CHAPTER 5

RESULT FINDINGS AND ANALYSIS

5.1 System Specification

5.1.1 Hardware

The hardware specification is as follows:

- Intel i5 2410M 2.3 GHz Processor
- 8GB RAM
- 750 GB HDD

5.1.2 Software

The software specification is as follows:

- Windows 7 (64 bit)
- Matlab Version 7.11.0.584 (R2010b) 32-bit (win32)
- WEKA Version 3.7.4

5.2 Research Data

The input data of the research are the images feature extractions. Each image is represented by 833 dimensions of feature extraction. It consists of 1 dimension of image's class (of which class the image belongs: U is the Understand class, N is Not-understand class), 768 dimensions of color-based feature (C1-C768) and 64 dimensions of arithmetic mean edge feature (E1-E64).

Class	C1	C2	C3	-----	C766	C767	C768	E1	E2	E3	-----	E61	E62	E63	E64
U	0	0	0		0	0	0	0	0	1.03E-02		3.50E-03	2.30E-02	2.40E-02	1.10E-02
U	0	0	0		0	0	0	0	0	9.14E-03		1.00E-03	3.25E-02	2.75E-02	8.00E-03
U	0	0	0		0	0	0	0	0	1.03E-02		1.00E-03	2.15E-02	3.15E-02	5.00E-03
U	0	0	0		0	0	0	0	0	9.71E-03		1.00E-03	2.05E-02	2.95E-02	5.00E-03
U	0	0	0		0	0	0	0	5.71E-04	5.71E-03		2.90E-02	3.65E-02	3.85E-02	3.30E-02
N	0	0	0		0	0	0	0	1.03E-02	0		2.90E-02	3.45E-02	3.40E-02	2.40E-02
N	0	0	0		0	0	0	0	1.03E-02	0		2.70E-02	3.50E-02	3.40E-02	2.50E-02
N	0	0	0		0	0	0	0	0	0		2.70E-02	3.45E-02	3.40E-02	2.50E-02
N	0	0	0		0	0	0	0	5.71E-04	1.83E-02		2.05E-02	1.70E-02	0	1.00E-02
N	0	0	0		0	0	0	5.71E-04	5.14E-03	1.94E-02		2.00E-02	1.65E-02	0	1.00E-02
N	0	0	0		0	0	0	1.14E-03	8.00E-03	2.17E-02		1.80E-02	1.50E-02	0	1.20E-02

Figure 5.1 Sample of research data

Each row of the sample picture in Figure 5.1 is a representation of the images feature extractions. There are 400 rows of data as there are 400 images (200 U class images and 200 N class images). The class dimension (Class) is the desired output of the classifier while the rest of the dimension (C1-C768 and E1-E64) are the input of the classifier. Figure 5.1 only shown 5 feature extractions of

Understand class images and 5 feature extraction of Not-understand class images due to the limited space.

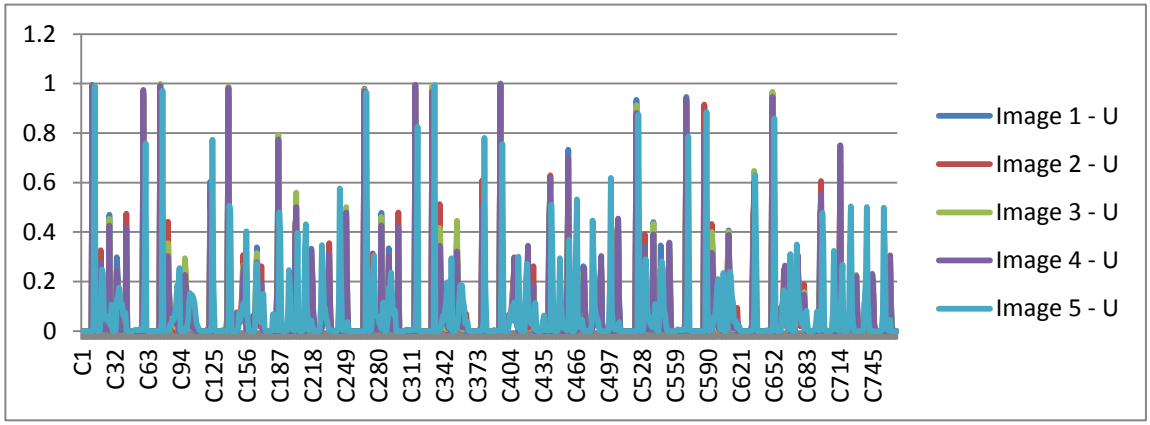

Figure 5.2 Sample of color-based feature extraction for Understand class

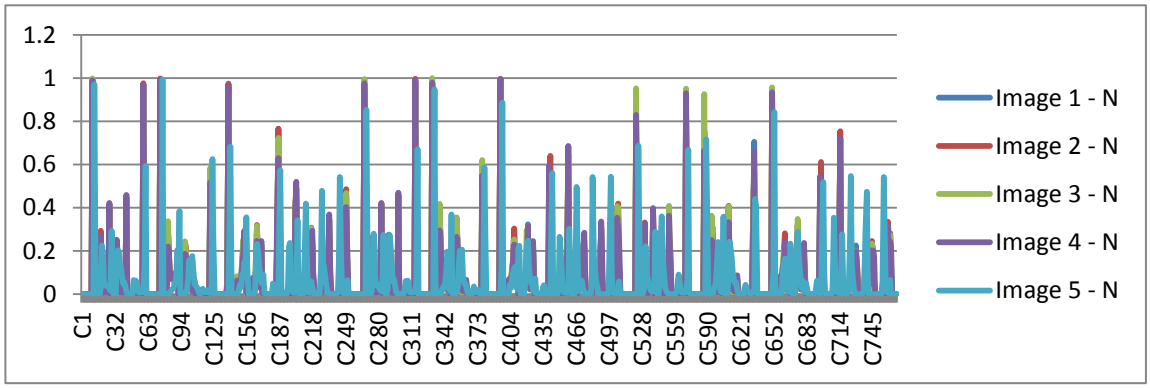

Figure 5.3 Sample of color-based feature extraction for Not-understand class

Figure 5.2 is the representation of the Image 1, Image 2, Image 3, Image 4, and Image 5 color-based feature extraction for Understand class images. Figure 5.3 is the representation of the Image 1, Image 2, Image 3, Image 4, and Image 5 color-based feature extraction for Not-understand class images. Both of the graphs might look the same; however there are significant differences between Understand class color-based feature and Not-understand class color-based feature. For example in feature C63 of Image 5 (light blue line), in Understand

class, the line almost reach 0.8 while in the Not-understand class the line only reach 0.6. This proves that there is indeed difference between understand face expression and not understand face expression of a learner.

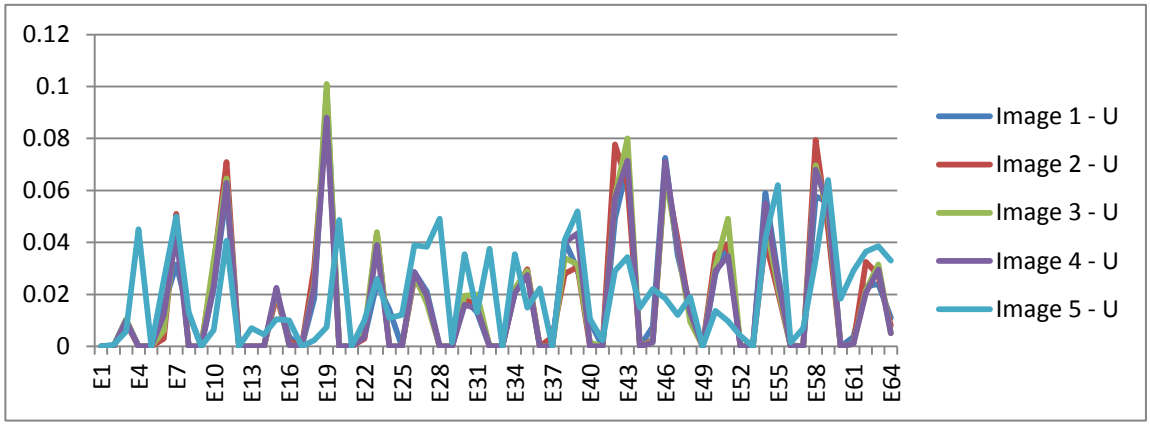

Figure 5.4 Sample of arithmetic mean edge feature extraction for Understand class

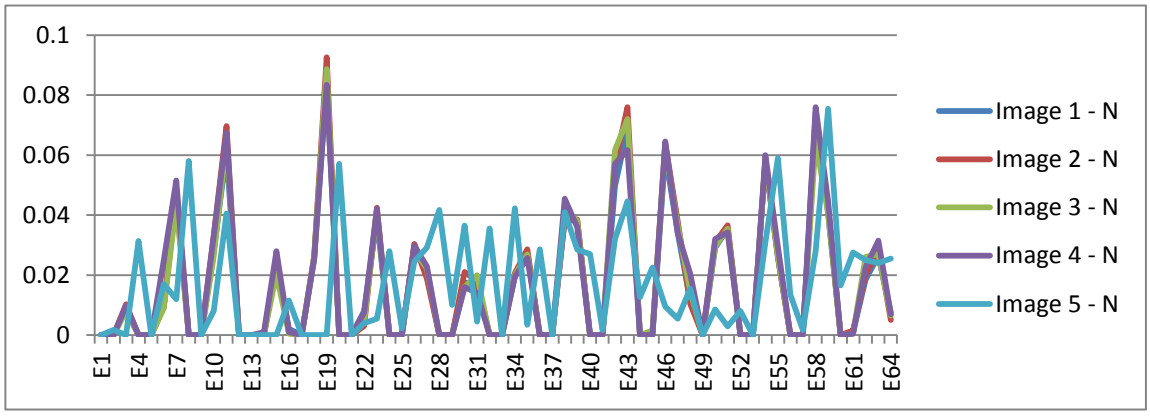

Figure 5.5 Sample of arithmetic mean edge feature extraction for Not-understand class

Figure 5.4 is the representation of the Image 1, Image 2, Image 3, Image 4, and Image 5 arithmetic mean edge feature extraction for Understand class images. Figure 5.5 is the representation of the Image 1, Image 2, Image 3, Image 4, and Image 5 arithmetic mean edge feature extraction for Not-understand class images. Both of the graphs might look the same; however there are significant

differences between Understand class arithmetic mean edge feature and Not-understand arithmetic mean edge feature. For example in feature E4 of Image 5 (light blue line), in Understand class, the line almost reach 0.5 while in the Not-understand class the line only reach 0.3. This proves that there is indeed difference between understand face expression and not understand face expression of a learner.

5.3 Test Plan

5.3.1 Cross Validation Testing

Cross Validation 10 Folds is used to prevent over fitting. In adjusting the portion of training set and test set from the research data, it is possible that the adjustment bring no causal relation to target output (over fitting). Cross validation testing divides the research data into ten folds where the 90% (9 folds) of data are used as training set and the rest 10% (1 fold) are used as the test set. All of the folds will take turn to be the 10% test set, this way the training result will be more reliable.

5.3.2 Test Accuracy

The test accuracy is conducted to get the best hidden layer and training epoch value that will improve the research result. The test was done in percentage split: 60% data as training set and 40 % data as test set.

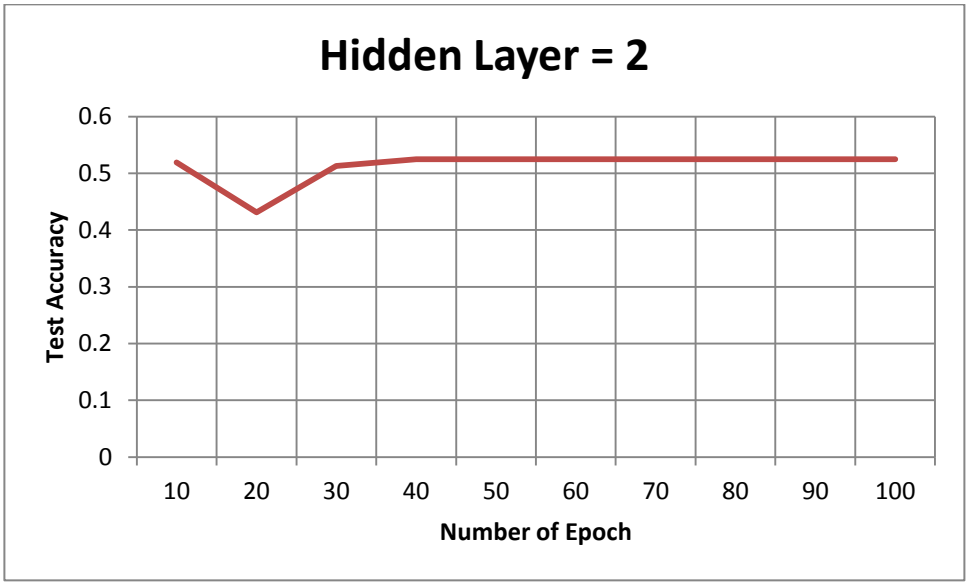

Figure 5.6 Test Accuracy for hidden layer = 2

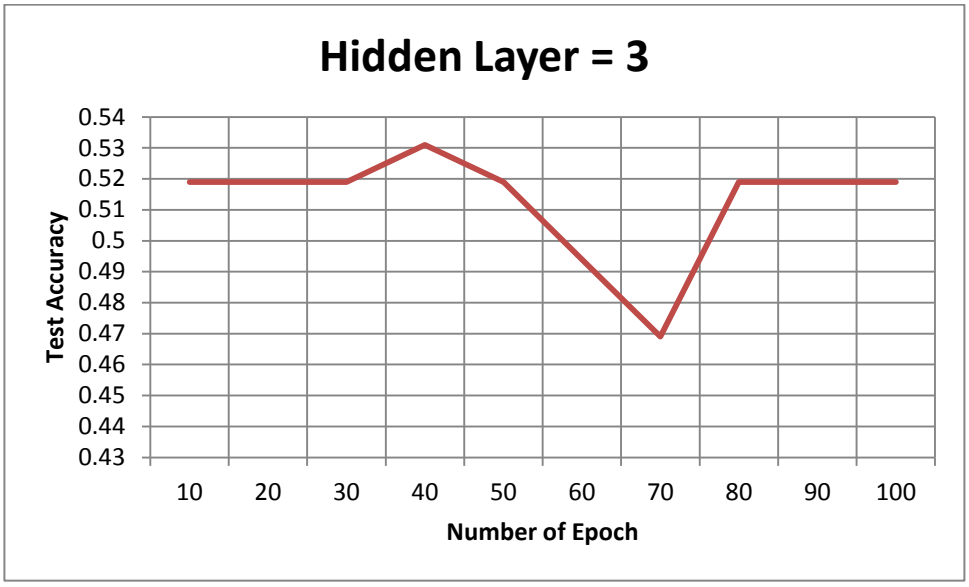

Figure 5.7 Test Accuracy for hidden layer = 3

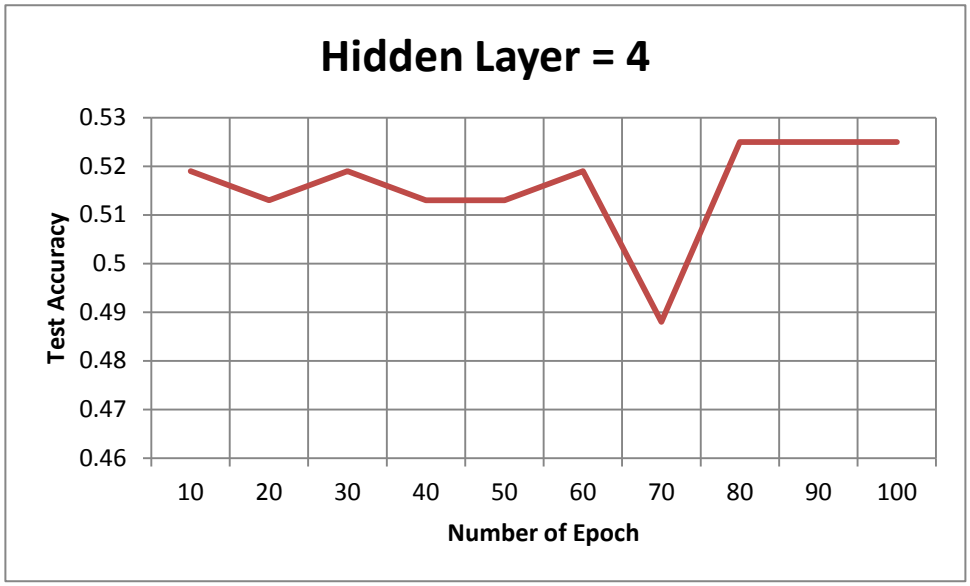

Figure 5.8Test Accuracy for hidden layer = 4

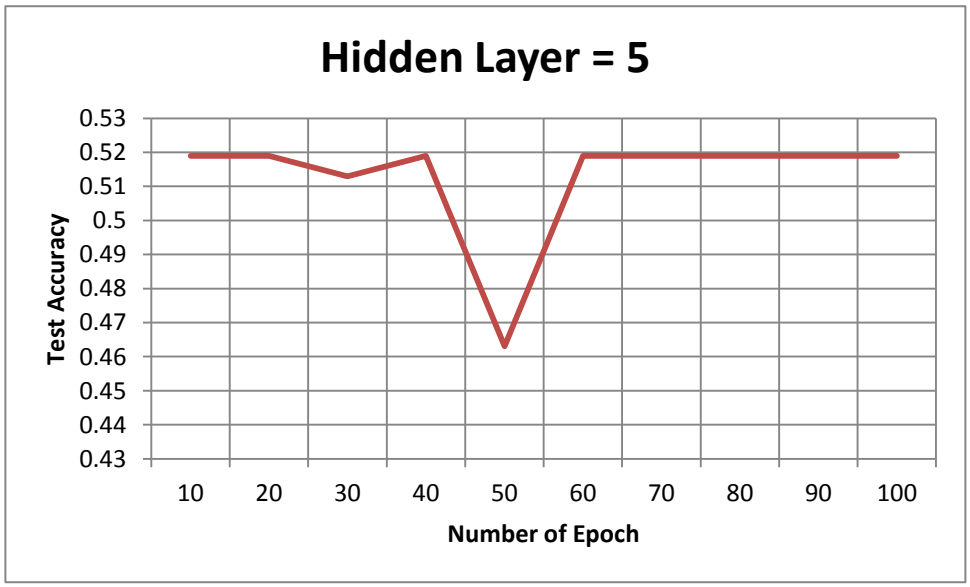

Figure 5.9Test Accuracy for hidden layer = 5

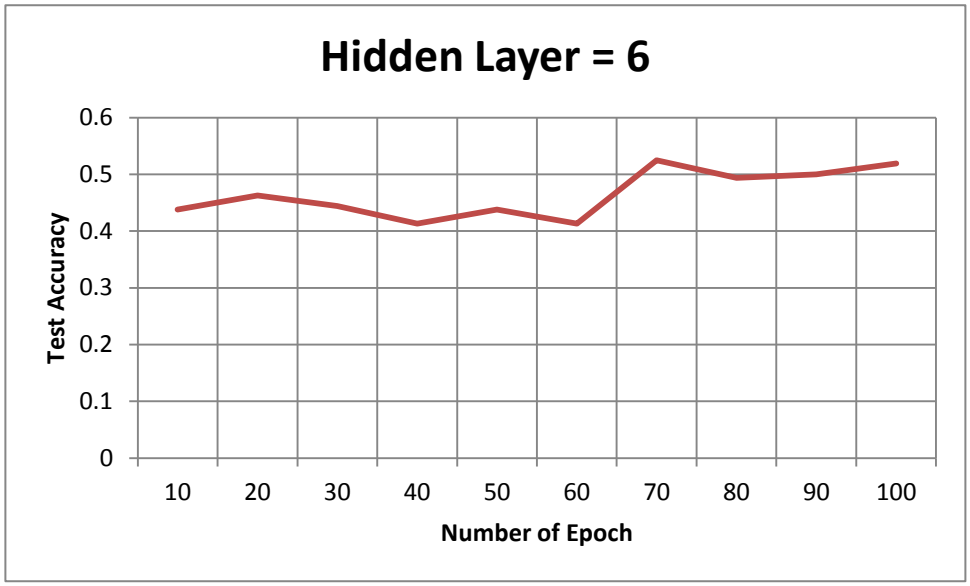

Figure 5.10 Test Accuracy for hidden layer = 6

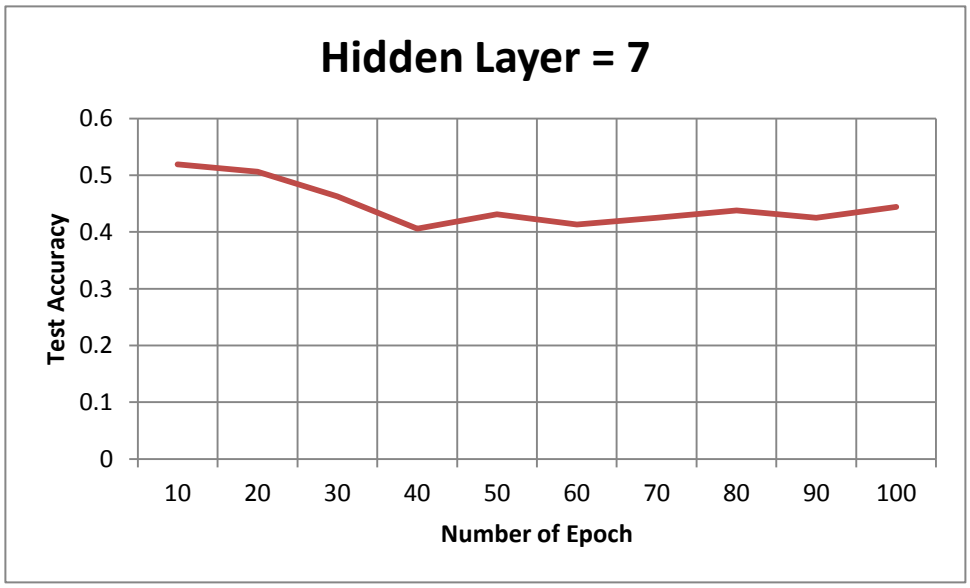

Figure 5.11 Test Accuracy for hidden layer = 7

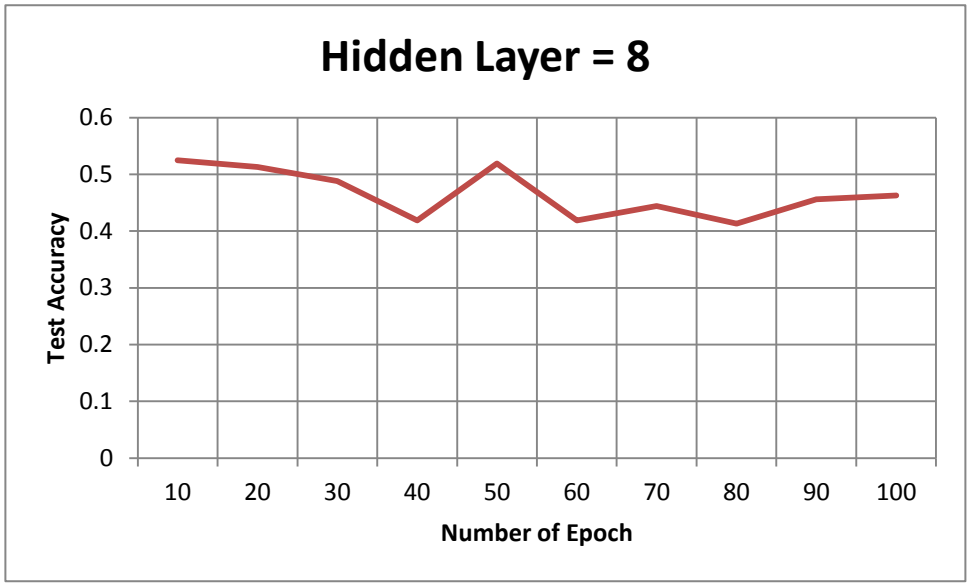

Figure 5.12 Test Accuracy for hidden layer = 8

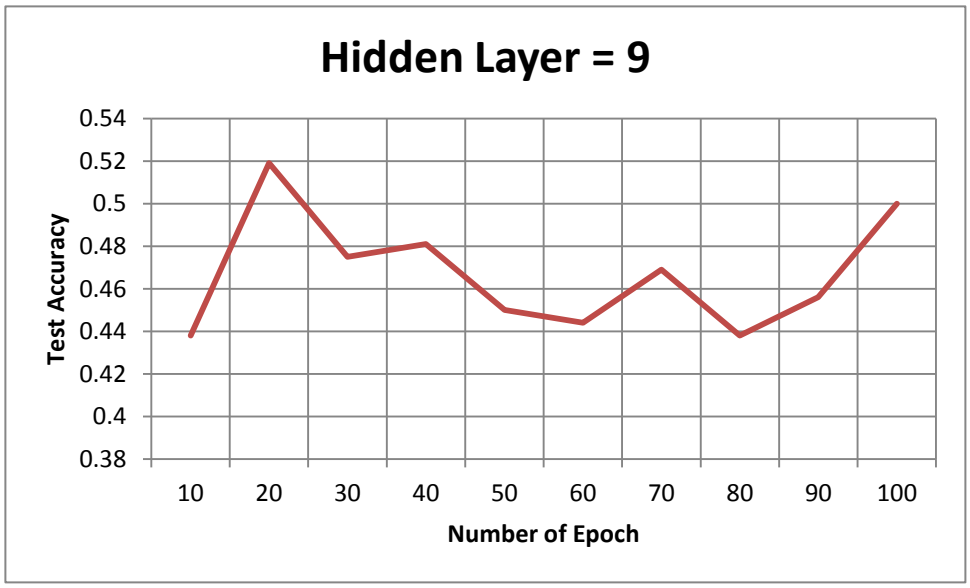

Figure 5.13Test Accuracy for hidden layer = 9

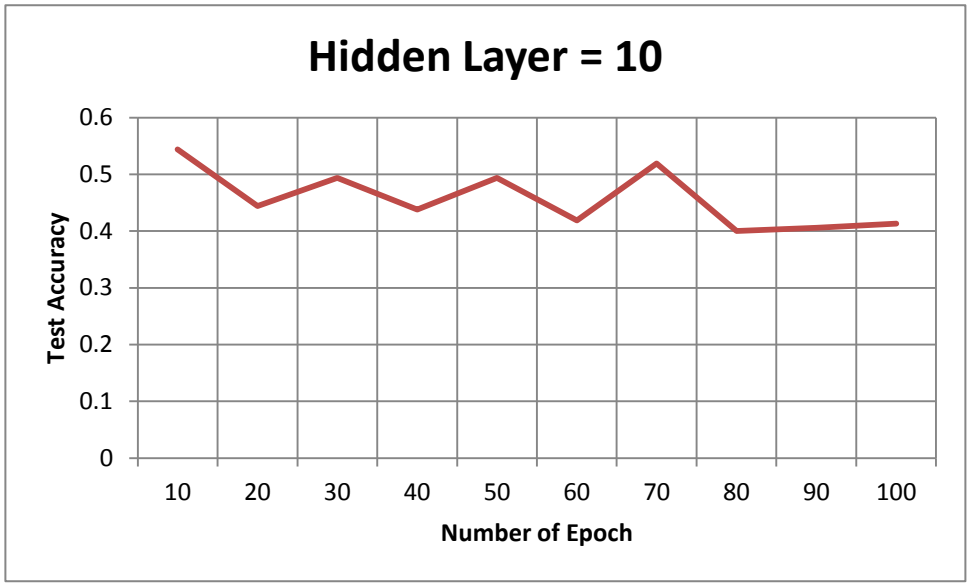

Figure 5.14 Test Accuracy for hidden layer = 10

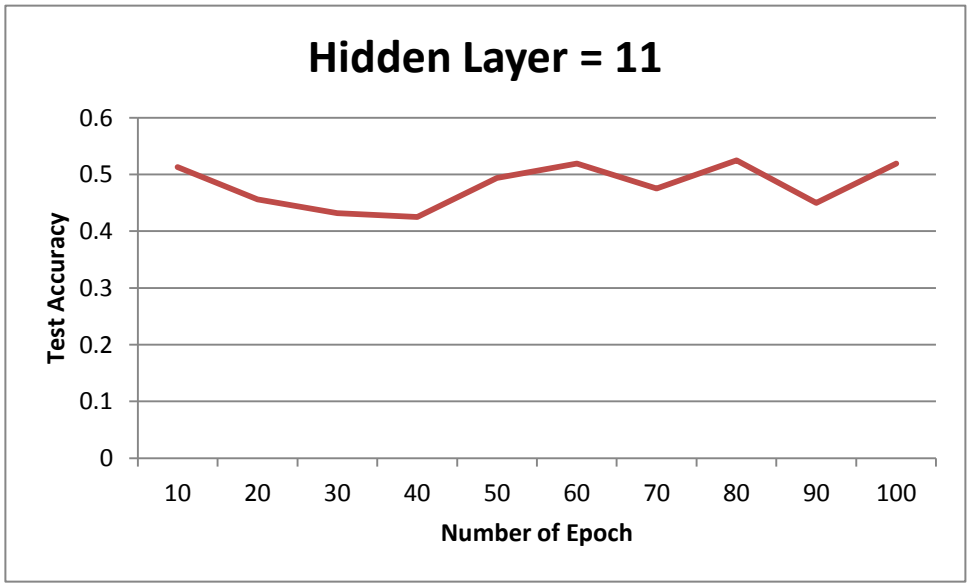

Figure 5.15 Test Accuracy for hidden layer = 11

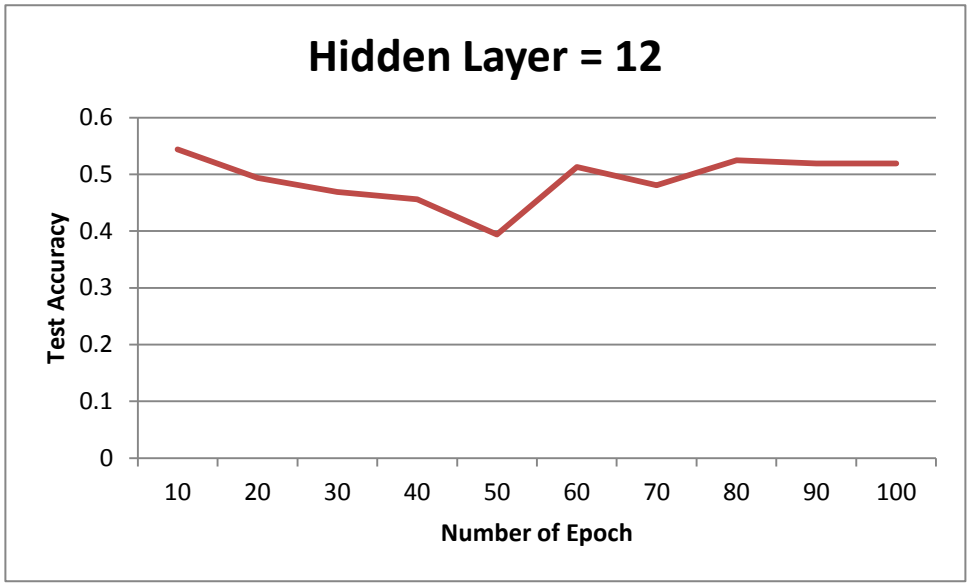

Figure 5.16 Test Accuracy for hidden layer = 12

From the figures above it can be seen that the best accuracy for ANN is 0.544 by using 12 hidden layers and 10 training epoch. It is decided that the ANN will has 12 hidden layers.

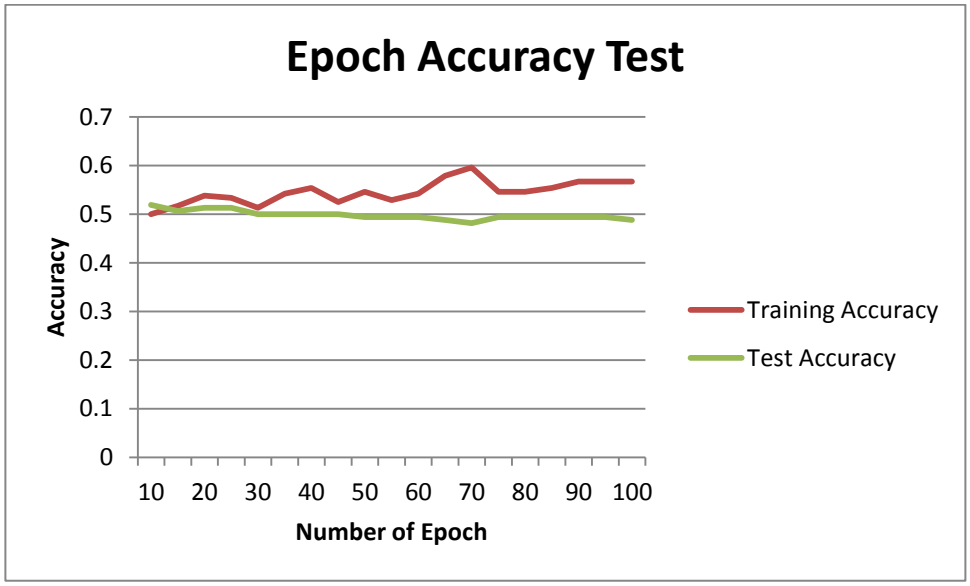

Figure 5.17 Epoch accuracy Test

The epoch accuracy test as shown in Figure 5.17 proves that the best test accuracy of the training process is at 25 with the accuracy of 0.519. It is decided that the ANN will has 25 training epoch.

5.4 Results Findings

The result of the research is presented in the form of confusion matrix, precision and recall as the performance measurement for each feature and classifier method.

5.4.1 Color-based Feature

The training result for color-based feature is as follow:

5.4.1.1 Artificial Neural Network

The result of the training process is concluded by confusion matrix. The confusion matrix of artificial neural network classifier is:

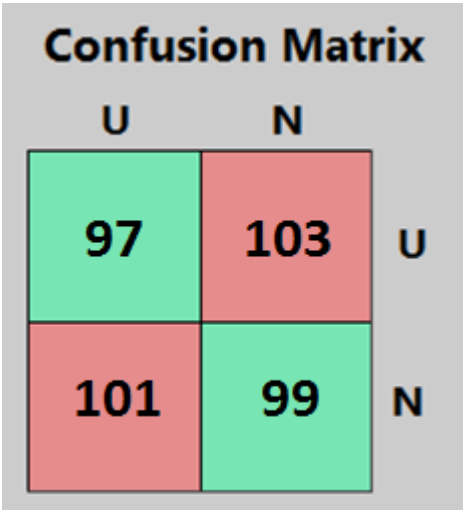

Figure 5.18 Artificial neural network confusion matrix

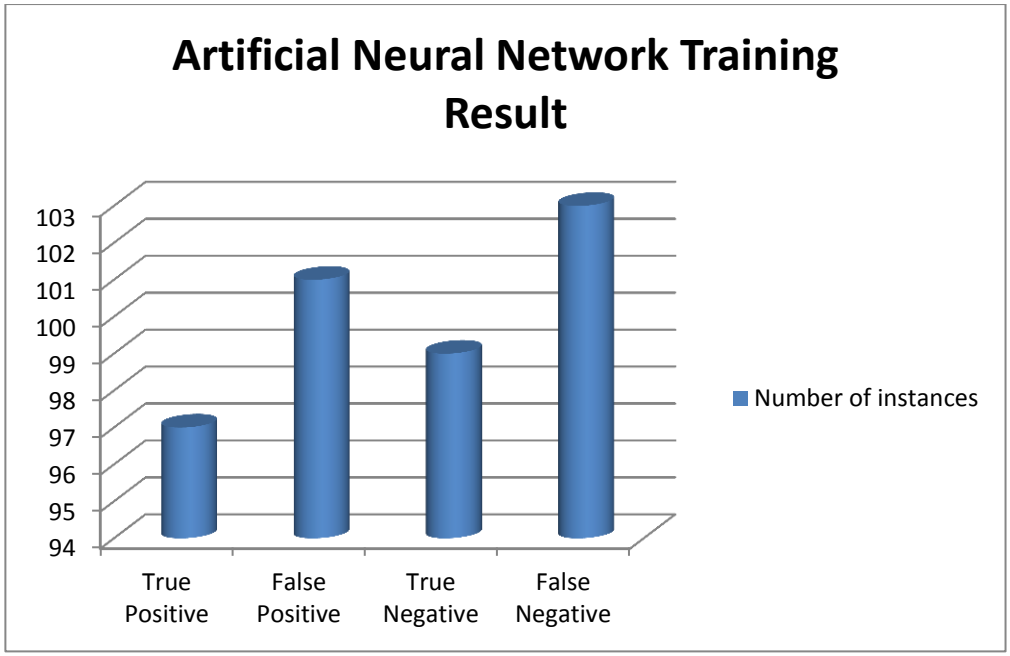

Figure 5.19 Artificial neural network confusion matrix diagram

The true positive value of the confusion matrix is 97, false positive value is 101, true negative value is 99, and false negative value is 103. This means that ANN successfully identified 97 Understand class images and 99 Not-understand class images while failing to identify 101 Understand class images and 103 Not-understand class images. This confusion matrix is used to calculate the precision and recall value.

Understand Class

Precision = 97 / (97 + 101) = 0.49

Recall = 97 / (97 + 99) = 0.485

Not- understand Class

Precision = 99 / (99 + 103) = 0.49

Recall = 99 / (99 + 97) = 0.495

(Refer to Chapter 3)

Precision and recall value of artificial neural network classifier are:

Table 5.1 ANN precision and recall

TP Rate	FP Rate	Precision	Recall	Class
0.485	0.505	0.49	0.485	U
0.495	0.515	0.49	0.495	N

TP Rate (True Positive Rate) for Understand class is 0.485 and for Not-understand class is 0.495. FP Rate (False Positive Rate) for Understand class is 0.505 and for Not-understand class is 0.515.

The summary of Artificial Neural Network training process is:

Table 5.2 ANN training process summary

No.	Category	ANN
1	Total number of instances	400
2	Correctly Classified Instances	196
3	Incorrectly Classified Instances	204
4	Mean absolute error	0.5028
5	Root mean square error	0.5268
6	Training time	5.46 s

The total number of instances of the training process is 400 instances. ANN successfully identified 196 instances while failing in identified 204 instances. The mean absolute error of ANN is 0.5028 and root mean square error is 0.5268. The time consumed in building the model is 5.46 s.

5.4.1.2 Support Vector Machine

The result of the training process is concluded by confusion matrix. The confusion matrix of support vector machine classifier is:

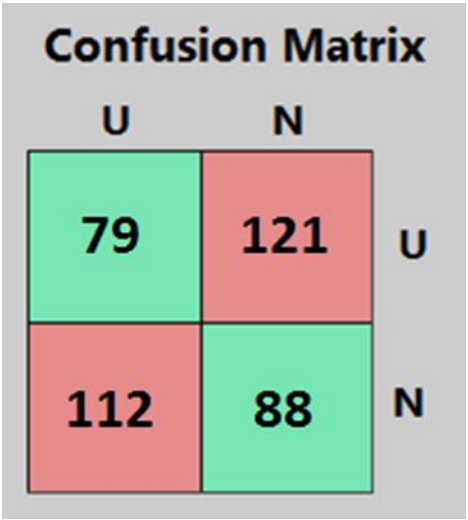

Figure 5.20 Support vector machine confusion matrix

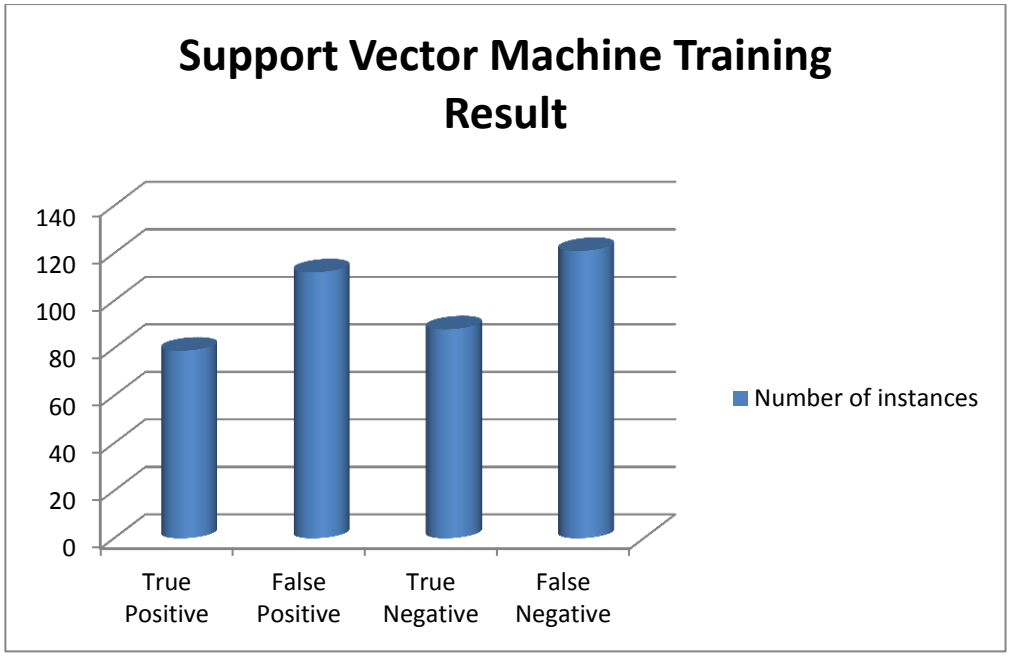

Figure 5.21 Support vector machine confusion matrix diagram

The true positive value of the confusion matrix is 79, false positive value is 112, true negative value is 88, and false negative value is 121. This means that SVM successfully identified 79 Understand class images and 88 Not-understand class images while failing to identify 121 Understand class images and 103 Not-understand class images. This confusion matrix is used to calculate the precision and recall value.

Understand Class

Precision = 79 / (79 + 112) = 0.414

Recall = 79 / (79 + 88) = 0.395

Not- understand Class

Precision = 88 / (88 + 121) = 0.421

Recall = 88 / (88 + 79) = 0.44

(Refer to Chapter 3)

Precision and recall value of support vector machine classifier are:

Table 5.3 SVM precision and recall

TP Rate	FP Rate	Precision	Recall	Class
0.395	0.56	0.414	0.395	U
0.44	0.605	0.421	0.44	N

TP Rate (True Positive Rate) for Understand class is 0.395 and for Not-understand class is 0.44. FP Rate (False Positive Rate) for Understand class is 0.56 and for Not-understand class is 0.605.

The summary of Support Vector Machine training process is:

Table 5.4 SVM training process summary

No.	Category	SVM
1	Total number of instances	400
2	Correctly Classified Instances	167
3	Incorrectly Classified Instances	233
4	Mean absolute error	0.5825
5	Root mean square error	0.7632
6	Training time	3.65 s

The total number of instances of the training process is 400 instances. SVM successfully identified 167 instances while failing in identified 233 instances. The mean absolute error of ANN is 0.5825 and root mean square error is 0.7632. The time consumed in building the model is 3.65 s.

5.4.2 Arithmetic Mean Edge Feature

The training result for arithmetic mean edge feature is as follow:

5.4.2.1 Artificial Neural Network

The result of the training process is concluded by confusion matrix. The confusion matrix of artificial neural network classifier is:

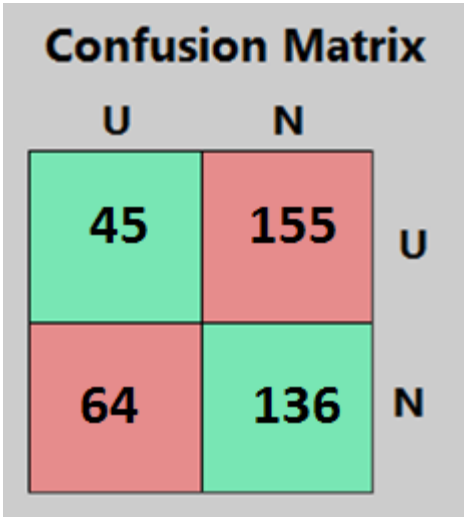

Figure 5.22 Artificial neural network confusion matrix

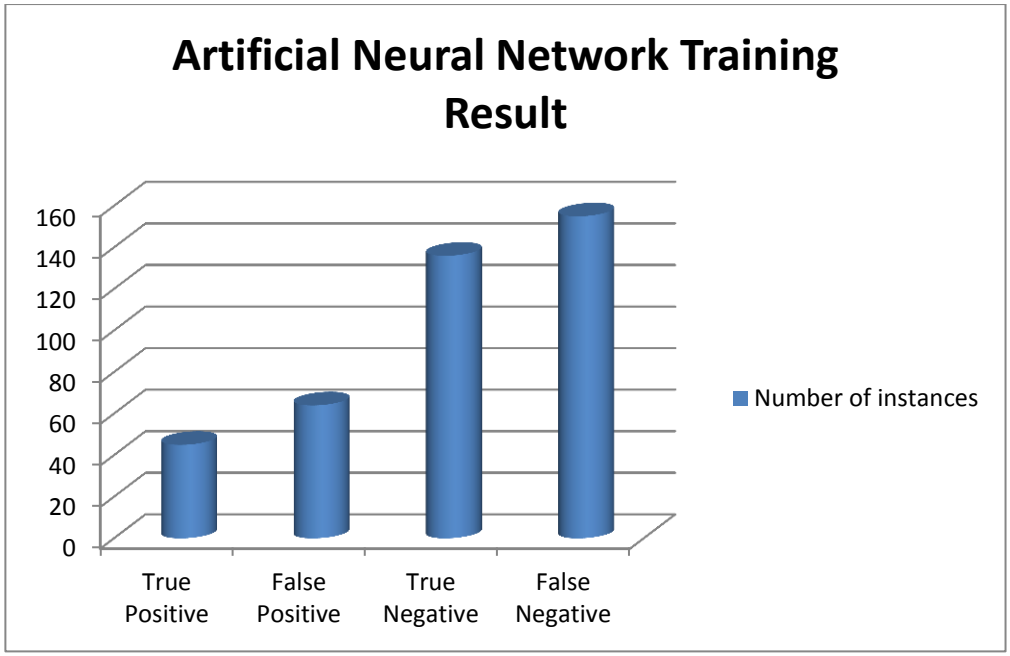

Figure 5.23 Artificial neural network confusion matrix diagram

The true positive value of the confusion matrix is 45, false positive value is 64, true negative value is 136, and false negative value is 155. This means that ANN successfully identified 45 Understand class images and 136 Not-understand class images while failing to identify 64 Understand class images and 155 Not-understand class images. This confusion matrix is used to calculate the precision and recall value.

Understand Class

Precision = 45 / (45 + 64) = 0.413

Recall = 45 / (45 + 136) = 0.225

Not- understand Class

Precision = 136 / (136 + 155) = 0.467

Recall = 136 / (136 + 45) = 0.68

(Refer to Chapter 3)

Precision and recall value of artificial neural network classifier are:

Table 5.5 ANN precision and recall

TP Rate	FP Rate	Precision	Recall	Class
0.225	0.32	0.413	0.225	U
0.68	0.775	0.467	0.68	N

TP Rate (True Positive Rate) for Understand class is 0.225 and for Not-understand class is 0.68. FP Rate (False Positive Rate) for Understand class is 0.32 and for Not-understand class is 0.775.

The summary of Artificial Neural Network training process is:

Table 5.6 ANN training process summary

No.	Category	ANN
1	Total number of instances	400
2	Correctly Classified Instances	181
3	Incorrectly Classified Instances	219
4	Mean absolute error	0.5097
5	Root mean square error	0.5177
6	Training time	0.63 s

The total number of instances of the training process is 400 instances. ANN successfully identified 181 instances while failing in identified 219 instances. The mean absolute error of ANN is 0.5097 and root mean square error is 0.5177. The time consumed in building the model is 0.63 s.

5.4.2.2 Support Vector Machine

The result of the training process is concluded by confusion matrix. The confusion matrix of support vector machine classifier is:

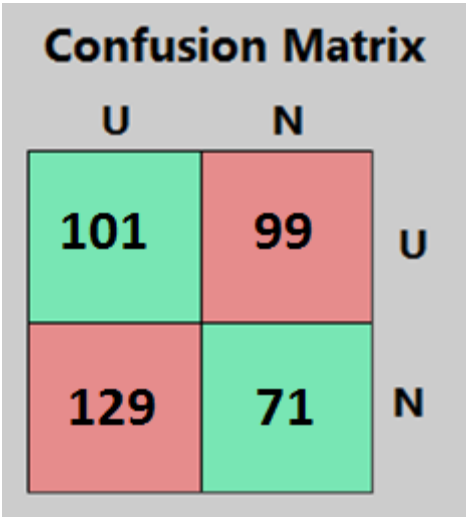

Figure 5.24 Support vector machine confusion matrix

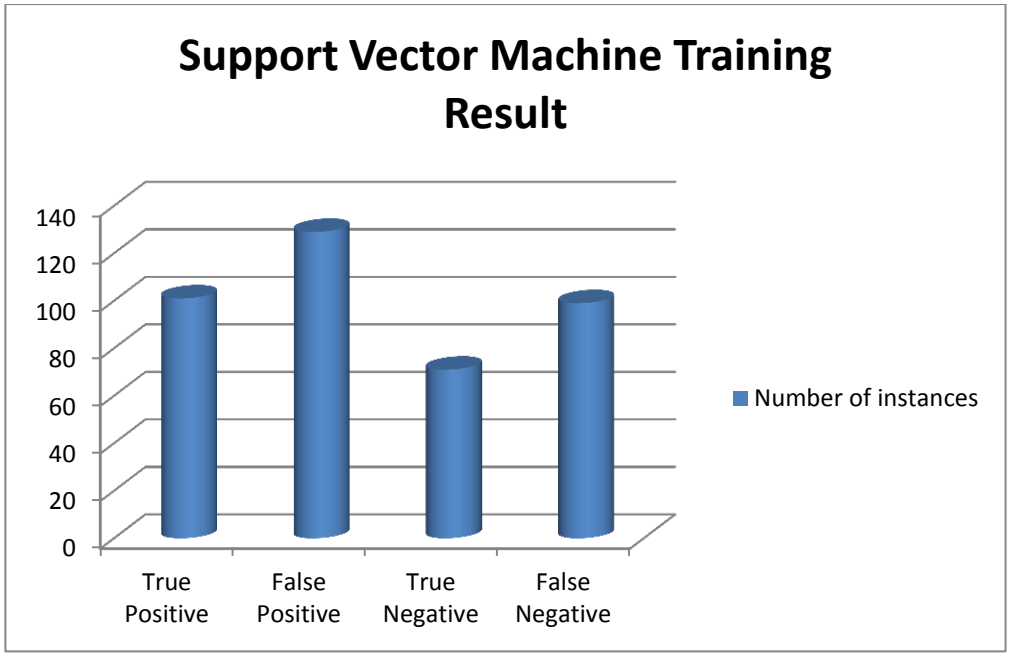

Figure 5.25 Support vector machine confusion matrix diagram

The true positive value of the confusion matrix is 101, false positive value is 129, true negative value is 71, and false negative value is 99. This means that SVM successfully identified 101 Understand class images and 71 Not-understand class images while failing to identify 129 Understand class images and 99 Not-understand class images. This confusion matrix is used to calculate the precision and recall value.

Understand Class

Precision	=	101 / (101 + 129)	=	0.439
Recall	=	101 / (101 + 71)	=	0.505

Not- understand Class

Precision	=	71 / (71 + 99)	=	0.418

Recall = 71 / (71 + 101) = 0.355

(Refer to Chapter 3)

Precision and recall value of support vector machine classifier are:

Table 5.7 SVM precision and recall

TP Rate	FP Rate	Precision	Recall	Class
0.505	0.645	0.439	0.505	U
0.355	0.495	0.418	0.355	N

TP Rate (True Positive Rate) for Understand class is 0.505 and for Not-understand class is 0.355. FP Rate (False Positive Rate) for Understand class is 0.645 and for Not-understand class is 0.495.

The summary of Support Vector Machine training process is:

Table 5.8 SVM training process summary

No.	Category	SVM
1	Total number of instances	400
2	Correctly Classified Instances	172
3	Incorrectly Classified Instances	228
4	Mean absolute error	0.57
5	Root mean square error	0.755
6	Training time	1.16 s

The total number of instances of the training process is 400 instances. SVM successfully identified 172 instances while failing in identified 228 instances. The mean absolute error of ANN is 0.57 and root mean square error is 0.755. The time consumed in building the model is 1.16 s.

5.4.3 Color-based Feature Arithmetic Mean Edge Feature

The training result for color-based feature and arithmetic mean edge is as follow:

5.4.3.1 Artificial Neural Network

The result of the training process is concluded by confusion matrix. The confusion matrix of artificial neural network classifier is:

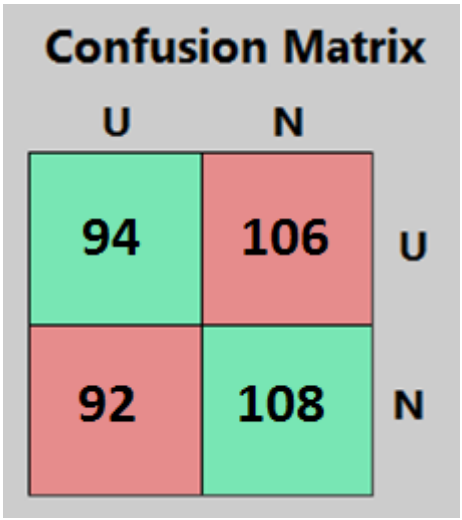

Figure 5.29 Artificial neural network confusion matrix

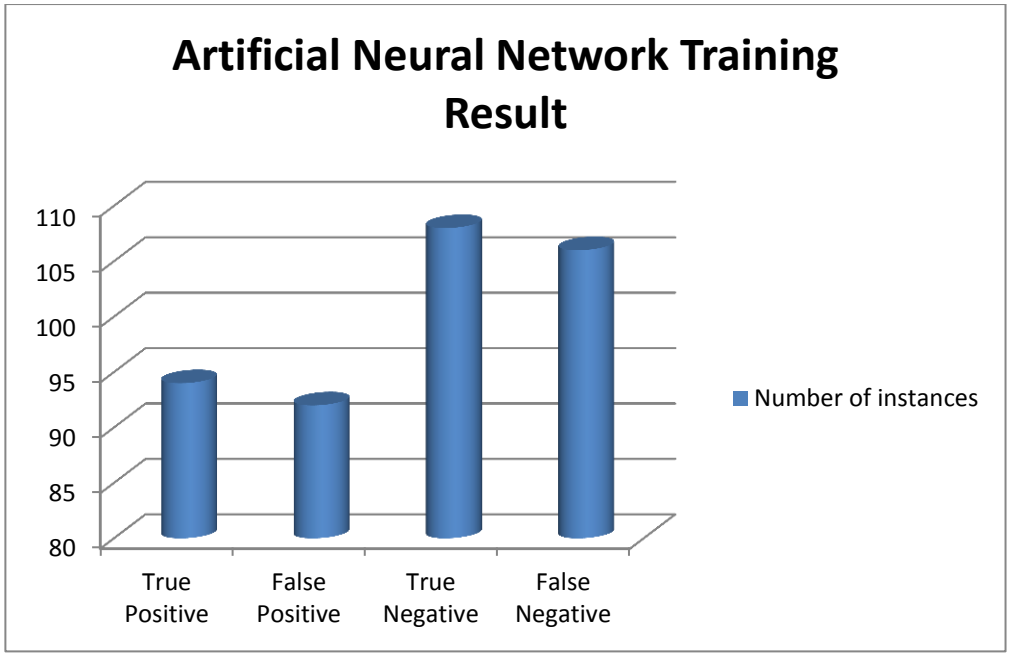

Figure 5.30 Artificial neural network confusion matrix diagram

The true positive value of the confusion matrix is 94, false positive value is 92, true negative value is 108, and false negative value is 106. This means that ANN successfully identified 94 Understand class images and 108 Not-understand class images while failing to identify 92 Understand class images and 106 Not-understand class images. This confusion matrix is used to calculate the precision and recall value.

Understand Class

Precision = 94 / (94 + 92) = 0.505

Recall = 94 / (94 + 108) = 0.47

Not- understand Class

Precision = 108 / (108 + 106) = 0.505

Recall = 108 / (108 + 94) = 0.54

(Refer to Chapter 3)

Precision and recall value of artificial neural network classifier are:

Table 5.9 ANN precision and recall

TP Rate	FP Rate	Precision	Recall	Class
0.47	0.46	0.505	0.47	U
0.54	0.53	0.505	0.54	N

TP Rate (True Positive Rate) for Understand class is 0.47 and for Not-understand class is 0.54. FP Rate (False Positive Rate) for Understand class is 0.46 and for Not-understand class is 0.53.

The summary of Artificial Neural Network training process is:

Table 5.10 ANN training process summary

No.	Category	ANN
1	Total number of instances	400
2	Correctly Classified Instances	202
3	Incorrectly Classified Instances	198
4	Mean absolute error	0.5045
5	Root mean square error	0.5195
6	Training time	5.34 s

The total number of instances of the training process is 400 instances. ANN successfully identified 202 instances while failing in identified 198 instances. The mean absolute error of ANN is 0.5045 and root mean square error is 0.5195. The time consumed in building the model is 5.34 s.

5.4.3.2 Support Vector Machine

The result of the training process is concluded by confusion matrix. The confusion matrix of support vector machine classifier is:

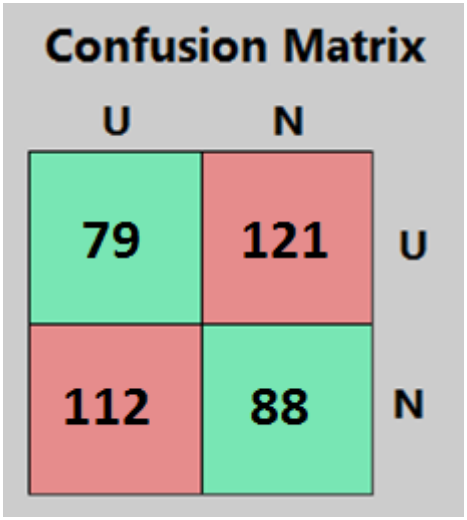

Figure 5.31 Support vector machine confusion matrix

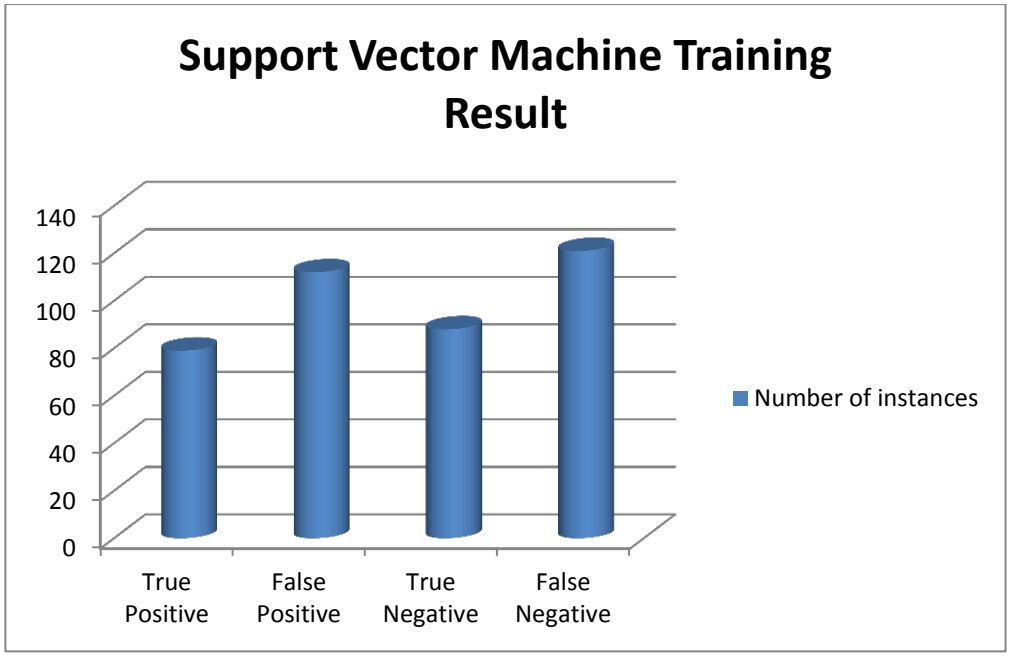

Figure 5.32 Support vector machine confusion matrix diagram

The true positive value of the confusion matrix is 79, false positive value is 112, true negative value is 88, and false negative value is 121. This means that SVM successfully identified 79 Understand class images and 88 Not-understand class images while failing to identify 112 Understand class images and 121 Not-understand class images. This confusion matrix is used to calculate the precision and recall value.

Understand Class

Precision = 79 / (79 + 112) = 0.414

Recall = 79 / (79 + 88) = 0.395

Not- understand Class

Precision = 88 / (88 + 121) = 0.421

Recall = 88 / (88 + 79) = 0.44

(Refer to Chapter 3)

Precision and recall value of support vector machine classifier are:

Table 5.11 SVM precision and recall

TP Rate	FP Rate	Precision	Recall	Class
0.395	0.56	0.414	0.395	U
0.44	0.605	0.421	0.44	N

TP Rate (True Positive Rate) for Understand class is 0.395 and for Not-understand class is 0.44. FP Rate (False Positive Rate) for Understand class is 0.56 and for Not-understand class is 0.605.

The summary of Support Vector Machine training process is:

Table 5.12 SVM training process summary

No.	Category	ANN
1	Total number of instances	400
2	Correctly Classified Instances	167
3	Incorrectly Classified Instances	233
4	Mean absolute error	0.5825
5	Root mean square error	0.7632
6	Training time	4.67 s

The total number of instances of the training process is 400 instances. SVM successfully identified 167 instances while failing in identified 233 instances. The mean absolute error of ANN is 0.5825 and root mean square error is 0.7632. The time consumed in building the model is 3.65 s.

5.5 Analysis of the Results

5.5.1 Color-based Feature

From the confusion matrix in the training process, precision, recall, and accuracy of each classification method can be computed.

Artificial Neural Network

Precision	=	(0.49 + 0.49) / 2	=	0.49
Recall	=	(0.485 + 0.495) / 2	=	0.49
Accuracy	=	(97 + 99) / (97 + 101 + 99 + 103)	=	0.49

Support Vector Machine

Precision	=	(0.414 + 0.421) / 2	=	0.417
Recall	=	(0.395 + 0.44) / 2	=	0.418
Accuracy	=	(79 + 88) / (79 + 112 + 88 + 121)	=	0.418

(Refer to Chapter 3)

Table 5.13 ANN and SVM training process summary

No.	Category	ANN	SVM
1	Precision	0.49	0.417
2	Recall	0.49	0.418
3	Accuracy	0.49	0.418

5.5.2 Arithmetic Mean Edge Feature

From the confusion matrix in the training process, precision, recall, and accuracy of each classification method can be computed.

Artificial Neural Network

Precision	=	(0.413 + 0.467) / 2	=	0.548
Recall	=	(0.225 + 0.68) / 2	=	0.44
Accuracy	=	(45 + 136) / (45 + 64 + 136 + 155)	=	0.44

Support Vector Machine

Precision	=	(0.439 + 0.418) / 2	=	0.428
Recall	=	(0.505 + 0.355) / 2	=	0.43
Accuracy	=	(101 + 71) / (101 + 129 + 71 + 99)	=	0.43

(Refer to Chapter 3)

Table 5.14 ANN and SVM training process summary

No.	Category	ANN	SVM
1	Precision	0.548	0.428
2	Recall	0.44	0.43
3	Accuracy	0.44	0.43

5.5.3 Color-based Feature and Arithmetic Mean Edge

From the confusion matrix in the training process, precision, recall, and accuracy of each classification method can be computed.

Artificial Neural Network

Precision = (0.505 + 0.505) / 2 = 0.505

Recall = (0.47 + 0.54) / 2 = 0.505

Accuracy = (94 + 108) / (94 + 92 + 108 + 106) = 0.505

Support Vector Machine

Precision = (0.414 + 0.421) / 2 = 0.417

Recall = (0.395 + 0.44) / 2 = 0.418

Accuracy = (79 + 88) / (79 + 112 + 88 + 121) = 0.418

(Refer to Chapter 3)

Table 5.15 ANN and SVM training process summary

No.	Category	ANN	SVM
1	Precision	0.505	0.417
2	Recall	0.505	0.418
3	Accuracy	0.505	0.418