Melanoma Skin Cancer Detectior

Design of a computer–based system to automatically classify histopathologi

Importing Data – Training & Testing Set

In[1]:=
```
nImages = 100; (* number of sample images *)
nTrainset = 70; (* number of images used for training the ANN *)
data = Import["/home/gloria/Documents/ETH/Semester2/NN/ImageDatav2.xlsx",
   {"Data", 1, Range[2, nImages + 1], {1, 2, 3}}];
(* data file has a header in row 1 *)
target = Import["/home/gloria/Documents/ETH/Semester2/NN/ImageDatav2.xlsx",
   {"Data", 1, Range[2, nImages + 1], 4}];
(* 4th column corresponds to the ground truth *)
trainindex = RandomSample[Range[2, nImages], nTrainset];
(* Randomly split images betweeen training and testing set *)
testindex = Complement[Range[2, nImages], trainindex];
```

Defining the ANN with 1 hidden layer

In[7]:=
```
inNum = 3; hidNum = 3; outNum = 1; (* 3 input units,
3 hidden units and 1 output unit *)
wh = Table[Table[Random[Real, {-2.5, 2.5}], {inNum}], {hidNum}];
(* hidden weights *)
wo = Table[Table[Random[Real, {-2.5, 2.5}], {hidNum}], {outNum}];
(* output weights *)
eta = 0.5;(* learning rate *)
```

In[11]:=
```
sigmoid[x_] := 1 / (1 + Exp[-x]);
relu[x_] := Map[Max[0, #] &, x]; (* activation functions *)
l = nTrainset; (* number images in the training set *)
```

In[13]:=
```
(* funtion to train the ANN *)
TrainEpochs[n_] := Module[{iter = nTrainset}, Table[
    If[k ≤ l, r = trainindex[[k]], r = trainindex[[Mod[k, l] + 1]]];
    in = data[[r]];
    y = target[[r]];
    outhid = sigmoid[wh.in];
    out = sigmoid[wo.outhid];
    e = y - out;
    outdelta = e out (1 - out);
    hiddelta = outhid (1 - outhid) Transpose[wo].outdelta;
    wo += eta e.e Outer[Times, outdelta, outhid];
    wh += eta e.e Outer[Times, hiddelta, in];
    {e.e, wo, wh}, {k, 1, iter}]];
```

In[14]:=
```
(* function to evaluate the ANN *)
EvalNetwork[in_] := Module[{outhid}, outhid = sigmoid[wh.in];
  sigmoid[wo.outhid]]
```

In[15]:=
```
(* function to compute the testing error *)
testErrorfunc[n_] := Module[{},
  RootMeanSquare[Table[target[[testindex[[i]]]] - EvalNetwork[data[[testindex[[i]]]]],
      {i, 1, nImages - nTrainset - 1}] // Flatten] // N]
```

Training the ANN

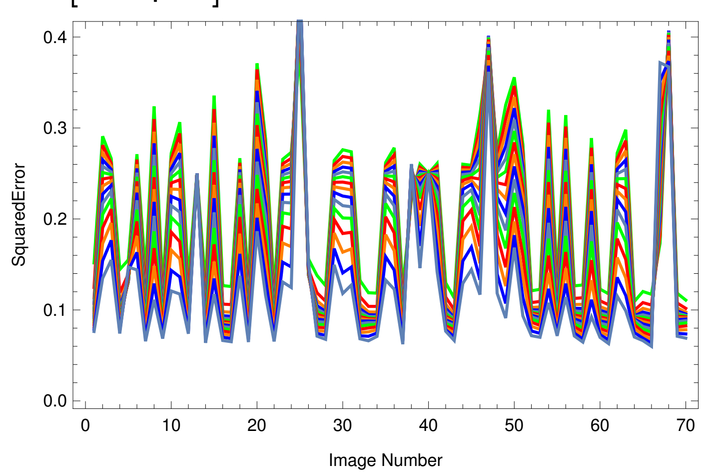
In[16]:=
```
nIterations = 15; (* number of iterations *)
ErrorList = Table[{TrainEpochs[1], testErrorfunc[k]}, {k, 1, nIterations}];
```

In[18]:=
```
colors = {Green, Red, Orange, Blue, Gray};
```

In[19]:=
```
trainplot = Table[ListPlot[ ErrorList[[pp, 1, All, 1]] // Flatten,
    PlotJoined → True, Frame → True, FrameLabel → {"Image Number", "SquaredError"},
    PlotRange → All, PlotStyle → colors[[Mod[pp, 5]]]], {pp, 1, nIterations}];
```

In[20]:=
```
Show[trainplot]
```

Out[20]=



In[21]:=
Performance Evaluation

In[22]:=
```
TP = 0; FP = 0; TN = 0;
FN = 0; (* true positives, false positives, true negatives and false negatives *)
For[i = 1, i ≤ Length[testindex], i++,
  in = data[[testindex[[i]]]];
  y = target[[testindex[[i]]]];
  outhid = sigmoid[wh.in];
  out = Round[sigmoid[wo.outhid]];
  Which[out[[1]] == y == 1, TP += 1, out[[1]] == y == 0, TN += 1,
   out[[1]] ≠ y && out [[1]] == 0, FN += 1, out[[1]] ≠ y && out[[1]] == 1, FP += 1]
 ];
```

In[24]:=
```
(* Compute True Positive Rate (TPR), also called recall or sensitivity*)
NSensitivity = TP / (TP + FN);
(* Compute Precision, also called Positive Predictive Value (PPV)*)
NPrecision = TP / (TP + FP);
(*Compute True Negative Rate (TNR), also called specificity*)
NSpecificity = TN / (TN + FP);
(* Compute Accuracy*)
NAccuracy = (TP + TN) / (TP + TN + FP + FN);
```

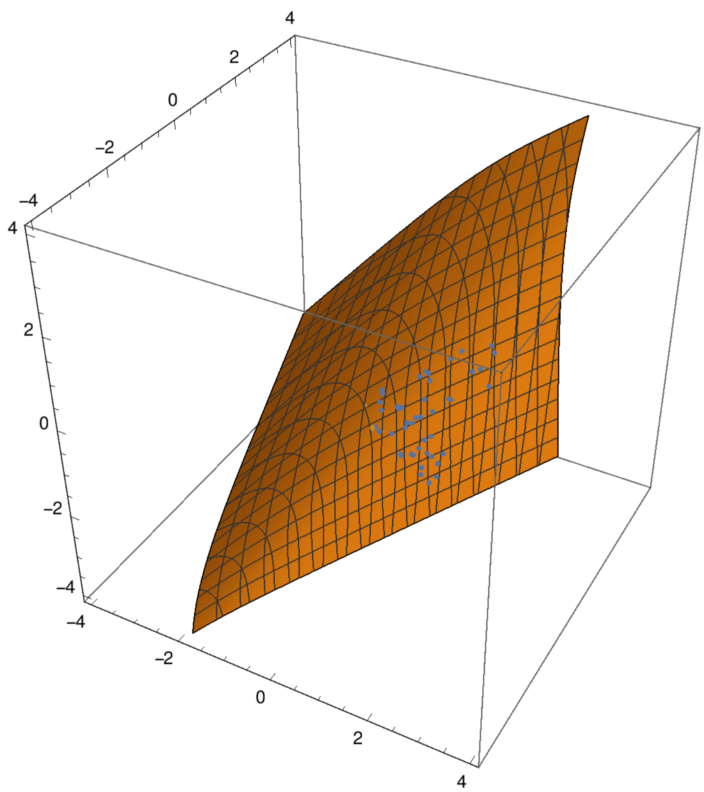
In[28]:=
```
Print["Sensitivity", "=", N[NSensitivity, 3]]
Print["Precision", "=", N[NPrecision, 3]]
Print["Specificity", "=", N[NSpecificity, 3]]
Print["Accuracy", "=", N[NAccuracy, 3]]
```

```
Sensitivity=1.00

Precision=0.933

Specificity=0.933

Accuracy=0.966
```

Visualizing the Classification Task

In[32]:=
```
signal = Position[target, _? (# == 1. &)] // Flatten;
bckg = Position[target, _? (# == 0. &)] // Flatten;
signaldata = Map[data[[#]] &, signal];
bckgdata = Map[data[[#]] &, bckg];
ip = ListPointPlot3D[{signaldata, bckgdata}];
op =
  ContourPlot3D[EvalNetwork[{xx, yy, zz}] == 1 / 2, {xx, -4, 4}, {yy, -4, 4}, {zz, -4, 4}];
Show[
 op,
 ip]
```

Out[38]=



Assessing Overfitting – Training & Testing Error

In[39]:=
```
trainingError = Table[RootMeanSquare[ErrorList[[i, 1, All, 1]]], {i, 1, nIterations}];
testError = Table[ErrorList[[i, 2]], {i, 1, nIterations}];
ListLinePlot[{trainingError, testError}, Frame → True,
 FrameLabel → {"Training Epoch", "RootMeanSquare Error"},
 PlotLegends → {"Training", "Testing"}]
```

Out[41]=