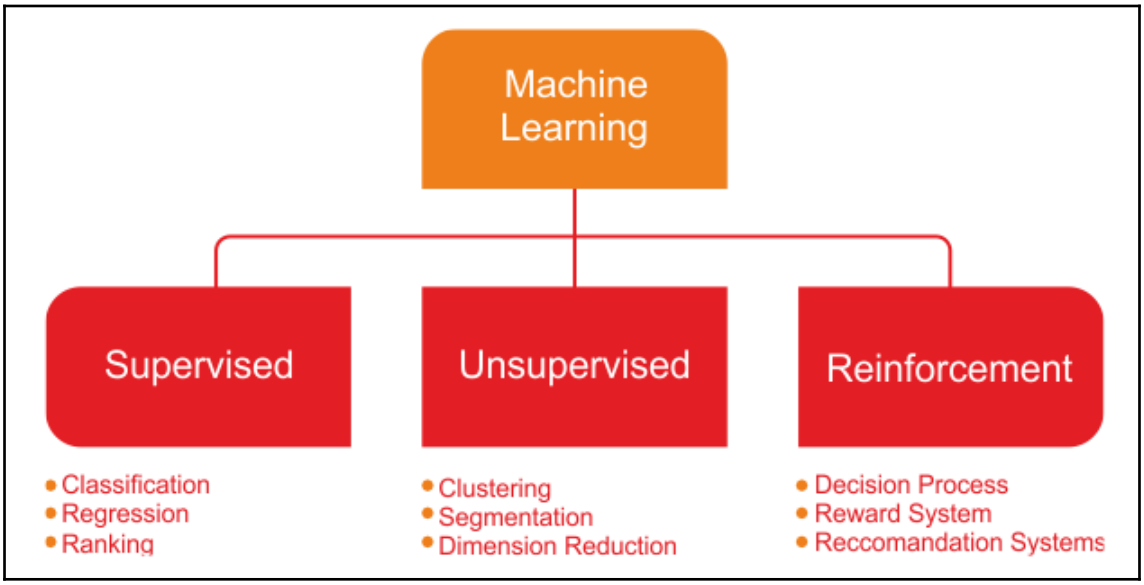
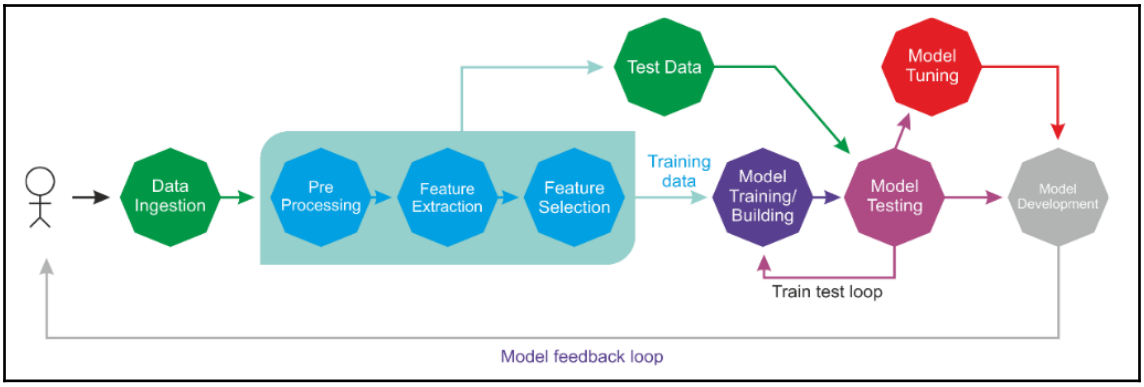
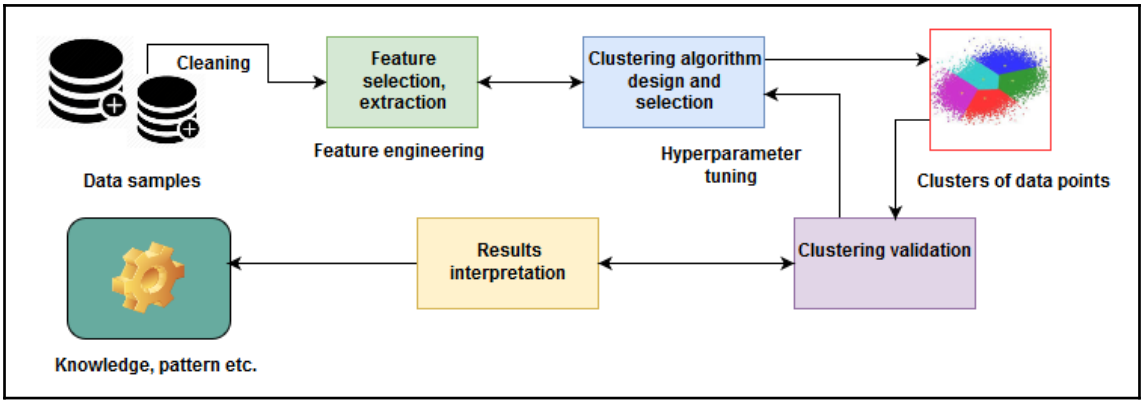
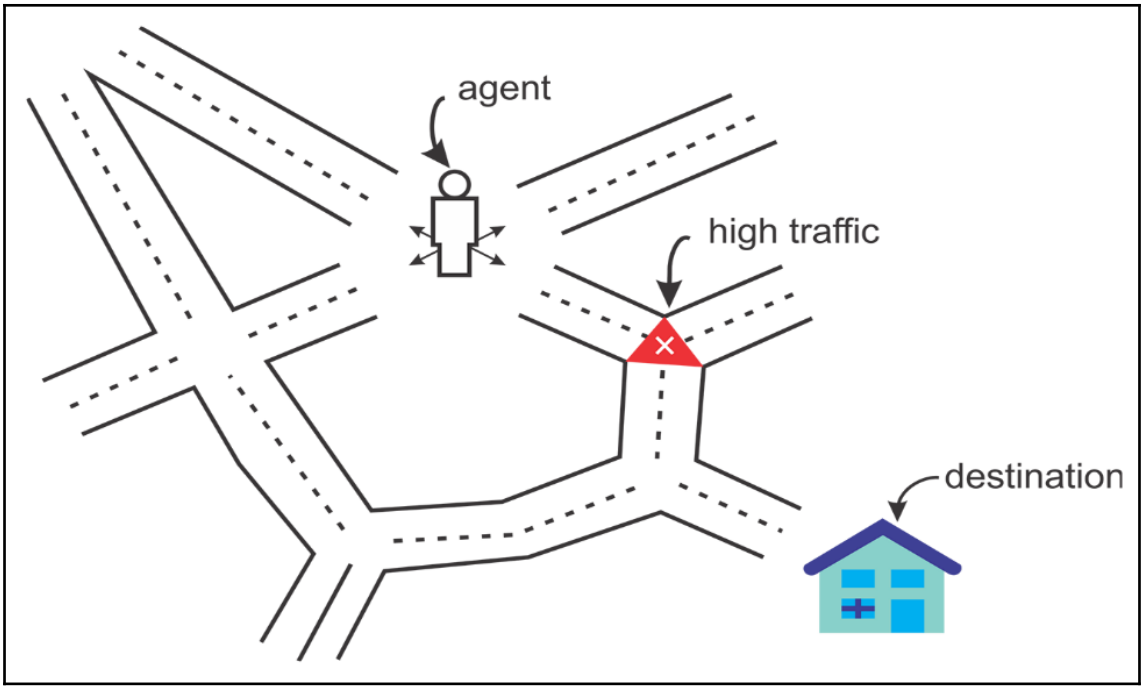
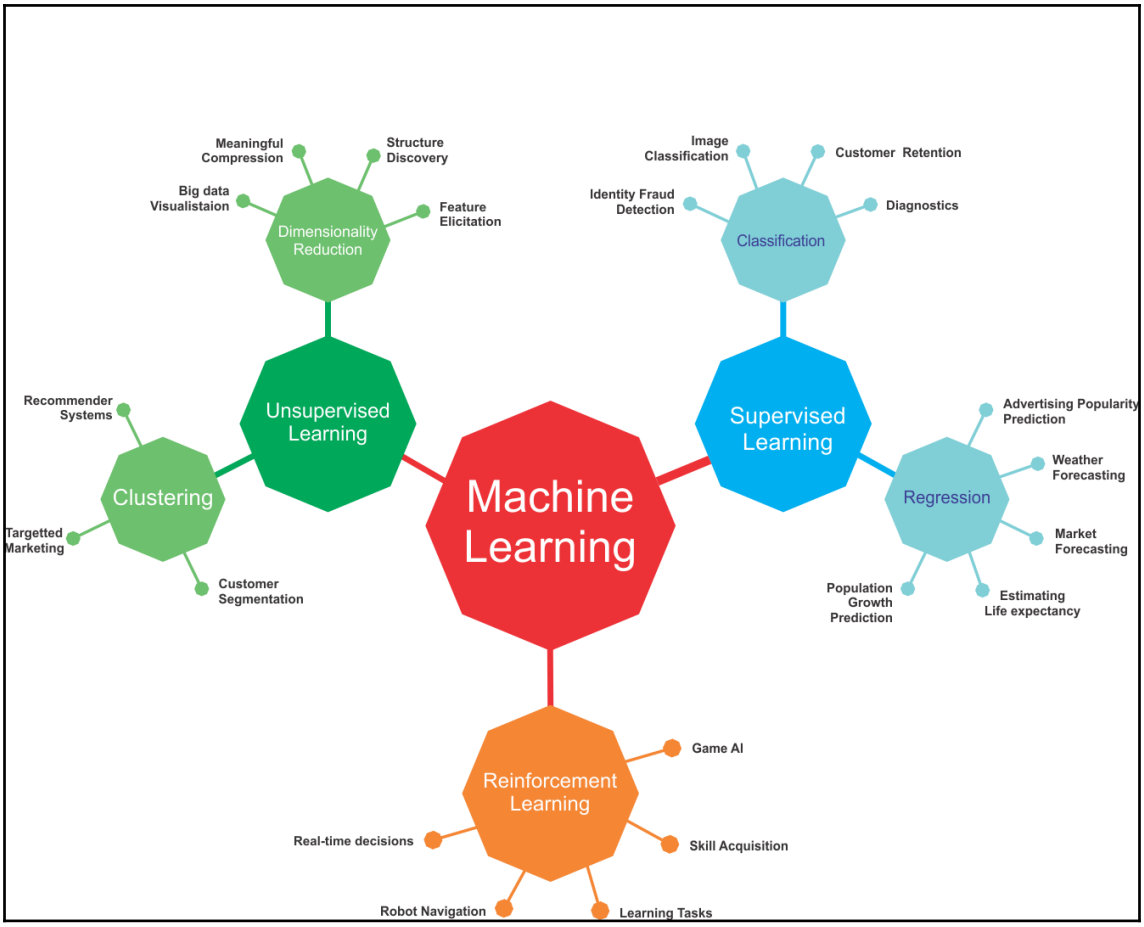
Chapter 1: Getting Started with Deep Learning

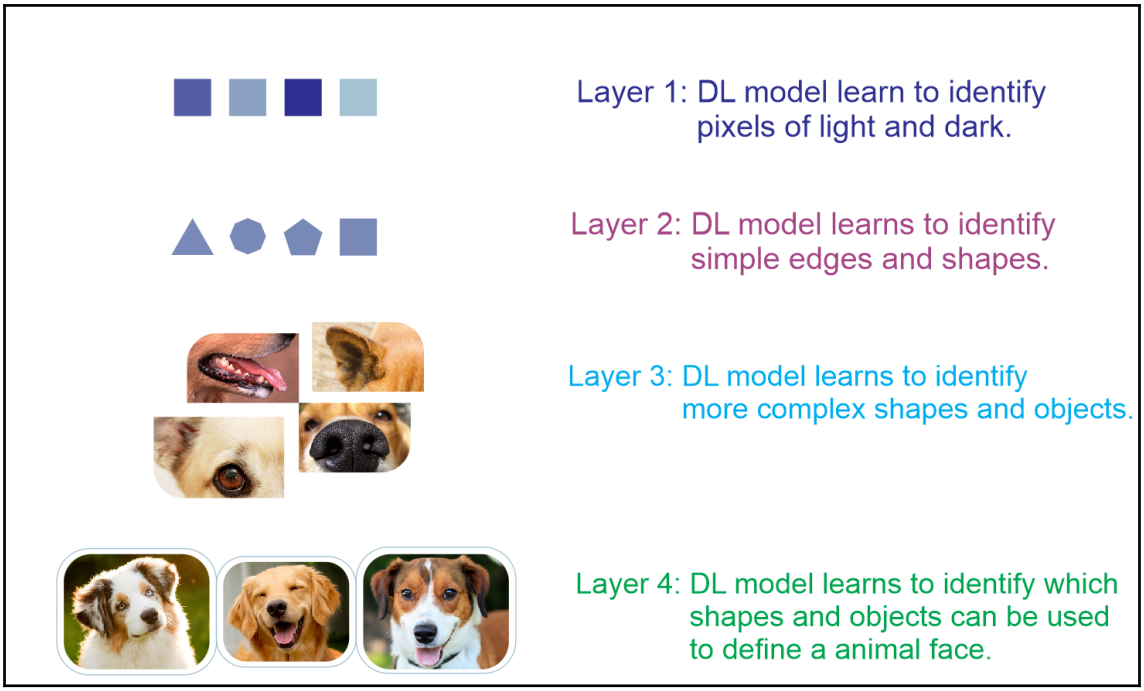


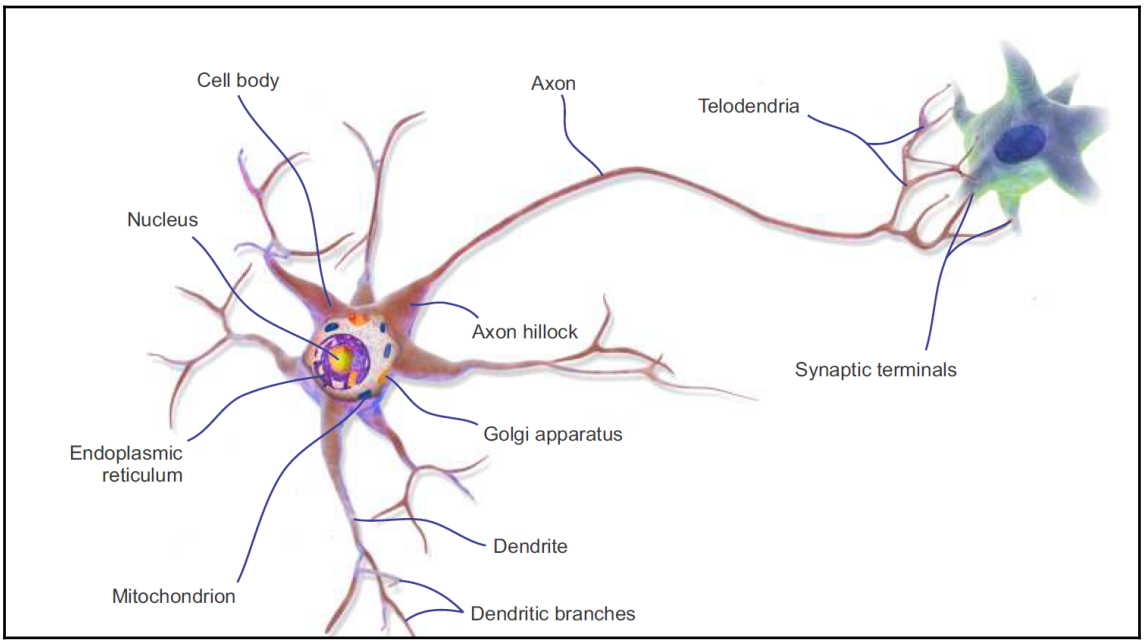


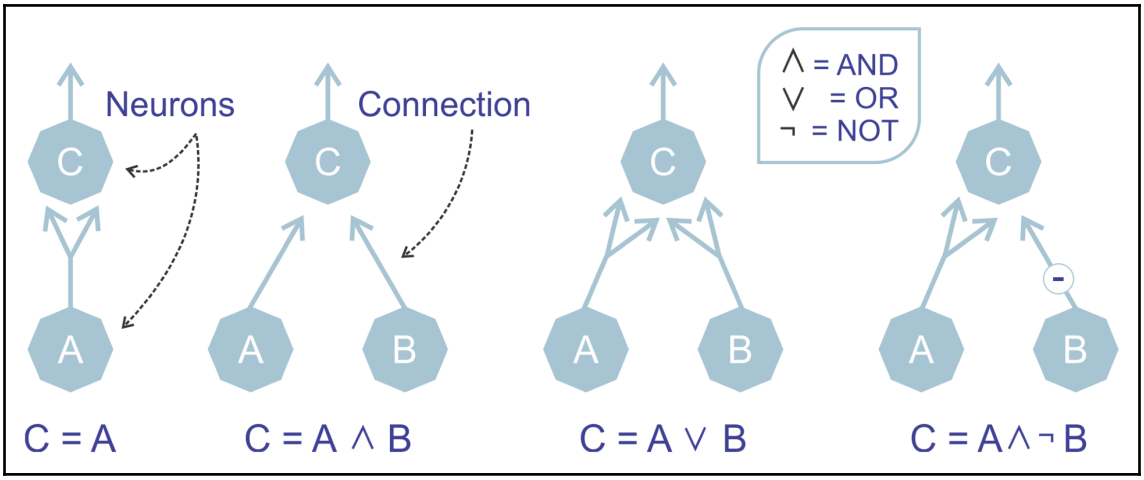

Cleaning
Feature selection, extraction
Clustering algorithm design and selection
Data samples
Feature engineering
Hyperparameter tuning
Clusters of data points
Results interpretation
Clustering validation
Knowledge, pattern etc.

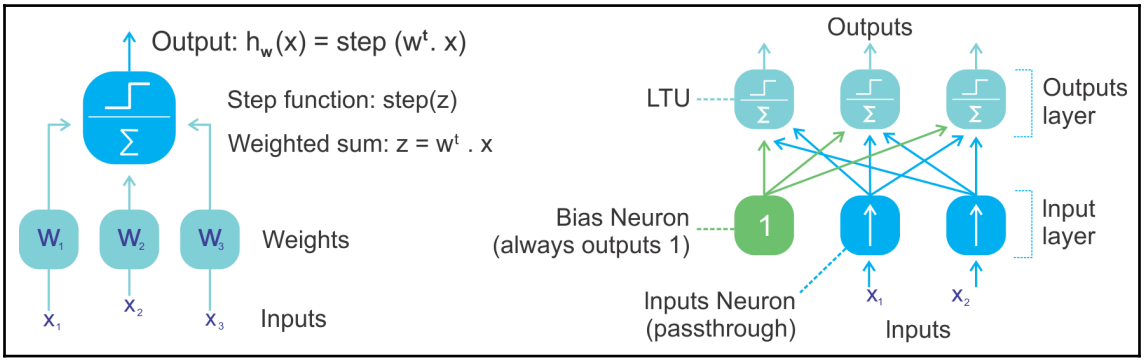

agent
high traffic
destination

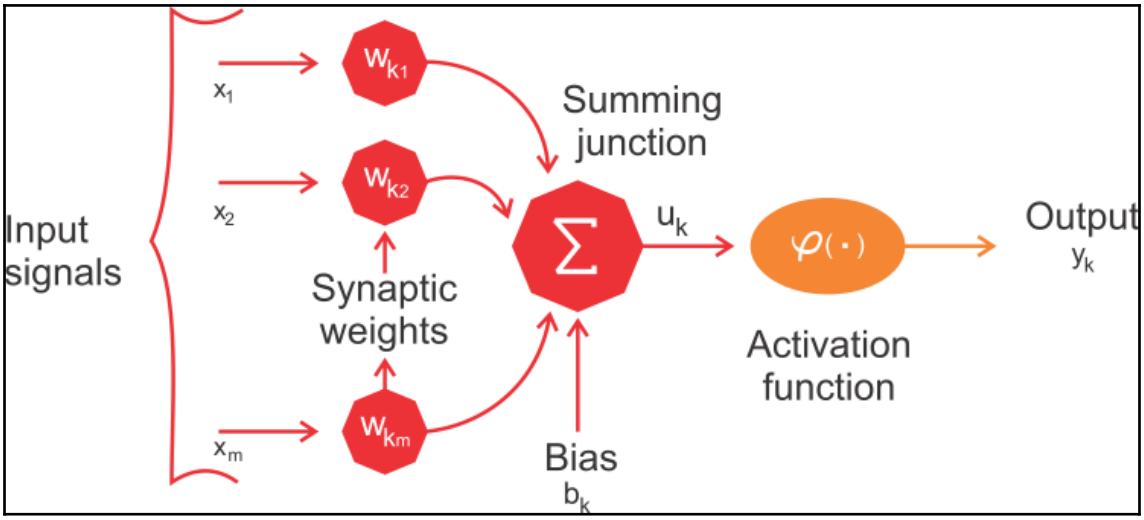

Machine Learning
Unsupervised Learning
Dimensionality Reduction
Meaningful Compression
Structure Discovery
Big data Visualistaion
Feature Elicitation
Clustering
Recommender Systems
Targetted Marketing
Customer Segmentation
Supervised Learning
Classification
Image Classification
Customer Retention
Identity Fraud Detection
Diagnostics
Regression
Advertising Popularity Prediction
Weather Forecasting
Market Forecasting
Population Growth Prediction
Estimating Life expectancy
Reinforcement Learning
Game AI
Real-time decisions
Skill Acquisition
Robot Navigation
Learning Tasks

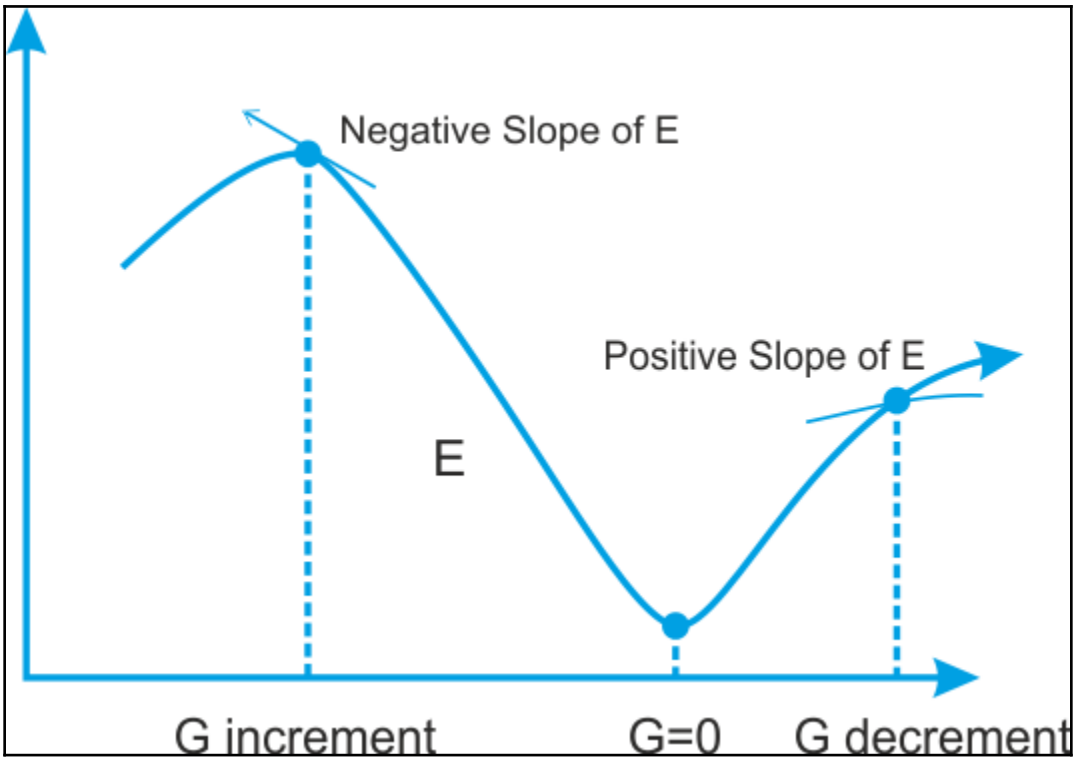

Layer 1: DL model learn to identify pixels of light and dark.
Layer 2: DL model learns to identify simple edges and shapes.
Layer 3: DL model learns to identify more complex shapes and objects.
Layer 4: DL model learns to identify which shapes and objects can be used to define a animal face.

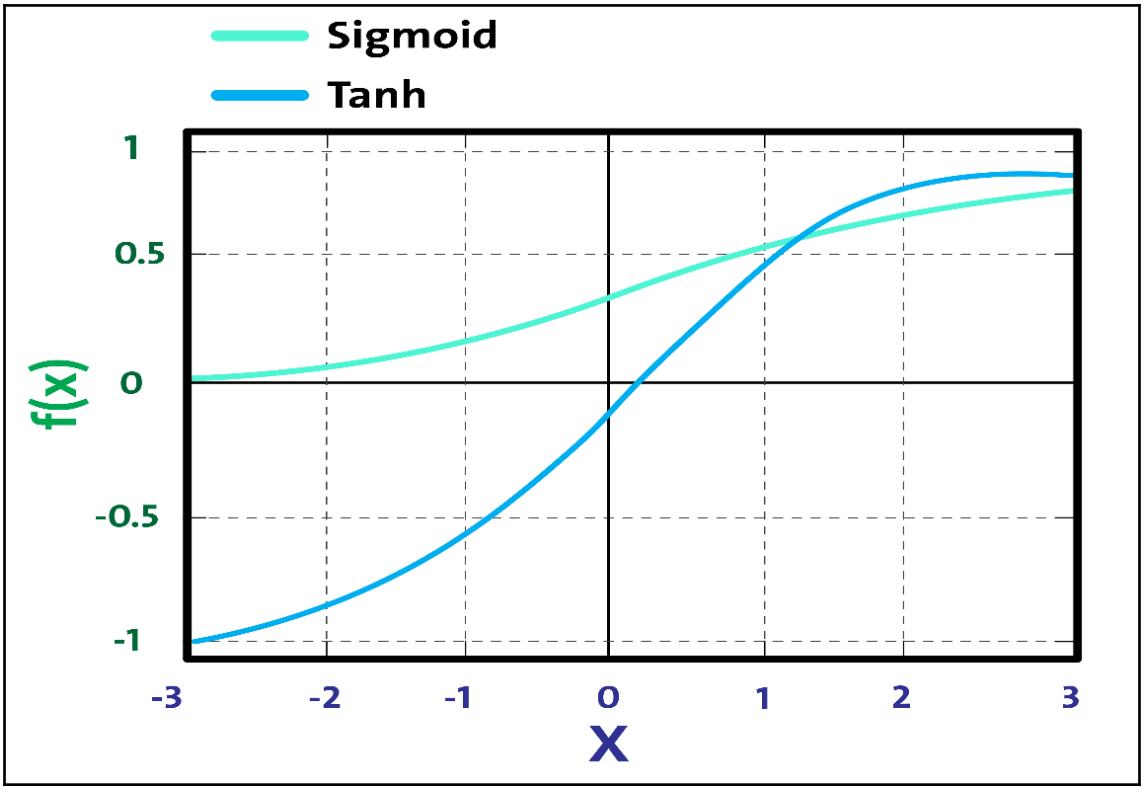

Cell body
Axon
Telodendria
Nucleus
Axon hillock
Synaptic terminals
Golgi apparatus
Endoplasmic reticulum
Dendrite
Mitochondrion
Dendritic branches

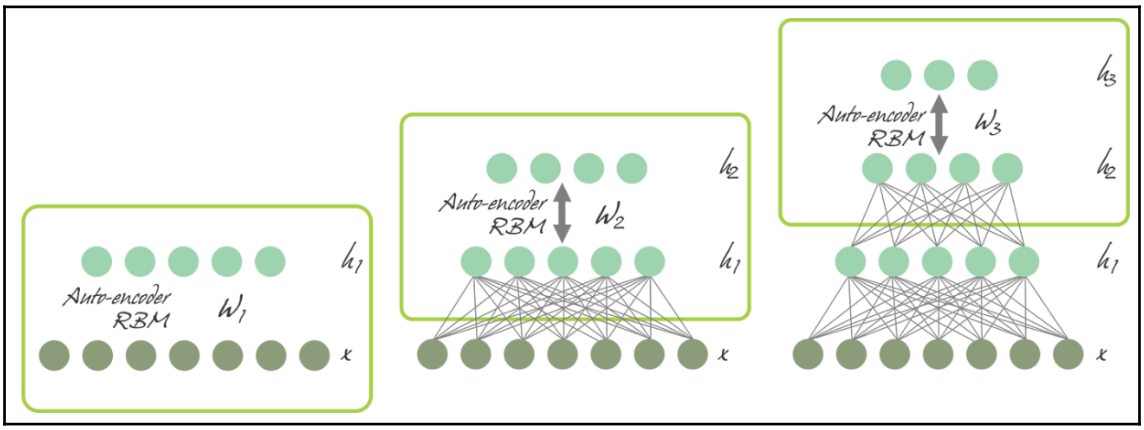

Neurons
Connection
∧ = AND
∨ = OR
¬ = NOT
C
A
B
C = A
C = A ∧ B
C = A ∨ B
C = A∧¬ B

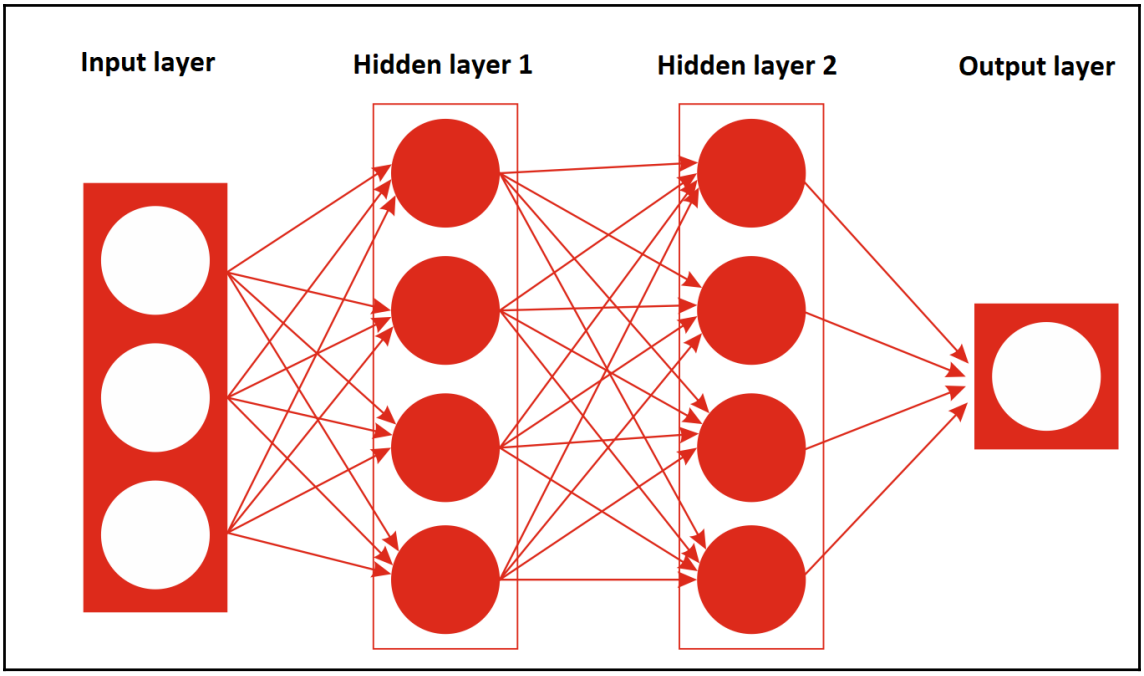

Output: $h_w(x)$ = step (w^t. x)
Step function: step(z)
Weighted sum: z = w^t . x
W_1
W_2
W_3
Weights
x_1
x_2
x_3
Inputs
Outputs
LTU
Outputs layer
Bias Neuron (always outputs 1)
1
Input layer
Inputs Neuron (passthrough)
x_1
x_2
Inputs

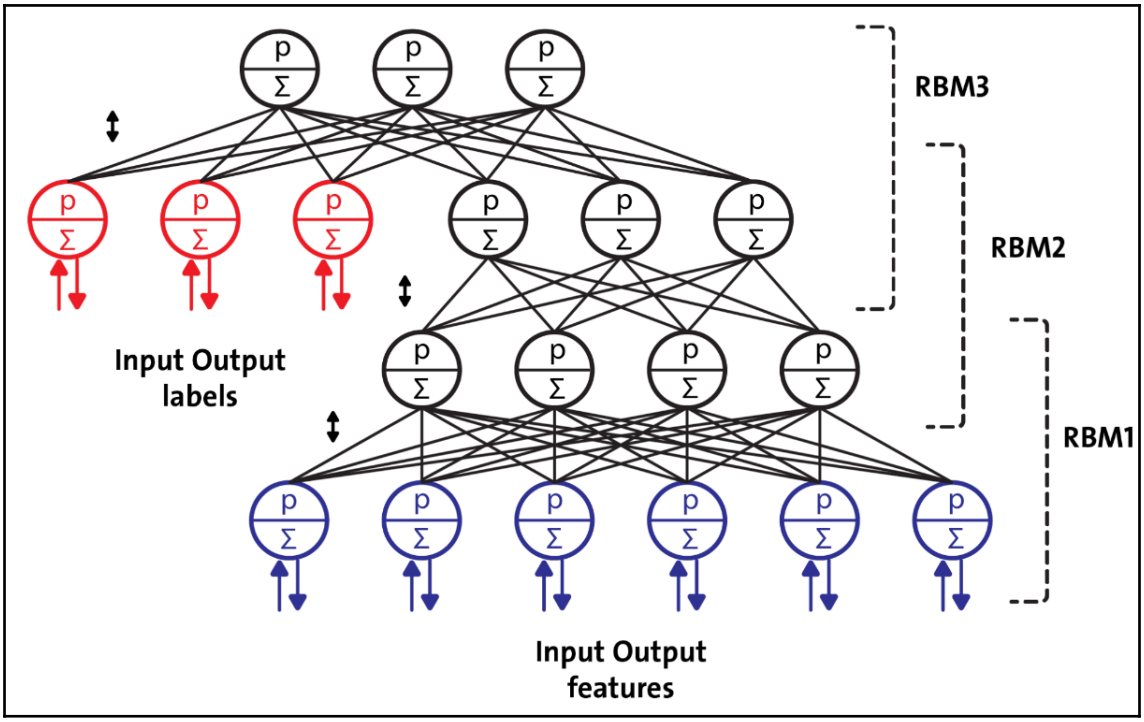

Input signals
x_1
x_2
x_m
w_{k1}
w_{k2}
w_{km}
Synaptic weights
Summing junction
Σ
u_k
$\varphi(\cdot)$
Activation function
Output
y_k
Bias
b_k

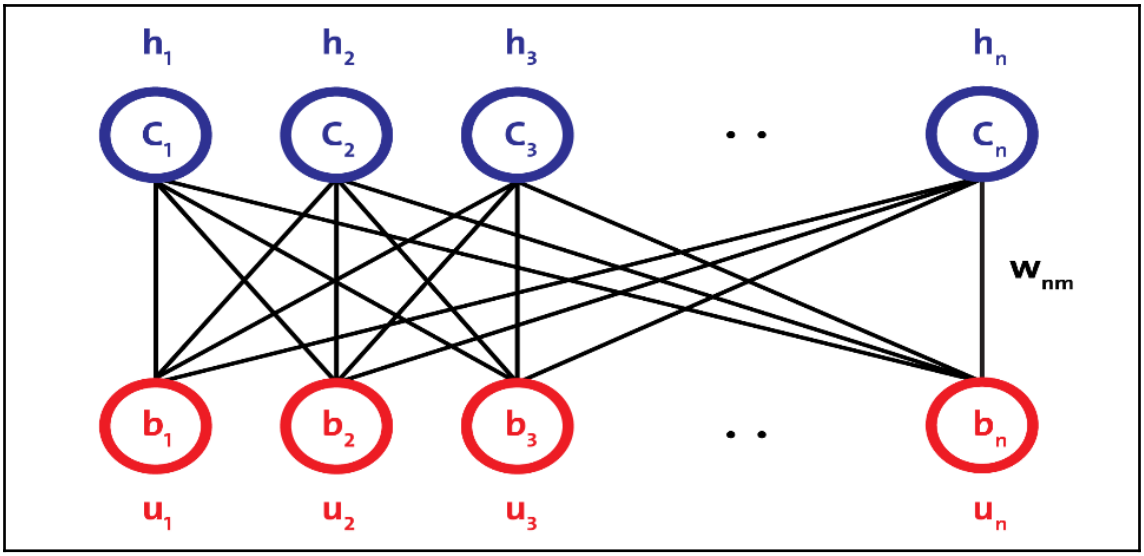

Negative Slope of E
Positive Slope of E
E
G increment
G=0
G decrement

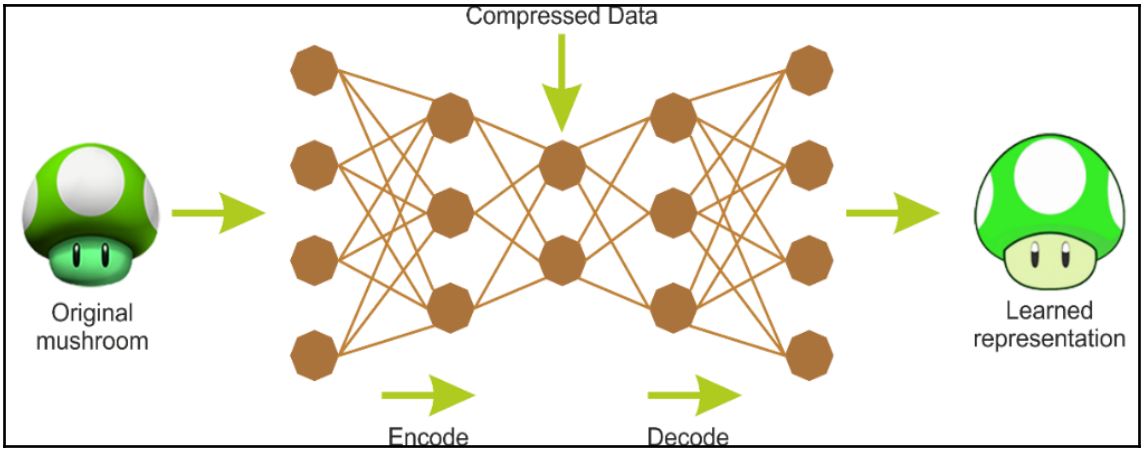

Sigmoid
Tanh
1
0.5
0
-0.5
-1
f(x)
-3
-2
-1
0
1
2
3
X

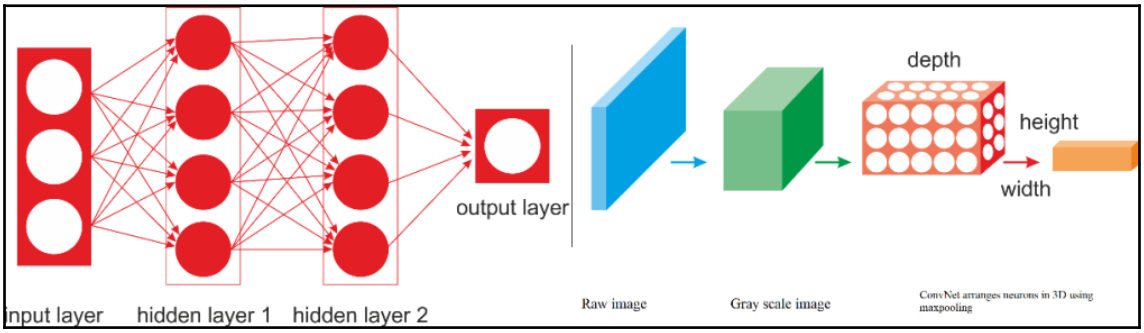

Auto-encoder RBM
W_1
h_1
x
Auto-encoder RBM
W_2
h_2
h_1
x
Auto-encoder RBM
W_3
h_3
h_2
h_1
x

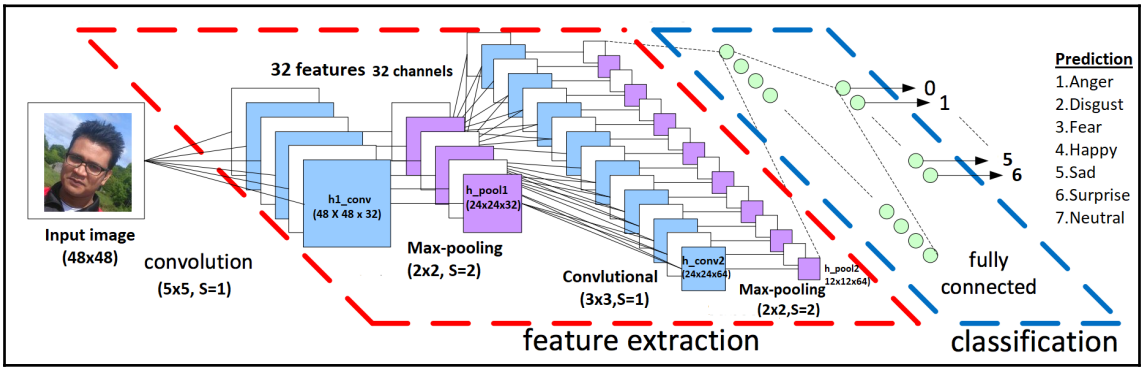

Input layer
Hidden layer 1
Hidden layer 2
Output layer

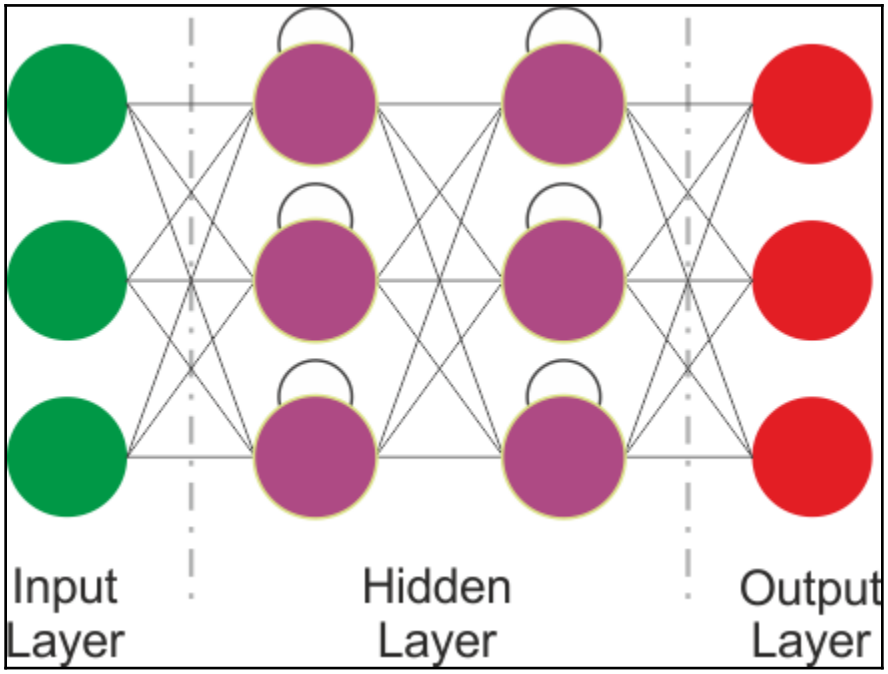

RBM3
RBM2
RBM1
Input Output
labels
Input Output
features

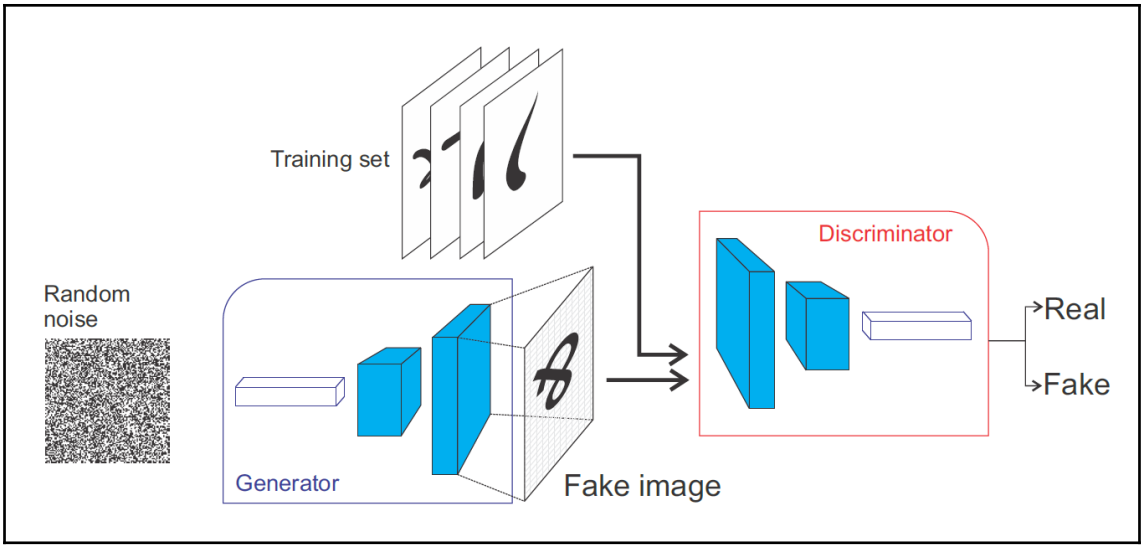

h_1
h_2
h_3
h_n
c_1
c_2
c_3
c_n
w_{nm}
b_1
b_2
b_3
b_n
u_1
u_2
u_3
u_n

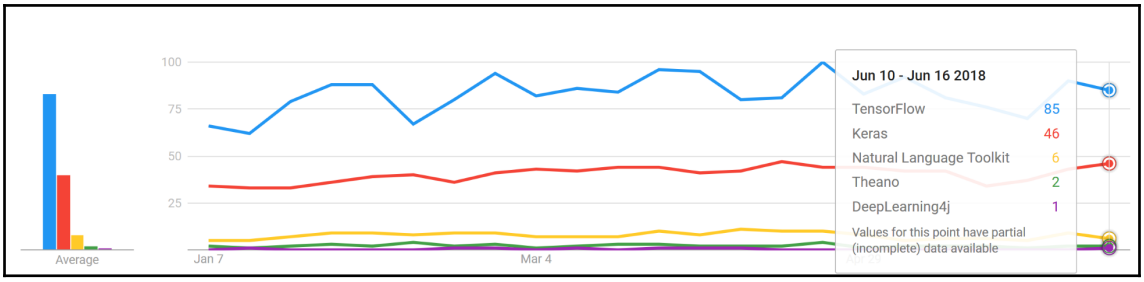

Compressed Data
Original mushroom
Learned representation
Encode
Decode


input layer
hidden layer 1
hidden layer 2
output layer
Raw image
Gray scale image
depth
height
width
ConvNet arranges neurons in 3D using maxpooling


32 features
32 channels
Input image
(48x48)
convolution
(5x5, S=1)
h1_conv
(48 X 48 x 32)
h_pool1
(24x24x32)
Max-pooling
(2x2, S=2)
Convlutional
(3x3,S=1)
h_conv2
(24x24x64)
h_pool2
12x12x64)
Max-pooling
(2x2,S=2)
fully connected
0
1
5
6
Prediction
1.Anger
2.Disgust
3.Fear
4.Happy
5.Sad
6.Surprise
7.Neutral
feature extraction
classification


Input
Layer
Hidden
Layer
Output
Layer


Training set
Random
noise
Generator
Fake image
Discriminator
Real
Fake

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+-----------+--------+------+--------------------+------+----+-----+-----+----------------+-------+-----+--------+
|PassengerId|Survived|Pclass|                Name|   Sex| Age|SibSp|Parch|          Ticket|   Fare|Cabin|Embarked|
+-----------+--------+------+--------------------+------+----+-----+-----+----------------+-------+-----+--------+
|          1|       0|     3|Braund, Mr. Owen ...|  male|22.0|    1|    0|       A/5 21171|   7.25| null|       S|
|          2|       1|     1|Cumings, Mrs. Joh...|female|38.0|    1|    0|        PC 17599|71.2833|  C85|       C|
|          3|       1|     3|Heikkinen, Miss. ...|female|26.0|    0|    0|STON/O2. 3101282|  7.925| null|       S|
|          4|       1|     1|Futrelle, Mrs. Ja...|female|35.0|    1|    0|          113803|   53.1| C123|       S|
|          5|       0|     3|Allen, Mr. Willia...|  male|35.0|    0|    0|          373450|   8.05| null|       S|
|          6|       0|     3|    Moran, Mr. James|  male|null|    0|    0|          330877| 8.4583| null|       Q|
|          7|       0|     1|McCarthy, Mr. Tim...|  male|54.0|    0|    0|           17463|51.8625|  E46|       S|
|          8|       0|     3|Palsson, Master. ...|  male| 2.0|    3|    1|          349909| 21.075| null|       S|
|          9|       1|     3|Johnson, Mrs. Osc...|female|27.0|    0|    2|          347742|11.1333| null|       S|
|         10|       1|     2|Nasser, Mrs. Nich...|female|14.0|    1|    0|          237736|30.0708| null|       C|
|         11|       1|     3|Sandstrom, Miss. ...|female| 4.0|    1|    1|         PP 9549|   16.7|   G6|       S|
|         12|       1|     1|Bonnell, Miss. El...|female|58.0|    0|    0|          113783|  26.55| C103|       S|
|         13|       0|     3|Saundercock, Mr. ...|  male|20.0|    0|    0|       A/5. 2151|   8.05| null|       S|
|         14|       0|     3|Andersson, Mr. An...|  male|39.0|    1|    5|          347082| 31.275| null|       S|
|         15|       0|     3|Vestrom, Miss. Hu...|female|14.0|    0|    0|          350406| 7.8542| null|       S|
|         16|       1|     2|Hewlett, Mrs. (Ma...|female|55.0|    0|    0|          248706|   16.0| null|       S|
|         17|       0|     3|Rice, Master. Eugene|  male| 2.0|    4|    1|          382652| 29.125| null|       Q|
|         18|       1|     2|Williams, Mr. Cha...|  male|null|    0|    0|          244373|   13.0| null|       S|
|         19|       0|     3|Vander Planke, Mr...|female|31.0|    1|    0|          345763|   18.0| null|       S|
|         20|       1|     3|Masselmani, Mrs. ...|female|null|    0|    0|            2649|  7.225| null|       C|
+-----------+--------+------+--------------------+------+----+-----+-----+----------------+-------+-----+--------+
only showing top 20 rows
```

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+--------+-------+---+----+------+-----+-----+--------+
|Survived|   Fare|Sex| Age|Pclass|Parch|SibSp|Embarked|
+--------+-------+---+----+------+-----+-----+--------+
|       0|   7.25|  0|22.0|     3|    0|    1|       0|
|       1|71.2833|  1|38.0|     1|    0|    1|       1|
|       1|  7.925|  1|26.0|     3|    0|    0|       0|
|       1|   53.1|  1|35.0|     1|    0|    1|       0|
|       0|   8.05|  0|35.0|     3|    0|    0|       0|
|       0| 8.4583|  0|null|     3|    0|    0|       2|
|       0|51.8625|  0|54.0|     1|    0|    0|       0|
|       0| 21.075|  0| 2.0|     3|    1|    3|       0|
|       1|11.1333|  1|27.0|     3|    2|    0|       0|
|       1|30.0708|  1|14.0|     2|    0|    1|       1|
|       1|   16.7|  1| 4.0|     3|    1|    1|       0|
|       1|  26.55|  1|58.0|     1|    0|    0|       0|
|       0|   8.05|  0|20.0|     3|    0|    0|       0|
|       0| 31.275|  0|39.0|     3|    5|    1|       0|
|       0| 7.8542|  1|14.0|     3|    0|    0|       0|
|       1|   16.0|  1|55.0|     2|    0|    0|       0|
|       0| 29.125|  0| 2.0|     3|    1|    4|       2|
|       1|   13.0|  0|null|     2|    0|    0|       0|
|       0|   18.0|  1|31.0|     3|    0|    1|       0|
|       1|  7.225|  1|null|     3|    0|    0|       1|
+--------+-------+---+----+------+-----+-----+--------+
only showing top 20 rows
```

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+--------+-------+---+------------------+------+-----+-----+--------+
|Survived|   Fare|Sex|               Age|Pclass|Parch|SibSp|Embarked|
+--------+-------+---+------------------+------+-----+-----+--------+
|       0|   7.25|  0|              22.0|     3|    0|    1|       0|
|       1|71.2833|  1|              38.0|     1|    0|    1|       1|
|       1|  7.925|  1|              26.0|     3|    0|    0|       0|
|       1|   53.1|  1|              35.0|     1|    0|    1|       0|
|       0|   8.05|  0|              35.0|     3|    0|    0|       0|
|       0| 8.4583|  0|23.799292929292942|     3|    0|    0|       2|
|       0|51.8625|  0|              54.0|     1|    0|    0|       0|
|       0| 21.075|  0|               2.0|     3|    1|    3|       0|
|       1|11.1333|  1|              27.0|     3|    2|    0|       0|
|       1|30.0708|  1|              14.0|     2|    0|    1|       1|
|       1|   16.7|  1|               4.0|     3|    1|    1|       0|
|       1|  26.55|  1|              58.0|     1|    0|    0|       0|
|       0|   8.05|  0|              20.0|     3|    0|    0|       0|
|       0| 31.275|  0|              39.0|     3|    5|    1|       0|
|       0| 7.8542|  1|              14.0|     3|    0|    0|       0|
|       1|   16.0|  1|              55.0|     2|    0|    0|       0|
|       0| 29.125|  0|               2.0|     3|    1|    4|       2|
|       1|   13.0|  0|23.799292929292942|     2|    0|    0|       0|
|       0|   18.0|  1|              31.0|     3|    0|    1|       0|
|       1|  7.225|  1|23.799292929292942|     3|    0|    0|       1|
+--------+-------+---+------------------+------+-----+-----+--------+
only showing top 20 rows
```

```
+--------------------+-----+
|            features|lable|
+--------------------+-----+
|[-0.5021631365156...|  0.0|
|[0.78640361783453...|  1.0|
|[-0.4885798515812...|  1.0|
|[0.42049406976541...|  1.0|
|[-0.4860644284452...|  0.0|
|[-0.4778480503138...|  0.0|
|[0.39559138071911...|  0.0|
|[-0.2239573376751...|  0.0|
|[-0.4240179952036...|  1.0|
|[-0.0429313901012...|  1.0|
|[-0.3119971474347...|  1.0|
|[-0.1137818043187...|  1.0|
|[-0.4860644284452...|  0.0|
|[-0.0186988097783...|  0.0|
|[-0.4900045872454...|  0.0|
|[-0.3260835169963...|  1.0|
|[-0.0619640877174...|  0.0|
|[-0.3864536722600...|  1.0|
|[-0.2858367468204...|  0.0|
|[-0.5026662211428...|  1.0|
+--------------------+-----+
only showing top 20 rows
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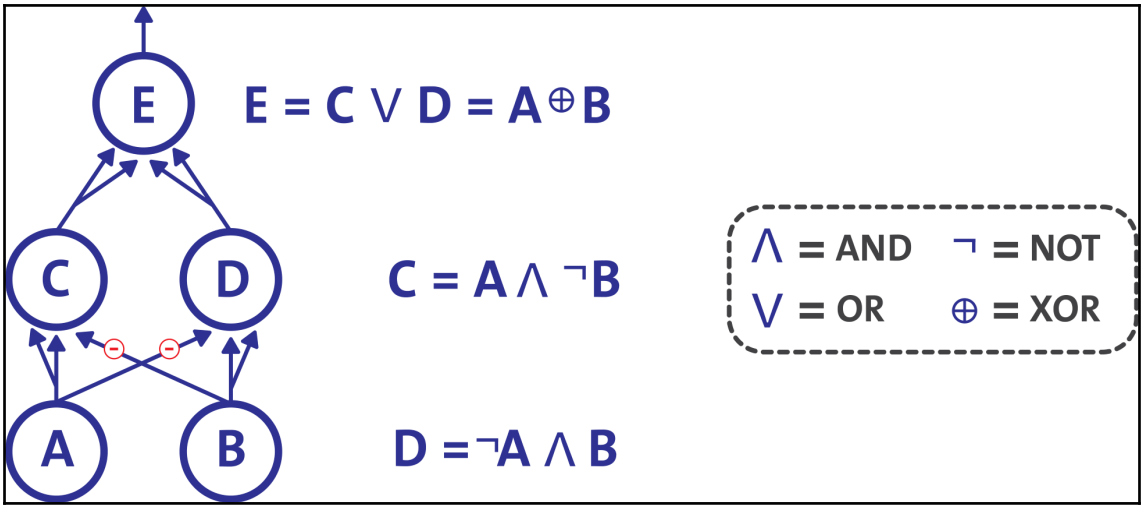
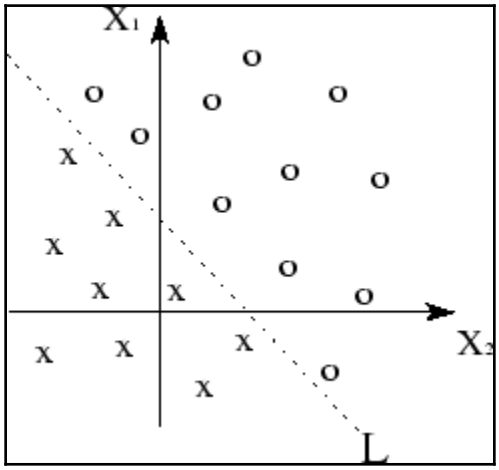
```
+--------------------+-----+--------------------+--------------------+----------+
|            features|label|       rawPrediction|         probability|prediction|
+--------------------+-----+--------------------+--------------------+----------+
|[-0.6480576784030...|  0.0|[1.43363517591707...|[0.96893349593122...|       0.0|
|[-0.6480576784030...|  0.0|[-8.1082996435819...|[4.02626228259359...|       1.0|
|[-0.6480576784030...|  0.0|[-8.1082996435819...|[4.02626228259359...|       1.0|
|[-0.5673125957377...|  0.0|[-0.1640322959336...|[0.39260137197488...|       1.0|
|[-0.5474407529634...|  0.0|[-2.0356964860504...|[0.03642107039370...|       1.0|
|[-0.5225380639171...|  0.0|[9.52109001355164...|[0.99999999757694...|       0.0|
|[-0.5061878135331...|  0.0|[0.78136459169634...|[0.85958947041939...|       0.0|
|[-0.5046785596515...|  0.0|[0.78485553806333...|[0.86092086461934...|       0.0|
|[-0.5043424991206...|  1.0|[0.81165826965175...|[0.86973786781644...|       0.0|
|[-0.5026662211428...|  0.0|[0.99991945120328...|[0.90539585458035...|       0.0|
|[-0.5025817029254...|  0.0|[2.02941913478983...|[0.97832651549972...|       0.0|
|[-0.5025817029254...|  0.0|[0.72874407797616...|[0.83968520050639...|       0.0|
|[-0.5021631365156...|  1.0|[-0.7715748122114...|[0.53732167552789...|       0.0|
|[-0.5021631365156...|  0.0|[0.94526514986850...|[0.89986599681597...|       0.0|
|[-0.5021631365156...|  0.0|[0.83225452435252...|[0.87478522475214...|       0.0|
|[-0.5021631365156...|  0.0|[0.76414347561137...|[0.85732315266212...|       0.0|
|[-0.5021631365156...|  0.0|[0.67965344587190...|[0.83225668146381...|       0.0|
|[-0.4961261209892...|  1.0|[-0.7703785744727...|[0.53787966880031...|       0.0|
|[-0.4941137824804...|  0.0|[1.13917954766187...|[0.93314414983304...|       0.0|
|[-0.4924375045026...|  1.0|[-1.4101139215228...|[0.25222774913860...|       1.0|
+--------------------+-----+--------------------+--------------------+----------+
only showing top 20 rows
```

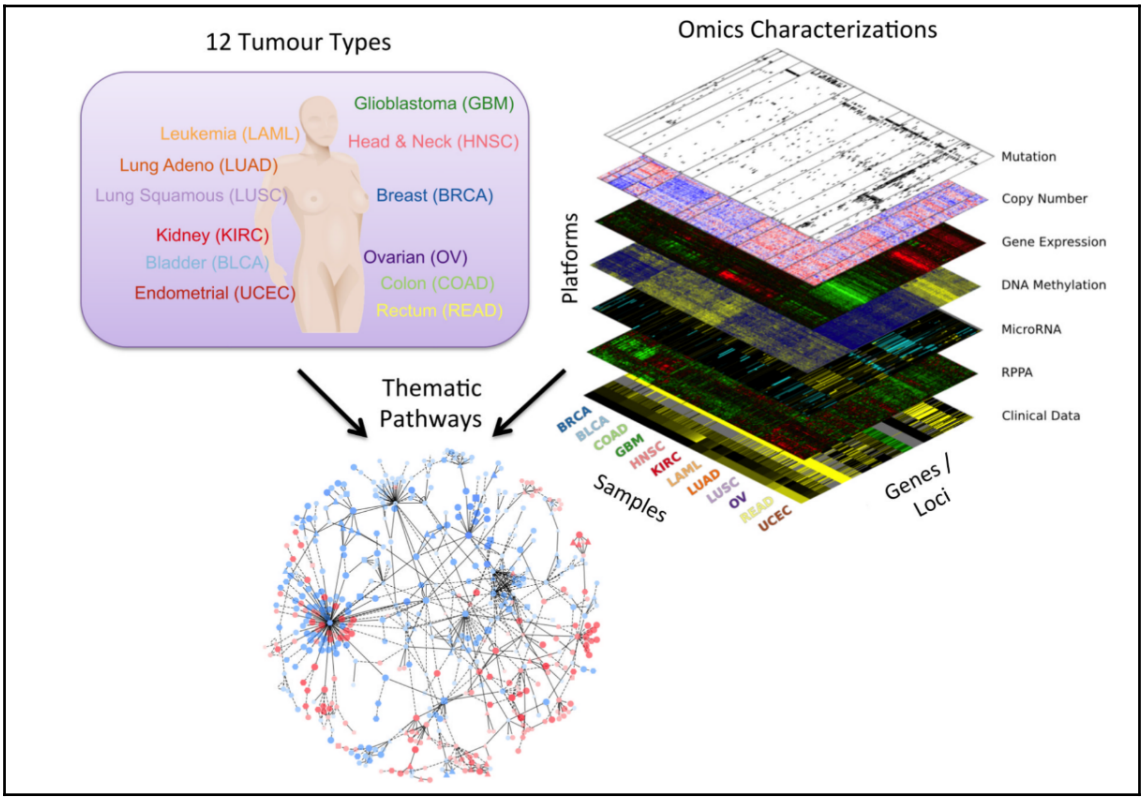
```
+-----------+----------+
|PassengerId|prediction|
+-----------+----------+
|      892.0|       0.0|
|      893.0|       0.0|
|      894.0|       0.0|
|      895.0|       1.0|
|      896.0|       0.0|
|      897.0|       0.0|
|      898.0|       1.0|
|      899.0|       0.0|
|      900.0|       1.0|
|      901.0|       0.0|
|      902.0|       0.0|
|      903.0|       0.0|
|      904.0|       1.0|
|      905.0|       0.0|
|      906.0|       1.0|
|      907.0|       1.0|
|      908.0|       0.0|
|      909.0|       1.0|
|      910.0|       1.0|
|      911.0|       0.0|
+-----------+----------+
only showing top 20 rows
```


E
C
D
A
B
E = C ∨ D = A⊕B
C = A ∧ ¬B
D = ¬A ∧ B
∧ = AND
¬ = NOT
∨ = OR
⊕ = XOR


X1
X2
L

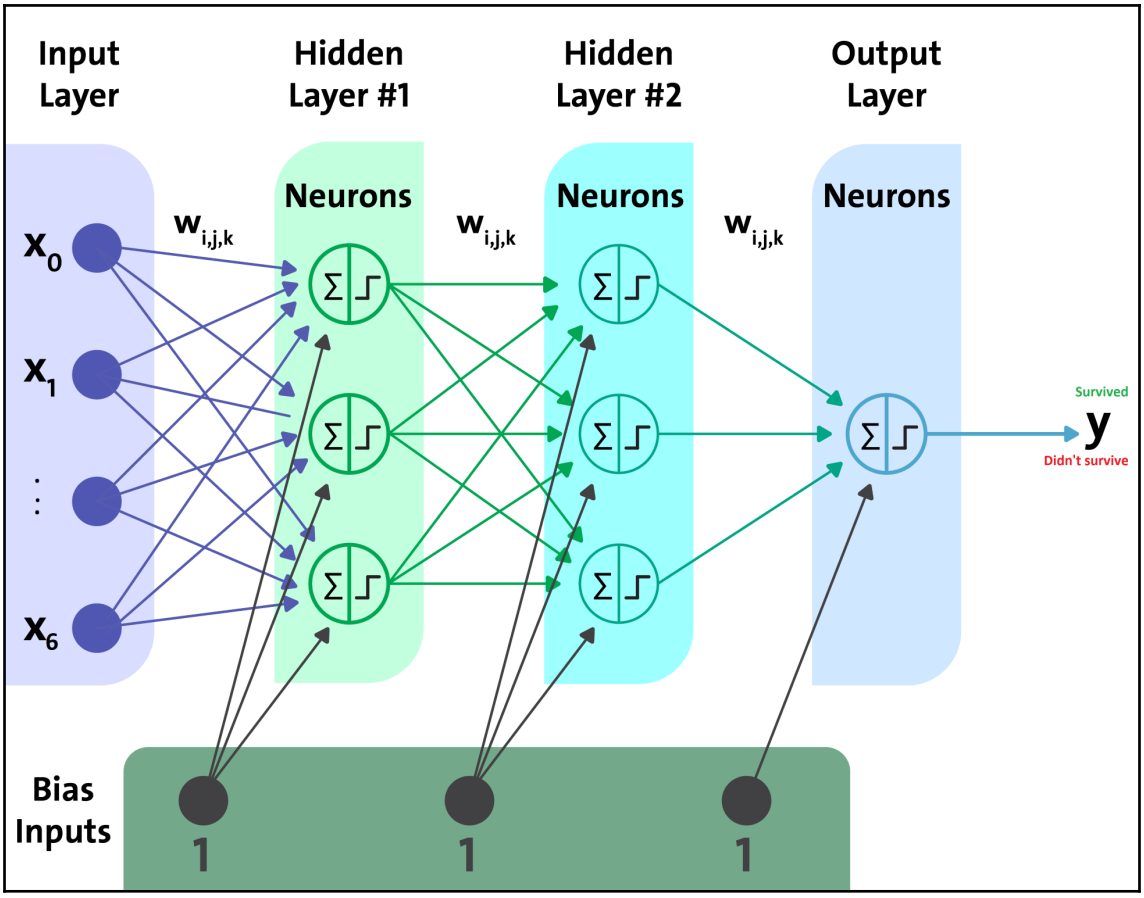
```
+-----+------+----------------+-----+--------+
| Name|   Sex|          Ticket|Cabin|Embarked|
+-----+------+----------------+-----+--------+
|  Mr.|  male|       A/5 21171| null|       S|
| Mrs.|female|        PC 17599|  C85|       C|
|Miss.|female|STON/O2. 3101282| null|       S|
| Mrs.|female|          113803| C123|       S|
|  Mr.|  male|          373450| null|       S|
+-----+------+----------------+-----+--------+
only showing top 5 rows
```

Chapter 2: Cancer Types Prediction Using Recurrent Type Networks



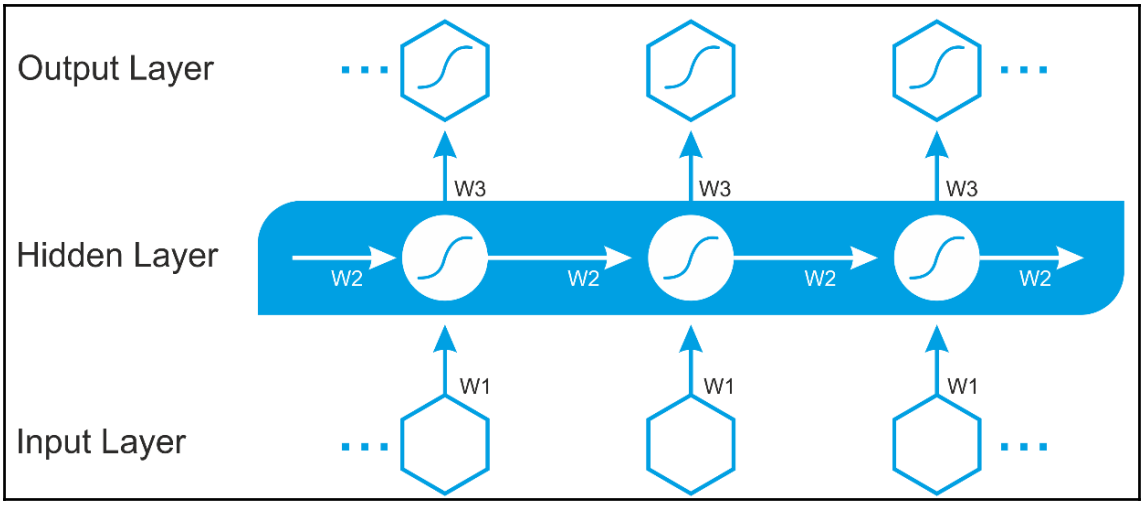
```
|        id|gene_0|         gene_1|        gene_2|        gene_3|        gene_4|
+---------+------+--------------+-------------+-------------+-------------+
| sample_0|   0.0| 2.01720929003|3.26552691165|5.47848651208|10.4319989607|
| sample_1|   0.0|0.592732094867|1.58842082049|7.58615673813|9.62301085621|
| sample_2|   0.0|  3.5117589779|4.32719871937|6.88178695937|9.87072997113|
| sample_3|   0.0| 3.66361787431|4.50764877794|6.65906827484|10.1961840717|
| sample_4|   0.0| 2.65574107476|2.82154695883|6.53945352515|9.73826456185|
| sample_5|   0.0| 3.46785331372|3.58191760772|6.62024328973|9.70682924127|
| sample_6|   0.0|   1.224966365|1.69117679681|6.57200741498|9.64051067136|
| sample_7|   0.0| 2.85485342652|1.75047787844|7.22672044861|9.75869126501|
| sample_8|   0.0| 3.99212487426|2.77273024777|6.54669231412|10.4882518866|
| sample_9|   0.0| 3.64249364243|4.42355800269|6.84951144203|9.46446610892|
|sample_10|   0.0| 3.49207108711|  3.553372792|7.15170663424|10.2534456958|
|sample_11|   0.0| 2.94118144936|2.66327629754|6.56168966691|9.37629255419|
|sample_12|   0.0|  3.9703475182|2.36429227014| 7.1454431001|9.24060531982|
|sample_13|   0.0|  1.5510483733|3.52984592804| 6.3268249381|10.6338489327|
|sample_14|   0.0|  1.9648421858|2.18301003676|6.59683230199|10.2481410545|
|sample_15|   0.0| 2.90137860229|3.68536833781|6.66966460873|9.99909803371|
|sample_16|   0.0|  3.4609128992|3.61847360308|5.66104837265|9.73121719013|
|sample_17|   0.0| 3.00451936963|3.00717755732|6.52420475302|9.06266141243|
|sample_18|   0.0| 1.54146527849|2.54153961931|6.84325527996|9.44446829832|
|sample_19|   0.0| 4.16758272913|3.84138948407|6.97612301373|9.98225207842|
+---------+------+--------------+-------------+-------------+-------------+
only showing top 20 rows
```

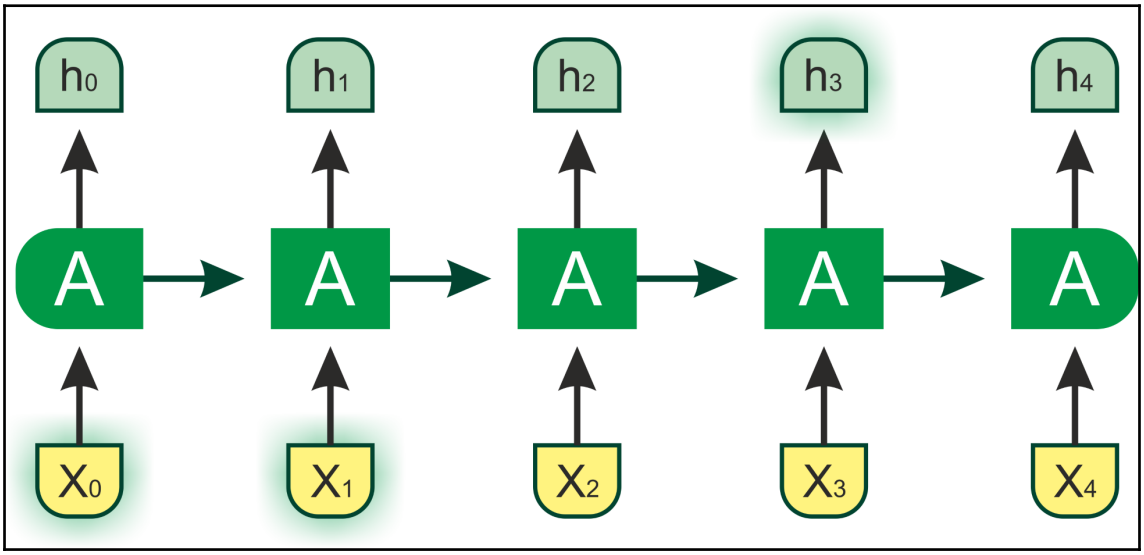
```
+---------+-----+
|       id|Class|
+---------+-----+
|sample_0| PRAD|
|sample_1| LUAD|
|sample_2| PRAD|
|sample_3| PRAD|
|sample_4| BRCA|
|sample_5| PRAD|
|sample_6| KIRC|
|sample_7| PRAD|
|sample_8| BRCA|
|sample_9| PRAD|
+---------+-----+
only showing top 10 rows
```

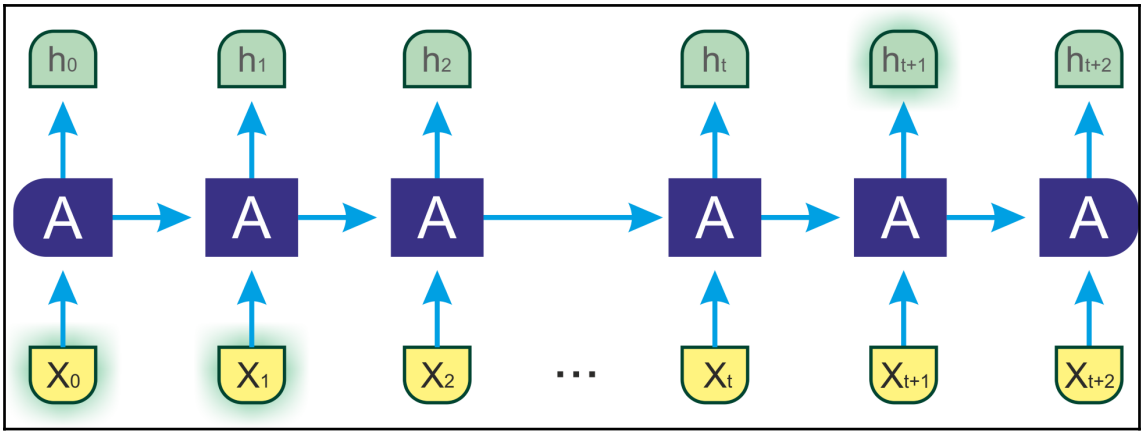

Input Layer
Hidden Layer #1
Hidden Layer #2
Output Layer
Neurons
Neurons
Neurons
$w_{i,j,k}$
$w_{i,j,k}$
$w_{i,j,k}$
x_0
x_1
x_6
Survived
y
Didn't survive
Bias Inputs
1
1
1

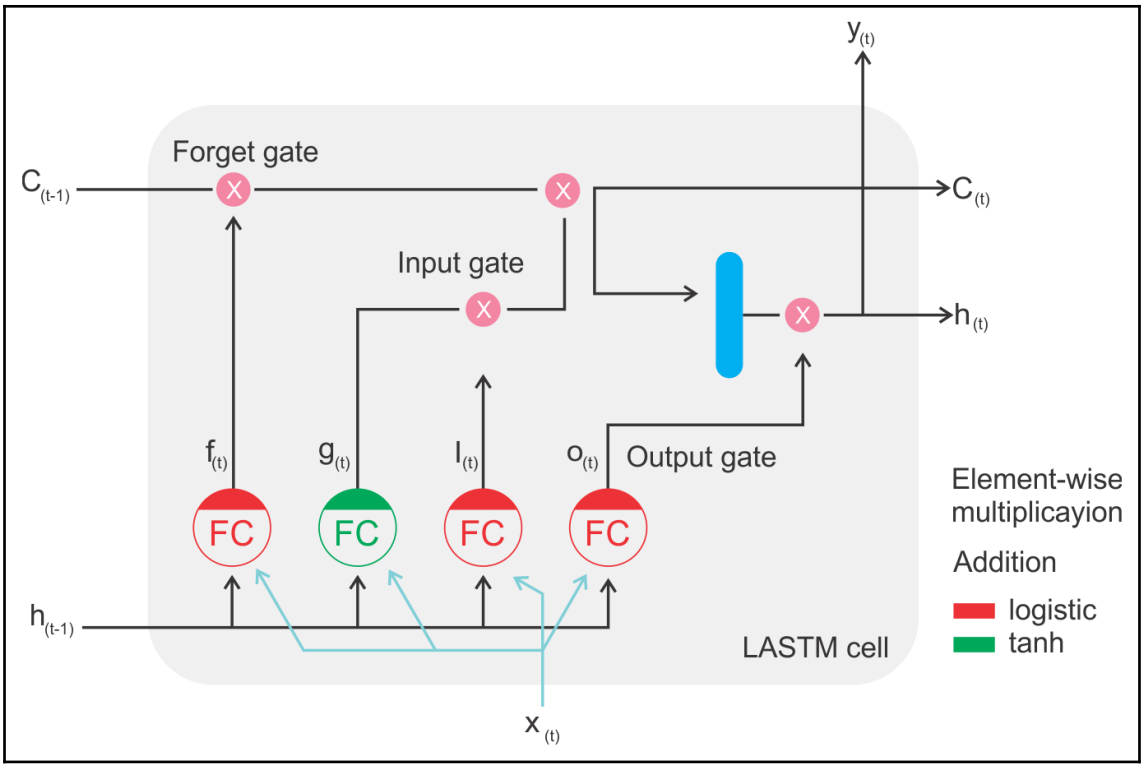
```
+--------+-----+
|      id|Class|
+--------+-----+
|sample_0| PRAD|
|sample_1| LUAD|
|sample_2| PRAD|
|sample_3| PRAD|
|sample_4| BRCA|
|sample_5| PRAD|
|sample_6| KIRC|
|sample_7| PRAD|
|sample_8| BRCA|
|sample_9| PRAD|
+--------+-----+
only showing top 10 rows
```

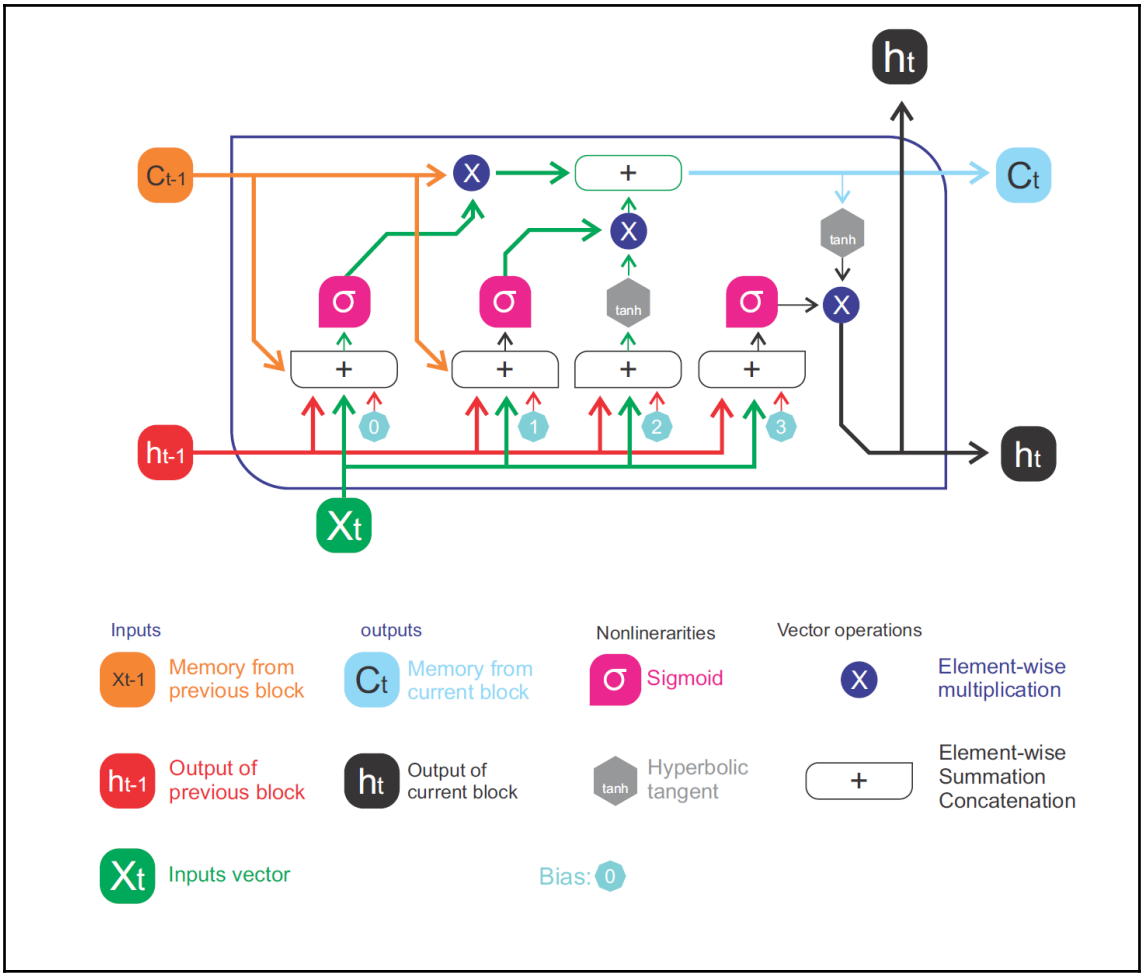
```
+-----+
|label|
+-----+
|    3|
|    2|
|    3|
|    3|
|    0|
|    3|
|    1|
|    3|
|    0|
|    3|
+-----+
only showing top 10 rows
```

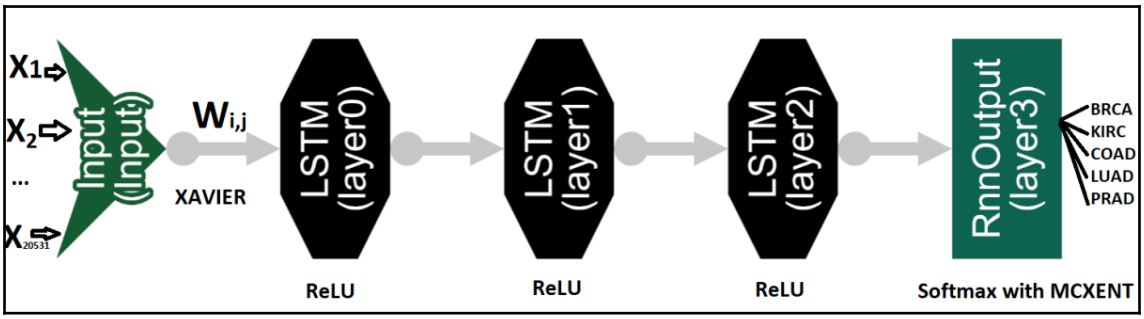

Output Layer
W3
W3
W3
Hidden Layer
W2
W2
W2
W2
W1
W1
W1
Input Layer

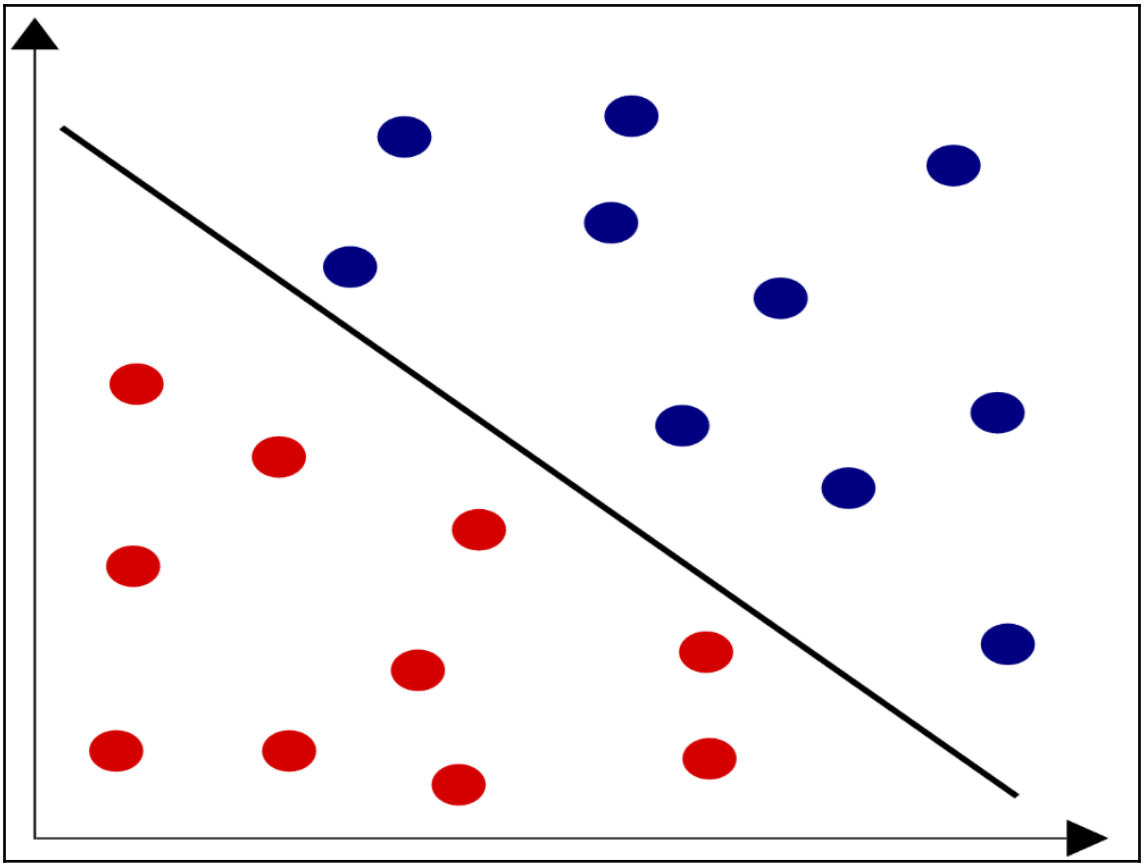

h0
h1
h2
h3
h4
A
A
A
A
A
X0
X1
X2
X3
X4

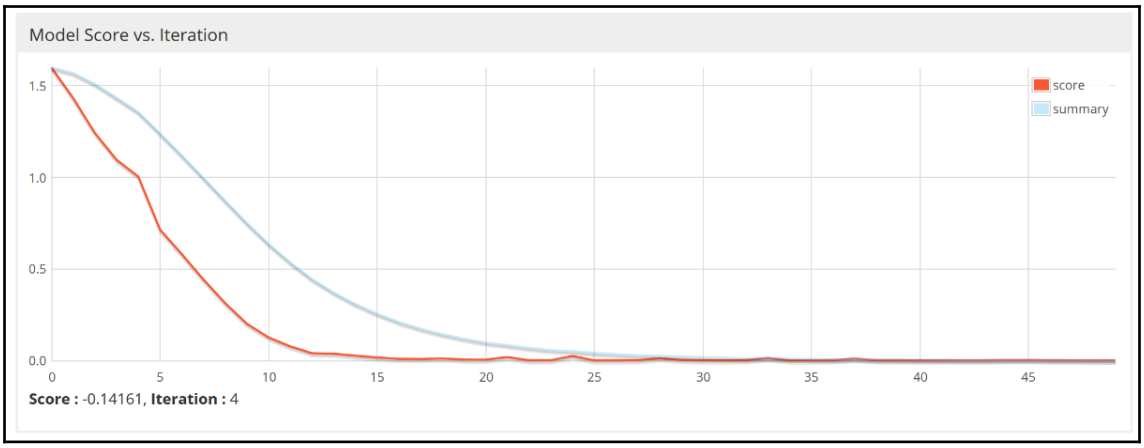

h0
h1
h2
ht
ht+1
ht+2
A
A
A
A
A
A
X0
X1
X2
...
Xt
Xt+1
Xt+2

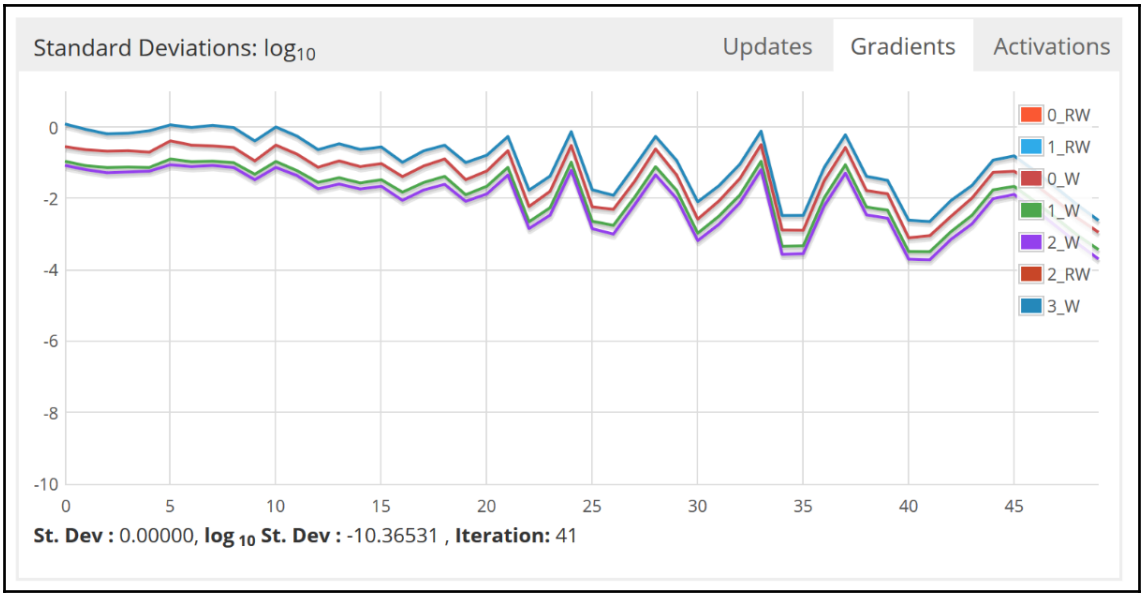

y(t)
Forget gate
C(t-1)
C(t)
Input gate
h(t)
f(t)
g(t)
I(t)
o(t)
Output gate
FC
FC
FC
FC
h(t-1)
LASTM cell
x (t)
Element-wise multiplicayion
Addition
logistic
tanh

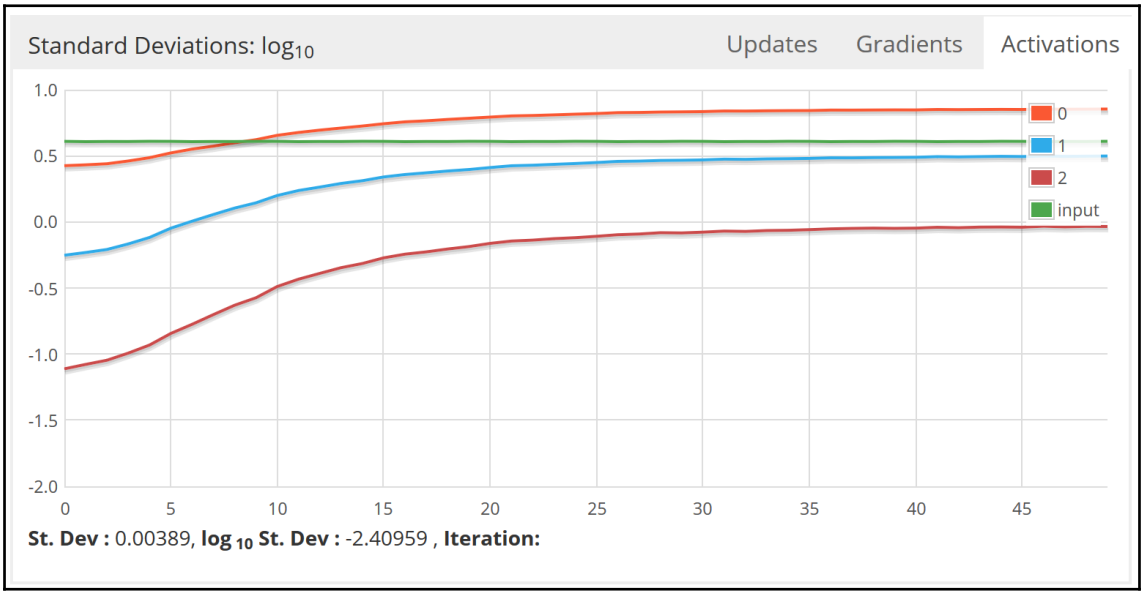

ht
Ct-1
Ct
tanh
ht-1
ht
Xt
Inputs
Memory from previous block
outputs
Memory from current block
Nonlinerarities
Sigmoid
Vector operations
Element-wise multiplication
Output of previous block
Output of current block
Hyperbolic tangent
Element-wise Summation Concatenation
Inputs vector
Bias: 0


X1
X2
...
X20531
Input (Input)
Wi,j
XAVIER
LSTM (layer0)
LSTM (layer1)
LSTM (layer2)
RnnOutput (layer3)
BRCA
KIRC
COAD
LUAD
PRAD
ReLU
ReLU
ReLU
Softmax with MCXENT

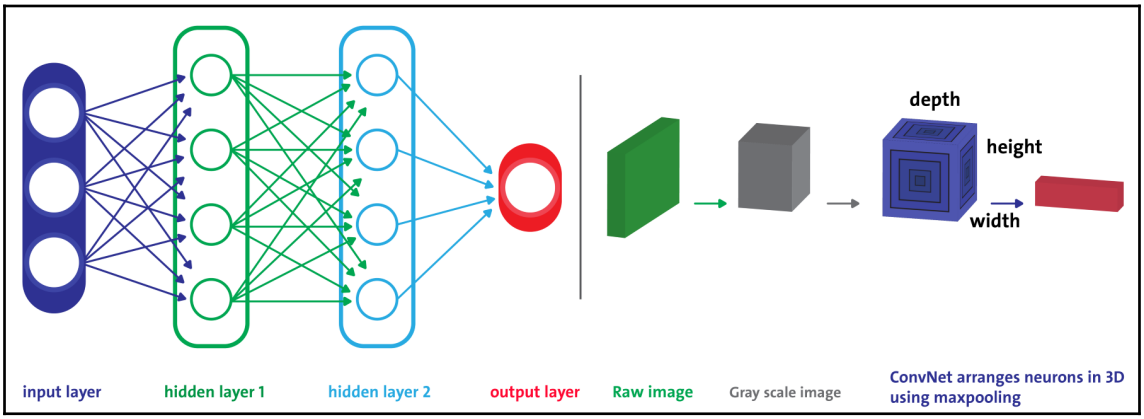


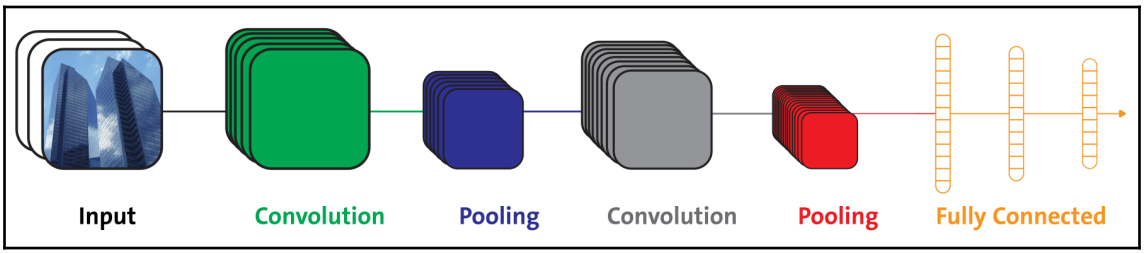

Model Score vs. Iteration
1.5
1.0
0.5
0.0
0
5
10
15
20
25
30
35
40
45
score
summary
Score : -0.14161, Iteration : 4

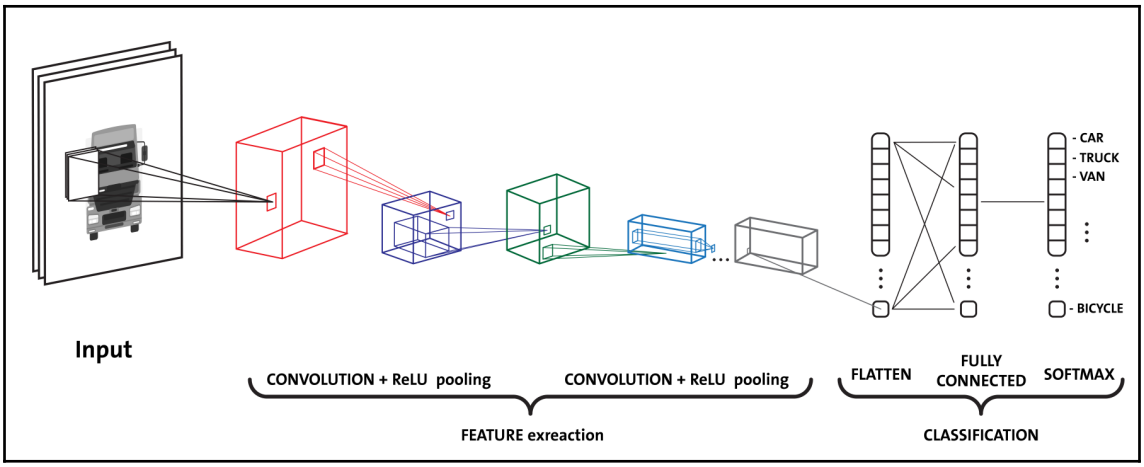

Standard Deviations: log10
Updates
Gradients
Activations
0
-2
-4
-6
-8
-10
0
5
10
15
20
25
30
35
40
45
0_RW
1_RW
0_W
1_W
2_W
2_RW
3_W
St. Dev : 0.00000, log 10 St. Dev : -10.36531 , Iteration: 41

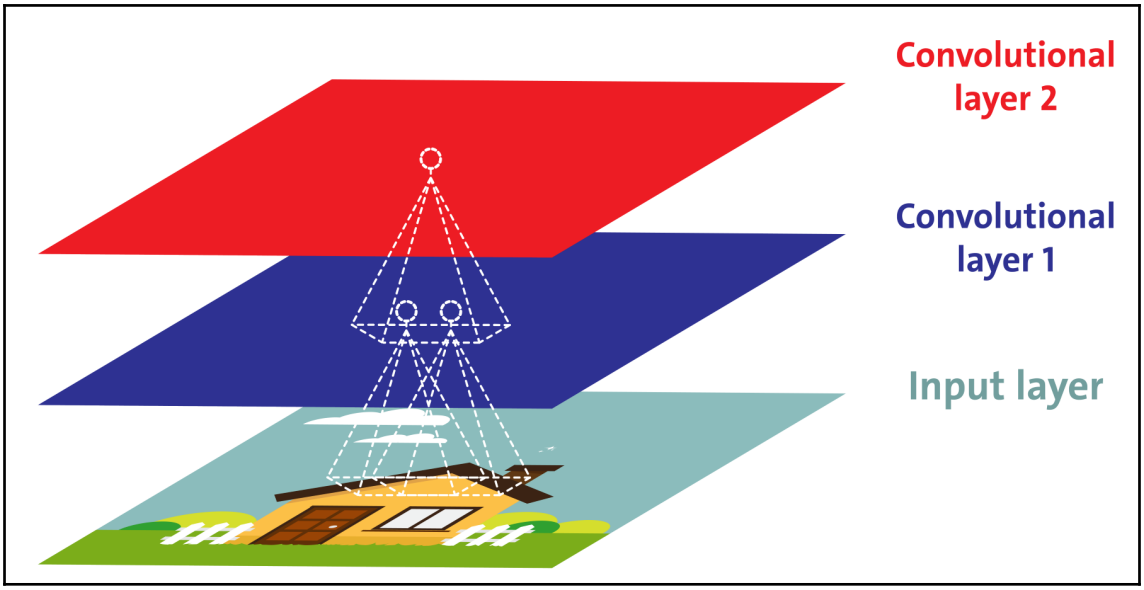

Standard Deviations: log10
Updates
Gradients
Activations
1.0
0.5
0.0
-0.5
-1.0
-1.5
-2.0
0
5
10
15
20
25
30
35
40
45
0
1
2
input
St. Dev : 0.00389, log 10 St. Dev : -2.40959 , Iteration:

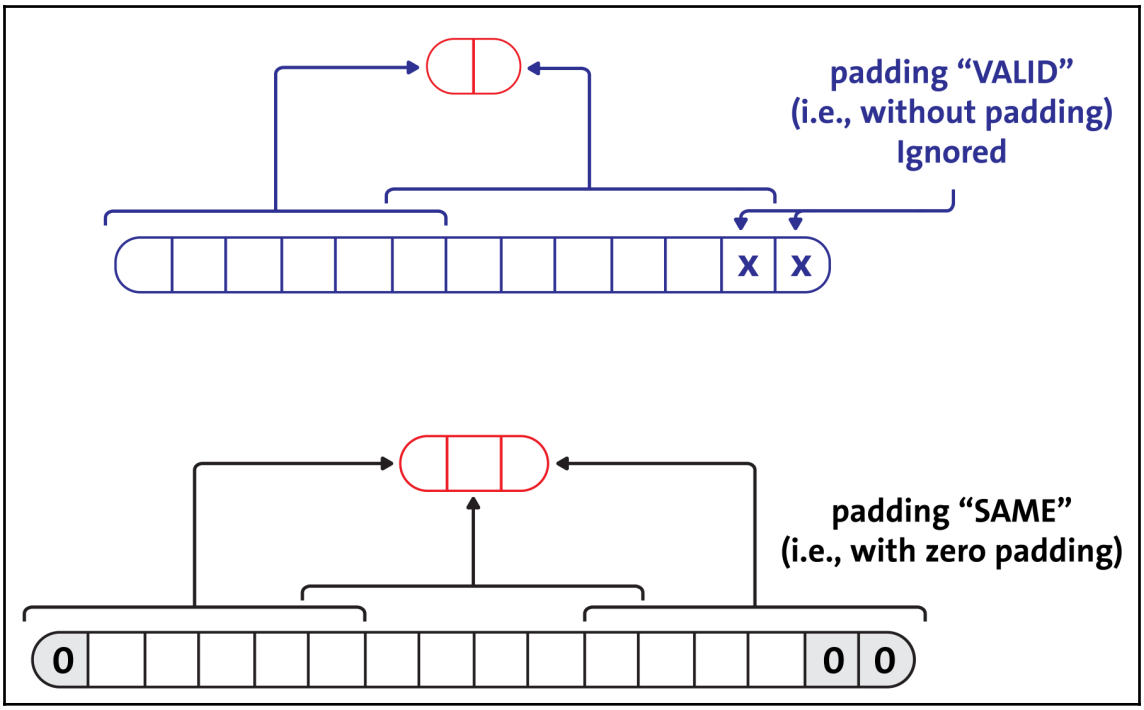
Chapter 3: Multi-Label Image Classification Using Convolutional Neural Networks

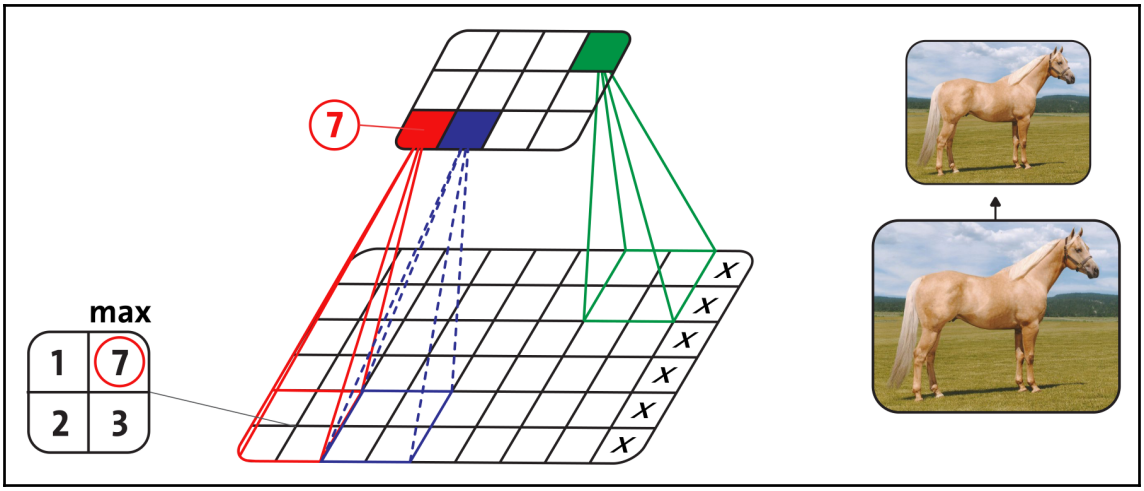




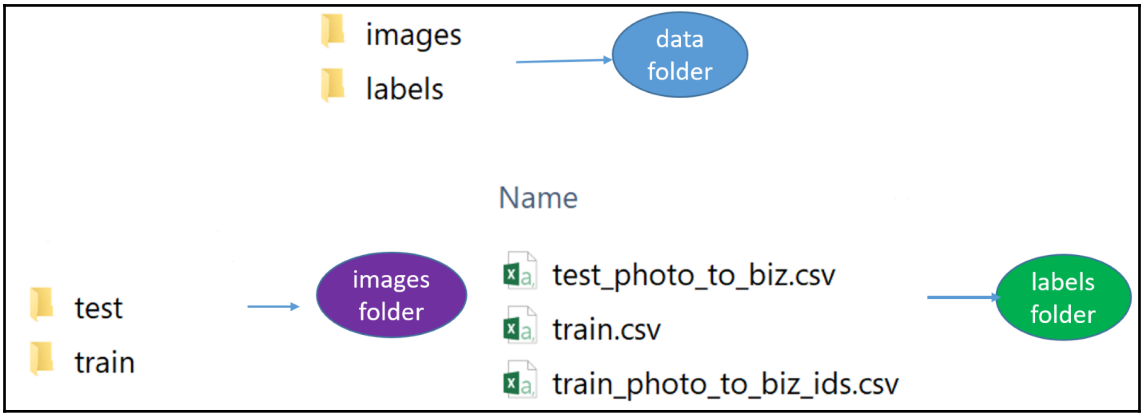


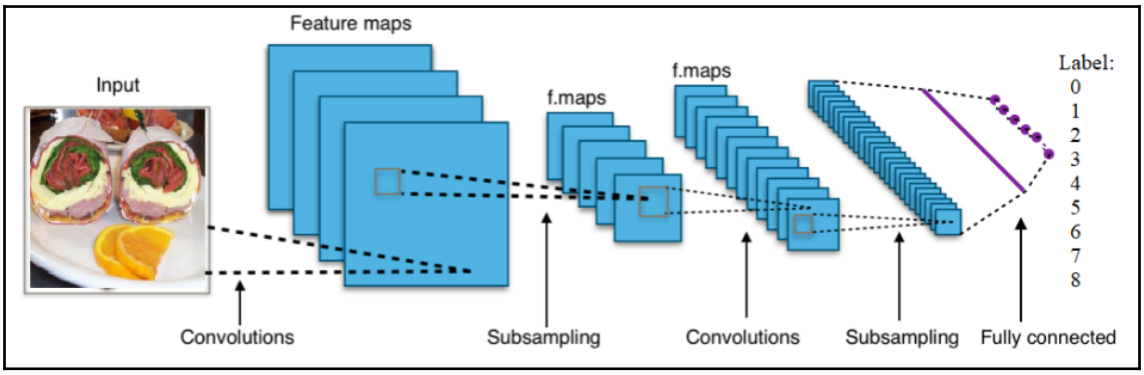

Convolutional layer 2
Convolutional layer 1
Input layer

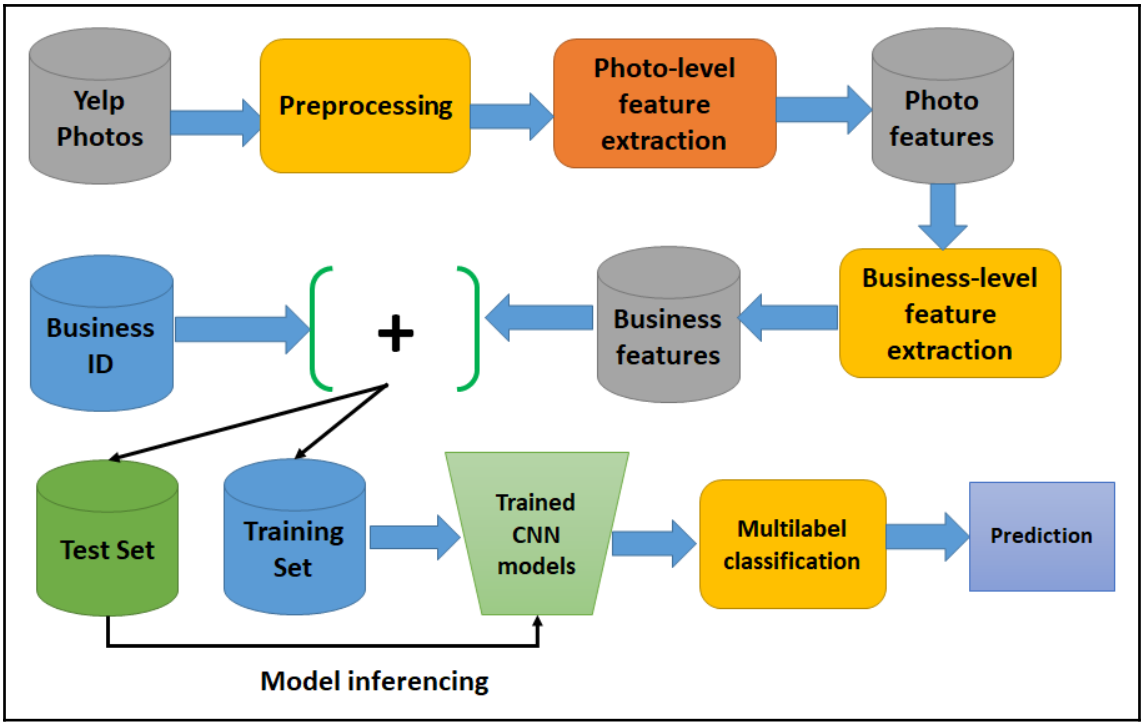

padding "VALID"
(i.e., without padding)
Ignored
X
X
padding "SAME"
(i.e., with zero padding)
0
0
0

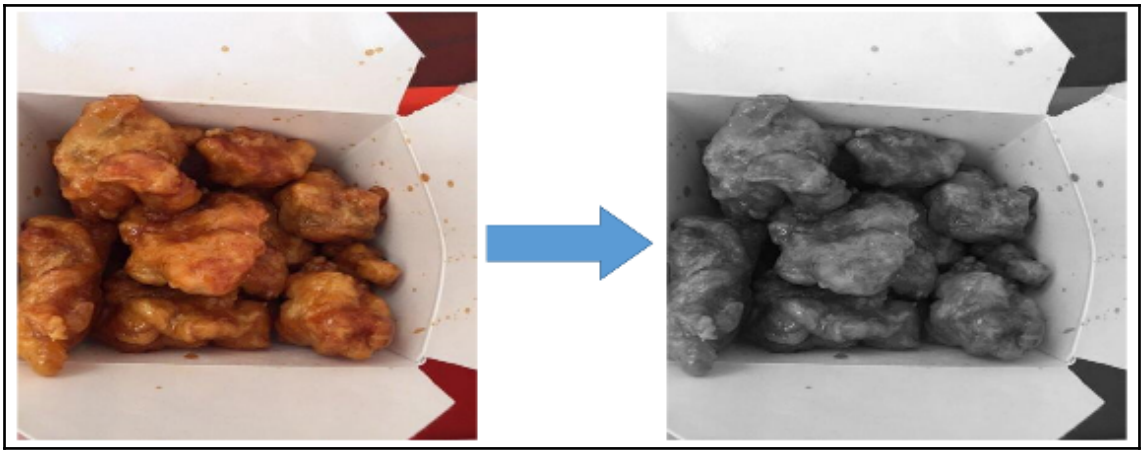

max
1
7
2
3
7

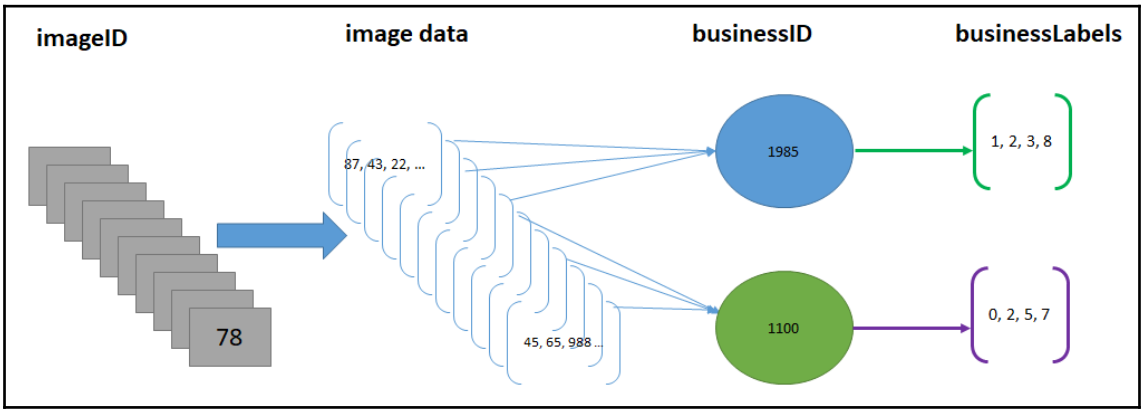

More business info
Takes Reservations No
Delivery No
Take-out Yes
Accepts Credit Cards Yes
Good For Breakfast
Parking Street
Bike Parking Yes
Wheelchair Accessible No
Good for kids No
Good for Groups No
Attire Casual
Ambience Casual

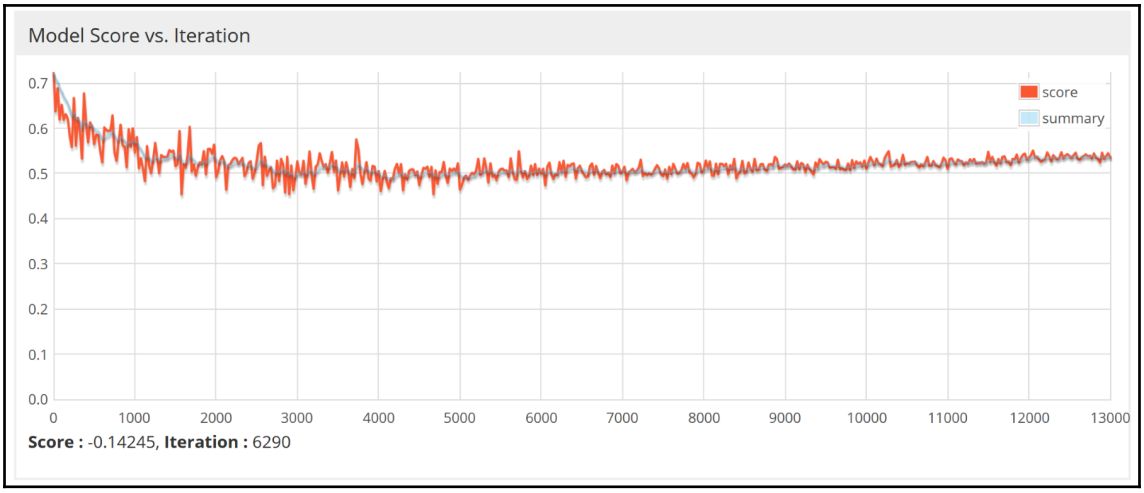

images
labels
data folder
Name
test
train
images folder
test_photo_to_biz.csv
train.csv
train_photo_to_biz_ids.csv
labels folder


Input
Feature maps
f.maps
f.maps
Label:
0
1
2
3
4
5
6
7
8
Convolutions
Subsampling
Convolutions
Subsampling
Fully connected

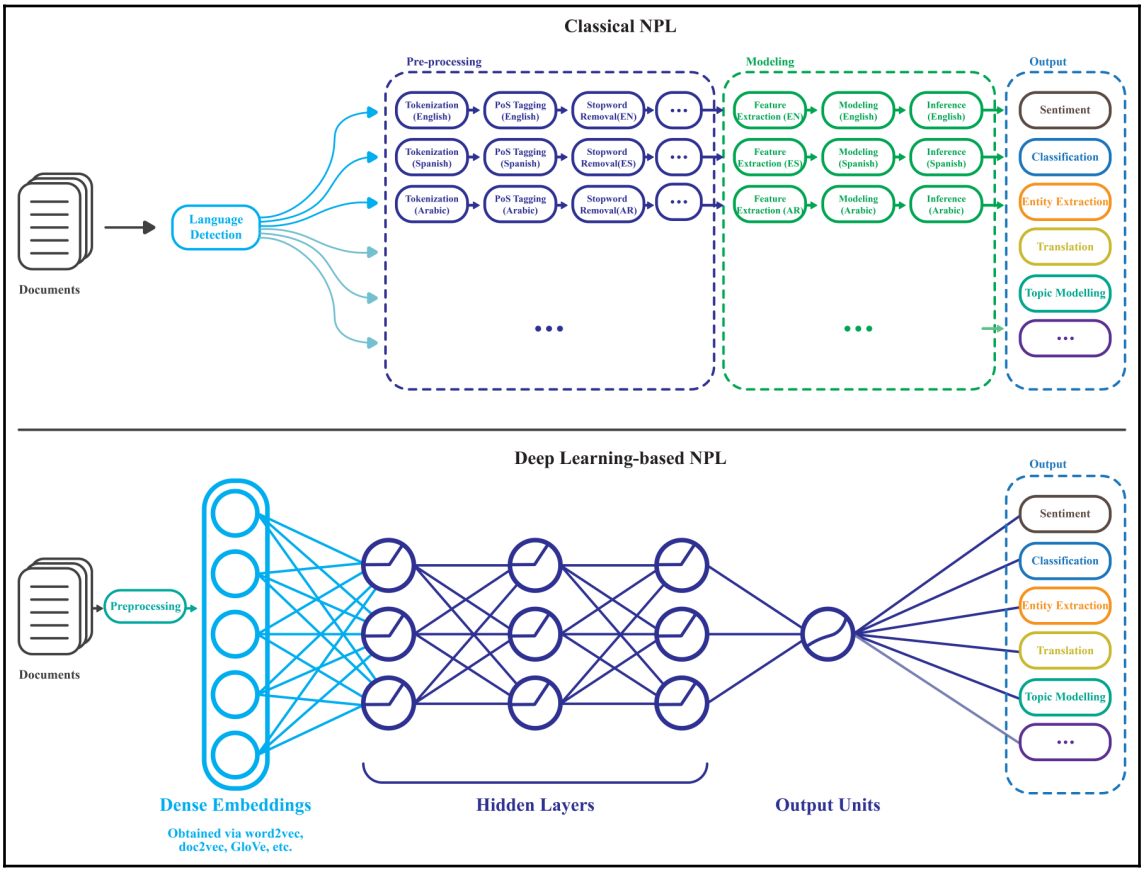

Yelp Photos
Preprocessing
Photo-level feature extraction
Photo features
Business-level feature extraction
Business features
Business ID
+
Test Set
Training Set
Trained CNN models
Multilabel classification
Prediction
Model inferencing

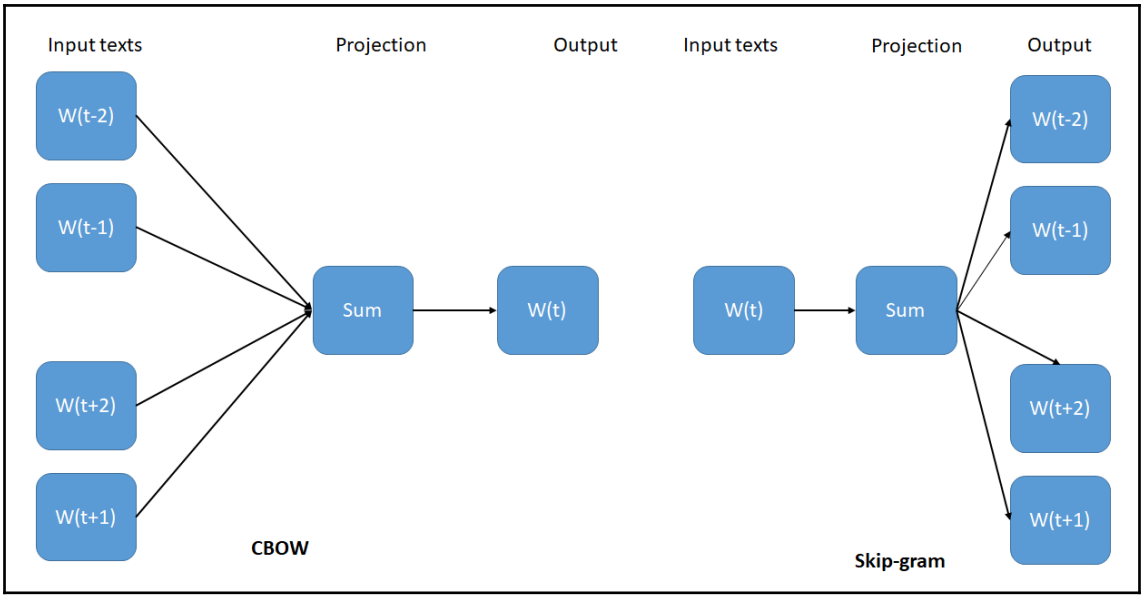


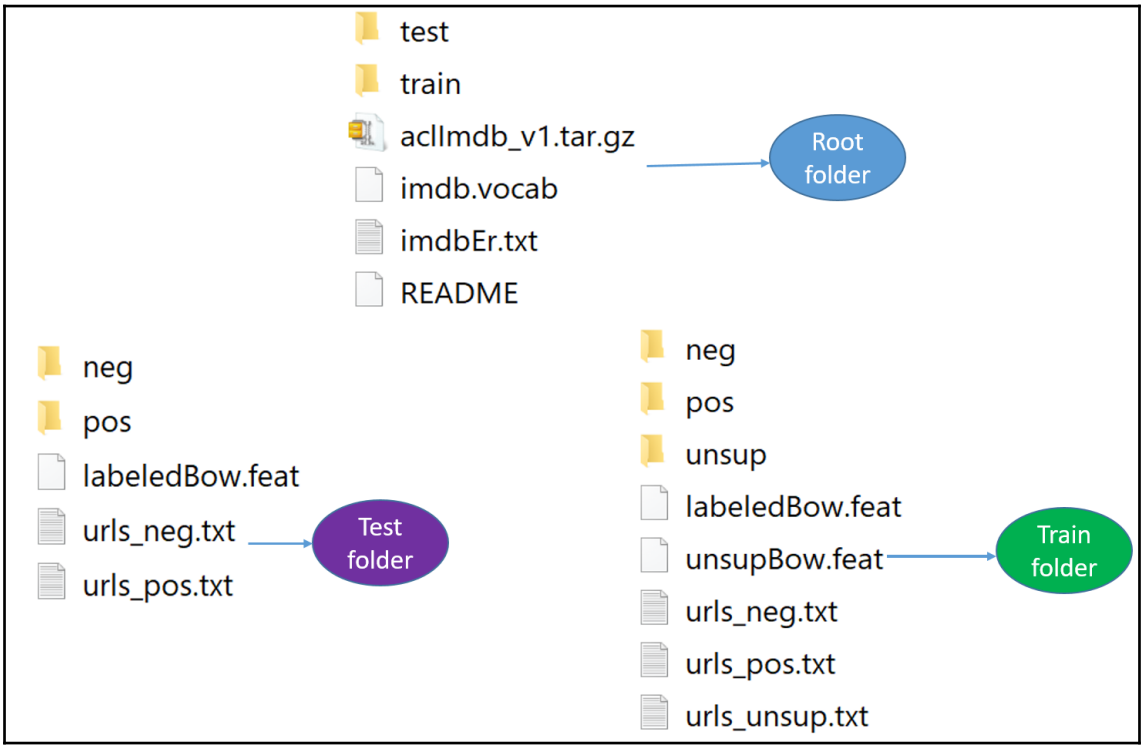

imageID
image data
businessID
businessLabels
78
87, 43, 22, ...
45, 65, 988 ...
1985
1100
1, 2, 3, 8
0, 2, 5, 7


Model Score vs. Iteration
score
summary
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
11000
12000
13000
Score : -0.14245, Iteration : 6290

Chapter 4: Sentiment Analysis Using Word2Vec and LSTM Network

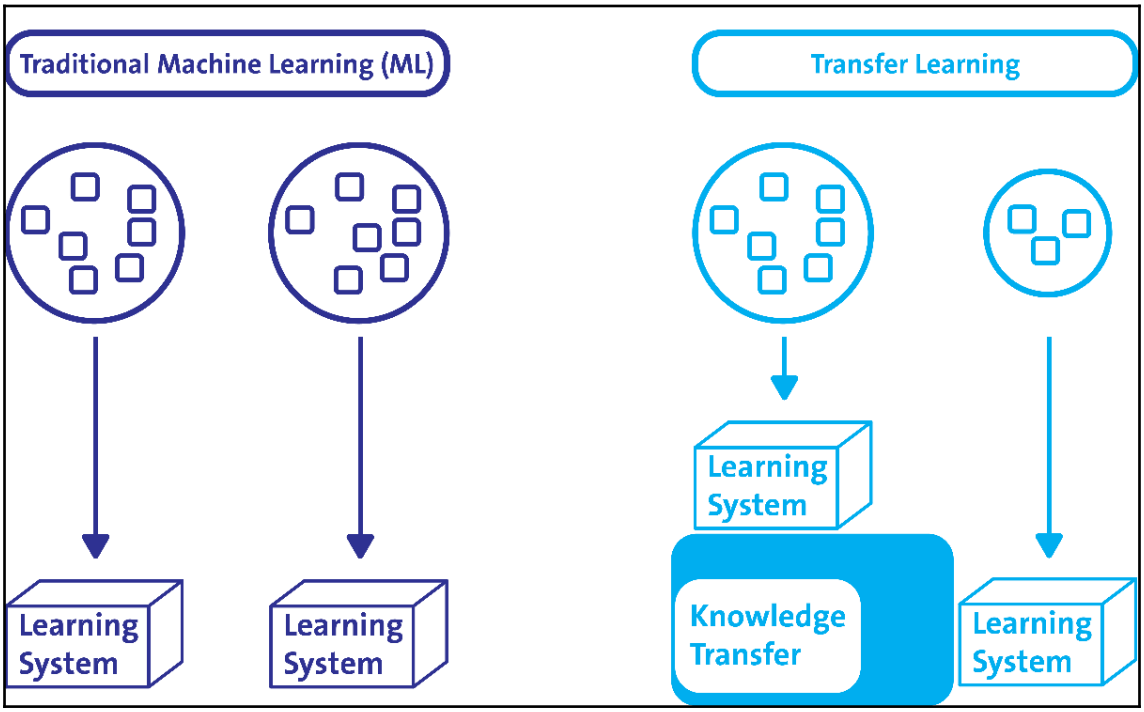


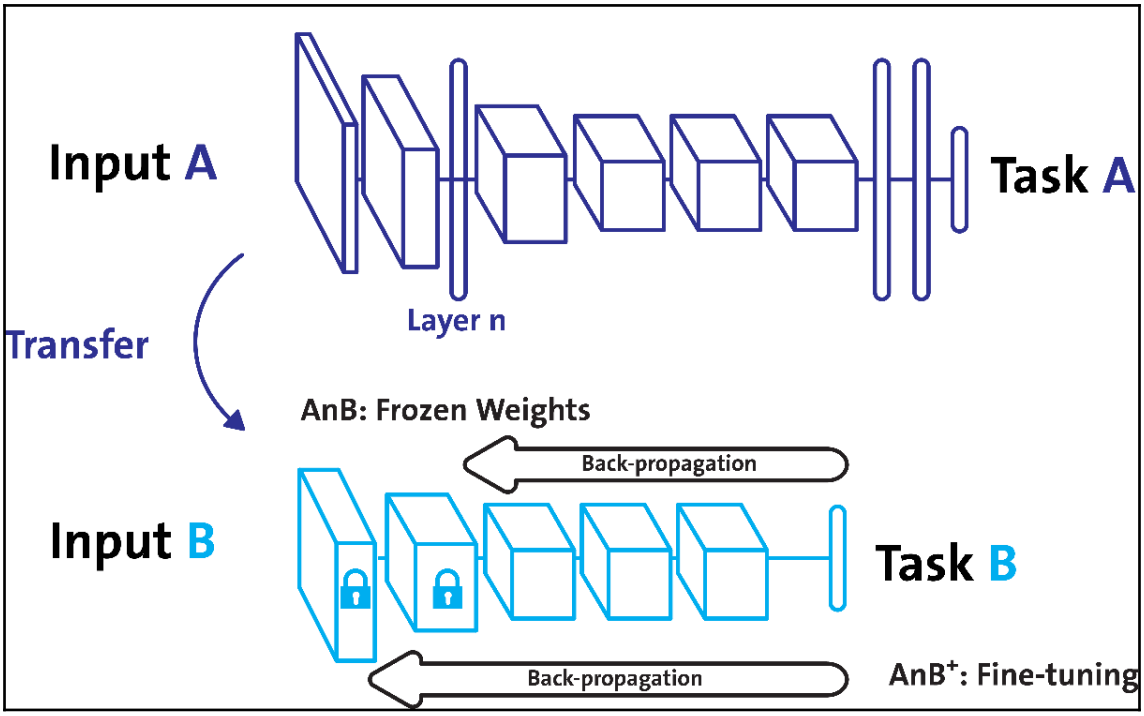

Input texts
Projection
Output
W(t-2)
W(t-1)
W(t+2)
W(t+1)
Sum
W(t)
CBOW
Input texts
Projection
Output
W(t)
Sum
W(t-2)
W(t-1)
W(t+2)
W(t+1)
Skip-gram

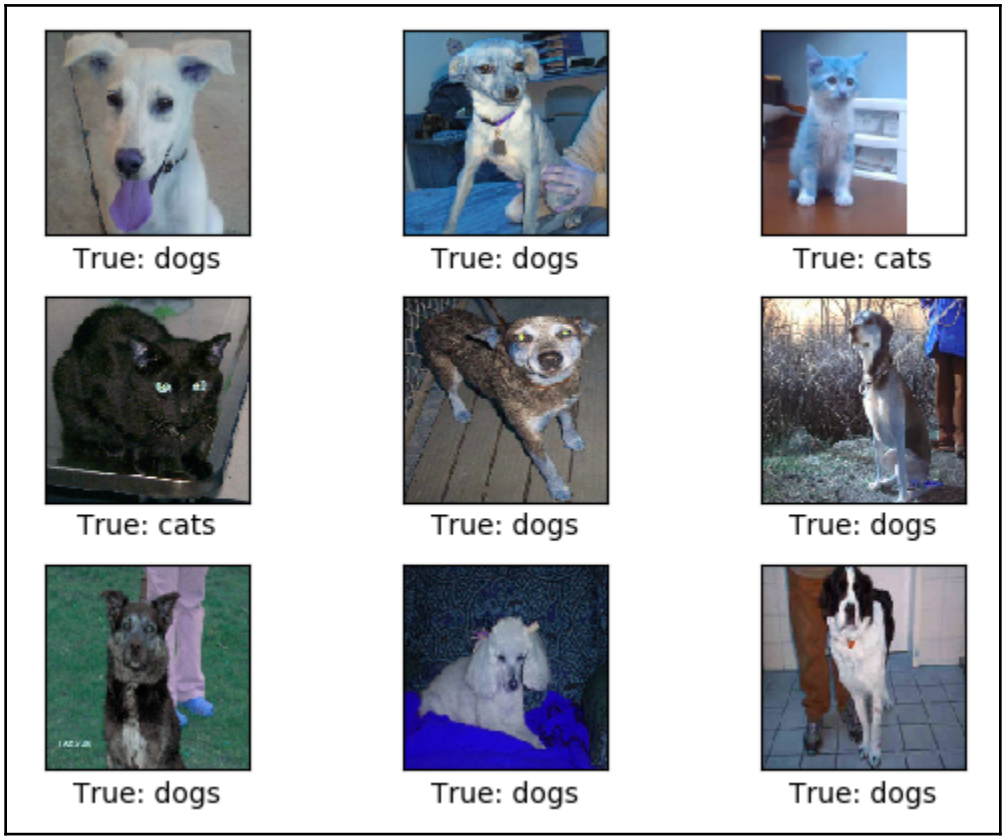

test
train
aclImdb_v1.tar.gz
imdb.vocab
imdbEr.txt
README
Root folder
neg
pos
labeledBow.feat
urls_neg.txt
urls_pos.txt
Test folder
neg
pos
unsup
labeledBow.feat
unsupBow.feat
urls_neg.txt
urls_pos.txt
urls_unsup.txt
Train folder

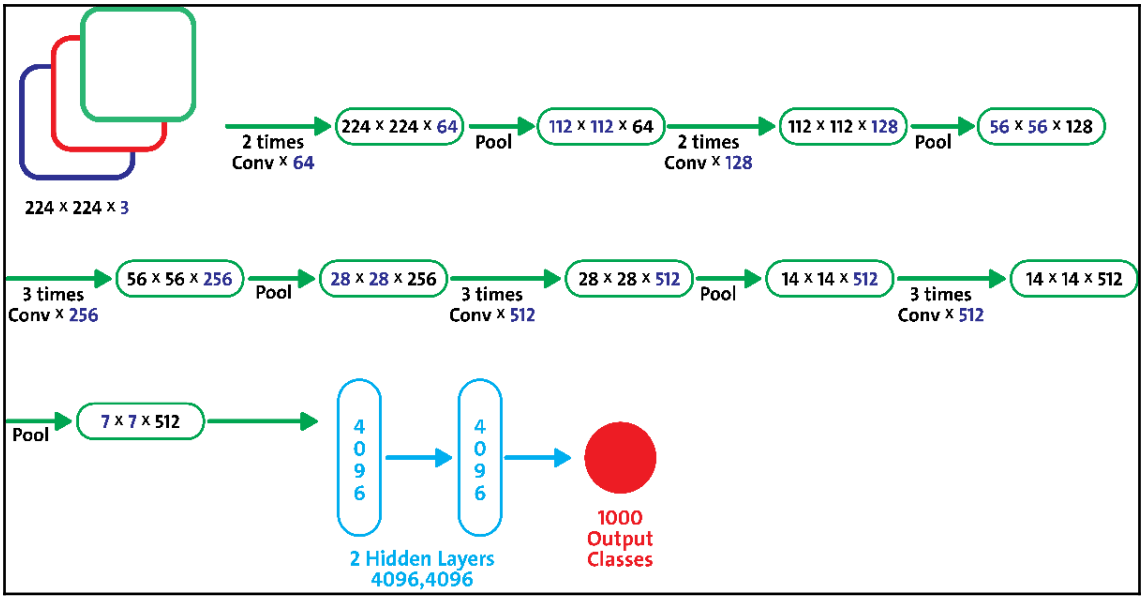

Model Score vs. Iteration
score
summary
Score : -0.02342, Iteration : 299
Model and Training Information
Model Type MultiLayerNetwork
Layers 2
Total Parameters 571650
Start Time
Total Runtime
Last Update 2018-04-22 15:14:51
Total Parameter Updates 1326
Updates/sec .41
Examples/sec 26.11
Update:Parameter Ratios (Mean Magnitudes): log10
0_RW
0_W
1_W
Ratio : 0.00008, log 10 Ratio : -4.07380 , Iteration: 3
Standard Deviations: log10
Updates
Gradients
Activations
0
input
St. Dev : 0.00191, log 10 St. Dev : -2.71833 , Iteration: 476

Chapter 5: Transfer Learning for Image Classification

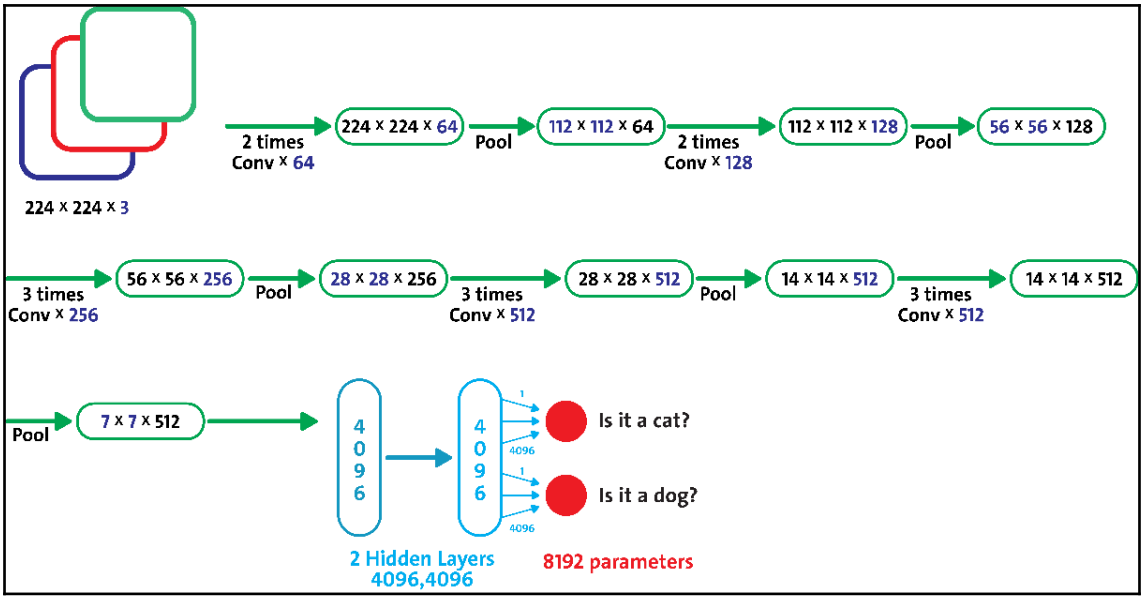



Input A
Task A
Layer n
Transfer
AnB: Frozen Weights
Back-propagation
Input B
Task B
Back-propagation
AnB+: Fine-tuning

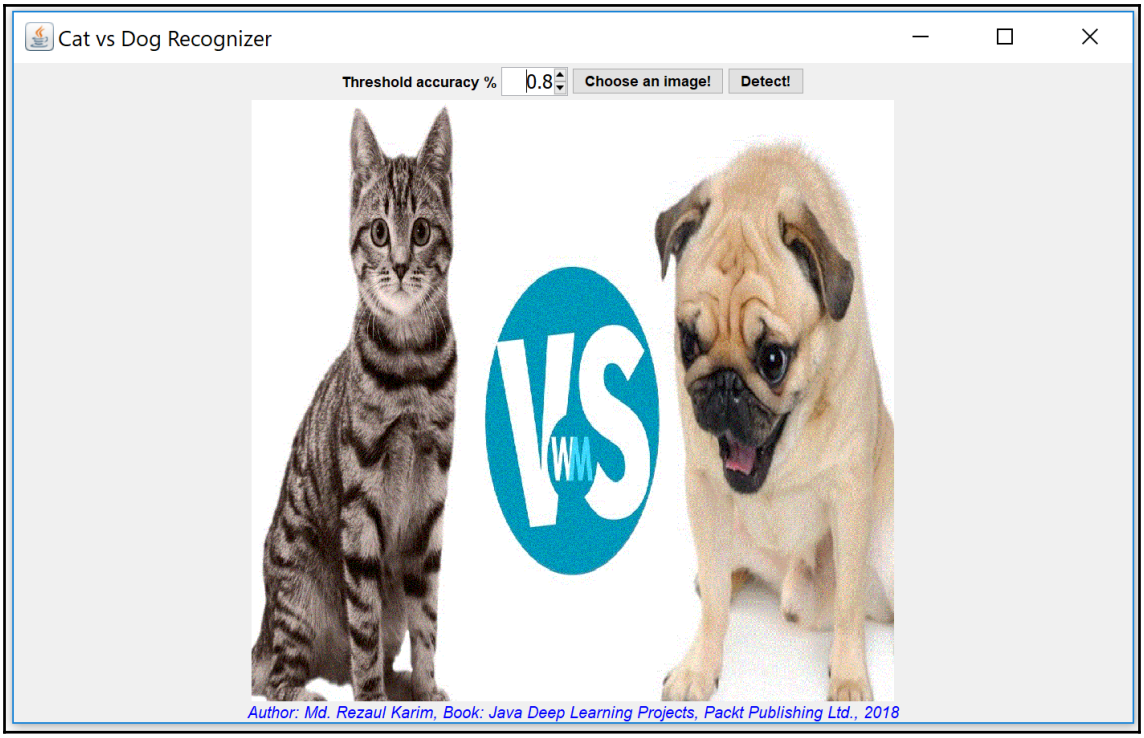

True: dogs
True: dogs
True: cats
True: cats
True: dogs
True: dogs
True: dogs
True: dogs
True: dogs

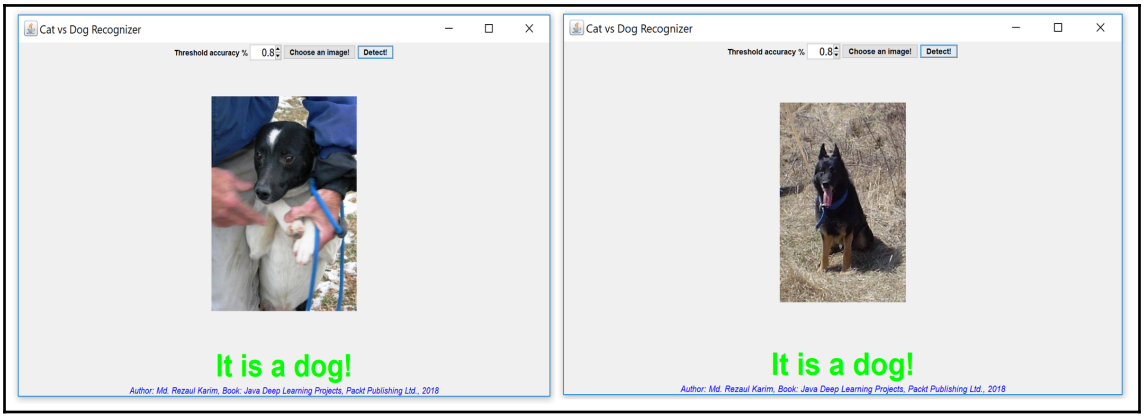


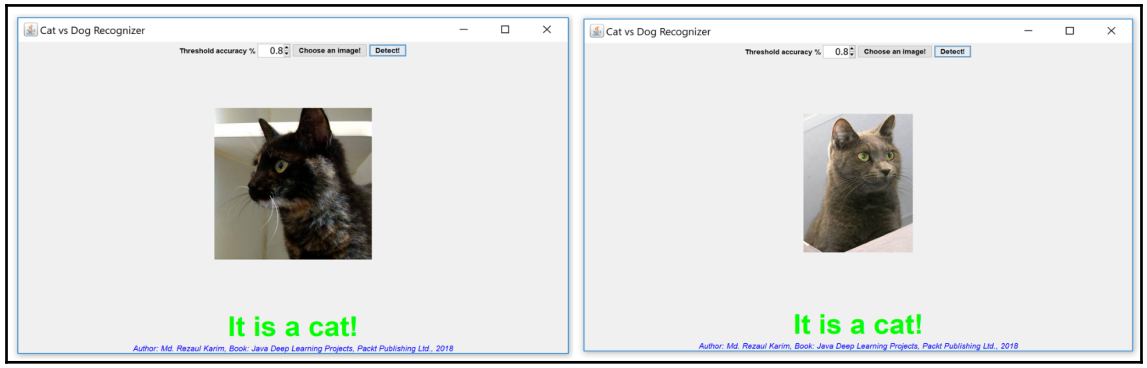

```
==================================================================================================================
VertexName (VertexType)                 nIn,nOut  TotalParams ParamsShape                                Vertex Inputs
==================================================================================================================
input_1 (InputVertex)                   -,-       -           -                                         -
block1_conv1 (ConvolutionLayer)         3,64      1792        W:{64,3,3,3}, b:{1,64}                    [input_1]
block1_conv2 (ConvolutionLayer)         64,64     36928       W:{64,64,3,3}, b:{1,64}                   [block1_conv1]
block1_pool (SubsamplingLayer)          -,-       0           -                                         [block1_conv2]
block2_conv1 (ConvolutionLayer)         64,128    73856       W:{128,64,3,3}, b:{1,128}                 [block1_pool]
block2_conv2 (ConvolutionLayer)         128,128   147584      W:{128,128,3,3}, b:{1,128}                [block2_conv1]
block2_pool (SubsamplingLayer)          -,-       0           -                                         [block2_conv2]
block3_conv1 (ConvolutionLayer)         128,256   295168      W:{256,128,3,3}, b:{1,256}                [block2_pool]
block3_conv2 (ConvolutionLayer)         256,256   590080      W:{256,256,3,3}, b:{1,256}                [block3_conv1]
block3_conv3 (ConvolutionLayer)         256,256   590080      W:{256,256,3,3}, b:{1,256}                [block3_conv2]
block3_pool (SubsamplingLayer)          -,-       0           -                                         [block3_conv3]
block4_conv1 (ConvolutionLayer)         256,512   1180160     W:{512,256,3,3}, b:{1,512}                [block3_pool]
block4_conv2 (ConvolutionLayer)         512,512   2359808     W:{512,512,3,3}, b:{1,512}                [block4_conv1]
block4_conv3 (ConvolutionLayer)         512,512   2359808     W:{512,512,3,3}, b:{1,512}                [block4_conv2]
block4_pool (SubsamplingLayer)          -,-       0           -                                         [block4_conv3]
block5_conv1 (ConvolutionLayer)         512,512   2359808     W:{512,512,3,3}, b:{1,512}                [block4_pool]
block5_conv2 (ConvolutionLayer)         512,512   2359808     W:{512,512,3,3}, b:{1,512}                [block5_conv1]
block5_conv3 (ConvolutionLayer)         512,512   2359808     W:{512,512,3,3}, b:{1,512}                [block5_conv2]
block5_pool (SubsamplingLayer)          -,-       0           -                                         [block5_conv3]
flatten (PreprocessorVertex)            -,-       -           -                                         [block5_pool]
fc1 (DenseLayer)                        25088,4096102764544   W:{25088,4096}, b:{1,4096}                [flatten]
fc2 (DenseLayer)                        4096,4096 16781312    W:{4096,4096}, b:{1,4096}                 [fc1]
predictions (DenseLayer)                4096,1000 4097000     W:{4096,1000}, b:{1,1000}                 [fc2]
------------------------------------------------------------------------------------------------------------------
            Total Parameters:  138357544
        Trainable Parameters:  138357544
           Frozen Parameters:  0
==================================================================================================================
```



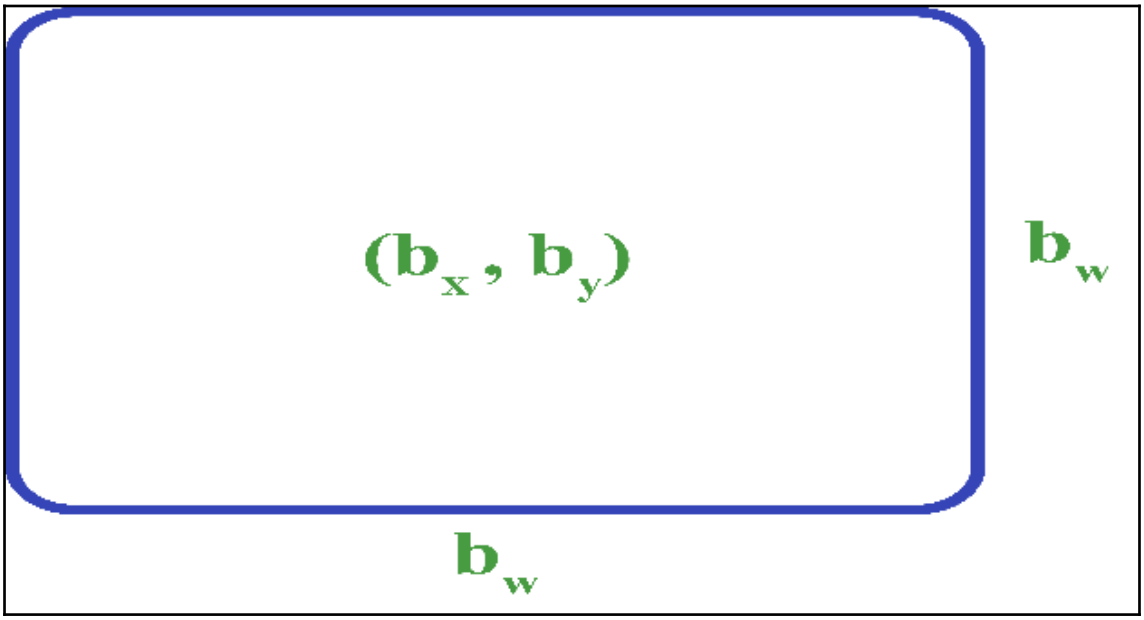

```
==================================================================================================================
VertexName (VertexType)                 nIn,nOut  TotalParams ParamsShape                                Vertex Inputs
==================================================================================================================
input_1 (InputVertex)                   -,-       -           -                                          -
block1_conv1 (Frozen ConvolutionLayer)  3,64      1792        W:{64,3,3,3}, b:{1,64}                     [input_1]
block1_conv2 (Frozen ConvolutionLayer)  64,64     36928       W:{64,64,3,3}, b:{1,64}                    [block1_conv1]
block1_pool (Frozen SubsamplingLayer)   -,-       0           -                                          [block1_conv2]
block2_conv1 (Frozen ConvolutionLayer)  64,128    73856       W:{128,64,3,3}, b:{1,128}                  [block1_pool]
block2_conv2 (Frozen ConvolutionLayer)  128,128   147584      W:{128,128,3,3}, b:{1,128}                 [block2_conv1]
block2_pool (Frozen SubsamplingLayer)   -,-       0           -                                          [block2_conv2]
block3_conv1 (Frozen ConvolutionLayer)  128,256   295168      W:{256,128,3,3}, b:{1,256}                 [block2_pool]
block3_conv2 (Frozen ConvolutionLayer)  256,256   590080      W:{256,256,3,3}, b:{1,256}                 [block3_conv1]
block3_conv3 (Frozen ConvolutionLayer)  256,256   590080      W:{256,256,3,3}, b:{1,256}                 [block3_conv2]
block3_pool (Frozen SubsamplingLayer)   -,-       0           -                                          [block3_conv3]
block4_conv1 (Frozen ConvolutionLayer)  256,512   1180160     W:{512,256,3,3}, b:{1,512}                 [block3_pool]
block4_conv2 (Frozen ConvolutionLayer)  512,512   2359808     W:{512,512,3,3}, b:{1,512}                 [block4_conv1]
block4_conv3 (Frozen ConvolutionLayer)  512,512   2359808     W:{512,512,3,3}, b:{1,512}                 [block4_conv2]
block4_pool (Frozen SubsamplingLayer)   -,-       0           -                                          [block4_conv3]
block5_conv1 (Frozen ConvolutionLayer)  512,512   2359808     W:{512,512,3,3}, b:{1,512}                 [block4_pool]
block5_conv2 (Frozen ConvolutionLayer)  512,512   2359808     W:{512,512,3,3}, b:{1,512}                 [block5_conv1]
block5_conv3 (Frozen ConvolutionLayer)  512,512   2359808     W:{512,512,3,3}, b:{1,512}                 [block5_conv2]
block5_pool (Frozen SubsamplingLayer)   -,-       0           -                                          [block5_conv3]
flatten (PreprocessorVertex)            -,-       -           -                                          [block5_pool]
fc1 (Frozen DenseLayer)                 25088,4096102764544   W:{25088,4096}, b:{1,4096}                 [flatten]
fc2 (Frozen DenseLayer)                 4096,4096 16781312    W:{4096,4096}, b:{1,4096}                  [fc1]
predictions (OutputLayer)               4096,2    8194        W:{4096,2}, b:{1,2}                        [fc2]
------------------------------------------------------------------------------------------------------------------
            Total Parameters:  134268738
        Trainable Parameters:  8194
           Frozen Parameters:  134260544
==================================================================================================================
```

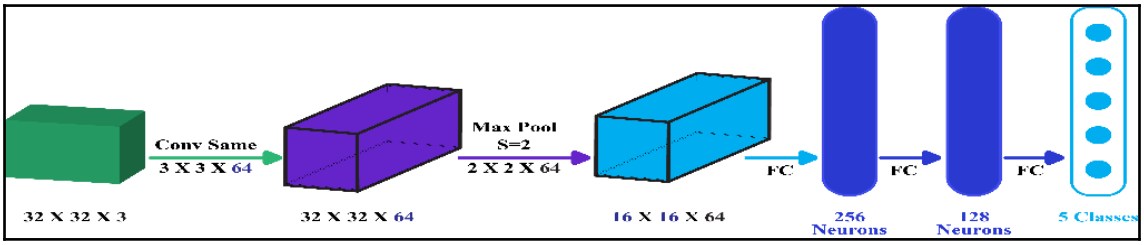

Cat vs Dog Recognizer
Threshold accuracy %
0.8
Choose an image!
Detect!
VS
Author: Md. Rezaul Karim, Book: Java Deep Learning Projects, Packt Publishing Ltd., 2018

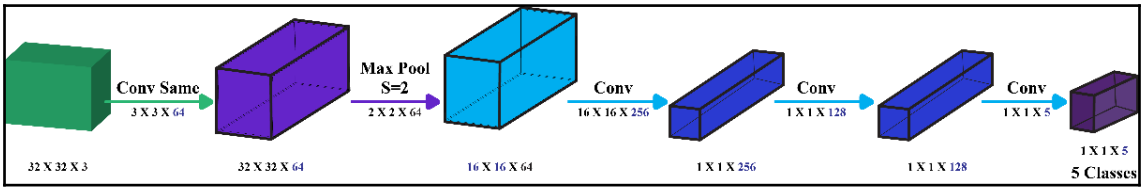

Cat vs Dog Recognizer
Threshold accuracy %
0.8
Choose an image!
Detect!
It is a dog!
Author: Md. Rezaul Karim, Book: Java Deep Learning Projects, Packt Publishing Ltd., 2018
Cat vs Dog Recognizer
Threshold accuracy %
0.8
Choose an image!
Detect!
It is a dog!
Author: Md. Rezaul Karim, Book: Java Deep Learning Projects, Packt Publishing Ltd., 2018

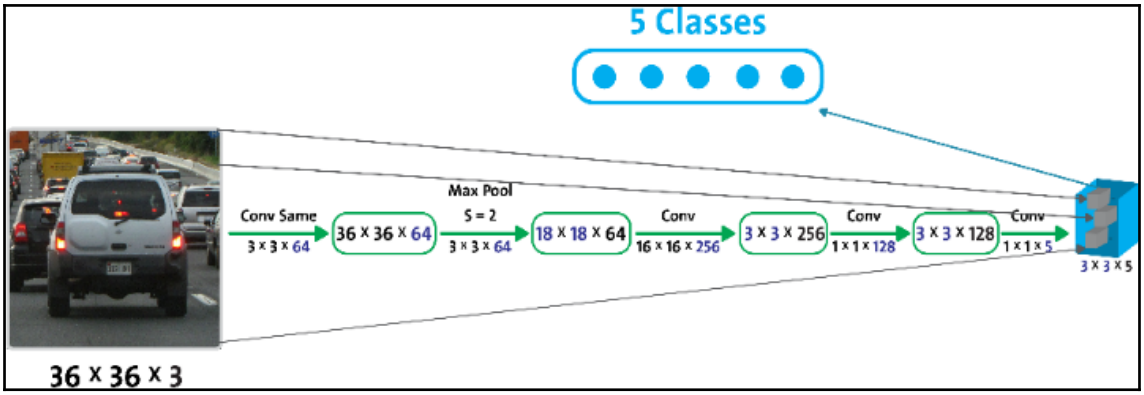

Cat vs Dog Recognizer
Threshold accuracy %
0.8
Choose an image!
Detect!
It is a cat!
Author: Md. Rezaul Karim, Book: Java Deep Learning Projects, Packt Publishing Ltd., 2018
Cat vs Dog Recognizer
Threshold accuracy %
0.8
Choose an image!
Detect!
It is a cat!
Author: Md. Rezaul Karim, Book: Java Deep Learning Projects, Packt Publishing Ltd., 2018

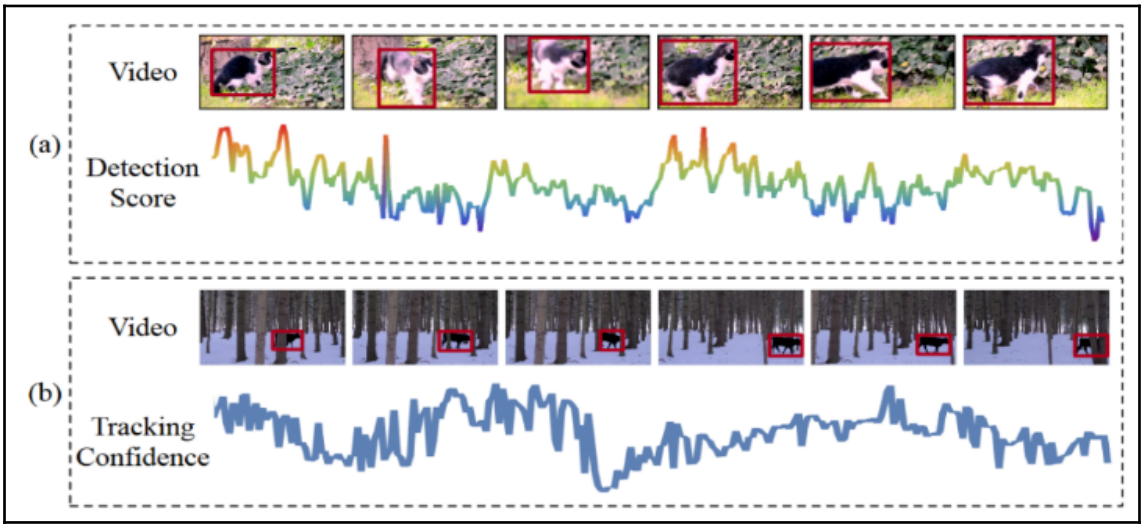
Chapter 6: Real-Time Object Detection using YOLO, JavaCV, and DL4J

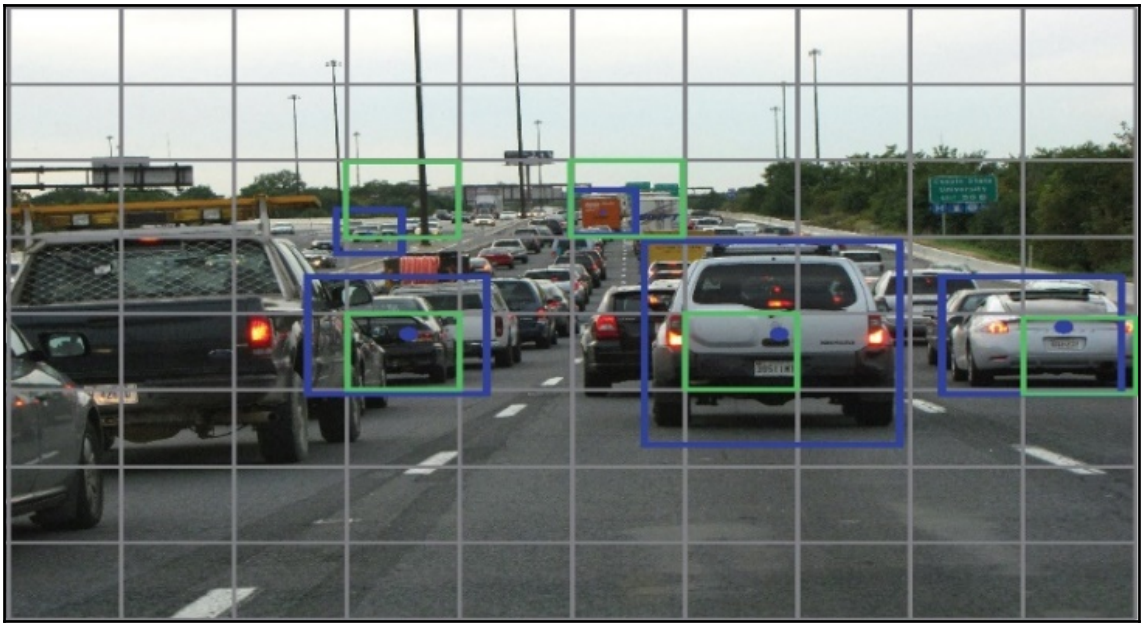


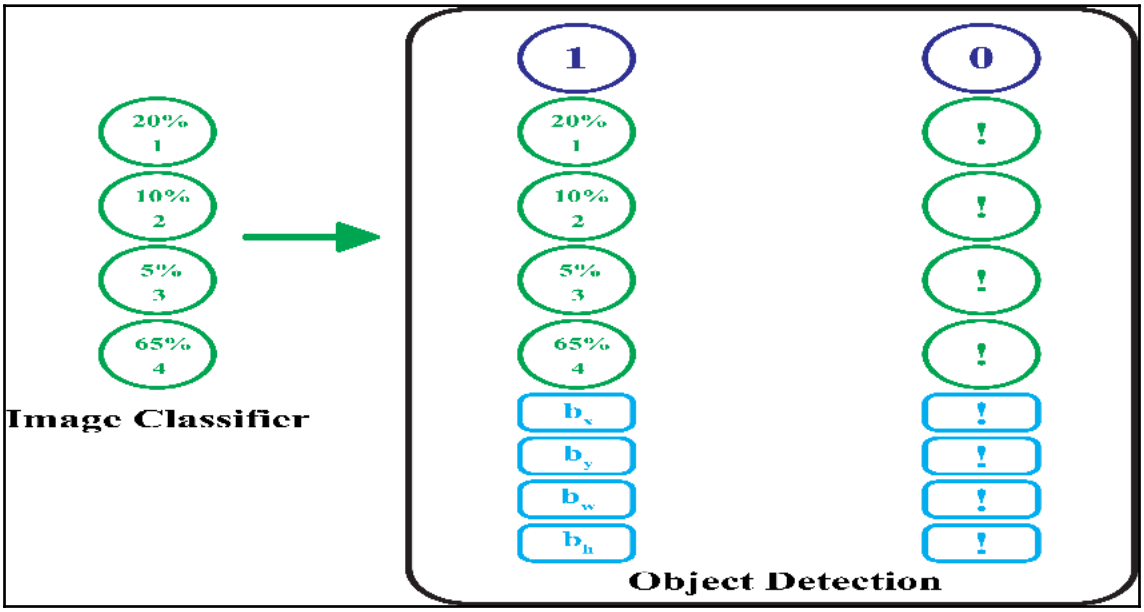

Conv Same
3 X 3 X 64
Max Pool
S=2
2 X 2 X 64
FC
FC
FC
32 X 32 X 3
32 X 32 X 64
16 X 16 X 64
256
Neurons
128
Neurons
5 Classes

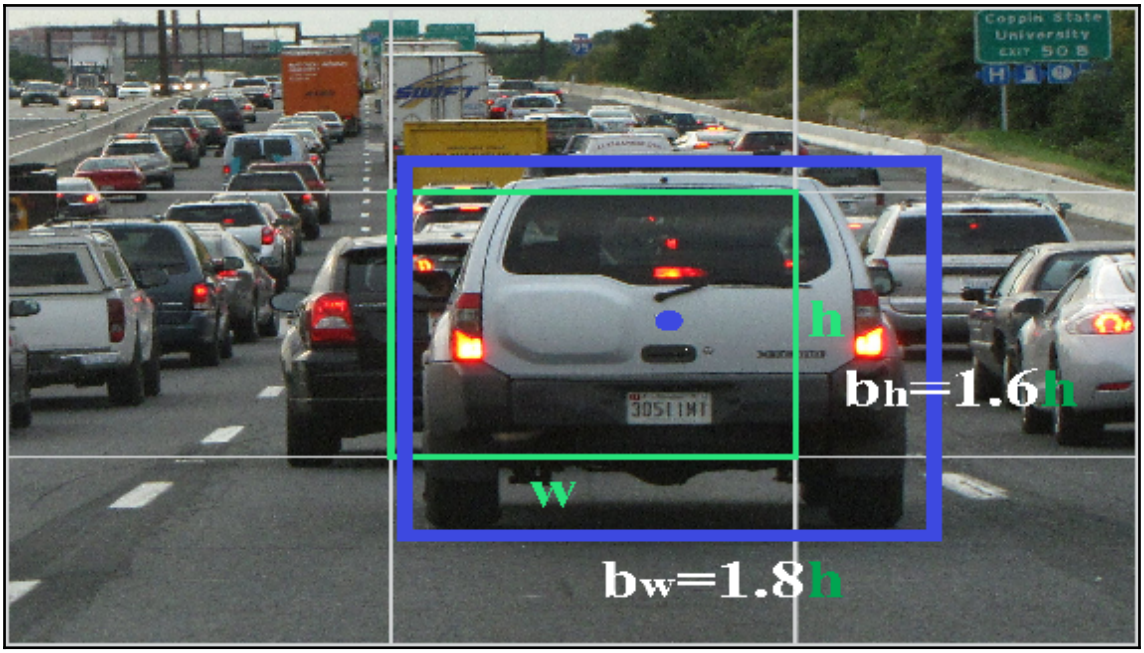

Conv Same
3 X 3 X 64
Max Pool
S=2
2 X 2 X 64
Conv
16 X 16 X 256
Conv
1 X 1 X 128
Conv
1 X 1 X 5
32 X 32 X 3
32 X 32 X 64
16 X 16 X 64
1 X 1 X 256
1 X 1 X 128
1 X 1 X 5
5 Classes

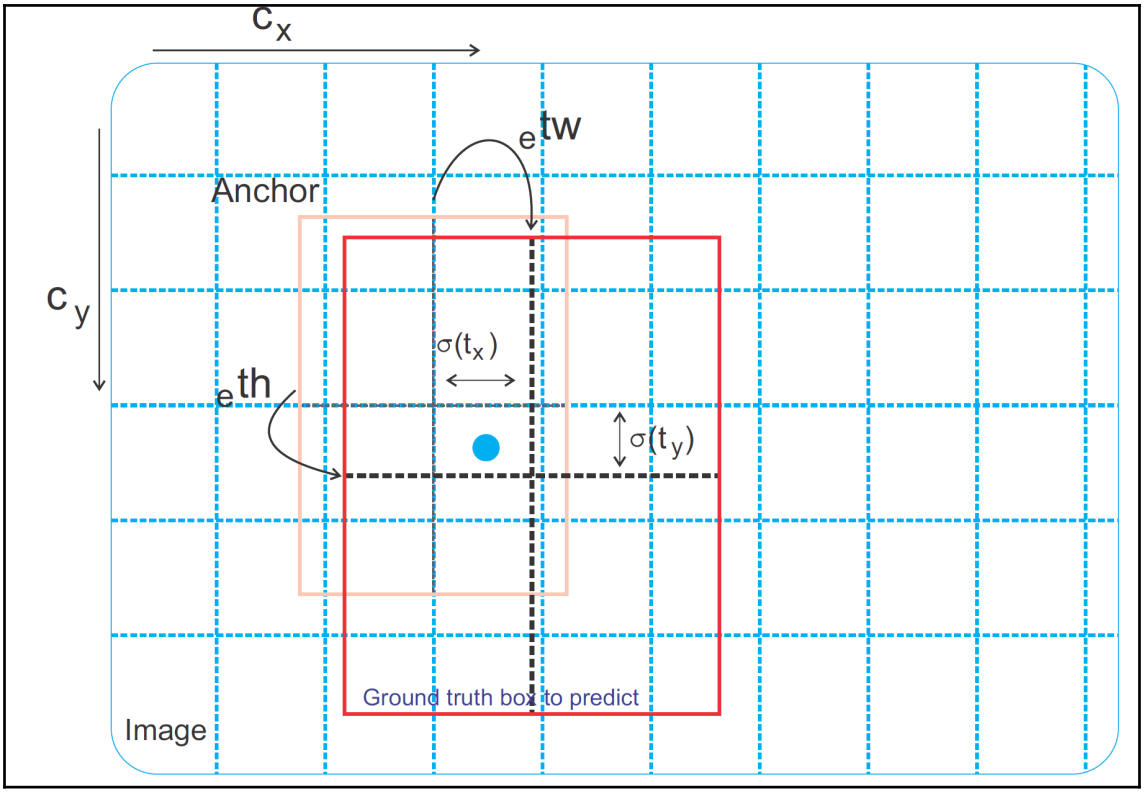

5 Classes
Conv Same
3 x 3 x 64
36 x 36 x 64
Max Pool
S = 2
3 x 3 x 64
18 x 18 x 64
Conv
16 x 16 x 256
3 x 3 x 256
Conv
1 x 1 x 128
3 x 3 x 128
Conv
1 x 1 x 5
3 x 3 x 5
36 x 36 x 3


(a)
Video
Detection Score
(b)
Video
Tracking Confidence




20%
1
10%
2
5%
3
65%
4
Image Classifier
1
20%
1
10%
2
5%
3
65%
4
b_x
b_y
b_w
b_h
0
!
!
!
!
!
!
!
!
Object Detection


Coppin State
University
EXIT 50 B
h
bh=1.6h
w
bw=1.8h


c_x
c_y
e^{tw}
Anchor
$\sigma(t_x)$
e^{th}
$\sigma(t_y)$
Ground truth box to predict
Image

```
==========================================================================================================================
VertexName (VertexType)                 nIn,nOut  TotalParams ParamsShape                                  Vertex Inputs
==========================================================================================================================
input_1 (InputVertex)                   -,-       -           -                                          -
conv2d_1 (ConvolutionLayer)             3,16      432         W:{16,3,3,3}                               [input_1]
batch_normalization_1 (BatchNormalization)16,16     64          gamma:{1,16}, beta:{1,16}, mean:{1,16}, var:{1,16}[conv2d_1]
leaky_re_lu_1 (ActivationLayer)         -,-       0           -                                          [batch_normalization_1]
max_pooling2d_1 (SubsamplingLayer)      -,-       0           -                                          [leaky_re_lu_1]
conv2d_2 (ConvolutionLayer)             16,32     4608        W:{32,16,3,3}                              [max_pooling2d_1]
batch_normalization_2 (BatchNormalization)32,32     128         gamma:{1,32}, beta:{1,32}, mean:{1,32}, var:{1,32}[conv2d_2]
leaky_re_lu_2 (ActivationLayer)         -,-       0           -                                          [batch_normalization_2]
max_pooling2d_2 (SubsamplingLayer)      -,-       0           -                                          [leaky_re_lu_2]
conv2d_3 (ConvolutionLayer)             32,64     18432       W:{64,32,3,3}                              [max_pooling2d_2]
batch_normalization_3 (BatchNormalization)64,64     256         gamma:{1,64}, beta:{1,64}, mean:{1,64}, var:{1,64}[conv2d_3]
leaky_re_lu_3 (ActivationLayer)         -,-       0           -                                          [batch_normalization_3]
max_pooling2d_3 (SubsamplingLayer)      -,-       0           -                                          [leaky_re_lu_3]
conv2d_4 (ConvolutionLayer)             64,128    73728       W:{128,64,3,3}                             [max_pooling2d_3]
batch_normalization_4 (BatchNormalization)128,128   512         gamma:{1,128}, beta:{1,128}, mean:{1,128}, var:{1,128}[conv2d_4]
leaky_re_lu_4 (ActivationLayer)         -,-       0           -                                          [batch_normalization_4]
max_pooling2d_4 (SubsamplingLayer)      -,-       0           -                                          [leaky_re_lu_4]
conv2d_5 (ConvolutionLayer)             128,256   294912      W:{256,128,3,3}                            [max_pooling2d_4]
batch_normalization_5 (BatchNormalization)256,256   1024        gamma:{1,256}, beta:{1,256}, mean:{1,256}, var:{1,256}[conv2d_5]
leaky_re_lu_5 (ActivationLayer)         -,-       0           -                                          [batch_normalization_5]
max_pooling2d_5 (SubsamplingLayer)      -,-       0           -                                          [leaky_re_lu_5]
conv2d_6 (ConvolutionLayer)             256,512   1179648     W:{512,256,3,3}                            [max_pooling2d_5]
batch_normalization_6 (BatchNormalization)512,512   2048        gamma:{1,512}, beta:{1,512}, mean:{1,512}, var:{1,512}[conv2d_6]
leaky_re_lu_6 (ActivationLayer)         -,-       0           -                                          [batch_normalization_6]
max_pooling2d_6 (SubsamplingLayer)      -,-       0           -                                          [leaky_re_lu_6]
conv2d_7 (ConvolutionLayer)             512,1024  4718592     W:{1024,512,3,3}                           [max_pooling2d_6]
batch_normalization_7 (BatchNormalization)1024,1024 4096        gamma:{1,1024}, beta:{1,1024}, mean:{1,1024}, var:{1,1024}[conv2d_7]
leaky_re_lu_7 (ActivationLayer)         -,-       0           -                                          [batch_normalization_7]
conv2d_8 (ConvolutionLayer)             1024,1024 9437184     W:{1024,1024,3,3}                          [leaky_re_lu_7]
batch_normalization_8 (BatchNormalization)1024,1024 4096        gamma:{1,1024}, beta:{1,1024}, mean:{1,1024}, var:{1,1024}[conv2d_8]
leaky_re_lu_8 (ActivationLayer)         -,-       0           -                                          [batch_normalization_8]
conv2d_9 (ConvolutionLayer)             1024,125  128125      W:{125,1024,1,1}, b:{1,125}                [leaky_re_lu_8]
outputs (Yolo2OutputLayer)              -,-       0           -                                          [conv2d_9]
--------------------------------------------------------------------------------------------------------------------------
            Total Parameters:  15867885
        Trainable Parameters:  15867885
           Frozen Parameters:  0
==========================================================================================================================
```

118.jpg

119.jpg

122.jpg

123.jpg

126.jpg

127.jpg

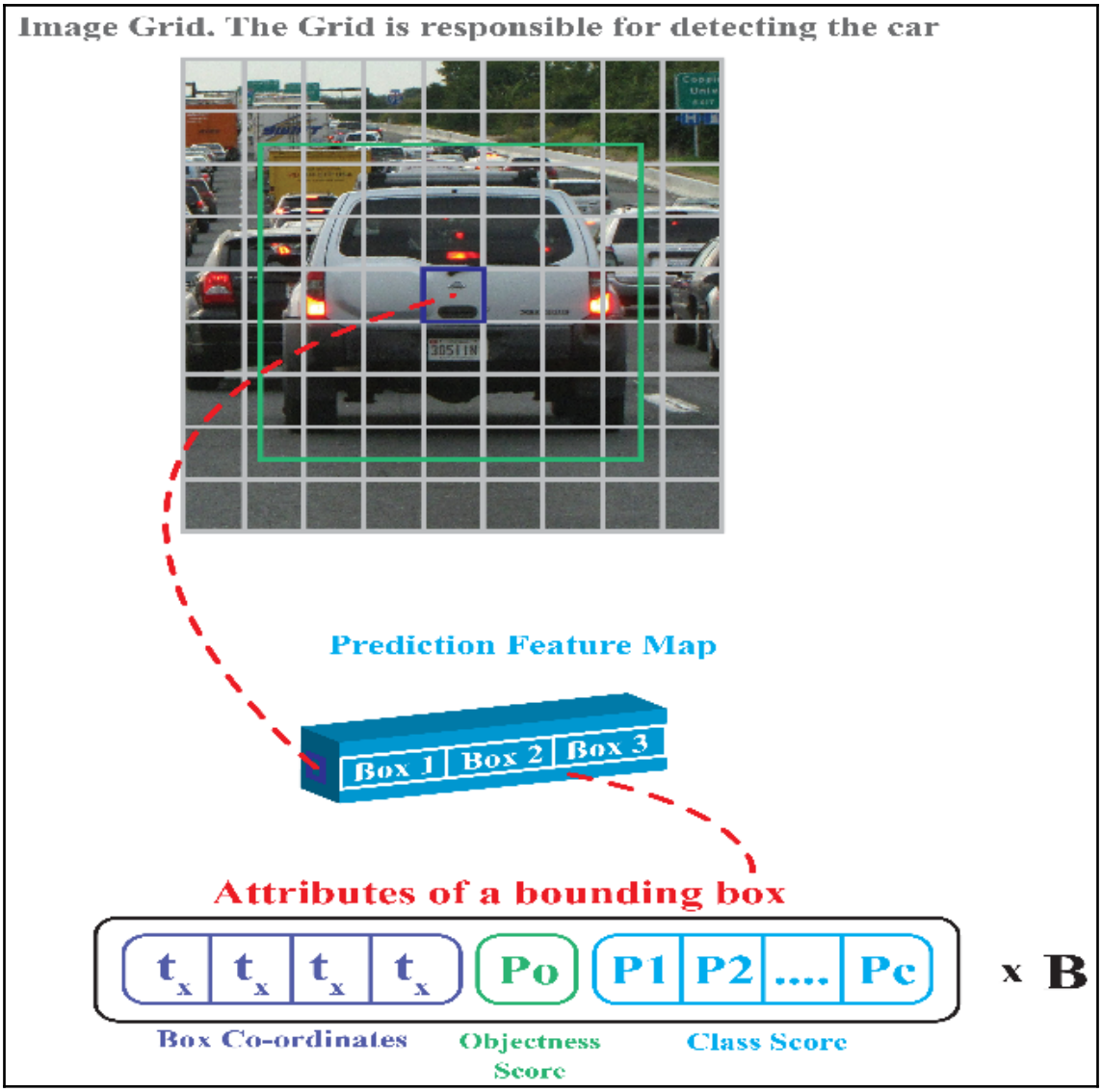
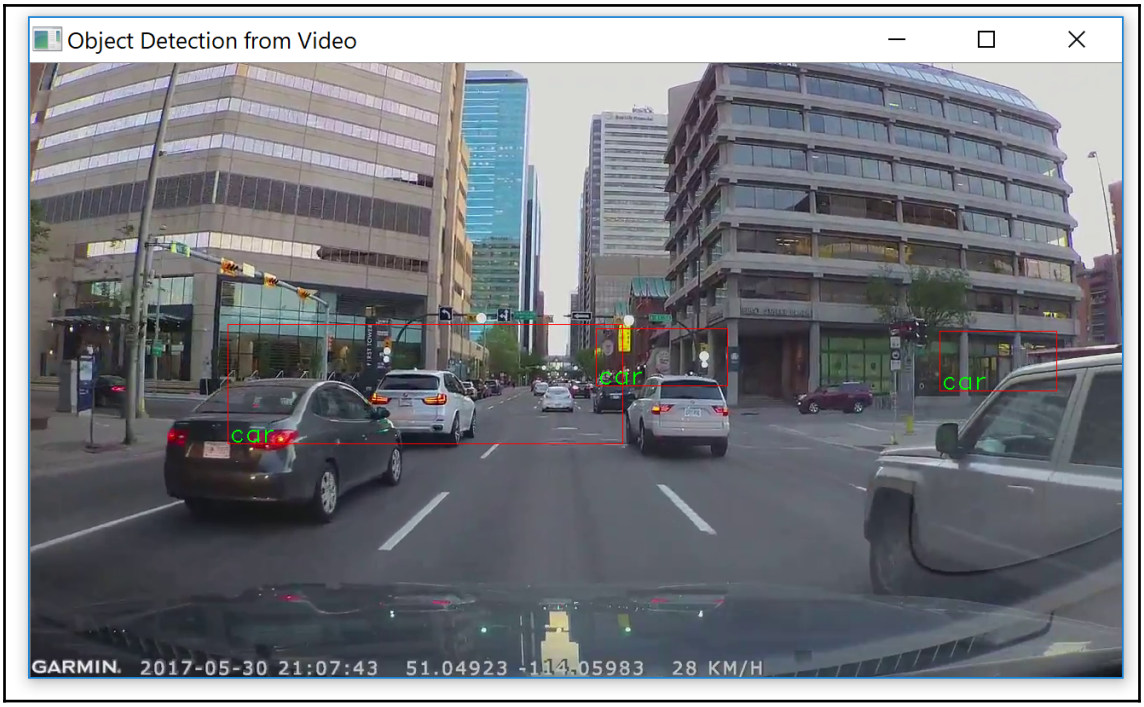
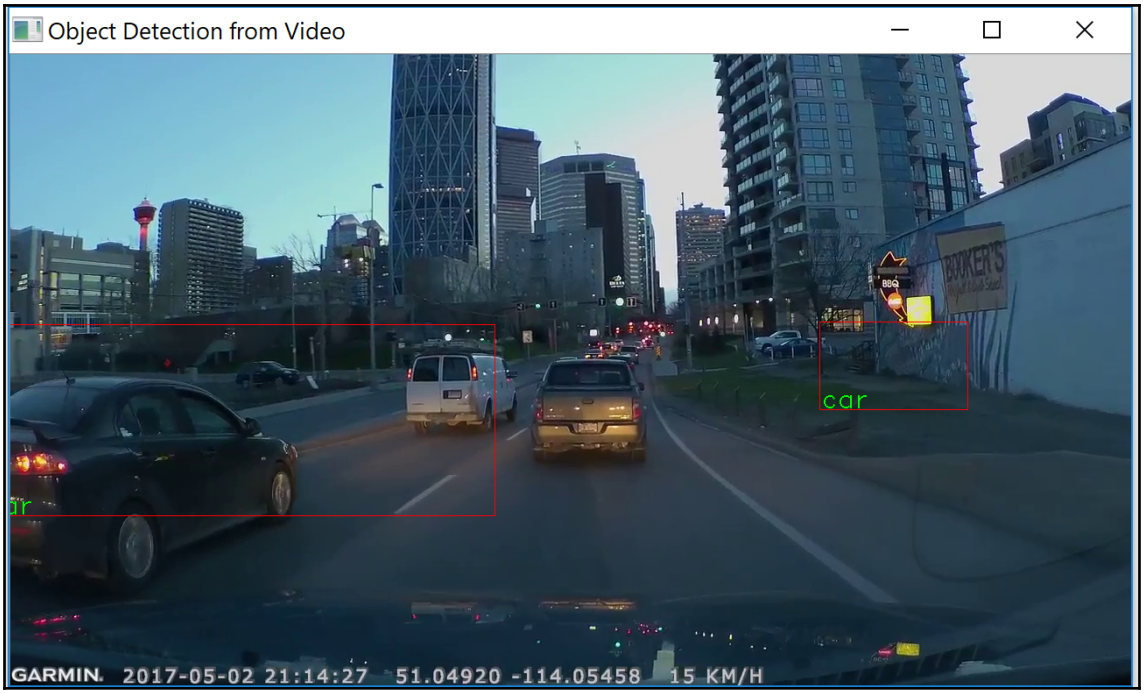
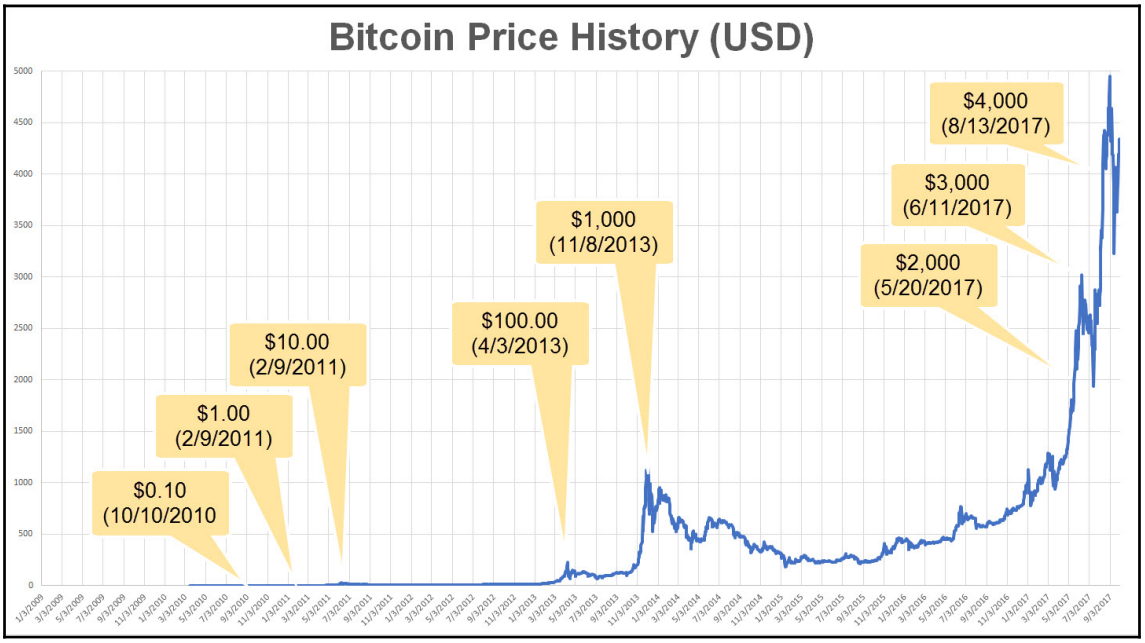


Image Grid. The Grid is responsible for detecting the car
Prediction Feature Map
Box 1
Box 2
Box 3
Attributes of a bounding box
t_x
t_x
t_x
t_x
Po
P1
P2
....
Pc
x B
Box Co-ordinates
Objectness Score
Class Score


Object Detection from Video
car
car
car
GARMIN. 2017-05-30 21:07:43 51.04923 -114.05983 28 KM/H


Object Detection from Video
car
jr
GARMIN. 2017-05-02 21:14:27 51.04920 -114.05458 15 KM/H

Chapter 7: Stock Price Prediction Using LSTM Network



Sell Orders

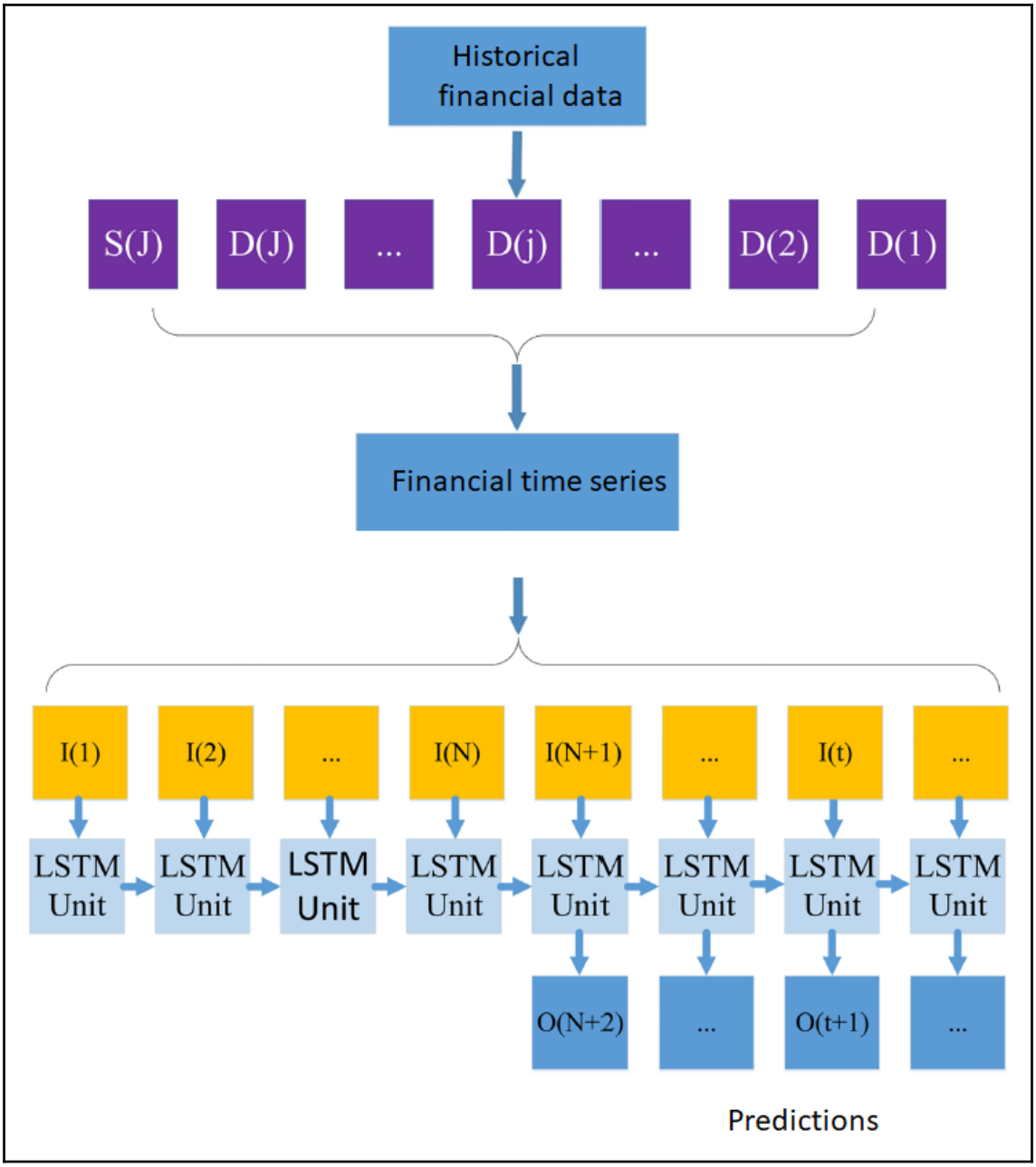
Total BTC available: 1389.60434169

Price per BTC	BTC Amount	Total: (USD)
6721.0	฿0.02010571	$ 135.14
6737.9	฿0.60000000	$ 4042.74
6738.1	฿0.60000000	$ 4042.86
6746.0	฿0.03300000	$ 222.62
6746.1	฿0.00373000	$ 25.17
6750.5	฿0.25000000	$ 1687.63
6752.8	฿0.06569999	$ 443.66
6755.9	฿0.42262157	$ 2855.19
6756.0	฿2.41686827	$ 16328.37
6757.1	฿0.25000000	$ 1689.28

Buy Orders

Total USD available: 7169835.14

Price per BTC	BTC Amount	Total: (USD)
6720.4	฿0.05000000	$ 336.02
6720.3	฿0.08851000	$ 594.82
6720.2	฿0.60000000	$ 4032.12
6720.0	฿0.03385000	$ 227.48
6717.0	฿0.01200000	$ 80.61
6716.1	฿0.10000000	$ 671.61
6713.4	฿0.25000000	$ 1678.35
6712.0	฿0.01472736	$ 98.86
6709.6	฿0.07018430	$ 470.91
6709.3	฿0.25000000	$ 1677.33


Historical financial data
S(J)
D(J)
...
D(j)
...
D(2)
D(1)
Financial time series
I(1)
I(2)
...
I(N)
I(N+1)
...
I(t)
...
LSTM Unit
LSTM Unit
LSTM Unit
LSTM Unit
LSTM Unit
LSTM Unit
LSTM Unit
LSTM Unit
O(N+2)
...
O(t+1)
...
Predictions

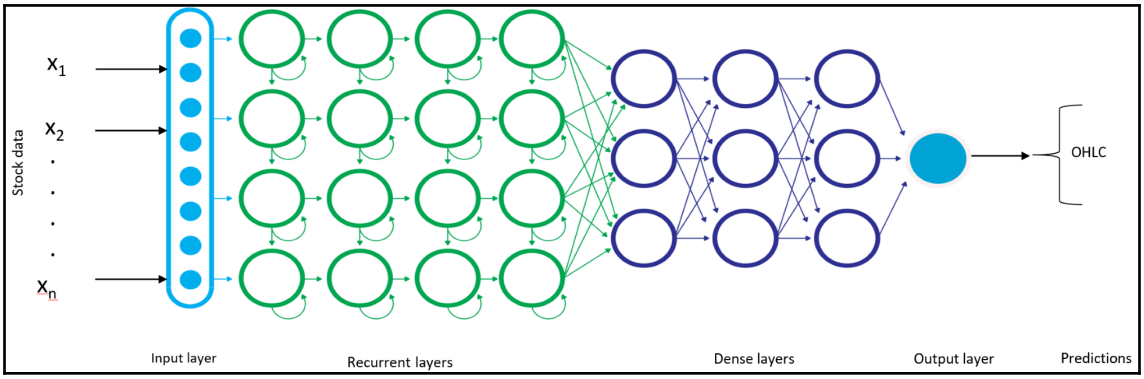
```
+----------+------+----------+----------+----------+----------+---------+
|      date|symbol|      open|     close|       low|      high|   volume|
+----------+------+----------+----------+----------+----------+---------+
|2016-01-05|  WLTW|    123.43|125.839996|122.309998|    126.25|2163600.0|
|2016-01-06|  WLTW|125.239998|119.980003|119.940002|125.540001|2386400.0|
|2016-01-07|  WLTW|116.379997|114.949997|    114.93|119.739998|2489500.0|
|2016-01-08|  WLTW|115.480003|116.620003|     113.5|117.440002|2006300.0|
|2016-01-11|  WLTW|117.010002|114.970001|114.089996|117.330002|1408600.0|
|2016-01-12|  WLTW|115.510002|115.550003|     114.5|116.059998|1098000.0|
|2016-01-13|  WLTW|116.459999|112.849998|112.589996|    117.07| 949600.0|
|2016-01-14|  WLTW|113.510002|114.379997|110.050003|115.029999| 785300.0|
|2016-01-15|  WLTW|113.330002|112.529999|111.919998|114.879997|1093700.0|
|2016-01-19|  WLTW|113.660004|110.379997|109.870003|115.870003|1523500.0|
+----------+------+----------+----------+----------+----------+---------+
only showing top 10 rows
```

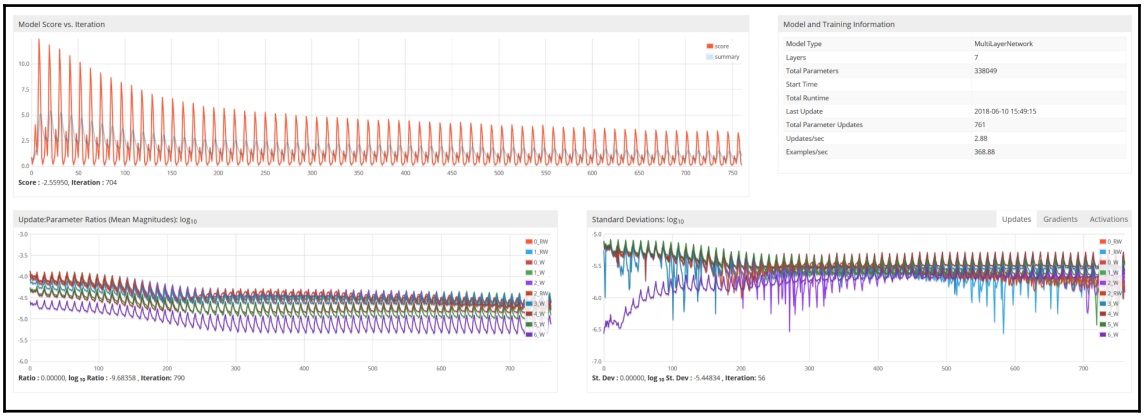
```
+------+
|symbol|
+------+
|  ALXN|
|   GIS|
|     K|
|   LEN|
|  SPGI|
|   AVY|
|   AIV|
|   MMM|
|   PKI|
|   PPG|
+------+
only showing top 10 rows
```

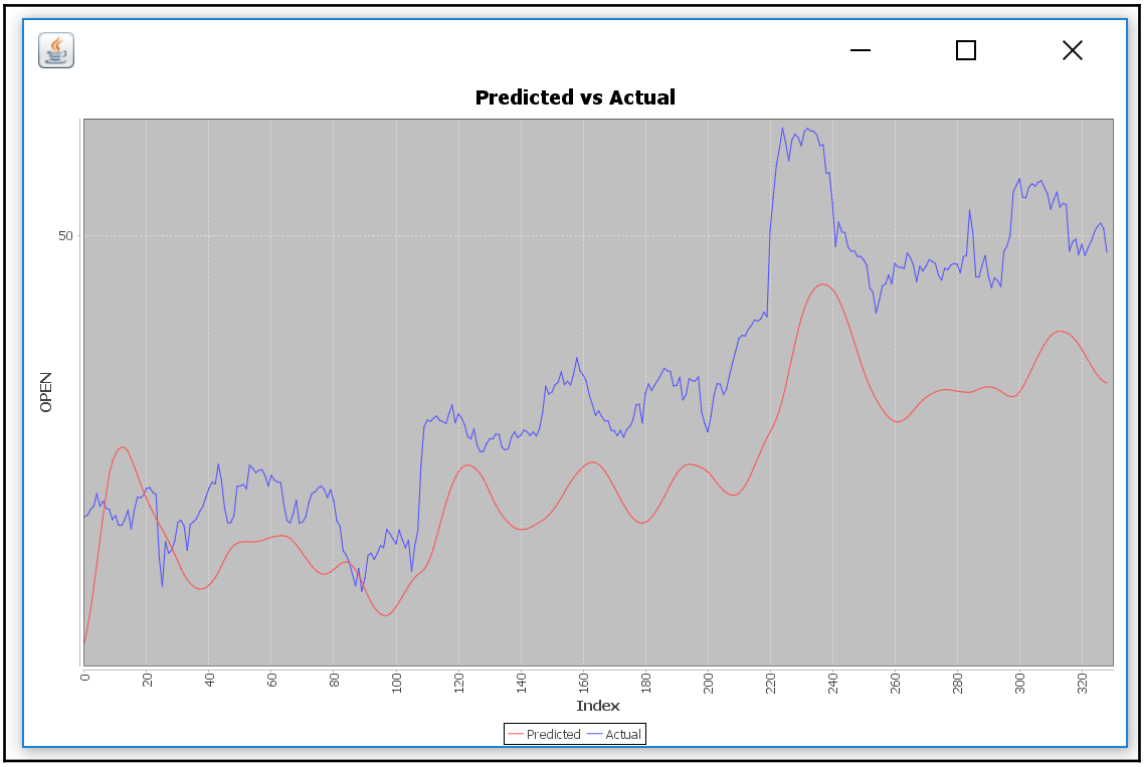
1	Ticker symbol	Security	SEC filings	GICS Sector	GICS Sub Industry	Address of Headquarte
2	MMM	3M Company	reports	Industrials	Industrial Conglomerates	St. Paul, Minnesota
3	ABT	Abbott Laboratories	reports	Health Care	Health Care Equipment	North Chicago, Illinois
4	ABBV	AbbVie	reports	Health Care	Pharmaceuticals	North Chicago, Illinois
5	ACN	Accenture plc	reports	Information Technology	IT Consulting & Other Services	Dublin, Ireland
6	ATVI	Activision Blizzard	reports	Information Technology	Home Entertainment Software	Santa Monica, California
7	AYI	Acuity Brands Inc	reports	Industrials	Electrical Components & Equipment	Atlanta, Georgia
8	ADBE	Adobe Systems Inc	reports	Information Technology	Application Software	San Jose, California
9	AAP	Advance Auto Parts	reports	Consumer Discretionary	Automotive Retail	Roanoke, Virginia
10	AES	AES Corp	reports	Utilities	Independent Power Producers & Energy Traders	Arlington, Virginia

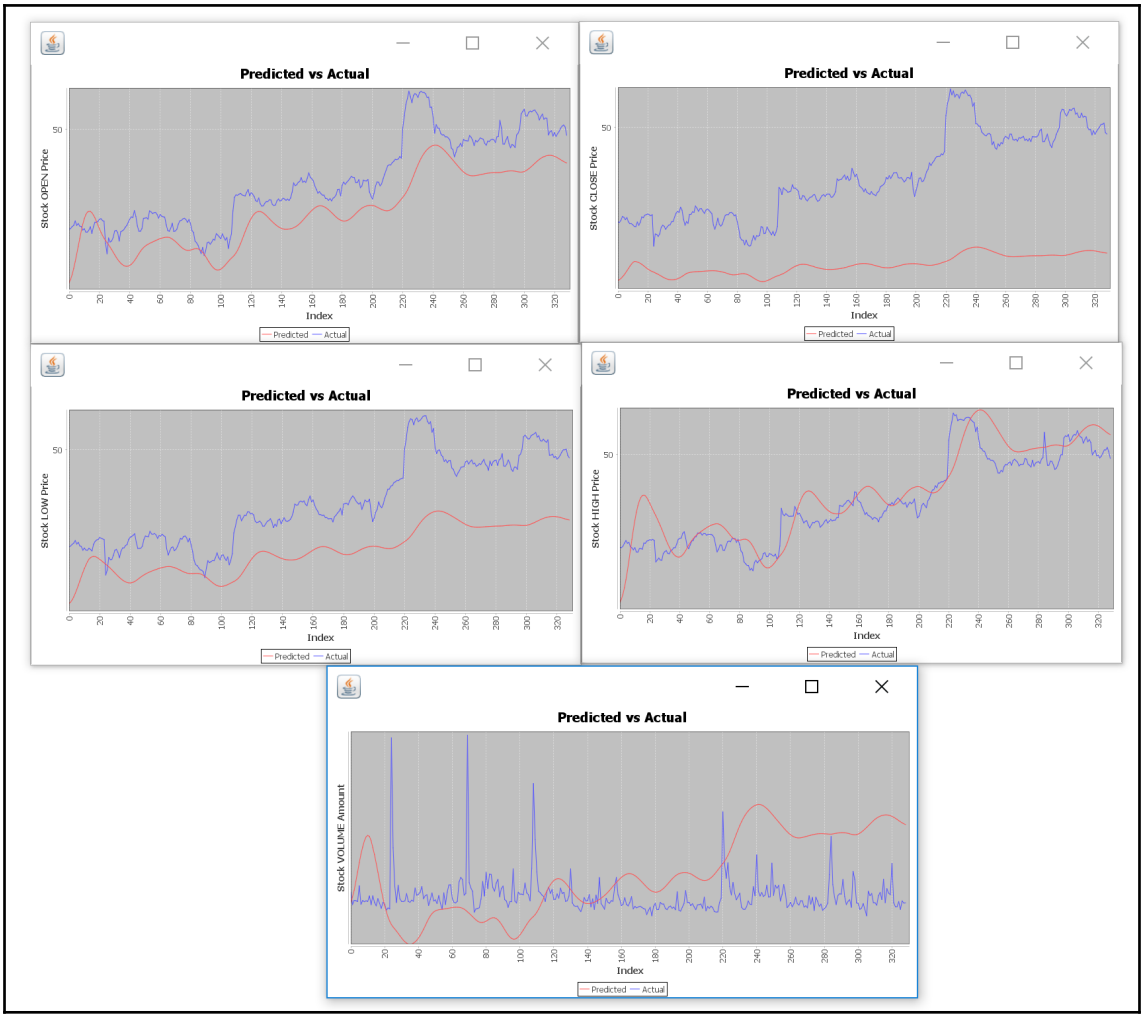
```
+------+------------------+------------------+------------------+------------------+
|symbol|          avg_open|         avg_close|           avg_low|          avg_high|
+------+------------------+------------------+------------------+------------------+
|  ALXN|108.80929055675361|108.80724465210005|107.01665432179338| 110.4220716129398|
|   GIS| 47.50769861662885| 47.53702609988646| 47.20578890436999| 47.81829174035188|
|     K|  60.7798750891033|60.812451743473225|60.396668640181694| 61.18173103064723|
|   LEN| 33.70927924404085| 33.69652100794552| 33.21101586038595| 34.17997733144158|
|  SPGI|  67.3407944982973|  67.3793473399546| 66.71868329568667| 67.96350737741204|
|   AVY| 46.31455735584563| 46.33024974460847| 45.88852444948926| 46.74310443303073|
|   AIV|30.436407484676547| 30.45744606526678|30.130329164585707| 30.74774691770716|
|   MMM|120.07449489443817|120.14518169636774| 119.2890012593643|120.88434149375733|
|   PKI| 36.43588534619753| 36.45435866685586| 36.10356980363221| 36.76804199318962|
|   PPG| 73.98004543104427|  74.0137713237798| 73.34484397985231| 74.61900109335991|
+------+------------------+------------------+------------------+------------------+
only showing top 10 rows
```

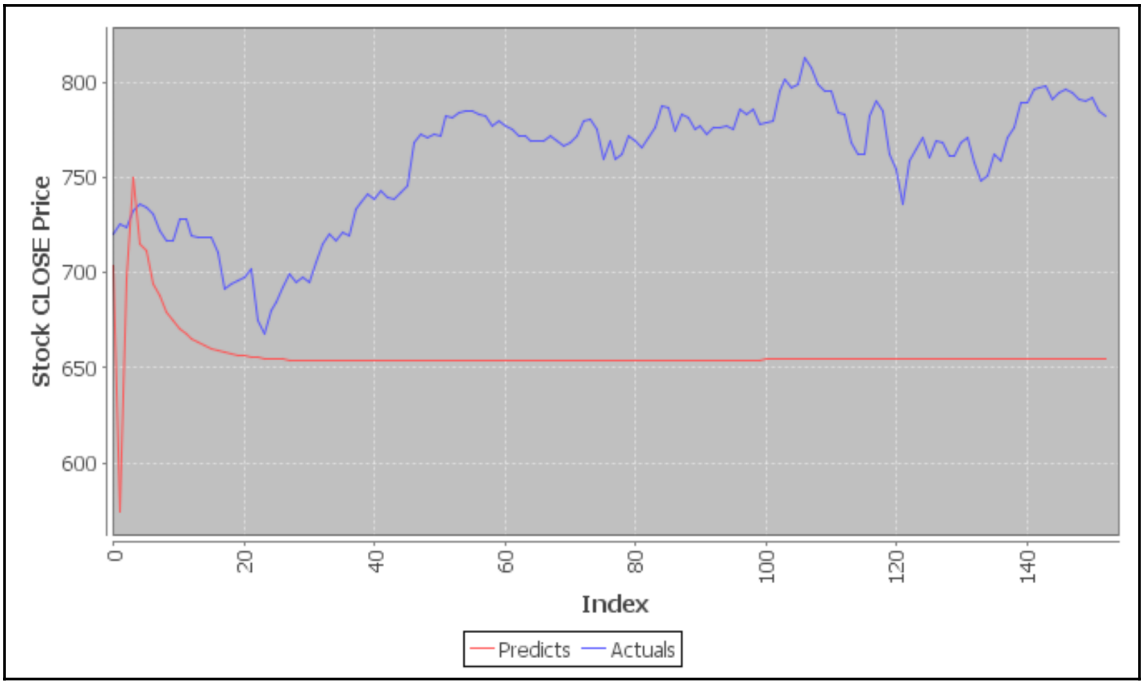
```
+------+----------+----------+---------+----------+----------+----------+----------+----------+
|symbol|  min_open|  max_open|min_close|  max_close|   min_low|   max_low|  min_high|  max_high|
+------+----------+----------+---------+----------+----------+----------+----------+----------+
|  ALXN|22.7250005|206.660004|    22.75| 207.839996|22.4300005|205.509995|22.8999995|208.880005|
|   GIS| 33.419998| 72.650002|    33.57|  72.639999| 33.110001|      72.0|     33.73| 72.949997|
|     K| 46.549999| 86.900002|46.509998|  86.980003| 46.330002| 85.400002|     46.84| 87.160004|
|   LEN|      12.4| 55.360001|    12.71|      55.59|     11.93| 54.810001|     12.82| 56.040001|
|  SPGI| 27.049999|127.900002|    27.02| 127.559998| 26.950001|126.559998| 27.809999|128.399994|
|   AVY|     23.59| 78.839996|23.969999|  78.839996|     23.52| 78.480003|     24.66| 79.269997|
|   AIV|     15.38|     47.82|    15.21|      47.59|     15.01| 47.080002|     15.56|     47.91|
|   MMM| 70.129997|181.729996|    70.93| 181.419998| 68.629997|181.320007|     72.18|182.270004|
|   PKI|      17.5| 56.869999|    17.49|  56.919998| 17.450001| 56.599998| 17.719999| 57.279999|
|   PPG|28.8199995|118.480003|    28.84|118.8499985|28.4799995|117.900002|     29.25|118.949997|
+------+----------+----------+---------+----------+----------+----------+----------+----------+
only showing top 10 rows
```


Stock data
x_1
x_2
x_n
OHLC
Input layer
Recurrent layers
Dense layers
Output layer
Predictions

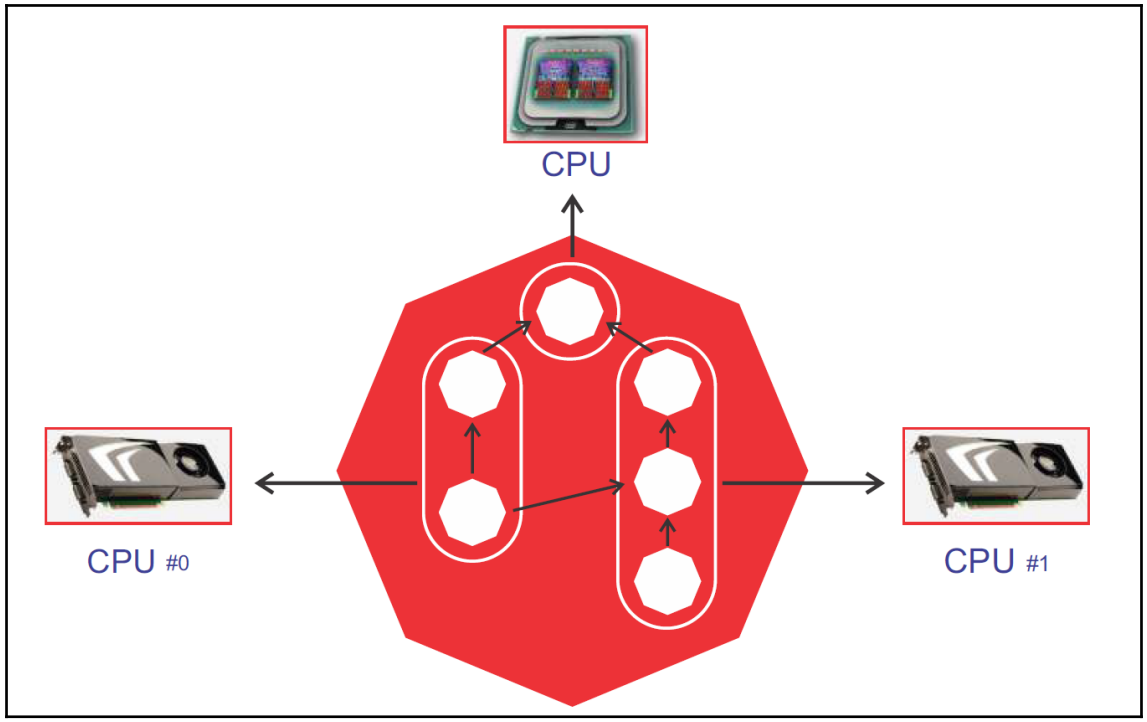

Model Score vs. Iteration
score
summary
Score : -2.55950, Iteration : 704
Model and Training Information
Model Type MultiLayerNetwork
Layers 7
Total Parameters 338049
Start Time
Total Runtime
Last Update 2018-06-10 15:49:15
Total Parameter Updates 761
Updates/sec 2.88
Examples/sec 368.88
Update:Parameter Ratios (Mean Magnitudes): log10
Ratio : 0.00000, log 10 Ratio : -9.68358 , Iteration: 790
Standard Deviations: log10
Updates
Gradients
Activations
St. Dev : 0.00000, log 10 St. Dev : -5.44834 , Iteration: 56

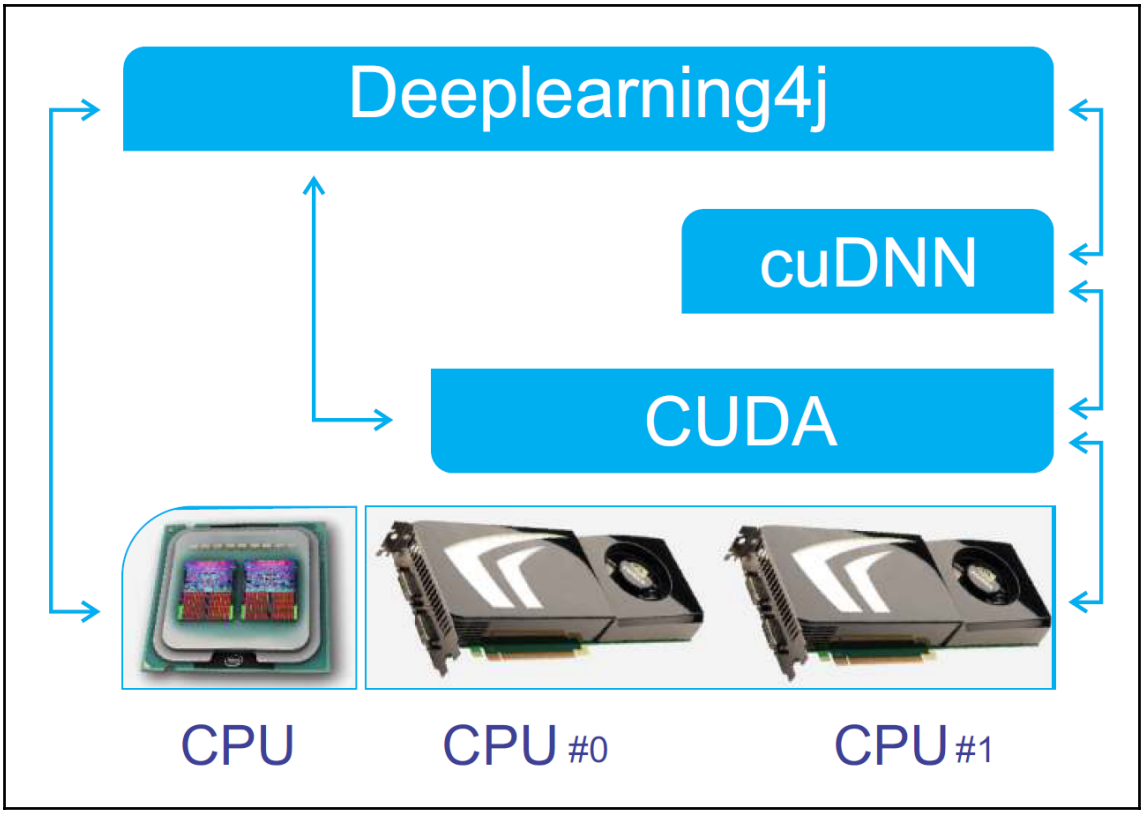

Predicted vs Actual
50
OPEN
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
320
Index
Predicted
Actual

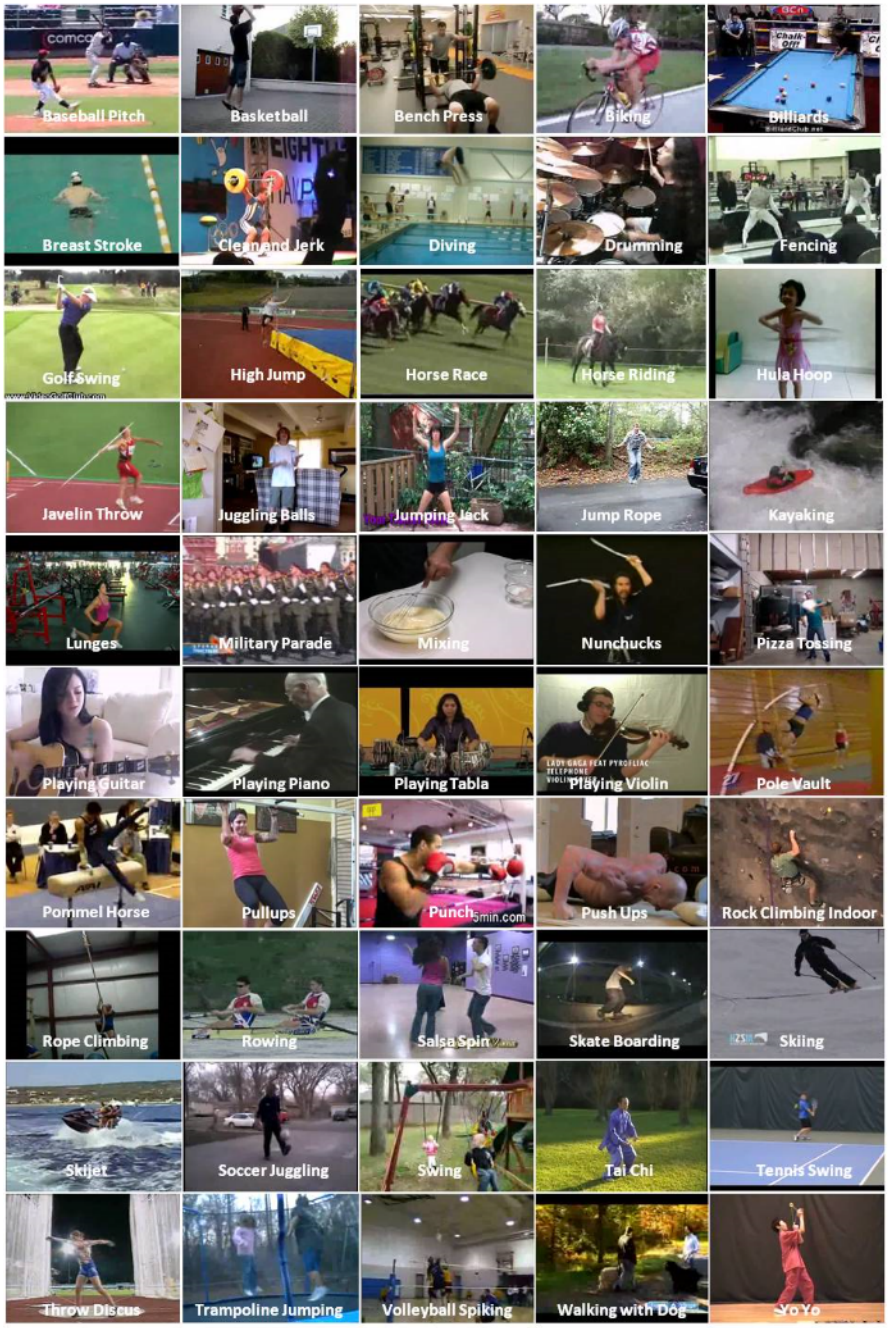

Predicted vs Actual
Stock OPEN Price
Index
Predicted
Actual
Predicted vs Actual
Stock CLOSE Price
Index
Predicted
Actual
Predicted vs Actual
Stock LOW Price
Index
Predicted
Actual
Predicted vs Actual
Stock HIGH Price
Index
Predicted
Actual
Predicted vs Actual
Stock VOLUME Amount
Index
Predicted
Actual

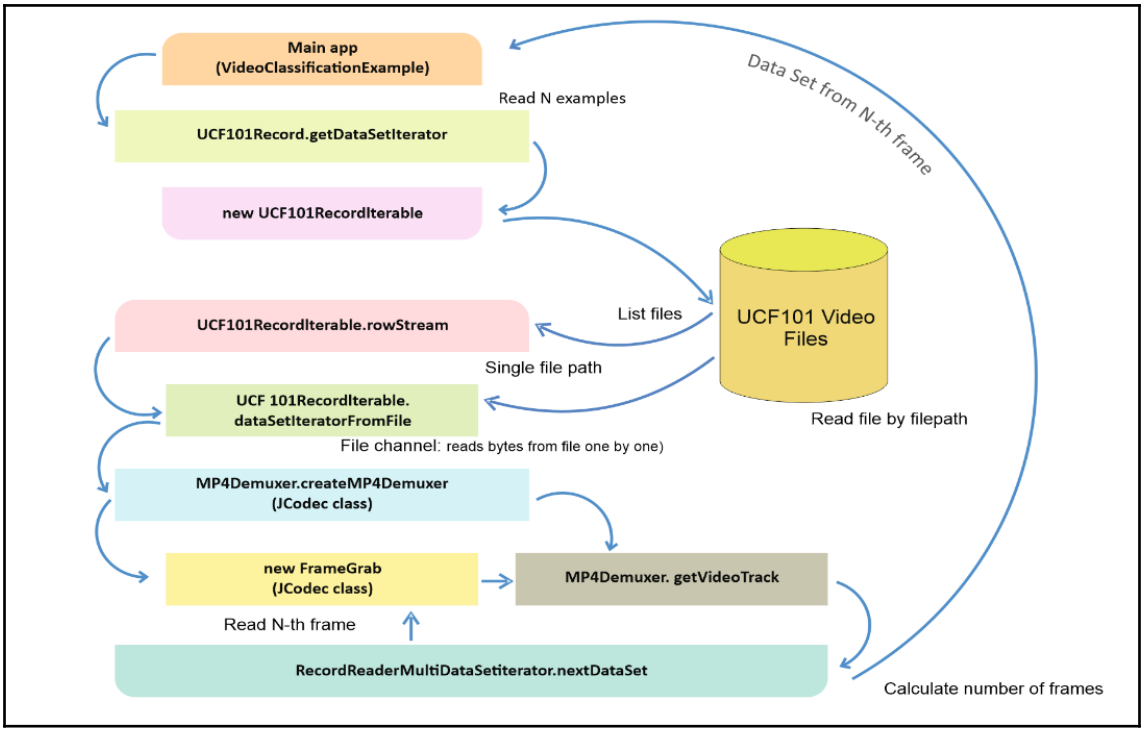

Stock CLOSE Price
800
750
700
650
600
0
20
40
60
80
100
120
140
Index
Predicts
Actuals

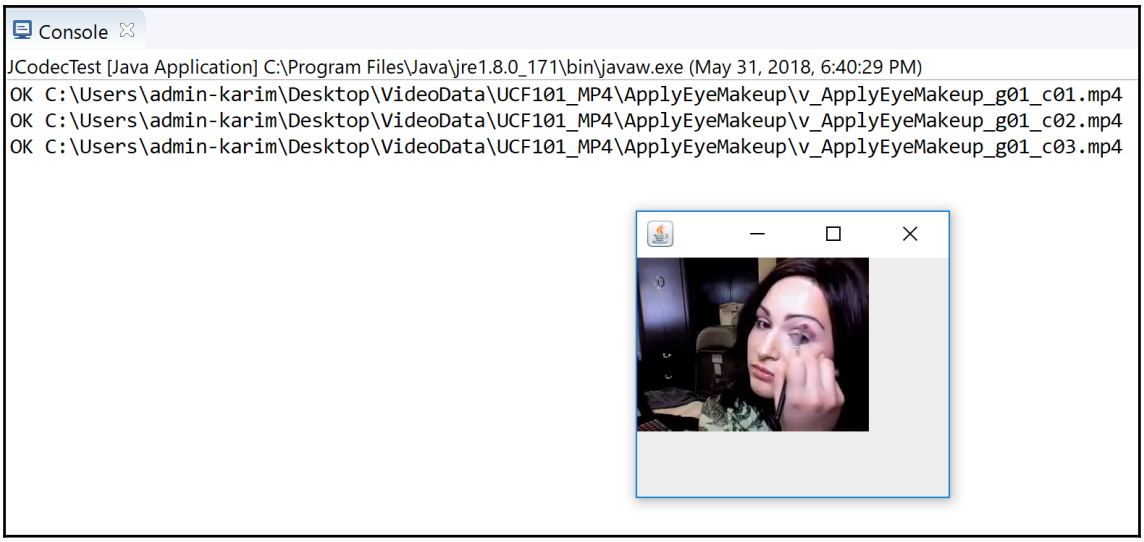
Chapter 8: Distributed Deep Learning – Video Classification Using Convolutional LSTM Networks




Deeplearning4j
cuDNN
CUDA
CPU
CPU #0
CPU #1

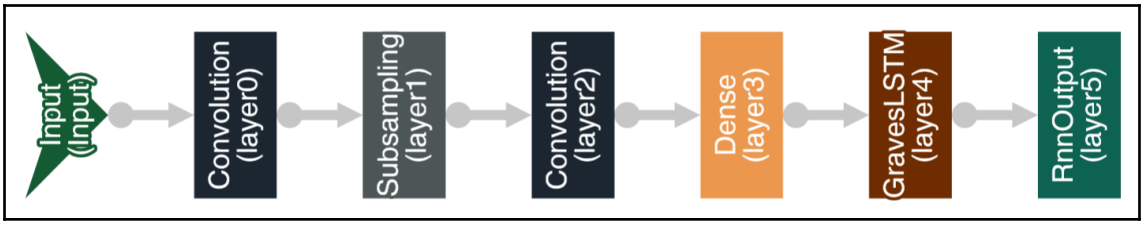

Baseball Pitch
Basketball
Bench Press
Biking
Billiards
Breast Stroke
Clean and Jerk
Diving
Drumming
Fencing
Golf Swing
High Jump
Horse Race
Horse Riding
Hula Hoop
Javelin Throw
Juggling Balls
Jumping Jack
Jump Rope
Kayaking
Lunges
Military Parade
Mixing
Nunchucks
Pizza Tossing
Playing Guitar
Playing Piano
Playing Tabla
Playing Violin
Pole Vault
Pommel Horse
Pullups
Punch
Push Ups
Rock Climbing Indoor
Rope Climbing
Rowing
Salsa Spin
Skate Boarding
Skiing
Skijet
Soccer Juggling
Swing
Tai Chi
Tennis Swing
Throw Discus
Trampoline Jumping
Volleyball Spiking
Walking with Dog
Yo Yo


Main app
(VideoClassificationExample)
Read N examples
Data Set from N-th frame
UCF101Record.getDataSetIterator
new UCF101RecordIterable
UCF101 Video Files
List files
UCF101RecordIterable.rowStream
Single file path
UCF 101RecordIterable.
dataSetIteratorFromFile
Read file by filepath
File channel: reads bytes from file one by one)
MP4Demuxer.createMP4Demuxer
(JCodec class)
new FrameGrab
(JCodec class)
MP4Demuxer. getVideoTrack
Read N-th frame
RecordReaderMultiDataSetiterator.nextDataSet
Calculate number of frames


Console
JCodecTest [Java Application] C:\Program Files\Java\jre1.8.0_171\bin\javaw.exe (May 31, 2018, 6:40:29 PM)
OK C:\Users\admin-karim\Desktop\VideoData\UCF101_MP4\ApplyEyeMakeup\v_ApplyEyeMakeup_g01_c01.mp4
OK C:\Users\admin-karim\Desktop\VideoData\UCF101_MP4\ApplyEyeMakeup\v_ApplyEyeMakeup_g01_c02.mp4
OK C:\Users\admin-karim\Desktop\VideoData\UCF101_MP4\ApplyEyeMakeup\v_ApplyEyeMakeup_g01_c03.mp4

/home/karim/VideoData/UCF101_MP4/

Name	S...	Changed	Rights	Owner
..		5/6/2018 11:19:24 AM	rwxrwxr-x	karim
ApplyEyeMakeup		5/6/2018 11:22:26 AM	rwxrwxr-x	karim
ApplyLipstick		5/6/2018 11:24:45 AM	rwxrwxr-x	karim
Archery		5/6/2018 11:23:20 AM	rwxrwxr-x	karim
BabyCrawling		5/6/2018 11:21:36 AM	rwxrwxr-x	karim
BalanceBeam		5/6/2018 11:19:59 AM	rwxrwxr-x	karim
BandMarching		5/6/2018 11:26:18 AM	rwxrwxr-x	karim
BaseballPitch		5/6/2018 11:24:05 AM	rwxrwxr-x	karim
Basketball		5/6/2018 11:20:40 AM	rwxrwxr-x	karim
BasketballDunk		5/6/2018 11:23:28 AM	rwxrwxr-x	karim



P2 Instance Details

Name	GPUs	vCPUs	RAM (GiB)	Network Bandwidth	Price/Hour*	RI Price / Hour**
p2.xlarge	1	4	61	High	$0.900	$0.425
p2.8xlarge	8	32	488	10 Gbps	$7.200	$3.400
p2.16xlarge	16	64	732	20 Gbps	$14.400	$6.800


```
ubuntu@ip-172-31-40-27:~$ nvidia-smi
Sat Jun  2 18:29:31 2018
+-----------------------------------------------------------------------------+
| NVIDIA-SMI 384.111                Driver Version: 384.111                   |
|-------------------------------+----------------------+----------------------+
| GPU  Name        Persistence-M| Bus-Id        Disp.A | Volatile Uncorr. ECC |
| Fan  Temp  Perf  Pwr:Usage/Cap|         Memory-Usage | GPU-Util  Compute M. |
|===============================+======================+======================|
|   0  Tesla K80           On   | 00000000:00:17.0 Off |                    0 |
| N/A   41C    P8    26W / 149W |      1MiB / 11439MiB |      0%      Default |
+-------------------------------+----------------------+----------------------+
|   1  Tesla K80           On   | 00000000:00:18.0 Off |                    0 |
| N/A   35C    P8    30W / 149W |      1MiB / 11439MiB |      0%      Default |
+-------------------------------+----------------------+----------------------+
|   2  Tesla K80           On   | 00000000:00:19.0 Off |                    0 |
| N/A   44C    P8    26W / 149W |      1MiB / 11439MiB |      0%      Default |
+-------------------------------+----------------------+----------------------+
|   3  Tesla K80           On   | 00000000:00:1A.0 Off |                    0 |
| N/A   39C    P8    29W / 149W |      1MiB / 11439MiB |      0%      Default |
+-------------------------------+----------------------+----------------------+
|   4  Tesla K80           On   | 00000000:00:1B.0 Off |                    0 |
| N/A   44C    P8    27W / 149W |      1MiB / 11439MiB |      0%      Default |
+-------------------------------+----------------------+----------------------+
|   5  Tesla K80           On   | 00000000:00:1C.0 Off |                    0 |
| N/A   34C    P8    28W / 149W |      1MiB / 11439MiB |      0%      Default |
+-------------------------------+----------------------+----------------------+
|   6  Tesla K80           On   | 00000000:00:1D.0 Off |                    0 |
| N/A   43C    P8    27W / 149W |      1MiB / 11439MiB |      0%      Default |
+-------------------------------+----------------------+----------------------+
|   7  Tesla K80           On   | 00000000:00:1E.0 Off |                    0 |
| N/A   36C    P8    29W / 149W |      1MiB / 11439MiB |      0%      Default |
+-------------------------------+----------------------+----------------------+

+-----------------------------------------------------------------------------+
| Processes:                                                       GPU Memory |
|  GPU       PID   Type   Process name                             Usage      |
|=============================================================================|
|  No running processes found                                                 |
+-----------------------------------------------------------------------------+
ubuntu@ip-172-31-40-27:~$
```

```
ubuntu@ip-172-31-40-27:~$ nvidia-smi
Sat Jun  2 13:50:01 2018
+-----------------------------------------------------------------------------+
| NVIDIA-SMI 384.111                Driver Version: 384.111                   |
|-------------------------------+----------------------+----------------------+
| GPU  Name        Persistence-M| Bus-Id        Disp.A | Volatile Uncorr. ECC |
| Fan  Temp  Perf  Pwr:Usage/Cap|         Memory-Usage | GPU-Util  Compute M. |
|===============================+======================+======================|
|   0  Tesla K80           On   | 00000000:00:17.0 Off |                    0 |
| N/A   67C    P0    61W / 149W |   1244MiB / 11439MiB |      0%      Default |
+-------------------------------+----------------------+----------------------+
|   1  Tesla K80           On   | 00000000:00:18.0 Off |                    0 |
| N/A   56C    P0    73W / 149W |    666MiB / 11439MiB |      0%      Default |
+-------------------------------+----------------------+----------------------+
|   2  Tesla K80           On   | 00000000:00:19.0 Off |                    0 |
| N/A   67C    P0    61W / 149W |    666MiB / 11439MiB |      0%      Default |
+-------------------------------+----------------------+----------------------+
|   3  Tesla K80           On   | 00000000:00:1A.0 Off |                    0 |
| N/A   55C    P0    71W / 149W |    666MiB / 11439MiB |      0%      Default |
+-------------------------------+----------------------+----------------------+
|   4  Tesla K80           On   | 00000000:00:1B.0 Off |                    0 |
| N/A   69C    P0    61W / 149W |    666MiB / 11439MiB |      0%      Default |
+-------------------------------+----------------------+----------------------+
|   5  Tesla K80           On   | 00000000:00:1C.0 Off |                    0 |
| N/A   52C    P0    70W / 149W |    666MiB / 11439MiB |      0%      Default |
+-------------------------------+----------------------+----------------------+
|   6  Tesla K80           On   | 00000000:00:1D.0 Off |                    0 |
| N/A   68C    P0    62W / 149W |    666MiB / 11439MiB |      0%      Default |
+-------------------------------+----------------------+----------------------+
|   7  Tesla K80           On   | 00000000:00:1E.0 Off |                    0 |
| N/A   55C    P0    71W / 149W |    666MiB / 11439MiB |      0%      Default |
+-------------------------------+----------------------+----------------------+

+-----------------------------------------------------------------------------+
| Processes:                                                       GPU Memory |
|  GPU       PID   Type   Process name                             Usage      |
|=============================================================================|
|    0     26536      C   java                                       1229MiB |
|    1     26536      C   java                                        651MiB |
|    2     26536      C   java                                        651MiB |
|    3     26536      C   java                                        651MiB |
|    4     26536      C   java                                        651MiB |
|    5     26536      C   java                                        651MiB |
|    6     26536      C   java                                        651MiB |
|    7     26536      C   java                                        651MiB |
+-----------------------------------------------------------------------------+
ubuntu@ip-172-31-40-27:~$
```

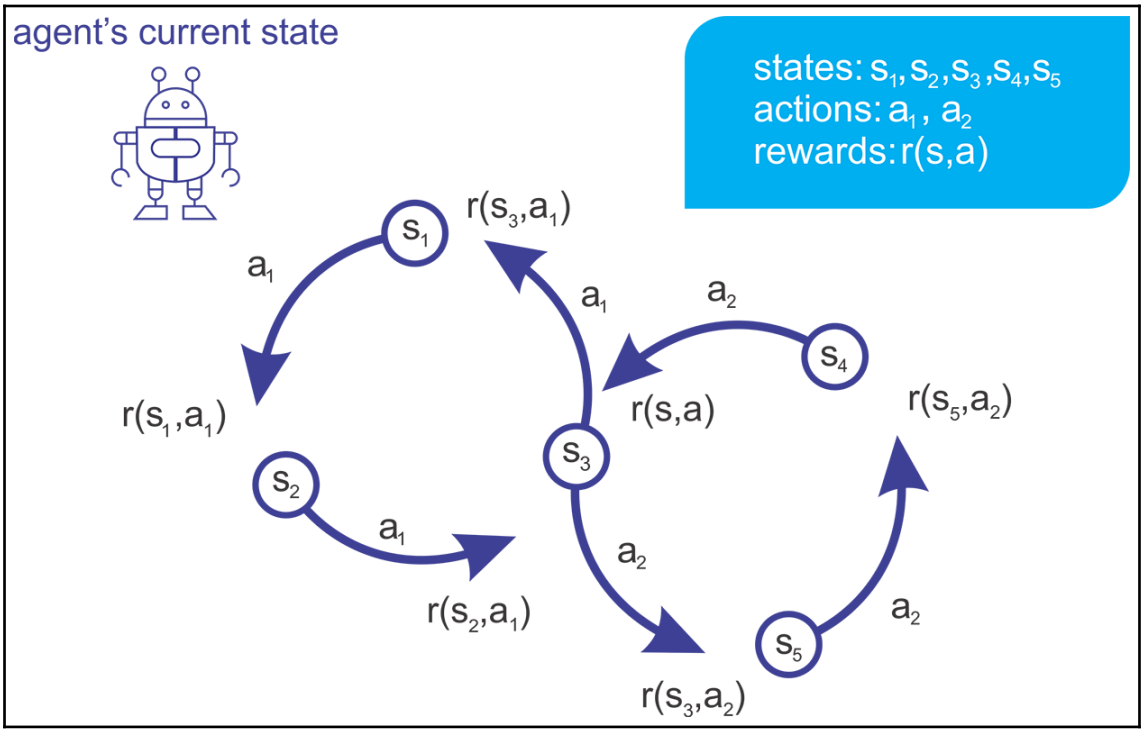
```
ubuntu@ip-172-31-38-158:~$ df -h
Filesystem      Size  Used Avail Use% Mounted on
udev            241G     0  241G   0% /dev
tmpfs            49G  8.6M   49G   1% /run
/dev/xvda1      7.7G  856M  6.9G  11% /
tmpfs           241G     0  241G   0% /dev/shm
tmpfs           5.0M     0  5.0M   0% /run/lock
tmpfs           241G     0  241G   0% /sys/fs/cgroup
tmpfs            49G     0   49G   0% /run/user/1000
ubuntu@ip-172-31-38-158:~$
```

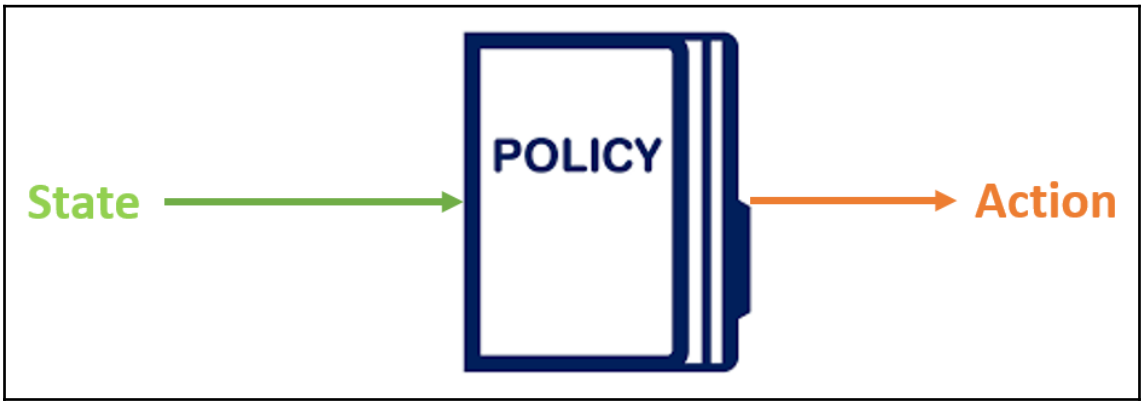
Step 4: Add Storage

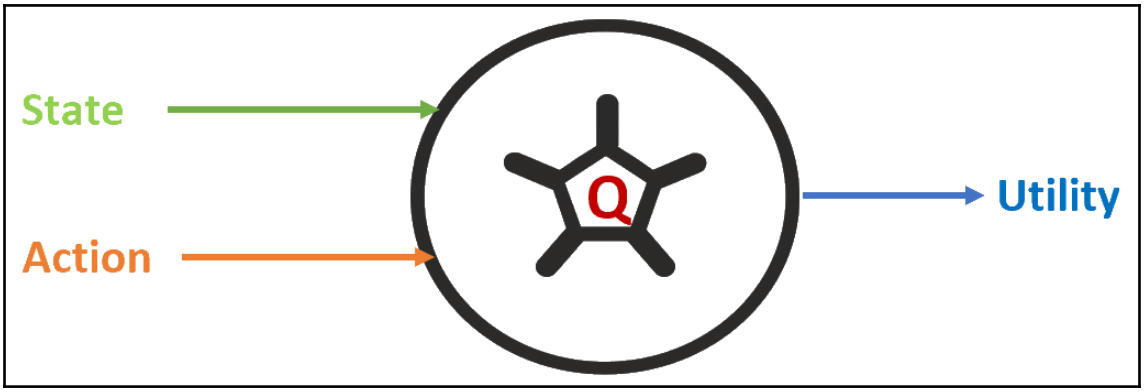
Your instance will be launched with the following storage device settings. You can attach additional EBS volumes and instance store volumes to your instance, or edit the settings of the root volume. You can also attach additional EBS volumes after launching an instance, but not instance store volumes. Learn more about storage options in Amazon EC2.

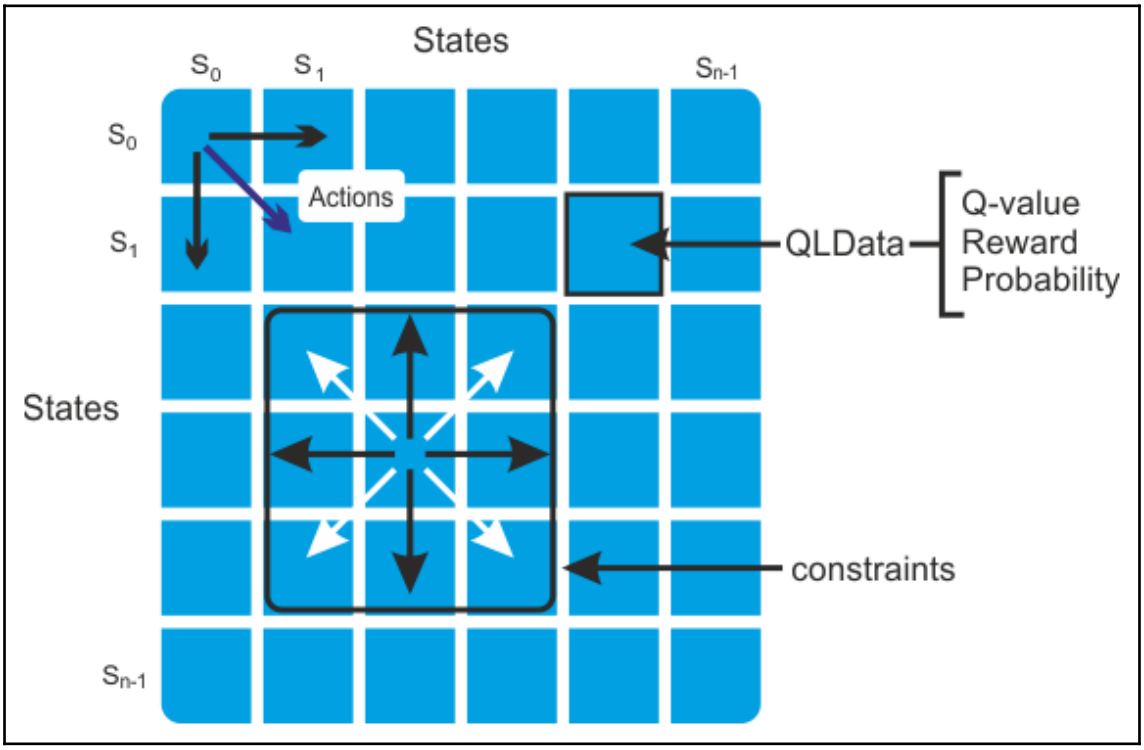
Volume Type	Device	Snapshot	Size (GiB)	Volume Type	IOPS	Throughput (MB/s)
Root	/dev/sda1	snap-03b3f6b054709c485	200	General Purpose SSD (GP2)	600 / 3000	N/A

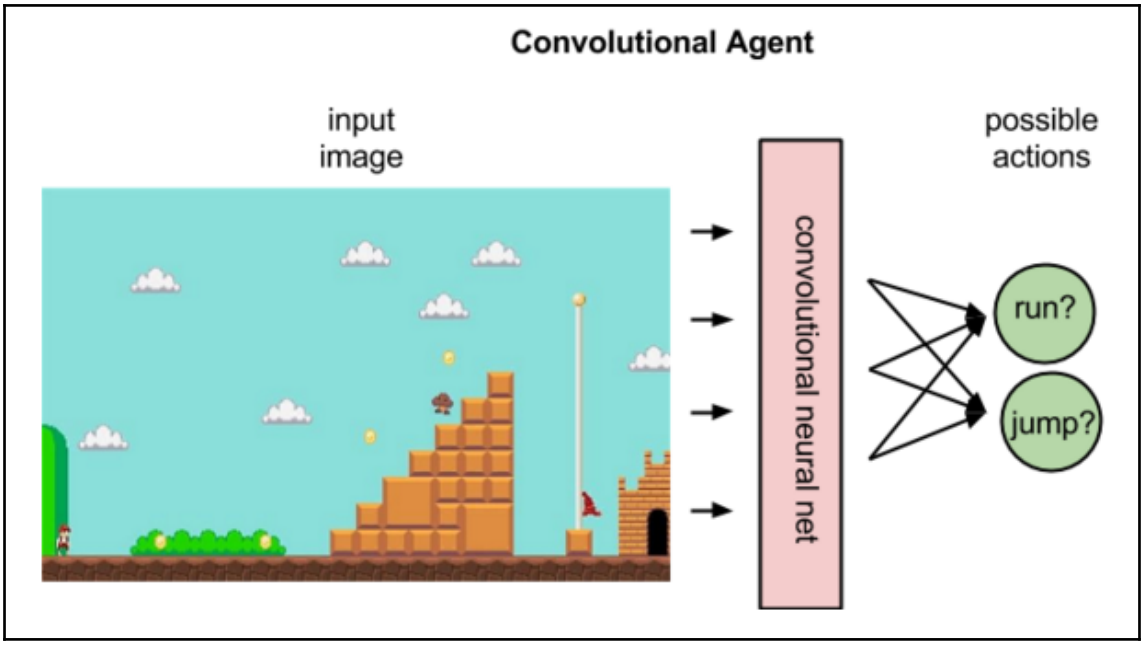
Chapter 9: Playing GridWorld Game Using Deep Reinforcement Learning

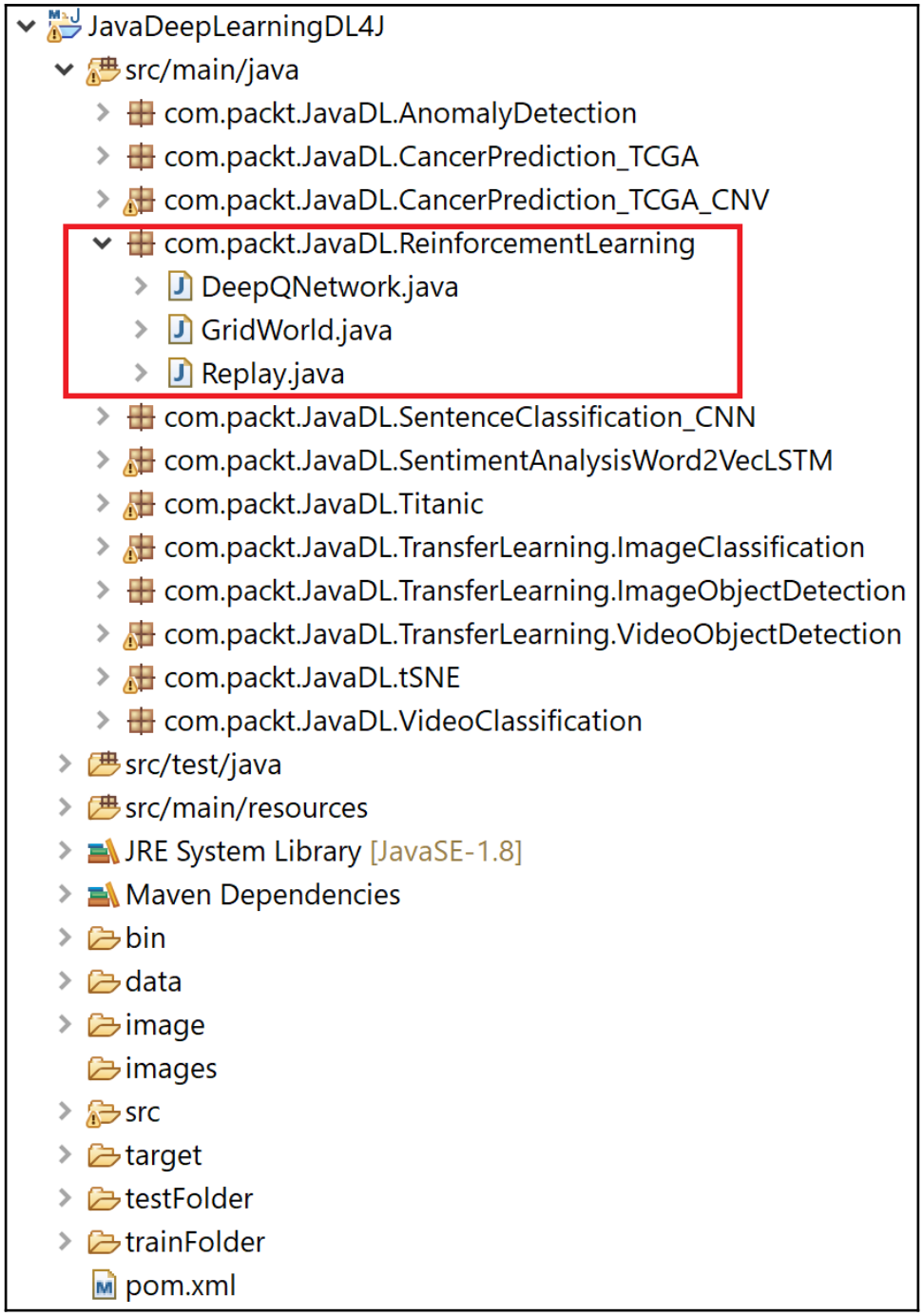


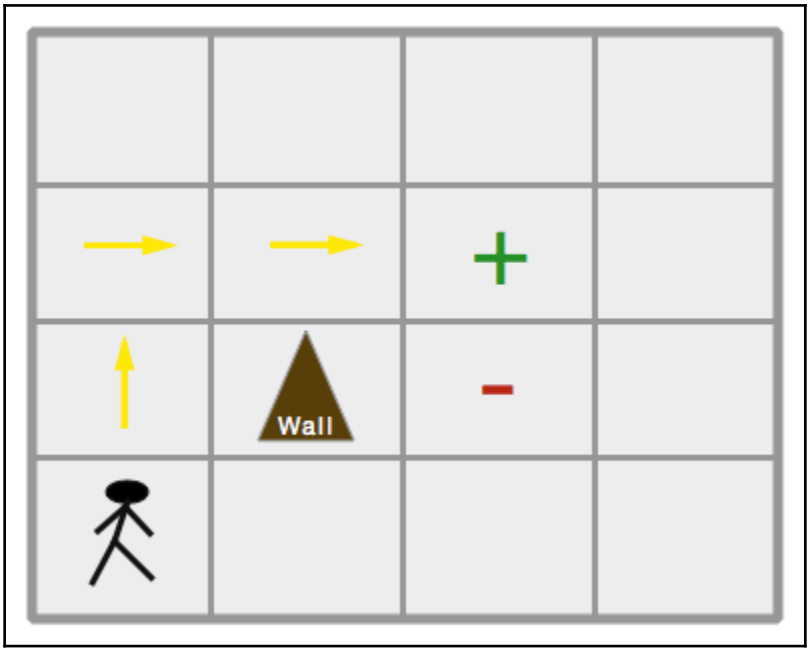


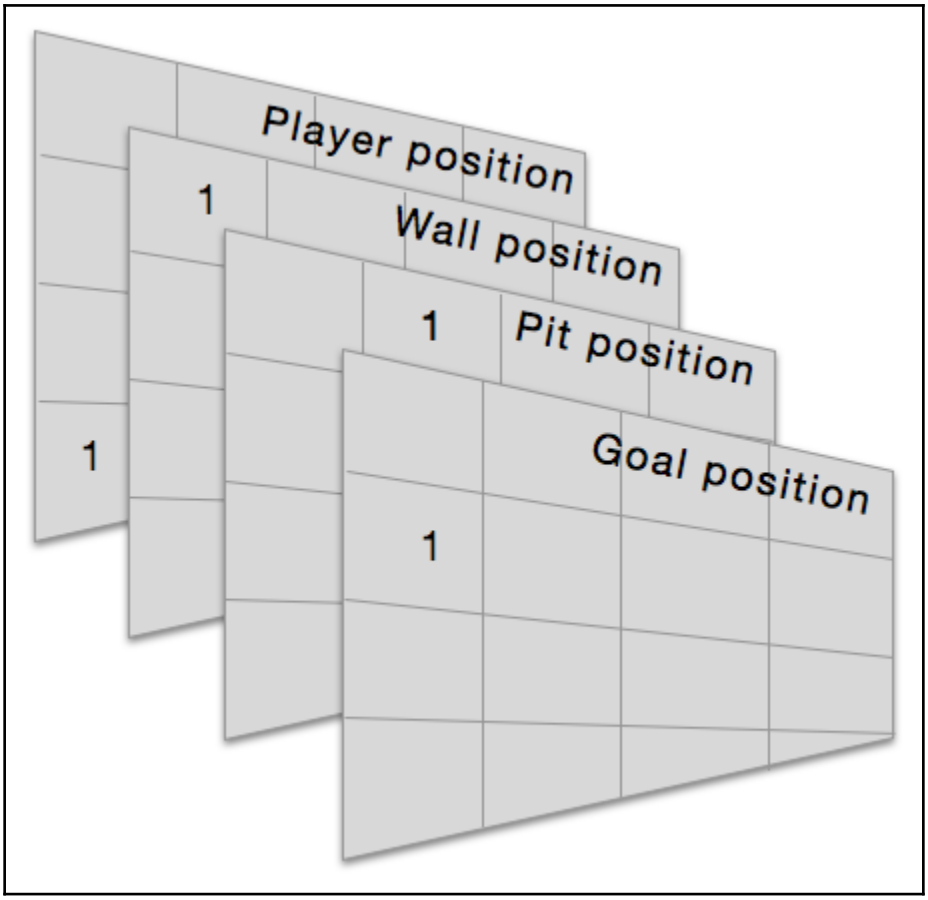

State
Action
Q
Utility

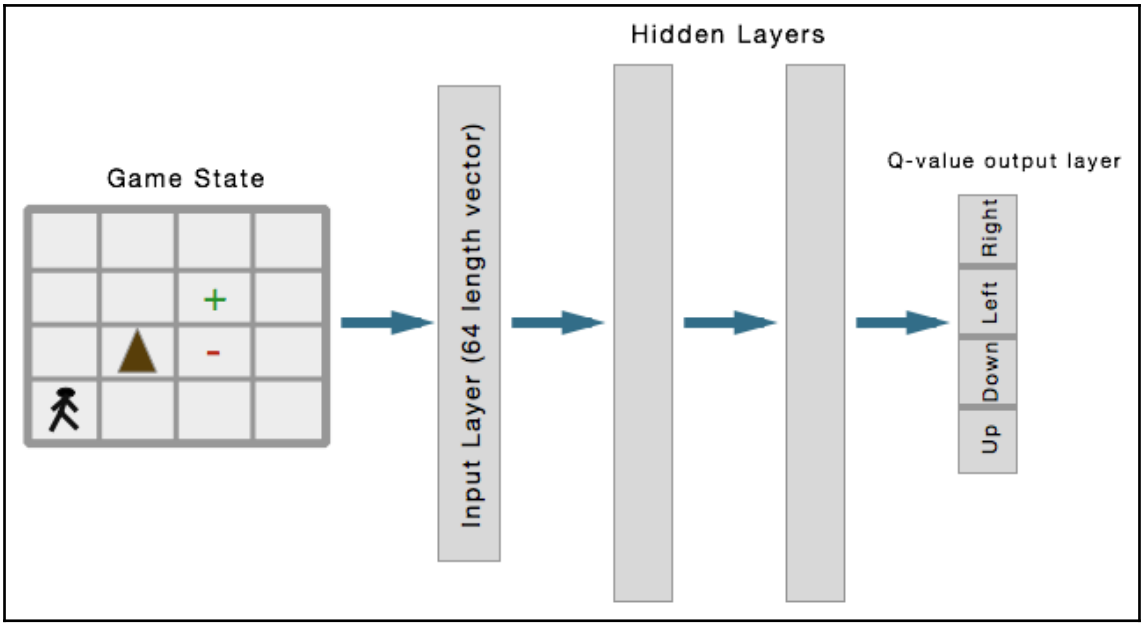

States
S_0
S_1
S_{n-1}
S_0
S_1
Actions
QLData
Q-value
Reward
Probability
States
constraints
S_{n-1}


Convolutional Agent
input
image
convolutional neural net
possible
actions
run?
jump?

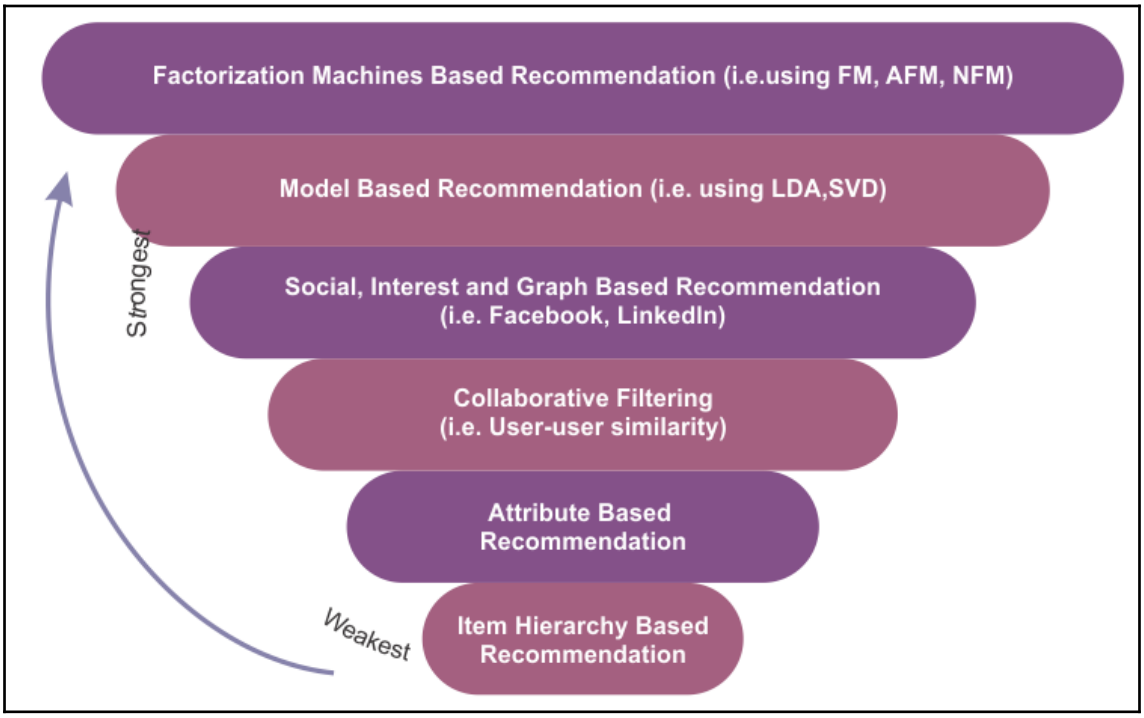

JavaDeepLearningDL4J
src/main/java
com.packt.JavaDL.AnomalyDetection
com.packt.JavaDL.CancerPrediction_TCGA
com.packt.JavaDL.CancerPrediction_TCGA_CNV
com.packt.JavaDL.ReinforcementLearning
DeepQNetwork.java
GridWorld.java
Replay.java
com.packt.JavaDL.SentenceClassification_CNN
com.packt.JavaDL.SentimentAnalysisWord2VecLSTM
com.packt.JavaDL.Titanic
com.packt.JavaDL.TransferLearning.ImageClassification
com.packt.JavaDL.TransferLearning.ImageObjectDetection
com.packt.JavaDL.TransferLearning.VideoObjectDetection
com.packt.JavaDL.tSNE
com.packt.JavaDL.VideoClassification
src/test/java
src/main/resources
JRE System Library [JavaSE-1.8]
Maven Dependencies
bin
data
image
images
src
target
testFolder
trainFolder
pom.xml


Wall


Player position
1
1
Wall position
1
Pit position
Goal position
1


Hidden Layers
Game State
+
-
Input Layer (64 length vector)
Q-value output layer
Right
Left
Down
Up

Chapter 10: Developing Movie Recommendation Systems Using Factorization Machines



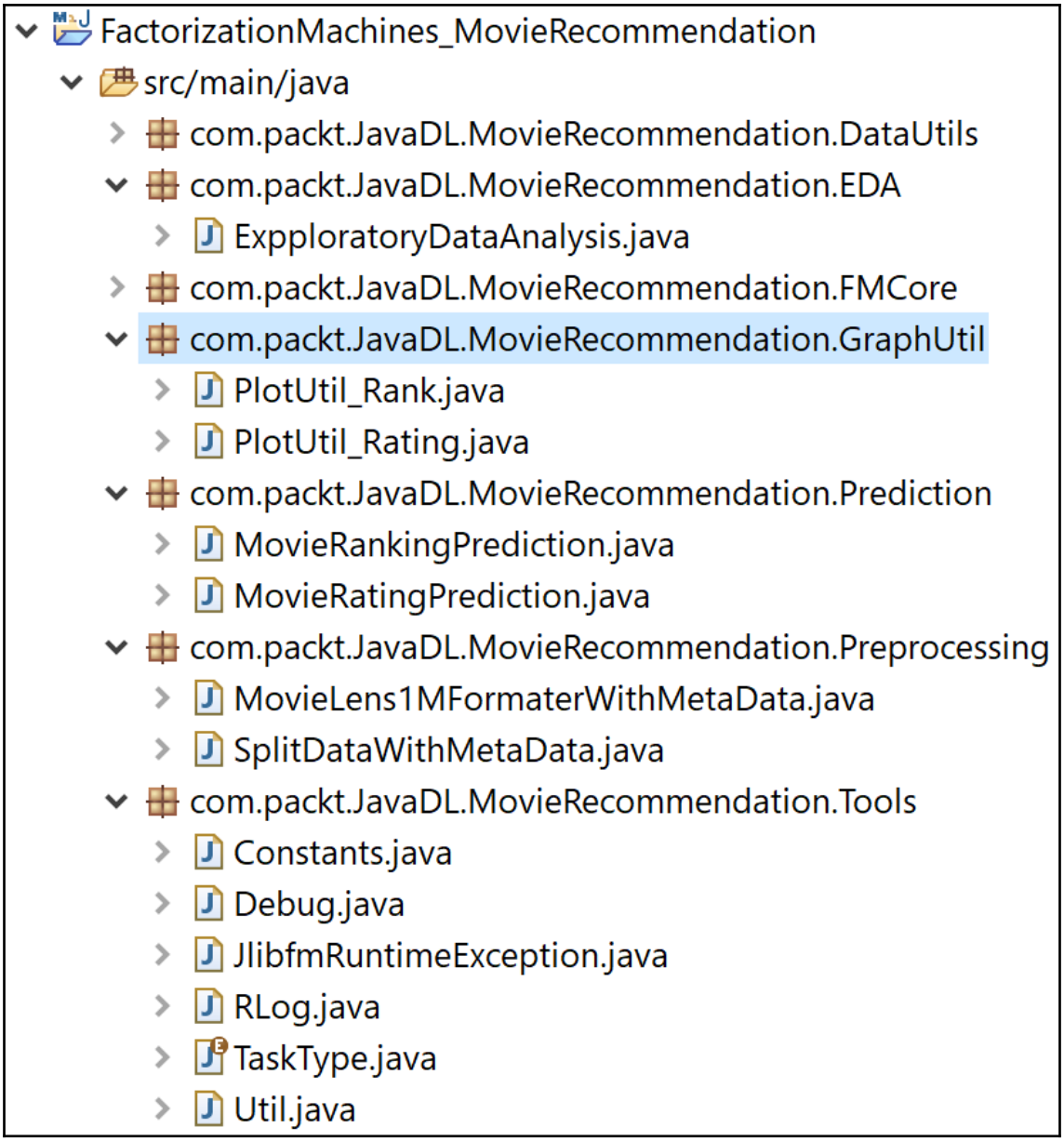
	HP1	HP2	HP3	TW	SW1	SW2	SW3
A	4			5	1		
B	5	5	4				
C				2	4	5	
D		3					3

users

items	1	2	3	4	5	6	7	8	9	10	...	n
1	1		1			1				1		
2							1	1	1			
3	1	1		1				1	1			1
4		1			1			1	1			
...			1				1					
m												

Feature vector **x**

	User				Movie					Other Movie rated					Time	Last Movie rated					Target y	
	A	B	C	...	TI	NH	SW	ST	...	TI	NH	SW	ST	...		TI	NH	SW	ST	...		
x_1	1	0	0	...	1	0	0	0	...	0.3	0.3	0.3	0	...	13	0	0	0	0	...	5	y_1
x_2	1	0	0	...	0	1	0	0	...	0.3	0.3	0.3	0	...	14	1	0	0	0	...	3	y_2
x_3	1	0	0	...	0	0	1	0	...	0.3	0.3	0.3	0	...	16	0	1	0	0	...	1	y_3
x_4	0	1	0	...	0	0	1	0	...	0	0	0.5	0.5	...	5	0	0	0	0	...	4	y_4
x_5	0	1	0	...	0	0	0	1	...	0	0	0.5	0.5	...	8	0	0	1	0	...	5	y_5
x_6	0	0	1	...	1	0	0	0	...	0.5	0	0.5	0	...	9	0	0	0	0	...	1	y_6
x_7	0	0	1	...	0	0	1	0	...	0.5	0	0.5	0	...	12	1	0	0	0	...	5	y_7


FactorizationMachines_MovieRecommendation
src/main/java
com.packt.JavaDL.MovieRecommendation.DataUtils
com.packt.JavaDL.MovieRecommendation.EDA
ExpploratoryDataAnalysis.java
com.packt.JavaDL.MovieRecommendation.FMCore
com.packt.JavaDL.MovieRecommendation.GraphUtil
PlotUtil_Rank.java
PlotUtil_Rating.java
com.packt.JavaDL.MovieRecommendation.Prediction
MovieRankingPrediction.java
MovieRatingPrediction.java
com.packt.JavaDL.MovieRecommendation.Preprocessing
MovieLens1MFormaterWithMetaData.java
SplitDataWithMetaData.java
com.packt.JavaDL.MovieRecommendation.Tools
Constants.java
Debug.java
JlibfmRuntimeException.java
RLog.java
TaskType.java
Util.java

```
+------+-------+------+----------+
|userId|movieId|rating| timestamp|
+------+-------+------+----------+
|     1|     31|   2.5|1260759144|
|     1|   1029|   3.0|1260759179|
|     1|   1061|   3.0|1260759182|
|     1|   1129|   2.0|1260759185|
|     1|   1172|   4.0|1260759205|
|     1|   1263|   2.0|1260759151|
|     1|   1287|   2.0|1260759187|
|     1|   1293|   2.0|1260759148|
|     1|   1339|   3.5|1260759125|
|     1|   1343|   2.0|1260759131|
+------+-------+------+----------+
only showing top 10 rows
```

```
+-------+--------------------+--------------------+
|movieId|               title|              genres|
+-------+--------------------+--------------------+
|      1|    Toy Story (1995)|Adventure|Animati...|
|      2|      Jumanji (1995)|Adventure|Childre...|
|      3|Grumpier Old Men ...|      Comedy|Romance|
|      4|Waiting to Exhale...|Comedy|Drama|Romance|
|      5|Father of the Bri...|              Comedy|
|      6|         Heat (1995)|Action|Crime|Thri...|
|      7|      Sabrina (1995)|      Comedy|Romance|
|      8| Tom and Huck (1995)|  Adventure|Children|
|      9| Sudden Death (1995)|              Action|
|     10|    GoldenEye (1995)|Action|Adventure|...|
+-------+--------------------+--------------------+
only showing top 10 rows
```

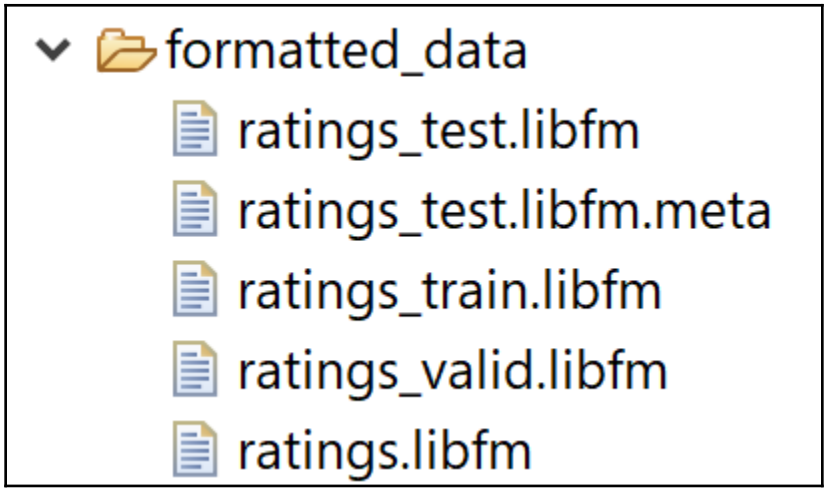
```
+--------------------+----+----+----+
|               title|maxr|minr|cntu|
+--------------------+----+----+----+
| Forrest Gump (1994)| 5.0| 1.0| 341|
| Pulp Fiction (1994)| 5.0| 0.5| 324|
|Shawshank Redempt...| 5.0| 1.0| 311|
|Silence of the La...| 5.0| 0.5| 304|
|Star Wars: Episod...| 5.0| 0.5| 291|
|Jurassic Park (1993)| 5.0| 0.5| 274|
|  Matrix, The (1999)| 5.0| 1.0| 259|
|    Toy Story (1995)| 5.0| 1.0| 247|
|Schindler's List ...| 5.0| 0.5| 244|
|Terminator 2: Jud...| 5.0| 1.0| 237|
+--------------------+----+----+----+
only showing top 10 rows
```

userId	ct
547	2391
564	1868
624	1735
15	1700
73	1610
452	1340
468	1291
380	1063
311	1019
30	1011

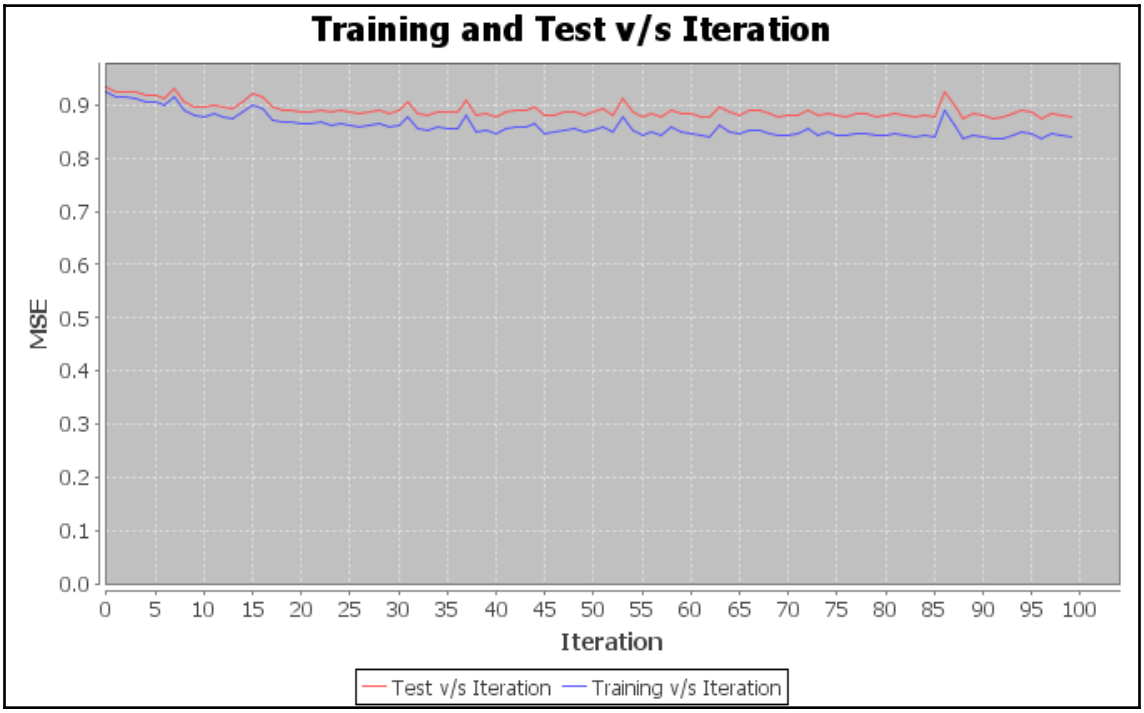
```
+------+-------+------+--------------------+
|userId|movieId|rating|               title|
+------+-------+------+--------------------+
|   668|    296|   5.0| Pulp Fiction (1994)|
|   668|    593|   5.0|Silence of the La...|
|   668|    608|   5.0|        Fargo (1996)|
|   668|   1213|   5.0|   Goodfellas (1990)|
|   668|   1221|   5.0|Godfather: Part I...|
|   668|   2324|   5.0|Life Is Beautiful...|
|   668|   2908|   5.0|Boys Don't Cry (1...|
|   668|   2997|   5.0|Being John Malkov...|
+------+-------+------+--------------------+
```

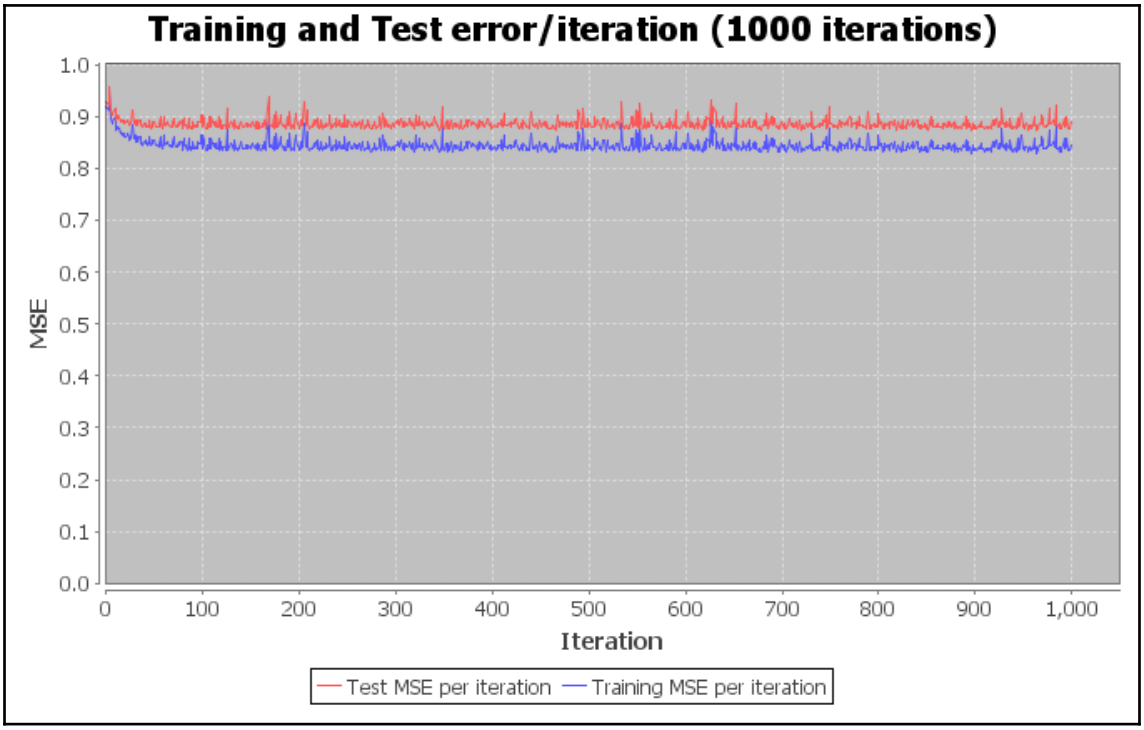
```
5 0:1 1:1 2:1 3:1 4:1 5:1#1 1193
3 0:1 6:1 2:1 3:1 4:1 7:1 8:1 9:1#1 661
3 0:1 10:1 2:1 3:1 4:1 9:1 11:1#1 914
4 0:1 12:1 2:1 3:1 4:1 5:1#1 3408
5 0:1 13:1 2:1 3:1 4:1 7:1 8:1 14:1#1 2355
3 0:1 15:1 2:1 3:1 4:1 16:1 17:1 14:1 11:1#1 1197
5 0:1 18:1 2:1 3:1 4:1 16:1 17:1 5:1#1 1287
5 0:1 19:1 2:1 3:1 4:1 14:1 5:1#1 2804
4 0:1 20:1 2:1 3:1 4:1 7:1 8:1 9:1#1 594
4 0:1 21:1 2:1 3:1 4:1 17:1 8:1 5:1 9:1#1 919
```

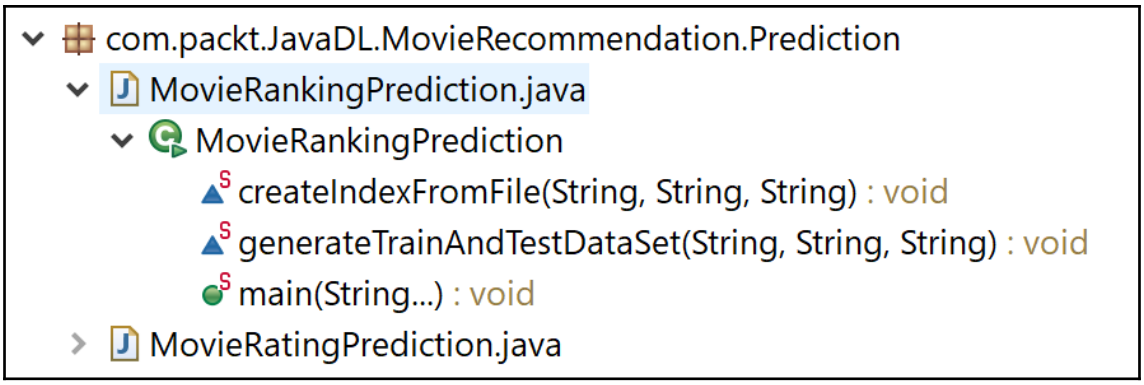
```
5 0:1 1:1 2:1 3:1 4:1 5:1
3 0:1 6:1 2:1 3:1 4:1 7:1 8:1 9:1
3 0:1 10:1 2:1 3:1 4:1 9:1 11:1
3 0:1 15:1 2:1 3:1 4:1 16:1 17:1 14:1 11:1
5 0:1 18:1 2:1 3:1 4:1 16:1 17:1 5:1
5 0:1 19:1 2:1 3:1 4:1 14:1 5:1
4 0:1 20:1 2:1 3:1 4:1 7:1 8:1 9:1
4 0:1 21:1 2:1 3:1 4:1 17:1 8:1 5:1 9:1
5 0:1 22:1 2:1 3:1 4:1 7:1 8:1 9:1
4 0:1 23:1 2:1 3:1 4:1 9:1
4 0:1 24:1 2:1 3:1 4:1 5:1
```

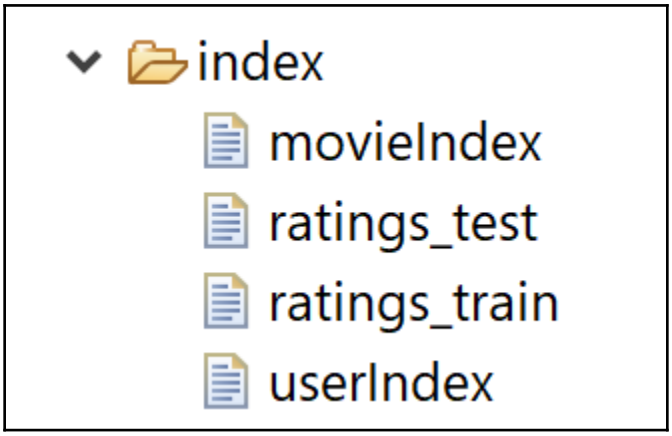


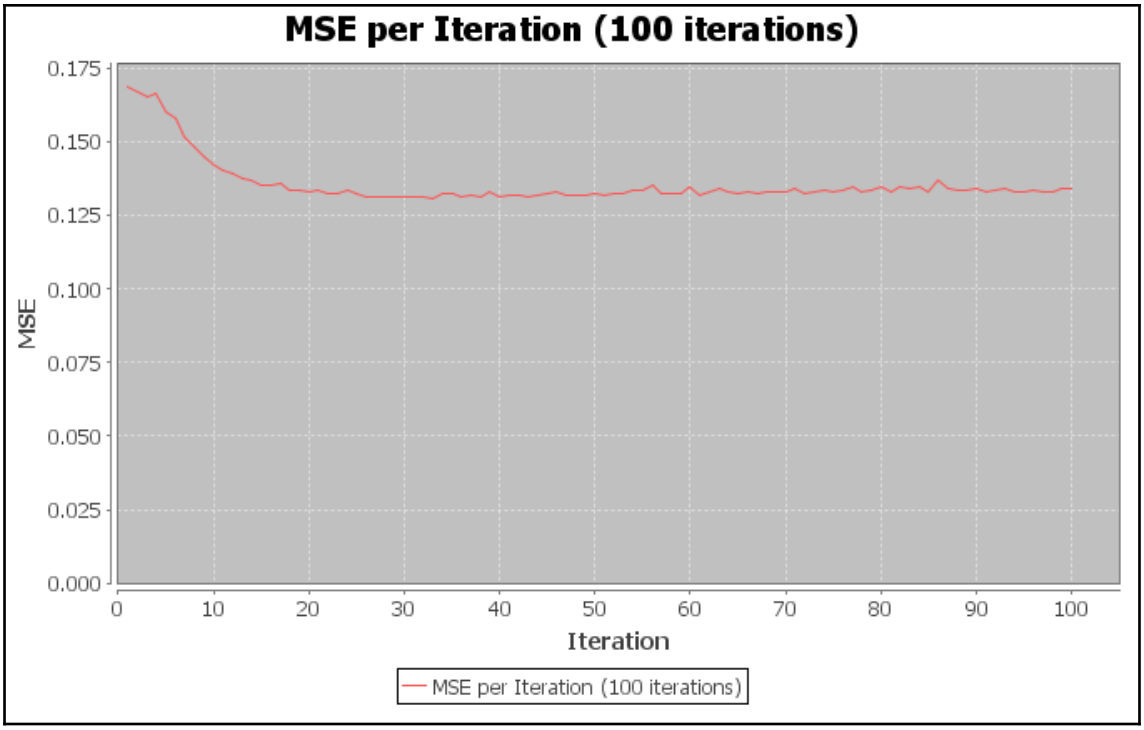
rmse	mae	time_pred	time_learn	time_learn2	time_learn4	rmse_train
0.9275955978932888	0.7365065595728909	0.0559999942779541	0.621999979019165	NaN	NaN	0.9198445445939268
0.9407647914787951	0.7294899596692839	0.03400015830993652	0.7159998416900635	NaN	NaN	0.9319879497222021
0.9184153371129748	0.7253438212645523	0.03299999237060547	0.5260000228881836	NaN	NaN	0.9070322657717291
0.9176294326054297	0.7242150425581235	0.03399991989135742	0.5379998683929443	NaN	NaN	0.9056342946016255
0.9132507564794741	0.7134487812431016	0.03600001335144043	0.5269999504089355	NaN	NaN	0.89951865257831
0.9137783879031901	0.7115911503494833	0.037999868392944336	0.7339999675750732	NaN	NaN	0.8996410144580471
0.9103229305286898	0.7207182087788873	0.03399991989135742	0.8540000915527344	NaN	NaN	0.8948129152871857
0.9112892202865233	0.72193143849607	0.03599977493286133	0.747999906539917	NaN	NaN	0.8940408851122638
0.9158240594263269	0.7326954653664787	0.03399991989135742	0.7970001697540283	NaN	NaN	0.8974186861344857

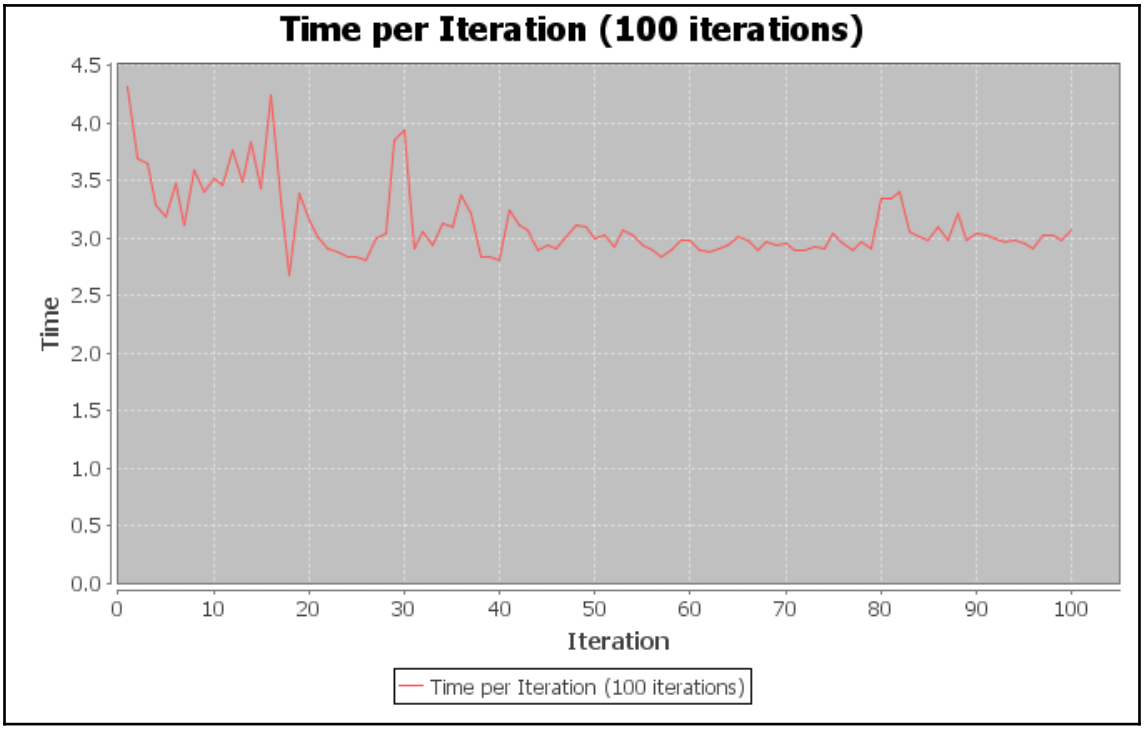



Training and Test error/iteration (1000 iterations)
MSE
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0
100
200
300
400
500
600
700
800
900
1,000
Iteration
Test MSE per iteration
Training MSE per iteration


com.packt.JavaDL.MovieRecommendation.Prediction
MovieRankingPrediction.java
MovieRankingPrediction
createIndexFromFile(String, String, String) : void
generateTrainAndTestDataSet(String, String, String) : void
main(String...) : void
MovieRatingPrediction.java


index
movieIndex
ratings_test
ratings_train
userIndex


MSE per Iteration (100 iterations)
MSE
0.175
0.150
0.125
0.100
0.075
0.050
0.025
0.000
0
10
20
30
40
50
60
70
80
90
100
Iteration
MSE per Iteration (100 iterations)


Time per Iteration (100 iterations)
Time
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0
10
20
30
40
50
60
70
80
90
100
Iteration
Time per Iteration (100 iterations)