Neural Networks to predict response

DENG, Yang

ydeng@se.cuhk.edu.hk

Overview

- What is Neural Network?
- Building Neural Network with Weka
- Momentum in Neural Network
- Building Neural Network using GUI
- Clustering Algorithms with Weka

Neural Network is a machine learning model inspired by the biological neural networks that simulate what our brain does.

Neural Network has several components including the Input Layer, Hidden Layers and Output Layer:

(1) Input Layer denotes the input variables that will be fed into the network,

(2) Hidden Layers are the computation layers (or parameters) that will be trained,

(3) **Output Layer** denotes the output of the model. For example, the class label in classification task or the real number in regression task.

A typical neural network model can be represented as follow:



As you can see in the figure, each layer contains different number of nodes.

Usually, the number of nodes in input layer will be the number of how many input variables while the number of nodes in output layer will be the number of outputs of the model, i.e, number of classes you have in classification.

The number of nodes in each hidden layer is specified by user.

Besides the structure of the neural network, there are another two core parts of the network, activation function and cost function.

Activation Function is one of the most powerful cores, which is responsible for powering Neural Networks. In other words, it decides which neurons will be activated. Just like our brain, it determines what information would be passed to further layers.

Without activation functions, the neural networks would not have such a meaningful representative power.

Sigmoid function, Hyperbolic tangent function and ReLu function are the activation functions widely used in modern neural network models.

Another core part is the **cost function**. It is used to calculate loss given the true and predicted results. The aim of the neural network is to minimize this loss. So cost function is to evaluate how well is our neural network and effectively drives the learning of neural network towards its goal.

Some of the most famous cost functions are Cross Entropy, which is used in classification task, and Mean Square Error, which is used in regression task.

Back to this figure, the network with this structure is called **Feed-Forward network** or **Multi-layer perceptron**.



There are some advanced neural networks with special structure. For example, the **recurrent neural network (RNN)** that can be used to handle time-series (weather of each day) or sequential data (text). Or **convolutional neural network (CNN)** that is widely used for handling image.



Also, there are many transformations of these neural networks. For example, RNN was developed into **Gated Recurrent Unit (GRU)** and **Long-Short Term Memory (LSTM)**. And there are many other advanced neural networks with different structure proposed in recent years, like Capsule Network, Graph Neural Network (GNN) and so on.

Neural Network in Weka

In this tutorial, we will focus on building the Multi-layer perceptron using Weka.

You can use Weka to easily construct a neural network and it will help you to configure most of the setting of it like the activation function and cost function.

All you need is to prepare the data for it.

Preparation for building Neural Network

Before constructing our neural network, again, we first need to prepare our training data.

Open Weka, choose Explorer in the Weka GUI Chooser



Preparation for building Neural Network

Click **Open file**, then open the bank.csv used in last tutorial

Again, please remember to change to **CSV data files(*.csv)** in file type.



Preparation for building Neural Network

Now, data is loaded into Explorer.

And then we can perform feature engineering before building the Neural Network but this time we simply use the original dataset to do it.

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Weka Explorer

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Here is the configuration of Multilayer Perceptron.

The default value of **HiddenLayers** is "a" which means Weka will help you to setup the hidden layers. You can also specify how many layer and how many nodes of each hidden layer. For example, type in 10,5,2 means 3 hidden layers with 10, 5, 2 nodes respectively.

trainingTime means how many iterations we want to train through. Let set it from 500 to 100.

Then, click OK

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In the Test options here, we simply use percentage split 66% as our testing option.

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Since neural network requires much more computation power compared with decision tree and logistic regression. We need to wait Weka to train our model. The training time depends on the number of parameters (number of layers and number of nodes in each layer), number of iterations and number of data we have.

Viewing the Classifier output

After the training is finished. The result is shown on the right panel.

The accuracy of our model is 88.2889%

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Save Neural Network Model

Suppose we want to save the trained multilayer perceptron model.

In the result list, right click the model

Click Save model

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Save Neural Network Model

Select a location and enter a filename such as mlp, click

Save Our model is now saved to the file "mlp.model".



Load Neural Network Model

Suppose we want to use our trained model to make prediction.

Right click on the Result list and click Load model, select the model saved in the previous slide "mlp.model".

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Load Neural Network Model

Now, the model is loaded, and we can see some information on the right panel.

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We want to evaluate our model on a new dataset.

Select the Supplied test set option in the Test options pane.

	Weka Explorer
Preprocess Classify Cluster Associate Select attributes Visua	lize
lassifier	
	5 20 JL-
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est options	Classifier output
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Log

Click Set, click the Open file on the options window and select the new dataset we just created with the name "bank-additional-test.arff".

For the Class, select y

Then, Click Close

Attributes: 17 Sum of weights: ?
Close

Right click on the list item for our loaded model in the Results list.

Choose Re-evaluate model on current test set

Choose MultilayerPerceptron -L 0.3 - M 0.2 - N 100 - V 0 - S 0 - E 20 - H a Test options Classifier output Use training set Set Supplied test set Set O ross-validation Folds Percentage split 66 More options - 1.50936802207134955 (Nom) y - 0.942805805662498 Attrib contact=unknown 2.744423857399556 Attrib contact=traiter or - 0.942805805662498 Attrib day -2.306214182743996 Attrib month-apr 0.94280566624398 Attrib month-apr 0.9428056662498 Attrib month-apr 0.94280566624333896 Attrib month-apr 0.94280576623 Attrib month-apr 0.9428057805831376682 Attrib month-apr 0.942805780584 Attrib month-apr 0.942805780584 Attrib month-apr 0.942805780584 Attrib month-apr 0.9428737878474652	lassifier	
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	Visualize threshold curve	

After the evaluation is finished. The result is shown on the right panel.

The accuracy of our model is 66.1%

					Weka Explorer
Preprocess Clas	ssify Cluster	Associate	Select attributes	Visualiz	e
lassifier					
Choose Mult	ilayerPercept	r on -L 0.3 -I	M 0.2 -N 100 -V 0)-S0-E	20 -Н а
est options					assifier output
\bigcirc Use training s	et				Input Node Ø
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	More o	options		וור	=== Re-evaluation on test set ===
					User supplied test set
(Nom) y					Instances: unknown (yet). Reading incrementally
· · ·					Attributes: 21
Start			Stop		=== Summary ===
esult list (right-o	click for optic	ons)			Correctly Classified Instances 1322 66.1 %
17:11:09 - funct	tions.Multilaye	rPerceptron			Incorrectly Classified Instances 678 33.9 % Kappa statistic 0.322
17:14:21 – funct	tions.Multilaye	rPerceptron f	rom file 'mlp.mode	21'	Mean absolute error 0.3443 Root mean squared error 0.5385
					Total Number of Instances 2000
					=== Detailed Accuracy By Class ===
					TP Rate FP Rate Precision Recall F-Measure MCC
					0.875 0.553 0.613 0.875 0.721 0.356 0.447 0.125 0.781 0.447 0.569 0.356
					Weighted Avg. 0.661 0.339 0.697 0.661 0.645 0.356
					=== Confusion Matrix ===
					a b < classified as
					875 125 a = no 553 447 b = yes
					555 yes
tatus					
OK					Log

If we want to make prediction on the new data, instead of evaluate on certain metrics, click the More options... to bring up options for evaluating the classifier.

	Weka Explorer	
Preprocess Classify Cluster Associate Select attribu	utes Visualize	
assifier		
Choose MultilayerPerceptron -L 0.3 -M 0.2 -N 100) -V 0 -S 0 -E 20 -H a	
ast ontions	Classifier output	
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Uncheck the the following information:

- Output model
- Output per-class stats
- ° Output confusion matrix
- ° Store predictions for visualization
- $^{\circ}$ Collect predictions for evaluation based on AUROC, etc.

For Output predictions, choose PlainText Click OK

Classifier evaluation options
Output model
Output models for training splits
Output per-class stats
Output entropy evaluation measures
Output confusion matrix
Store test data and predictions for visualization
Collect predictions for evaluation based on AUROC, etc.
Error plot point size proportional to margin
Output predictions Choose PlainText
Cost-sensitive evaluation Set
Random seed for XVal / % Split 1
Preserve order for % Split
Output source code WekaClassifier
Evaluation metrics
ОК

Right click on the list item for our loaded model in the Results list.

Choose Re-evaluate model again on current test set

lassifier		
Choose Multil	ayerPerceptron -L 0.3 -M 0.2 -N 100	-V 0 -S 0 -E 20 -H a
Test options		Classifier output
Use training set Use training set Supplied test set Cross-validatio Percentage spli (Nom) y Start Result list (right-cli 16:58:25 - functio 16:59:01 - functio	t Set n Folds 10 t % 66 More options Stop tck for options) ms.MultilayerPerceptron yes MultilayerPerceptron View in main window View in separate window Save result buffer Delete result buffer Delete result buffer(s) Load model Save model Re-evaluate model on current tes Re-apply this model's configuration Visualize classifier errors Visualize tree Visualize tree Visualize threshold curve Cost/Benefit analysis	Attrib botomet 0:005175547476750 Attrib loan=yes -1.523067227438941 Attrib contact=cellular -0.7415116453460897 Attrib contact=telephone -1.579068805807948 Attrib contact=telephone -1.579068805807948 Attrib month=oct 0.6932295963662498 Attrib month=apr 0.9428067042393896 Attrib month=iun -0.9058930661919828 Attrib month=de 1.673129375096913 Attrib month=iun -0.908930661919828 Attrib month=apr 0.9428067042393896 Attrib month=apr 0.9628930661919828 Attrib month=ete 1.673129375096913 Attrib month=se 0.82926234574084266 Attrib month=jul 0.06891962476388945 Attrib month=se 0.329623457408966 Attrib month=mar 1.0491649548876854 Attrib month=mar 1.049164954876854 Attrib month=mar 1.049164954876854 Attrib month=ar 1.9760996315704245 Attrib duration -3.46877998841270877 Attrib duration -3.4804799824772858 Attrib poutcome=afilure 2.5521276981914958 Attrib poutcome=failure -0.3109478431569075 Attrib poutcome=failure -0.3109478431569075 Attrib poutcome=ster -0.3109478431569017 Attrib poutcome=ster -0.3106478390690117 Attrib poutcome=ster -0.3106494827677258
Status	Visualize cost curve	

The predictions for each test instance are then listed in the Classifier Output.

Specifically, the middle column of the results is the predicted label which is "yes" or "no".

		Weka Expl	orer					
Preprocess Classify Cluster Associate Select attributes	Visualize							
issifier								
Choose MultilayerPerceptron -L 0.3 -M 0.2 -N 100 -V 0	-S0-E20-	·На						
st options	Classif	fier output						
Ulso training sot		100	1.110	1.110		1		
		104	1:no	1:no		1		
Supplied test set Set		105	1:no	1:no		0.999		
Cross validation Folds 10		100	1:00	1:00		1		
Cross-validation Folds 10		107	1:00	1.10		1 000		
O Percentage split % 66		100	2:ves	2:ves		0.999		
		110	1:no	1:no		0.946		
More options		111	2:ves	2:ves		0.988		
· · · · · · · · · · · · · · · · · · ·		112	1:no	1:no		1		
		113	1:no	1:no		1		
om) v	-	114	1:no	1:no		1		
		115	2:yes	1:no	+	0.638		
		116	2:yes	1:no	+	0.999		
Start Stop		117	1:no	1:no		1		
sult list (right-click for ontions)		118	1:no	1:no		1		
sur list (light check for options)		119	1:no	1:no		1		
6:58:25 – functions MultilaverPercentron		120	1:no	1:no		1		
10.50.01 functions Multilayer creeption		121	1:no	1:no		0.639		
16:59:01 - Tunctions.MultilayerPerceptron from file mip.model		122	1:no	1:no		1		
		125	1:10	1:10		1 0.001		
		124	1:00	1:10		0.991		
		125	2:ves	2:ves		0.999		
		120	2.903	21903		0.555		
	===	Summary ==	==					
	Corr	ectly Clas	sified In	stances		116	92.0635 %	
	Inco	orrectly Cl	lassified	Instances		10	7.9365 %	
	Kapp	a statisti	ic			0.6907		
	Mear	n absolute	error			0.0791		
	Root	mean squa	ared error			0.2383		
	Tota	al Number o	of Instanc	es		126		\bigcirc
								•
								7 F
atus								
					_			

In the configuration of neural network, we can see a momentum here. It is related to the optimization of the neural network. Let's briefly understand what is it in some illustrations.

In neural networks, we use gradient descent optimization algorithm to minimize the cost function to reach a global minimum. In an ideal situation, the cost function would look like this.



So we are guaranteed to find the global optimum because there is no local minimum where the optimization can get stuck.

However, that is not easy. In real world, the cost function looks like more complex which comprise of several local minima and may look like this



In this case, it gets stuck in a local minimum easily and the optimization algorithm may think we already reach the global minimum which leads to sub-optimal results.

To avoid this situation, we add a momentum when updating the parameters, which is a value between 0 and 1 that increases the size of the steps taken towards the minimum by trying to jump from a local minimum.



For more details about the optimization of neural network, you can find out more recourses in some optimization courses.

Let us investigate more configuration of the neural network.

Change GUI from False to True. This will provide a GUI windows after clicking Start.

Click OK to close the configuration.

🜍 weka.gui.GenericObje	ctEditor ×
veka.classifiers.functions.l	lultilayerPerceptron
About	
A classifier that uses b perceptron to classify i	ackpropagation to learn a multi-layer More Instances. Capabilities
GUI	True
autoBuild	True
batchSize	100
debug	False
decay	False
doNotCheckCapabilities	False
hiddenLayers	a
learningRate	0.3
momentum	0.2
nominalToBinaryFilter	True
normalizeAttributes	True
normalizeNumericClass	True
numDecimalPlaces	2

Leave other setting as the same as previous slides.

Click Start

Classifier	Select attributes	visualize								
Choose MultilayerPerceptron -L 0.3 -M 0	.2 -N 100 -V 0 -S 0 -E	20 - Ha								
Test options	Classifier output									
◯ Use training set	=== Evaluation	on test sp)lit ===							
O Supplied test set Set	Time taken to	test model	on test s	plit: 0.01	seconds					
Cross-validation Folds 10 Percentage split % 66	=== Summary ==	=								
More options	Correctly Clas	sified Inst	ances	1357		88.2889	*			
	Incorrectly Cl	assified Ir	stances	180		11.7111	90			
	Kappa statisti	c		0.38	31					
(Nom) y	Mean absolute	error red error		0.12	12					
	Relative absol	ute error		62.09	79 %					
Start Stop	Root relative	squared ern	or	96.96	6 %					
Result list (right-click for options)	Total Number o	f Instances	3	1537						
	=== Detailed A	couracy By	Class ===							
15:15:46 - functions.MultilayerPerceptron										
15:16:02 - functions.MultilayerPerceptron		TP Rate	FP Rate	Precision	Recall	F-Measure	MCC	ROC Area	PRC Area	Cla
15:16:14 - functions.MultilayerPerceptron		0.946	0.594	0.923	0.946	0.934	0.386	0.830	0.968	no
15:16:34 - functions.MultilayerPerceptron		0.406	0.054	0.500	0.406	0.448	0.386	0.830	0.416	yes
15:16:44 - functions.MultilayerPerceptron	Weighted Avg.	0.883	0.531	0.874	0.883	0.878	0.386	0.830	0.904	
15:21:02 - functions.MultilayerPerceptron	=== Confusion	Matrix ===								
	ab<	classifi	ed as							
	1284 73	a = no								
	107 73	b = yes								
										7 -

A GUI window will be shown.

Here, you can see the structure of the neural network.

Also, you can change some of the configurations here like number of Epochs (**trainingTime**), Learning Rate and Momentum.





You can click Stop to stop training.

Also, the current epoch and error per epoch will be updated continuously after each epoch.



You can click Accept to finish training although the training has not reached the 100 epochs.



After you click Accept, the result will be shown on the right panel, just like previous slides.

🥑 Weka Explorer			- 🗆 ×
Preprocess Classify Cluster Associat	e Select attributes Visualize		
Classifier			
Chasses H. Hilsun Bassanton I. S. S. h			
MultilayerPerceptron -L 0.3 -M	0.2 -N 100 -V 0 -S 0 -E 20 -H a		
Test options	Classifier output		
◯ Use training set	=== Evaluation on test split ===		Ā
Supplied test set			
	Time taken to test model on test split: 0.01 seconds		
Cross-validation Folds 10	Cummanus		
Percentage split % 66	Summary		
Mara antiana	Correctly Classified Instances 1357	88.2889 %	I
More options	Incorrectly Classified Instances 180	11.7111 %	
	Kappa statistic 0.3831		
(Nom) v	Mean absolute error 0.1272		
(Romy)	Root mean squared error 0.3118		
Start Stop	Relative absolute error 62.09/9 %		
	Total Number of Instances 1537		
Result list (right-click for options)			
15:15:46 - functions MultilaverPerceptron	=== Detailed Accuracy By Class ===		
15:16:02 - functions MultilaverPerceptron			
15:16:14 - functions MultilaverPerceptron	TP Rate FP Rate Precision Recall	F-Measure MCC RC	JC Area PRC Area Cla
15:16:34 - functions MultilaverPercentron		0.934 0.386 0	.030 0.966 no 830 0.416 ves
15:16:44 - functions MultilaverPercentron	Weighted Avg. 0.883 0.531 0.874 0.883	0.878 0.386 0	.830 0.904
15:21:02 - functions MultilaverPercentron			
15:26:27 - functions Multilayer erception	=== Confusion Matrix ===		
13.20.37 Inflorono.mennayon creepron			
	a b < classified as		
	1204 / 73 a = n0 107 / 73 b = ves		
	107 70 1 0 - 103		
	•[
Status			
OK			Log

As mentioned in previous slides, you can specify the number of hidden layers and the nodes of each layer. If you turn on the GUI mode, you can easily to verify it.

Let's change the hiddenLayers to 5,3,2

Click OK

🜍 weka.gui.GenericObje	ctEditor	\times
weka.classifiers.functions.l	/lultilayerPerceptron	
About		
A classifier that uses b perceptron to classify in	ackpropagation to learn a multi-layer More Capabilities	
GUI	True	•
autoBuild	True	•
batchSize	100	
debug	False	•
decay	False	•
doNotCheckCapabilities	False	•
hiddenLayers	5, 3, 2	
learningRate	0.3	
momentum	0.2	

After clicking Start, you can see now your network has 3 hidden layers where 5 nodes in layer 1, 3 nodes in layer 2 and 2 nodes in layer 3.



Remarks on Neural Network

The performance of the neural network can be easily affected by the setup of the **hyperparameters**. The hyperparameters include the number of hidden layers, number of nodes, learning rate, momentum, batch size, etc. To achieve a better performing neural network always requires tons of hyperparameters tuning. You can play with different hyperparameters setting and investigate which combination can achieve a better result.

A clustering algorithm finds groups of similar instances in the entire dataset. WEKA supports several clustering algorithms such as EM, FilteredClusterer, HierarchicalClusterer, SimpleKMeans and so on. You should understand these algorithms completely to fully exploit the WEKA capabilities.

As in the case of classification, WEKA allows you to visualize the detected clusters graphically.

After loading data into Explorer, click Cluster

😮 Weka Explorer	- 🗆 X
Preprocess Classify Cluster Associate Select attributes Visualize	
Open file Open URL Open DB Ger Filter	nerate Undo Edit Save
Choose Standardize	Apply Stop
Current relation	Selected attribute
Relation: bank Attributes: 17 Instances: 4521 Sum of weights: 4521	Name: age Type: Numeric Missing: 0 (0%) Distinct: 67 Unique: 4 (0%)
Attributes	Statistic Value
	Minimum 19 Maximum 87
All None Invert Pattern	Mean 41.17
2 job 3 marital 4 education 5 default 6 balance 7 housing 8 loan 9 contact 10 day 11 month 12 duration 13 campaign 14 pdays 15 previous 16 poutcome	Class: y (Nom) Visualize All
17 y Remove Status OK	14 20 14 20 15 15 7 19 10 9 8 13 1 5 2 19 53 Log x0

Click Choose

	Weka Explorer
Preprocess Classify Cluster Associate Select	attributes Visualize
Clusterer	
Choose EM -1100 -N -1 -X 10 -max -1 -II-cv	1.0E-6 -II-iter 1.0E-6 -M 1.0E-6 -K 10 -num-slots 1 -S 100
Cluster mode	Clusterer output
 Use training set 	
O Supplied test set Set	
O Percentage split % 66	
○ Classes to clusters evaluation	
(Nom) y	
✓ Store clusters for visualization	
Ignore attributes	
Start Stop	
Result list (right-click for options)	
Status	
ОК	Log 🗸 🕰 K

Under clusterers choose EM

Preprocess Classify Cluster Associate Select attrib	
	ates visualize
lusterer	
🔻 🗁 weka	-II-iter 1.0E-6 -M 1.0E-6 -K 10 -num-slots 1 -S 100
🔻 📄 clusterers	
Canopy	terer output
Cobweb	
FarthestFirSt	
FilteredClusterer	
HierarchicalClusterer	
Simplek Means	
-	
-	
-	
6	
Close	
tatus	
014	

In the **Cluster mode** sub window, select the **Classes to clusters evaluation** option.

Click on the **Start** button to process the data. After a while, the results will be presented on the screen.

	Weka Explorer
Preprocess Classify Cluster Associate Sel	ect attributes Visualize
Clusterer	
Choose EM -I 100 -N -1 -X 10 -max -1 -I	I-cv 1.0E-6 -II-iter 1.0E-6 -M 1.0E-6 -K 10 -num-slots 1 -S 100
Cluster mode	Clusterer output
O Use training set	
Supplied test set Set	
O Percentage split % 66	
Classes to clusters evaluation	
Store clusters for visualization	
Ignore attributes	
Start Stop	
Result list (right click for ontions)	
Status	
OK	Log x0

From the output screen, you can observe that –

There are 3 clustered instances detected in the database.

The **Cluster 0** represents no class, **Cluster 1** represents no, **Cluster 2** represents yes.

	Weka Explorer	
Preprocess Classify Cluster Associate Select at	tributes Visualize	
Clusterer		
Choose EM -I 100 -N -1 -X 10 -max -1 -II-cv 1	.0E-6 -II-iter 1.0E-6 -M 1.0E-6 -K 10 -num-slots 1 -S 100	
Cluster mode	Clusterer output	
Use training set	failure 24.0238 1 467.9762	
O Supplied test set Set	other 9.8659 1 189.1341 success 21.2438 1 109.7562 [total] 1255.227 2380.5011 897.2719	
Classes to clusters evaluation		
(Nom) y ▼ ✓ Store clusters for visualization	=== Model and evaluation on training set ===	
Ignore attributes	Clustered Instances	
Start Stop Result list (right-click for options)	0 69 (2%) 1 3636 (80%) 2 816 (18%)	
11:56:39 - EM	Log likelihood: -20.33263	
	Class attribute: y Classes to Clusters:	
	0 1 2 < assigned to cluster 64 3304 632 no 5 332 184 yes	
	Cluster 0 < No class Cluster 1 < no Cluster 2 < yes	
	Incorrectly clustered instances : 1033.0 22.8489 %	
Status		
ОК	Log	x 0

From the output screen, you can observe that -

Incorrectly clustered instances

-> accuracy

	Weka Explorer	
Preprocess Classify Cluster Associate Selec	t attributes Visualize	
usterer		
Choose EM -I 100 -N -1 -X 10 -max -1 -II-0	сv 1.0E-6 –II-iter 1.0E-6 –М 1.0E-6 –К 10 –num-slots 1 –S 100	
uster mode	Clusterer output	
 Use training set Supplied test set Percentage split Classes to clusters evaluation 	Instruction Instruction Instruction failure 24.0238 1 467.9762 other 9.8659 1 189.1341 success 21.2438 1 109.7562 [total] 1255.227 2380.5011 897.2719	Å
(Nom) y Store clusters for visualization	Time taken to build model (full training data) : 11.05 seconds === Model and evaluation on training set ===	
Ignore attributes Start Stop sult list (right-click for options) 11:56:39 - EM	0 69 (2%) 1 3636 (80%) 2 816 (18%) Log likelihood: -20.33263	
	Class attribute: y Classes to Clusters: 0 1 2 < assigned to cluster	
	64 3304 632 no 5 332 184 yes Cluster 0 < No class Cluster 1 < no Cluster 2 < yes	_
	Incorrectly clustered instances : 1033.0 22.8489 %	7
atus		
~~~~		

From the output screen, you can observe that –

some statistics that gives the mean and standard deviation for each of the attributes in the various detected clusters.

	W	/eka Explorer	
Preprocess Classify Cluster Associate Select att	tributes Visualize		
Clusterer			
Clusterer			
Choose EM -1 100 -N -1 -X 10 -max -1 -11-0/1	OF_6_II_iter 1 OF_6_M	1 0E_6 _K 10 _num_clots 1 _S 100	
	.02-0-11-1121 1.02-0-14	1.02-0 -K 10 -Hum-3003 1 -5 100	
Charten made	Cl		
Cluster mode	Clusterer output		
O Use training set			
C Supplied test est		Cluster	
Supplied test set	Attribute	0 1 2	
O Percentage split % 66		(0.28) (0.53) (0.2)	
Classes to clusters evaluation			
Classes to cluster's evaluation	age	44 0044 - 00 6504 - 40 0045	
(Nom) y	mean std dev	44.8244 39.6504 40.0945	
Store clusters for visualization	stu. uev.	12.4304 9.1090 9.9554	
	job		
	unemployed	40.7249 67.3525 22.9226	
ignore attributes	services	52.4085 306.9947 60.5968	
	management	366.1032 319.8473 286.0495	
Start Stop	blue-collar	8/.2286 /09.0651 152./063	
Result list (right-click for options)	technician	52.7040 101.4270 51.0070 273.0823 353.3342 144.5835	
Contraction of the second seco	entrepreneur	47.0988 95.4659 28.4353	
11:56:39 – EM	admin.	85.349 290.9171 104.7339	
	student	32.4238 31.5781 22.9981	
	housemaid	52.5518 47.0312 15.4169	
	retired	149.2976 54.5619 29.1405	
	[tota]]	24.2538 10.9253 5.8209	
	marital	1203.227 2303.3011 903.2713	
	married	776.0077 1499.9887 524.0036	
	single	328.2829 587.721 282.9962	
	divorced	149.9364 291.7914 89.2722	
	[total]	1254.227 2379.5011 896.2719	
	education	158 1106 431 4318 91 4576	
	secondary	516.6243 1392.4705 399.9052	
	tertiary	524.2259 456.1673 372.6068	
	unknown	56.2661 100.4315 33.3024	
	[total]	1255.227 2380.5011 897.2719	▼
			)
Status			

Log

ОК

#### Visualize Clusters with Weka

To visualize the clusters, right click on the **EM** result in the **Result list**. You will see the following options

Select Visualize cluster assignments.

	Weka Explorer
Preprocess Classify Cluster Associate Select att	ributes Visualize
Clusterer	
Choose EM -I 100 -N -1 -X 10 -max -1 -II-cv 1.	.0E-6 -II-iter 1.0E-6 -M 1.0E-6 -K 10 -num-slots 1 -S 100
Cluster mode	Clusterer output
<ul> <li>Use training set</li> <li>Supplied test set Set</li> <li>Percentage split % 66</li> <li>Classes to clusters evaluation <ul> <li>(Nom) y</li> <li>✓ Store clusters for visualization</li> </ul> </li> </ul>	Intervent       12000000000000000000000000000000000000
Ignore attributes	Clustered Instances 0 69 (2%) 1 3636 (80%) 2 816 (18%)
11:56:39 - EM       View in main window         View in separate window       Save result buffer         Delete result buffer       Delete result buffer(s)         Load model       Save model         Re-evaluate model on currer       Re-apply this model's confi         Visualize cluster assignmen       Visualize tree	<pre>Les libelihood: -20.33263 ttribute: y to Clusters:     1 2 &lt; assigned to cluster     304 632   no     332 184   yes ent test set iguration 0 &lt; No class 1 &lt; no 2 &lt; yes mecorrectly clustered instances : 1033.0 22.8489 %</pre>
Status	

Log

# Visualize Clusters with Weka

You can play around by changing the X and Y axes to analyze the results. You may use jittering as in the case of classification to find out the concentration of correctly identified instances.



cluster0 cluster1 cluster2