171), dan test 5% dari total (171). Dari hasil nilai training yang terlihat pada Confusion Matrix, jumlah nilai target yang benar-benar terklasifikasi oleh neural network menjadi kelasnya masing-masing ditunjukkan dengan warna hijau, sedangkan warna merah muda adalah jumlah data yang gagal terklasifikasikan pada kelasnya. Pada Confusion Matrix hasil training dari run 1 hingga run 10 menunjukkan jumlah error lebih besar dari 10% dari total data training (309). Sedangkan, untuk Confusion Matrix hasil validation dan testing dari run 1 hingga run 10 menunjukkan jumlah error lebih besar dari 10% dari total data (17). Sehingga, dapat disimpulkan hasil training, validation, dan test terkategori tidak excellent.

Dalam analisis visualisasi Receiver Operating Characteristics (ROC) menggunakan model SCG dengan Hidden Neuron 15, terlihat bahwa bentuk kurva menunjukkan kesamaan baik dari ROC training, validation, dan testing. Grafik memiliki bentuk yang tidak siku alias mendekati garis diagonal. Sehingga training RGB to HSV dengan model SCG Hidden Neuron 15 menunjukkan hasil yang excellent.

### C. HASIL TRAINING UNTUK MODEL 2 Hidden Node 20

#### 4. Hasil akurasi Training, Validasi, Testing Model SCG dengan Hidden Node 20.


Tabel 2.1 Hasil All, Best Epoch dan Akurasi Training, Validasi dan Testing

Training	All	Best	Acc Training (%)	Acc Vaidasi (%)	Acc Testing (%)	Time
Run 1	69	63	84,3	86,0	80,2	0:00:07
Run 2	121	127	89,3	87,2	86,0	0:00:01
Run 3	92	86	86,6	86,6	84,9	0:00:01
Run 4	58	52	84,7	85,5	82,0	0:00:01
Run 5	137	131	89,2	87,8	89,5	0:00:01
Run 6	33	27	76,1	69,2	75,0	0:00:00
Run 7	77	71	83,8	83,1	84,9	0:00:01
Run 8	63	57	83,5	84,3	84,3	0:00:01
Run 9	68	62	84,2	80,2	78,5	0:00:01
Run 10	48	42	82,8	86,0	79,7	0:00:00
Average±Deviation			84,45 ± 3,721	83,59 ± 5,521	82,5 ± 4,237	

Berdasarkan Tabel 2.1, bahwa hasil pelatihan dari sepuluh kali percobaan dengan model klasifikasi SCG dan HN 20 diperoleh dari nilai *epoch* tertinggi sebesar 137 dan nilai terendah sebesar 33 Sementara itu, nilai *best epoch* tertinggi adalah 131 dan nilai terendahnya adalah 27. Akurasi *training* memiliki rata-rata sebesar 84,45%, dengan nilai pelatihan tertinggi mencapai 89,3% pada percobaan kedua. Untuk *validation*, nilai rata-ratanya adalah 83,59%, dengan nilai tertinggi mencapai 87,8% pada percobaan kelima. Sedangkan untuk testing, nilai rata-ratanya adalah 82,5%, dengan nilai tertinggi mencapai 89,5% pada percobaan

kelima. Data *best epoch validation* diperoleh dari grafik *training performance*, sementara data *training*, *validation* dan *testing* berasal dari *confusion matrix*.

## 5. Confision Matrix dan ROC Curve Model SCG Hidden Node 20

Training	Confision Matrix (standard) untuk Training, Validasi, Testing and All
Run 1	<div>     </div>
Run 2	<div>     </div>
Run 3	<div>     </div>



Run 4

Training Confusion Matrix				
Output Class	1	2	3	4
	416	55	61	7
	13.3%	1.8%	2.0%	0.2%
	31	229	22	56
	1.0%	7.4%	0.7%	2.1%
Target Class	1	2	3	4
	10	183	1587	9
	0.6%	3.3%	51.3%	0.3%
	7	66	6	394
	0.2%	2.3%	0.2%	12.7%

Run 8

Training Confusion Matrix

1	394	64	34	6	79.1%
2	12.7%	2.1%	1.1%	0.2%	20.9%
3	22	228	98	83	58.0%
4	0.7%	7.4%	3.0%	42.2%	
5	45	71	1982	5	92.9%
6	1.5%	2.3%	51.2%	0.2%	7.1%
7	10	104	5	379	78.1%
8	0.3%	3.4%	0.2%	22.3%	
9	53.7%	48.8%	94.7%	75.5%	83.8%
10	16.3%	51.2%	5.3%	21.5%	16.8%

Validation Confusion Matrix

1	35	4	2	1	83.3%
2	20.3%	2.3%	1.2%	0.6%	16.7%
3	6	14	2	3	71.7%
4	0.0%	6.1%	1.2%	1.7%	26.3%
5	2	6	85	0	91.4%
6	1.2%	3.5%	49.4%	0.0%	8.6%
7	0	7	0	11	61.1%
8	0.0%	4.1%	0.0%	6.4%	26.6%
9	64.0%	45.2%	95.5%	73.3%	84.3%
10	5.4%	64.8%	4.5%	26.7%	15.7%

Test Confusion Matrix

1	23	8	4	9	89.2%
2	13.4%	0.0%	2.3%	0.0%	14.8%
3	1	14	3	2	70.0%
4	0.0%	8.1%	1.7%	1.2%	20.0%
5	1	6	83	9	92.5%
6	0.6%	3.5%	48.3%	0.0%	7.8%
7	0	10	0	25	71.4%
8	0.0%	5.6%	0.0%	14.9%	28.6%
9	82.0%	46.7%	92.2%	82.5%	84.3%
10	8.0%	53.3%	7.8%	7.4%	19.7%

All Confusion Matrix

1	452	68	40	7	79.7%
2	13.2%	2.0%	1.2%	0.2%	20.3%
3	23	256	55	98	69.3%
4	0.7%	7.5%	1.5%	2.9%	45.7%
5	48	83	1790	5	95.6%
6	1.4%	2.4%	50.9%	0.1%	7.2%
7	10	121	5	415	75.3%
8	0.3%	3.8%	0.1%	12.1%	24.7%
9	64.8%	48.8%	94.8%	70.0%	83.6%
10	15.2%	51.3%	5.4%	21.0%	16.4%

Run 9

Training Confusion Matrix

1	435	57	98	9	77.8%
2	14.1%	1.8%	1.9%	0.3%	22.2%
3	9	212	29	58	69.7%
4	0.3%	6.9%	0.9%	2.2%	33.3%
5	32	91	1567	6	92.4%
6	1.0%	2.9%	50.7%	0.2%	7.6%
7	8	115	5	391	75.3%
8	0.3%	3.7%	0.2%	12.6%	24.7%
9	55.0%	44.2%	94.0%	82.5%	84.2%
10	16.1%	55.4%	5.0%	17.6%	15.8%

Validation Confusion Matrix

1	18	4	7	1	60.0%
2	10.5%	2.3%	4.1%	0.6%	45.0%
3	1	18	3	6	64.3%
4	0.6%	10.5%	1.7%	3.9%	35.7%
5	3	4	82	0	95.1%
6	1.7%	2.3%	47.7%	0.0%	7.9%
7	0	5	0	20	60.0%
8	0.0%	4.8%	0.0%	11.8%	20.0%
9	81.3%	65.1%	95.1%	74.1%	86.2%
10	18.2%	41.9%	10.0%	25.9%	19.8%

Test Confusion Matrix

1	18	6	6	9	60.0%
2	10.0%	3.5%	3.6%	0.0%	40.0%
3	4	6	1	4	40.0%
4	2.3%	3.5%	0.0%	2.3%	30.0%
5	4	6	80	1	89.3%
6	2.3%	3.5%	83.6%	0.6%	10.7%
7	1	4	0	19	79.2%
8	0.6%	2.3%	0.0%	11.0%	20.8%
9	66.7%	17.3%	62.6%	75.2%	78.9%
10	33.3%	72.7%	7.1%	20.8%	21.0%

All Confusion Matrix

1	471	67	71	19	76.1%
2	13.7%	1.9%	2.1%	0.3%	21.9%
3	14	236	33	78	65.4%
4	0.4%	6.9%	1.0%	2.3%	34.6%
5	39	104	1741	7	90.2%
6	1.1%	2.9%	50.7%	0.2%	7.8%
7	9	124	5	430	75.7%
8	0.3%	3.6%	0.1%	12.8%	24.3%
9	68.4%	44.7%	94.1%	81.9%	83.8%
10	11.6%	55.2%	5.1%	18.1%	16.2%

Run 10

Training Confusion Matrix

1	436	60	81	5	74.9%
2	14.1%	1.9%	2.0%	0.2%	25.1%
3	21	221	37	86	69.0%
4	0.7%	7.1%	1.2%	2.8%	39.0%
5	30	90	1591	6	92.0%
6	1.0%	3.1%	48.9%	0.2%	8.0%
7	5	89	7	391	77.9%
8	0.2%	3.2%	0.2%	12.6%	22.1%
9	58.6%	46.4%	92.4%	80.1%	82.8%
10	11.4%	53.6%	7.6%	19.9%	17.2%

Validation Confusion Matrix

1	20	3	2	1	75.0%
2	11.6%	1.7%	1.2%	0.6%	23.1%
3	1	11	3	2	64.7%
4	0.6%	6.4%	1.7%	1.2%	20.2%
5	1	3	89	0	96.1%
6	0.6%	1.7%	57.8%	0.0%	3.9%
7	1	5	2	18	69.2%
8	0.6%	2.9%	1.2%	10.5%	30.8%
9	67.0%	50.0%	93.4%	85.7%	88.6%
10	13.0%	49.0%	6.6%	14.3%	14.6%

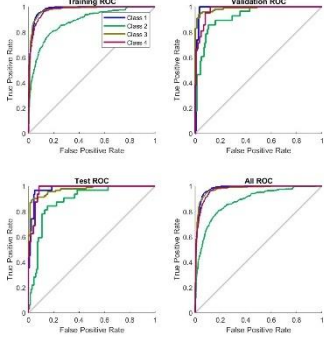
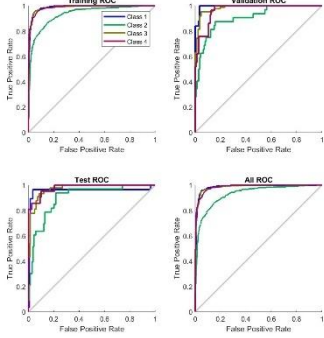
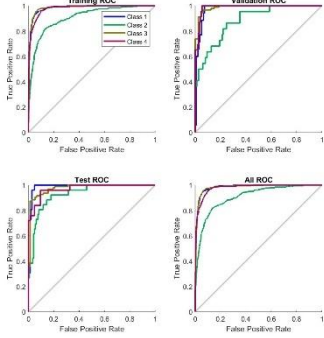
Test Confusion Matrix

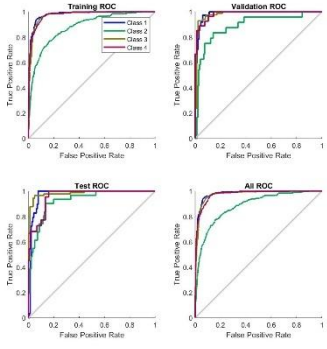
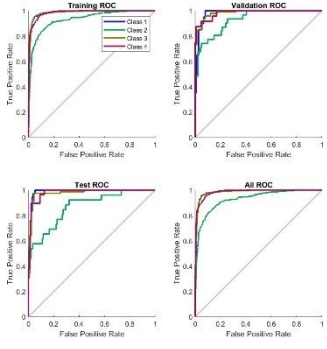
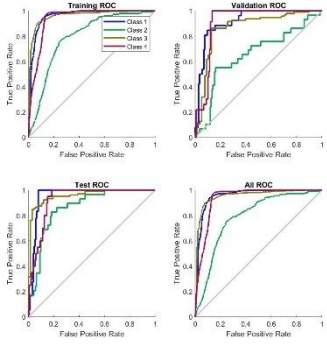
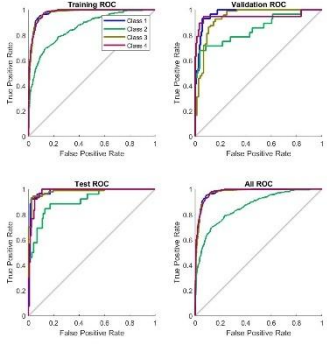
1	16	7	4	1	57.1%
2	9.3%	4.1%	2.3%	0.6%	42.9%
3	0	8	3	3	57.1%
4	0.0%	4.7%	1.7%	1.7%	42.9%
5	2	6	101	9	92.7%
6	1.2%	3.5%	86.7%	0.0%	7.8%
7	0	9	0	12	57.1%
8	0.0%	5.2%	0.0%	7.0%	42.9%
9	68.0%	26.7%	93.8%	75.0%	79.7%
10	11.1%	73.3%	6.6%	25.0%	20.3%

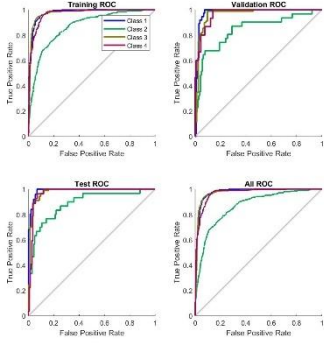
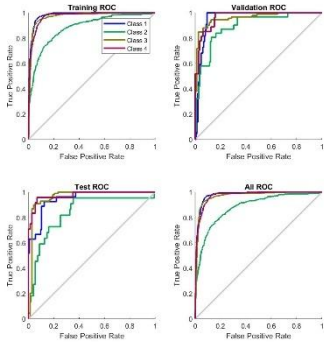
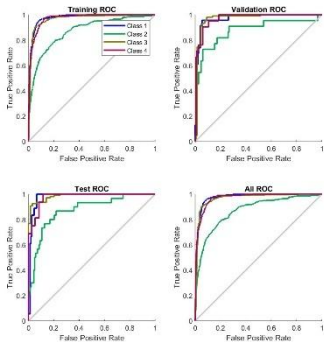
All Confusion Matrix

1	472	78	87	7	74.2%
2	13.7%	2.0%	2.5%	0.2%	25.8%
3	22	240	43	91	60.6%
4	0.6%	7.0%	1.3%	2.6%	38.4%
5	33	105	1711	6	90.2%
6	1.0%	3.1%	49.8%	0.2%	7.8%
7	6	113	9	421	76.7%
8	0.2%	3.3%	0.3%	12.3%	21.3%
9	68.0%	45.9%	92.8%	80.2%	83.8%
10	11.4%	54.0%	7.3%	19.8%	17.2%

## 6. ROC Curve Model SCG Hidden Node 20

Training	ROC Curve untuk Training, Validasi, Testing and All
<b>Run 1</b>	 <p>ROC curves for Run 1 showing True Positive Rate vs False Positive Rate for Training, Validation, Test, and All data sets. The curves are plotted for Class 1 (blue), Class 2 (green), Class 3 (red), and Class 4 (purple). The Training ROC curve shows the highest performance, followed by Validation, Test, and All data sets.</p>
<b>Run 2</b>	 <p>ROC curves for Run 2 showing True Positive Rate vs False Positive Rate for Training, Validation, Test, and All data sets. The curves are plotted for Class 1 (blue), Class 2 (green), Class 3 (red), and Class 4 (purple). The Training ROC curve shows the highest performance, followed by Validation, Test, and All data sets.</p>
<b>Run 3</b>	 <p>ROC curves for Run 3 showing True Positive Rate vs False Positive Rate for Training, Validation, Test, and All data sets. The curves are plotted for Class 1 (blue), Class 2 (green), Class 3 (red), and Class 4 (purple). The Training ROC curve shows the highest performance, followed by Validation, Test, and All data sets.</p>

<b>Run 4</b>	 <p>ROC curves for Run 4. The figure contains four subplots: Training ROC, Validation ROC, Test ROC, and All ROC. Each plot shows True Positive Rate (Y-axis) versus False Positive Rate (X-axis) for four classes (Class 1, Class 2, Class 3, Class 4). The curves are generally high, indicating good model performance across all classes.</p>
<b>Run 5</b>	 <p>ROC curves for Run 5. The figure contains four subplots: Training ROC, Validation ROC, Test ROC, and All ROC. Each plot shows True Positive Rate (Y-axis) versus False Positive Rate (X-axis) for four classes (Class 1, Class 2, Class 3, Class 4). The curves are generally high, indicating good model performance across all classes.</p>
<b>Run 6</b>	 <p>ROC curves for Run 6. The figure contains four subplots: Training ROC, Validation ROC, Test ROC, and All ROC. Each plot shows True Positive Rate (Y-axis) versus False Positive Rate (X-axis) for four classes (Class 1, Class 2, Class 3, Class 4). The curves are generally high, indicating good model performance across all classes.</p>
<b>Run 7</b>	 <p>ROC curves for Run 7. The figure contains four subplots: Training ROC, Validation ROC, Test ROC, and All ROC. Each plot shows True Positive Rate (Y-axis) versus False Positive Rate (X-axis) for four classes (Class 1, Class 2, Class 3, Class 4). The curves are generally high, indicating good model performance across all classes.</p>

Run 8	
Run 9	
Run 10	

Dari hasil penggunaan model *Scaled Conjugate Gradient* (SCG) dengan Hidden Neuron 20, terbentuk grafik performa yang menampilkan tiga baris berbeda. Garis biru mencerminkan nilai train, garis hijau menggambarkan nilai validation, sementara garis merah menunjukkan nilai test. Dilihat dari gambar dengan 10 grafik performance baik dari grafik *train*, *validation* dan *test*. Terlihat bahwa grafik menunjukkan penurunan error yang signifikan pada rentang epoch 0 hingga 10. Sedangkan performa grafik menurun errornya menlandai dari sekitar epoch 10 hingga epoch maksimal terlihat pada run 1 hingga run 10.

Berdasarkan 10 fold cross validation, data training adalah 90% dari data total (3092), validation 5% dari total (171), dan test 5% dari total (171). Dari hasil nilai training yang terlihat pada Confusion Matrix, jumlah nilai target yang benar-benar terklasifikasi oleh neural network menjadi kelasnya masing-masing ditunjukkan dengan warna hijau, sedangkan warna merah muda adalah jumlah data yang gagal terklasifikasi pada kelasnya. Pada Confusion Matrix hasil training dari run 1 hingga run 10 menunjukkan jumlah error lebih besar dari 10% dari total data training (309). Sedangkan, untuk Confusion Matrix hasil validation dan testing dari run 1 hingga run 10 menunjukkan jumlah error lebih besar dari 10% dari total data (17). Sehingga, dapat disimpulkan hasil training, validation, dan test terkategori tidak excellent.

Dalam analisis visualisasi Receiver Operating Characteristics (ROC) menggunakan model SCG dengan Hidden Neuron 15, terlihat bahwa bentuk kurva menunjukkan kesamaan baik dari ROC training, validation, dan testing. Grafik memiliki bentuk yang tidak siku alias mendekati garis diagonal. Sehingga training RGB to HSV dengan model SCG Hidden Neuron 20 menunjukkan hasil yang excellent.

## 7. Hasil akurasi Training, Validasi, Testing Model LM dengan Hidden Node 15.

Tabel 2.1 Hasil All, Best Epoch dan Akurasi Training, Validasi dan Testing

Training	All	Best	Acc Training (%)	Acc Vaidasi (%)	Acc Testing (%)	Time
Run 1	49	43	96,0	95,9	96,5	0:00:02
Run 2	50	44	97,9	93,0	94,8	0:00:02
Run 3	33	27	94,3	94,2	91,9	0:00:02
Run 4	33	27	96,3	95,3	92,4	0:00:02
Run 5	47	41	97,0	96,5	93,6	0:00:02
Run 6	61	55	96,8	95,3	95,9	0:00:03
Run 7	32	26	94,0	94,2	93,6	0:00:02
Run 8	39	33	95,4	94,8	94,2	0:00:02
Run 9	41	35	95,3	94,2	95,3	0:00:02
Run 10	42	36	94,5	92,4	91,9	0:00:02
Average ± STD			95,75 ± 1,278	94,58 ± 1,25	94,01 ± 1,630	

Berdasarkan Tabel 2.1, bahwa hasil pelatihan dari sepuluh kali percobaan dengan model klasifikasi LM dan HN 15 diperoleh dari nilai *epoch* tertinggi sebesar 61 dan nilai terendah sebesar 32 Sementara itu, nilai *best epoch* tertinggi adalah 55 dan nilai terendahnya adalah 26. Akurasi *training* memiliki rata-rata sebesar 95,75%, dengan nilai pelatihan tertinggi mencapai 97,9% pada percobaan kedua. Untuk *validation*, nilai rata-ratanya adalah 94,58%, dengan nilai tertinggi mencapai 96,5% pada percobaan kelima. Sedangkan untuk testing, nilai rata-ratanya adalah 94,01%, dengan nilai tertinggi mencapai 96,5% pada percobaan pertama. Data *best epoch validation* diperoleh dari grafik *training performance*, sementara data *training*, *validation* dan *testing* berasal dari *confusion matrix*.

## 8. Confusion Matrix dan ROC Curve Model LM HN 15.

Training	Confision Matrix (standard) untuk Training, Validasi, Testing and All																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																				
Run 1	<div><div><div>Training Confusion Matrix</div><table><tr><td>467</td><td>24</td><td>2</td><td>2</td></tr><tr><td>15.1%</td><td>0.8%</td><td>0.1%</td><td>0.1%</td></tr><tr><td>7</td><td>390</td><td>0</td><td>22</td></tr><tr><td>0.2%</td><td>12.9%</td><td>0.0%</td><td>0.7%</td></tr><tr><td>4</td><td>24</td><td>1647</td><td>1</td></tr><tr><td>0.1%</td><td>0.8%</td><td>53.3%</td><td>0.0%</td></tr><tr><td>9</td><td>24</td><td>4</td><td>456</td></tr><tr><td>0.3%</td><td>0.8%</td><td>0.1%</td><td>14.7%</td></tr><tr><td>95.0%</td><td>64.7%</td><td>99.6%</td><td>98.9%</td></tr><tr><td>4.1%</td><td>15.2%</td><td>0.4%</td><td>5.2%</td></tr></table></div><div><div>Validation Confusion Matrix</div><table><tr><td>29</td><td>1</td><td>0</td><td>0</td></tr><tr><td>11.0%</td><td>0.6%</td><td>0.0%</td><td>0.0%</td></tr><tr><td>1</td><td>21</td><td>0</td><td>2</td></tr><tr><td>0.0%</td><td>12.2%</td><td>0.0%</td><td>1.2%</td></tr><tr><td>0</td><td>1</td><td>92</td><td>0</td></tr><tr><td>0.0%</td><td>0.6%</td><td>53.5%</td><td>0.0%</td></tr><tr><td>0</td><td>0</td><td>2</td><td>32</td></tr><tr><td>0.0%</td><td>0.0%</td><td>1.2%</td><td>10.6%</td></tr><tr><td>65.2%</td><td>81.3%</td><td>97.3%</td><td>94.1%</td></tr><tr><td>4.8%</td><td>8.7%</td><td>2.1%</td><td>5.9%</td></tr></table></div></div> <div><div><div>Test Confusion Matrix</div><table><tr><td>24</td><td>0</td><td>0</td><td>0</td></tr><tr><td>14.0%</td><td>0.0%</td><td>0.0%</td><td>0.0%</td></tr><tr><td>0</td><td>30</td><td>0</td><td>1</td></tr><tr><td>0.0%</td><td>17.4%</td><td>0.0%</td><td>0.6%</td></tr><tr><td>0</td><td>2</td><td>103</td><td>0</td></tr><tr><td>0.0%</td><td>1.2%</td><td>69.9%</td><td>0.0%</td></tr><tr><td>1</td><td>2</td><td>0</td><td>9</td></tr><tr><td>0.8%</td><td>1.2%</td><td>0.0%</td><td>5.2%</td></tr><tr><td>96.0%</td><td>88.2%</td><td>100%</td><td>90.0%</td></tr><tr><td>1.0%</td><td>11.0%</td><td>0.0%</td><td>10.0%</td></tr></table></div><div><div>All Confusion Matrix</div><table><tr><td>511</td><td>25</td><td>2</td><td>2</td></tr><tr><td>14.9%</td><td>6.7%</td><td>0.1%</td><td>0.1%</td></tr><tr><td>4</td><td>408</td><td>0</td><td>25</td></tr><tr><td>0.2%</td><td>13.1%</td><td>0.0%</td><td>0.7%</td></tr><tr><td>4</td><td>27</td><td>1842</td><td>1</td></tr><tr><td>0.1%</td><td>0.8%</td><td>53.8%</td><td>0.0%</td></tr><tr><td>19</td><td>28</td><td>6</td><td>497</td></tr><tr><td>0.3%</td><td>0.8%</td><td>0.2%</td><td>14.5%</td></tr><tr><td>95.9%</td><td>85.2%</td><td>99.6%</td><td>94.7%</td></tr><tr><td>4.1%</td><td>14.6%</td><td>0.4%</td><td>5.3%</td></tr></table></div></div> <tr><td>Run 2</td><td><div><div><div>Training Confusion Matrix</div><table><tr><td>456</td><td>11</td><td>1</td><td>0</td></tr><tr><td>15.1%</td><td>0.4%</td><td>0.0%</td><td>0.0%</td></tr><tr><td>4</td><td>440</td><td>5</td><td>13</td></tr><tr><td>0.1%</td><td>14.5%</td><td>0.2%</td><td>0.4%</td></tr><tr><td>2</td><td>14</td><td>1658</td><td>5</td></tr><tr><td>0.1%</td><td>0.5%</td><td>53.6%</td><td>0.2%</td></tr><tr><td>8</td><td>2</td><td>0</td><td>456</td></tr><tr><td>0.3%</td><td>0.1%</td><td>0.0%</td><td>14.7%</td></tr><tr><td>97.1%</td><td>94.3%</td><td>99.6%</td><td>97.9%</td></tr><tr><td>2.8%</td><td>5.7%</td><td>0.4%</td><td>3.8%</td></tr></table></div><div><div>Validation Confusion Matrix</div><table><tr><td>24</td><td>3</td><td>0</td><td>0</td></tr><tr><td>14.0%</td><td>1.7%</td><td>0.0%</td><td>0.0%</td></tr><tr><td>1</td><td>19</td><td>0</td><td>3</td></tr><tr><td>0.0%</td><td>11.6%</td><td>0.0%</td><td>1.7%</td></tr><tr><td>0</td><td>2</td><td>93</td><td>0</td></tr><tr><td>0.0%</td><td>1.2%</td><td>54.1%</td><td>0.0%</td></tr><tr><td>2</td><td>1</td><td>0</td><td>24</td></tr><tr><td>1.2%</td><td>0.6%</td><td>0.0%</td><td>14.0%</td></tr><tr><td>88.9%</td><td>75.0%</td><td>100%</td><td>88.9%</td></tr><tr><td>11.1%</td><td>24.0%</td><td>0.0%</td><td>11.1%</td></tr></table></div></div><div><div><div>Test Confusion Matrix</div><table><tr><td>26</td><td>2</td><td>2</td><td>0</td></tr><tr><td>15.1%</td><td>1.2%</td><td>1.2%</td><td>0.0%</td></tr><tr><td>0</td><td>21</td><td>1</td><td>0</td></tr><tr><td>0.0%</td><td>12.2%</td><td>0.0%</td><td>0.0%</td></tr><tr><td>0</td><td>3</td><td>92</td><td>0</td></tr><tr><td>0.0%</td><td>1.7%</td><td>53.5%</td><td>0.0%</td></tr><tr><td>0</td><td>1</td><td>0</td><td>24</td></tr><tr><td>0.0%</td><td>0.6%</td><td>0.0%</td><td>14.0%</td></tr><tr><td>100%</td><td>77.5%</td><td>98.0%</td><td>100%</td></tr><tr><td>0.0%</td><td>22.2%</td><td>2.2%</td><td>0.0%</td></tr></table></div><div><div>All Confusion Matrix</div><table><tr><td>516</td><td>16</td><td>3</td><td>0</td></tr><tr><td>15.0%</td><td>0.9%</td><td>0.1%</td><td>0.0%</td></tr><tr><td>5</td><td>409</td><td>6</td><td>16</td></tr><tr><td>0.1%</td><td>14.2%</td><td>0.2%</td><td>0.5%</td></tr><tr><td>2</td><td>19</td><td>1841</td><td>5</td></tr><tr><td>0.1%</td><td>0.6%</td><td>53.8%</td><td>0.1%</td></tr><tr><td>19</td><td>4</td><td>0</td><td>504</td></tr><tr><td>0.3%</td><td>0.1%</td><td>0.0%</td><td>14.7%</td></tr><tr><td>95.9%</td><td>85.2%</td><td>99.6%</td><td>94.7%</td></tr><tr><td>3.2%</td><td>7.4%</td><td>0.4%</td><td>5.3%</td></tr></table></div></div><tr><td>Run 3</td><td><div><div><div>Training Confusion Matrix</div><table><tr><td>456</td><td>45</td><td>11</td><td>1</td></tr><tr><td>15.1%</td><td>1.5%</td><td>0.4%</td><td>0.0%</td></tr><tr><td>9</td><td>362</td><td>14</td><td>29</td></tr><tr><td>0.3%</td><td>12.4%</td><td>0.5%</td><td>0.9%</td></tr><tr><td>4</td><td>33</td><td>1639</td><td>5</td></tr><tr><td>0.1%</td><td>1.1%</td><td>53.0%</td><td>0.2%</td></tr><tr><td>9</td><td>13</td><td>2</td><td>430</td></tr><tr><td>0.3%</td><td>5.4%</td><td>0.1%</td><td>13.9%</td></tr><tr><td>95.1%</td><td>89.6%</td><td>99.4%</td><td>94.2%</td></tr><tr><td>4.9%</td><td>10.2%</td><td>1.6%</td><td>5.7%</td></tr></table></div><div><div>Validation Confusion Matrix</div><table><tr><td>23</td><td>1</td><td>1</td><td>0</td></tr><tr><td>13.4%</td><td>0.6%</td><td>0.6%</td><td>0.0%</td></tr><tr><td>1</td><td>28</td><td>1</td><td>4</td></tr><tr><td>0.6%</td><td>11.6%</td><td>0.6%</td><td>2.2%</td></tr><tr><td>0</td><td>2</td><td>93</td><td>0</td></tr><tr><td>0.0%</td><td>1.2%</td><td>54.1%</td><td>0.0%</td></tr><tr><td>0</td><td>0</td><td>0</td><td>28</td></tr><tr><td>0.0%</td><td>0.0%</td><td>0.0%</td><td>15.1%</td></tr><tr><td>95.8%</td><td>97.0%</td><td>97.3%</td><td>96.7%</td></tr><tr><td>4.2%</td><td>13.0%</td><td>2.1%</td><td>13.3%</td></tr></table></div></div><div><div><div>Test Confusion Matrix</div><table><tr><td>19</td><td>4</td><td>1</td><td>0</td></tr><tr><td>11.0%</td><td>2.3%</td><td>0.6%</td><td>0.0%</td></tr><tr><td>0</td><td>25</td><td>2</td><td>2</td></tr><tr><td>0.0%</td><td>14.5%</td><td>1.2%</td><td>1.2%</td></tr><tr><td>1</td><td>1</td><td>96</td><td>0</td></tr><tr><td>0.6%</td><td>0.8%</td><td>50.0%</td><td>0.0%</td></tr><tr><td>1</td><td>2</td><td>0</td><td>28</td></tr><tr><td>0.6%</td><td>1.2%</td><td>0.0%</td><td>16.3%</td></tr><tr><td>95.8%</td><td>78.1%</td><td>85.6%</td><td>81.9%</td></tr><tr><td>9.9%</td><td>21.0%</td><td>3.4%</td><td>8.1%</td></tr></table></div><div><div>All Confusion Matrix</div><table><tr><td>508</td><td>50</td><td>13</td><td>1</td></tr><tr><td>14.8%</td><td>1.5%</td><td>0.4%</td><td>0.0%</td></tr><tr><td>19</td><td>427</td><td>17</td><td>39</td></tr><tr><td>0.3%</td><td>12.4%</td><td>0.5%</td><td>1.0%</td></tr><tr><td>5</td><td>36</td><td>1618</td><td>5</td></tr><tr><td>0.1%</td><td>1.0%</td><td>52.9%</td><td>0.1%</td></tr><tr><td>19</td><td>15</td><td>2</td><td>484</td></tr><tr><td>0.3%</td><td>0.4%</td><td>0.1%</td><td>14.1%</td></tr><tr><td>95.3%</td><td>85.9%</td><td>98.3%</td><td>92.2%</td></tr><tr><td>4.7%</td><td>14.1%</td><td>1.7%</td><td>7.8%</td></tr></table></div></div></td></tr></td></tr>	467	24	2	2	15.1%	0.8%	0.1%	0.1%	7	390	0	22	0.2%	12.9%	0.0%	0.7%	4	24	1647	1	0.1%	0.8%	53.3%	0.0%	9	24	4	456	0.3%	0.8%	0.1%	14.7%	95.0%	64.7%	99.6%	98.9%	4.1%	15.2%	0.4%	5.2%	29	1	0	0	11.0%	0.6%	0.0%	0.0%	1	21	0	2	0.0%	12.2%	0.0%	1.2%	0	1	92	0	0.0%	0.6%	53.5%	0.0%	0	0	2	32	0.0%	0.0%	1.2%	10.6%	65.2%	81.3%	97.3%	94.1%	4.8%	8.7%	2.1%	5.9%	24	0	0	0	14.0%	0.0%	0.0%	0.0%	0	30	0	1	0.0%	17.4%	0.0%	0.6%	0	2	103	0	0.0%	1.2%	69.9%	0.0%	1	2	0	9	0.8%	1.2%	0.0%	5.2%	96.0%	88.2%	100%	90.0%	1.0%	11.0%	0.0%	10.0%	511	25	2	2	14.9%	6.7%	0.1%	0.1%	4	408	0	25	0.2%	13.1%	0.0%	0.7%	4	27	1842	1	0.1%	0.8%	53.8%	0.0%	19	28	6	497	0.3%	0.8%	0.2%	14.5%	95.9%	85.2%	99.6%	94.7%	4.1%	14.6%	0.4%	5.3%	Run 2	<div><div><div>Training Confusion Matrix</div><table><tr><td>456</td><td>11</td><td>1</td><td>0</td></tr><tr><td>15.1%</td><td>0.4%</td><td>0.0%</td><td>0.0%</td></tr><tr><td>4</td><td>440</td><td>5</td><td>13</td></tr><tr><td>0.1%</td><td>14.5%</td><td>0.2%</td><td>0.4%</td></tr><tr><td>2</td><td>14</td><td>1658</td><td>5</td></tr><tr><td>0.1%</td><td>0.5%</td><td>53.6%</td><td>0.2%</td></tr><tr><td>8</td><td>2</td><td>0</td><td>456</td></tr><tr><td>0.3%</td><td>0.1%</td><td>0.0%</td><td>14.7%</td></tr><tr><td>97.1%</td><td>94.3%</td><td>99.6%</td><td>97.9%</td></tr><tr><td>2.8%</td><td>5.7%</td><td>0.4%</td><td>3.8%</td></tr></table></div><div><div>Validation Confusion Matrix</div><table><tr><td>24</td><td>3</td><td>0</td><td>0</td></tr><tr><td>14.0%</td><td>1.7%</td><td>0.0%</td><td>0.0%</td></tr><tr><td>1</td><td>19</td><td>0</td><td>3</td></tr><tr><td>0.0%</td><td>11.6%</td><td>0.0%</td><td>1.7%</td></tr><tr><td>0</td><td>2</td><td>93</td><td>0</td></tr><tr><td>0.0%</td><td>1.2%</td><td>54.1%</td><td>0.0%</td></tr><tr><td>2</td><td>1</td><td>0</td><td>24</td></tr><tr><td>1.2%</td><td>0.6%</td><td>0.0%</td><td>14.0%</td></tr><tr><td>88.9%</td><td>75.0%</td><td>100%</td><td>88.9%</td></tr><tr><td>11.1%</td><td>24.0%</td><td>0.0%</td><td>11.1%</td></tr></table></div></div> <div><div><div>Test Confusion Matrix</div><table><tr><td>26</td><td>2</td><td>2</td><td>0</td></tr><tr><td>15.1%</td><td>1.2%</td><td>1.2%</td><td>0.0%</td></tr><tr><td>0</td><td>21</td><td>1</td><td>0</td></tr><tr><td>0.0%</td><td>12.2%</td><td>0.0%</td><td>0.0%</td></tr><tr><td>0</td><td>3</td><td>92</td><td>0</td></tr><tr><td>0.0%</td><td>1.7%</td><td>53.5%</td><td>0.0%</td></tr><tr><td>0</td><td>1</td><td>0</td><td>24</td></tr><tr><td>0.0%</td><td>0.6%</td><td>0.0%</td><td>14.0%</td></tr><tr><td>100%</td><td>77.5%</td><td>98.0%</td><td>100%</td></tr><tr><td>0.0%</td><td>22.2%</td><td>2.2%</td><td>0.0%</td></tr></table></div><div><div>All Confusion Matrix</div><table><tr><td>516</td><td>16</td><td>3</td><td>0</td></tr><tr><td>15.0%</td><td>0.9%</td><td>0.1%</td><td>0.0%</td></tr><tr><td>5</td><td>409</td><td>6</td><td>16</td></tr><tr><td>0.1%</td><td>14.2%</td><td>0.2%</td><td>0.5%</td></tr><tr><td>2</td><td>19</td><td>1841</td><td>5</td></tr><tr><td>0.1%</td><td>0.6%</td><td>53.8%</td><td>0.1%</td></tr><tr><td>19</td><td>4</td><td>0</td><td>504</td></tr><tr><td>0.3%</td><td>0.1%</td><td>0.0%</td><td>14.7%</td></tr><tr><td>95.9%</td><td>85.2%</td><td>99.6%</td><td>94.7%</td></tr><tr><td>3.2%</td><td>7.4%</td><td>0.4%</td><td>5.3%</td></tr></table></div></div> <tr><td>Run 3</td><td><div><div><div>Training Confusion Matrix</div><table><tr><td>456</td><td>45</td><td>11</td><td>1</td></tr><tr><td>15.1%</td><td>1.5%</td><td>0.4%</td><td>0.0%</td></tr><tr><td>9</td><td>362</td><td>14</td><td>29</td></tr><tr><td>0.3%</td><td>12.4%</td><td>0.5%</td><td>0.9%</td></tr><tr><td>4</td><td>33</td><td>1639</td><td>5</td></tr><tr><td>0.1%</td><td>1.1%</td><td>53.0%</td><td>0.2%</td></tr><tr><td>9</td><td>13</td><td>2</td><td>430</td></tr><tr><td>0.3%</td><td>5.4%</td><td>0.1%</td><td>13.9%</td></tr><tr><td>95.1%</td><td>89.6%</td><td>99.4%</td><td>94.2%</td></tr><tr><td>4.9%</td><td>10.2%</td><td>1.6%</td><td>5.7%</td></tr></table></div><div><div>Validation Confusion 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Matrix</div><table><tr><td>508</td><td>50</td><td>13</td><td>1</td></tr><tr><td>14.8%</td><td>1.5%</td><td>0.4%</td><td>0.0%</td></tr><tr><td>19</td><td>427</td><td>17</td><td>39</td></tr><tr><td>0.3%</td><td>12.4%</td><td>0.5%</td><td>1.0%</td></tr><tr><td>5</td><td>36</td><td>1618</td><td>5</td></tr><tr><td>0.1%</td><td>1.0%</td><td>52.9%</td><td>0.1%</td></tr><tr><td>19</td><td>15</td><td>2</td><td>484</td></tr><tr><td>0.3%</td><td>0.4%</td><td>0.1%</td><td>14.1%</td></tr><tr><td>95.3%</td><td>85.9%</td><td>98.3%</td><td>92.2%</td></tr><tr><td>4.7%</td><td>14.1%</td><td>1.7%</td><td>7.8%</td></tr></table></div></div></td></tr>	456	11	1	0	15.1%	0.4%	0.0%	0.0%	4	440	5	13	0.1%	14.5%	0.2%	0.4%	2	14	1658	5	0.1%	0.5%	53.6%	0.2%	8	2	0	456	0.3%	0.1%	0.0%	14.7%	97.1%	94.3%	99.6%	97.9%	2.8%	5.7%	0.4%	3.8%	24	3	0	0	14.0%	1.7%	0.0%	0.0%	1	19	0	3	0.0%	11.6%	0.0%	1.7%	0	2	93	0	0.0%	1.2%	54.1%	0.0%	2	1	0	24	1.2%	0.6%	0.0%	14.0%	88.9%	75.0%	100%	88.9%	11.1%	24.0%	0.0%	11.1%	26	2	2	0	15.1%	1.2%	1.2%	0.0%	0	21	1	0	0.0%	12.2%	0.0%	0.0%	0	3	92	0	0.0%	1.7%	53.5%	0.0%	0	1	0	24	0.0%	0.6%	0.0%	14.0%	100%	77.5%	98.0%	100%	0.0%	22.2%	2.2%	0.0%	516	16	3	0	15.0%	0.9%	0.1%	0.0%	5	409	6	16	0.1%	14.2%	0.2%	0.5%	2	19	1841	5	0.1%	0.6%	53.8%	0.1%	19	4	0	504	0.3%	0.1%	0.0%	14.7%	95.9%	85.2%	99.6%	94.7%	3.2%	7.4%	0.4%	5.3%	Run 3	<div><div><div>Training Confusion Matrix</div><table><tr><td>456</td><td>45</td><td>11</td><td>1</td></tr><tr><td>15.1%</td><td>1.5%</td><td>0.4%</td><td>0.0%</td></tr><tr><td>9</td><td>362</td><td>14</td><td>29</td></tr><tr><td>0.3%</td><td>12.4%</td><td>0.5%</td><td>0.9%</td></tr><tr><td>4</td><td>33</td><td>1639</td><td>5</td></tr><tr><td>0.1%</td><td>1.1%</td><td>53.0%</td><td>0.2%</td></tr><tr><td>9</td><td>13</td><td>2</td><td>430</td></tr><tr><td>0.3%</td><td>5.4%</td><td>0.1%</td><td>13.9%</td></tr><tr><td>95.1%</td><td>89.6%</td><td>99.4%</td><td>94.2%</td></tr><tr><td>4.9%</td><td>10.2%</td><td>1.6%</td><td>5.7%</td></tr></table></div><div><div>Validation Confusion 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Run 6	<div><div><div>Training Confusion Matrix</div><table><tr><td>455</td><td>10</td><td>2</td><td>1</td></tr><tr><td>15.0%</td><td>0.6%</td><td>0.1%</td><td>0.0%</td></tr><tr><td>9</td><td>441</td><td>6</td><td>21</td></tr><tr><td>0.3%</td><td>14.3%</td><td>0.2%</td><td>7.2%</td></tr><tr><td>3</td><td>30</td><td>1653</td><td>5</td></tr><tr><td>0.1%</td><td>0.6%</td><td>53.5%</td><td>0.2%</td></tr><tr><td>8</td><td>6</td><td>0</td><td>433</td></tr><tr><td>0.3%</td><td>0.2%</td><td>0.0%</td><td>54.0%</td></tr><tr><td>55.0%</td><td>55.0%</td><td>55.0%</td><td>54.1%</td></tr><tr><td>4.1%</td><td>9.2%</td><td>0.0%</td><td>5.9%</td></tr></table></div><div><div>Validation Confusion Matrix</div><table><tr><td>21</td><td>0</td><td>0</td><td>0</td></tr><tr><td>12.2%</td><td>0.0%</td><td>0.0%</td><td>0.0%</td></tr><tr><td>1</td><td>22</td><td>1</td><td>0</td></tr><tr><td>0.0%</td><td>12.8%</td><td>0.8%</td><td>0.0%</td></tr><tr><td>0</td><td>1</td><td>30</td><td>0</td></tr><tr><td>0.0%</td><td>0.6%</td><td>52.3%</td><td>0.0%</td></tr><tr><td>1</td><td>2</td><td>2</td><td>31</td></tr><tr><td>0.0%</td><td>1.2%</td><td>1.2%</td><td>18.0%</td></tr><tr><td>51.3%</td><td>55.0%</td><td>55.0%</td><td>100%</td></tr><tr><td>8.7%</td><td>12.0%</td><td>2.2%</td><td>4.9%</td></tr></table></div><div><div>Test Confusion Matrix</div><table><tr><td>22</td><td>1</td><td>0</td><td>0</td></tr><tr><td>12.0%</td><td>0.8%</td><td>0.0%</td><td>0.0%</td></tr><tr><td>2</td><td>15</td><td>1</td><td>1</td></tr><tr><td>1.2%</td><td>8.7%</td><td>0.0%</td><td>21.7%</td></tr><tr><td>1</td><td>1</td><td>95</td><td>0</td></tr><tr><td>0.6%</td><td>0.8%</td><td>52.5%</td><td>0.2%</td></tr><tr><td>0</td><td>0</td><td>0</td><td>33</td></tr><tr><td>0.0%</td><td>0.0%</td><td>0.0%</td><td>19.2%</td></tr><tr><td>55.0%</td><td>55.0%</td><td>57.1%</td><td>55.9%</td></tr><tr><td>12.0%</td><td>11.5%</td><td>1.0%</td><td>4.7%</td></tr></table></div><div><div>All Confusion Matrix</div><table><tr><td>568</td><td>20</td><td>2</td><td>1</td></tr><tr><td>14.8%</td><td>0.6%</td><td>0.1%</td><td>0.0%</td></tr><tr><td>12</td><td>478</td><td>8</td><td>22</td></tr><tr><td>0.3%</td><td>13.9%</td><td>0.2%</td><td>6.1%</td></tr><tr><td>1</td><td>33</td><td>1838</td><td>5</td></tr><tr><td>0.1%</td><td>0.6%</td><td>53.5%</td><td>0.1%</td></tr><tr><td>9</td><td>8</td><td>2</td><td>497</td></tr><tr><td>0.3%</td><td>0.2%</td><td>0.1%</td><td>14.5%</td></tr><tr><td>55.3%</td><td>55.3%</td><td>55.4%</td><td>54.7%</td></tr><tr><td>4.7%</td><td>9.0%</td><td>0.6%</td><td>3.2%</td></tr></table></div></div>	455	10	2	1	15.0%	0.6%	0.1%	0.0%	9	441	6	21	0.3%	14.3%	0.2%	7.2%	3	30	1653	5	0.1%	0.6%	53.5%	0.2%	8	6	0	433	0.3%	0.2%	0.0%	54.0%	55.0%	55.0%	55.0%	54.1%	4.1%	9.2%	0.0%	5.9%	21	0	0	0	12.2%	0.0%	0.0%	0.0%	1	22	1	0	0.0%	12.8%	0.8%	0.0%	0	1	30	0	0.0%	0.6%	52.3%	0.0%	1	2	2	31	0.0%	1.2%	1.2%	18.0%	51.3%	55.0%	55.0%	100%	8.7%	12.0%	2.2%	4.9%	22	1	0	0	12.0%	0.8%	0.0%	0.0%	2	15	1	1	1.2%	8.7%	0.0%	21.7%	1	1	95	0	0.6%	0.8%	52.5%	0.2%	0	0	0	33	0.0%	0.0%	0.0%	19.2%	55.0%	55.0%	57.1%	55.9%	12.0%	11.5%	1.0%	4.7%	568	20	2	1	14.8%	0.6%	0.1%	0.0%	12	478	8	22	0.3%	13.9%	0.2%	6.1%	1	33	1838	5	0.1%	0.6%	53.5%	0.1%	9	8	2	497	0.3%	0.2%	0.1%	14.5%	55.3%	55.3%	55.4%	54.7%	4.7%	9.0%	0.6%	3.2%	
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Run 7	<div><div><div>Training Confusion Matrix</div><table><tr><td>491</td><td>40</td><td>12</td><td>3</td></tr><tr><td>14.6%</td><td>1.0%</td><td>0.4%</td><td>0.1%</td></tr><tr><td>9</td><td>382</td><td>10</td><td>20</td></tr><tr><td>0.3%</td><td>12.4%</td><td>0.3%</td><td>11.2%</td></tr><tr><td>8</td><td>40</td><td>1637</td><td>7</td></tr><tr><td>0.3%</td><td>1.3%</td><td>52.6%</td><td>0.2%</td></tr><tr><td>9</td><td>9</td><td>0</td><td>437</td></tr><tr><td>0.3%</td><td>0.3%</td><td>0.0%</td><td>54.1%</td></tr><tr><td>54.5%</td><td>79.0%</td><td>57.1%</td><td>54.9%</td></tr><tr><td>5.5%</td><td>20.4%</td><td>1.3%</td><td>6.8%</td></tr></table></div><div><div>Validation Confusion Matrix</div><table><tr><td>22</td><td>2</td><td>1</td><td>0</td></tr><tr><td>12.8%</td><td>1.7%</td><td>0.6%</td><td>0.0%</td></tr><tr><td>0</td><td>24</td><td>0</td><td>2</td></tr><tr><td>0.0%</td><td>14.0%</td><td>0.0%</td><td>1.2%</td></tr><tr><td>0</td><td>3</td><td>39</td><td>0</td></tr><tr><td>0.0%</td><td>1.7%</td><td>57.6%</td><td>0.0%</td></tr><tr><td>0</td><td>1</td><td>0</td><td>17</td></tr><tr><td>0.0%</td><td>0.6%</td><td>0.0%</td><td>9.9%</td></tr><tr><td>100%</td><td>77.4%</td><td>59.2%</td><td>55.5%</td></tr><tr><td>0.0%</td><td>20.6%</td><td>1.0%</td><td>10.2%</td></tr></table></div><div><div>Test Confusion Matrix</div><table><tr><td>32</td><td>1</td><td>2</td><td>0</td></tr><tr><td>16.0%</td><td>0.6%</td><td>1.2%</td><td>0.0%</td></tr><tr><td>1</td><td>14</td><td>0</td><td>3</td></tr><tr><td>0.6%</td><td>8.1%</td><td>0.0%</td><td>1.7%</td></tr><tr><td>0</td><td>1</td><td>89</td><td>1</td></tr><tr><td>0.0%</td><td>0.6%</td><td>51.7%</td><td>0.6%</td></tr><tr><td>1</td><td>1</td><td>0</td><td>26</td></tr><tr><td>0.8%</td><td>0.8%</td><td>0.0%</td><td>15.1%</td></tr><tr><td>54.1%</td><td>52.4%</td><td>57.8%</td><td>53.8%</td></tr><tr><td>5.9%</td><td>7.0%</td><td>2.2%</td><td>13.3%</td></tr></table></div><div><div>All Confusion Matrix</div><table><tr><td>595</td><td>53</td><td>15</td><td>3</td></tr><tr><td>14.7%</td><td>1.5%</td><td>0.4%</td><td>0.1%</td></tr><tr><td>19</td><td>420</td><td>10</td><td>34</td></tr><tr><td>0.3%</td><td>12.2%</td><td>0.3%</td><td>10.9%</td></tr><tr><td>8</td><td>44</td><td>1825</td><td>8</td></tr><tr><td>0.2%</td><td>1.3%</td><td>53.1%</td><td>0.2%</td></tr><tr><td>13</td><td>11</td><td>0</td><td>480</td></tr><tr><td>0.3%</td><td>0.3%</td><td>0.0%</td><td>14.0%</td></tr><tr><td>54.7%</td><td>79.0%</td><td>58.0%</td><td>51.4%</td></tr><tr><td>5.3%</td><td>20.6%</td><td>1.4%</td><td>8.6%</td></tr></table></div></div>	491	40	12	3	14.6%	1.0%	0.4%	0.1%	9	382	10	20	0.3%	12.4%	0.3%	11.2%	8	40	1637	7	0.3%	1.3%	52.6%	0.2%	9	9	0	437	0.3%	0.3%	0.0%	54.1%	54.5%	79.0%	57.1%	54.9%	5.5%	20.4%	1.3%	6.8%	22	2	1	0	12.8%	1.7%	0.6%	0.0%	0	24	0	2	0.0%	14.0%	0.0%	1.2%	0	3	39	0	0.0%	1.7%	57.6%	0.0%	0	1	0	17	0.0%	0.6%	0.0%	9.9%	100%	77.4%	59.2%	55.5%	0.0%	20.6%	1.0%	10.2%	32	1	2	0	16.0%	0.6%	1.2%	0.0%	1	14	0	3	0.6%	8.1%	0.0%	1.7%	0	1	89	1	0.0%	0.6%	51.7%	0.6%	1	1	0	26	0.8%	0.8%	0.0%	15.1%	54.1%	52.4%	57.8%	53.8%	5.9%	7.0%	2.2%	13.3%	595	53	15	3	14.7%	1.5%	0.4%	0.1%	19	420	10	34	0.3%	12.2%	0.3%	10.9%	8	44	1825	8	0.2%	1.3%	53.1%	0.2%	13	11	0	480	0.3%	0.3%	0.0%	14.0%	54.7%	79.0%	58.0%	51.4%	5.3%	20.6%	1.4%	8.6%	
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13	11	0	480																																																																																																																																																															
0.3%	0.3%	0.0%	14.0%																																																																																																																																																															
54.7%	79.0%	58.0%	51.4%																																																																																																																																																															
5.3%	20.6%	1.4%	8.6%																																																																																																																																																															

**Run 8**

**Training Confusion Matrix**

	491	31	2	1	
491	14.9%	3.7%	0.1%	0.0%	4.9%
7	0.2%	12.6%	0.2%	0.6%	8.9%
4	0.1%	0.3%	53.6%	0.2%	2.2%
8	0.3%	0.5%	0.3%	14.1%	8.8%
	36.0%	53.7%	59.0%	53.6%	59.4%
	1.0%	53.3%	1.0%	6.4%	6.6%

Output Class

Target Class

**Validation Confusion Matrix**

	22	3	0	6	
22	12.2%	1.7%	0.2%	0.0%	12.0%
1	0.8%	17.4%	0.8%	0.0%	19.0%
0	0.0%	0.4%	96.0%	0.0%	1.1%
2	1.2%	0.0%	0.8%	14.5%	16.7%
	88.2%	88.2%	97.7%	100%	94.8%
	12.2%	11.6%	2.3%	3.0%	6.2%

Output Class

Target Class

**Test Confusion Matrix**

	26	1	0	9	
26	16.1%	0.6%	0.0%	0.0%	3.7%
1	0.6%	35.1%	0.0%	2.3%	10.9%
0	0.6%	1.2%	47.1%	0.0%	3.8%
9	0.0%	0.0%	0.0%	99.4%	0.0%
	52.0%	59.7%	59.4%	57.0%	54.2%
	7.1%	10.3%	1.2%	12.1%	5.8%

Output Class

Target Class

**All Confusion Matrix**

	909	36	2	1	
909	14.9%	1.0%	0.1%	0.0%	0.9%
9	0.3%	13.0%	0.3%	0.9%	8.4%
0	0.1%	0.9%	53.3%	0.1%	2.2%
4	0.3%	0.5%	0.3%	14.3%	8.7%
	59.5%	54.2%	56.7%	53.3%	58.2%
	4.9%	15.7%	1.1%	6.0%	4.7%

Output Class

Target Class

**Training Confusion Matrix**

Output Class \ Target Class	1	2	3	4	5	6	7	8	9	10
1	449	29	6	1	1	0	0	0	0	0
14.5%	0.9%	0.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
2	0	396	6	26	0	0	0	0	0	0
0.3%	12.6%	0.2%	0.8%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
3	5	33	1660	4	0	0	0	0	0	0
0.2%	1.1%	53.7%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
4	10	14	3	441	0	0	0	0	0	0
0.3%	0.5%	0.1%	14.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
5	56.9%	63.9%	69.1%	63.4%	69.3%	67.1%	66.7%	66.9%	66.9%	67.2%
6	5.1%	66.7%	6.9%	6.8%	6.7%	6.7%	6.7%	6.7%	6.7%	6.7%

**Validation Confusion Matrix**

Output Class \ Target Class	1	2	3	4	5	6	7	8	9	10
1	29	1	0	0	0	0	0	0	0	0
17.4%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
2	0	17	0	2	0	0	0	0	0	0
0.0%	9.0%	0.0%	1.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
3	0	6	95	1	0	0	0	0	0	0
0.0%	3.0%	56.2%	0.4%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
4	0	0	0	29	0	0	0	0	0	0
0.0%	0.0%	0.0%	14.6%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
5	100%	70.8%	100%	87.0%	94.2%	94.2%	94.2%	94.2%	94.2%	94.2%
6	0.0%	29.2%	1.2%	1.2%	6.8%	6.8%	6.8%	6.8%	6.8%	6.8%

**Test Confusion Matrix**

Output Class \ Target Class	1	2	3	4	5	6	7	8	9	10
1	36	4	0	0	0	0	0	0	0	0
17.4%	2.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
2	0	25	1	0	0	0	0	0	0	0
0.0%	14.9%	0.6%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
3	0	0	9	0	0	0	0	0	0	0
0.0%	0.0%	4.9%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
4	0	3	0	30	0	0	0	0	0	0
0.0%	1.7%	0.0%	17.4%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
5	100%	70.1%	88.6%	100%	99.3%	99.3%	99.3%	99.3%	99.3%	99.3%
6	0.0%	21.8%	1.2%	0.0%	6.7%	6.7%	6.7%	6.7%	6.7%	6.7%

**All Confusion Matrix**

Output Class \ Target Class	1	2	3	4	5	6	7	8	9	10
1	509	34	6	1	1	0	0	0	0	0
14.8%	1.0%	0.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
2	0	438	7	28	0	0	0	0	0	0
0.3%	12.7%	0.2%	0.8%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
3	0	9	39	1634	5	0	0	0	0	0
0.1%	1.1%	53.4%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
4	10	17	3	481	0	0	0	0	0	0
0.3%										

# Run 10

**Training Confusion Matrix**

Output Class \ Target Class	1	2	3	4	5	6	7	8	9	10
1	448	31	7	2	11.8%	44.5%	1.2%	0.2%	0.1%	4.2%
2	15	392	10	40	64.9%	0.5%	12.7%	0.3%	1.5%	15.2%
3	4	35	1601	4	97.5%	0.1%	51.4%	0.1%	0.2%	0.1%
4	0	7	1	431	95.2%	0.3%	0.2%	0.0%	13.9%	3.8%
5	56.1%	64.3%	68.9%	69.4%	68.9%	5.9%	62.7%	1.1%	10.0%	5.2%

**Validation Confusion Matrix**

Output Class \ Target Class	1	2	3	4	5	6	7	8	9	10
1	32	6	0	0	84.2%	19.6%	3.5%	0.1%	0.0%	11.0%
2	0	27	1	2	90.0%	0.0%	15.7%	0.8%	1.2%	10.0%
3	0	1	81	0	98.9%	0.0%	0.0%	47.1%	0.0%	1.2%
4	1	1	1	19	86.4%	0.6%	0.6%	0.8%	11.0%	13.6%
5	97.0%	77.1%	97.6%	80.5%	92.4%	3.0%	22.8%	2.4%	9.5%	7.6%

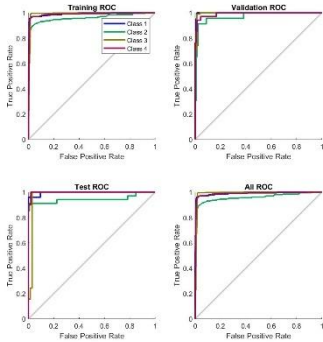
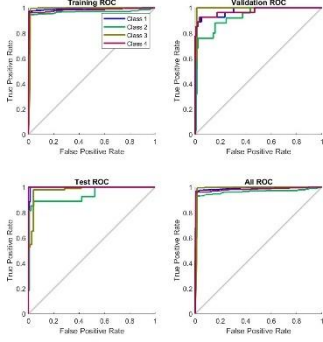
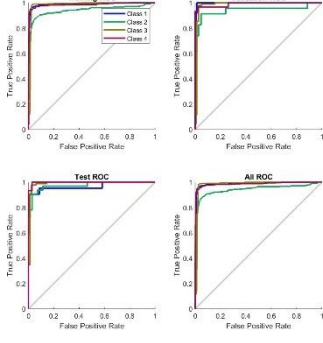
**Test Confusion Matrix**

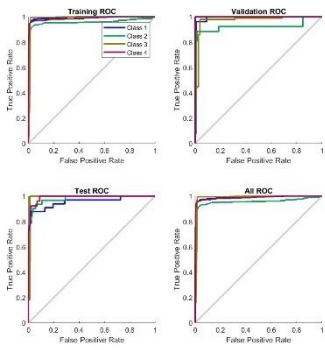
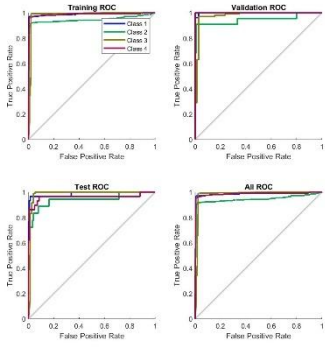
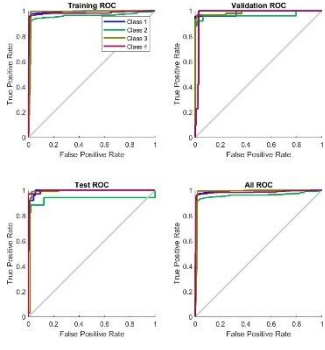
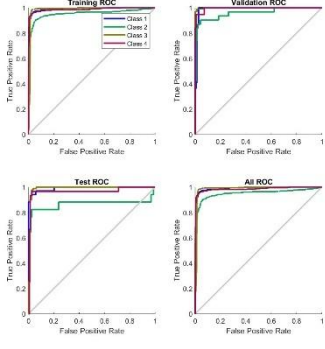
Output Class \ Target Class	1	2	3	4	5	6	7	8	9	10
1	23	4	1	0	61.1%	13.4%	2.3%	0.0%	0.0%	17.9%
2	1	21	1	2	64.0%	0.0%	22.2%	0.0%	1.2%	15.0%
3	0	3	84	0	98.0%	0.0%	1.7%	56.7%	0.0%	3.1%
4	0	0	2	20	60.0%	0.0%	0.0%	1.2%	11.6%	9.1%
5	65.0%	75.0%	65.0%	90.0%	97.0%	4.2%	20.0%	4.1%	9.1%	8.1%

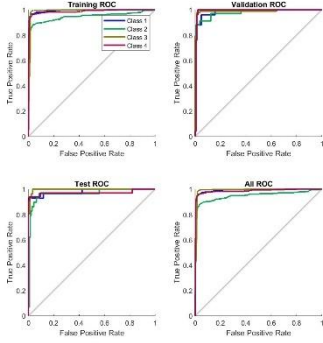
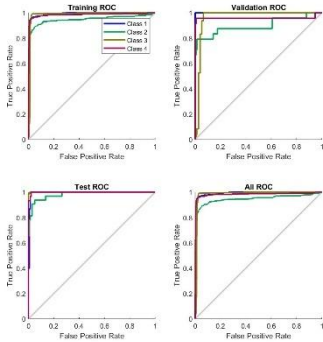
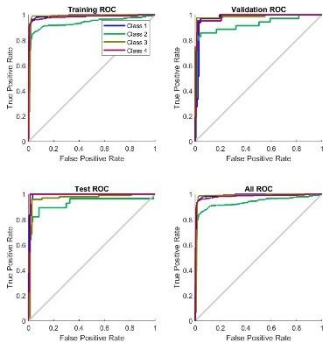
**All Confusion Matrix**

Output Class \ Target Class	1	2	3	4	5	6	7	8	9	10
1	503	41	8	2	91.0%	14.0%	1.2%	0.2%	0.1%	9.2%
2	16	440	12	49	89.1%	0.5%	12.6%	0.2%	1.4%	14.9%
3	4	39	1626	4	97.6%	0.1%	1.1%	53.1%	0.1%	2.9%
4	10	8	4	470	95.5%	0.2%	0.2%	0.1%	13.7%	4.6%
5	94.0%	83.3%	96.7%	89.3%	94.5%	5.0%	16.7%	1.3%	10.5%	8.7%

9. ROC Curve Model LM HN 15.

Training	ROC Curve untuk Training, Validasi, Testing and All
Run 1	 <p>ROC curves for Run 1. The figure contains four subplots: Training ROC, Validation ROC, Test ROC, and All ROC. Each plot shows True Positive Rate (Y-axis) versus False Positive Rate (X-axis) for four classes (Class 1, Class 2, Class 3, Class 4). The curves are generally close to the top-left corner, indicating good model performance. The Training ROC shows the highest performance, followed by Validation, Test, and All.</p>
Run 2	 <p>ROC curves for Run 2. The figure contains four subplots: Training ROC, Validation ROC, Test ROC, and All ROC. Each plot shows True Positive Rate (Y-axis) versus False Positive Rate (X-axis) for four classes (Class 1, Class 2, Class 3, Class 4). The curves are generally close to the top-left corner, indicating good model performance. The Training ROC shows the highest performance, followed by Validation, Test, and All.</p>
Run 3	 <p>ROC curves for Run 3. The figure contains four subplots: Training ROC, Validation ROC, Test ROC, and All ROC. Each plot shows True Positive Rate (Y-axis) versus False Positive Rate (X-axis) for four classes (Class 1, Class 2, Class 3, Class 4). The curves are generally close to the top-left corner, indicating good model performance. The Training ROC shows the highest performance, followed by Validation, Test, and All.</p>

<b>Run 4</b>	 <p>ROC curves for Run 4. The figure contains four subplots: Training ROC, Validation ROC, Test ROC, and All ROC. Each plot shows True Positive Rate (Y-axis) versus False Positive Rate (X-axis) for four classes (Class 1, Class 2, Class 3, Class 4). The curves are very close to the top-left corner, indicating high performance.</p>
<b>Run 5</b>	 <p>ROC curves for Run 5. The figure contains four subplots: Training ROC, Validation ROC, Test ROC, and All ROC. Each plot shows True Positive Rate (Y-axis) versus False Positive Rate (X-axis) for four classes (Class 1, Class 2, Class 3, Class 4). The curves are very close to the top-left corner, indicating high performance.</p>
<b>Run 6</b>	 <p>ROC curves for Run 6. The figure contains four subplots: Training ROC, Validation ROC, Test ROC, and All ROC. Each plot shows True Positive Rate (Y-axis) versus False Positive Rate (X-axis) for four classes (Class 1, Class 2, Class 3, Class 4). The curves are very close to the top-left corner, indicating high performance.</p>
<b>Run 7</b>	 <p>ROC curves for Run 7. The figure contains four subplots: Training ROC, Validation ROC, Test ROC, and All ROC. Each plot shows True Positive Rate (Y-axis) versus False Positive Rate (X-axis) for four classes (Class 1, Class 2, Class 3, Class 4). The curves are very close to the top-left corner, indicating high performance.</p>

Run 8	 <p>ROC curves for Run 8. The figure contains four subplots: Training ROC, Validation ROC, Test ROC, and All ROC. Each plot shows True Positive Rate (Y-axis) versus False Positive Rate (X-axis) for four classes (Class 1, Class 2, Class 3, Class 4). The curves are very close to the top-left corner, indicating high performance.</p>
Run 9	 <p>ROC curves for Run 9. The figure contains four subplots: Training ROC, Validation ROC, Test ROC, and All ROC. Each plot shows True Positive Rate (Y-axis) versus False Positive Rate (X-axis) for four classes (Class 1, Class 2, Class 3, Class 4). The curves are very close to the top-left corner, indicating high performance.</p>
Run 10	 <p>ROC curves for Run 10. The figure contains four subplots: Training ROC, Validation ROC, Test ROC, and All ROC. Each plot shows True Positive Rate (Y-axis) versus False Positive Rate (X-axis) for four classes (Class 1, Class 2, Class 3, Class 4). The curves are very close to the top-left corner, indicating high performance.</p>

Dari hasil penggunaan model *Levenberg-Marquardt* (LM) dengan Hidden Neuron 15, terbentuk grafik performa yang menampilkan tiga baris berbeda. Garis biru mencerminkan nilai train, garis hijau menggambarkan nilai validation, sementara garis merah menunjukkan nilai test. Dilihat dari gambar dengan 10 grafik performance baik dari grafik *train*, *validation* dan *test*. Terlihat bahwa grafik menunjukkan penurunan error yang signifikan pada rentang epoch 0 hingga 5. Sedangkan performa grafik menurun errornya menlandai dari sekitar epoch 5 hingga epoch maksimal terlihat pada run 1 hingga run 10.

Berdasarkan 10 fold cross validation, data training adalah 90% dari data total (3092), validation 5% dari total (171), dan test 5% dari total (171). Dari hasil nilai training yang terlihat pada Confusion Matrix, jumlah nilai target yang benar-benar terklasifikasi oleh neural network menjadi kelasnya masing-masing ditunjukkan dengan warna hijau, sedangkan warna merah muda adalah jumlah data yang gagal terklasifikasi pada kelasnya. Pada Confusion Matrix hasil training dari run 1 hingga run 10 menunjukkan jumlah error lebih kecil dari 10% dari total data training (309). Sedangkan, untuk Confusion Matrix hasil validation dan testing dari run 1 hingga run 10 menunjukkan jumlah error lebih kecil dari 10% dari total data (17). Sehingga, dapat disimpulkan hasil training, validation, dan test terkategori excellent.

Dalam analisis visualisasi Receiver Operating Characteristics (ROC) menggunakan model *Levenberg-Marquardt* (LM) dengan Hidden Neuron 15, terlihat bahwa bentuk kurva menunjukkan kesamaan baik dari ROC training, validation, dan testing. Grafik memiliki bentuk yang siku alias menjauhi garis diagonal. Sehingga training RGB to HSV dengan model LM Hidden Neuron 15 menunjukkan hasil yang excellent.

### 10. Hasil akurasi Training, Validasi, Testing Model LM dengan Hidden Node 20.

Tabel 2.1 Hasil All, Best Epoch dan Akurasi Training, Validasi dan Testing

Training	All	Best	Acc Training (%)	Acc Vaidasi (%)	Acc Testing (%)	Time
Run 1	55	49	96,4	93,0	95,3	0:00:04
Run 2	78	72	96,7	95,3	95,3	0:00:06
Run 3	117	111	94,6	93,0	94,2	0:00:09
Run 4	51	45	95,5	93,6	94,2	0:00:04
Run 5	57	51	96,8	97,1	91,9	0:00:04
Run 6	76	70	97,5	98,3	94,2	0:00:05
Run 7	77	71	95,6	94,2	94,2	0:00:06
Run 8	37	31	95,4	93,0	89,5	0:00:03
Run 9	84	78	96,1	95,3	93,0	0:00:06
Run 10	72	66	96,5	94,8	96,5	0:00:05
Average $\pm$ STD			96,11 $\pm$ 0,843	94,76 $\pm$ 1,811	93,83 $\pm$ 1,976	

Berdasarkan Tabel 2.1, bahwa hasil pelatihan dari sepuluh kali percobaan dengan model klasifikasi LM dan HN 20 diperoleh dari nilai *epoch* tertinggi sebesar 117 dan nilai terendah sebesar 37 Sementara itu, nilai *best epoch* tertinggi adalah 111 dan nilai terendahnya adalah 31. Akurasi *training* memiliki rata-rata sebesar 96,11%, dengan nilai pelatihan tertinggi mencapai 97,5% pada percobaan keenam. Untuk *validation*, nilai rata-ratanya adalah 94,76%, dengan nilai tertinggi mencapai 98,3% pada percobaan keenam. Sedangkan untuk testing, nilai rata-ratanya adalah 93,83%, dengan nilai tertinggi mencapai 96,5% pada percobaan kesepuluh. Data *best epoch validation* diperoleh dari grafik *training performance*, sementara data *training*, *validation* dan *testing* berasal dari *confusion matrix*.

## 11. Confusion Matrix dan ROC Curve Model LM 20.

Training	Confision Matrix (standard) untuk Training, Validasi, Testing and All																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																				
Run 1	<div><div><div>Training Confusion Matrix</div><table><tr><td>476</td><td>20</td><td>1</td><td>1</td></tr><tr><td>15.4%</td><td>0.0%</td><td>0.0%</td><td>4.4%</td></tr><tr><td>12</td><td>410</td><td>2</td><td>29</td></tr><tr><td>0.4%</td><td>13.0%</td><td>0.1%</td><td>9.3%</td></tr><tr><td>2</td><td>23</td><td>1057</td><td>4</td></tr><tr><td>0.1%</td><td>0.7%</td><td>83.6%</td><td>1.7%</td></tr><tr><td>9</td><td>7</td><td>0</td><td>430</td></tr><tr><td>0.3%</td><td>0.2%</td><td>0.0%</td><td>12.9%</td></tr><tr><td>95.4%</td><td>88.2%</td><td>88.1%</td><td>82.7%</td></tr><tr><td>4.6%</td><td>10.7%</td><td>0.2%</td><td>7.3%</td></tr></table></div><div><div>Validation Confusion Matrix</div><table><tr><td>14</td><td>5</td><td>0</td><td>0</td></tr><tr><td>8.1%</td><td>2.9%</td><td>0.0%</td><td>0.0%</td></tr><tr><td>1</td><td>28</td><td>0</td><td>2</td></tr><tr><td>0.6%</td><td>11.0%</td><td>0.0%</td><td>1.2%</td></tr><tr><td>1</td><td>1</td><td>95</td><td>0</td></tr><tr><td>0.6%</td><td>0.6%</td><td>55.2%</td><td>0.0%</td></tr><tr><td>1</td><td>1</td><td>0</td><td>31</td></tr><tr><td>0.6%</td><td>0.6%</td><td>0.0%</td><td>10.3%</td></tr><tr><td>82.4%</td><td>74.1%</td><td>100%</td><td>83.3%</td></tr><tr><td>17.6%</td><td>25.9%</td><td>0.0%</td><td>6.1%</td></tr></table></div></div> <div><div><div>Test Confusion Matrix</div><table><tr><td>16</td><td>1</td><td>0</td><td>0</td></tr><tr><td>9.3%</td><td>0.6%</td><td>0.0%</td><td>0.0%</td></tr><tr><td>0</td><td>30</td><td>1</td><td>4</td></tr><tr><td>0.0%</td><td>17.4%</td><td>0.6%</td><td>2.3%</td></tr><tr><td>0</td><td>1</td><td>94</td><td>0</td></tr><tr><td>0.0%</td><td>0.6%</td><td>54.7%</td><td>0.0%</td></tr><tr><td>1</td><td>0</td><td>0</td><td>24</td></tr><tr><td>0.8%</td><td>0.0%</td><td>0.0%</td><td>14.0%</td></tr><tr><td>94.1%</td><td>93.5%</td><td>93.0%</td><td>85.7%</td></tr><tr><td>5.9%</td><td>6.5%</td><td>7.0%</td><td>14.3%</td></tr></table></div><div><div>All Confusion 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Matrix</div><table><tr><td>489</td><td>31</td><td>9</td><td>1</td></tr><tr><td>14.5%</td><td>8.9%</td><td>0.3%</td><td>0.0%</td></tr><tr><td>16</td><td>455</td><td>8</td><td>29</td></tr><tr><td>0.5%</td><td>13.2%</td><td>0.2%</td><td>0.8%</td></tr><tr><td>8</td><td>27</td><td>1032</td><td>4</td></tr><tr><td>0.2%</td><td>0.8%</td><td>53.2%</td><td>0.1%</td></tr><tr><td>10</td><td>15</td><td>1</td><td>491</td></tr><tr><td>0.3%</td><td>0.4%</td><td>0.0%</td><td>14.3%</td></tr><tr><td>93.8%</td><td>88.2%</td><td>99.2%</td><td>93.5%</td></tr><tr><td>6.4%</td><td>11.8%</td><td>1.2%</td><td>5.5%</td></tr></table></div></div></td></tr>	497	27	6	2	14.6%	0.9%	0.2%	0.1%	7	425	3	15	0.2%	13.7%	0.1%	0.5%	2	17	1053	4	0.1%	0.5%	83.5%	0.1%	9	11	0	454	0.3%	0.4%	0.0%	14.7%	96.2%	89.2%	89.2%	85.7%	3.8%	11.0%	0.0%	4.4%	23	1	0	0	10.2%	0.6%	0.0%	0.0%	1	13	1	2	0.6%	7.6%	0.6%	1.2%	1	1	93	0	0.6%	0.6%	52.3%	0.0%	0	1	1	28	0.0%	0.6%	0.0%	16.3%	84.3%	81.2%	98.0%	83.3%	15.7%	18.8%	1.1%	6.7%	22	3	1	0	12.6%	1.7%	0.6%	0.0%	0	26	0	0	0.0%	15.1%	0.0%	0.0%	0	1	96	0	0.0%	0.6%	93.6%	0.0%	1	2	0	20	0.8%	1.2%	0.0%	11.8%	95.7%	81.2%	99.0%	85.3%	4.3%	18.8%	1.0%	4.7%	519	31	7	2	14.0%	6.9%	0.2%	0.1%	8	464	4	17	0.2%	13.9%	0.1%	0.5%	3	19	1033	4	0.1%	0.6%	53.3%	0.1%	10	14	0	502	0.3%	0.4%	0.0%	14.9%	96.1%	87.9%	99.4%	95.5%	3.9%	12.1%	0.6%	4.5%	Run 3	<div><div><div>Training Confusion Matrix</div><table><tr><td>448</td><td>27</td><td>9</td><td>1</td></tr><tr><td>14.4%</td><td>0.9%</td><td>0.3%</td><td>0.0%</td></tr><tr><td>12</td><td>411</td><td>4</td><td>26</td></tr><tr><td>0.4%</td><td>13.3%</td><td>0.1%</td><td>0.8%</td></tr><tr><td>5</td><td>36</td><td>1058</td><td>4</td></tr><tr><td>0.2%</td><td>0.8%</td><td>83.6%</td><td>0.1%</td></tr><tr><td>8</td><td>14</td><td>1</td><td>440</td></tr><tr><td>0.3%</td><td>0.5%</td><td>0.0%</td><td>14.2%</td></tr><tr><td>94.5%</td><td>89.2%</td><td>89.2%</td><td>83.4%</td></tr><tr><td>5.5%</td><td>10.8%</td><td>0.0%</td><td>4.8%</td></tr></table></div><div><div>Validation Confusion 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Run 5	<div><div><div>Training Confusion Matrix</div><table><tr><td>456</td><td>22</td><td>2</td><td>1</td></tr><tr><td>14.7%</td><td>0.7%</td><td>0.1%</td><td>0.0%</td></tr><tr><td>9</td><td>441</td><td>8</td><td>22</td></tr><tr><td>0.3%</td><td>14.5%</td><td>0.3%</td><td>0.7%</td></tr><tr><td>2</td><td>19</td><td>1654</td><td>3</td></tr><tr><td>0.1%</td><td>0.6%</td><td>53.5%</td><td>0.1%</td></tr><tr><td>9</td><td>3</td><td>0</td><td>441</td></tr><tr><td>0.3%</td><td>0.1%</td><td>0.0%</td><td>14.3%</td></tr><tr><td>55.0%</td><td>53.5%</td><td>55.4%</td><td>54.4%</td></tr><tr><td>1.2%</td><td>9.1%</td><td>0.6%</td><td>5.6%</td></tr></table><div>Output Class</div><div>Target Class</div></div><div><div>Validation Confusion Matrix</div><table><tr><td>26</td><td>0</td><td>1</td><td>0</td></tr><tr><td>15.1%</td><td>0.0%</td><td>0.6%</td><td>0.0%</td></tr><tr><td>0</td><td>23</td><td>0</td><td>3</td></tr><tr><td>0.0%</td><td>13.4%</td><td>0.0%</td><td>1.7%</td></tr><tr><td>0</td><td>1</td><td>88</td><td>0</td></tr><tr><td>0.0%</td><td>0.6%</td><td>51.2%</td><td>0.0%</td></tr><tr><td>0</td><td>0</td><td>0</td><td>39</td></tr><tr><td>0.0%</td><td>0.0%</td><td>0.0%</td><td>17.4%</td></tr><tr><td>100%</td><td>55.8%</td><td>56.2%</td><td>52.3%</td></tr><tr><td>0.0%</td><td>4.2%</td><td>1.1%</td><td>9.1%</td></tr></table><div>Output Class</div><div>Target Class</div></div><div><div>Test Confusion Matrix</div><table><tr><td>31</td><td>2</td><td>1</td><td>9</td></tr><tr><td>18.0%</td><td>1.2%</td><td>0.6%</td><td>8.3%</td></tr><tr><td>0</td><td>13</td><td>2</td><td>4</td></tr><tr><td>0.0%</td><td>7.6%</td><td>1.2%</td><td>2.3%</td></tr><tr><td>9</td><td>3</td><td>94</td><td>1</td></tr><tr><td>0.0%</td><td>1.7%</td><td>54.7%</td><td>0.6%</td></tr><tr><td>0</td><td>1</td><td>0</td><td>20</td></tr><tr><td>0.0%</td><td>0.6%</td><td>0.0%</td><td>11.6%</td></tr><tr><td>100%</td><td>68.4%</td><td>68.0%</td><td>80.0%</td></tr><tr><td>0.0%</td><td>31.6%</td><td>3.1%</td><td>20.0%</td></tr></table><div>Output Class</div><div>Target Class</div></div><div><div>All Confusion Matrix</div><table><tr><td>513</td><td>24</td><td>4</td><td>1</td></tr><tr><td>14.9%</td><td>0.7%</td><td>0.1%</td><td>0.0%</td></tr><tr><td>9</td><td>477</td><td>10</td><td>29</td></tr><tr><td>0.3%</td><td>13.9%</td><td>0.3%</td><td>0.8%</td></tr><tr><td>2</td><td>23</td><td>1836</td><td>4</td></tr><tr><td>0.1%</td><td>0.7%</td><td>53.4%</td><td>0.1%</td></tr><tr><td>9</td><td>4</td><td>0</td><td>491</td></tr><tr><td>0.3%</td><td>0.1%</td><td>0.0%</td><td>14.3%</td></tr><tr><td>86.2%</td><td>82.3%</td><td>88.2%</td><td>83.5%</td></tr><tr><td>3.8%</td><td>9.7%</td><td>0.8%</td><td>6.5%</td></tr></table><div>Output Class</div><div>Target Class</div></div></div>	456	22	2	1	14.7%	0.7%	0.1%	0.0%	9	441	8	22	0.3%	14.5%	0.3%	0.7%	2	19	1654	3	0.1%	0.6%	53.5%	0.1%	9	3	0	441	0.3%	0.1%	0.0%	14.3%	55.0%	53.5%	55.4%	54.4%	1.2%	9.1%	0.6%	5.6%	26	0	1	0	15.1%	0.0%	0.6%	0.0%	0	23	0	3	0.0%	13.4%	0.0%	1.7%	0	1	88	0	0.0%	0.6%	51.2%	0.0%	0	0	0	39	0.0%	0.0%	0.0%	17.4%	100%	55.8%	56.2%	52.3%	0.0%	4.2%	1.1%	9.1%	31	2	1	9	18.0%	1.2%	0.6%	8.3%	0	13	2	4	0.0%	7.6%	1.2%	2.3%	9	3	94	1	0.0%	1.7%	54.7%	0.6%	0	1	0	20	0.0%	0.6%	0.0%	11.6%	100%	68.4%	68.0%	80.0%	0.0%	31.6%	3.1%	20.0%	513	24	4	1	14.9%	0.7%	0.1%	0.0%	9	477	10	29	0.3%	13.9%	0.3%	0.8%	2	23	1836	4	0.1%	0.7%	53.4%	0.1%	9	4	0	491	0.3%	0.1%	0.0%	14.3%	86.2%	82.3%	88.2%	83.5%	3.8%	9.7%	0.8%	6.5%	
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Run 6	<div><div><div>Training Confusion Matrix</div><table><tr><td>453</td><td>17</td><td>1</td><td>0</td></tr><tr><td>14.7%</td><td>0.6%</td><td>0.0%</td><td>0.0%</td></tr><tr><td>5</td><td>427</td><td>6</td><td>11</td></tr><tr><td>0.2%</td><td>13.9%</td><td>0.2%</td><td>0.4%</td></tr><tr><td>3</td><td>16</td><td>1673</td><td>5</td></tr><tr><td>0.1%</td><td>0.5%</td><td>54.1%</td><td>0.2%</td></tr><tr><td>9</td><td>4</td><td>0</td><td>482</td></tr><tr><td>0.3%</td><td>0.1%</td><td>0.0%</td><td>14.9%</td></tr><tr><td>54.4%</td><td>52.2%</td><td>55.6%</td><td>57.8%</td></tr><tr><td>5.8%</td><td>8.2%</td><td>0.6%</td><td>3.3%</td></tr></table><div>Output Class</div><div>Target Class</div></div><div><div>Validation Confusion Matrix</div><table><tr><td>23</td><td>2</td><td>1</td><td>0</td></tr><tr><td>15.2%</td><td>1.2%</td><td>0.6%</td><td>0.0%</td></tr><tr><td>0</td><td>29</td><td>0</td><td>0</td></tr><tr><td>0.0%</td><td>15.9%</td><td>0.0%</td><td>0.0%</td></tr><tr><td>0</td><td>0</td><td>93</td><td>0</td></tr><tr><td>0.0%</td><td>0.0%</td><td>48.3%</td><td>0.0%</td></tr><tr><td>0</td><td>0</td><td>0</td><td>24</td></tr><tr><td>0.0%</td><td>0.0%</td><td>0.0%</td><td>14.0%</td></tr><tr><td>100%</td><td>63.5%</td><td>68.8%</td><td>100%</td></tr><tr><td>0.0%</td><td>6.0%</td><td>1.2%</td><td>9.0%</td></tr></table><div>Output Class</div><div>Target Class</div></div><div><div>Test Confusion Matrix</div><table><tr><td>29</td><td>2</td><td>0</td><td>9</td></tr><tr><td>16.3%</td><td>1.2%</td><td>0.0%</td><td>8.3%</td></tr><tr><td>0</td><td>30</td><td>1</td><td>3</td></tr><tr><td>0.0%</td><td>17.4%</td><td>0.6%</td><td>1.7%</td></tr><tr><td>0</td><td>1</td><td>85</td><td>1</td></tr><tr><td>0.0%</td><td>0.6%</td><td>49.4%</td><td>0.6%</td></tr><tr><td>2</td><td>6</td><td>0</td><td>19</td></tr><tr><td>1.2%</td><td>0.0%</td><td>0.0%</td><td>11.0%</td></tr><tr><td>83.3%</td><td>80.0%</td><td>88.0%</td><td>84.3%</td></tr><tr><td>6.7%</td><td>9.1%</td><td>1.2%</td><td>17.4%</td></tr></table><div>Output Class</div><div>Target Class</div></div><div><div>All Confusion Matrix</div><table><tr><td>514</td><td>21</td><td>2</td><td>0</td></tr><tr><td>15.0%</td><td>0.6%</td><td>0.1%</td><td>0.0%</td></tr><tr><td>5</td><td>466</td><td>7</td><td>14</td></tr><tr><td>0.1%</td><td>14.1%</td><td>0.2%</td><td>0.4%</td></tr><tr><td>3</td><td>17</td><td>1841</td><td>6</td></tr><tr><td>0.1%</td><td>0.6%</td><td>52.6%</td><td>0.2%</td></tr><tr><td>11</td><td>4</td><td>0</td><td>505</td></tr><tr><td>0.3%</td><td>0.1%</td><td>0.0%</td><td>14.7%</td></tr><tr><td>86.4%</td><td>82.0%</td><td>88.5%</td><td>87.4%</td></tr><tr><td>3.6%</td><td>8.0%</td><td>0.2%</td><td>3.8%</td></tr></table><div>Output Class</div><div>Target Class</div></div></div>	453	17	1	0	14.7%	0.6%	0.0%	0.0%	5	427	6	11	0.2%	13.9%	0.2%	0.4%	3	16	1673	5	0.1%	0.5%	54.1%	0.2%	9	4	0	482	0.3%	0.1%	0.0%	14.9%	54.4%	52.2%	55.6%	57.8%	5.8%	8.2%	0.6%	3.3%	23	2	1	0	15.2%	1.2%	0.6%	0.0%	0	29	0	0	0.0%	15.9%	0.0%	0.0%	0	0	93	0	0.0%	0.0%	48.3%	0.0%	0	0	0	24	0.0%	0.0%	0.0%	14.0%	100%	63.5%	68.8%	100%	0.0%	6.0%	1.2%	9.0%	29	2	0	9	16.3%	1.2%	0.0%	8.3%	0	30	1	3	0.0%	17.4%	0.6%	1.7%	0	1	85	1	0.0%	0.6%	49.4%	0.6%	2	6	0	19	1.2%	0.0%	0.0%	11.0%	83.3%	80.0%	88.0%	84.3%	6.7%	9.1%	1.2%	17.4%	514	21	2	0	15.0%	0.6%	0.1%	0.0%	5	466	7	14	0.1%	14.1%	0.2%	0.4%	3	17	1841	6	0.1%	0.6%	52.6%	0.2%	11	4	0	505	0.3%	0.1%	0.0%	14.7%	86.4%	82.0%	88.5%	87.4%	3.6%	8.0%	0.2%	3.8%	
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Run 7	<div><div><div>Training Confusion Matrix</div><table><tr><td>461</td><td>20</td><td>7</td><td>1</td></tr><tr><td>14.9%</td><td>0.6%</td><td>0.2%</td><td>0.0%</td></tr><tr><td>13</td><td>417</td><td>9</td><td>24</td></tr><tr><td>0.4%</td><td>13.5%</td><td>0.3%</td><td>0.8%</td></tr><tr><td>5</td><td>24</td><td>1540</td><td>6</td></tr><tr><td>0.2%</td><td>0.8%</td><td>53.0%</td><td>0.2%</td></tr><tr><td>9</td><td>9</td><td>0</td><td>439</td></tr><tr><td>0.3%</td><td>0.3%</td><td>0.0%</td><td>14.2%</td></tr><tr><td>54.5%</td><td>57.2%</td><td>59.0%</td><td>53.4%</td></tr><tr><td>5.8%</td><td>12.5%</td><td>1.0%</td><td>6.6%</td></tr></table><div>Output Class</div><div>Target Class</div></div><div><div>Validation Confusion Matrix</div><table><tr><td>23</td><td>1</td><td>0</td><td>0</td></tr><tr><td>13.4%</td><td>0.6%</td><td>0.0%</td><td>0.0%</td></tr><tr><td>0</td><td>19</td><td>2</td><td>2</td></tr><tr><td>0.0%</td><td>11.0%</td><td>1.2%</td><td>1.2%</td></tr><tr><td>2</td><td>1</td><td>95</td><td>0</td></tr><tr><td>1.2%</td><td>0.6%</td><td>55.2%</td><td>0.0%</td></tr><tr><td>0</td><td>2</td><td>0</td><td>25</td></tr><tr><td>0.0%</td><td>1.2%</td><td>0.0%</td><td>14.5%</td></tr><tr><td>82.0%</td><td>82.6%</td><td>97.8%</td><td>92.6%</td></tr><tr><td>8.0%</td><td>17.4%</td><td>2.1%</td><td>7.4%</td></tr></table><div>Output Class</div><div>Target Class</div></div><div><div>Test Confusion Matrix</div><table><tr><td>18</td><td>2</td><td>0</td><td>9</td></tr><tr><td>10.0%</td><td>1.2%</td><td>0.0%</td><td>8.3%</td></tr><tr><td>0</td><td>22</td><td>1</td><td>1</td></tr><tr><td>0.0%</td><td>12.6%</td><td>0.6%</td><td>0.6%</td></tr><tr><td>1</td><td>2</td><td>96</td><td>1</td></tr><tr><td>0.6%</td><td>1.2%</td><td>65.6%</td><td>0.6%</td></tr><tr><td>1</td><td>1</td><td>0</td><td>26</td></tr><tr><td>0.6%</td><td>0.6%</td><td>0.0%</td><td>15.1%</td></tr><tr><td>90.0%</td><td>81.5%</td><td>89.0%</td><td>82.0%</td></tr><tr><td>10.0%</td><td>18.5%</td><td>1.0%</td><td>7.1%</td></tr></table><div>Output Class</div><div>Target Class</div></div><div><div>All Confusion Matrix</div><table><tr><td>502</td><td>31</td><td>7</td><td>1</td></tr><tr><td>14.6%</td><td>0.9%</td><td>0.2%</td><td>0.0%</td></tr><tr><td>13</td><td>458</td><td>12</td><td>27</td></tr><tr><td>0.4%</td><td>13.3%</td><td>0.3%</td><td>0.9%</td></tr><tr><td>8</td><td>27</td><td>1831</td><td>7</td></tr><tr><td>0.2%</td><td>0.8%</td><td>53.7%</td><td>0.2%</td></tr><tr><td>19</td><td>12</td><td>0</td><td>490</td></tr><tr><td>0.3%</td><td>0.3%</td><td>0.0%</td><td>14.3%</td></tr><tr><td>84.2%</td><td>88.7%</td><td>99.0%</td><td>93.3%</td></tr><tr><td>5.8%</td><td>13.3%</td><td>1.0%</td><td>6.7%</td></tr></table><div>Output Class</div><div>Target Class</div></div></div>	461	20	7	1	14.9%	0.6%	0.2%	0.0%	13	417	9	24	0.4%	13.5%	0.3%	0.8%	5	24	1540	6	0.2%	0.8%	53.0%	0.2%	9	9	0	439	0.3%	0.3%	0.0%	14.2%	54.5%	57.2%	59.0%	53.4%	5.8%	12.5%	1.0%	6.6%	23	1	0	0	13.4%	0.6%	0.0%	0.0%	0	19	2	2	0.0%	11.0%	1.2%	1.2%	2	1	95	0	1.2%	0.6%	55.2%	0.0%	0	2	0	25	0.0%	1.2%	0.0%	14.5%	82.0%	82.6%	97.8%	92.6%	8.0%	17.4%	2.1%	7.4%	18	2	0	9	10.0%	1.2%	0.0%	8.3%	0	22	1	1	0.0%	12.6%	0.6%	0.6%	1	2	96	1	0.6%	1.2%	65.6%	0.6%	1	1	0	26	0.6%	0.6%	0.0%	15.1%	90.0%	81.5%	89.0%	82.0%	10.0%	18.5%	1.0%	7.1%	502	31	7	1	14.6%	0.9%	0.2%	0.0%	13	458	12	27	0.4%	13.3%	0.3%	0.9%	8	27	1831	7	0.2%	0.8%	53.7%	0.2%	19	12	0	490	0.3%	0.3%	0.0%	14.3%	84.2%	88.7%	99.0%	93.3%	5.8%	13.3%	1.0%	6.7%	
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5.8%	13.3%	1.0%	6.7%																																																																																																																																																															

Run 8

Training Confusion Matrix					Validation Confusion Matrix				
Output Class	1	458	29	5	1	29	2	2	0
		14.0%	0.9%	0.2%	0.0%	16.3%	1.2%	1.2%	0.0%
	2	5	396	8	22	1	28	1	4
		0.2%	12.6%	0.3%	0.7%	0.6%	11.6%	0.3%	2.3%
	3	3	38	1654	6	0	3	91	0
		0.1%	1.2%	53.5%	0.2%	0.0%	1.7%	52.9%	0.0%
Output Class	4	9	13	3	442	0	0	0	29
		0.3%	0.4%	0.1%	14.2%	0.0%	0.0%	0.0%	11.5%
		56.4%	53.2%	99.0%	95.6%	98.7%	82.0%	97.8%	83.3%
		3.8%	16.8%	1.0%	6.2%	3.3%	20.0%	2.2%	16.7%
Target Class					Target Class				

Test Confusion Matrix					All Confusion Matrix				
Output Class	1	26	1	2	0	513	32	9	1
		15.1%	0.6%	1.2%	0.0%	14.9%	0.9%	0.3%	0.0%
	2	1	17	1	3	7	433	9	29
		0.6%	6.5%	0.6%	1.7%	0.2%	12.6%	0.3%	8.4%
	3	0	6	84	0	3	47	1929	6
		0.0%	3.6%	48.6%	0.0%	0.1%	1.4%	53.2%	0.2%
Output Class	4	1	3	0	27	19	16	3	489
		0.6%	1.3%	0.0%	10.7%	0.3%	0.8%	0.1%	14.2%
		92.9%	83.3%	98.6%	98.8%	98.2%	82.0%	98.3%	93.1%
		7.1%	17.0%	3.4%	10.9%	3.8%	19.0%	1.1%	9.9%
Target Class					Target Class				

Run 9

Training Confusion Matrix					Validation Confusion Matrix				
Output Class	1	463	25	3	1	21	1	0	0
		15.0%	0.8%	0.1%	0.0%	12.2%	0.6%	0.0%	0.0%
	2	13	411	6	18	0	29	1	3
		0.4%	13.3%	0.2%	0.6%	0.0%	16.9%	0.3%	1.7%
	3	4	25	1638	3	0	1	190	0
		0.1%	0.8%	52.9%	0.1%	0.0%	0.6%	58.1%	0.0%
Output Class	4	9	9	4	462	1	0	1	14
		0.3%	0.3%	0.1%	14.2%	0.5%	0.0%	0.3%	8.7%
		54.7%	57.4%	99.3%	98.0%	95.2%	93.5%	98.2%	98.3%
		5.3%	12.6%	0.8%	4.5%	4.8%	6.5%	2.0%	17.6%
Target Class					Target Class				

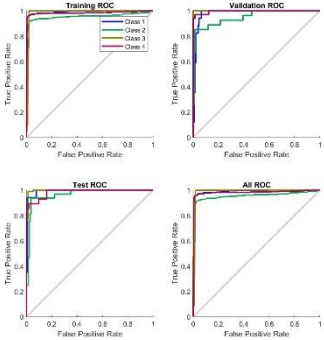
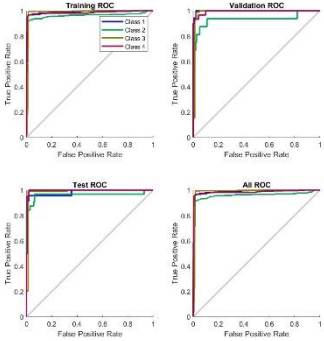
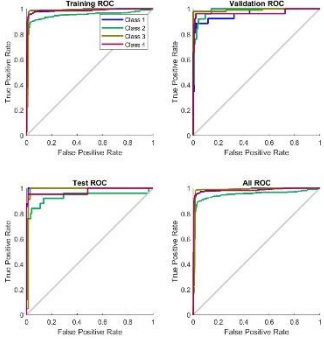
Test Confusion Matrix					All Confusion Matrix				
Output Class	1	19	2	0	0	563	28	3	1
		11.0%	1.2%	0.0%	0.0%	14.6%	0.8%	0.1%	0.0%
	2	1	19	0	0	14	439	7	21
		0.6%	11.0%	0.0%	0.0%	0.4%	13.4%	0.2%	0.6%
	3	1	3	99	1	3	29	1939	4
		0.6%	1.7%	57.6%	0.6%	0.1%	0.8%	53.4%	0.1%
Output Class	4	1	3	0	23	11	12	5	499
		0.6%	1.7%	0.0%	13.4%	0.3%	0.3%	0.1%	14.5%
		86.4%	70.4%	100%	95.0%	94.4%	88.9%	99.2%	98.0%
		13.6%	29.6%	0.0%	4.0%	8.8%	13.1%	0.8%	9.9%
Target Class					Target Class				

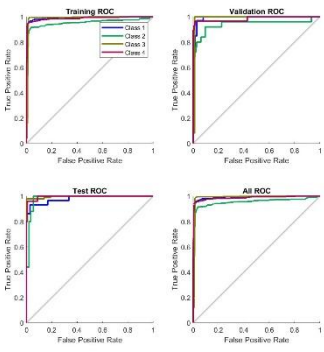
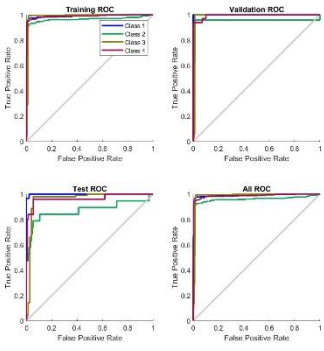
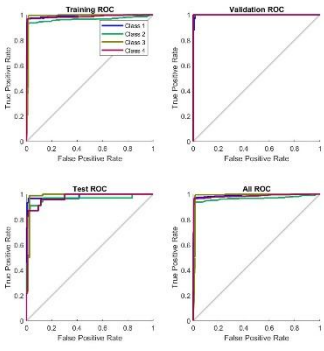
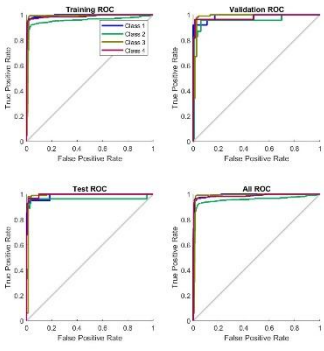
Run 10

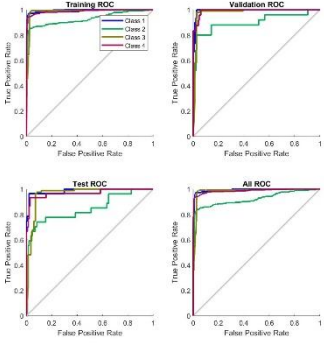
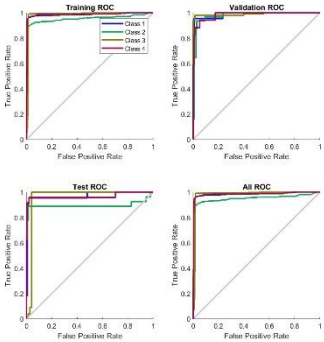
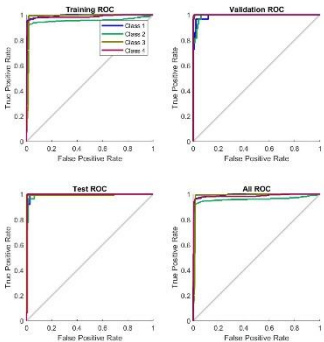
Training Confusion Matrix					Validation Confusion Matrix				
Output Class	1	466	16	5	1	25	3	0	0
		14.6%	0.5%	0.2%	0.0%	14.3%	1.7%	0.0%	0.0%
	2	10	430	5	25	3	23	1	0
		0.3%	13.9%	0.2%	0.8%	1.7%	13.4%	0.9%	0.0%
	3	2	22	1668	5	0	1	90	0
		0.1%	0.7%	53.3%	0.2%	0.0%	0.6%	50.0%	0.0%
Output Class	4	9	7	1	449	1	0	0	29
		0.3%	0.2%	0.0%	14.6%	0.8%	0.0%	0.0%	16.9%
		56.0%	60.7%	95.3%	95.5%	88.2%	85.2%	98.9%	100%
		4.4%	9.3%	0.7%	6.5%	13.8%	14.8%	1.1%	9.0%
Target Class					Target Class				

Test Confusion Matrix					All Confusion Matrix				
Output Class	1	23	2	1	0	566	28	6	1
		13.4%	1.2%	0.6%	0.0%	14.7%	0.6%	0.2%	0.0%
	2	2	25	0	0	15	478	6	25
		1.2%	14.5%	0.0%	0.0%	0.4%	13.9%	0.2%	0.7%
	3	0	5	102	0	2	23	1936	5
		0.0%	0.0%	59.3%	0.0%	0.1%	0.7%	52.4%	0.1%
Output Class	4	0	6	1	16	19	7	2	484
		0.0%	0.0%	0.6%	9.3%	0.3%	0.2%	0.1%	14.6%
		92.0%	82.6%	98.1%	100%	94.9%	82.8%	99.2%	94.1%
		0.0%	7.4%	1.9%	9.0%	5.1%	9.0%	0.8%	5.9%
Target Class					Target Class				

12. ROC Curve Model LM 20.

Training	ROC Curve untuk Training, Validasi, Testing and All
Run 1	 <p>ROC curves for Run 1. The figure contains four subplots: Training ROC, Validation ROC, Test ROC, and All ROC. Each plot shows True Positive Rate (Y-axis) versus False Positive Rate (X-axis) for four classes (Class 1, Class 2, Class 3, Class 4). The curves are generally high, indicating good model performance across all data sets.</p>
Run 2	 <p>ROC curves for Run 2. The figure contains four subplots: Training ROC, Validation ROC, Test ROC, and All ROC. Each plot shows True Positive Rate (Y-axis) versus False Positive Rate (X-axis) for four classes (Class 1, Class 2, Class 3, Class 4). The curves are generally high, indicating good model performance across all data sets.</p>
Run 3	 <p>ROC curves for Run 3. The figure contains four subplots: Training ROC, Validation ROC, Test ROC, and All ROC. Each plot shows True Positive Rate (Y-axis) versus False Positive Rate (X-axis) for four classes (Class 1, Class 2, Class 3, Class 4). The curves are generally high, indicating good model performance across all data sets.</p>

<b>Run 4</b>	 <p>ROC curves for Run 4. The figure contains four subplots: Training ROC, Validation ROC, Test ROC, and All ROC. Each plot shows True Positive Rate (Y-axis) versus False Positive Rate (X-axis) for four classes (Class 1, Class 2, Class 3, Class 4). The curves are very close to the top-left corner, indicating high performance across all classes and datasets.</p>
<b>Run 5</b>	 <p>ROC curves for Run 5. The figure contains four subplots: Training ROC, Validation ROC, Test ROC, and All ROC. Each plot shows True Positive Rate (Y-axis) versus False Positive Rate (X-axis) for four classes (Class 1, Class 2, Class 3, Class 4). The curves are very close to the top-left corner, indicating high performance across all classes and datasets.</p>
<b>Run 6</b>	 <p>ROC curves for Run 6. The figure contains four subplots: Training ROC, Validation ROC, Test ROC, and All ROC. Each plot shows True Positive Rate (Y-axis) versus False Positive Rate (X-axis) for four classes (Class 1, Class 2, Class 3, Class 4). The curves are very close to the top-left corner, indicating high performance across all classes and datasets.</p>
<b>Run 7</b>	 <p>ROC curves for Run 7. The figure contains four subplots: Training ROC, Validation ROC, Test ROC, and All ROC. Each plot shows True Positive Rate (Y-axis) versus False Positive Rate (X-axis) for four classes (Class 1, Class 2, Class 3, Class 4). The curves are very close to the top-left corner, indicating high performance across all classes and datasets.</p>

Run 8	
Run 9	
Run 10	

Dari hasil penggunaan model *Levenberg-Marquardt* (LM) dengan Hidden Neuron 20, terbentuk grafik performa yang menampilkan tiga baris berbeda. Garis biru mencerminkan nilai train, garis hijau menggambarkan nilai validation, sementara garis merah menunjukkan nilai test. Dilihat dari gambar dengan 10 grafik performance baik dari grafik *train*, *validation* dan *test*. Terlihat bahwa grafik menunjukkan penurunan error yang signifikan pada rentang epoch 0 hingga 10. Sedangkan performa grafik menurun errornya menlandai dari sekitar epoch 10 hingga epoch maksimal terlihat pada run 1 hingga run 10.

Berdasarkan 10 fold cross validation, data training adalah 90% dari data total (3092), validation 5% dari total (171), dan test 5% dari total (171). Dari hasil nilai training yang terlihat pada Confusion Matrix, jumlah nilai target yang benar-benar terklasifikasi oleh neural network menjadi kelasnya masing-masing ditunjukkan dengan warna hijau, sedangkan warna merah muda adalah jumlah data yang gagal terklasifikasi pada kelasnya. Pada Confusion Matrix hasil training dari run 1 hingga run 10 menunjukkan jumlah error lebih kecil dari 10% dari total data training (309). Sedangkan, untuk Confusion Matrix hasil validation dan testing dari run 1 hingga run 10 menunjukkan jumlah error lebih kecil dari 10% dari total data (17). Sehingga, dapat disimpulkan hasil training, validation, dan test terkategori excellent.

Dalam analisis visualisasi Receiver Operating Characteristics (ROC) menggunakan model *Levenberg-Marquardt* (LM) dengan Hidden Neuron 20, terlihat bahwa bentuk kurva menunjukkan kesamaan baik dari ROC training, validation, dan testing. Grafik memiliki bentuk yang siku alias menjauhi garis diagonal. Sehingga training RGB to HSV dengan model LM Hidden Neuron 20 menunjukkan hasil yang excellent.

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