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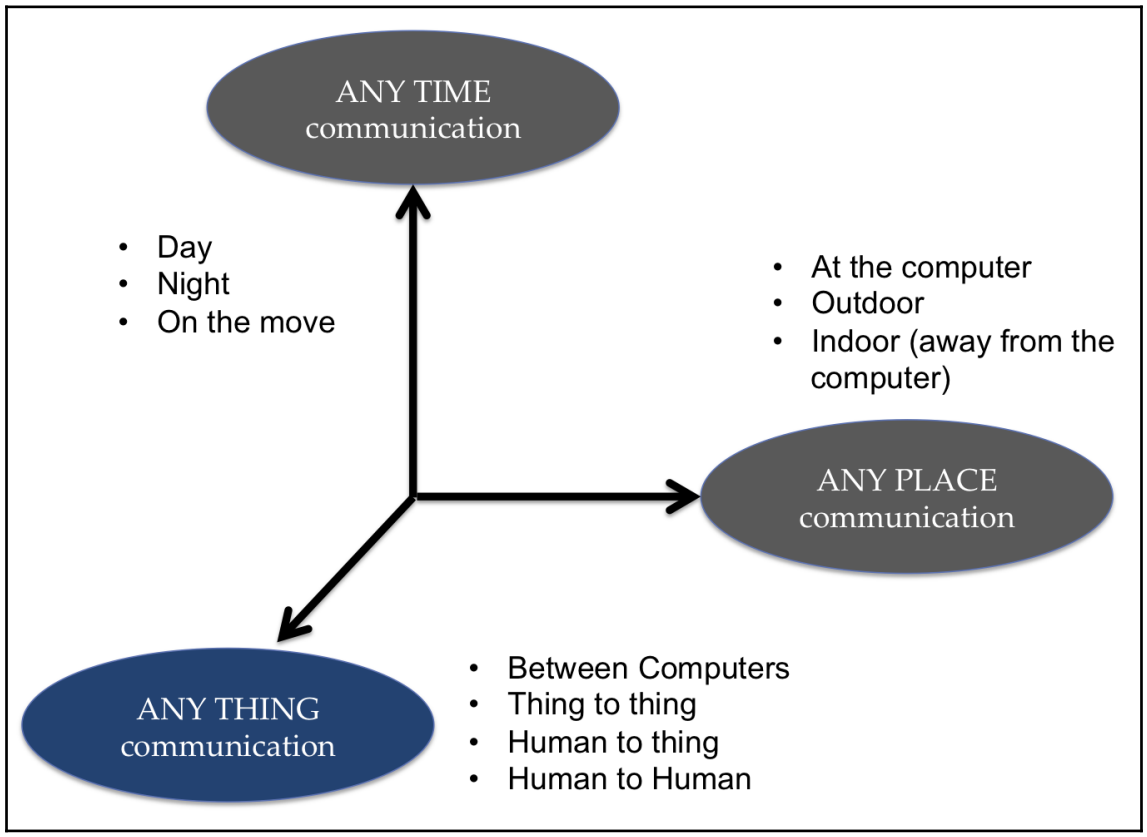
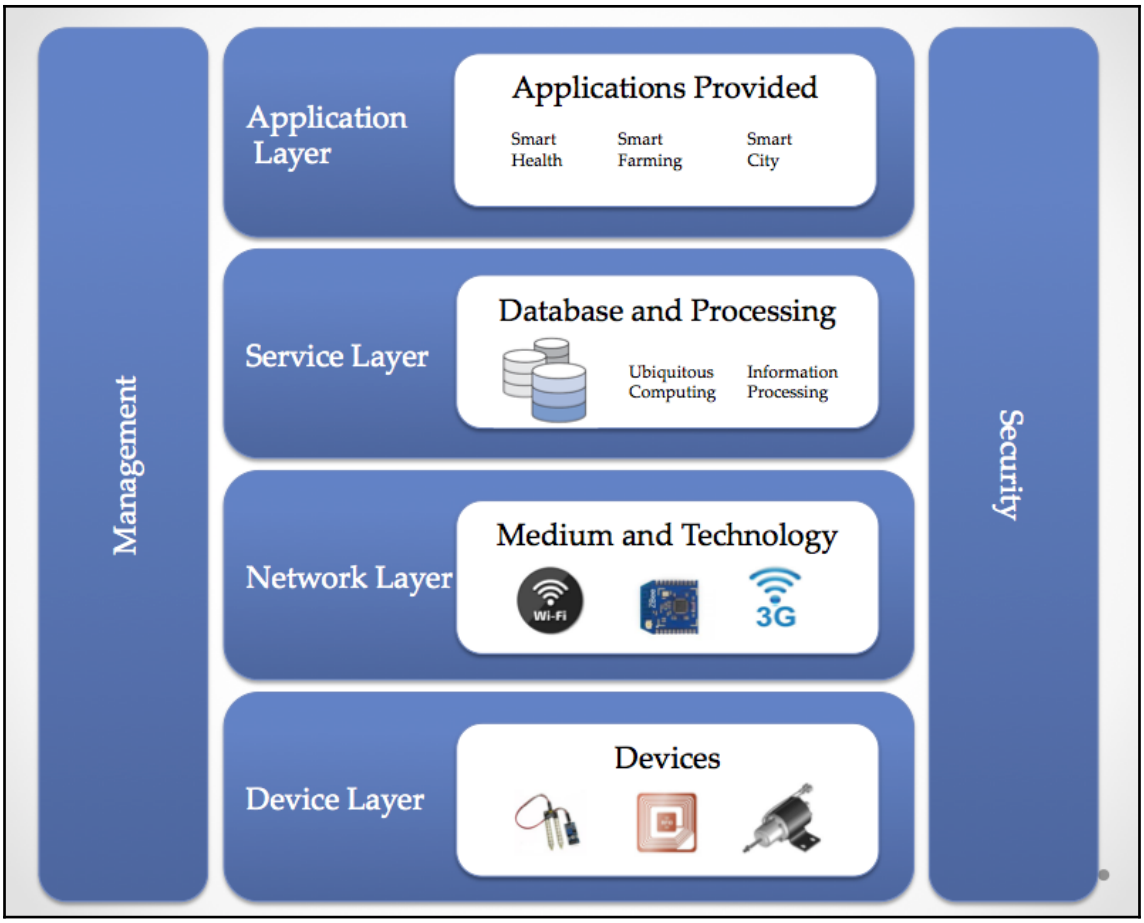
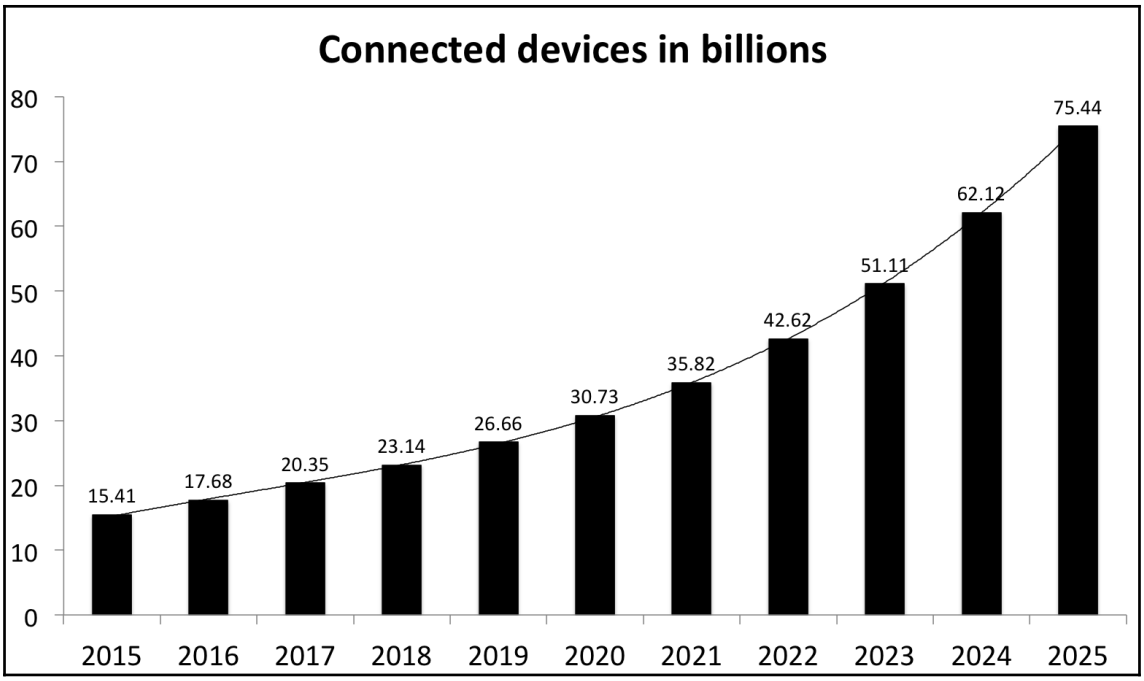
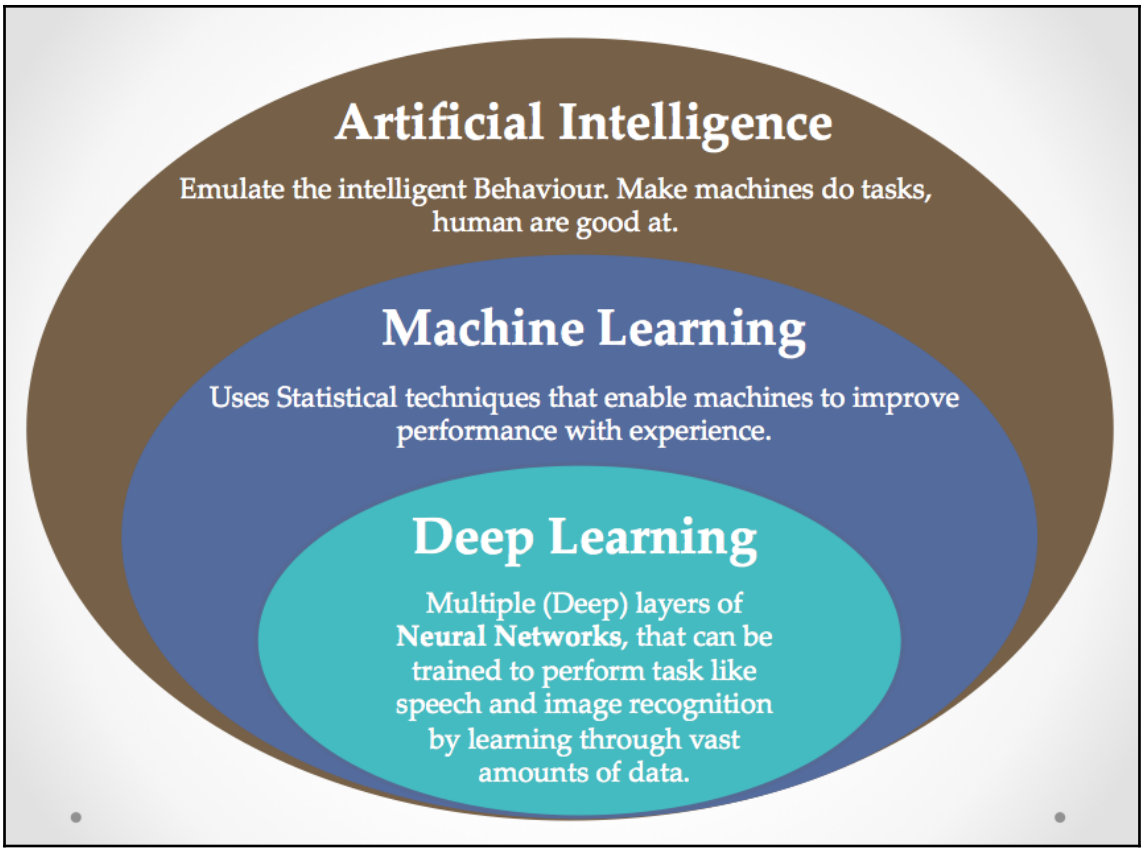
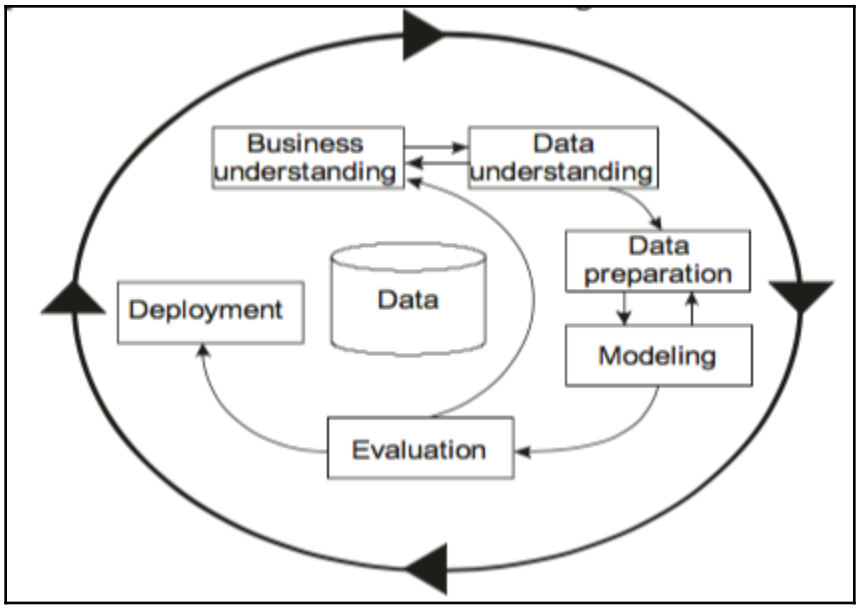
Chapter 1: Principles and Foundations of IoT and AI




Management
Application Layer
Applications Provided
Smart Health
Smart Farming
Smart City
Service Layer
Database and Processing
Ubiquitous Computing
Information Processing
Network Layer
Medium and Technology
Wi-Fi
3G
Device Layer
Devices
Security


Connected devices in billions
80
70
60
50
40
30
20
10
0
15.41
17.68
20.35
23.14
26.66
30.73
35.82
42.62
51.11
62.12
75.44
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024
2025


Artificial Intelligence
Emulate the intelligent Behaviour. Make machines do tasks, human are good at.
Machine Learning
Uses Statistical techniques that enable machines to improve performance with experience.
Deep Learning
Multiple (Deep) layers of Neural Networks, that can be trained to perform task like speech and image recognition by learning through vast amounts of data.


Business understanding
Data understanding
Data preparation
Modeling
Evaluation
Deployment
Data


Research
Application Development
Visualization
Device Management
Application Domains of IoT Cloud Platforms
Deployment Management
System Management
Analytics
Data Management

Chapter 2: Data Access and Distributed Processing for IoT

```
     type                name            tbl_name  rootpage  \
0   table    sqlite_sequence    sqlite_sequence         4
1   table  Player_Attributes  Player_Attributes        11
2   table             Player             Player        14
3   table              Match              Match        18
4   table             League             League        24
5   table            Country            Country        26
6   table               Team               Team        29
7   table    Team_Attributes    Team_Attributes         2

                                                  sql
0             CREATE TABLE sqlite_sequence(name,seq)
1  CREATE TABLE "Player_Attributes" (\n\t`id`\tIN...
2  CREATE TABLE `Player` (\n\t`id`\tINTEGER PRIMA...
3  CREATE TABLE `Match` (\n\t`id`\tINTEGER PRIMAR...
4  CREATE TABLE `League` (\n\t`id`\tINTEGER PRIMA...
5  CREATE TABLE `Country` (\n\t`id`\tINTEGER PRIM...
6  CREATE TABLE "Team" (\n\t`id`\tINTEGER PRIMARY...
7  CREATE TABLE `Team_Attributes` (\n\t`id`\tINTE...
```

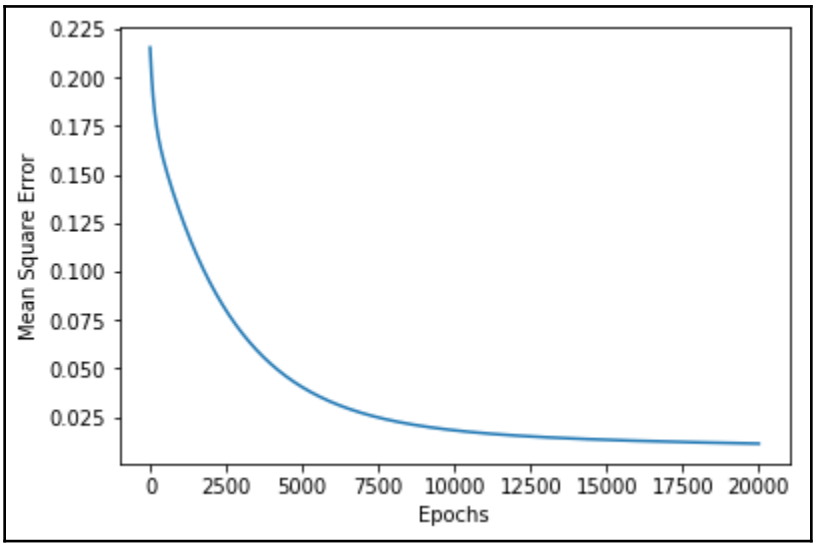
	id	name
0	1	Belgium
1	1729	England
2	4769	France
3	7809	Germany
4	10257	Italy

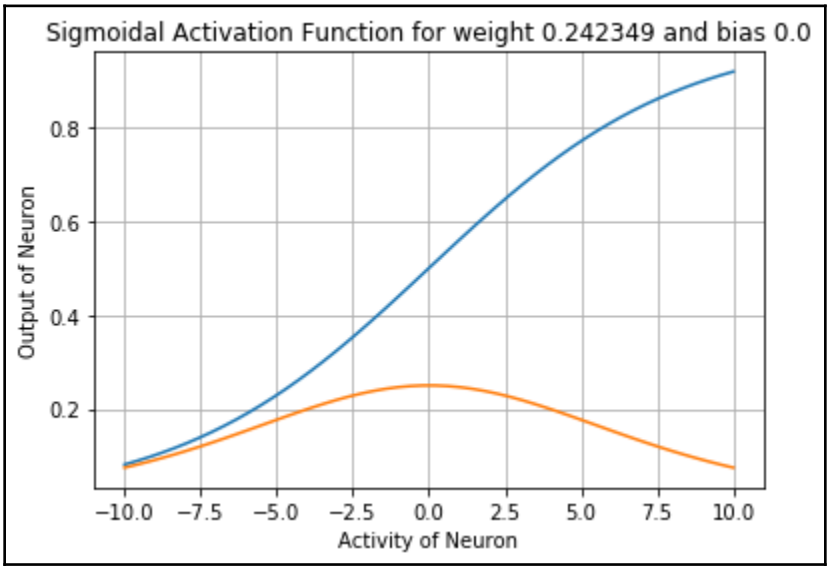
	id	player_api_id	player_name	player_fifa_api_id	\
0	1	505942	Aaron Appindangoye	218353	
1	4	30572	Aaron Galindo	140161	
2	9	528212	Aaron Lennox	206592	
3	11	23889	Aaron Mokoena	47189	
4	17	161644	Aaron Taylor-Sinclair	213569	
5	20	46447	Abasse Ba	156626	
6	24	42664	Abdelkader Ghezzal	178063	
7	29	306735	Abdelouahed Chakhsi	210504	
8	31	31684	Abdeslam Ouaddou	33022	
9	32	32637	Abdessalam Benjelloun	177295	
10	34	41093	Abdou Traore	187048	

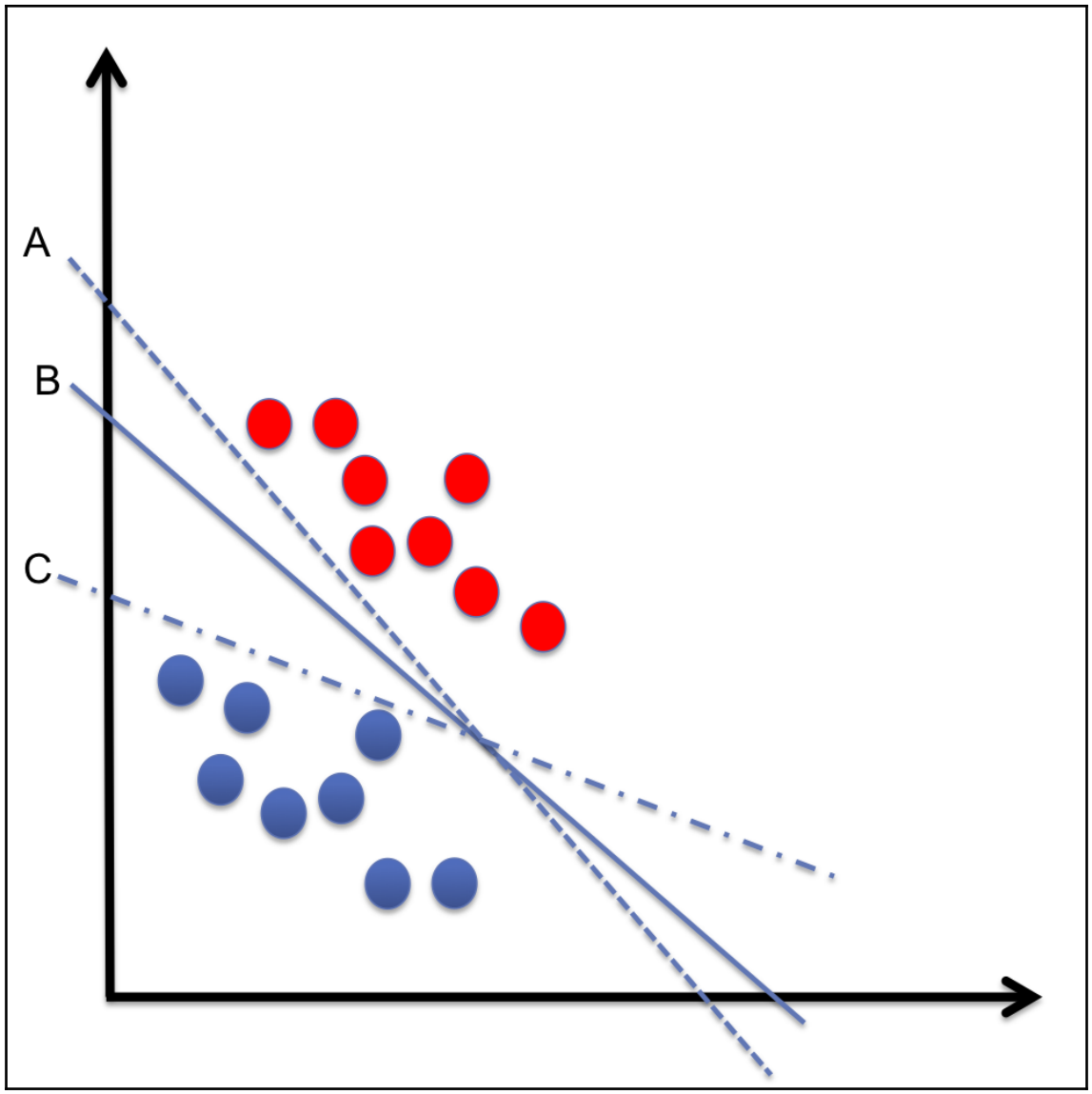
```
('information_schema',)
('mysql',)
('performance_schema',)
('sys',)
```

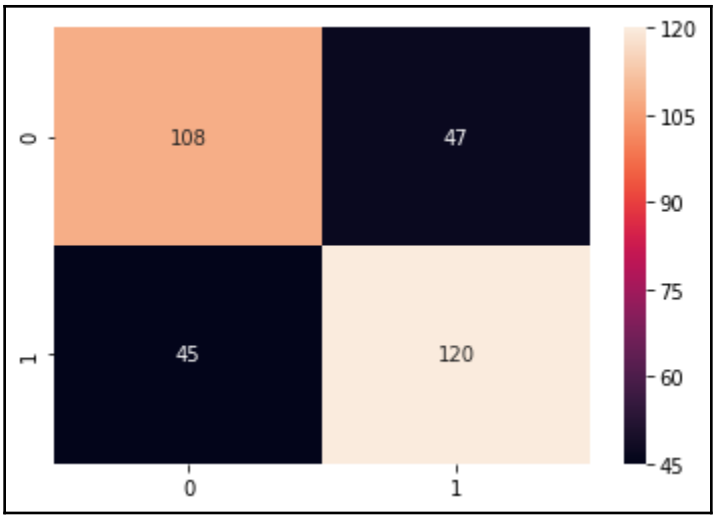
```
                          _id  \
0  5ba272f0d82f8a68a1fa33ab

                                                columns  \
0  [[mean radius], [mean texture], [mean perimete...

                                                  data  \
0  [[17.99, 10.38, 122.8, 1001.0, 0.1184, 0.2776,...

                                                 index
0  [0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13,...
```

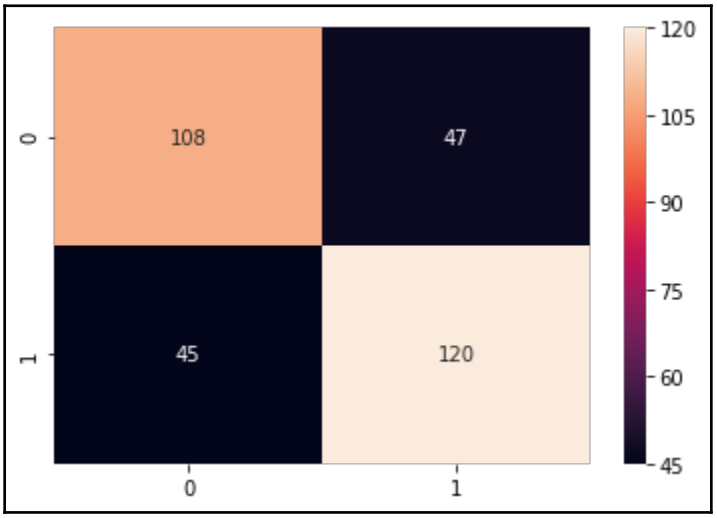
Chapter 3: Machine Learning for IoT

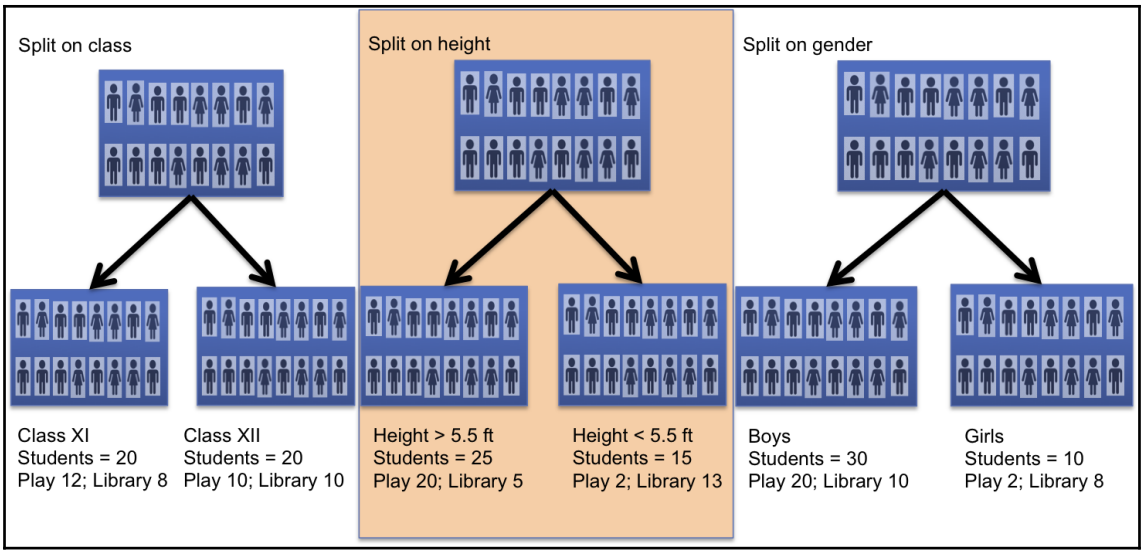


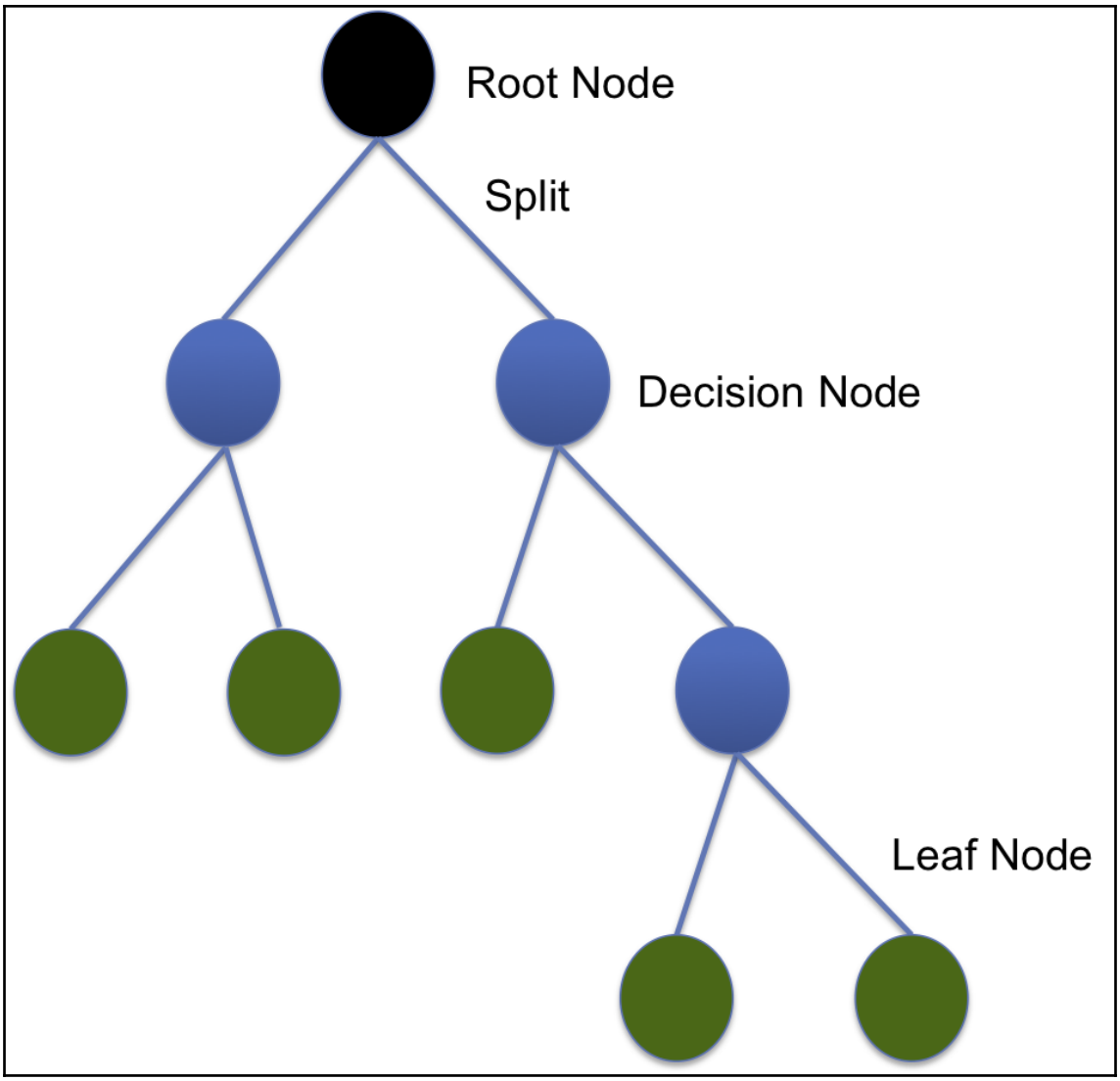


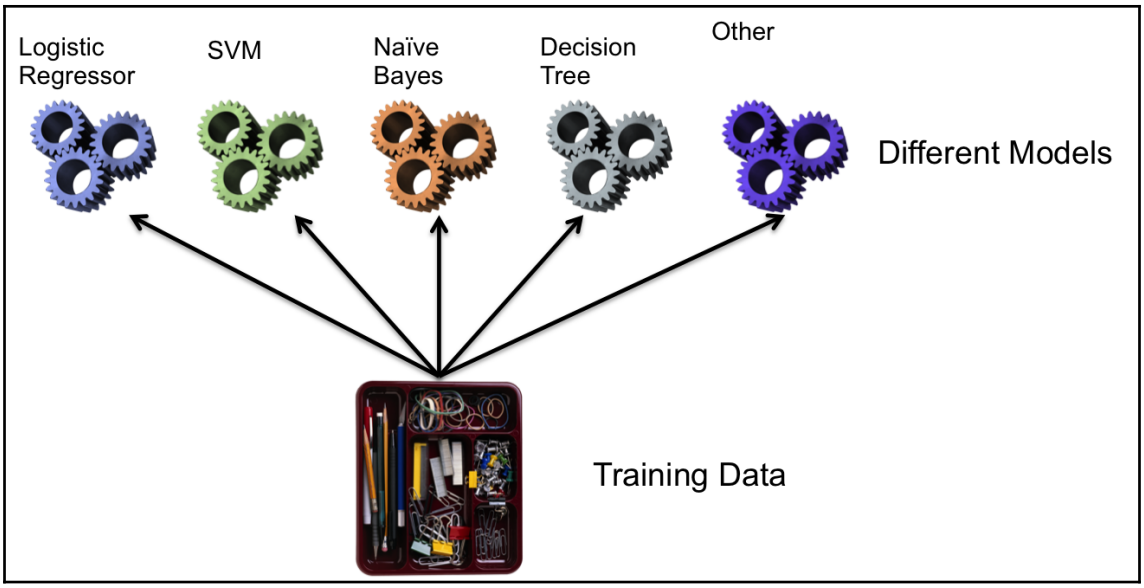

A
B
C

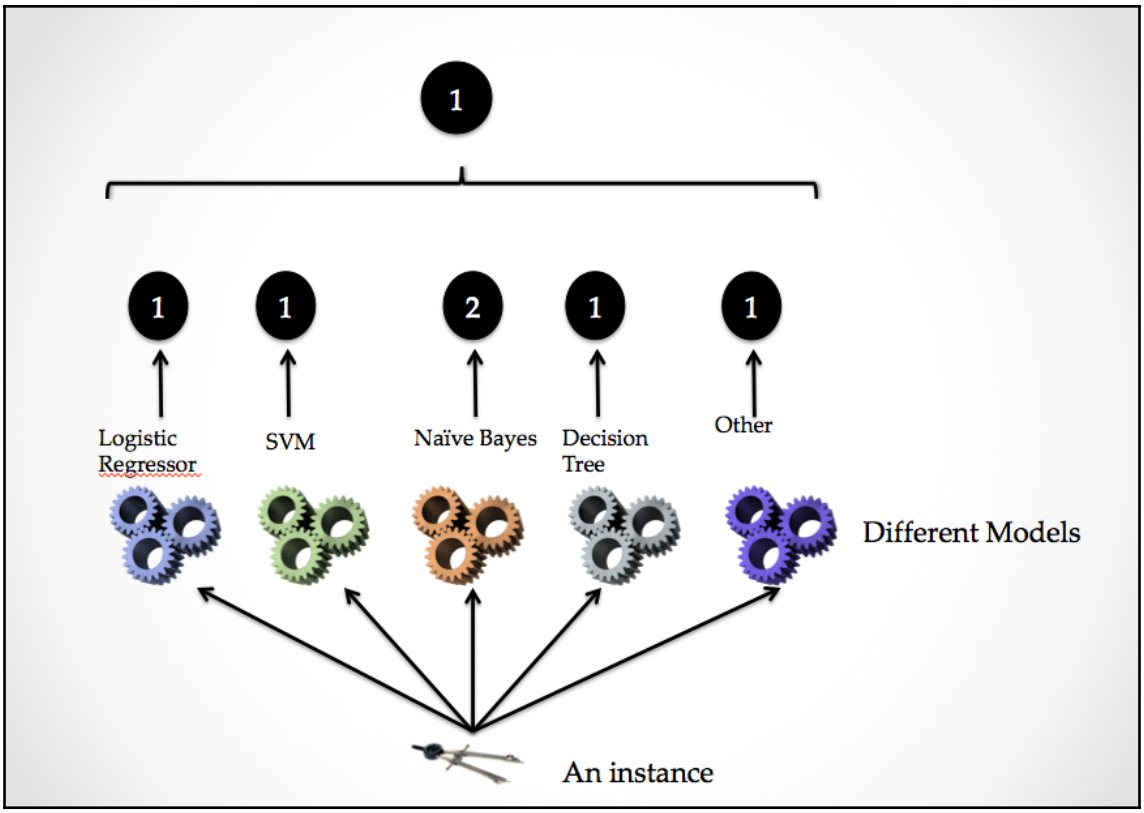

108
47
45
120
0
1
0
1
120
105
90
75
60
45


108
47
45
120
0
1
0
1
120
105
90
75
60
45

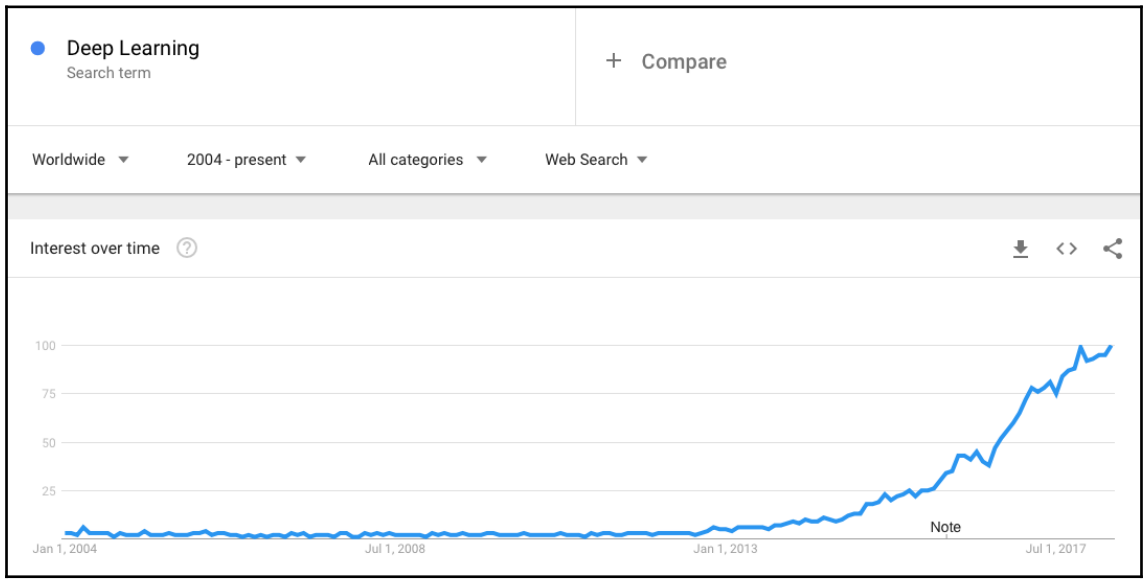

Split on class
Class XI
Students = 20
Play 12; Library 8
Class XII
Students = 20
Play 10; Library 10
Split on height
Height > 5.5 ft
Students = 25
Play 20; Library 5
Height < 5.5 ft
Students = 15
Play 2; Library 13
Split on gender
Boys
Students = 30
Play 20; Library 10
Girls
Students = 10
Play 2; Library 8

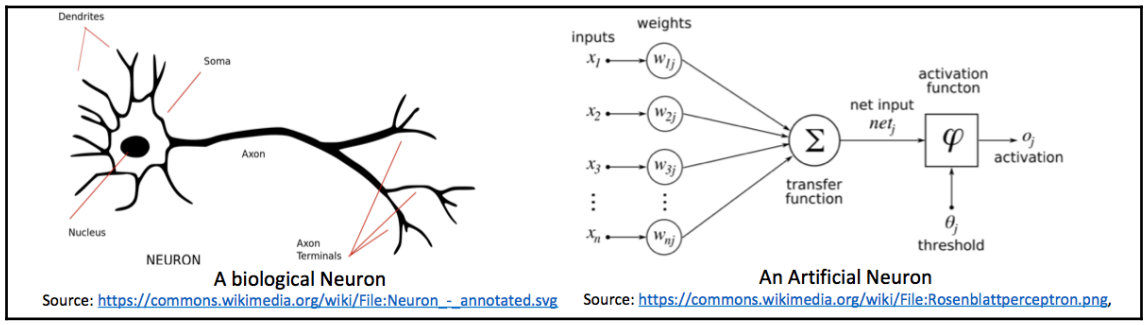

Root Node
Split
Decision Node
Leaf Node


Logistic Regressor
SVM
Naïve Bayes
Decision Tree
Other
Different Models
Training Data


1
1
1
2
1
1
Logistic Regressor
SVM
Naïve Bayes
Decision Tree
Other
Different Models
An instance

Chapter 4: Deep Learning for IoT



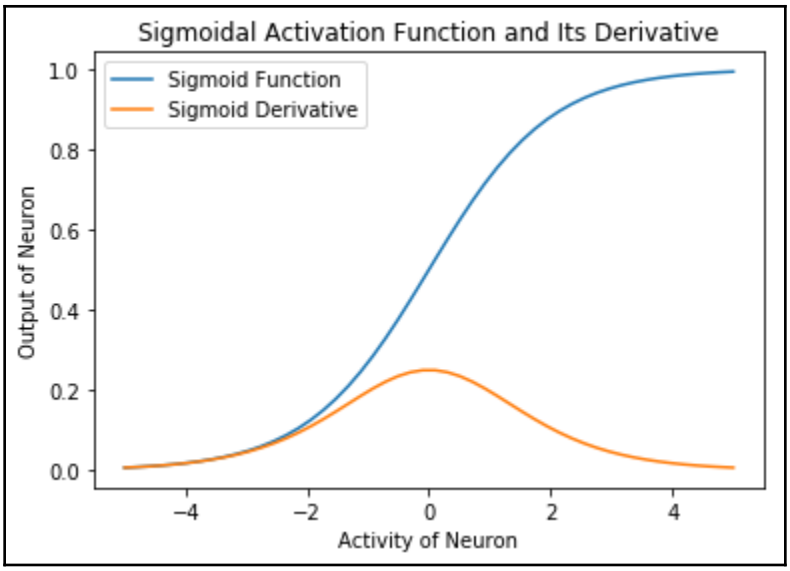


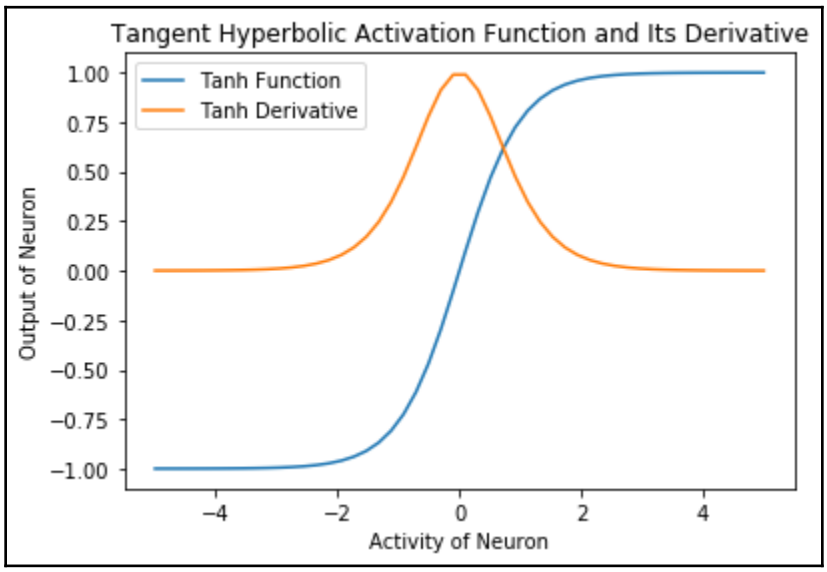
A biological Neuron

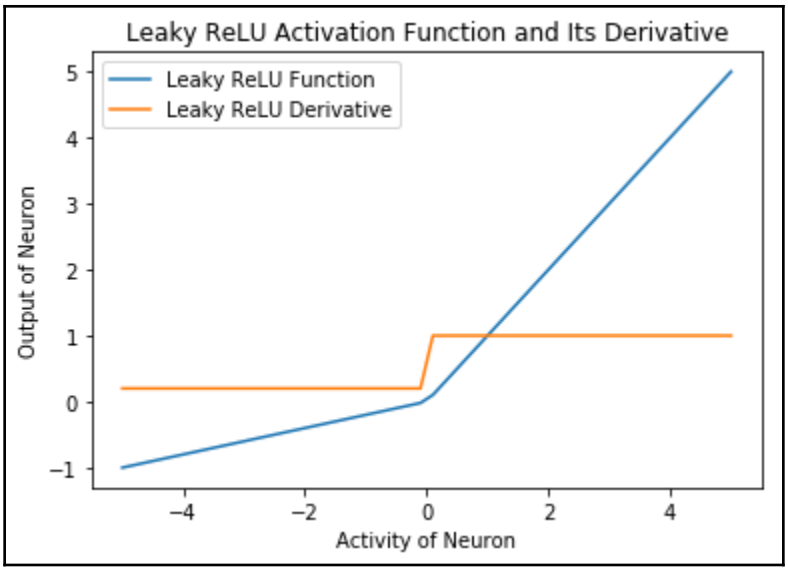
Source: https://commons.wikimedia.org/wiki/File:Neuron_-_annotated.svg

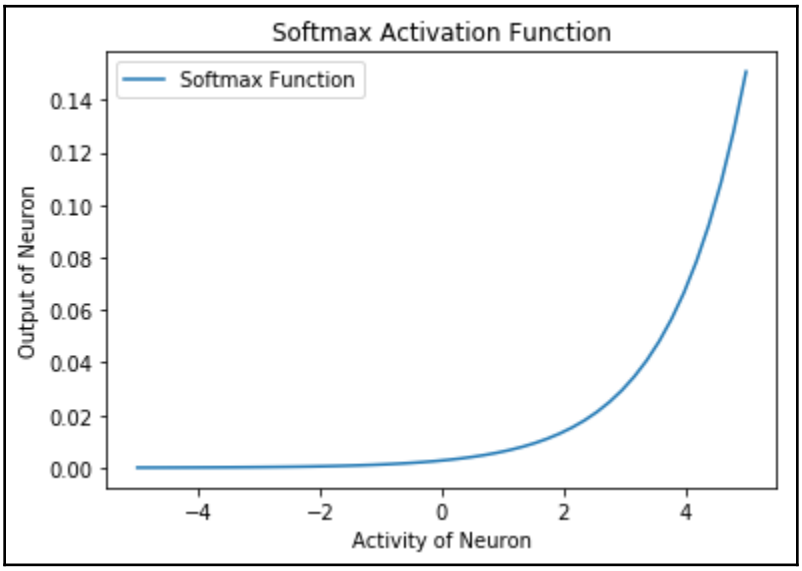
An Artificial Neuron

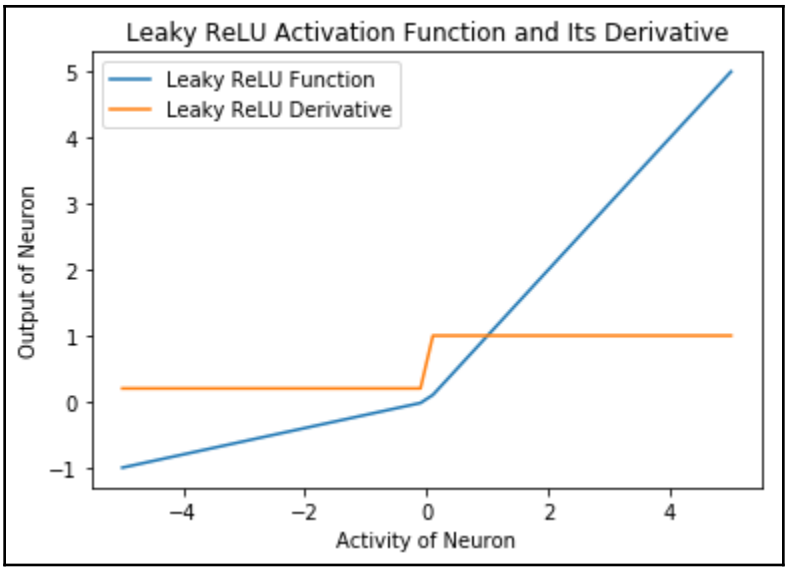
Source: https://commons.wikimedia.org/wiki/File:Rosenblattperceptron.png,

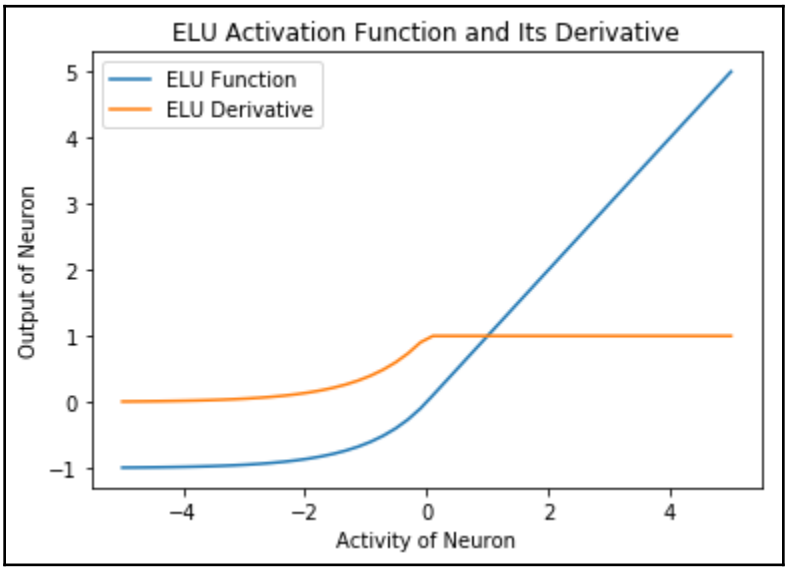

Sigmoidal Activation Function and Its Derivative
Sigmoid Function
Sigmoid Derivative
Output of Neuron
Activity of Neuron
1.0
0.8
0.6
0.4
0.2
0.0
−4
−2
0
2
4

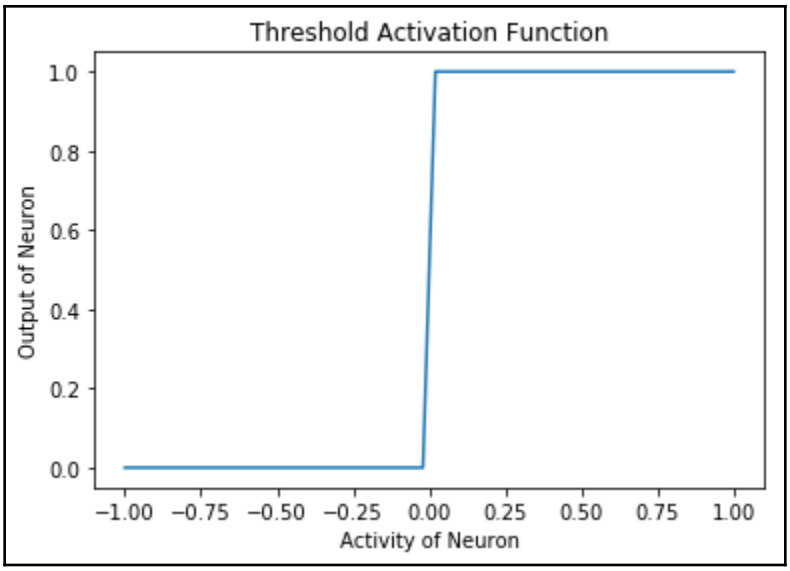

Tangent Hyperbolic Activation Function and Its Derivative
Tanh Function
Tanh Derivative
Output of Neuron
Activity of Neuron
1.00
0.75
0.50
0.25
0.00
−0.25
−0.50
−0.75
−1.00
−4
−2
0
2
4

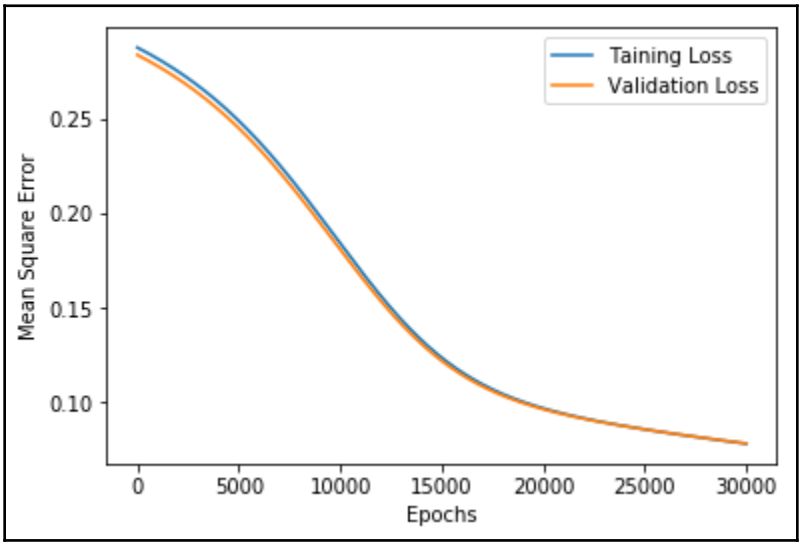

Leaky ReLU Activation Function and Its Derivative
Leaky ReLU Function
Leaky ReLU Derivative
Output of Neuron
Activity of Neuron
5
4
3
2
1
0
−1
−4
−2
0
2
4

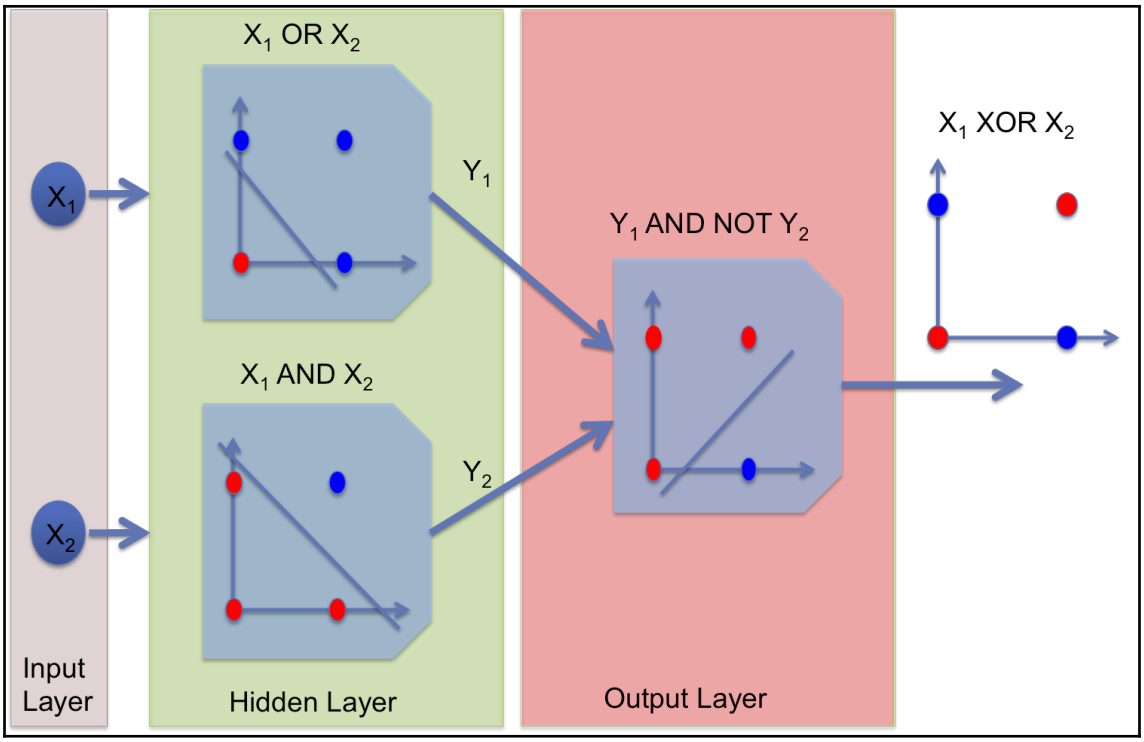

Softmax Activation Function
Softmax Function
Output of Neuron
Activity of Neuron
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
−4
−2
0
2
4

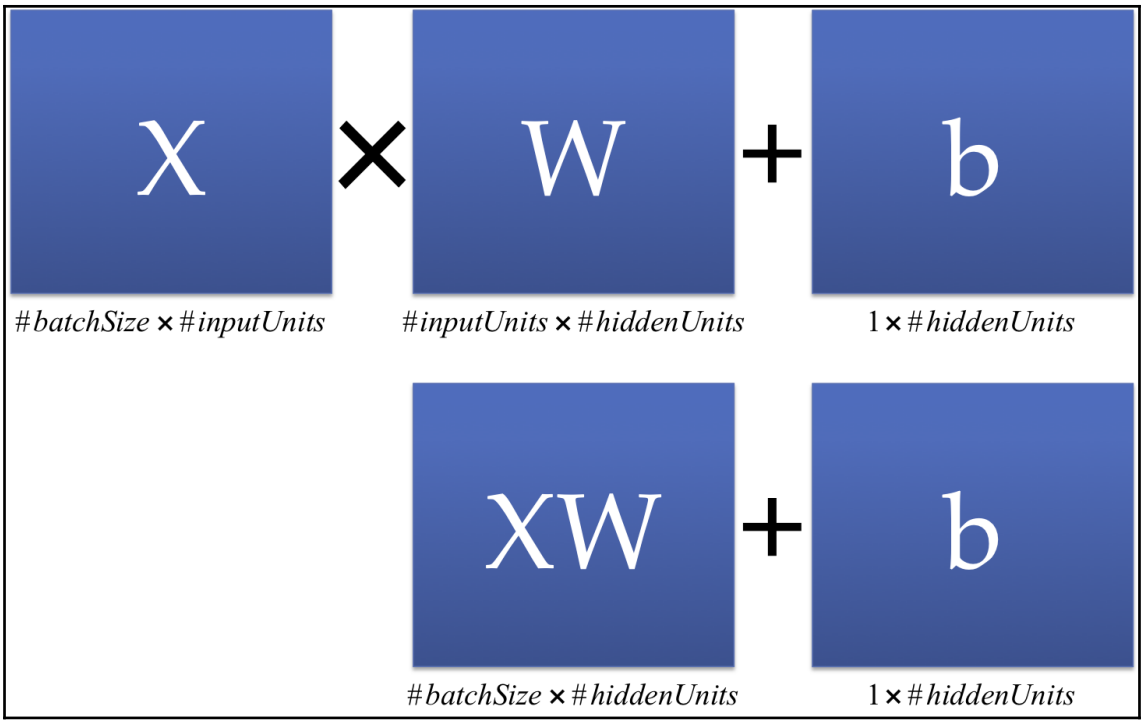

Leaky ReLU Activation Function and Its Derivative
Leaky ReLU Function
Leaky ReLU Derivative
Output of Neuron
Activity of Neuron
5
4
3
2
1
0
−1
−4
−2
0
2
4

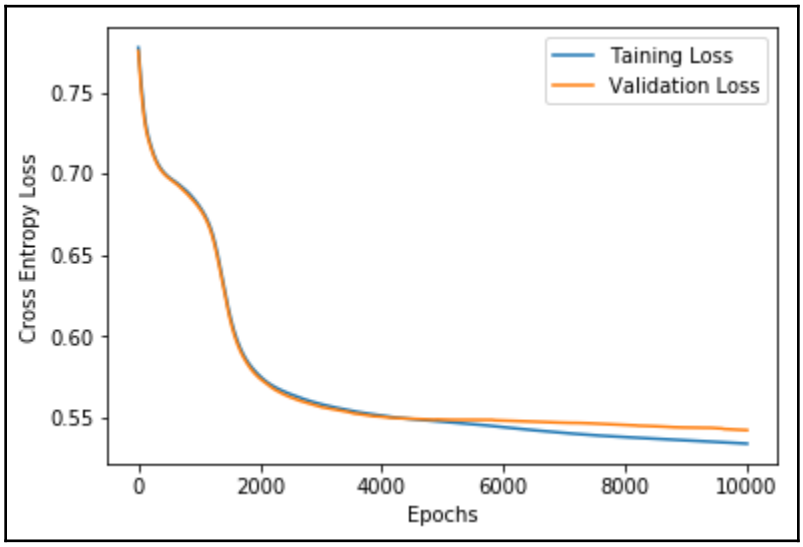

ELU Activation Function and Its Derivative
ELU Function
ELU Derivative
Output of Neuron
Activity of Neuron
5
4
3
2
1
0
−1
−4
−2
0
2
4

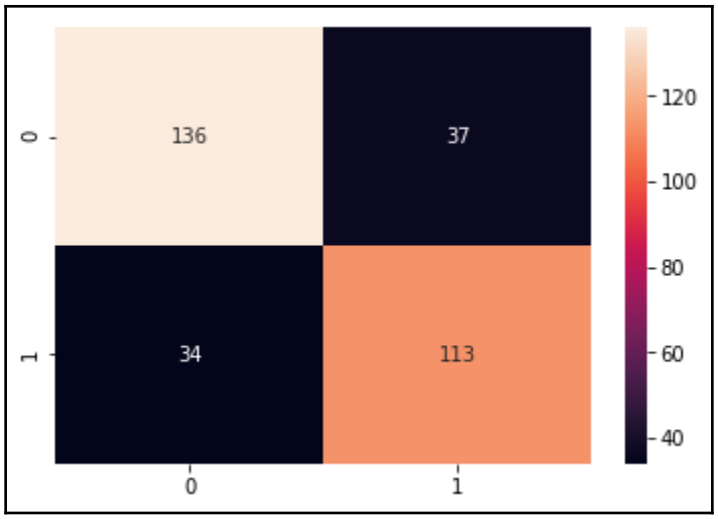

Threshold Activation Function
Output of Neuron
1.0
0.8
0.6
0.4
0.2
0.0
−1.00
−0.75
−0.50
−0.25
0.00
0.25
0.50
0.75
1.00
Activity of Neuron

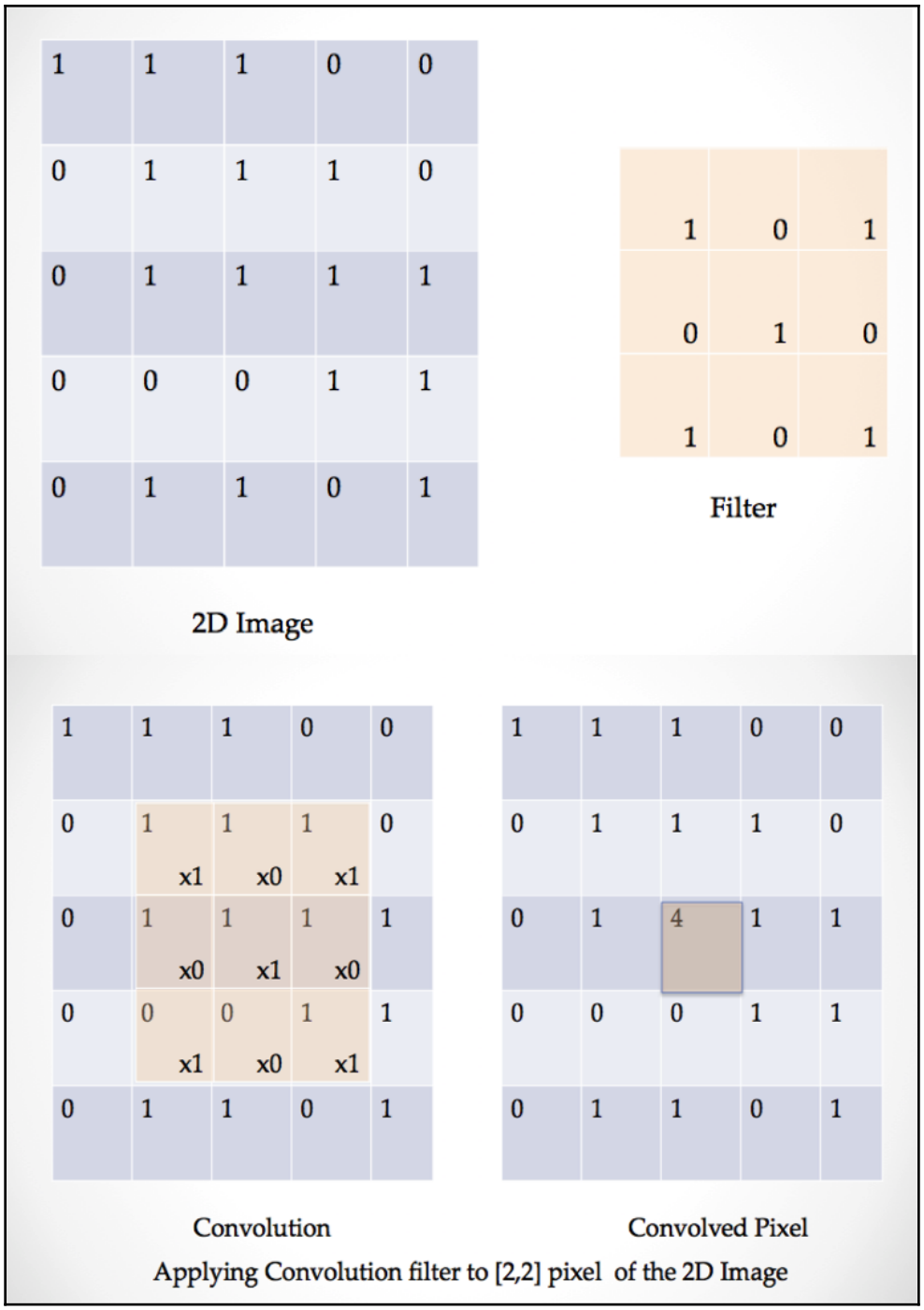

Taining Loss
Validation Loss
Mean Square Error
0.25
0.20
0.15
0.10
0
5000
10000
15000
20000
25000
30000
Epochs

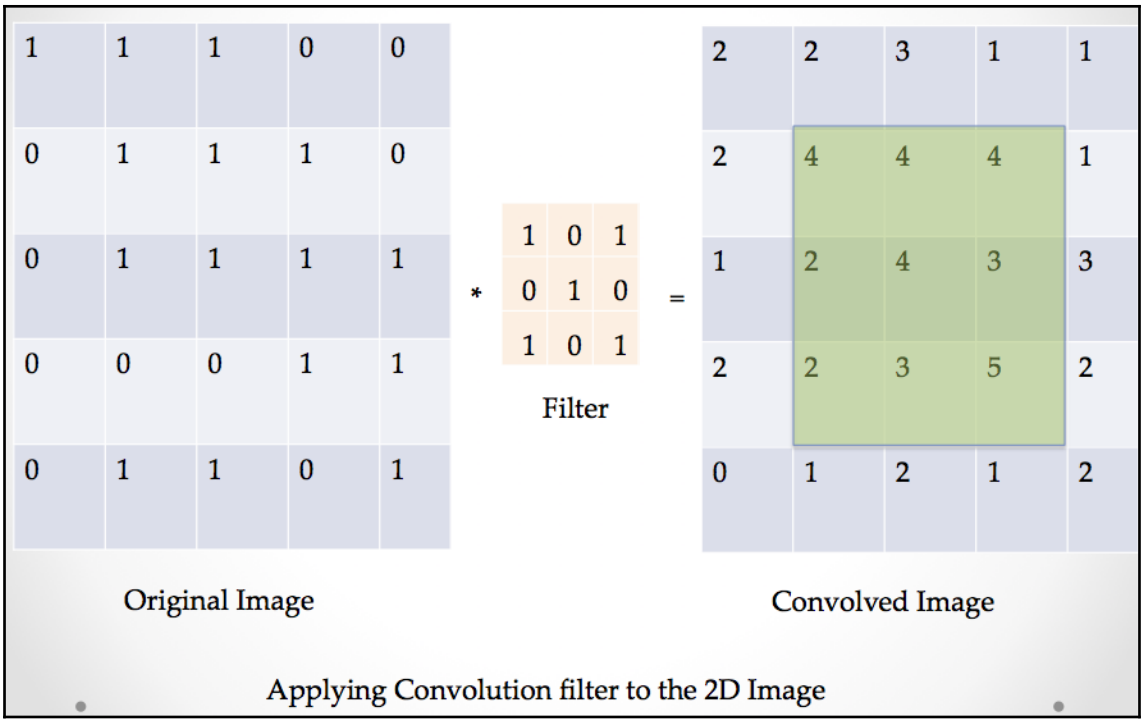

X1 OR X2
X1
Y1
Y1 AND NOT Y2
X1 XOR X2
X1 AND X2
X2
Y2
Input Layer
Hidden Layer
Output Layer

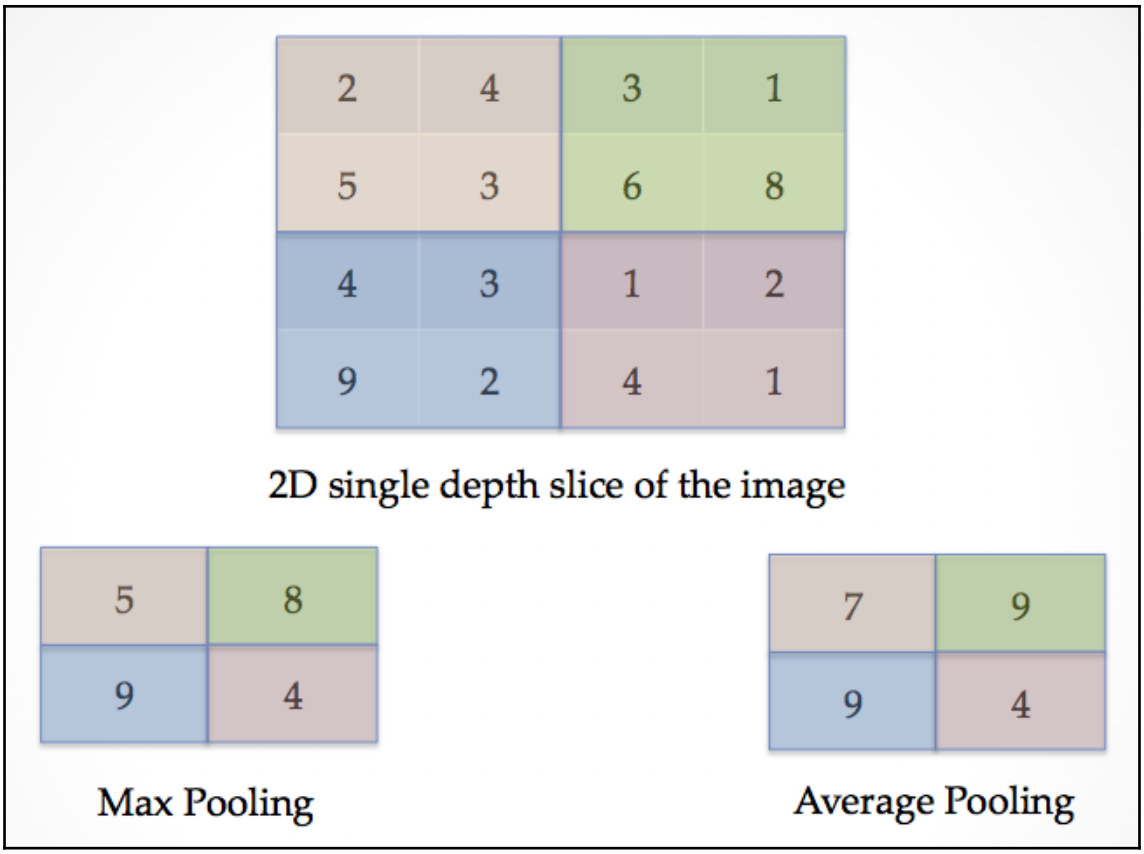

X
×
W
+
b
#batchSize × #inputUnits
#inputUnits × #hiddenUnits
1 × #hiddenUnits
XW
+
b
#batchSize × #hiddenUnits
1 × #hiddenUnits

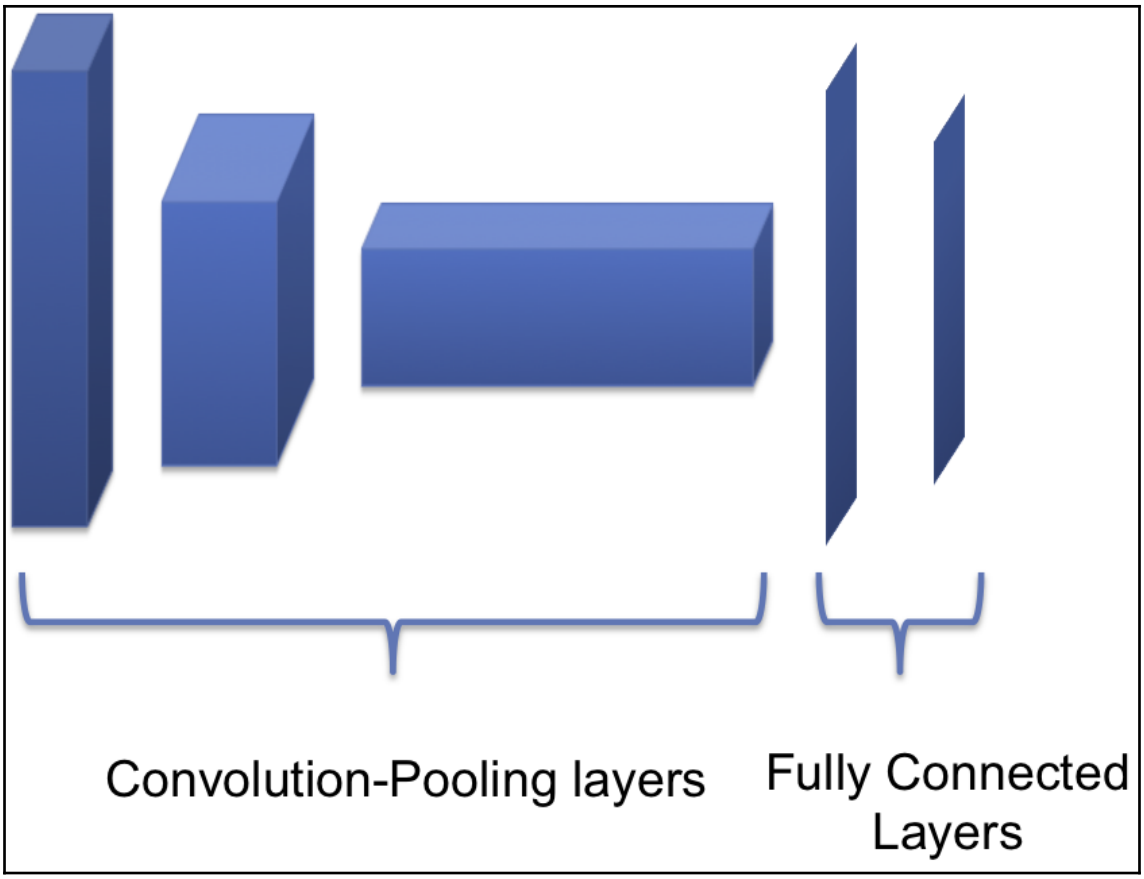

Taining Loss
Validation Loss
Cross Entropy Loss
0.75
0.70
0.65
0.60
0.55
0
2000
4000
6000
8000
10000
Epochs

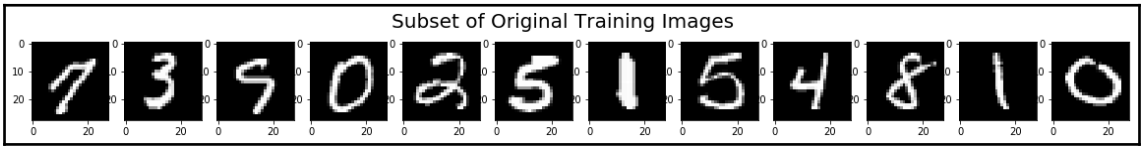

136
37
34
113
0
1
0
1
120
100
80
60
40

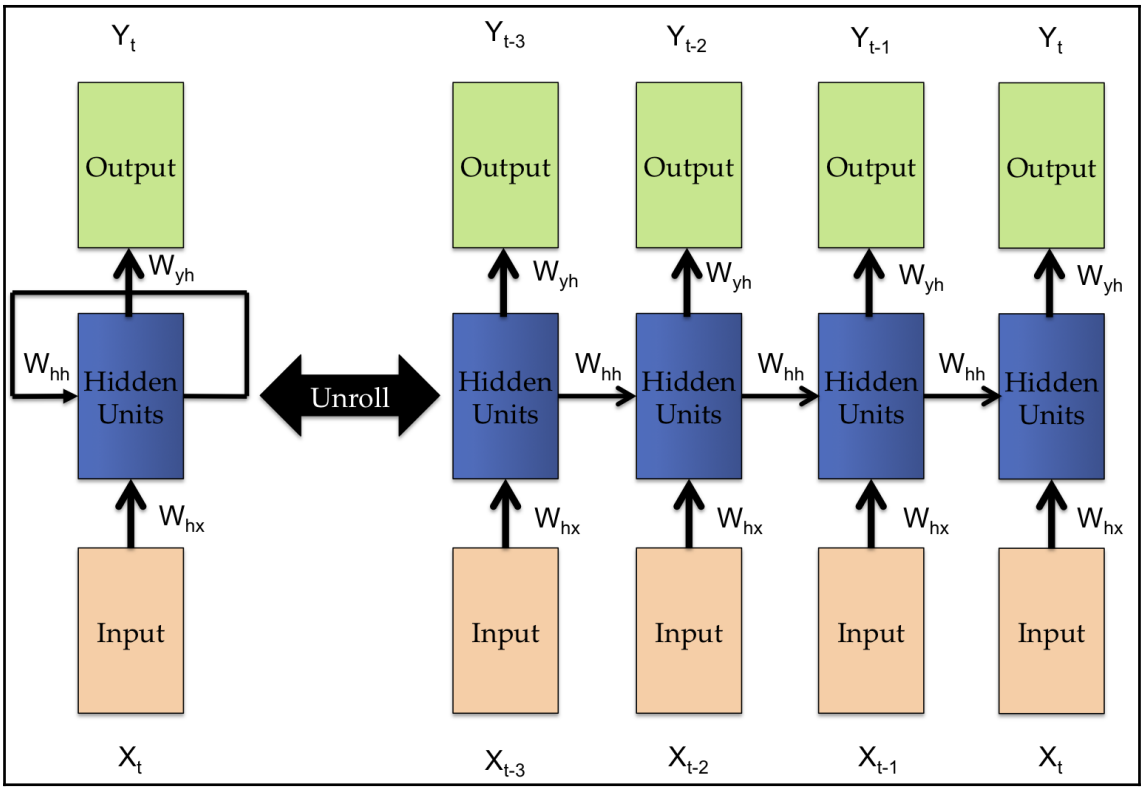

1 1 1 0 0
0 1 1 1 0
0 1 1 1 1
0 0 0 1 1
0 1 1 0 1
2D Image
1 0 1
0 1 0
1 0 1
Filter
1 1 1 0 0
0 1 x1 1 x0 1 x1 0
0 1 x0 1 x1 1 x0 1
0 0 x1 0 x0 1 x1 1
0 1 1 0 1
Convolution
1 1 1 0 0
0 1 1 1 0
0 1 4 1 1
0 0 0 1 1
0 1 1 0 1
Convolved Pixel
Applying Convolution filter to [2,2] pixel of the 2D Image

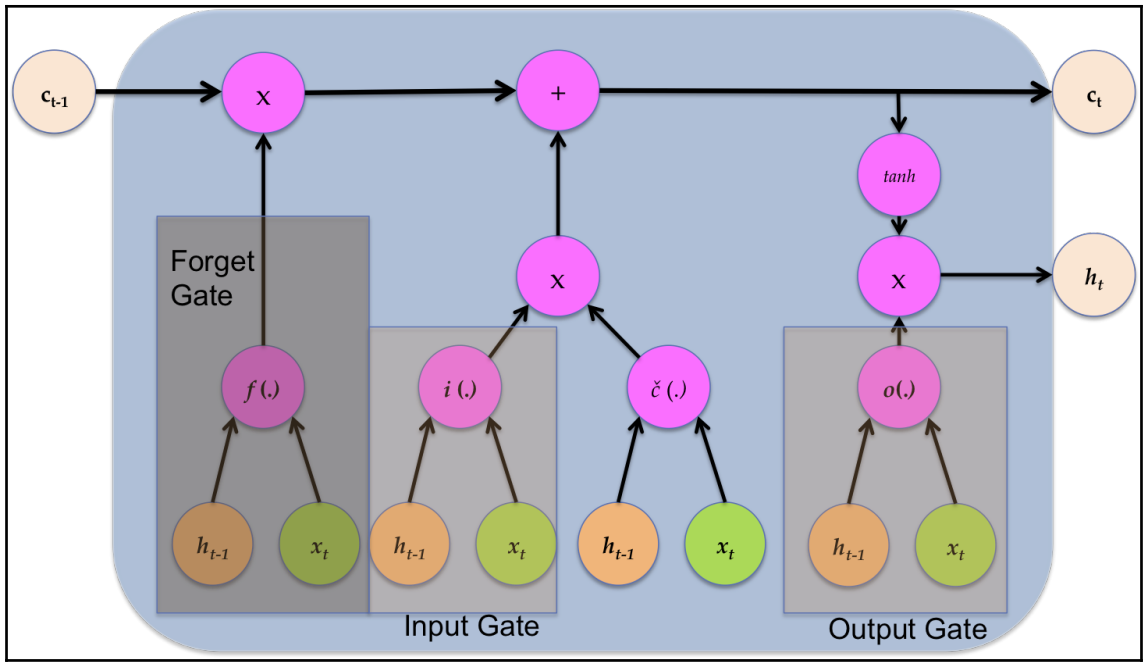

1 1 1 0 0
0 1 1 1 0
0 1 1 1 1
0 0 0 1 1
0 1 1 0 1
*
1 0 1
0 1 0
1 0 1
Filter
=
2 2 3 1 1
2 4 4 4 1
1 2 4 3 3
2 2 3 5 2
0 1 2 1 2
Original Image
Convolved Image
Applying Convolution filter to the 2D Image

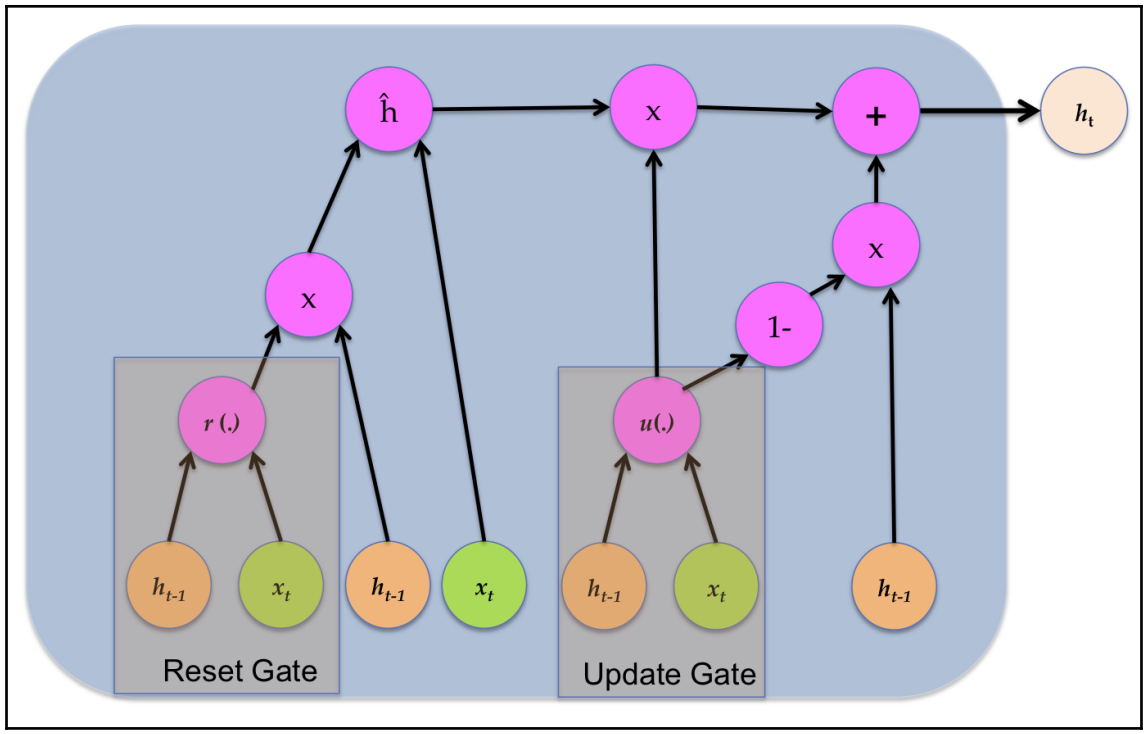

2 4 3 1
5 3 6 8
4 3 1 2
9 2 4 1
2D single depth slice of the image
5 8
9 4
Max Pooling
7 9
9 4
Average Pooling

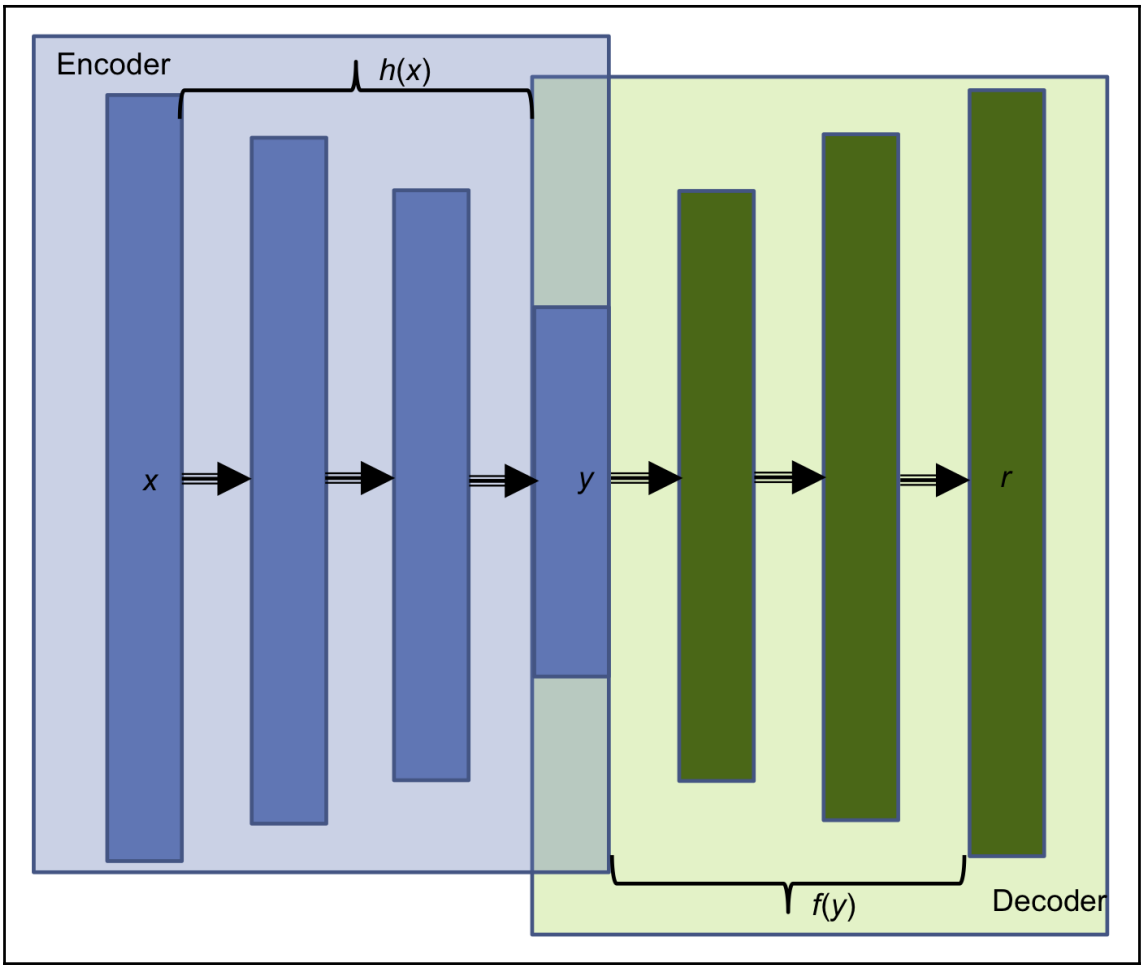

Convolution-Pooling layers
Fully Connected Layers


Subset of Original Training Images

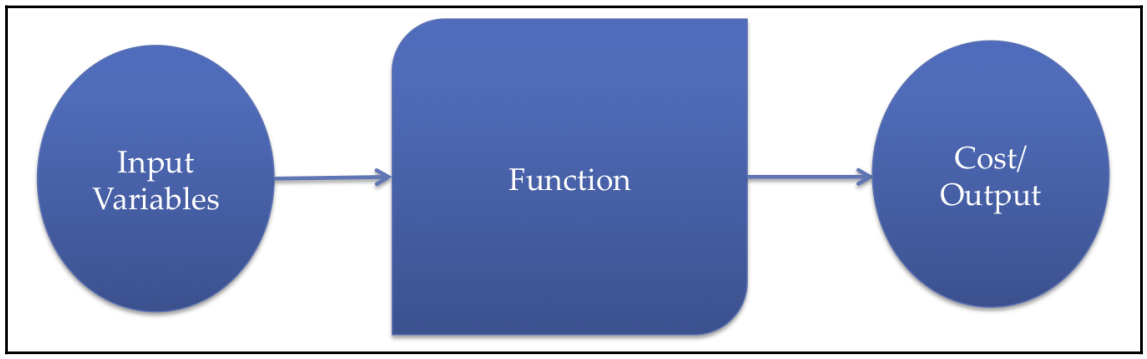

Y_t
Y_t-3
Y_t-2
Y_t-1
Y_t
Output
W_yh
W_hh
Hidden Units
Unroll
W_hx
Input
X_t
X_t-3
X_t-2
X_t-1

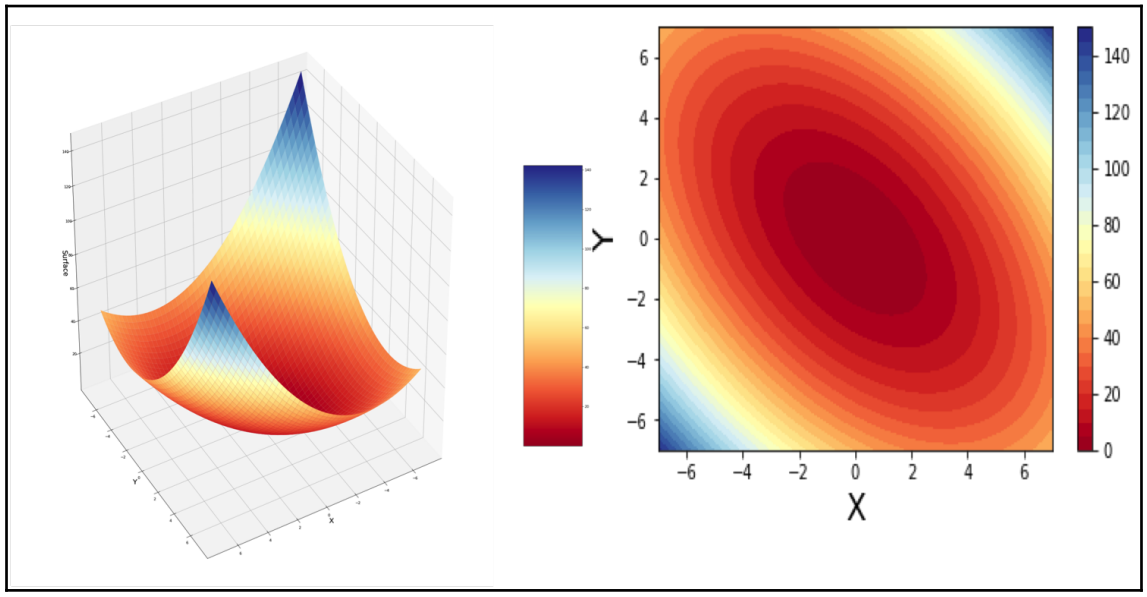

c_{t-1}
x
+
c_t
tanh
Forget Gate
x
x
h_t
$f(.)$
$i(.)$
$\check{c}(.)$
$o(.)$
h_{t-1}
x_t
h_{t-1}
x_t
h_{t-1}
x_t
h_{t-1}
x_t
Input Gate
Output Gate

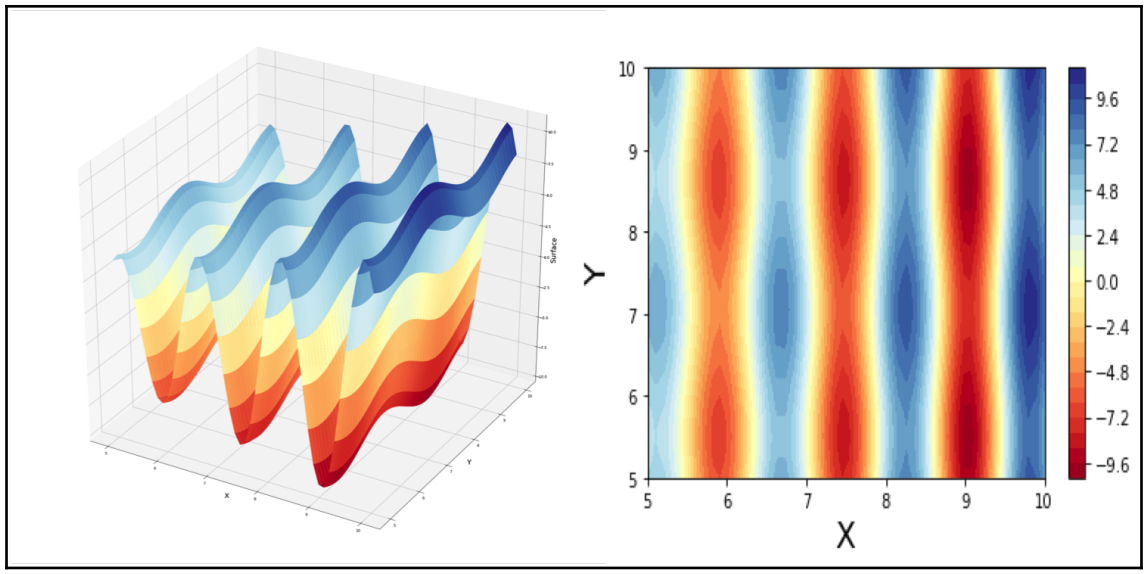

ĥ
x
+
h_t
x
1-
x
$r(.)$
$u(.)$
h_{t-1}
x_t
h_{t-1}
x_t
h_{t-1}
x_t
h_{t-1}
Reset Gate
Update Gate

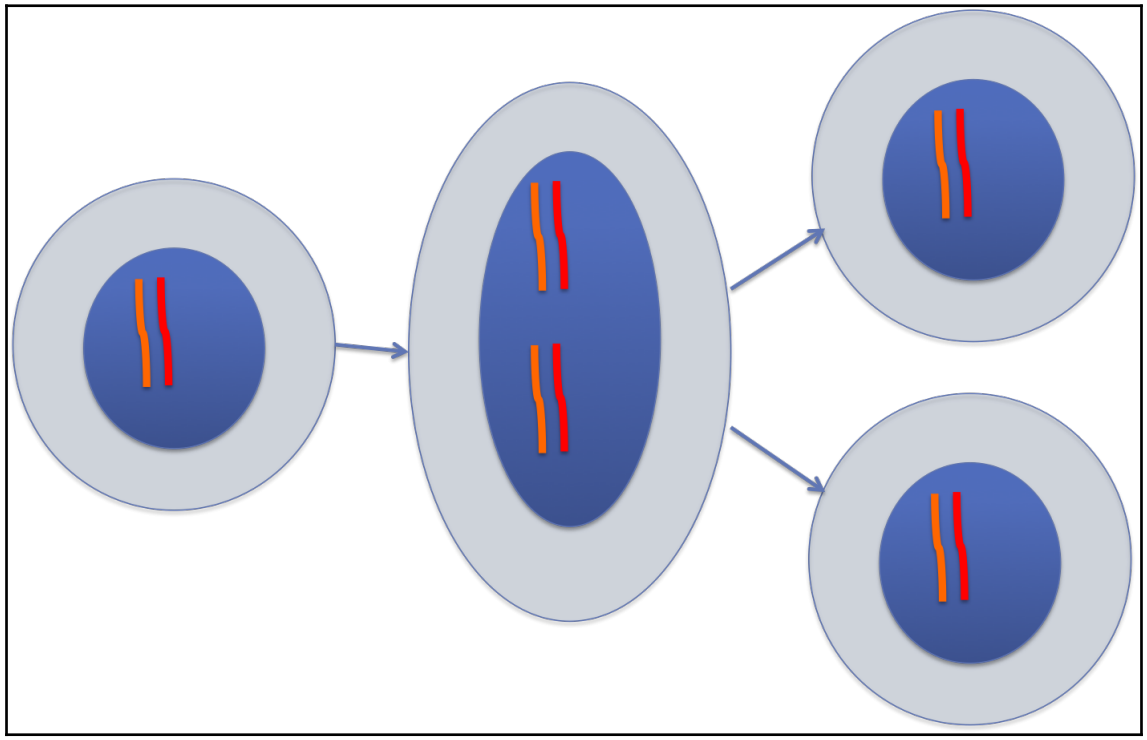

Encoder
h(x)
x
y
r
f(y)
Decoder

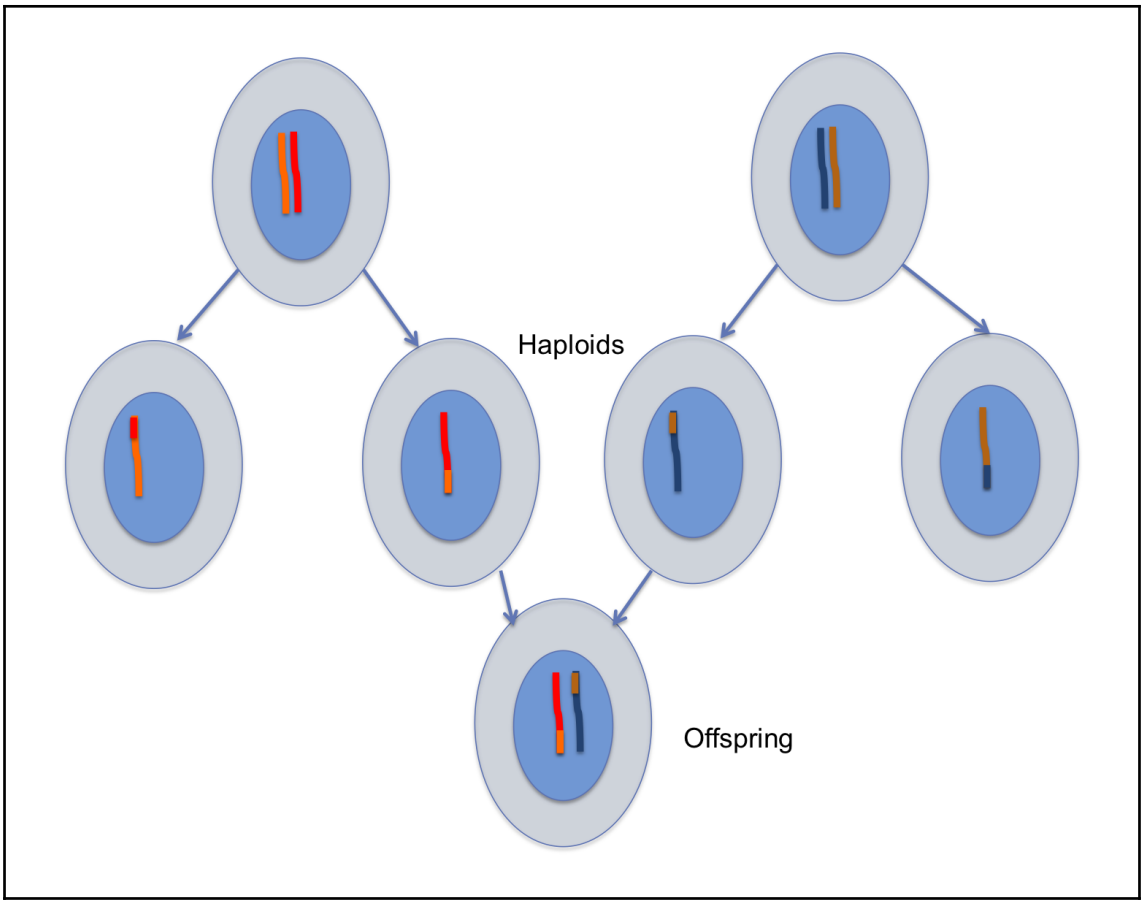
Chapter 5: Genetic Algorithms for IoT

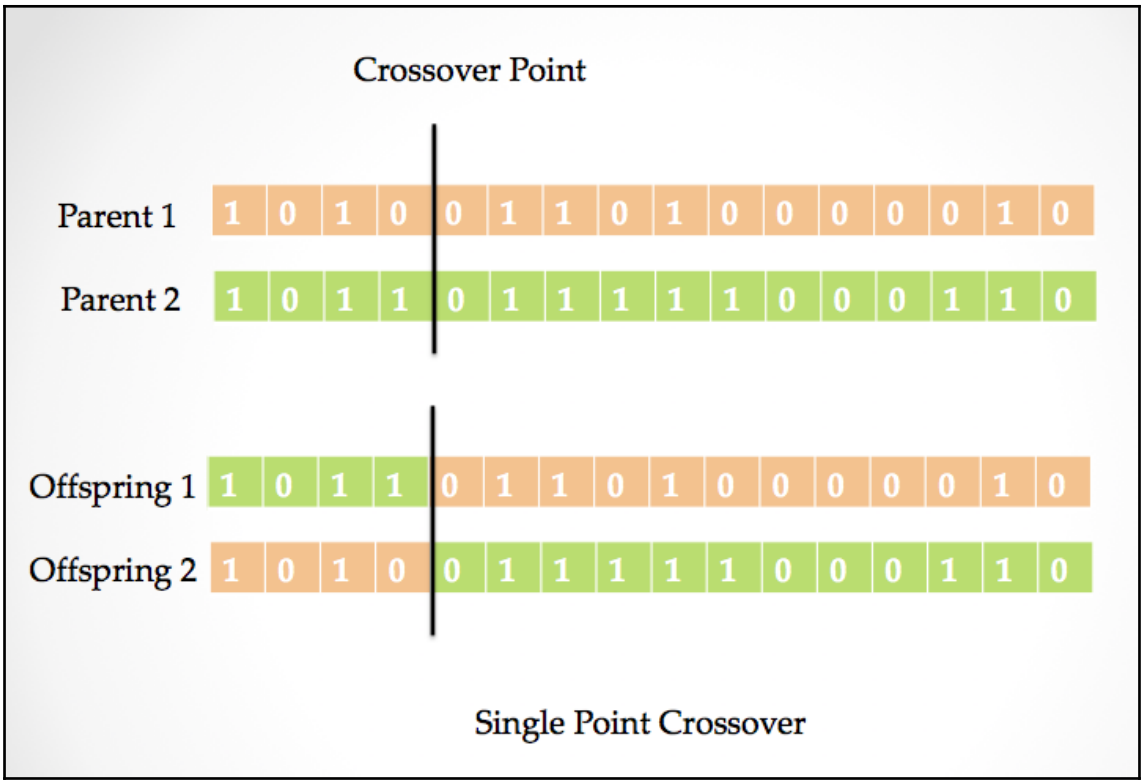


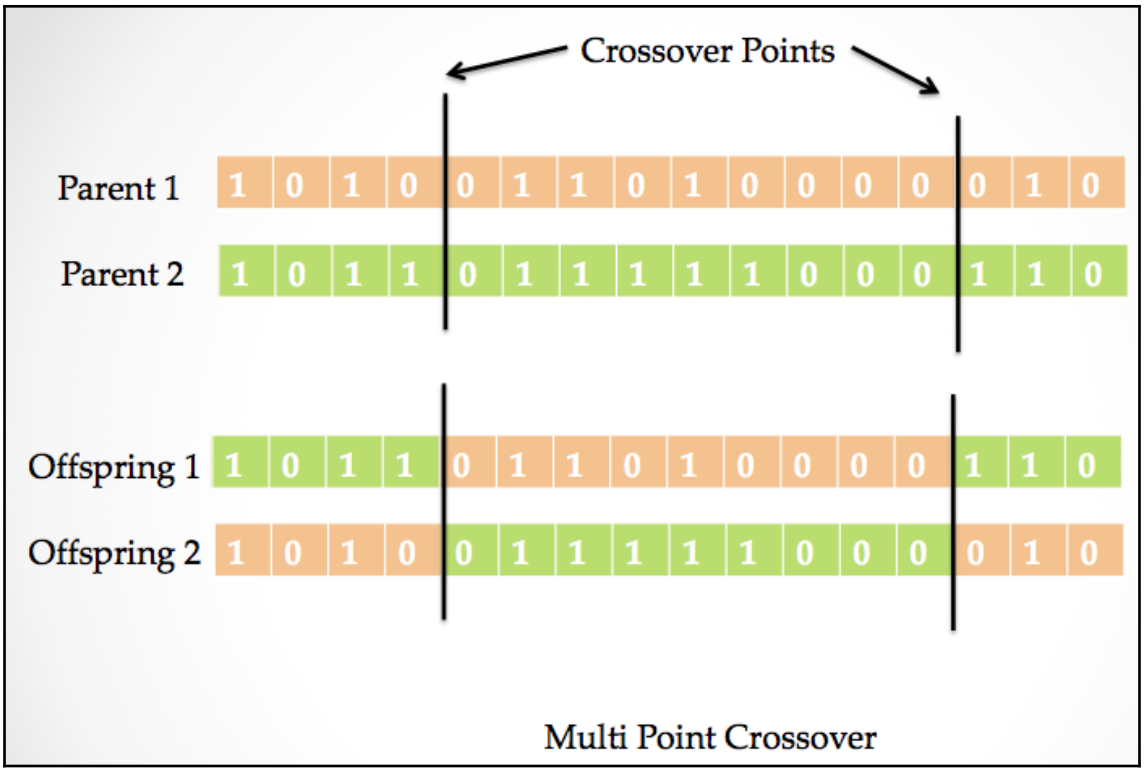



Surface
X
Y
10
9
8
7
6
5
5
6
7
8
9
10
9.6
7.2
4.8
2.4
0.0
−2.4
−4.8
−7.2
−9.6

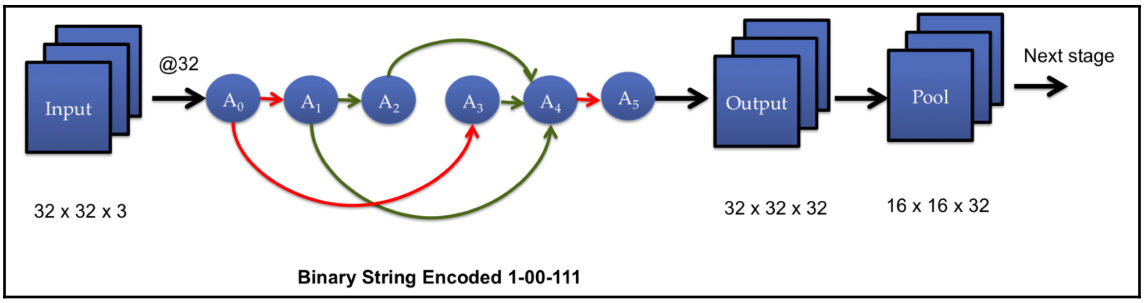



Haploids
Offspring


Crossover Point
Parent 1
1 0 1 0 0 1 1 0 1 0 0 0 0 0 1 0
Parent 2
1 0 1 1 0 1 1 1 1 1 0 0 0 1 1 0
Offspring 1
1 0 1 1 0 1 1 0 1 0 0 0 0 0 1 0
Offspring 2
1 0 1 0 0 1 1 1 1 1 0 0 0 1 1 0
Single Point Crossover

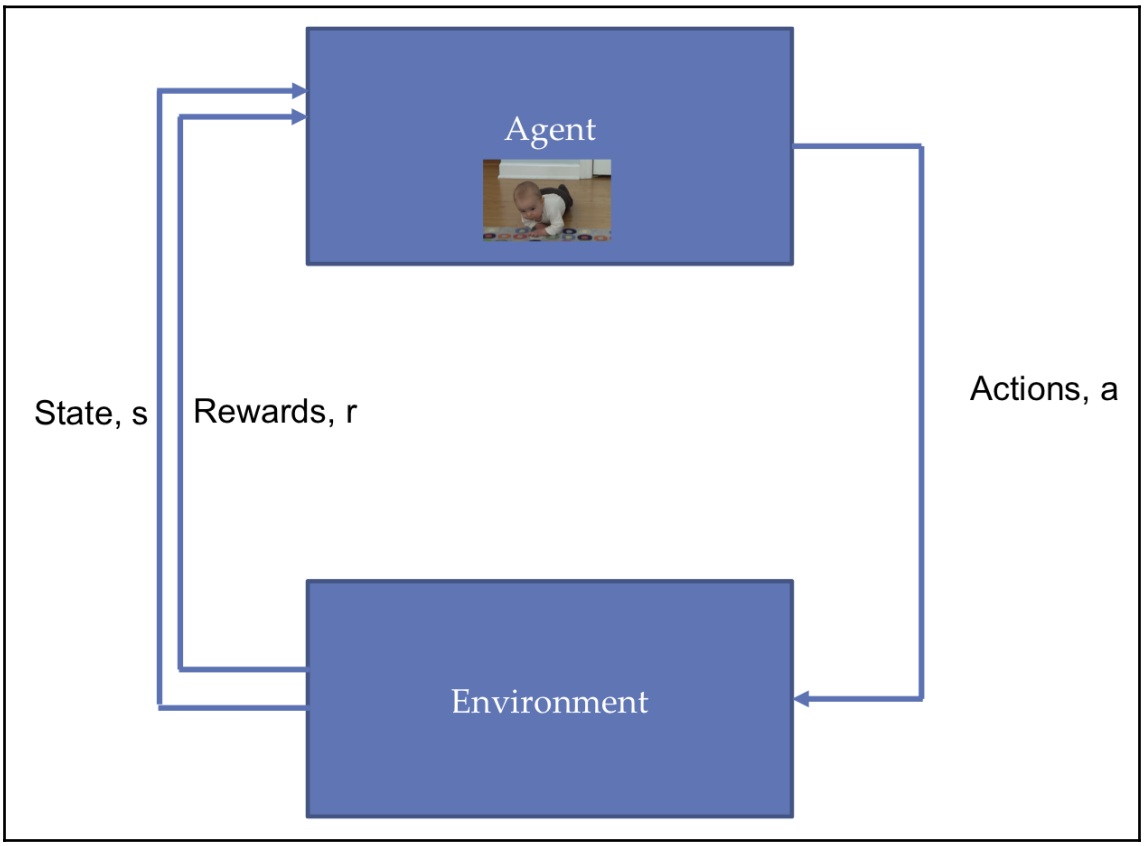

Crossover Points
Parent 1
1 0 1 0 0 1 1 0 1 0 0 0 0 0 1 0
Parent 2
1 0 1 1 0 1 1 1 1 1 0 0 0 1 1 0
Offspring 1
1 0 1 1 0 1 1 0 1 0 0 0 0 1 1 0
Offspring 2
1 0 1 0 0 1 1 1 1 1 0 0 0 0 1 0
Multi Point Crossover

```
Start of evolution
  Evaluated 300 individuals
-- Generation 1 --
  Evaluated 178 individuals
  Min 0.0
  Max 2.0
  Avg 0.22
  Std 0.4526956299030656
-- Generation 2 --
  Evaluated 174 individuals
  Min 0.0
  Max 2.0
  Avg 0.51
  Std 0.613650280425803
-- Generation 3 --
  Evaluated 191 individuals
  Min 0.0
  Max 3.0
  Avg 0.9766666666666667
  Std 0.6502221842484989
-- Generation 4 --
  Evaluated 167 individuals
  Min 0.0
  Max 4.0
  Avg 1.45
  Std 0.6934214687571574
-- Generation 5 --
  Evaluated 191 individuals
  Min 0.0
  Max 4.0
  Avg 1.9833333333333334
  Std 0.7765665171481163
-- Generation 6 --
  Evaluated 168 individuals
  Min 0.0
  Max 4.0
  Avg 2.48
  Std 0.7678541528180985
-- Generation 7 --
  Evaluated 192 individuals
  Min 1.0
  Max 5.0
  Avg 3.013333333333333
  Std 0.6829999186595044
-- End of (successful) evolution --
Best individual is hello, (5.0,)
```

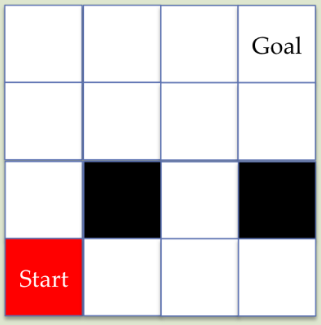



```
[0, 1, 0, 1, 0, 0, 0, 0, 1, 1, 1, 0, 0, 0, 1, 0, 1, 0, 0]
[1, 0, 0, 0, 1, 0, 1, 0, 0, 0, 1, 0, 1, 1, 1, 1, 1, 1, 0]
[0, 1, 0, 1, 0, 0, 0, 0, 1, 1, 1, 0, 1, 1, 1, 1, 1, 1, 0]
```

Chapter 6: Reinforcement Learning for IoT



Agent finding path in the maze



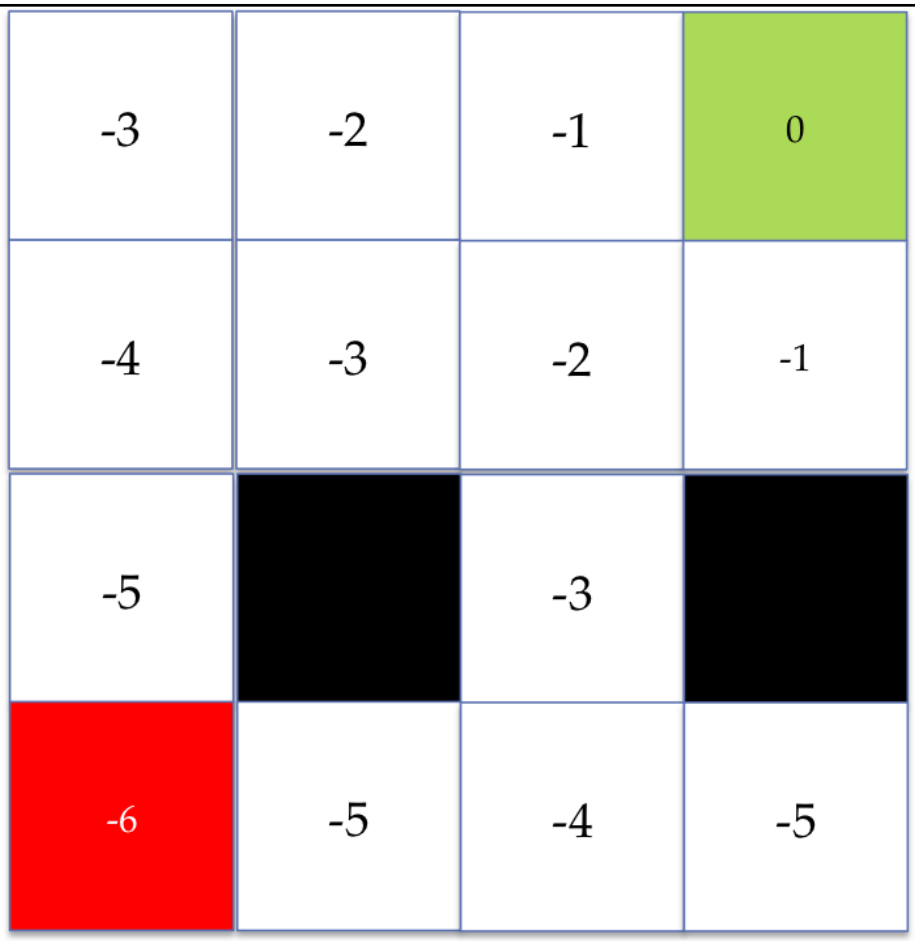
s = [[0,0,0,0]
[0,0,0,0]
[0,X,0,X]
[1,0,0,0]]

a = [up, down, left, right, no change]

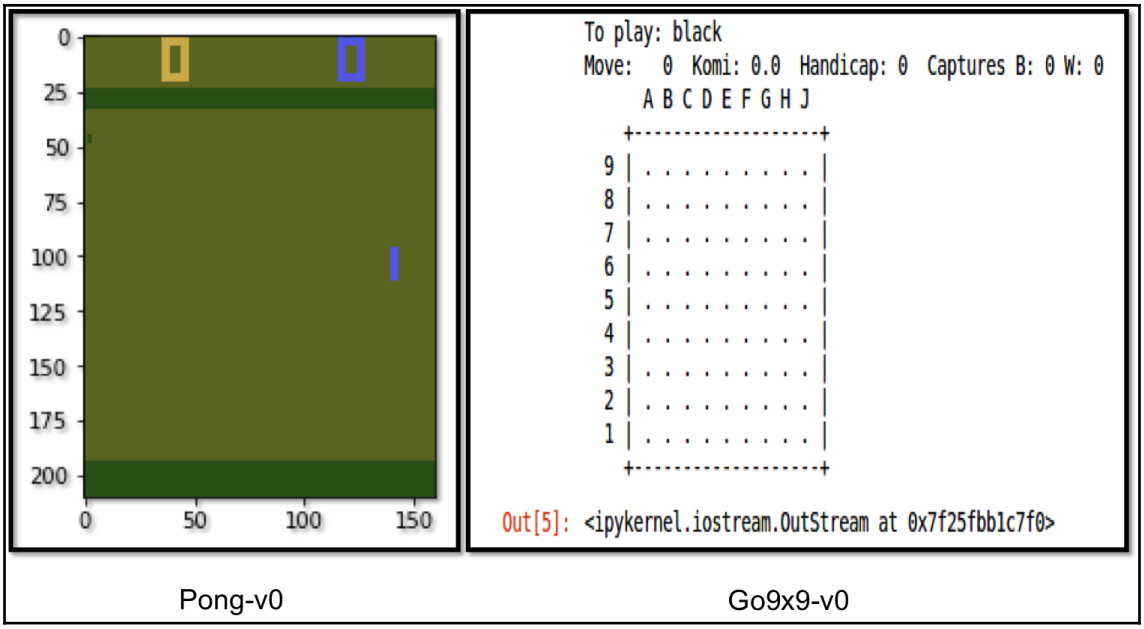
Agent controlling steering wheel in self-driving car

s = The image of the road in-front

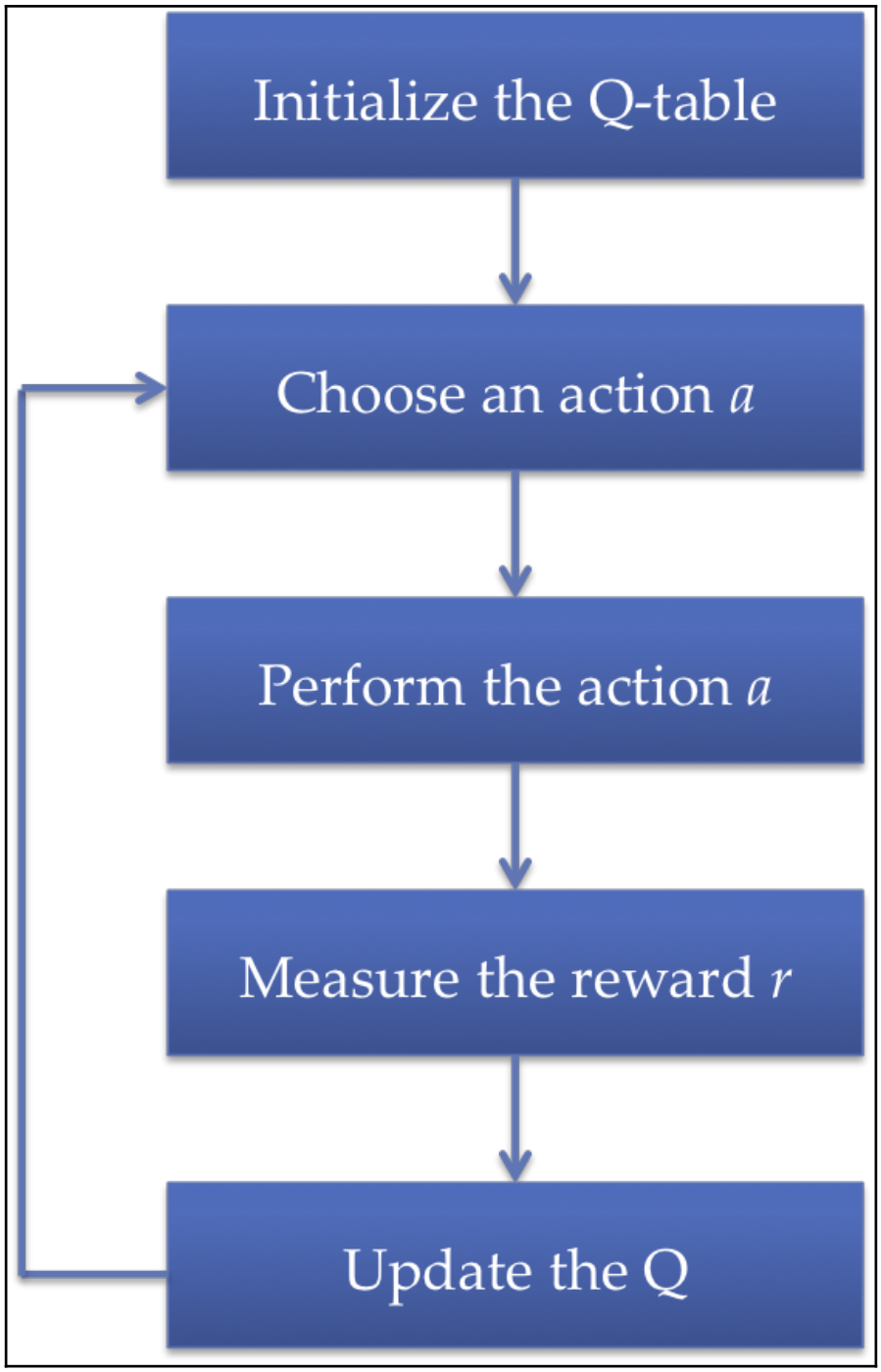
a = The angle by which steering wheel is to be rotated

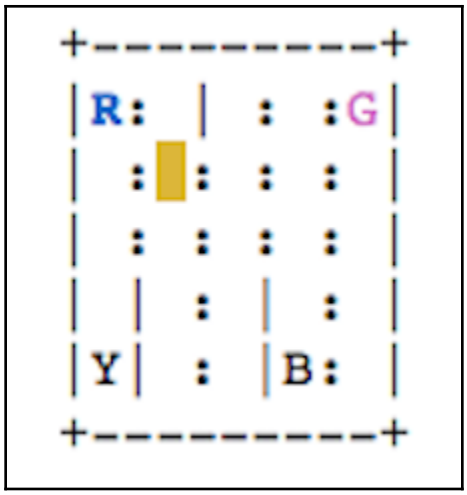


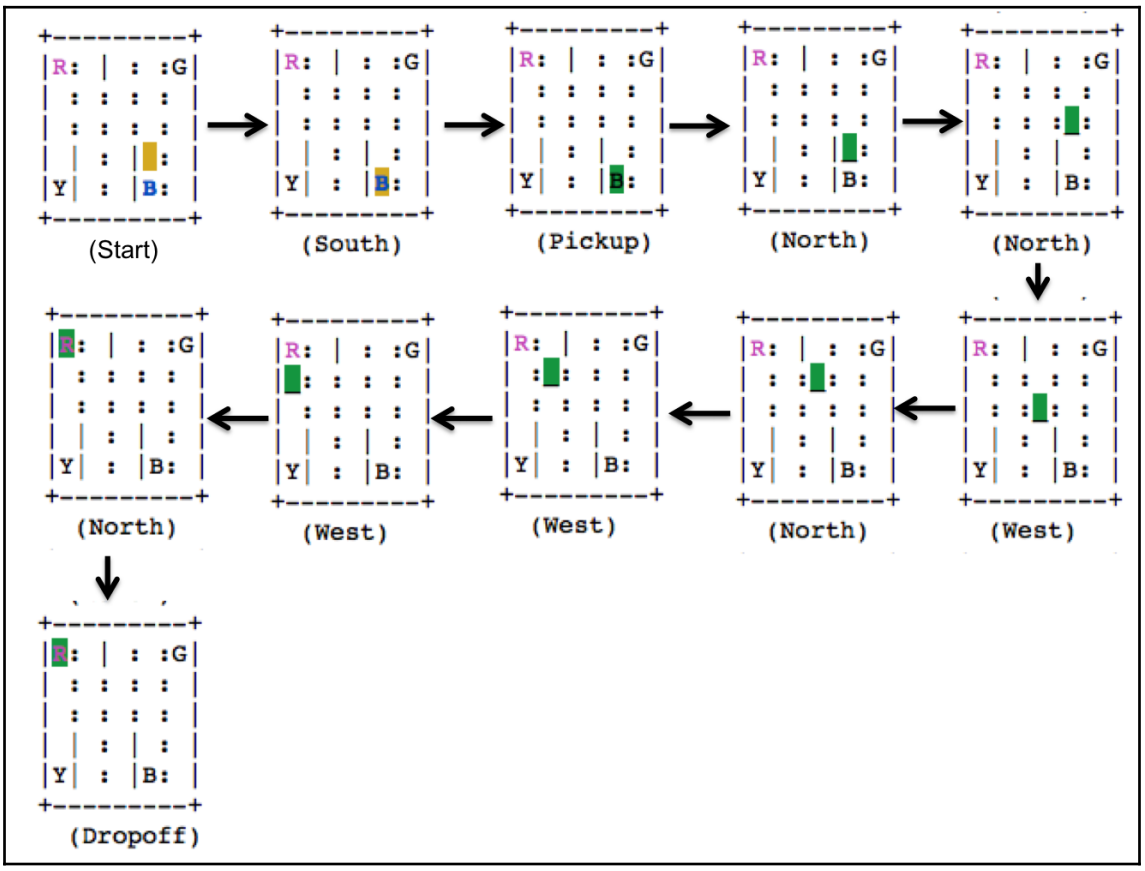
Each box has the value function:
Number of steps needed to reach goal (green box)

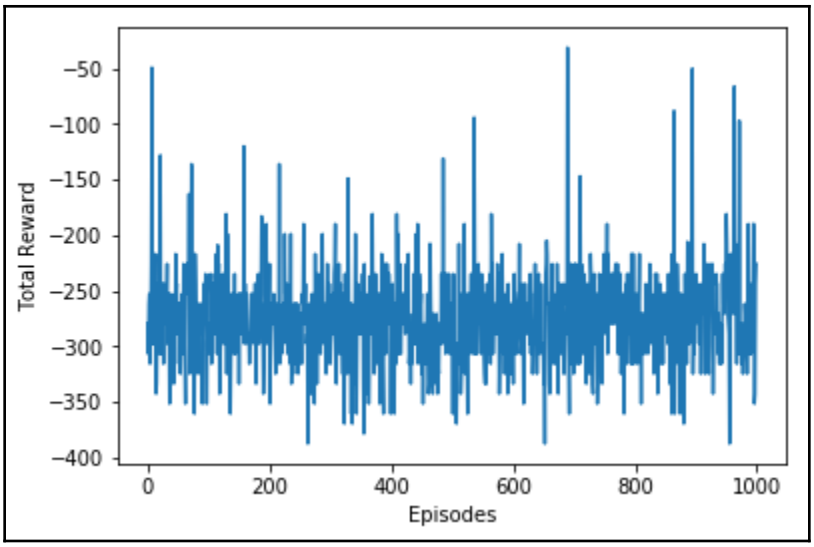


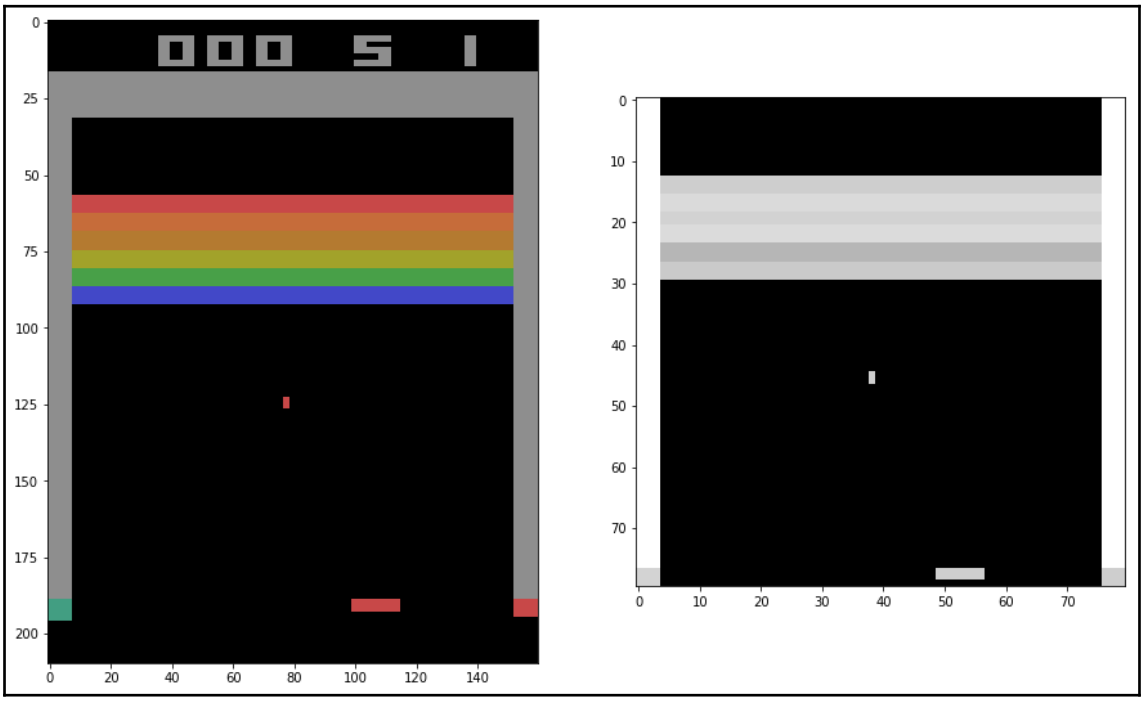
Pong-v0 Go9x9-v0

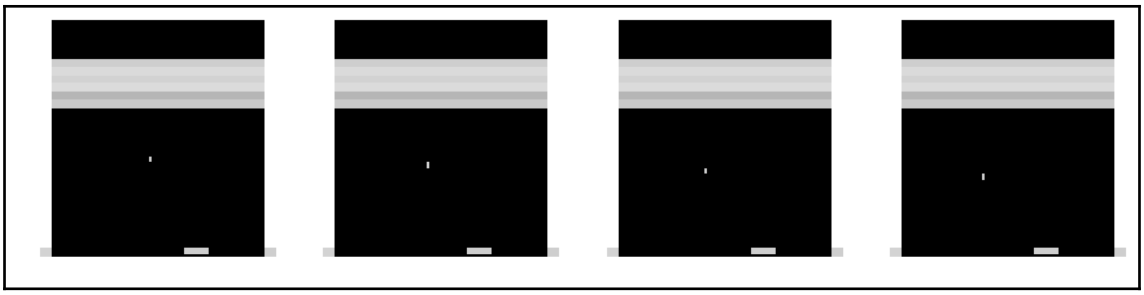

Initialize the Q-table
Choose an action a
Perform the action a
Measure the reward r
Update the Q

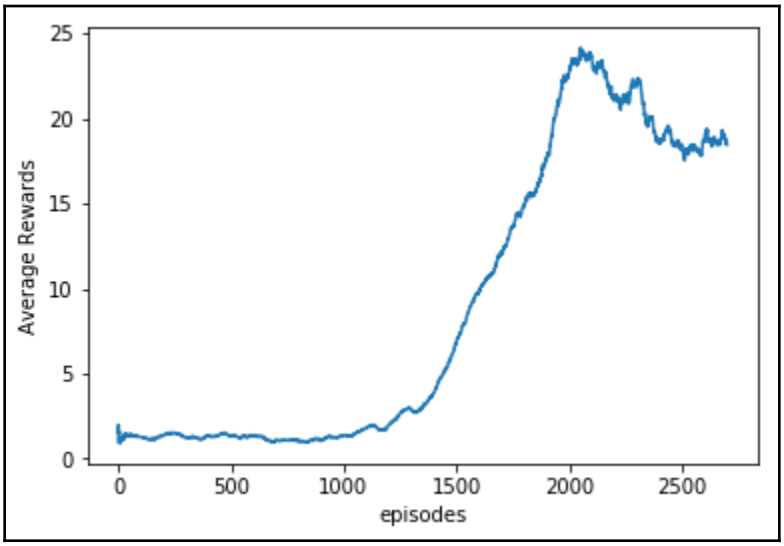

R: : :G
Y : B:

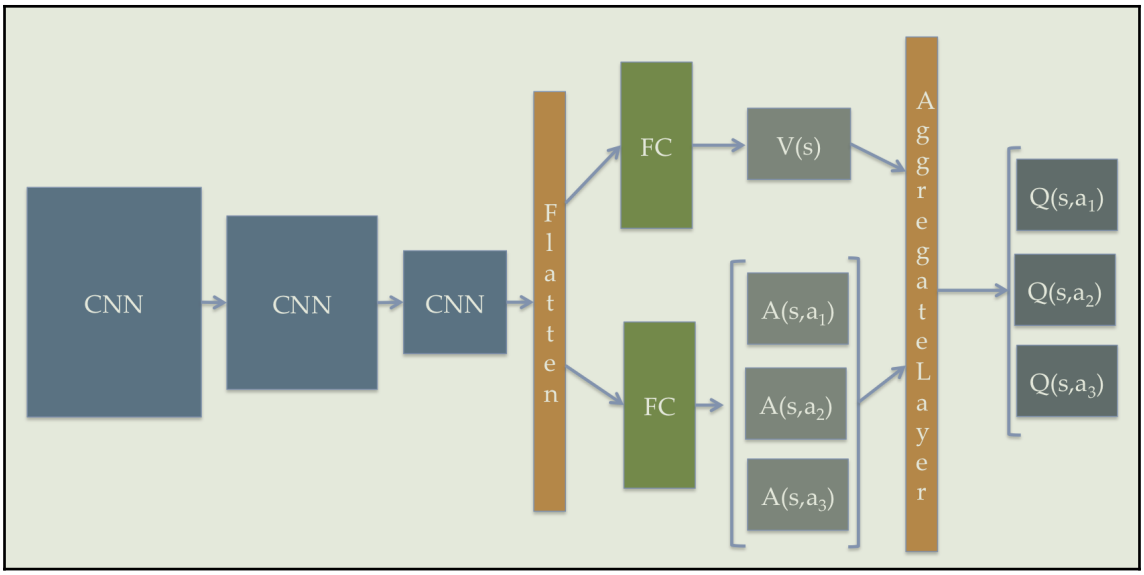

(Start)
(South)
(Pickup)
(North)
(North)
(West)
(North)
(West)
(West)
(North)
(Dropoff)

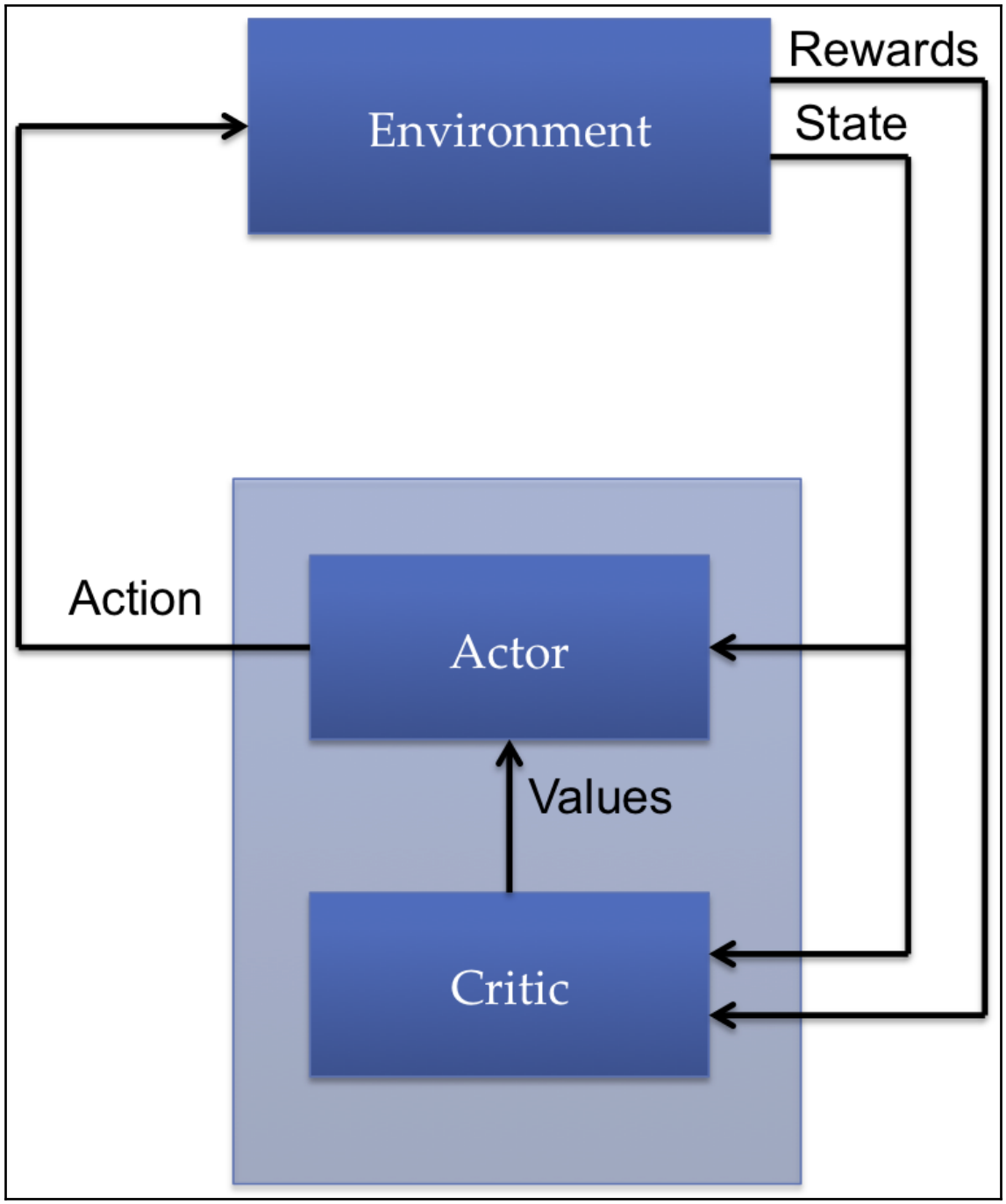

Total Reward
−50
−100
−150
−200
−250
−300
−350
−400
0
200
400
600
800
1000
Episodes


000 5 1
0
25
50
75
100
125
150
175
200
0
20
40
60
80
100
120
140
0
10
20
30
40
50
60
70
0
10
20
30
40
50
60
70

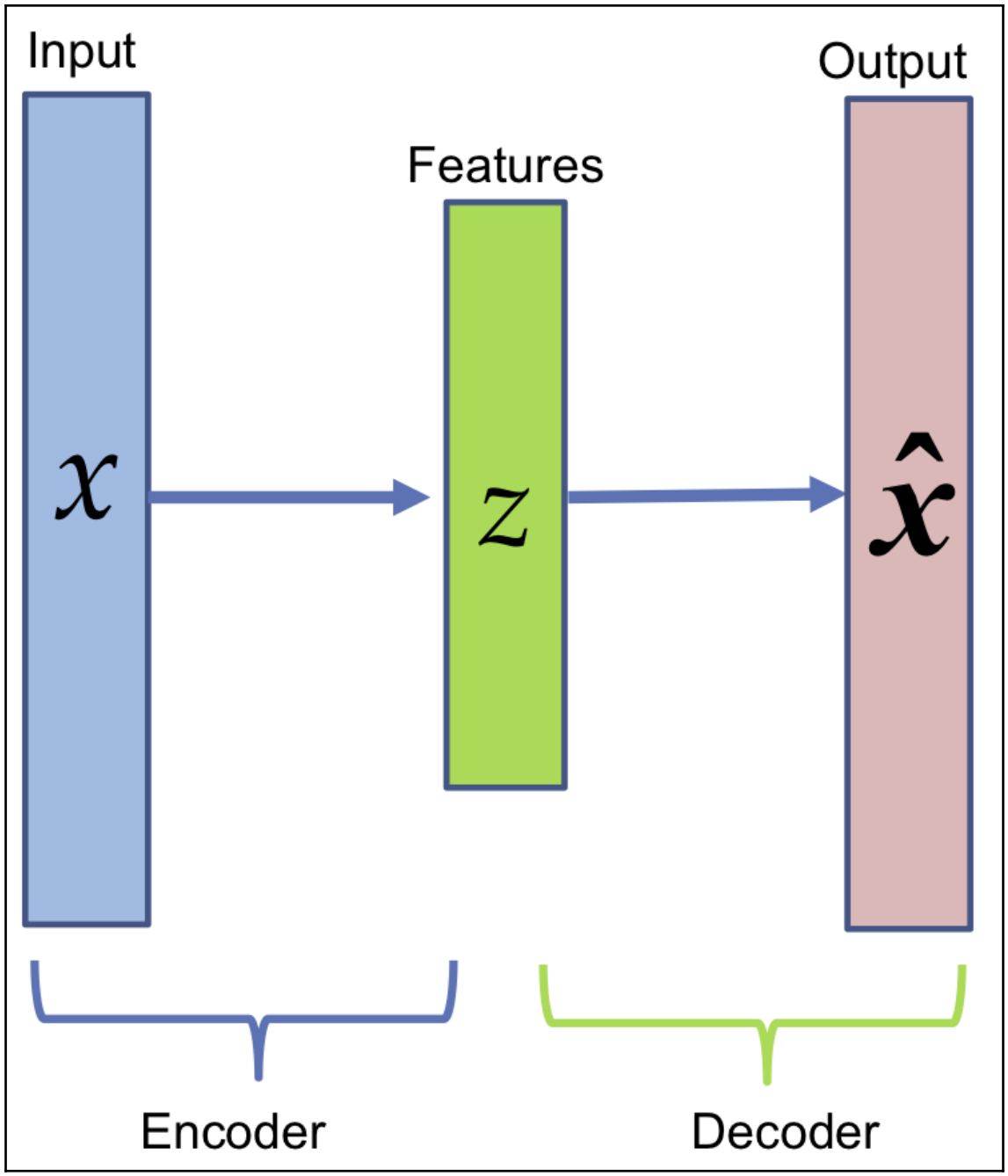


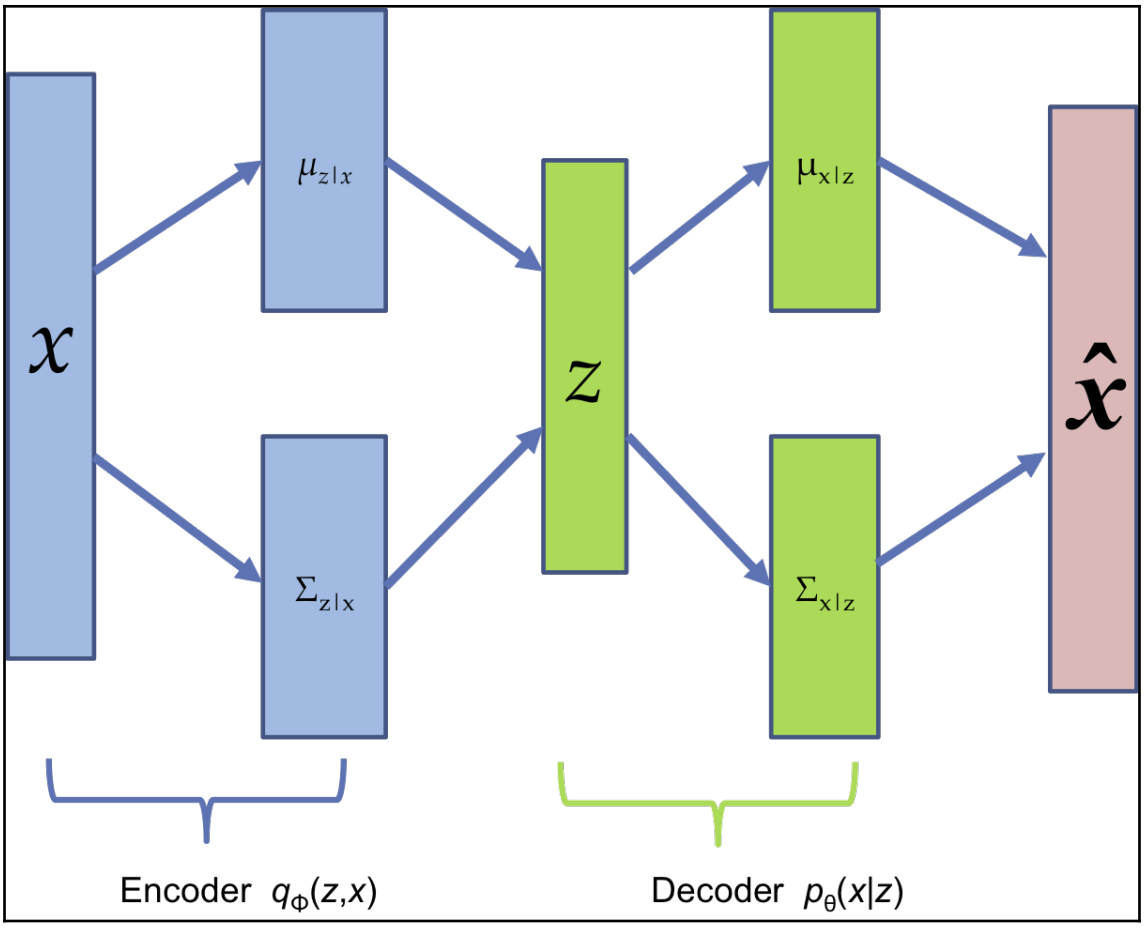

25
20
15
10
5
0
Average Rewards
0
500
1000
1500
2000
2500
episodes

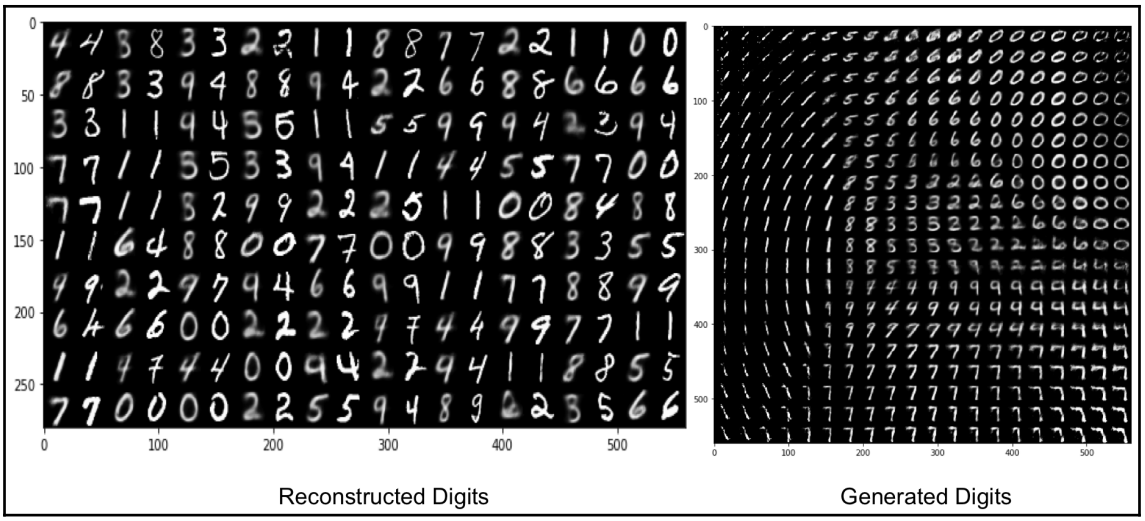

CNN
CNN
CNN
Flatten
FC
V(s)
FC
A(s,a1)
A(s,a2)
A(s,a3)
Aggregate Layer
Q(s,a1)
Q(s,a2)
Q(s,a3)

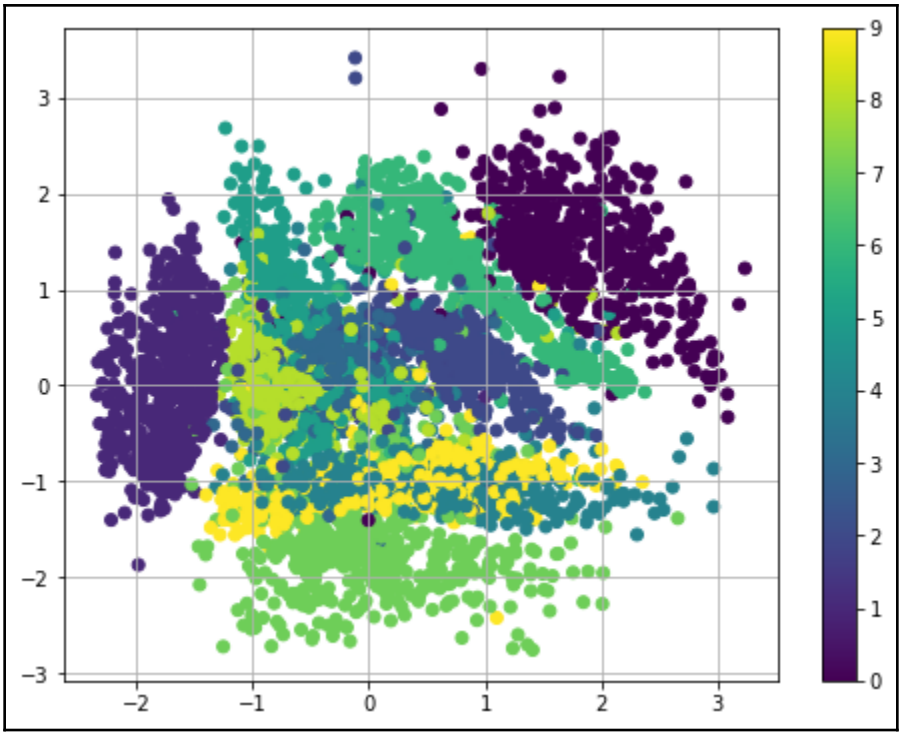

Environment
Rewards
State
Action
Actor
Values
Critic

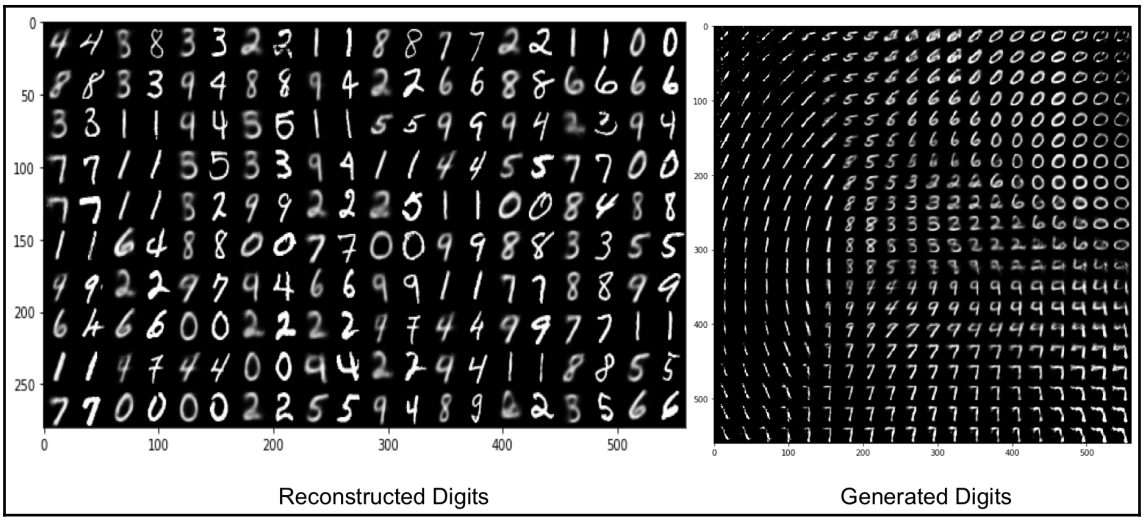
Chapter 7: Generative Models for IoT

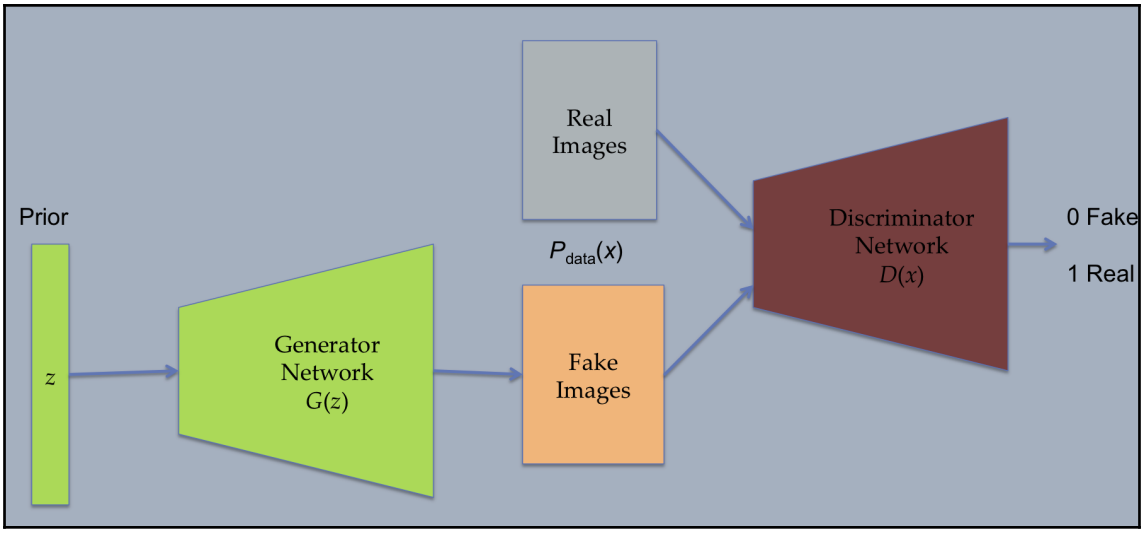

Input
Output
Features
x
z
$\hat{x}$
Encoder
Decoder

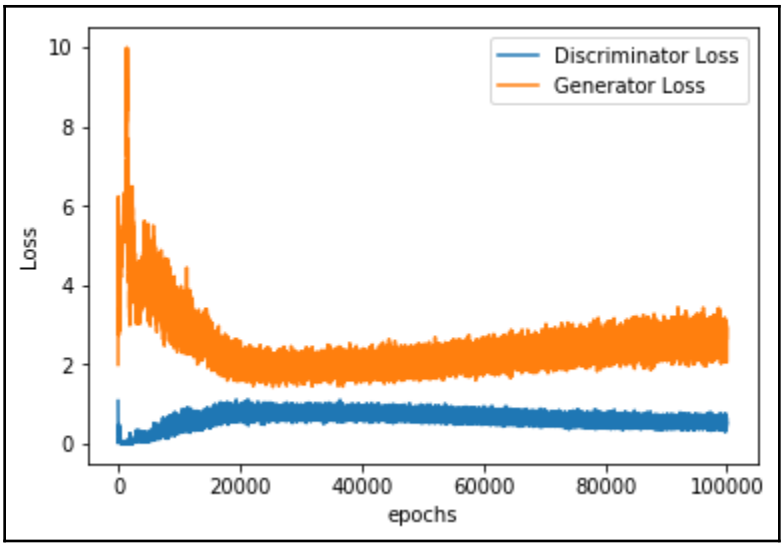

x
$\mu_{z|x}$
$\Sigma_{z|x}$
z
$\mu_{x|z}$
$\Sigma_{x|z}$
$\hat{x}$
Encoder $q_\Phi(z,x)$
Decoder $p_\theta(x|z)$

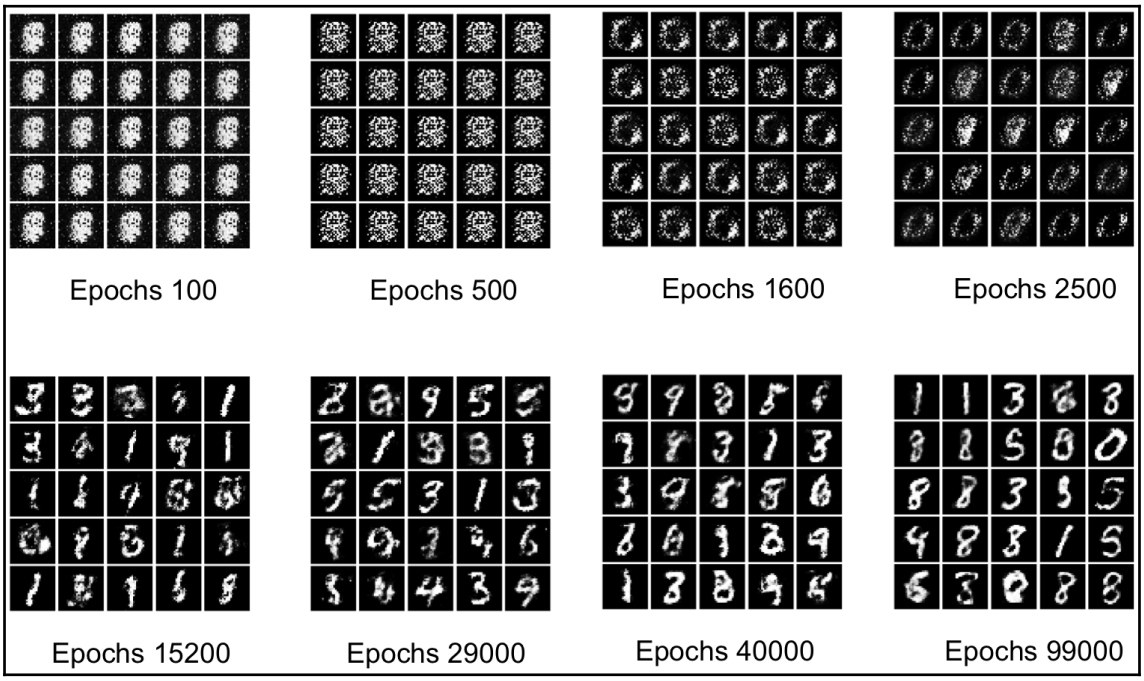

Reconstructed Digits
Generated Digits

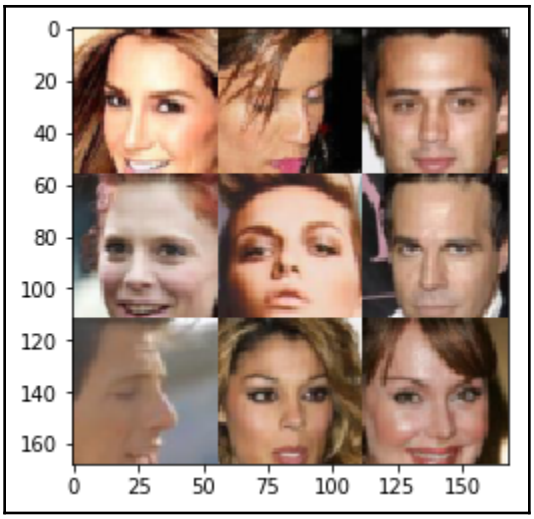


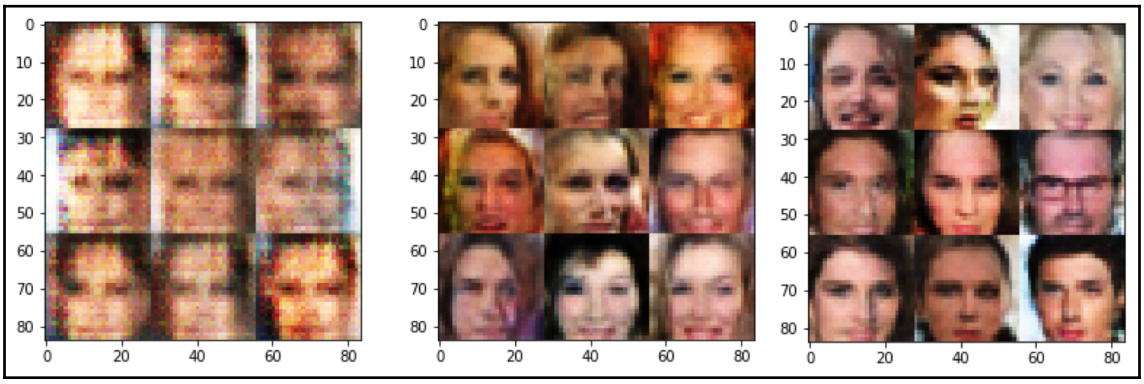

Reconstructed Digits
Generated Digits

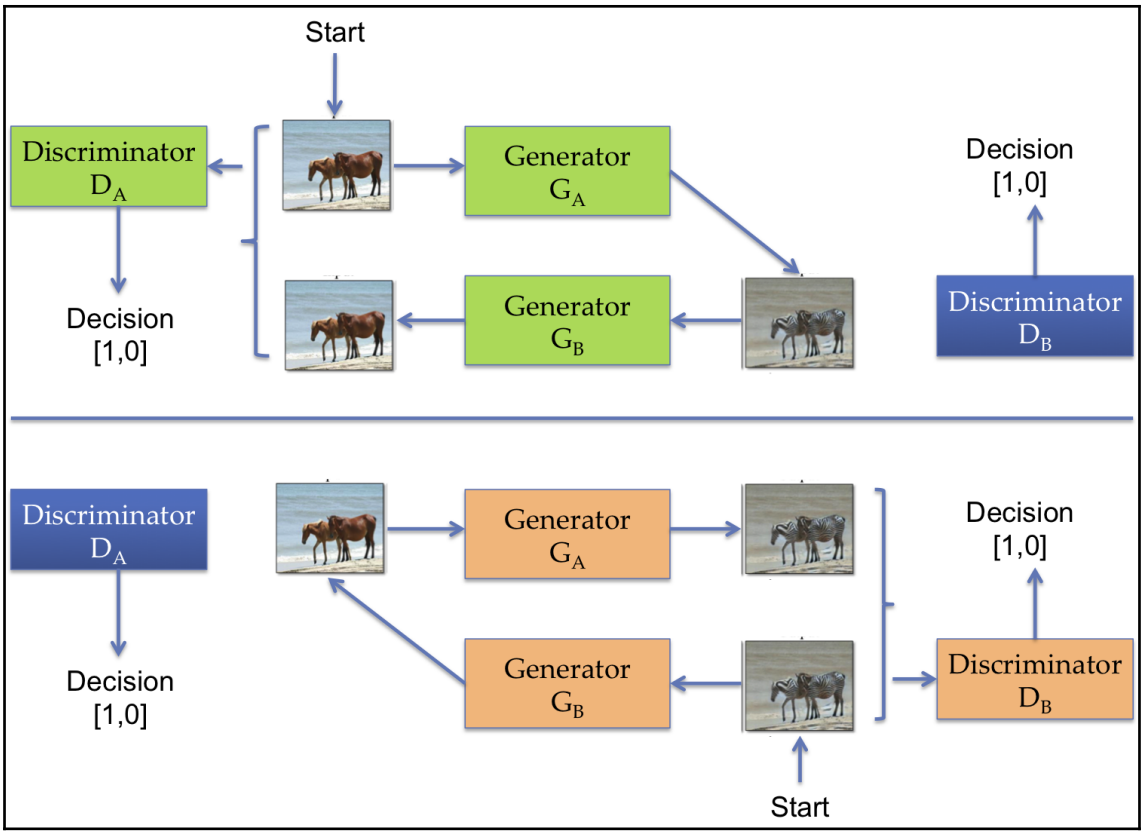

Prior
z
Generator Network G(z)
Real Images
$P_{data}(x)$
Fake Images
Discriminator Network D(x)
0 Fake
1 Real

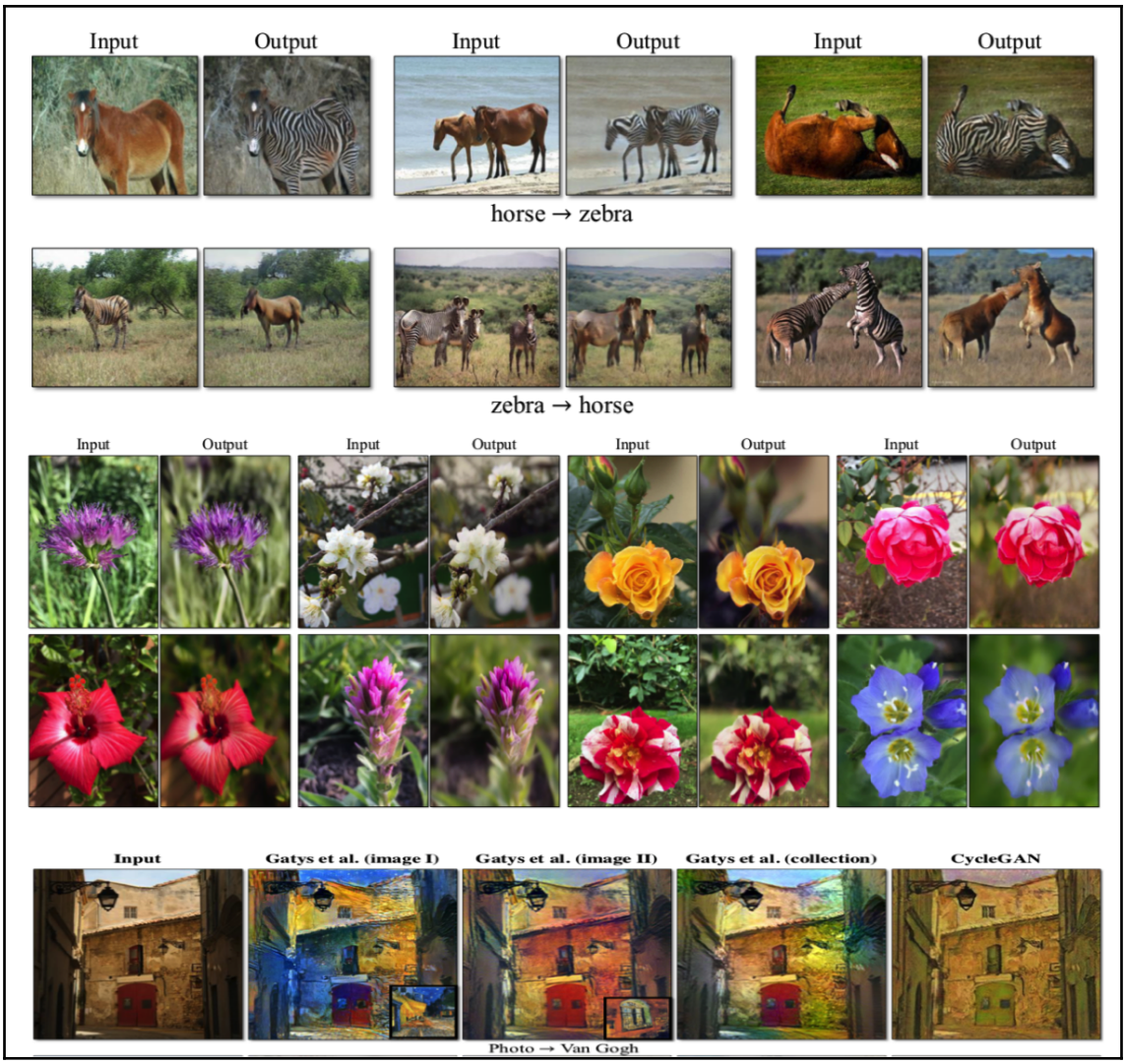

Discriminator Loss
Generator Loss
Loss
epochs
10
8
6
4
2
0
0
20000
40000
60000
80000
100000


Epochs 100
Epochs 500
Epochs 1600
Epochs 2500
Epochs 15200
Epochs 29000
Epochs 40000
Epochs 99000

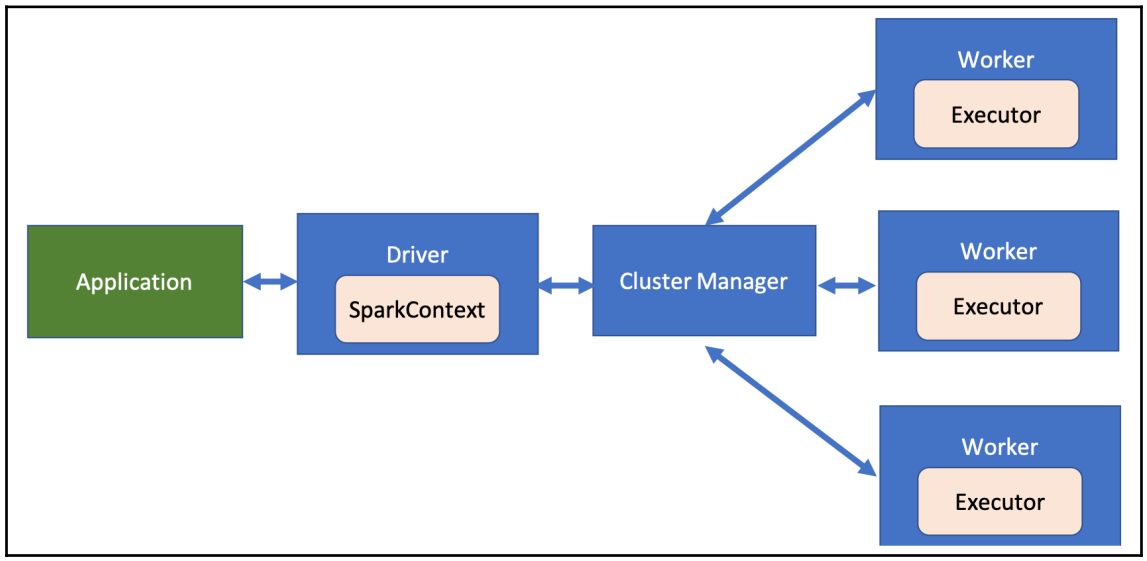

0
20
40
60
80
100
120
140
160
0
25
50
75
100
125
150

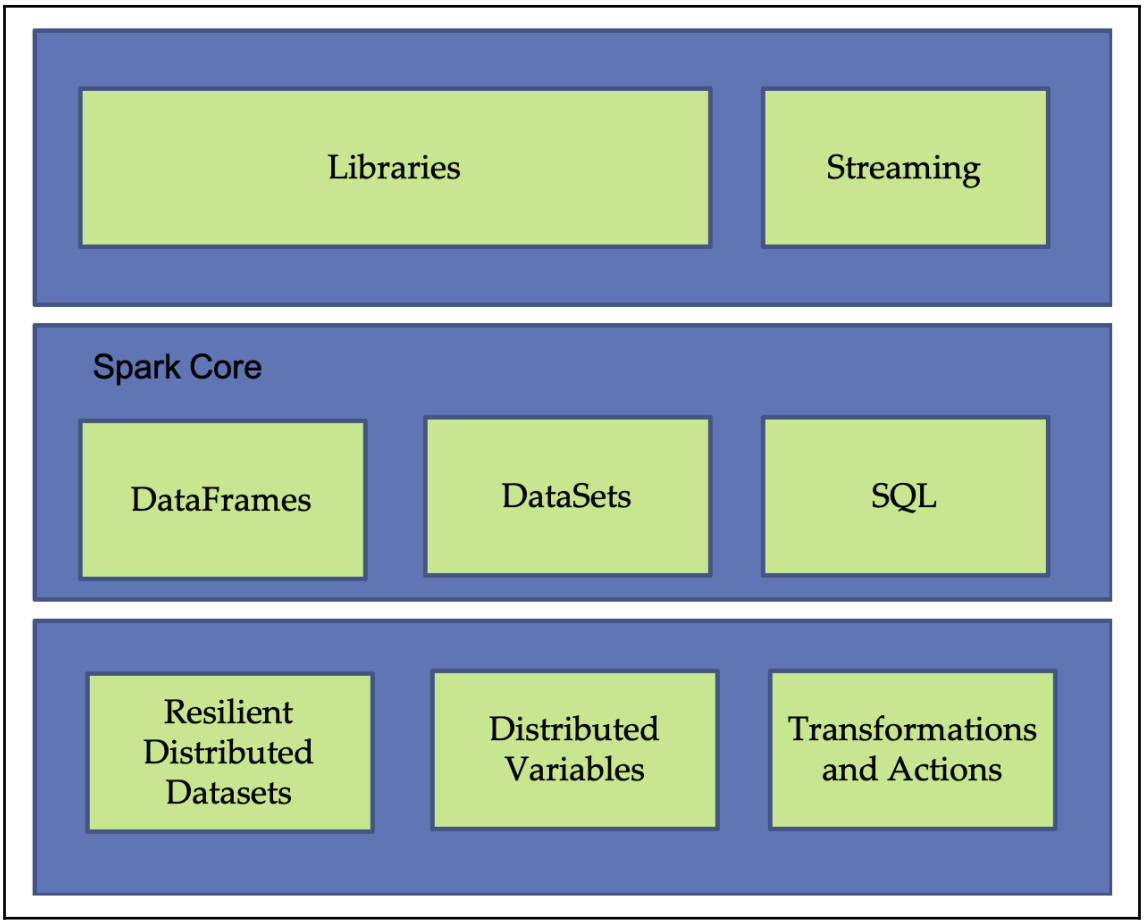

0
10
20
30
40
50
60
70
80
0
20
40
60
80


Start
Discriminator
D_A
Generator
G_A
Decision
[1,0]
Decision
[1,0]
Discriminator
D_B
Generator
G_B
Discriminator
D_A
Generator
G_A
Decision
[1,0]
Decision
[1,0]
Discriminator
D_B
Generator
G_B
Start


Input
Output
Input
Output
Input
Output
horse → zebra
zebra → horse
Input
Output
Input
Output
Input
Output
Input
Output
Input
Gatys et al. (image I)
Gatys et al. (image II)
Gatys et al. (collection)
CycleGAN
Photo → Van Gogh

Chapter 8: Distributed AI for IoT




Libraries
Streaming
Spark Core
DataFrames
DataSets
SQL
Resilient Distributed Datasets
Distributed Variables
Transformations and Actions

```
In [3]: house_df.show(3)
```

```
+---+-------+----+-----+----+-----+-----+----+------+---+---+-------+------+-----+----+
| ID|   crim|  zn|indus|chas|  nox|   rm| age|   dis|rad|tax|ptratio| black|lstat|medv|
+---+-------+----+-----+----+-----+-----+----+------+---+---+-------+------+-----+----+
|  1|0.00632|18.0| 2.31|   0|0.538|6.575|65.2|  4.09|  1|296|   15.3| 396.9| 4.98|24.0|
|  2|0.02731| 0.0| 7.07|   0|0.469|6.421|78.9|4.9671|  2|242|   17.8| 396.9| 9.14|21.6|
|  4|0.03237| 0.0| 2.18|   0|0.458|6.998|45.8|6.0622|  3|222|   18.7|394.63| 2.94|33.4|
+---+-------+----+-----+----+-----+-----+----+------+---+---+-------+------+-----+----+
only showing top 3 rows
```

```
In [4]: # DataFrame Schema
house_df.printSchema()
```

```
root
 |-- ID: integer (nullable = true)
 |-- crim: double (nullable = true)
 |-- zn: double (nullable = true)
 |-- indus: double (nullable = true)
 |-- chas: integer (nullable = true)
 |-- nox: double (nullable = true)
 |-- rm: double (nullable = true)
 |-- age: double (nullable = true)
 |-- dis: double (nullable = true)
 |-- rad: integer (nullable = true)
 |-- tax: integer (nullable = true)
 |-- ptratio: double (nullable = true)
 |-- black: double (nullable = true)
 |-- lstat: double (nullable = true)
 |-- medv: double (nullable = true)
```

```
In [5]: house_df.describe().toPandas().transpose()
```

Out[5]:

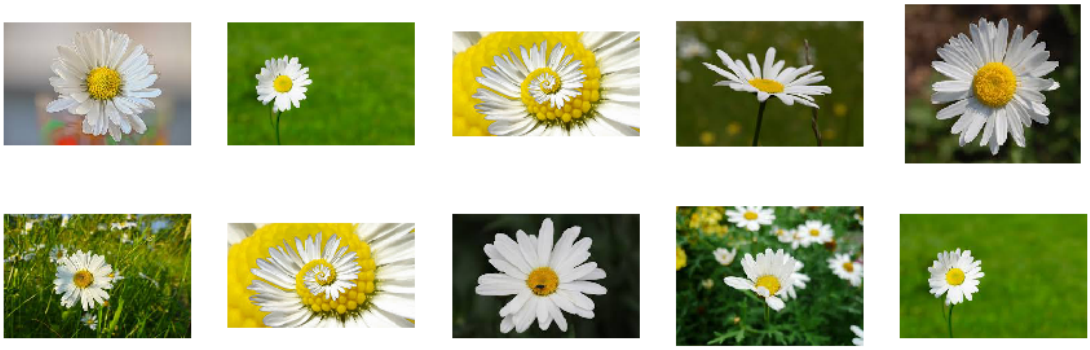
	0	1	2	3	4
summary	count	mean	stddev	min	max
ID	333	250.95195195195194	147.8594378018597	1	506
crim	333	3.3603414714714708	7.352271836781104	0.00632	73.5341
zn	333	10.68918918918919	22.674761796618217	0.0	100.0
indus	333	11.29348348348346	6.998123104477312	0.74	27.74
chas	333	0.06006006006006006	0.2379556428164483	0	1
nox	333	0.557144144144145	0.11495450830289312	0.385	0.871
rm	333	6.265618618618616	0.7039515757334471	3.561	8.725
age	333	68.22642642642641	28.13334360562338	6.0	100.0
dis	333	3.7099336336336335	1.9811230514407001	1.1296	10.7103
rad	333	9.633633633633634	8.742174349631064	1	24
tax	333	409.27927927927925	170.84198846058237	188	711
ptratio	333	18.448048048047994	2.1518213294390836	12.6	21.2
black	333	359.4660960960953	86.58456685718393	3.5	396.9
lstat	333	12.515435435435432	7.0677808035857845	1.73	37.97
medv	333	22.768768768768783	9.173468027315415	5.0	50.0

```
+--------------------+----+
|            features|medv|
+--------------------+----+
|[0.00632,18.0,2.3...|24.0|
|[0.02731,0.0,7.07...|21.6|
|[0.03237,0.0,2.18...|33.4|
|[0.06905,0.0,2.18...|36.2|
|[0.08829,12.5,7.8...|22.9|
+--------------------+----+
only showing top 5 rows
```

```
Coefficients: [-0.010279413081980417,0.034113414577108085,0.0,5.6415385374198,-7.7832643486443
99,3.085680504353533,0.0,-0.8290283633263736,0.016467345168122184,0.0,-0.5849152858717687,0.00
9195354138663316,-0.5627105522578837]
Intercept: 24.28872820161242
```

In [12]:
```
print("Beta Coefficients:", model.coefficientMatrix)
print("Interceptors: ", model.interceptVector)
```

```
Beta Coefficients: DenseMatrix([[-3.53097049e-02, -1.25709923e+00, -1.270
86275e+00,
                 -8.55944290e-02, -4.85804489e-01,  1.46697237e-02,
                  3.27206803e-03,  8.87358597e+00, -6.98378596e-01,
                 -4.19883998e-01, -4.15213016e-01],
                [-1.84038640e-03,  2.97769739e+00, -3.08531351e-01,
                  8.04546607e-02,  5.70434666e+00, -1.80503443e-02,
                 -3.20013995e-03, -4.47205103e+00,  2.46506380e+00,
                 -1.47617653e+00, -4.08041588e-01],
                [ 3.71500913e-02, -1.72059816e+00,  1.57939410e+00,
                  5.13976829e-03, -5.21854217e+00,  3.38062055e-03,
                 -7.19280761e-05, -4.40153494e+00, -1.76668521e+00,
                  1.89606053e+00,  8.23254604e-01]])
Interceptors:  [2.5177699762432026,-0.5458267035288586,-1.971943272714343
8]
```












```
In [11]: dfdaisy.show(5)
```

```
+--------------------+-----+
|               image|label|
+--------------------+-----+
|[file:/home/am/Dr...|    1|
|[file:/home/am/Dr...|    1|
|[file:/home/am/Dr...|    1|
|[file:/home/am/Dr...|    1|
|[file:/home/am/Dr...|    1|
+--------------------+-----+
only showing top 5 rows
```

```
In [12]: dftulips.show(5)
```

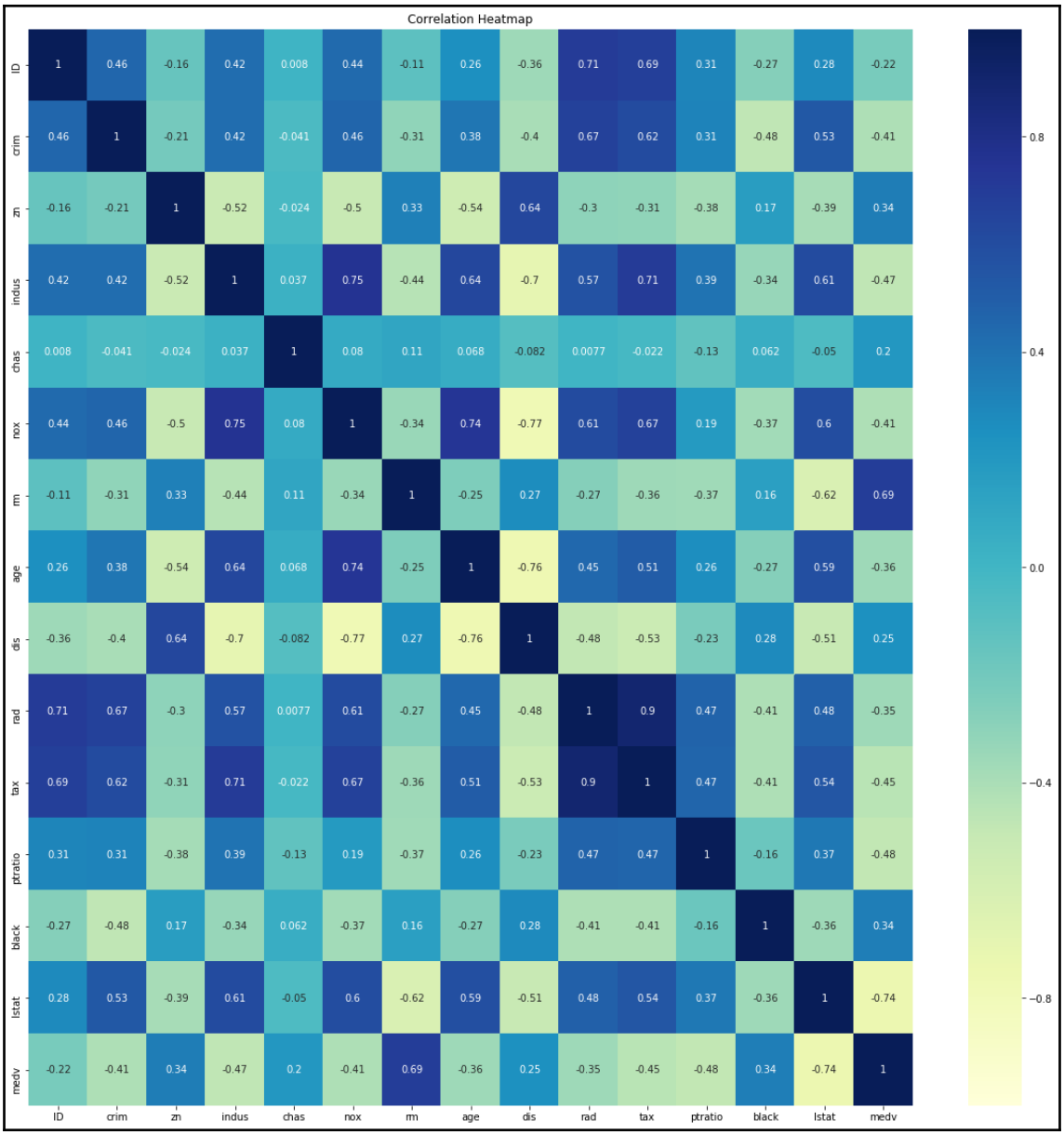
```
+--------------------+-----+
|               image|label|
+--------------------+-----+
|[file:/home/am/Dr...|    0|
|[file:/home/am/Dr...|    0|
|[file:/home/am/Dr...|    0|
|[file:/home/am/Dr...|    0|
|[file:/home/am/Dr...|    0|
+--------------------+-----+
only showing top 5 rows
```

```
In [17]: predictDF.crosstab('prediction', 'label').show()
```

```
+----------------+---+---+
|prediction_label|  0|  1|
+----------------+---+---+
|             1.0|  0| 12|
|             0.0| 16|  3|
+----------------+---+---+
```

```
Checking whether there is an H2O instance running at http://localhost:54321..... not found.
Attempting to start a local H2O server...
  Java Version: java version "1.8.0_191"; Java(TM) SE Runtime Environment (build 1.8.0_191-b12
); Java HotSpot(TM) 64-Bit Server VM (build 25.191-b12, mixed mode)
  Starting server from /home/am/anaconda3/envs/h2o/lib/python3.5/site-packages/h2o/backend/bin
/h2o.jar
  Ice root: /tmp/tmp7hjshd9o
  JVM stdout: /tmp/tmp7hjshd9o/h2o_am_started_from_python.out
  JVM stderr: /tmp/tmp7hjshd9o/h2o_am_started_from_python.err
  Server is running at http://127.0.0.1:54321
Connecting to H2O server at http://127.0.0.1:54321... successful.
```

H2O cluster uptime:	01 secs
H2O cluster timezone:	Asia/Kolkata
H2O data parsing timezone:	UTC
H2O cluster version:	3.22.0.2
H2O cluster version age:	18 days
H2O cluster name:	H2O_from_python_am_3z4r3u
H2O cluster total nodes:	1
H2O cluster free memory:	6.957 Gb
H2O cluster total cores:	8
H2O cluster allowed cores:	8
H2O cluster status:	accepting new members, healthy
H2O connection url:	http://127.0.0.1:54321
H2O connection proxy:	None
H2O internal security:	False
H2O API Extensions:	XGBoost, Algos, AutoML, Core V3, Core V4
Python version:	3.5.6 final


Correlation Heatmap
ID crim zn indus chas nox rm age dis rad tax ptratio black lstat medv
1 0.46 -0.16 0.42 0.008 0.44 -0.11 0.26 -0.36 0.71 0.69 0.31 -0.27 0.28 -0.22
0.46 1 -0.21 0.42 -0.041 0.46 -0.31 0.38 -0.4 0.67 0.62 0.31 -0.48 0.53 -0.41
-0.16 -0.21 1 -0.52 -0.024 -0.5 0.33 -0.54 0.64 -0.3 -0.31 -0.38 0.17 -0.39 0.34
0.42 0.42 -0.52 1 0.037 0.75 -0.44 0.64 -0.7 0.57 0.71 0.39 -0.34 0.61 -0.47
0.008 -0.041 -0.024 0.037 1 0.08 0.11 0.068 -0.082 0.0077 -0.022 -0.13 0.062 -0.05 0.2
0.44 0.46 -0.5 0.75 0.08 1 -0.34 0.74 -0.77 0.61 0.67 0.19 -0.37 0.6 -0.41
-0.11 -0.31 0.33 -0.44 0.11 -0.34 1 -0.25 0.27 -0.27 -0.36 -0.37 0.16 -0.62 0.69
0.26 0.38 -0.54 0.64 0.068 0.74 -0.25 1 -0.76 0.45 0.51 0.26 -0.27 0.59 -0.36
-0.36 -0.4 0.64 -0.7 -0.082 -0.77 0.27 -0.76 1 -0.48 -0.53 -0.23 0.28 -0.51 0.25
0.71 0.67 -0.3 0.57 0.0077 0.61 -0.27 0.45 -0.48 1 0.9 0.47 -0.41 0.48 -0.35
0.69 0.62 -0.31 0.71 -0.022 0.67 -0.36 0.51 -0.53 0.9 1 0.47 -0.41 0.54 -0.45
0.31 0.31 -0.38 0.39 -0.13 0.19 -0.37 0.26 -0.23 0.47 0.47 1 -0.16 0.37 -0.48
-0.27 -0.48 0.17 -0.34 0.062 -0.37 0.16 -0.27 0.28 -0.41 -0.41 -0.16 1 -0.36 0.34
0.28 0.53 -0.39 0.61 -0.05 0.6 -0.62 0.59 -0.51 0.48 0.54 0.37 -0.36 1 -0.74
-0.22 -0.41 0.34 -0.47 0.2 -0.41 0.69 -0.36 0.25 -0.35 -0.45 -0.48 0.34 -0.74 1
0.8
0.4
0.0
−0.4
−0.8

```
glm Model Build progress: |████████████████████████████████████████████████| 100%
Model Details
to expand output; double click to hide output
-------------
H2OGeneralizedLinearEstimator :  Generalized Linear Modeling
Model Key:  boston_glm


ModelMetricsRegressionGLM: glm
** Reported on train data. **

MSE: 25.29061565365854
RMSE: 5.028977595263131
MAE: 3.5119806236622573
RMSLE: 0.21879597717063684
R^2: 0.6585836959508422
Mean Residual Deviance: 25.29061565365854
Null degrees of freedom: 199
Residual degrees of freedom: 188
Null deviance: 14815.118876113953
Residual deviance: 5058.123130731708
AIC: 1239.662094110731

ModelMetricsRegressionGLM: glm
** Reported on validation data. **

MSE: 29.45943429400654
RMSE: 5.427654584994014
MAE: 3.9827620428290818
RMSLE: 0.23155132773489584
R^2: 0.6075220878659529
Mean Residual Deviance: 29.45943429400654
Null degrees of freedom: 57
Residual degrees of freedom: 46
Null deviance: 4379.649896571945
Residual deviance: 1708.6471890523794
AIC: 386.81169393537243
```

```
ModelMetricsRegressionGLM: glm
** Reported on test data. **

MSE: 58.79022368779993
RMSE: 7.667478313487423
MAE: 4.535525812229012
RMSLE: 0.2716211906586539
R^2: 0.4911310682143256
Mean Residual Deviance: 58.79022368779993
Null degrees of freedom: 74
Residual degrees of freedom: 63
Null deviance: 8748.76368890764
Residual deviance: 4409.266776584995
AIC: 544.388948275823
```

In [25]:
```
print(aml.leaderboard)
```

model_id	mean_residual_deviance	rmse	mse	mae	rmsle
StackedEnsemble_AllModels_AutoML_20181210_223722	9.82793	3.13495	9.82793	2.13917	0.139589
StackedEnsemble_BestOfFamily_AutoML_20181210_223722	9.94461	3.15351	9.94461	2.14671	0.138903
GBM_3_AutoML_20181210_223722	10.2273	3.19802	10.2273	2.24126	0.14437
GBM_2_AutoML_20181210_223722	10.2627	3.20355	10.2627	2.23899	0.143894
GBM_1_AutoML_20181210_223722	10.2719	3.20498	10.2719	2.21991	0.147681
GBM_4_AutoML_20181210_223722	10.287	3.20734	10.287	2.24546	0.144326
XGBoost_2_AutoML_20181210_223722	10.3645	3.21939	10.3645	2.05124	0.143118
XGBoost_1_AutoML_20181210_223722	11.068	3.32686	11.068	2.16475	0.14958
XGBoost_3_AutoML_20181210_223722	11.3421	3.3678	11.3421	2.26389	0.147565
XRT_1_AutoML_20181210_223722	12.0748	3.47488	12.0748	2.31572	0.141624

```
In [9]: test_glm = model_glm.model_performance(test_df)
        print(test_glm)
```

```
ModelMetricsBinomialGLM: glm
** Reported on test data. **

MSE: 0.017228193204603934
RMSE: 0.1312562120610066
LogLoss: 0.13988271775187358
Null degrees of freedom: 317
Residual degrees of freedom: 306
Null deviance: 53.187557984070224
Residual deviance: 88.96540849019598
AIC: 112.96540849019598
AUC: 0.6038338658146964
pr_auc: 0.03346490361472496
Gini: 0.2076677316293929
Confusion Matrix (Act/Pred) for max f1 @ threshold = 0.17042651179749857:
```

	0	1	Error	Rate
0	308.0	5.0	0.016	(5.0/313.0)
1	4.0	1.0	0.8	(4.0/5.0)
Total	312.0	6.0	0.0283	(9.0/318.0)

```
Maximum Metrics: Maximum metrics at their respective thresholds
```

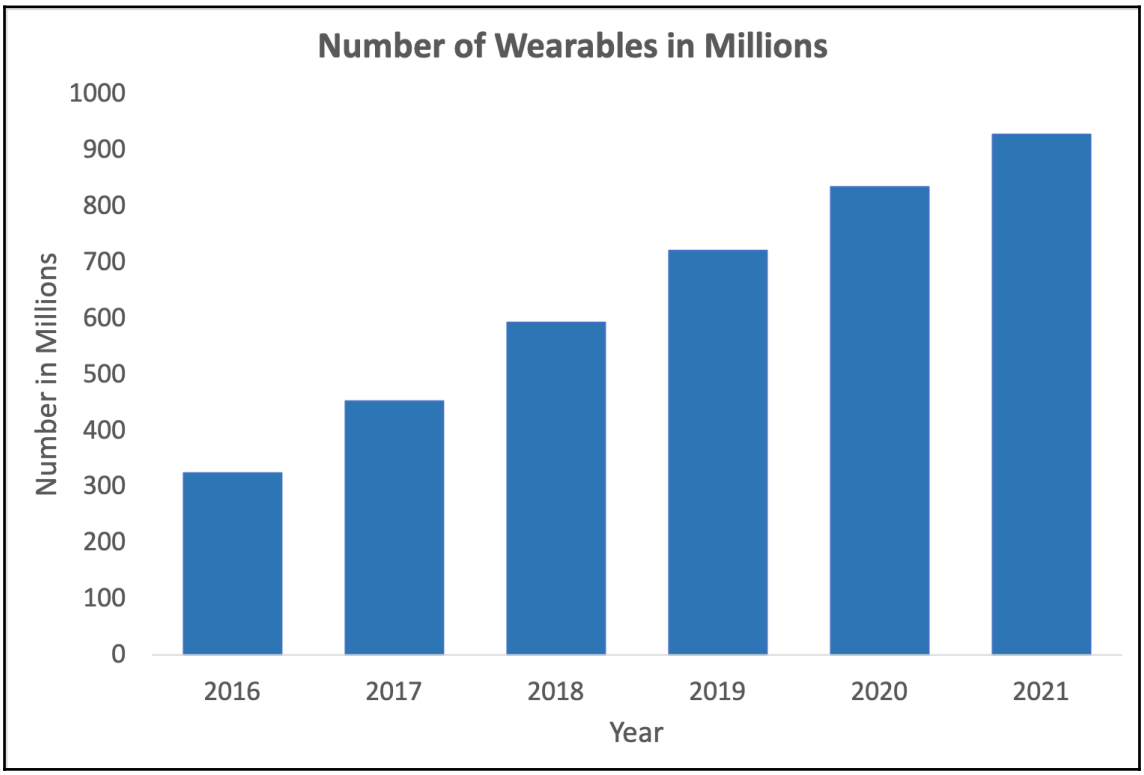
metric	threshold	value	idx
max f1	0.1704265	0.1818182	5.0
max f2	0.1704265	0.1923077	5.0
max f0point5	0.1704265	0.1724138	5.0
max accuracy	0.4984876	0.9811321	0.0
max precision	0.1704265	0.1666667	5.0
max recall	0.0000002	1.0	253.0
max specificity	0.4984876	0.9968051	0.0
max absolute_mcc	0.1704265	0.1682606	5.0
max min_per_class_accuracy	0.0006228	0.6	109.0
max mean_per_class_accuracy	0.0006228	0.6226837	109.0

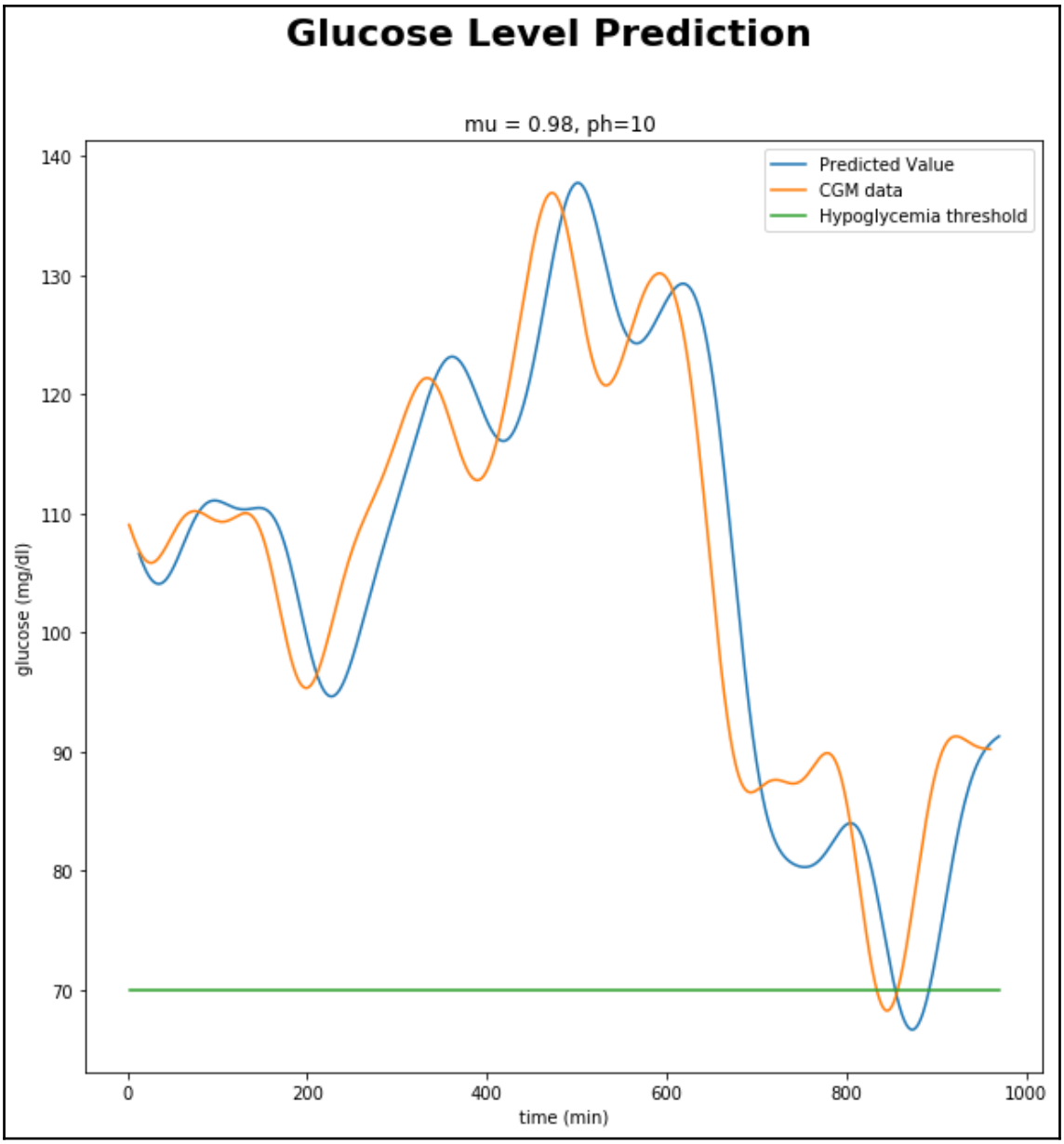
```
Gains/Lift Table: Avg response rate:  1.57 %, avg score:  1.20 %
```

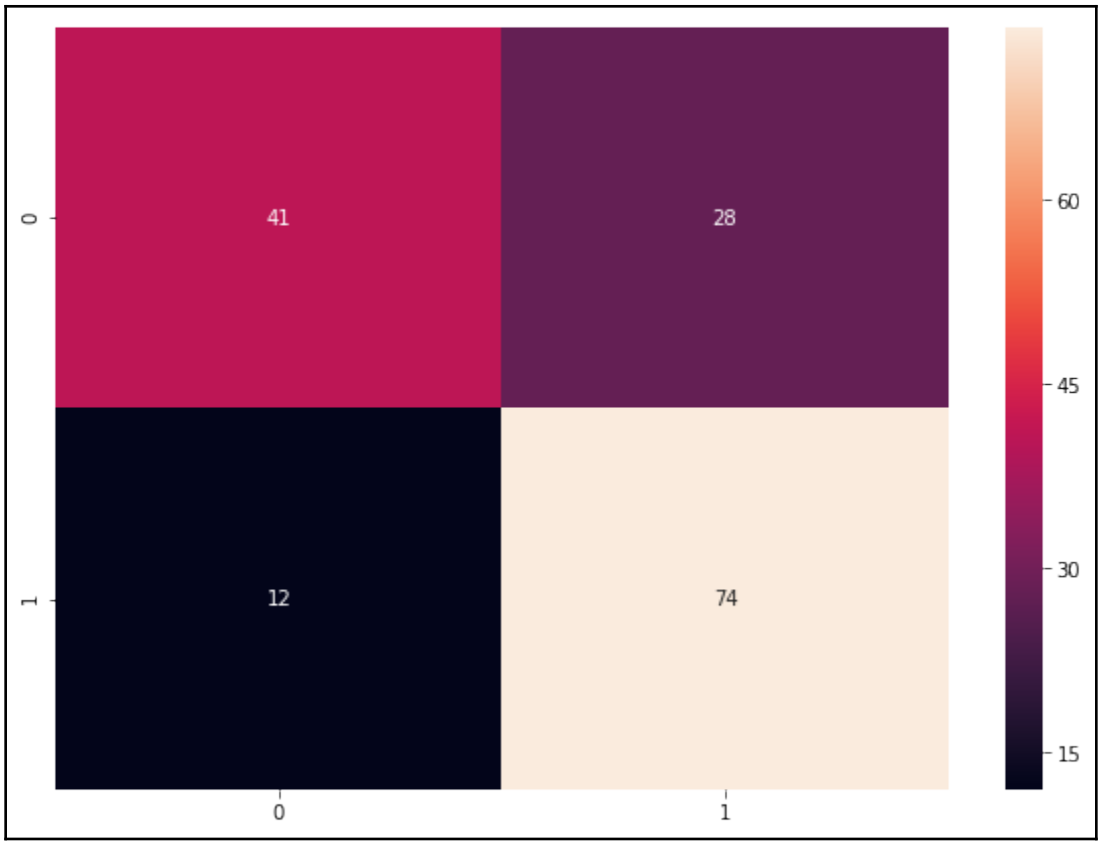
```
In [25]: print(aml.leaderboard)
```

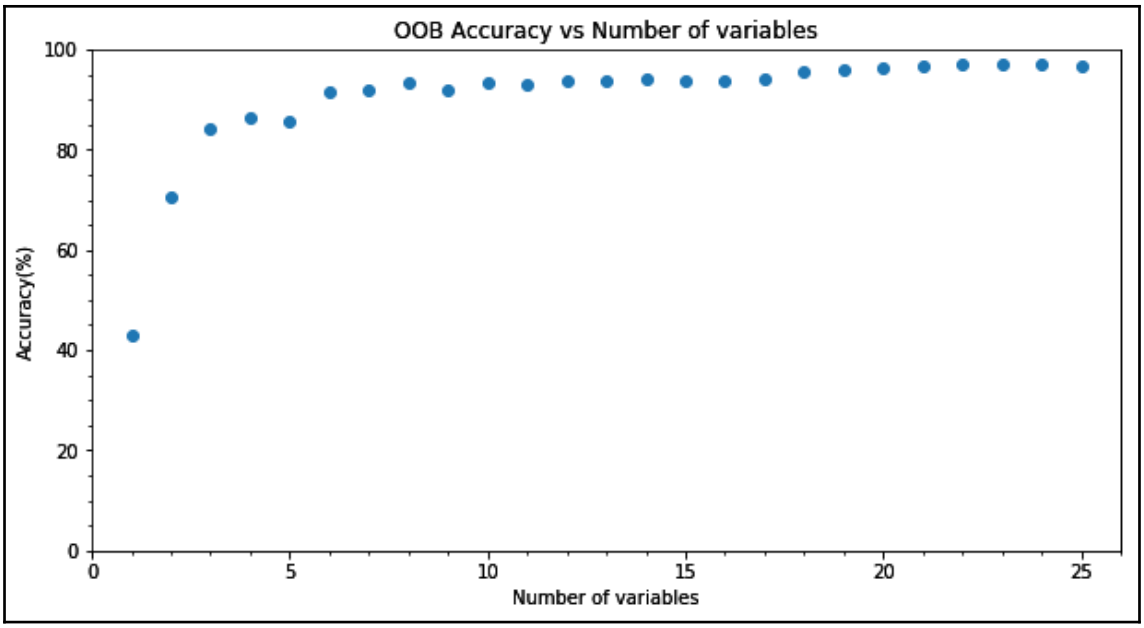
model_id	mean_residual_deviance	rmse	mse	mae	rmsle
StackedEnsemble_AllModels_AutoML_20181210_223722	9.82793	3.13495	9.82793	2.13917	0.139589
StackedEnsemble_BestOfFamily_AutoML_20181210_223722	9.94461	3.15351	9.94461	2.14671	0.138903
GBM_3_AutoML_20181210_223722	10.2273	3.19802	10.2273	2.24126	0.14437
GBM_2_AutoML_20181210_223722	10.2627	3.20355	10.2627	2.23899	0.143894
GBM_1_AutoML_20181210_223722	10.2719	3.20498	10.2719	2.21991	0.147681
GBM_4_AutoML_20181210_223722	10.287	3.20734	10.287	2.24546	0.144326
XGBoost_2_AutoML_20181210_223722	10.3645	3.21939	10.3645	2.05124	0.143118
XGBoost_1_AutoML_20181210_223722	11.068	3.32686	11.068	2.16475	0.14958
XGBoost_3_AutoML_20181210_223722	11.3421	3.3678	11.3421	2.26389	0.147565
XRT_1_AutoML_20181210_223722	12.0748	3.47488	12.0748	2.31572	0.141624

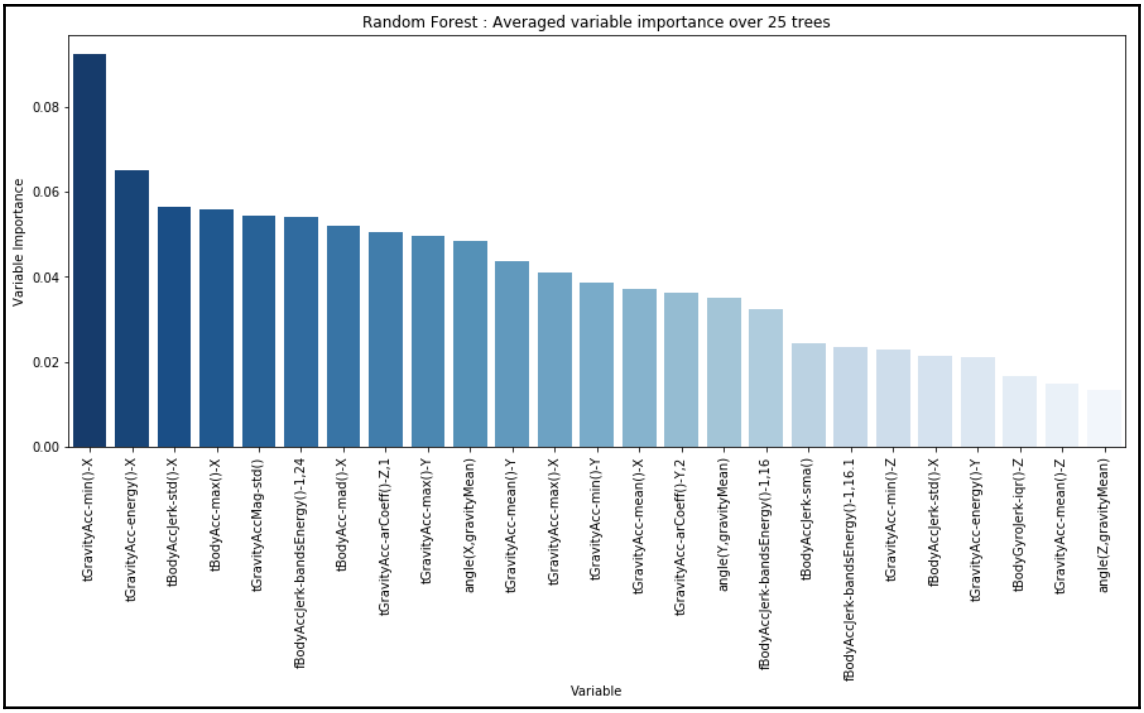
Chapter 9: Personal and Home IoT

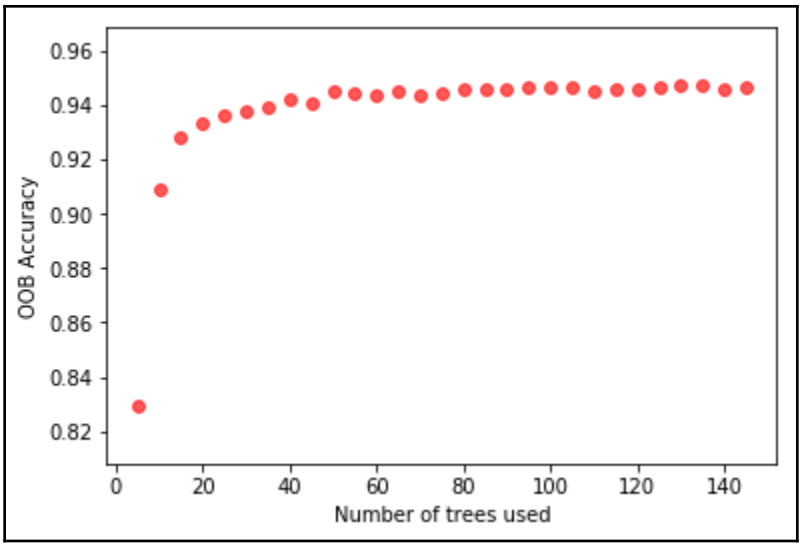


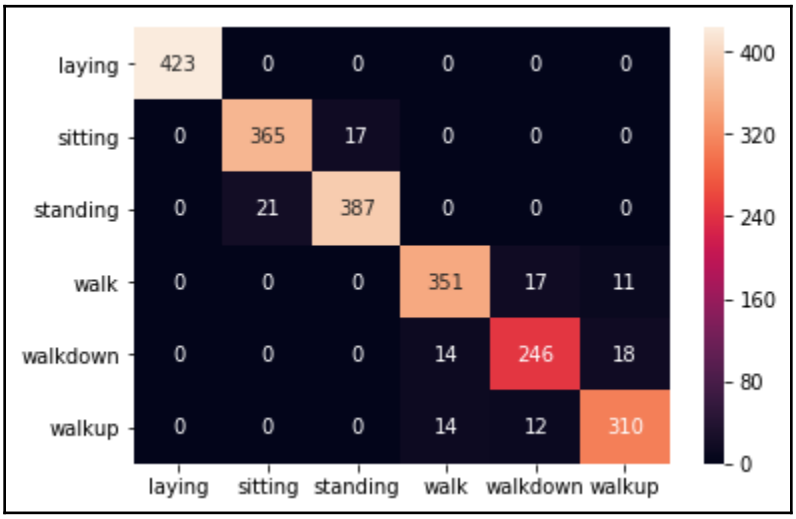

Glucose Level Prediction
mu = 0.98, ph=10
Predicted Value
CGM data
Hypoglycemia threshold
glucose (mg/dl)
time (min)
140
130
120
110
100
90
80
70
0
200
400
600
800
1000


41
28
12
74
0
1
0
1
60
45
30
15

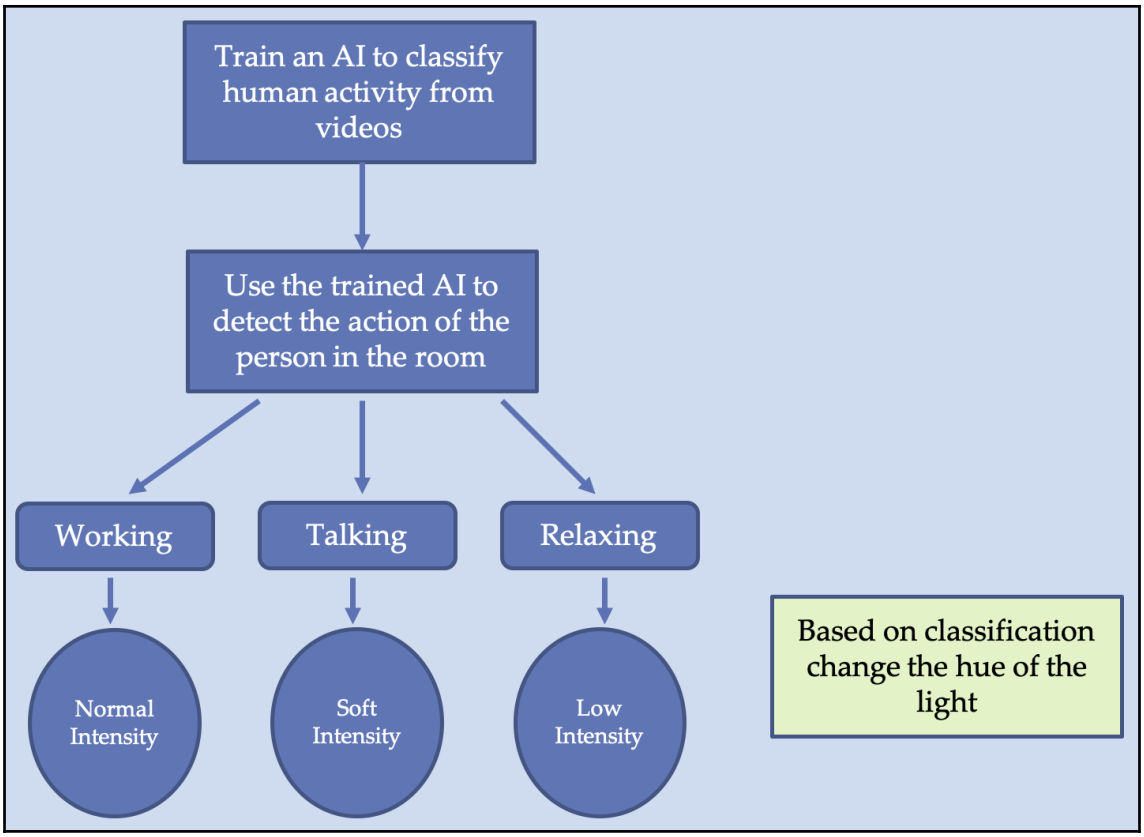

OOB Accuracy vs Number of variables
Accuracy(%)
Number of variables
0
20
40
60
80
100
0
5
10
15
20
25


Random Forest : Averaged variable importance over 25 trees
Variable Importance
Variable
0.00
0.02
0.04
0.06
0.08
tGravityAcc-min()-X
tGravityAcc-energy()-X
tBodyAccJerk-std()-X
tBodyAcc-max()-X
tGravityAccMag-std()
fBodyAccJerk-bandsEnergy()-1,24
tBodyAcc-mad()-X
tGravityAcc-arCoeff()-Z,1
tGravityAcc-max()-Y
angle(X,gravityMean)
tGravityAcc-mean()-Y
tGravityAcc-max()-X
tGravityAcc-min()-Y
tGravityAcc-mean()-X
tGravityAcc-arCoeff()-Y,2
angle(Y,gravityMean)
fBodyAccJerk-bandsEnergy()-1,16
tBodyAccJerk-sma()
fBodyAccJerk-bandsEnergy()-1,16,1
tGravityAcc-min()-Z
fBodyAccJerk-std()-X
tGravityAcc-energy()-Y
tBodyGyroJerk-iqr()-Z
tGravityAcc-mean()-Z
angle(Z,gravityMean)

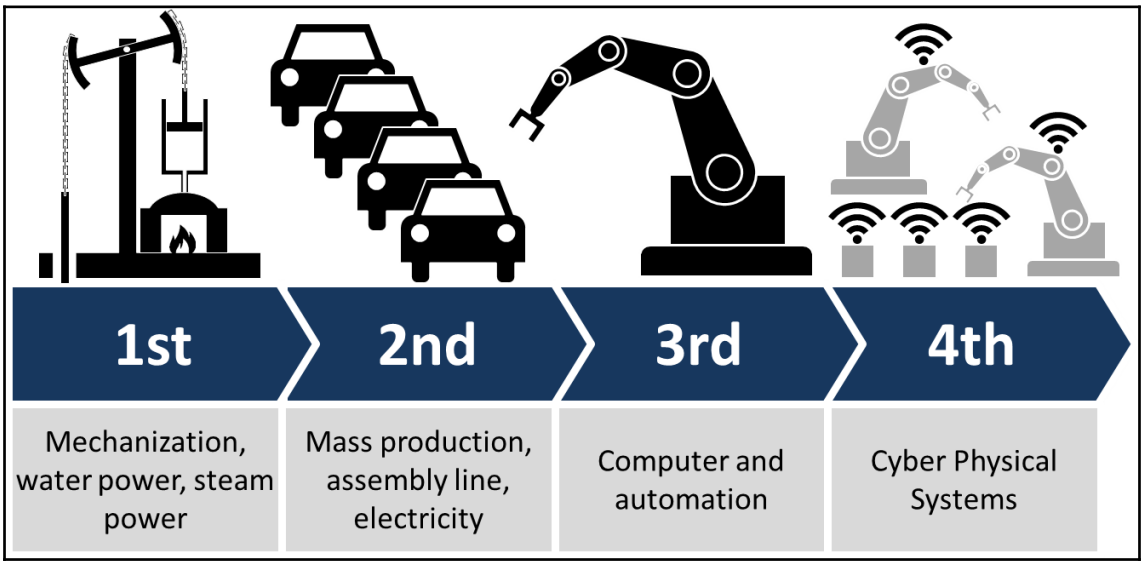

0.96
0.94
0.92
0.90
0.88
0.86
0.84
0.82
OOB Accuracy
0
20
40
60
80
100
120
140
Number of trees used


laying
sitting
standing
walk
walkdown
walkup
423 0 0 0 0 0
0 365 17 0 0 0
0 21 387 0 0 0
0 0 0 351 17 11
0 0 0 14 246 18
0 0 0 14 12 310
laying
sitting
standing
walk
walkdown
walkup
400
320
240
160
80
0

Scenario 1	Scenario 2	Scenario 3
		
		


Train an AI to classify human activity from videos
Use the trained AI to detect the action of the person in the room
Working
Talking
Relaxing
Normal Intensity
Soft Intensity
Low Intensity
Based on classification change the hue of the light

Chapter 10: AI for the Industrial IoT



Out[4]:

	id	cycle	setting1	setting2	setting3	s1	s2	s3	s4	s5	...	s15	s1
0	1	1	0.459770	0.166667	0.0	0.0	0.183735	0.406802	0.309757	0.0	...	0.363986	0.
1	1	2	0.609195	0.250000	0.0	0.0	0.283133	0.453019	0.352633	0.0	...	0.411312	0.
2	1	3	0.252874	0.750000	0.0	0.0	0.343373	0.369523	0.370527	0.0	...	0.357445	0.
3	1	4	0.540230	0.500000	0.0	0.0	0.343373	0.256159	0.331195	0.0	...	0.166603	0.
4	1	5	0.390805	0.333333	0.0	0.0	0.349398	0.257467	0.404625	0.0	...	0.402078	0.

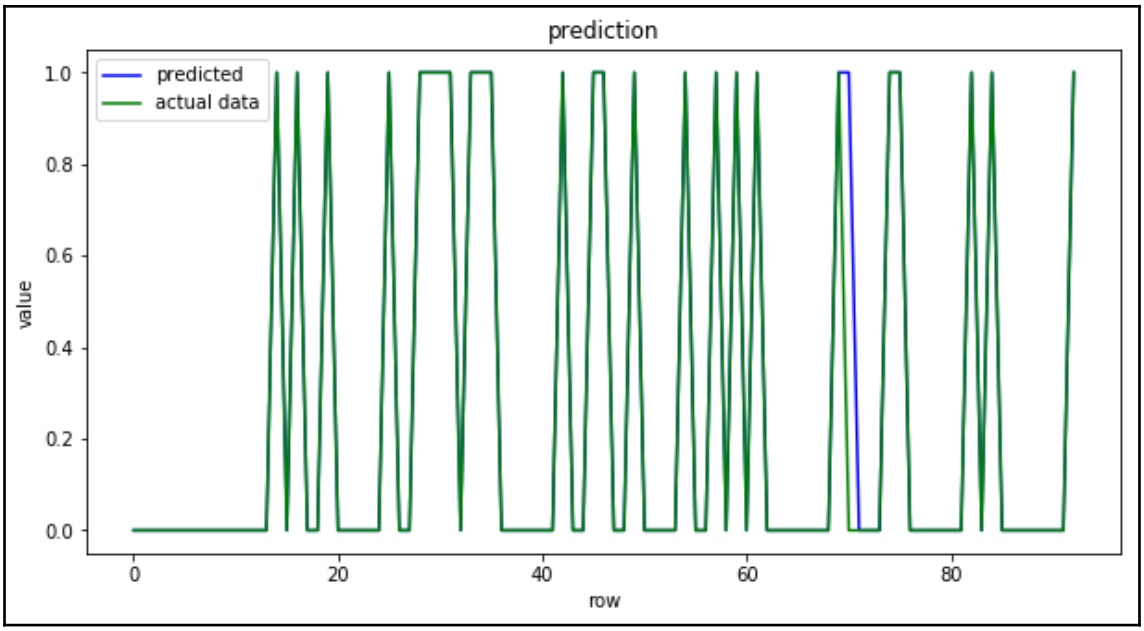
5 rows × 29 columns

Out[5]:

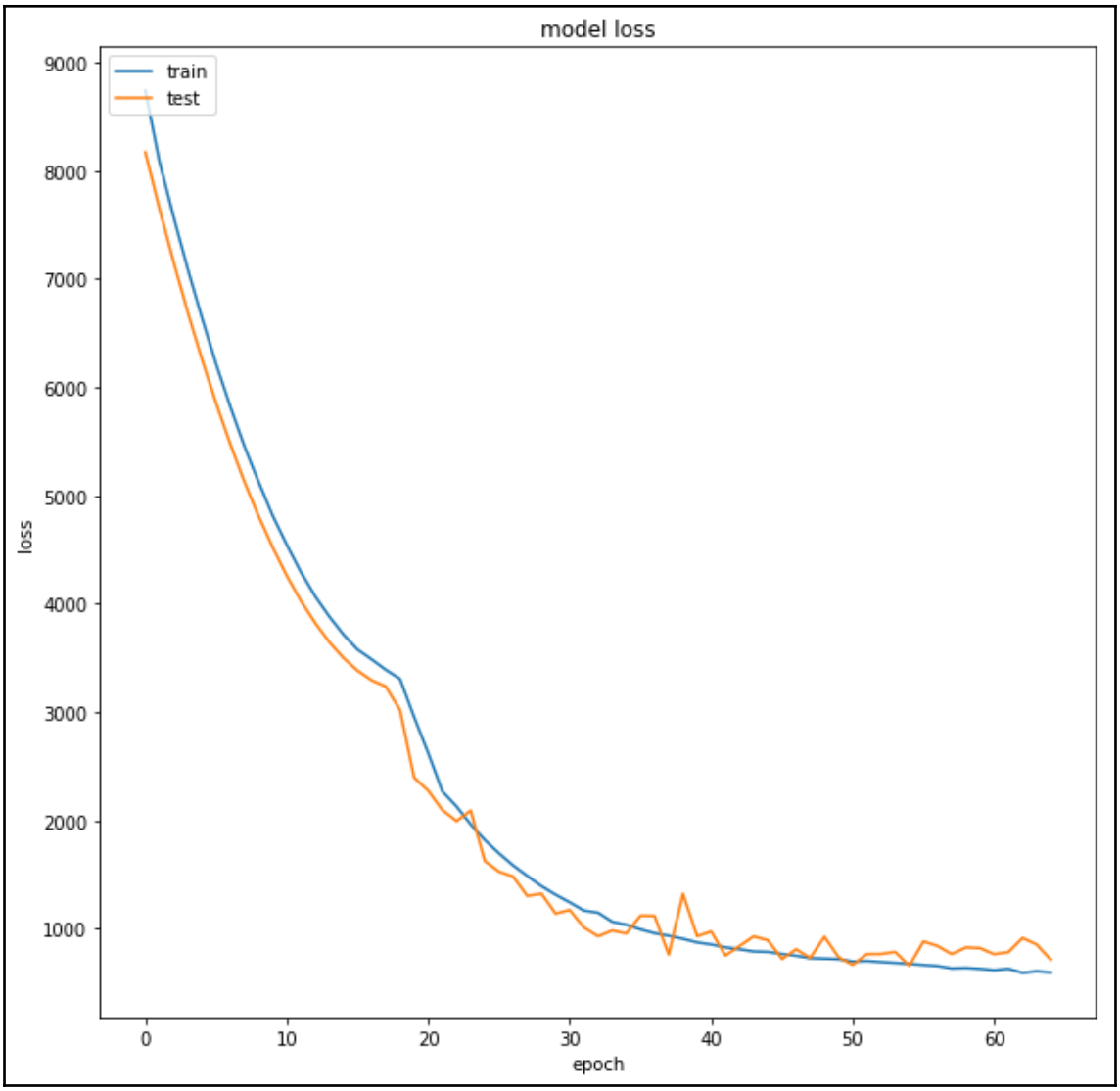
	id	cycle	setting1	setting2	setting3	s1	s2	s3	s4	s5	...	s15	s1
0	1	1	0.632184	0.750000	0.0	0.0	0.545181	0.310661	0.269413	0.0	...	0.308965	0.
1	1	2	0.344828	0.250000	0.0	0.0	0.150602	0.379551	0.222316	0.0	...	0.213159	0.
2	1	3	0.517241	0.583333	0.0	0.0	0.376506	0.346632	0.322248	0.0	...	0.458638	0.
3	1	4	0.741379	0.500000	0.0	0.0	0.370482	0.285154	0.408001	0.0	...	0.257022	0.
4	1	5	0.580460	0.500000	0.0	0.0	0.391566	0.352082	0.332039	0.0	...	0.300885	0.

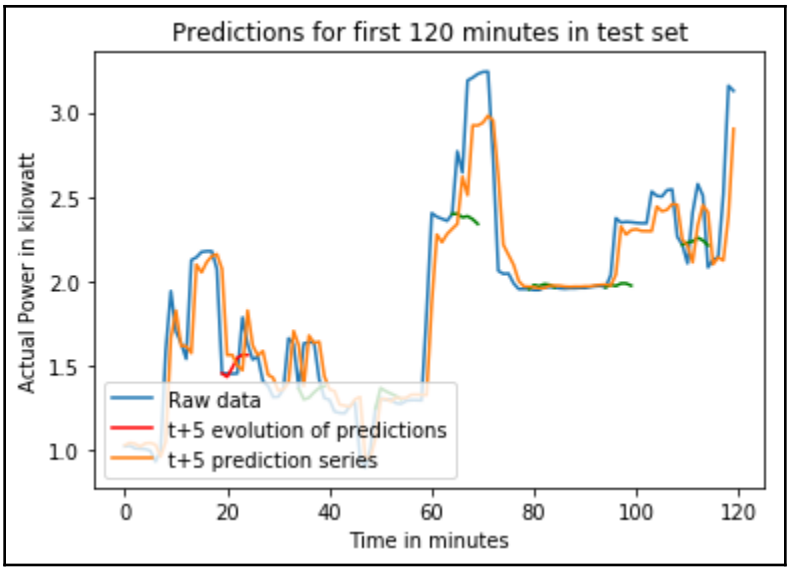
5 rows × 29 columns

```
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
lstm_1 (LSTM)                (None, 50, 100)           50400
_________________________________________________________________
dropout_1 (Dropout)          (None, 50, 100)           0
_________________________________________________________________
lstm_2 (LSTM)                (None, 50)                30200
_________________________________________________________________
dropout_2 (Dropout)          (None, 50)                0
_________________________________________________________________
dense_1 (Dense)              (None, 1)                 51
=================================================================
Total params: 80,651
Trainable params: 80,651
Non-trainable params: 0
```

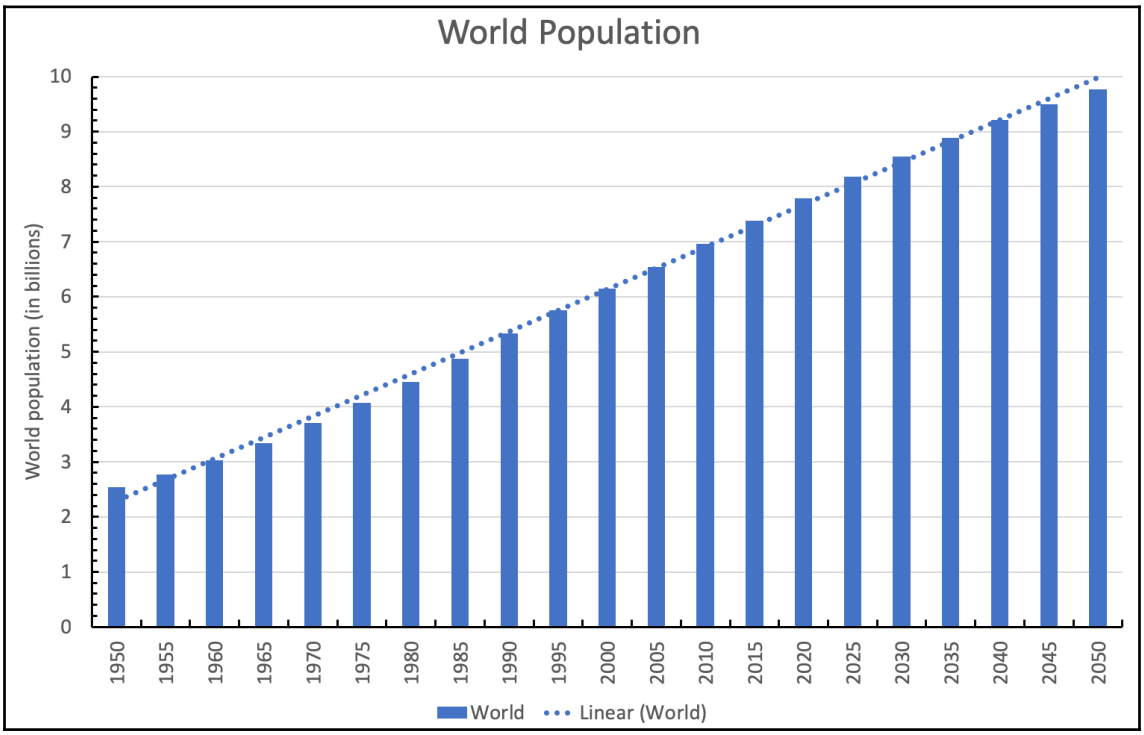


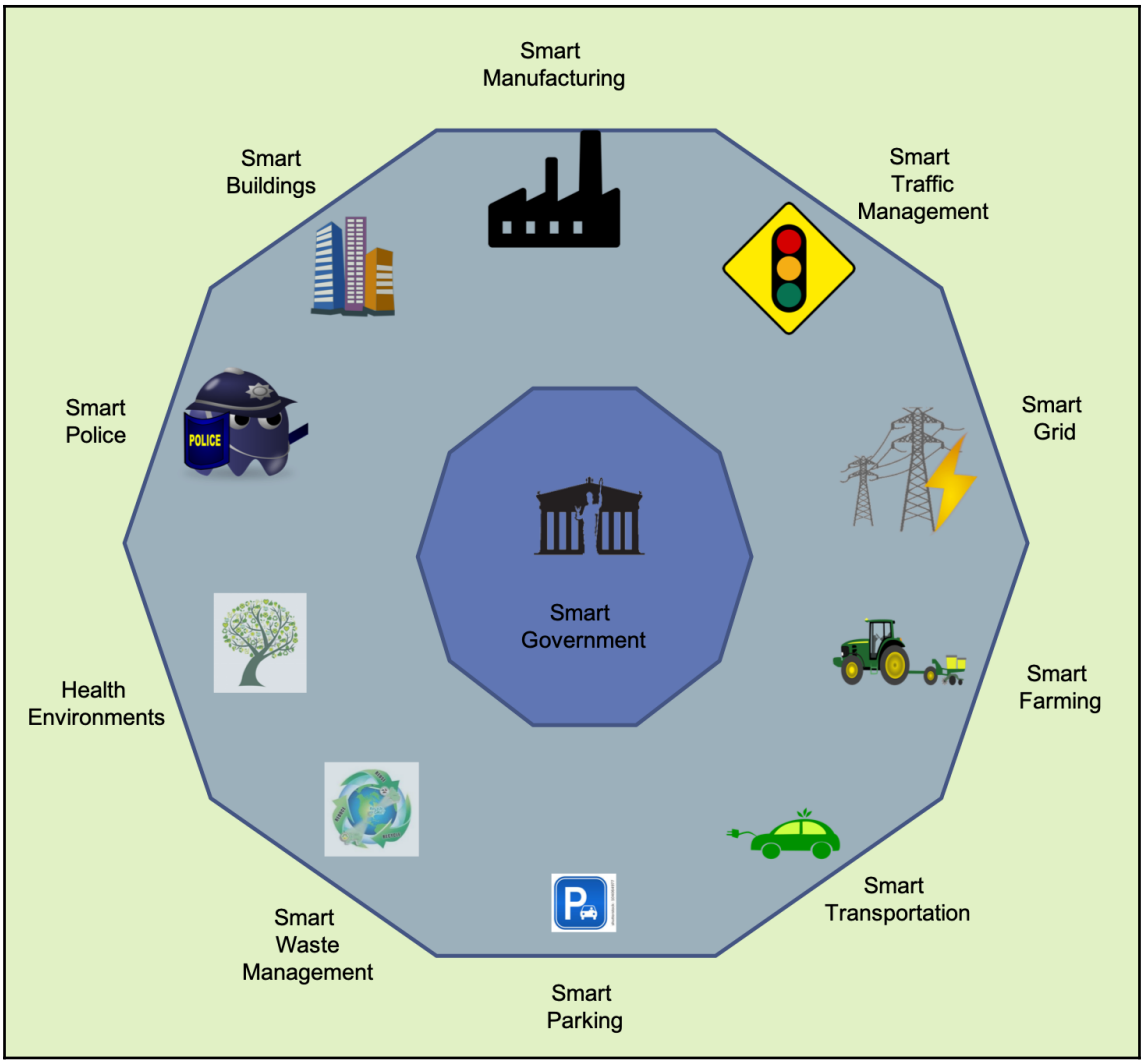

```
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
lstm_3 (LSTM)                (None, 50, 100)           50400
_________________________________________________________________
dropout_3 (Dropout)          (None, 50, 100)           0
_________________________________________________________________
lstm_4 (LSTM)                (None, 50)                30200
_________________________________________________________________
dropout_4 (Dropout)          (None, 50)                0
_________________________________________________________________
dense_2 (Dense)              (None, 1)                 51
_________________________________________________________________
activation_2 (Activation)    (None, 1)                 0
=================================================================
Total params: 80,651
Trainable params: 80,651
Non-trainable params: 0
```


model loss
train
test
loss
epoch
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
10
20
30
40
50
60


Predictions for first 120 minutes in test set
Actual Power in kilowatt
Time in minutes
Raw data
t+5 evolution of predictions
t+5 prediction series
3.0
2.5
2.0
1.5
1.0
0
20
40
60
80
100
120

Chapter 11: AI for Smart Cities IoT




Smart
Manufacturing
Smart
Buildings
Smart
Traffic
Management
Smart
Police
POLICE
Smart
Grid
Smart
Government
Health
Environments
Smart
Farming
Smart
Waste
Management
Smart
Transportation
Smart
Parking

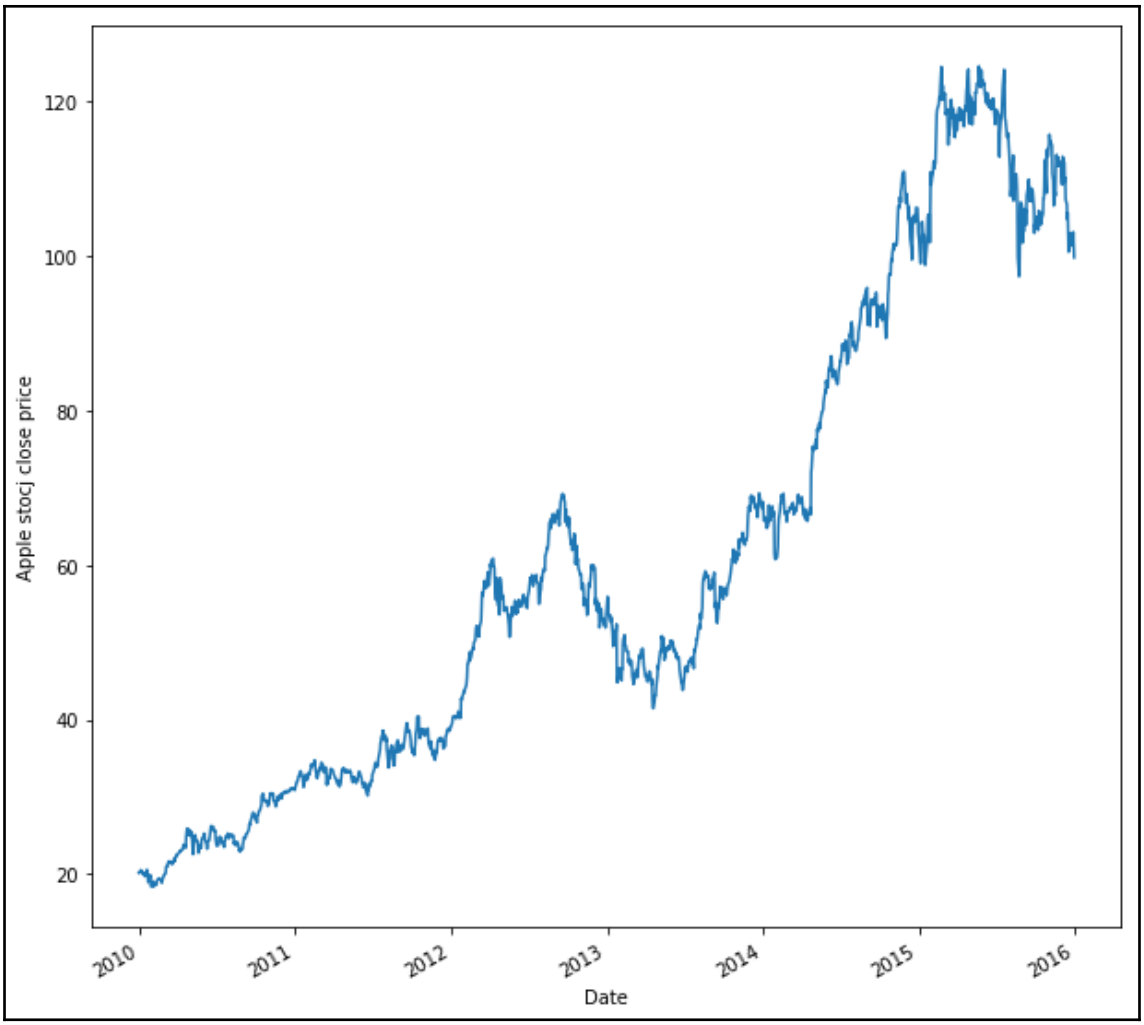
```
Out[3]: ['Dates',
         'Category',
         'Descript',
         'DayOfWeek',
         'PdDistrict',
         'Resolution',
         'Address',
         'X',
         'Y']
```

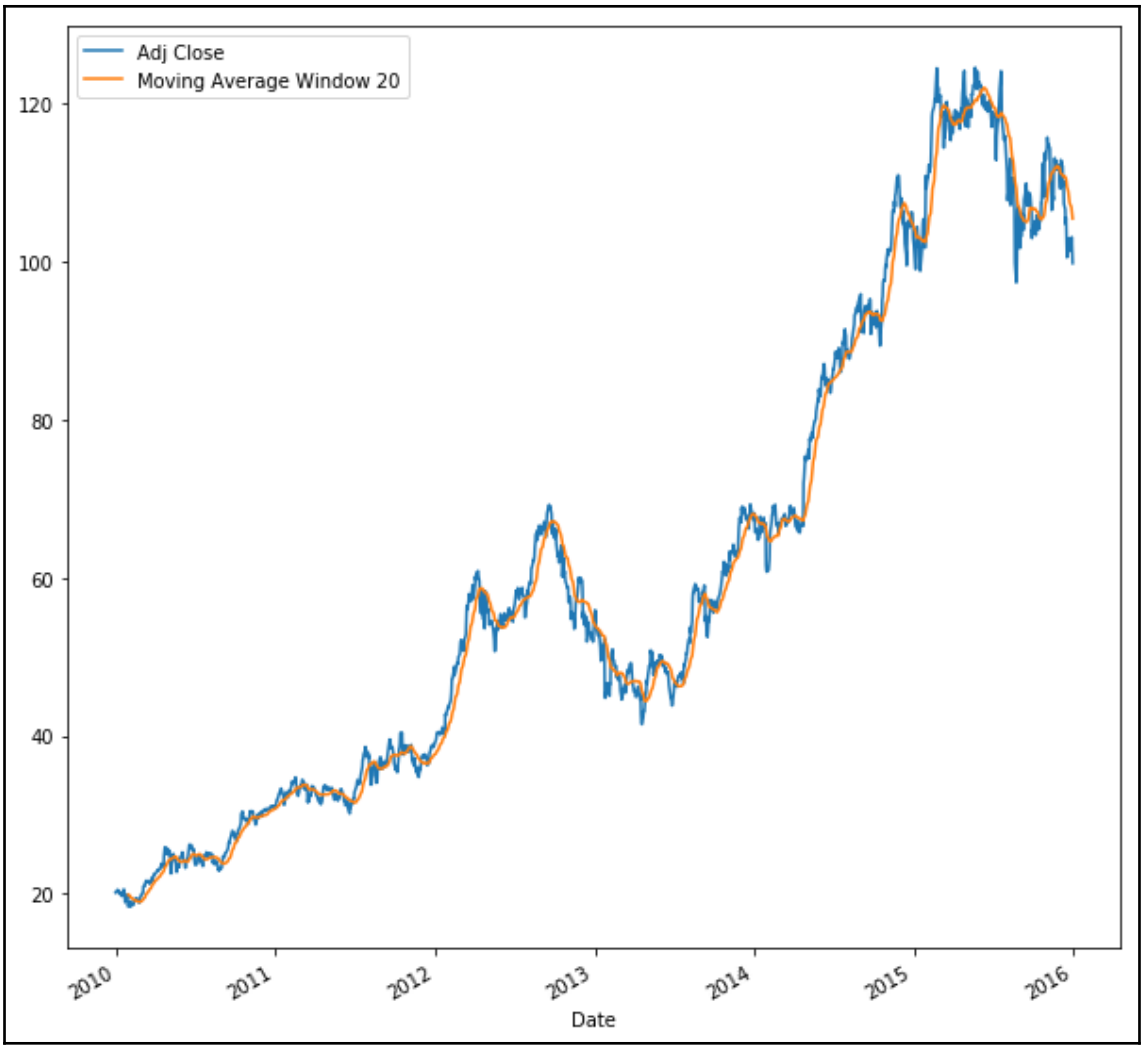
```
+--------------+--------------------+
|      Category|            Descript|
+--------------+--------------------+
|      WARRANTS|      WARRANT ARREST|
|OTHER OFFENSES|TRAFFIC VIOLATION...|
|OTHER OFFENSES|TRAFFIC VIOLATION...|
| LARCENY/THEFT|GRAND THEFT FROM ...|
| LARCENY/THEFT|GRAND THEFT FROM ...|
+--------------+--------------------+
only showing top 5 rows
```

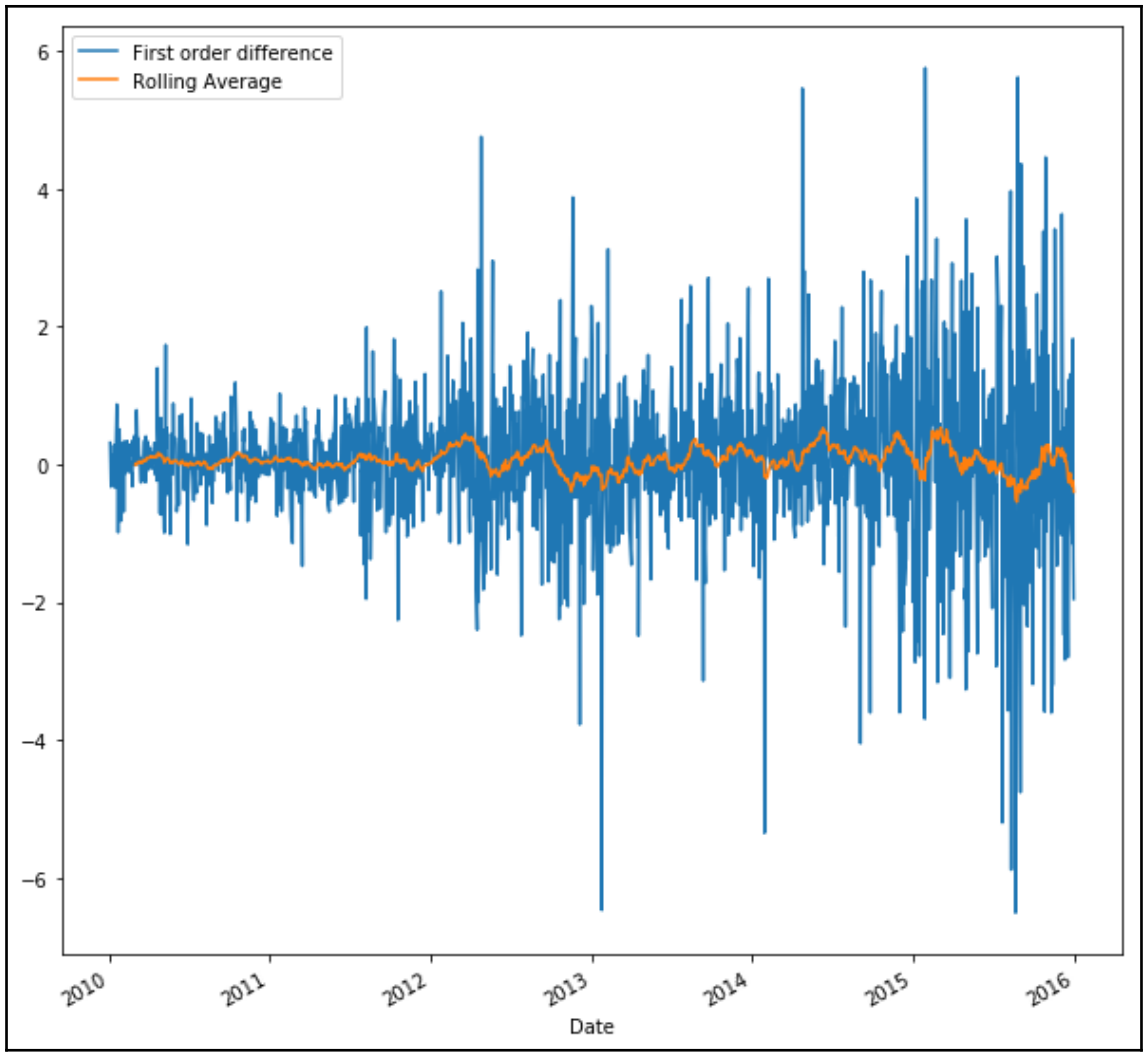
```
+--------------+--------------------+--------------------+--------------------+--------------------+-----+
|      Category|            Descript|               words|            filtered|            features|label|
+--------------+--------------------+--------------------+--------------------+--------------------+-----+
|      WARRANTS|      WARRANT ARREST|   [warrant, arrest]|   [warrant, arrest]|(809,[17,32],[1.0...|  7.0|
|OTHER OFFENSES|TRAFFIC VIOLATION...|[traffic, violati...|[traffic, violati...|(809,[11,17,35],[...|  1.0|
|OTHER OFFENSES|TRAFFIC VIOLATION...|[traffic, violati...|[traffic, violati...|(809,[11,17,35],[...|  1.0|
| LARCENY/THEFT|GRAND THEFT FROM ...|[grand, theft, fr...|[grand, theft, fr...|(809,[0,2,3,4,6],...|  0.0|
| LARCENY/THEFT|GRAND THEFT FROM ...|[grand, theft, fr...|[grand, theft, fr...|(809,[0,2,3,4,6],...|  0.0|
+--------------+--------------------+--------------------+--------------------+--------------------+-----+
only showing top 5 rows
```

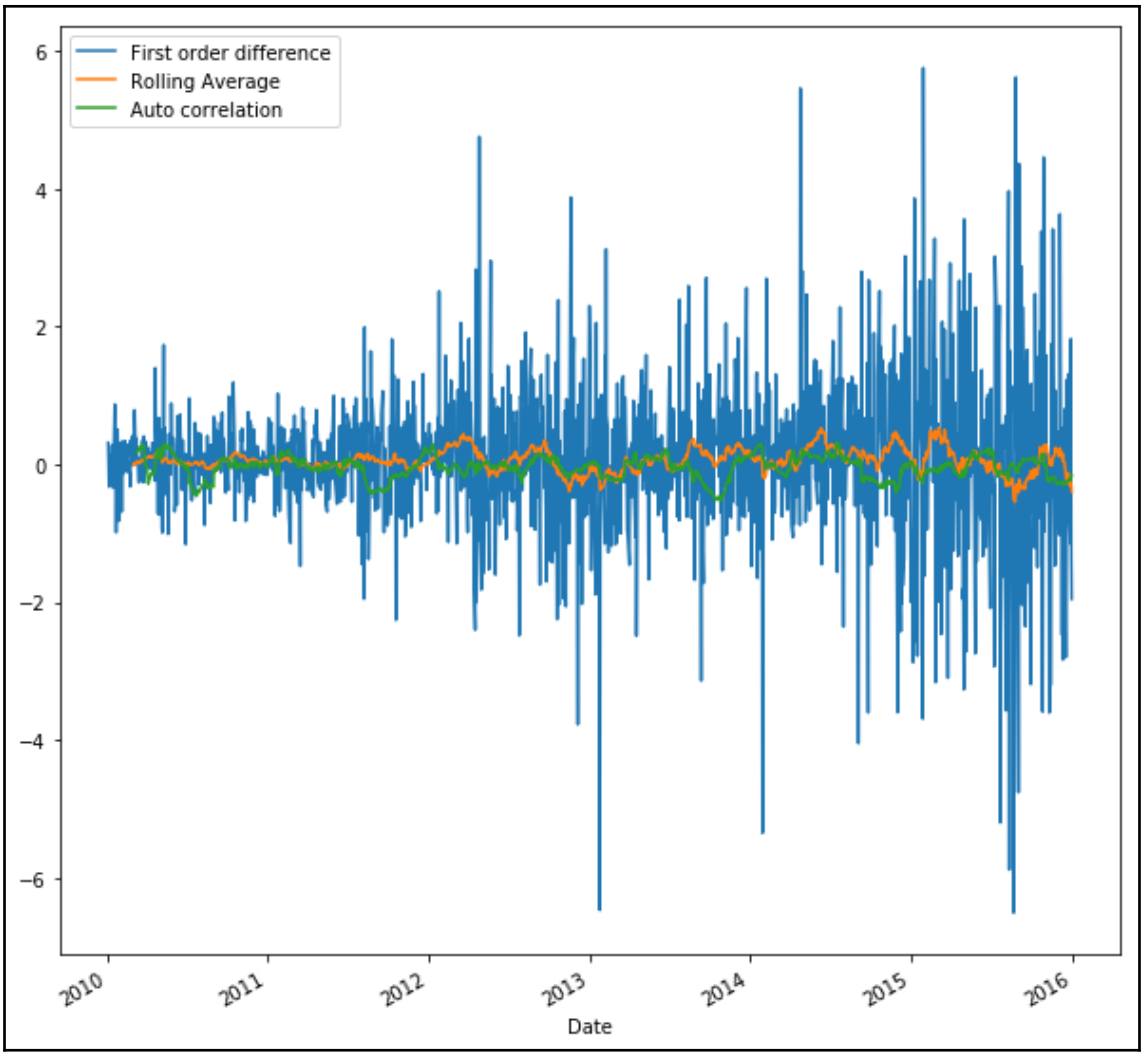
Out[2]:

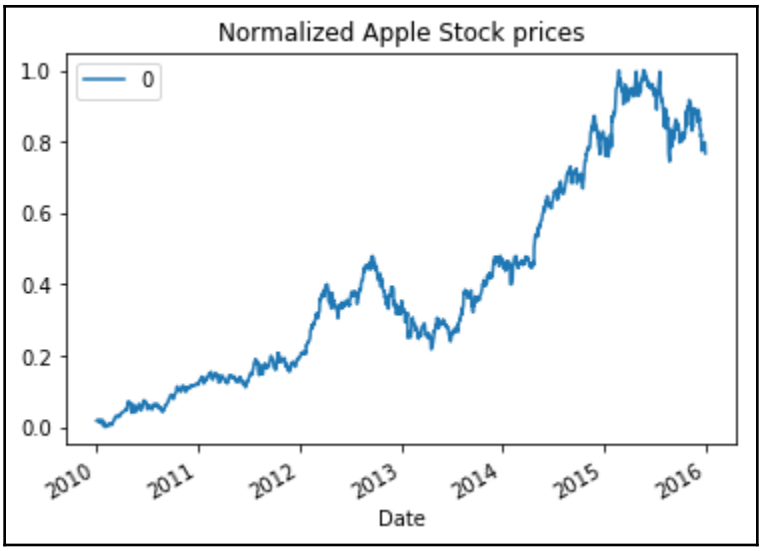
Date	High	Low	Open	Close	Volume	Adj Close
2009-12-31	30.478571	30.080000	30.447144	30.104286	88102700.0	20.159719
2010-01-04	30.642857	30.340000	30.490000	30.572857	123432400.0	20.473503
2010-01-05	30.798571	30.464285	30.657143	30.625713	150476200.0	20.508902
2010-01-06	30.747143	30.107143	30.625713	30.138571	138040000.0	20.182680
2010-01-07	30.285715	29.864286	30.250000	30.082857	119282800.0	20.145369

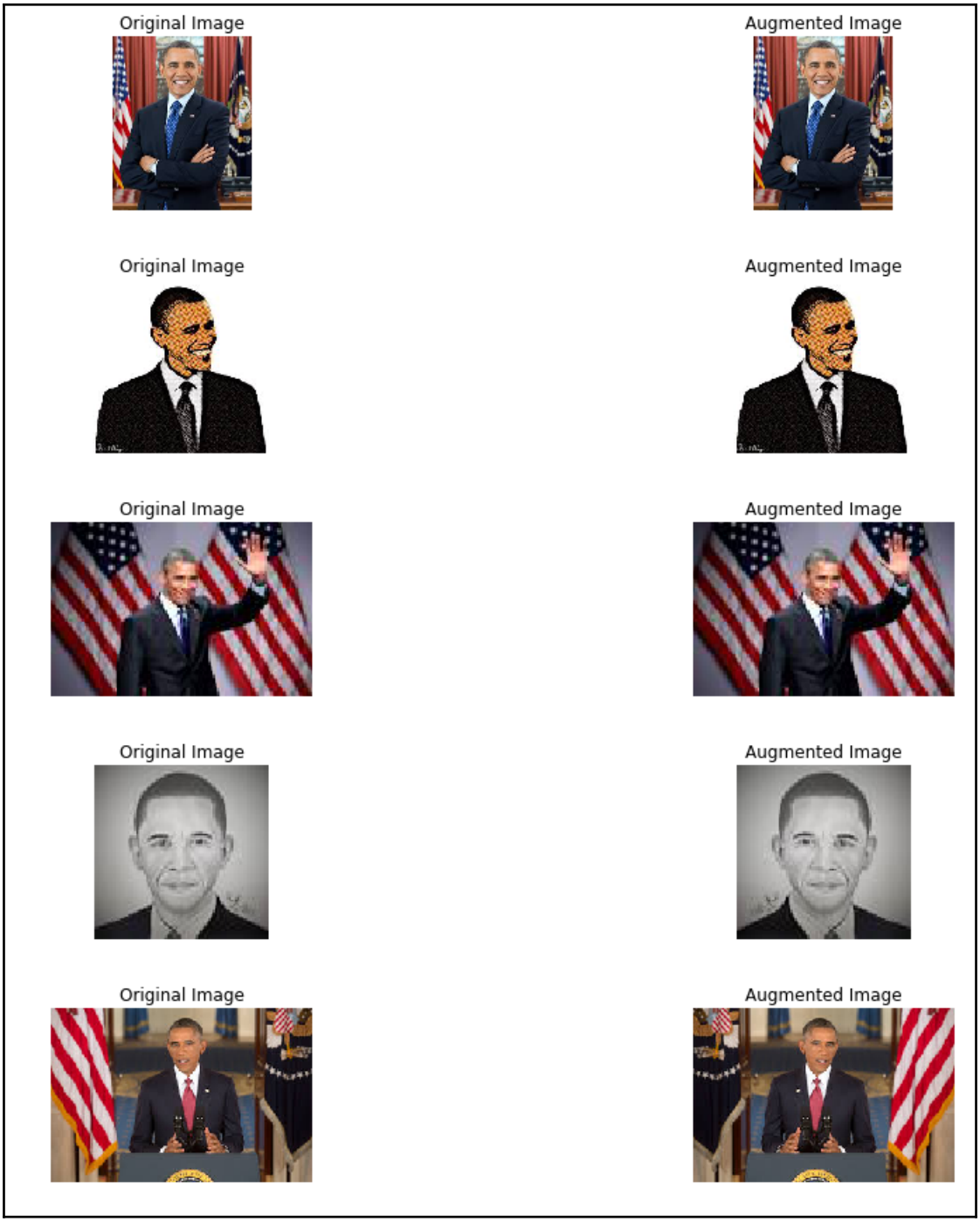

120
100
80
60
40
20
Apple stocj close price
2010
2011
2012
2013
2014
2015
2016
Date

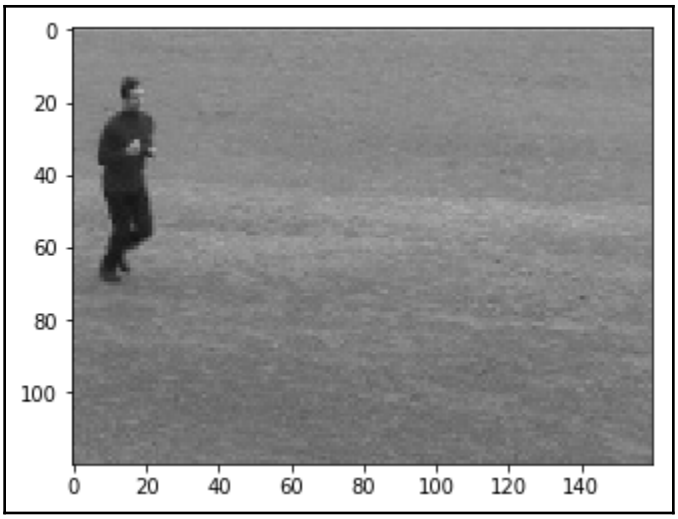

Adj Close
Moving Average Window 20
120
100
80
60
40
20
2010
2011
2012
2013
2014
2015
2016
Date

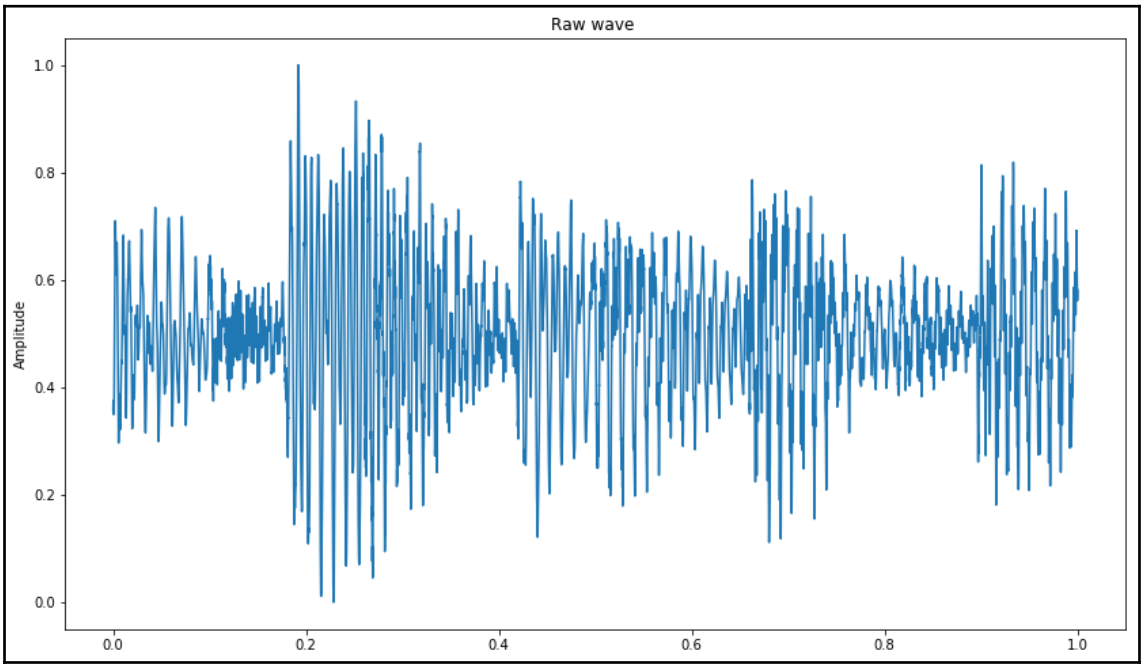

First order difference
Rolling Average
6
4
2
0
−2
−4
−6
2010
2011
2012
2013
2014
2015
2016
Date

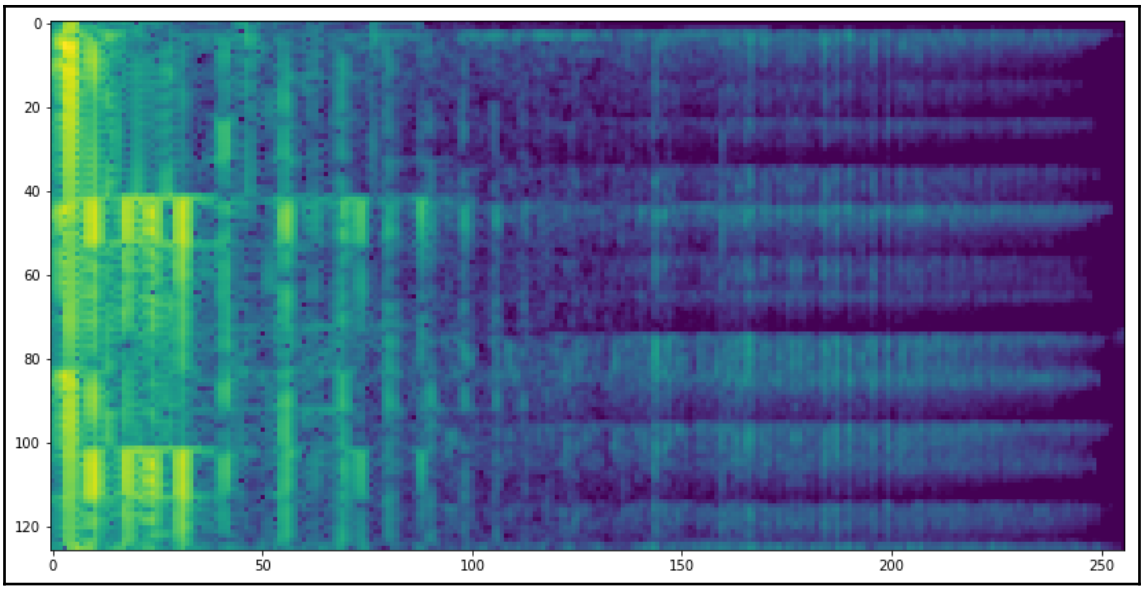

First order difference
Rolling Average
Auto correlation
6
4
2
0
−2
−4
−6
2010
2011
2012
2013
2014
2015
2016
Date


Normalized Apple Stock prices
0
1.0
0.8
0.6
0.4
0.2
0.0
2010
2011
2012
2013
2014
2015
2016
Date


Original Image
Augmented Image
Original Image
Augmented Image
Original Image
Augmented Image
Original Image
Augmented Image
Original Image
Augmented Image


0
20
40
60
80
100
0
20
40
60
80
100
120
140


Raw wave
Amplitude
1.0
0.8
0.6
0.4
0.2
0.0
0.0
0.2
0.4
0.6
0.8
1.0


0
20
40
60
80
100
120
0
50
100
150
200
250

Graphics Bundle Ends Here

Index