Main challenges of machine learning

Insufficient quantity of training data

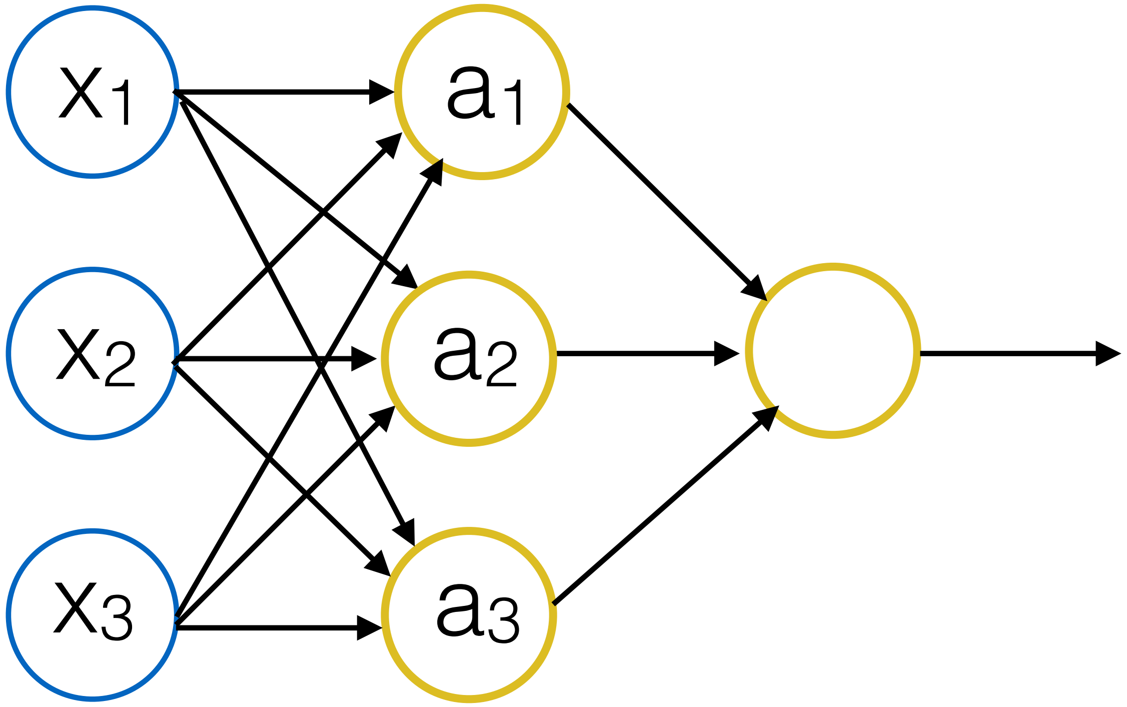
Non-representative training data

Poor quality data

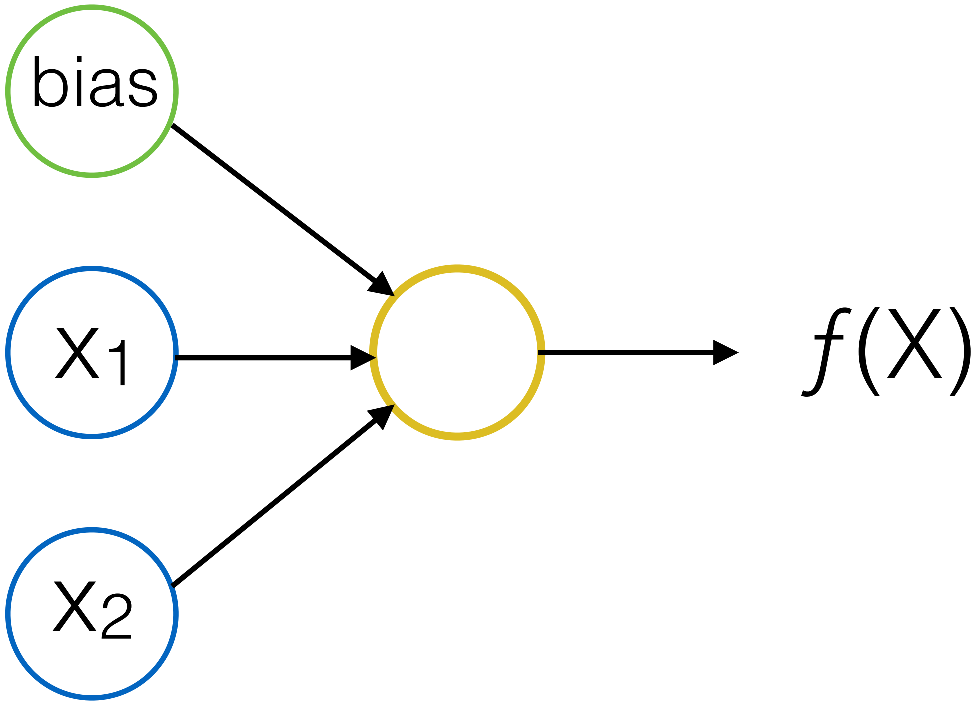
Irrelevant features

Neural Network

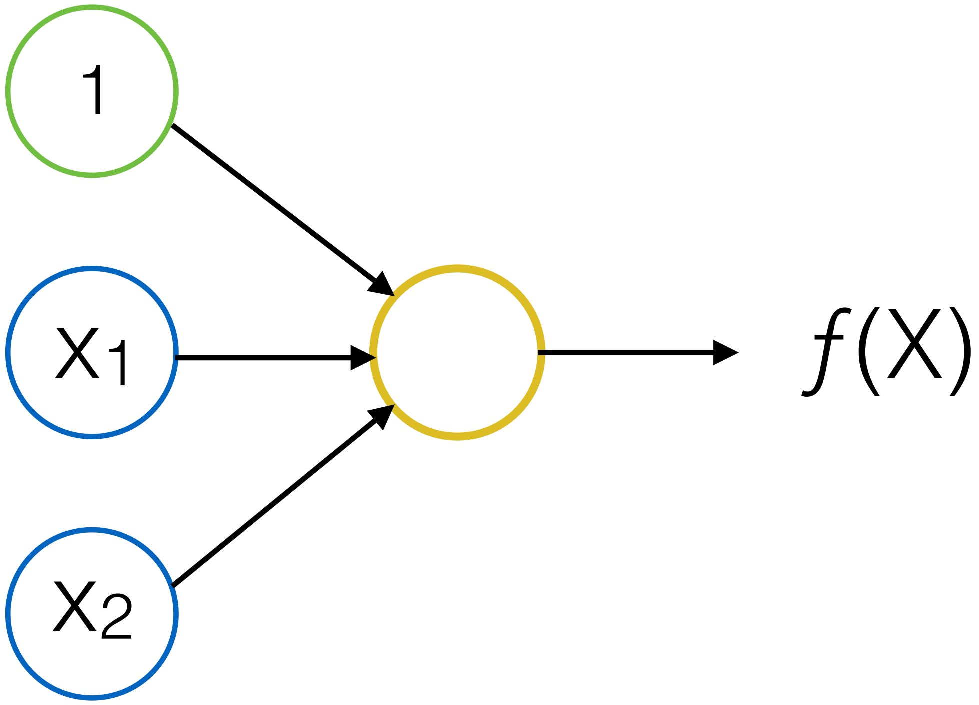
Neural Network



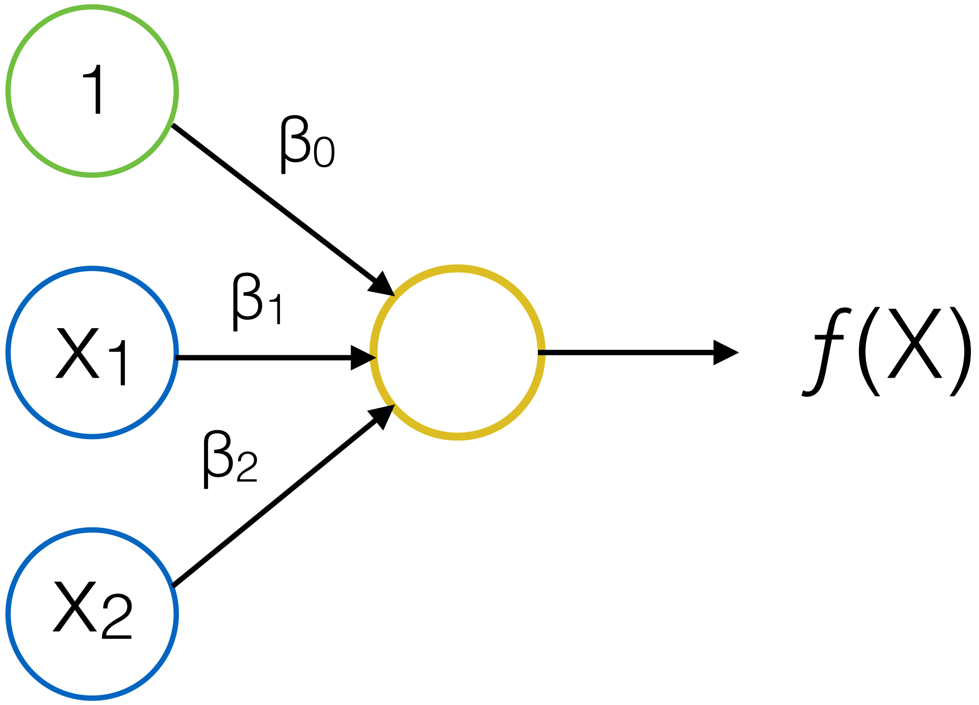
Perceptron



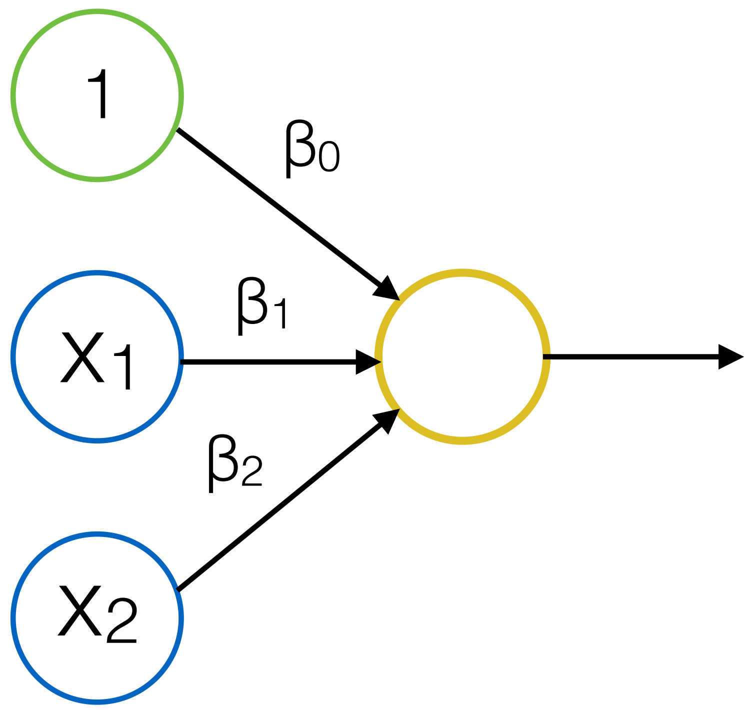
Perceptron



Perceptron



Perceptron

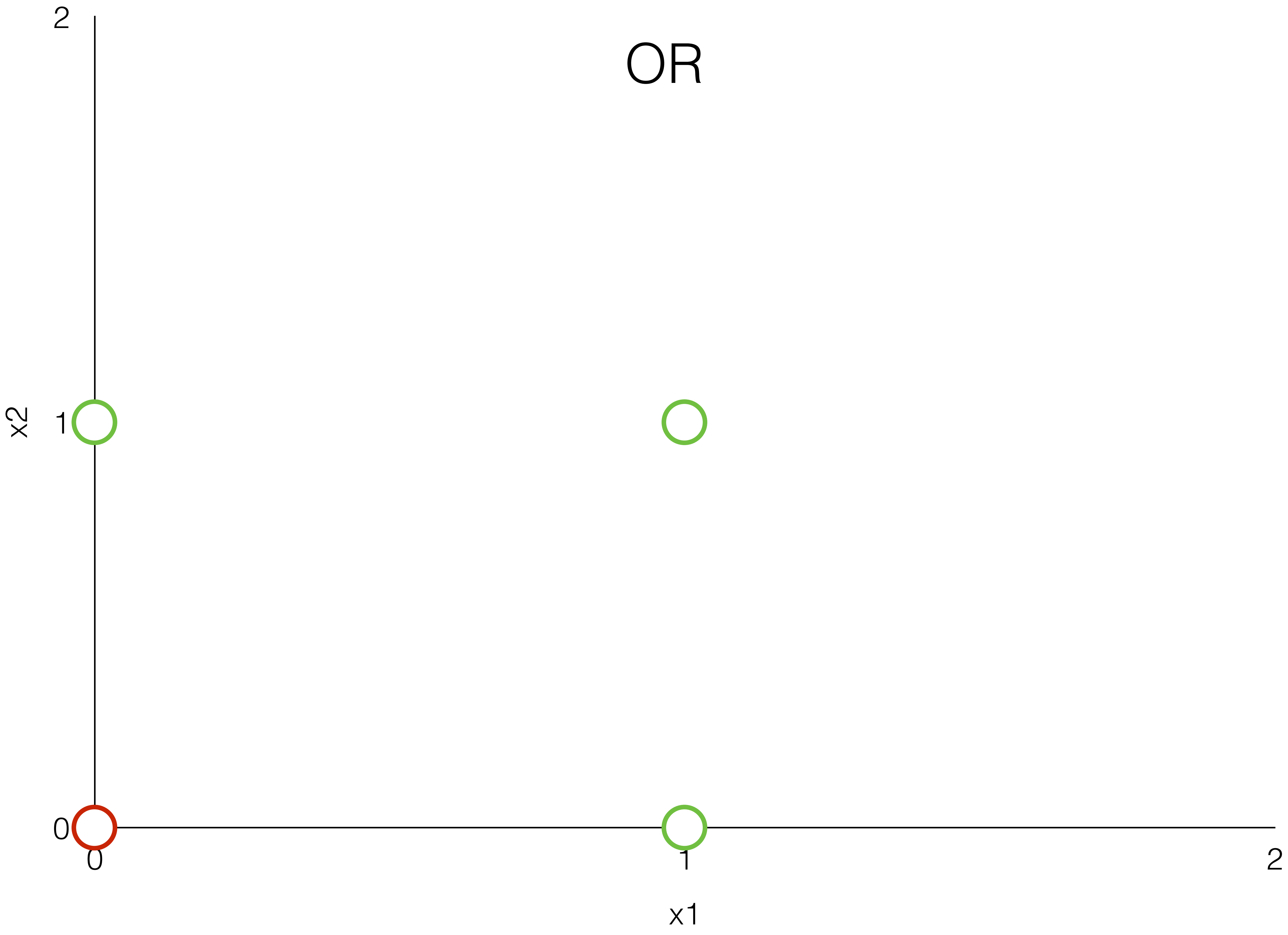


$$f(X) = \beta_0 + \beta_1 x_1 + \beta_2 x_2$$

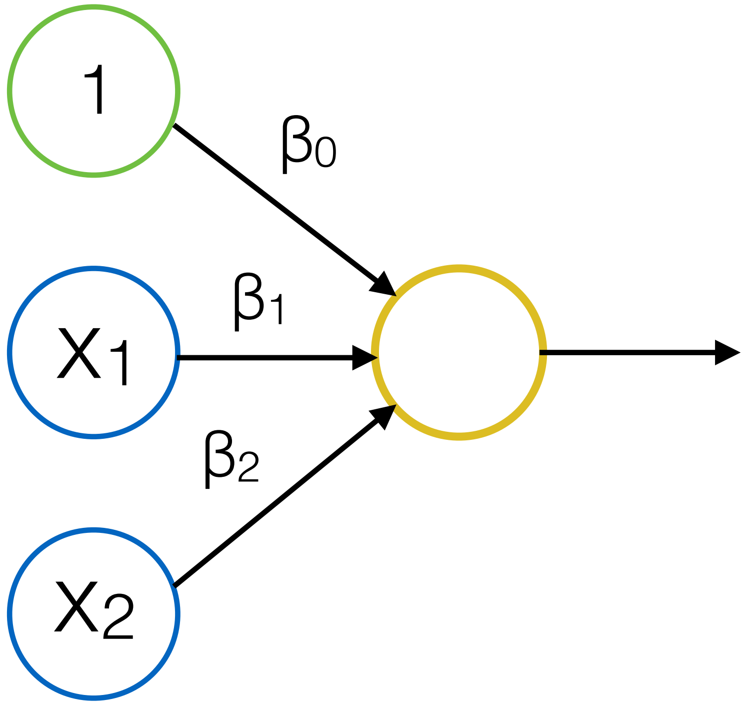
OR

Feature 1	Feature 2	Target
0	0	0
1	0	1
0	1	1
1	1	1

OR

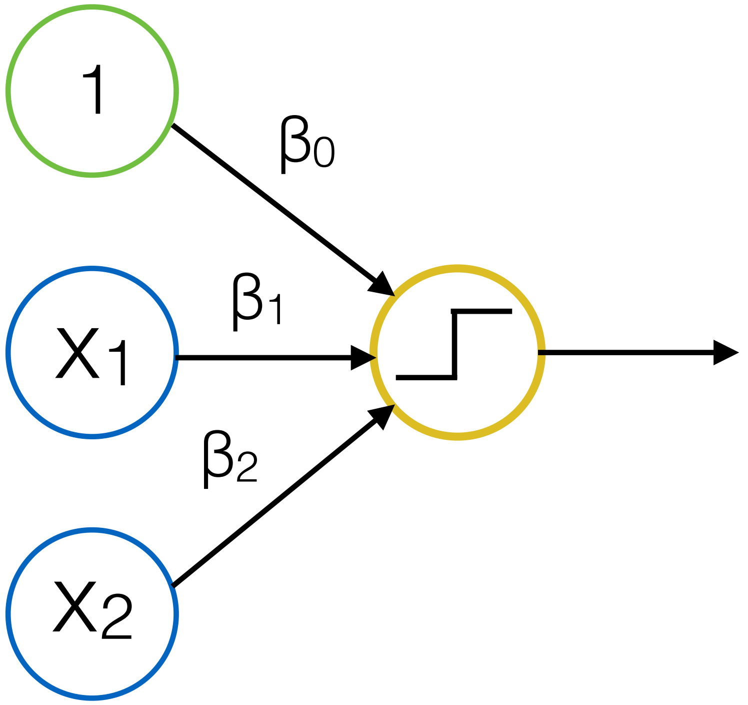


Feature 1	Feature 2	Target
0	0	0
1	0	1
0	1	1
1	1	1



$$f(X) = \beta_0 + \beta_1 X_1 + \beta_2 X_2$$

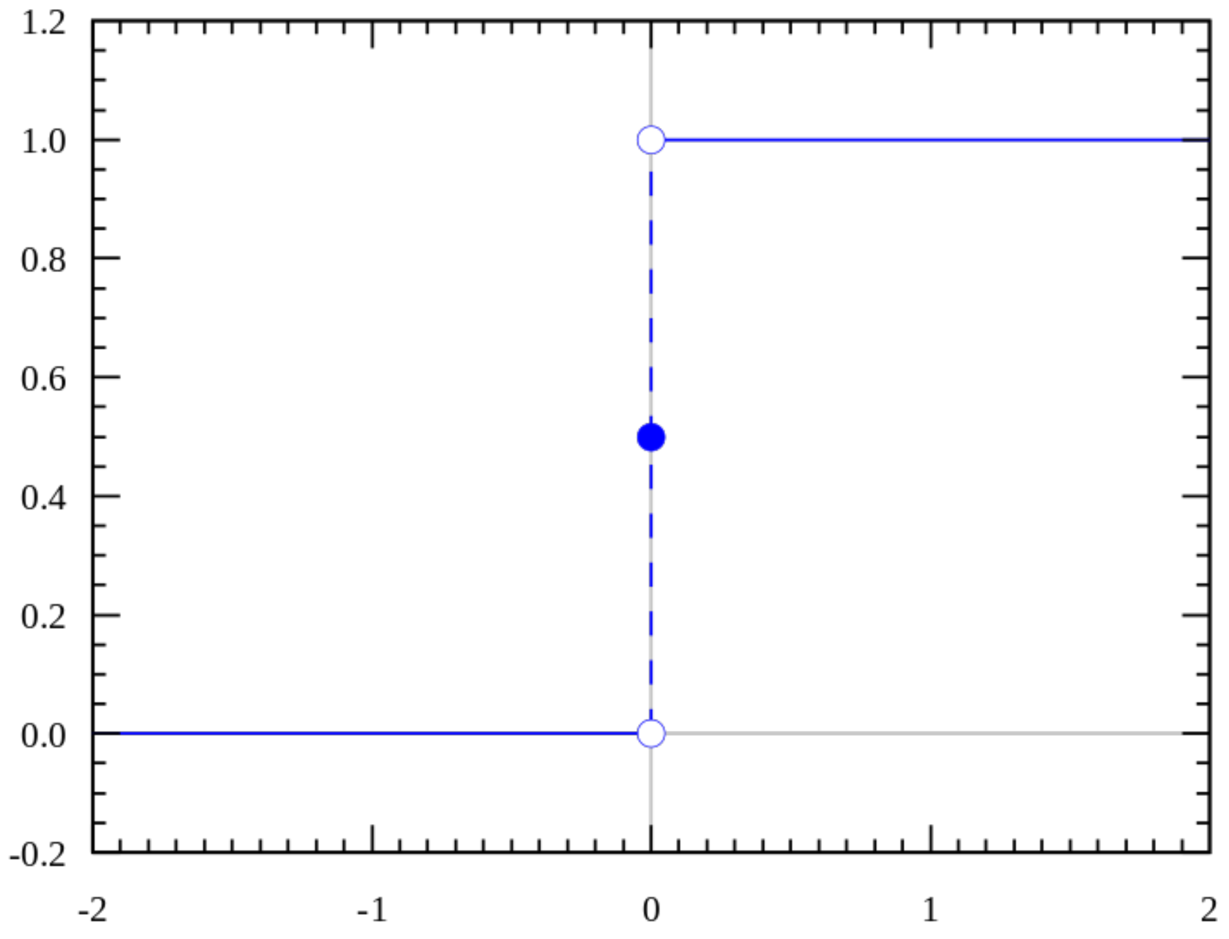
Feature 1	Feature 2	Target
0	0	0
1	0	1
0	1	1
1	1	1



$$f(X) = \beta_0 + \beta_1 X_1 + \beta_2 X_2$$

Activation Function: Threshold

step function

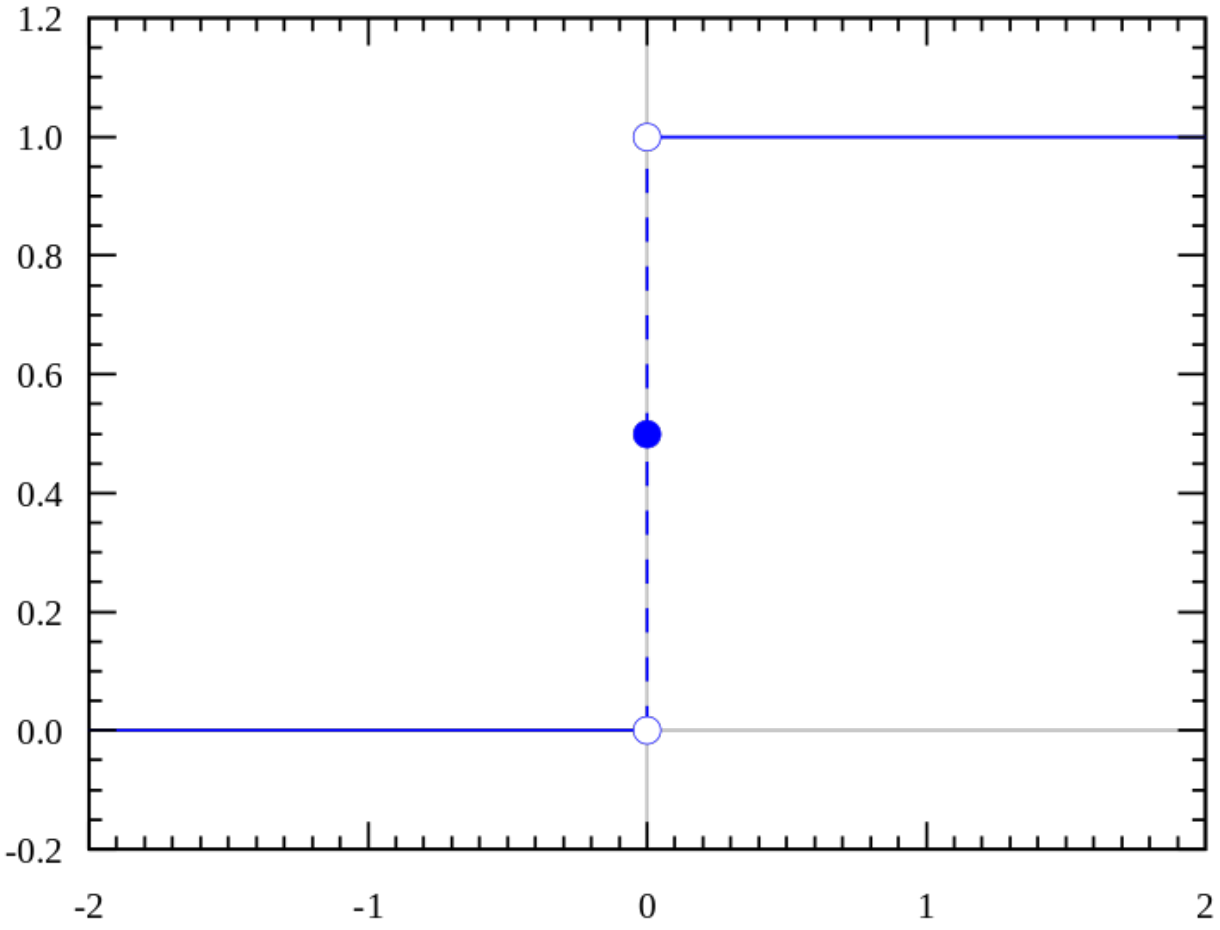


Activation Function: Threshold

if $\beta_0 + \beta_1 x_1 + \beta_2 x_2 > 0$: 1

Else: 0

step function



Activation Function: Threshold

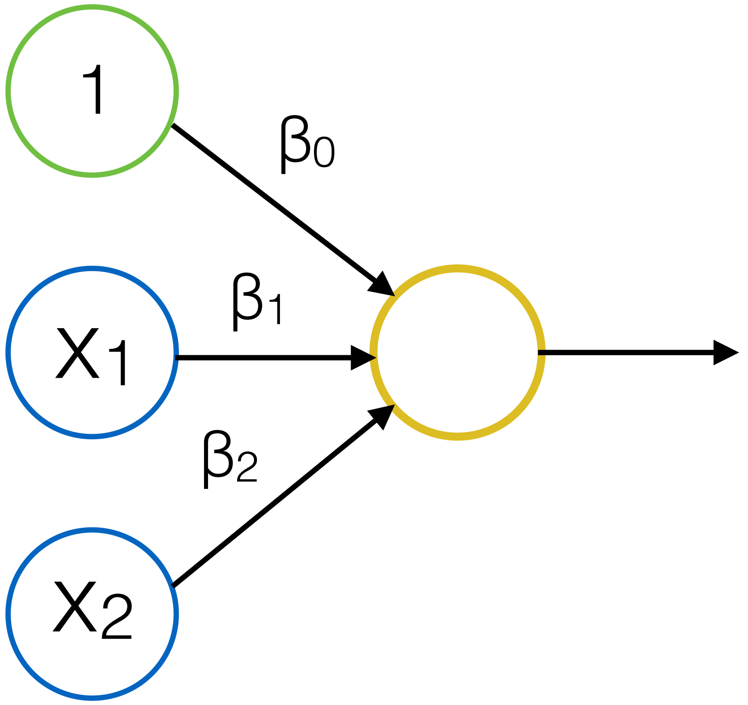
if $\beta_0 + \beta_1 x_1 + \beta_2 x_2 > 0$: 1

Else: 0

Update Rule:

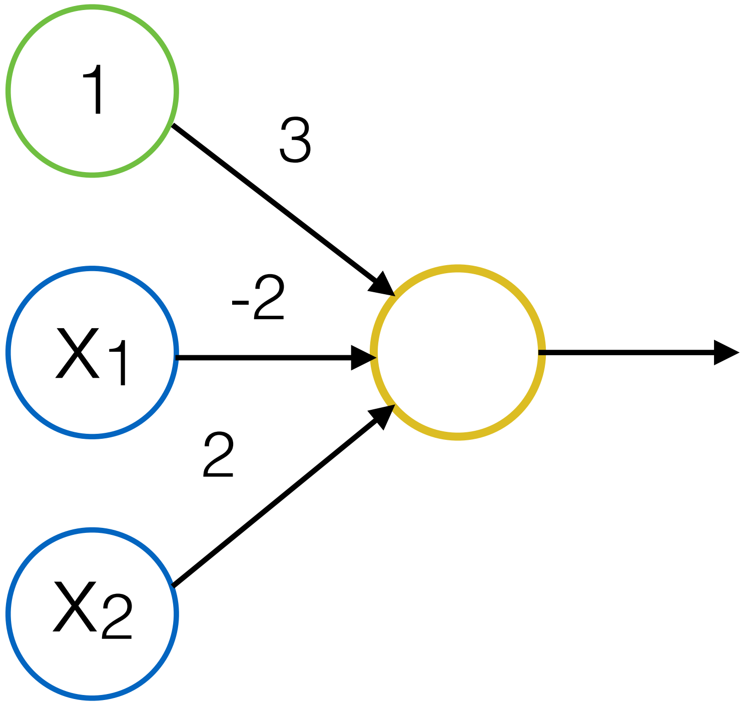
updated weight$_i$ = weight$_i$ - (output - target) * input$_i$

Feature 1	Feature 2	Target
0	0	0
1	0	1
0	1	1
1	1	1



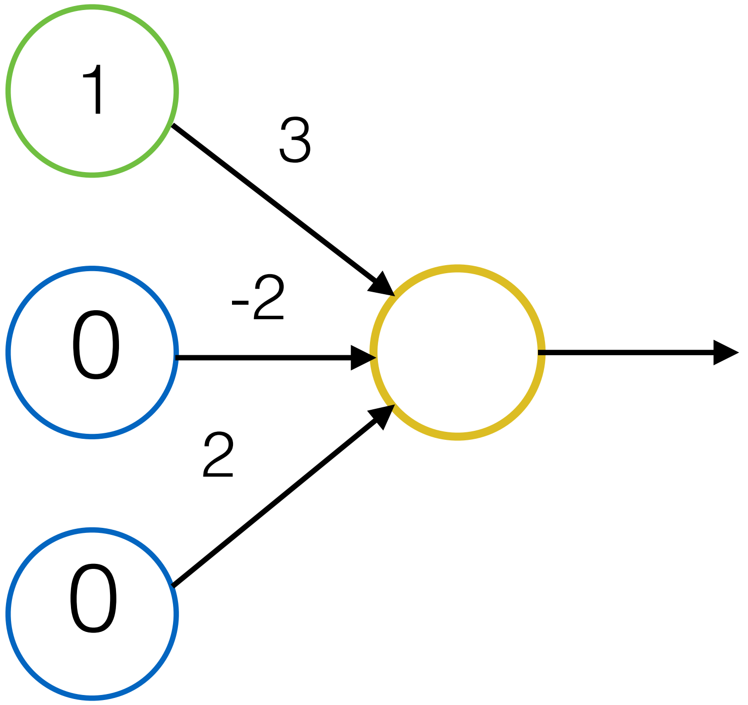
$$f(X) = \beta_0 + \beta_1 X_1 + \beta_2 X_2$$

Feature 1	Feature 2	Target
0	0	0
1	0	1
0	1	1
1	1	1



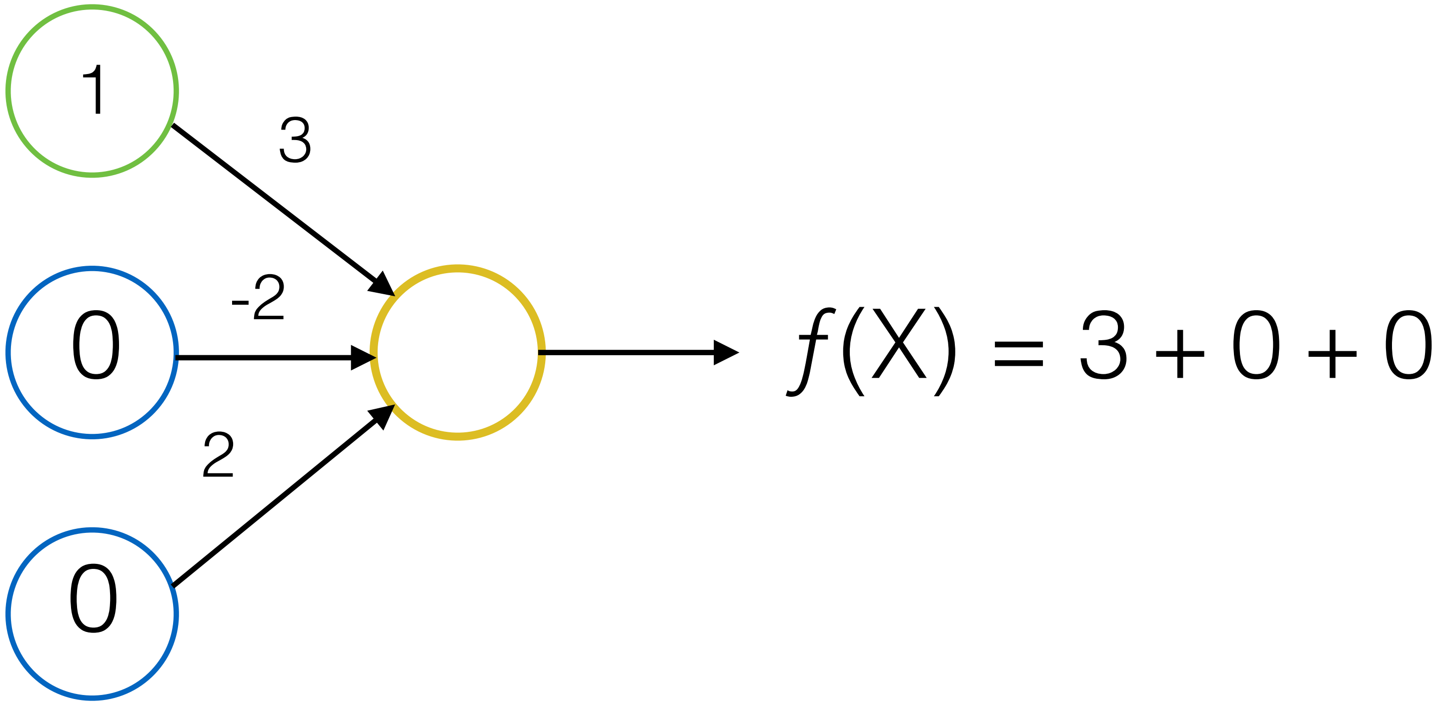
$$f(X) = \beta_0 + \beta_1 x_1 + \beta_2 x_2$$

Feature 1	Feature 2	Target
0	0	0
1	0	1
0	1	1
1	1	1

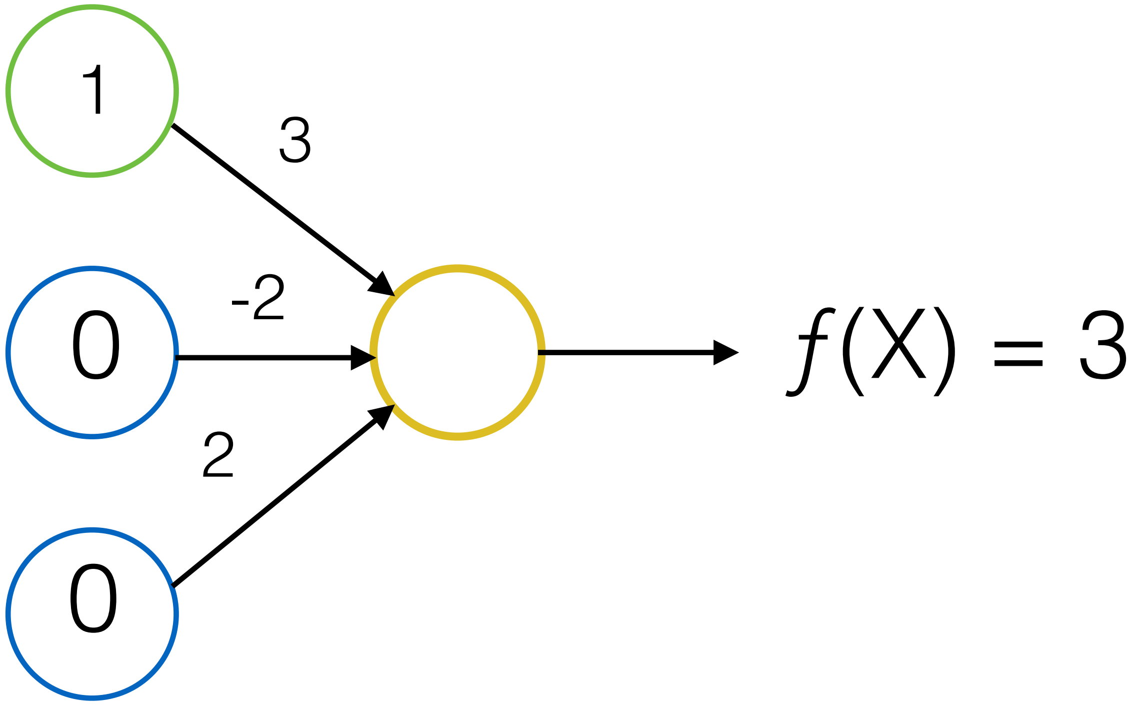


$$f(X) = \beta_0 + \beta_1 x_1 + \beta_2 x_2$$

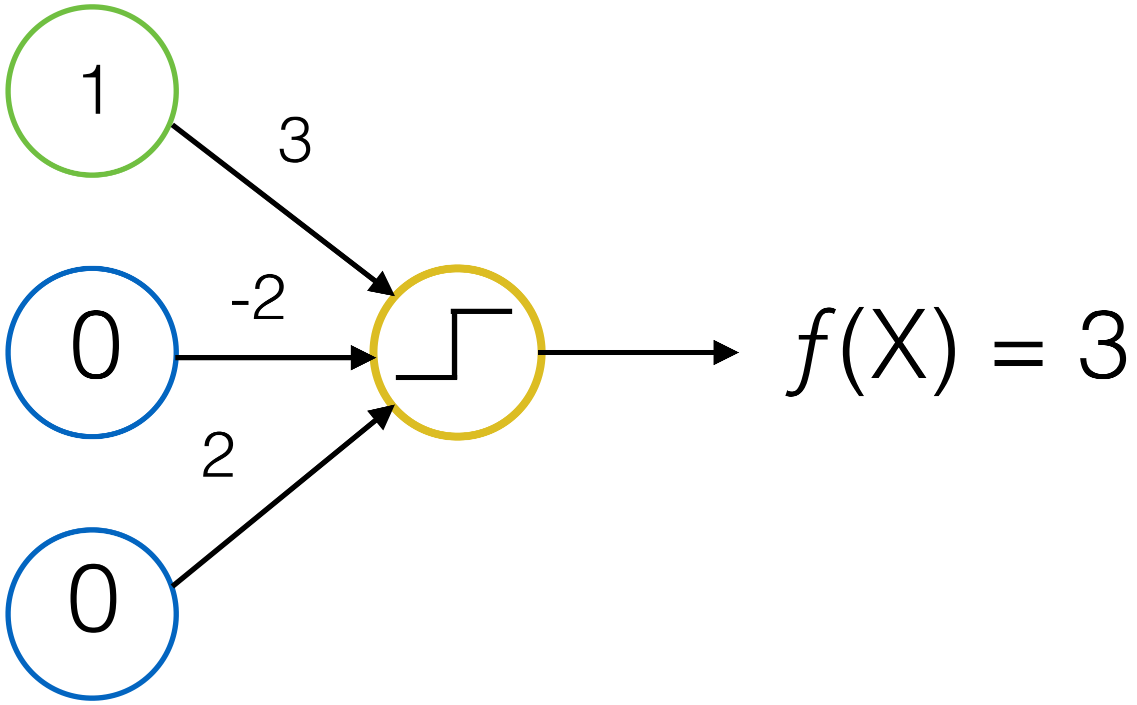
Feature 1	Feature 2	Target
0	0	0
1	0	1
0	1	1
1	1	1



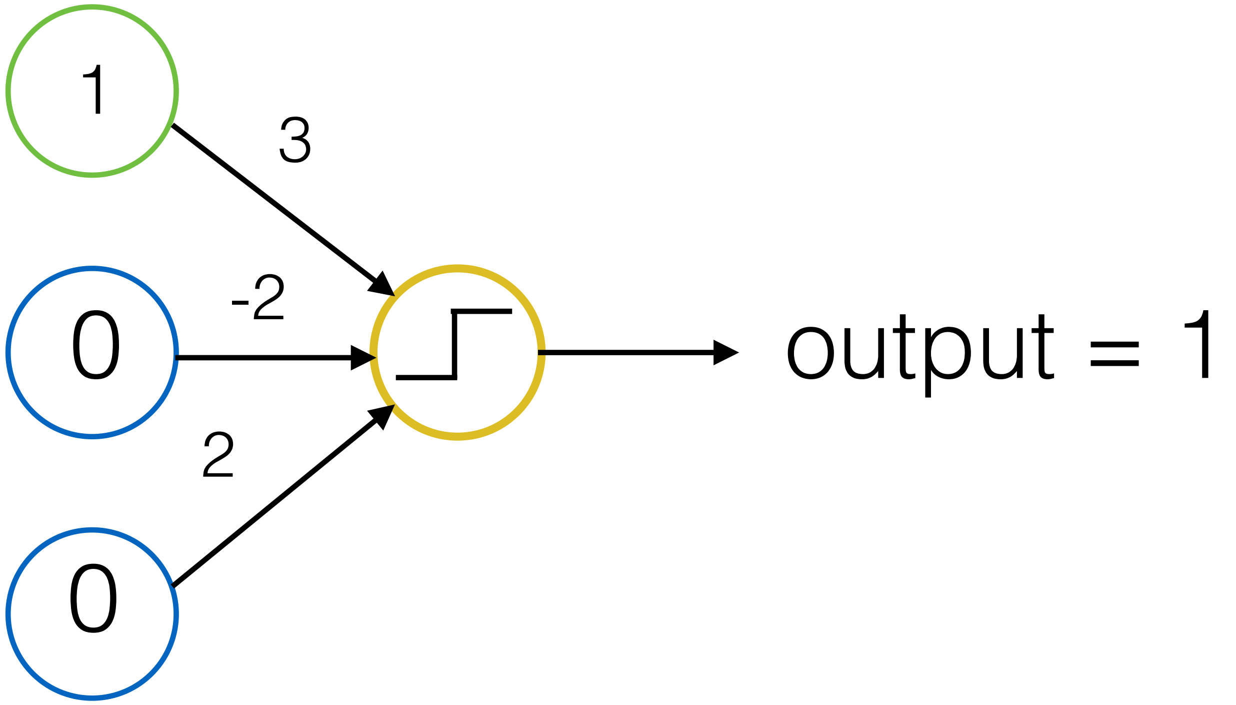
Feature 1	Feature 2	Target
0	0	0
1	0	1
0	1	1
1	1	1



Feature 1	Feature 2	Target
0	0	0
1	0	1
0	1	1
1	1	1



Feature 1	Feature 2	Target
0	0	0
1	0	1
0	1	1
1	1	1



weights: 3, -2, 2

input: 1, 0, 0

output: 1

target: 0

updated weight$_0$ = weight$_0$ - (output - target) * input$_0$

updated weight$_1$ = weight$_1$ - (output - target) * input$_1$

updated weight$_2$ = weight$_2$ - (output - target) * input$_2$

weights: 3, -2, 2

input: 1, 0, 0

output: 1

target: 0

updated weight$_0$ = 3 - (output - target) * input$_0$

updated weight$_1$ = -2 - (output - target) * input$_1$

updated weight$_2$ = 2 - (output - target) * input$_2$

weights: 3, -2, 2

input: 1, 0, 0

output: 1

target: 0

updated weight$_0$ = 3 - (1 - target) * input$_0$

updated weight$_1$ = -2 - (1 - target) * input$_1$

updated weight$_2$ = 2 - (1 - target) * input$_2$

weights: 3, -2, 2

output: 1

input: 1, 0, 0

target: 0

updated weight$_0$ = 3 - (1 - 0) * input$_0$

updated weight$_1$ = -2 - (1 - 0) * input$_1$

updated weight$_2$ = 2 - (1 - 0) * input$_2$

weights: 3, -2, 2

output: 1

input: 1, 0, 0

target: 0

updated weight_0 = 3 - (1 - 0) * 1

updated weight_1 = -2 - (1 - 0) * 0

updated weight_2 = 2 - (1 - 0) * 0

weights: 3, -2, 2

input: 1, 0, 0

output: 1

target: 0

updated weight_0 = 3 -1

updated weight_1 = -2 - 0

updated weight_2 = 2 - 0

weights: 3, -2, 2

input: 1, 0, 0

output: 1

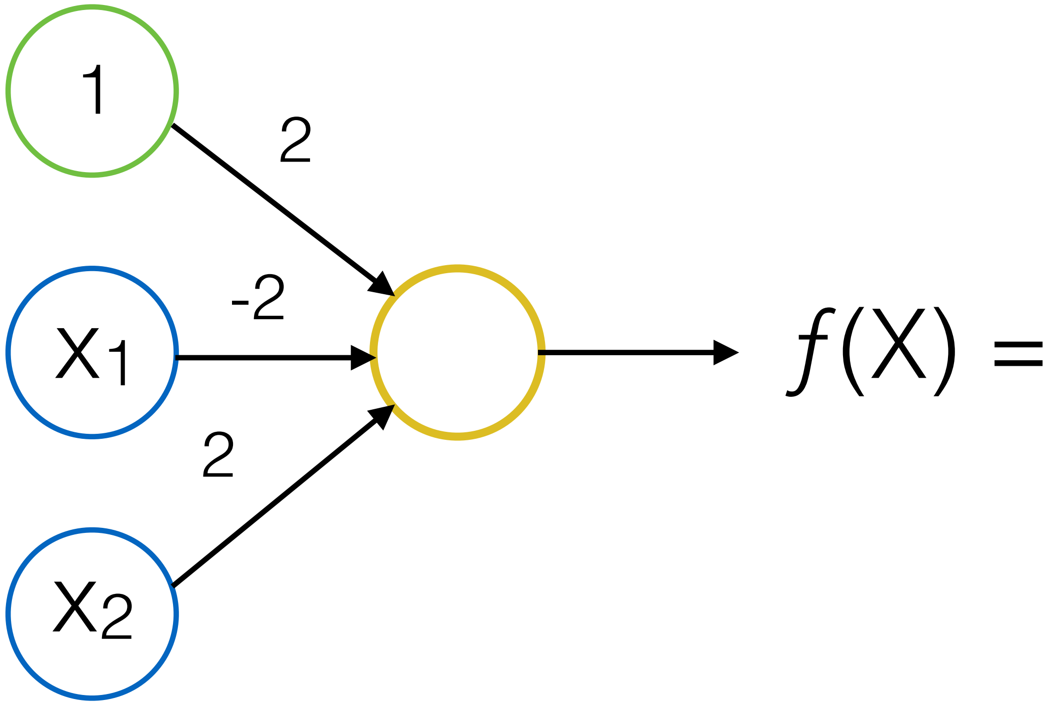
target: 0

updated weight_0 = 2

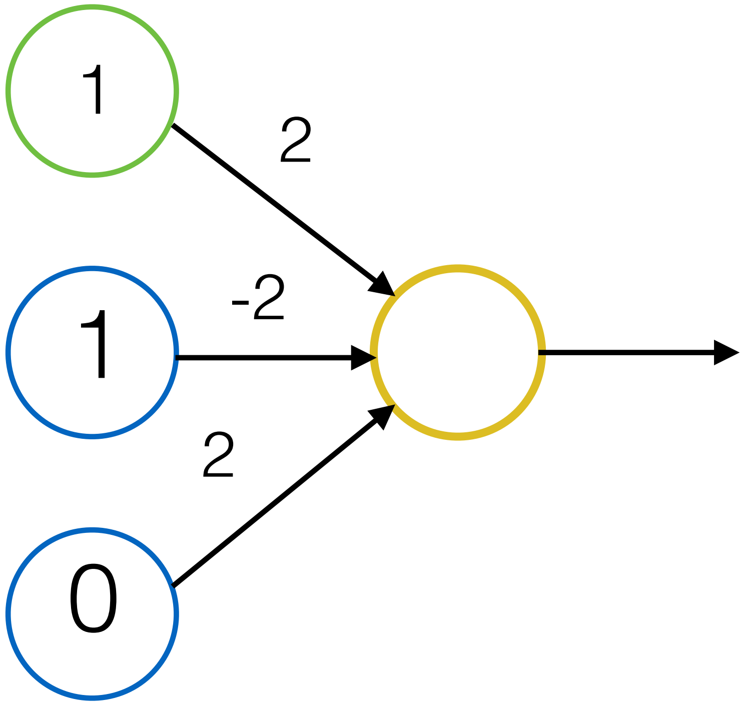
updated weight_1 = -2

updated weight_2 = 2

Feature 1	Feature 2	Target
0	0	0
1	0	1
0	1	1
1	1	1

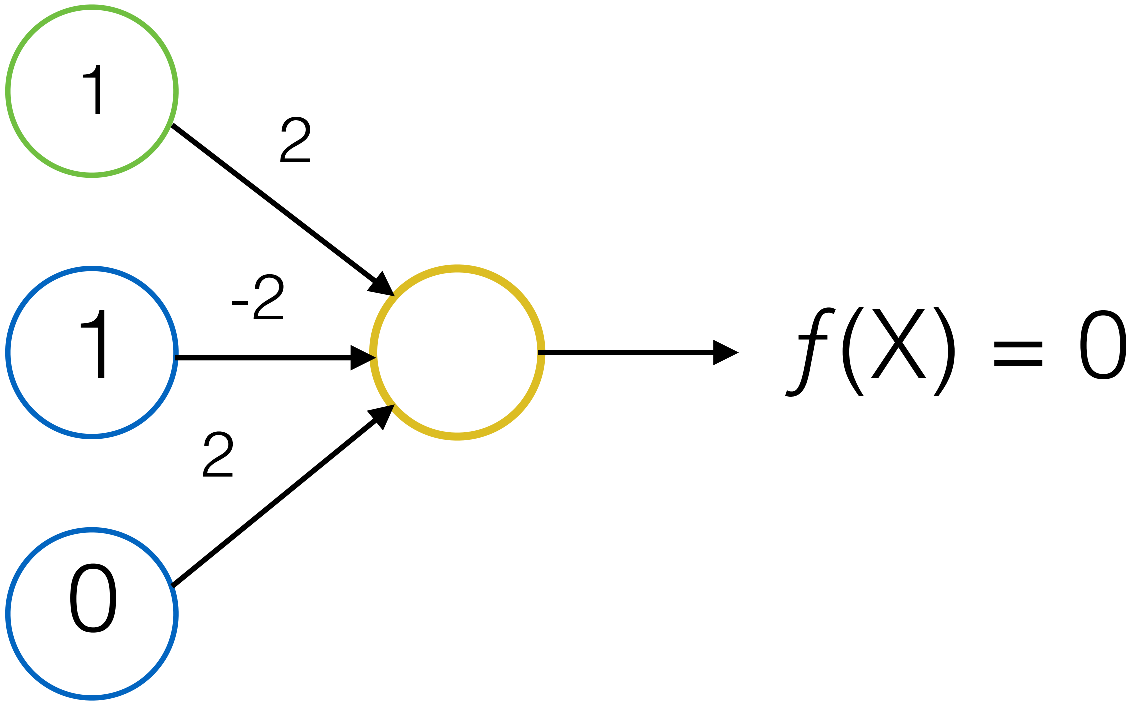


Feature 1	Feature 2	Target
0	0	0
1	0	1
0	1	1
1	1	1

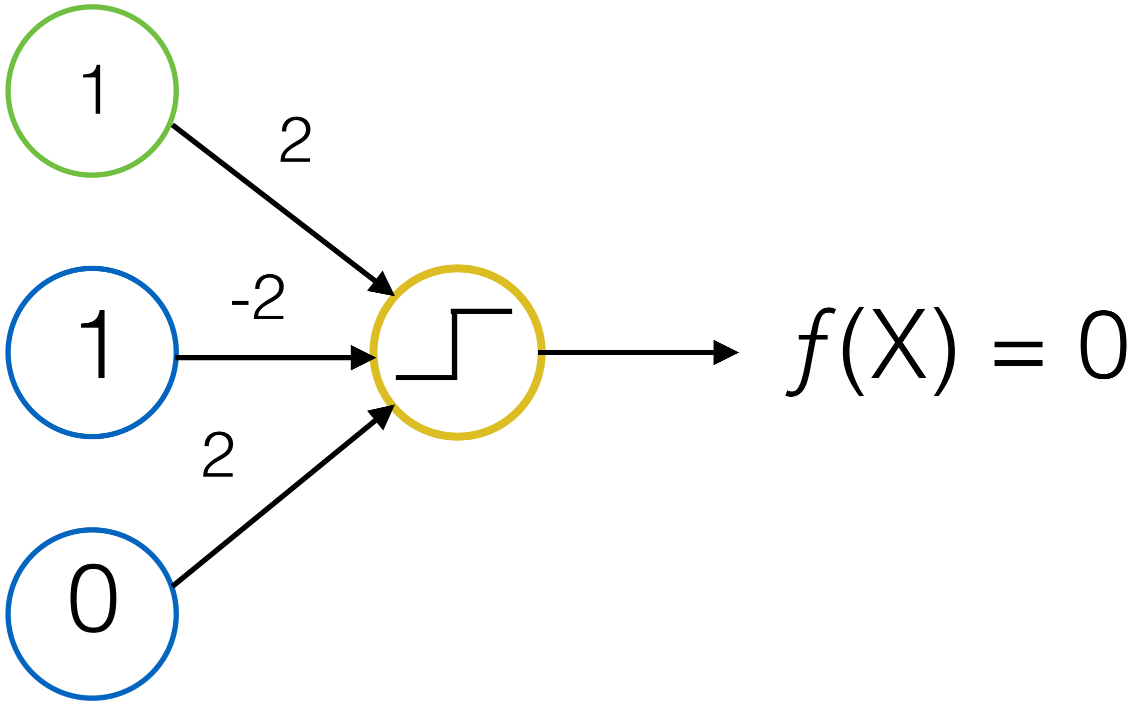


$f(X) = 2 - 2 + 0$

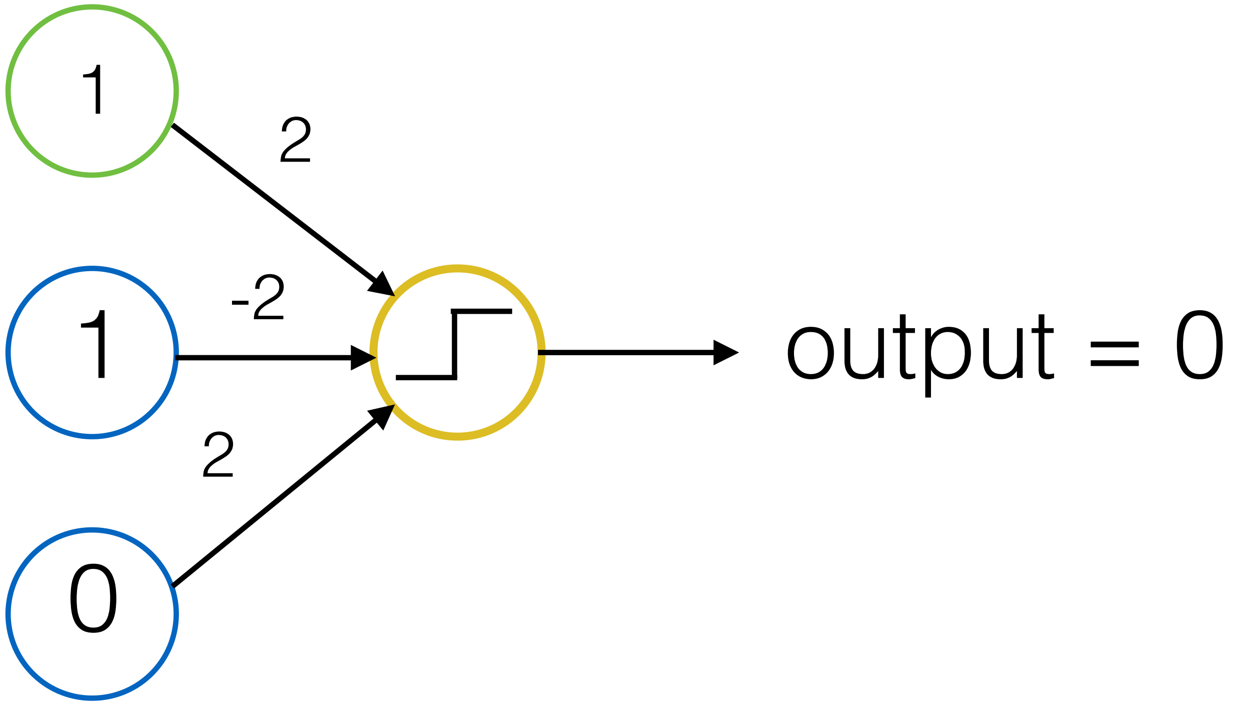
Feature 1	Feature 2	Target
0	0	0
1	0	1
0	1	1
1	1	1



Feature 1	Feature 2	Target
0	0	0
1	0	1
0	1	1
1	1	1



Feature 1	Feature 2	Target
0	0	0
1	0	1
0	1	1
1	1	1



weights: 2, -2, 2

input: 1, 1, 0

output: 0

target: 1

updated weight$_0$ = weight$_0$ - (output - target) * input$_0$

updated weight$_1$ = weight$_1$ - (output - target) * input$_1$

updated weight$_2$ = weight$_2$ - (output - target) * input$_2$

weights: 2, -2, 2

input: 1, 1, 0

output: 0

target: 1

updated weight$_0$ = 2 - (output - target) * input$_0$

updated weight$_1$ = -2 - (output - target) * input$_1$

updated weight$_2$ = 2 - (output - target) * input$_2$

weights: 2, -2, 2

output: 0

input: 1, 1, 0

target: 1

updated weight_0 = 2 - (0 - target) * input_0

updated weight_1 = -2 - (0 - target) * input_1

updated weight_2 = 2 - (0 - target) * input_2

weights: 2, -2, 2

output: 0

input: 1, 1, 0

target: 1

updated $\text{weight}_0 = 2 - (0 - 1) * \text{input}_0$

updated $\text{weight}_1 = -2 - (0 - 1) * \text{input}_1$

updated $\text{weight}_2 = 2 - (0 - 1) * \text{input}_2$

weights: 2, -2, 2

input: 1, 1, 0

output: 0

target: 1

updated weight$_0$ = 2 - (0 - 1) * 1

updated weight$_1$ = -2 - (0 - 1) * 1

updated weight$_2$ = 2 - (0 - 1) * 0

weights: 2, -2, 2

input: 1, 1, 0

output: 0

target: 1

updated weight$_0$ = 2 - (-1)

updated weight$_1$ = -2 - (-1)

updated weight$_2$ = 2 - 0

weights: 2, -2, 2

input: 1, 1, 0

output: 0

target: 1

updated weight$_0$ = 2 + 1

updated weight$_1$ = -2 + 1

updated weight$_2$ = 2 - 0

weights: 2, -2, 2

input: 1, 1, 0

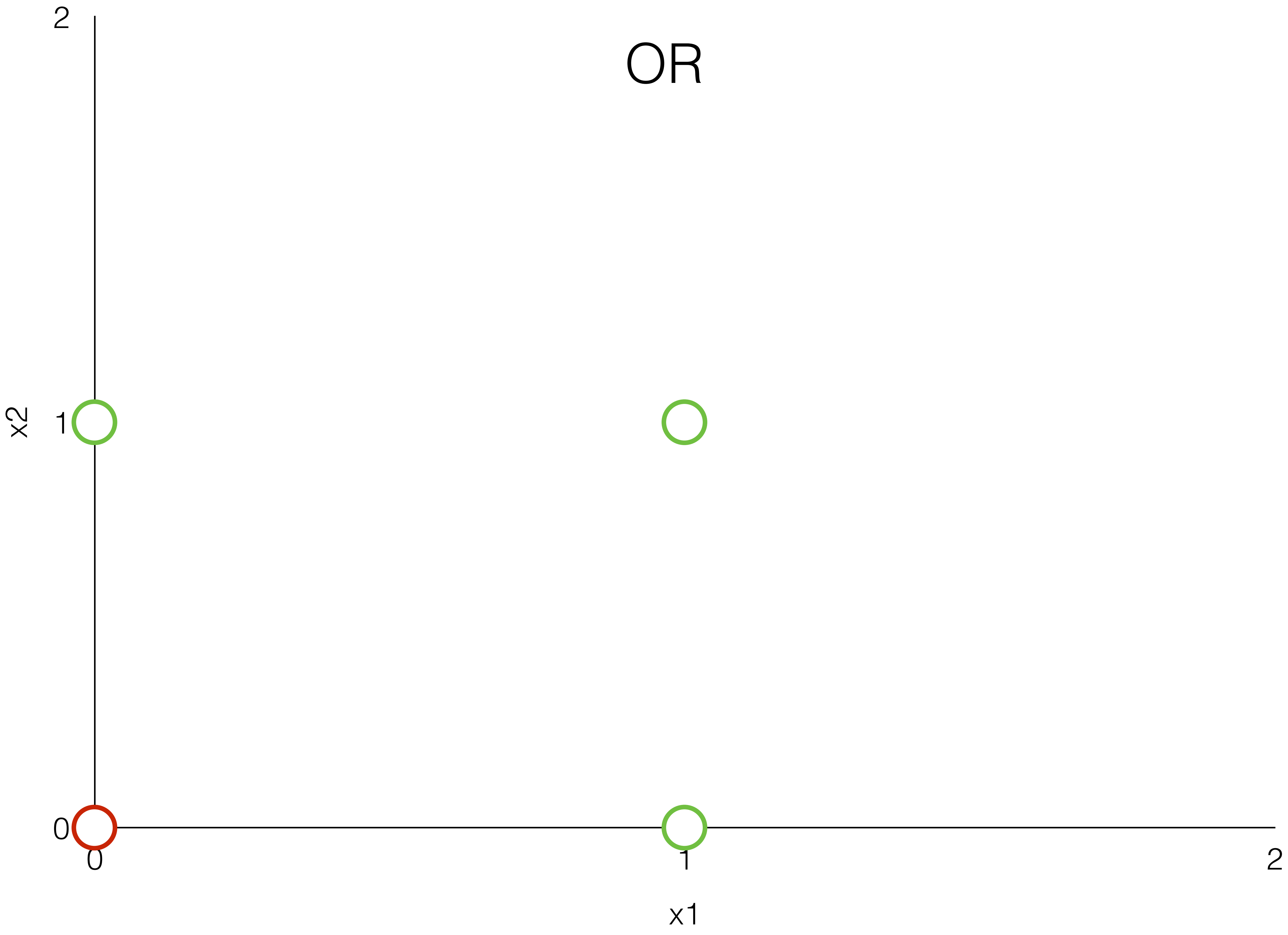
output: 0

target: 1

updated weight_0 = 3

updated weight_1 = -1

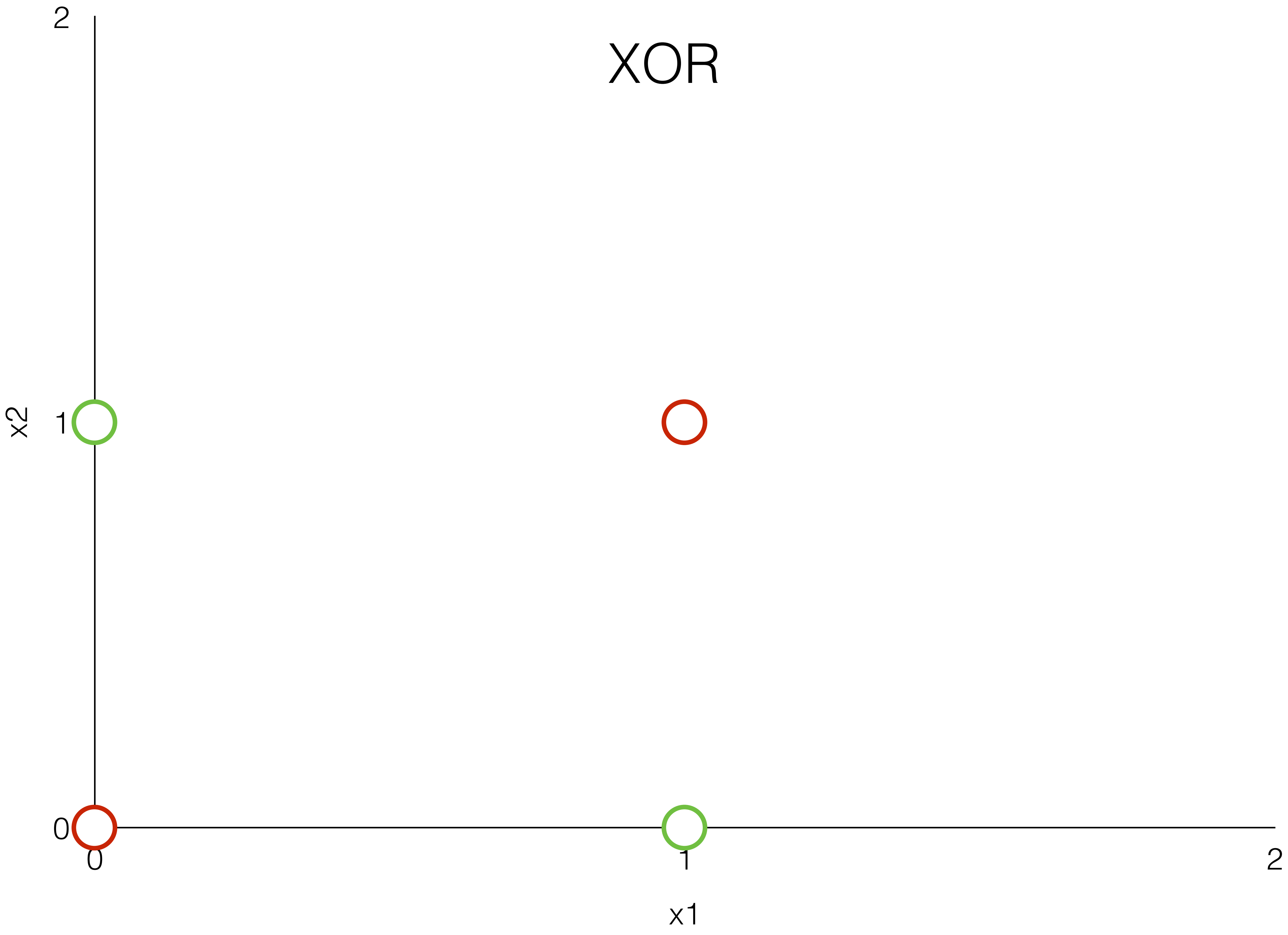
updated weight_2 = 2



OR

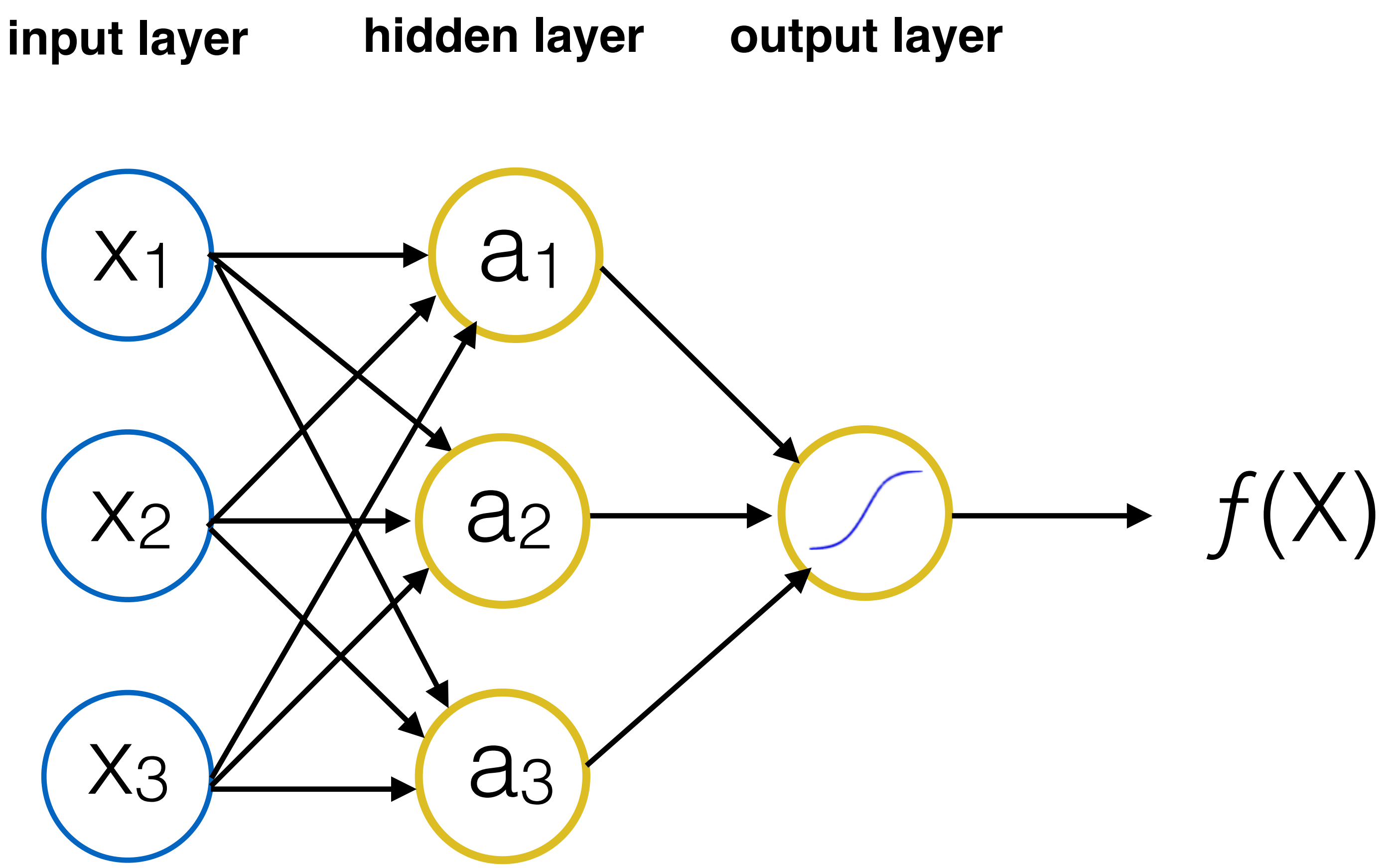
XOR

Feature 1	Feature 2	Target
0	0	0
1	0	1
0	1	1
1	1	0

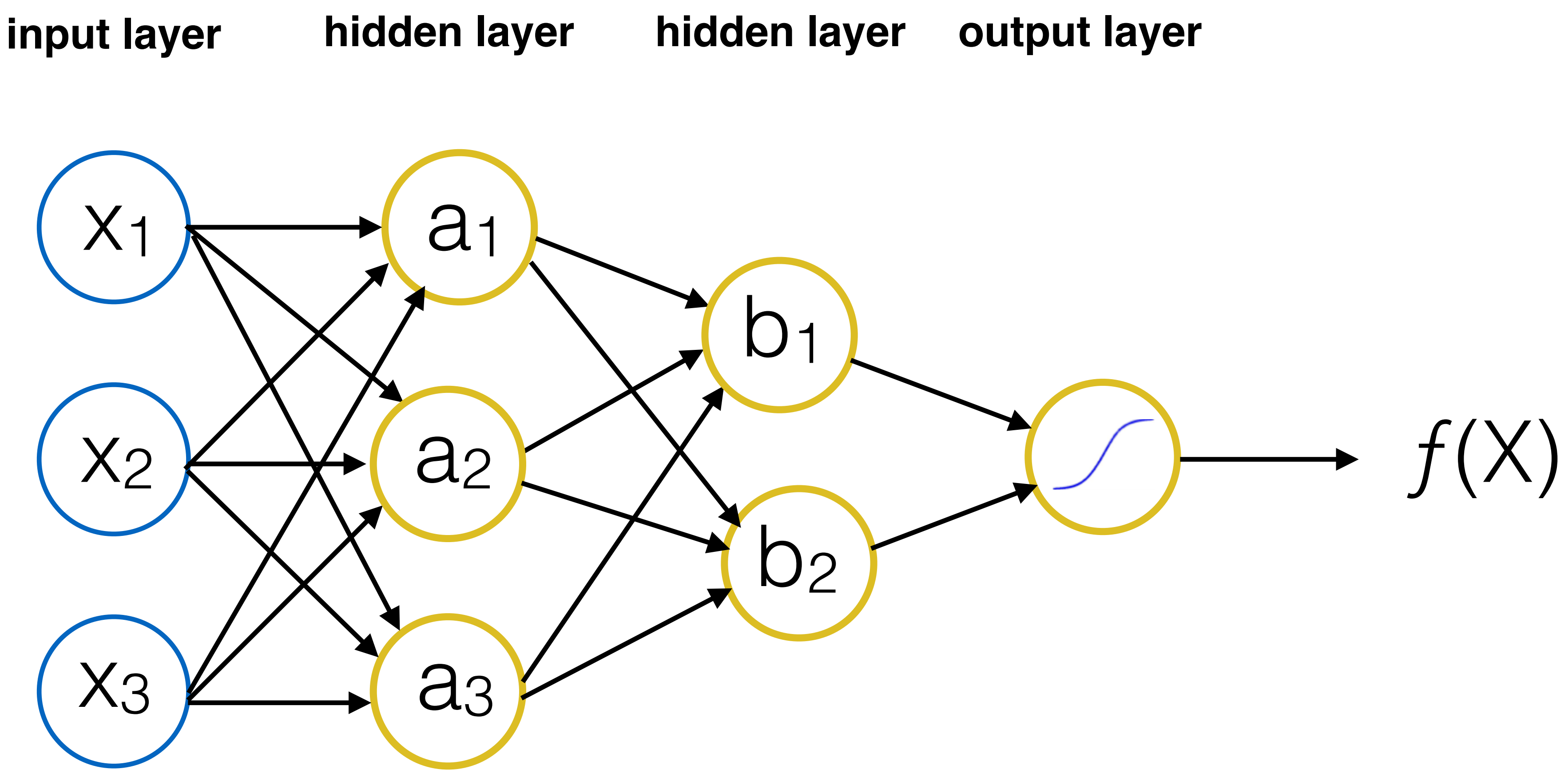


XOR

Multi-Layer Perceptron (MLP)



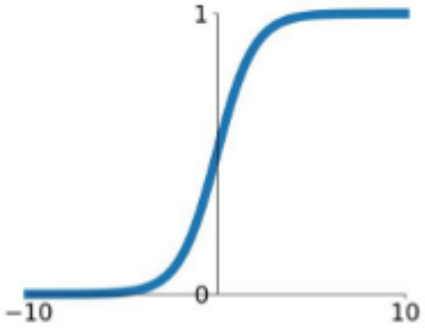
Multi-Layer Perceptron (MLP)



Activation Functions

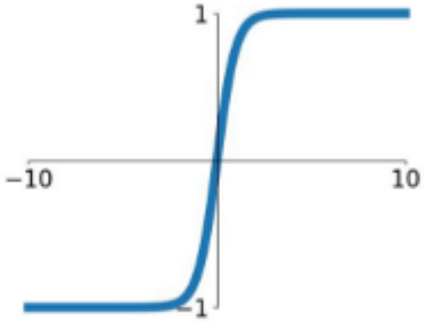
Sigmoid

$$\sigma(x) = \frac{1}{1+e^{-x}}$$



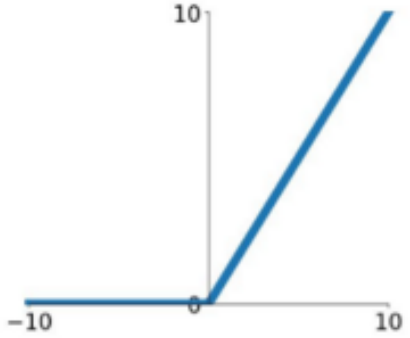
tanh

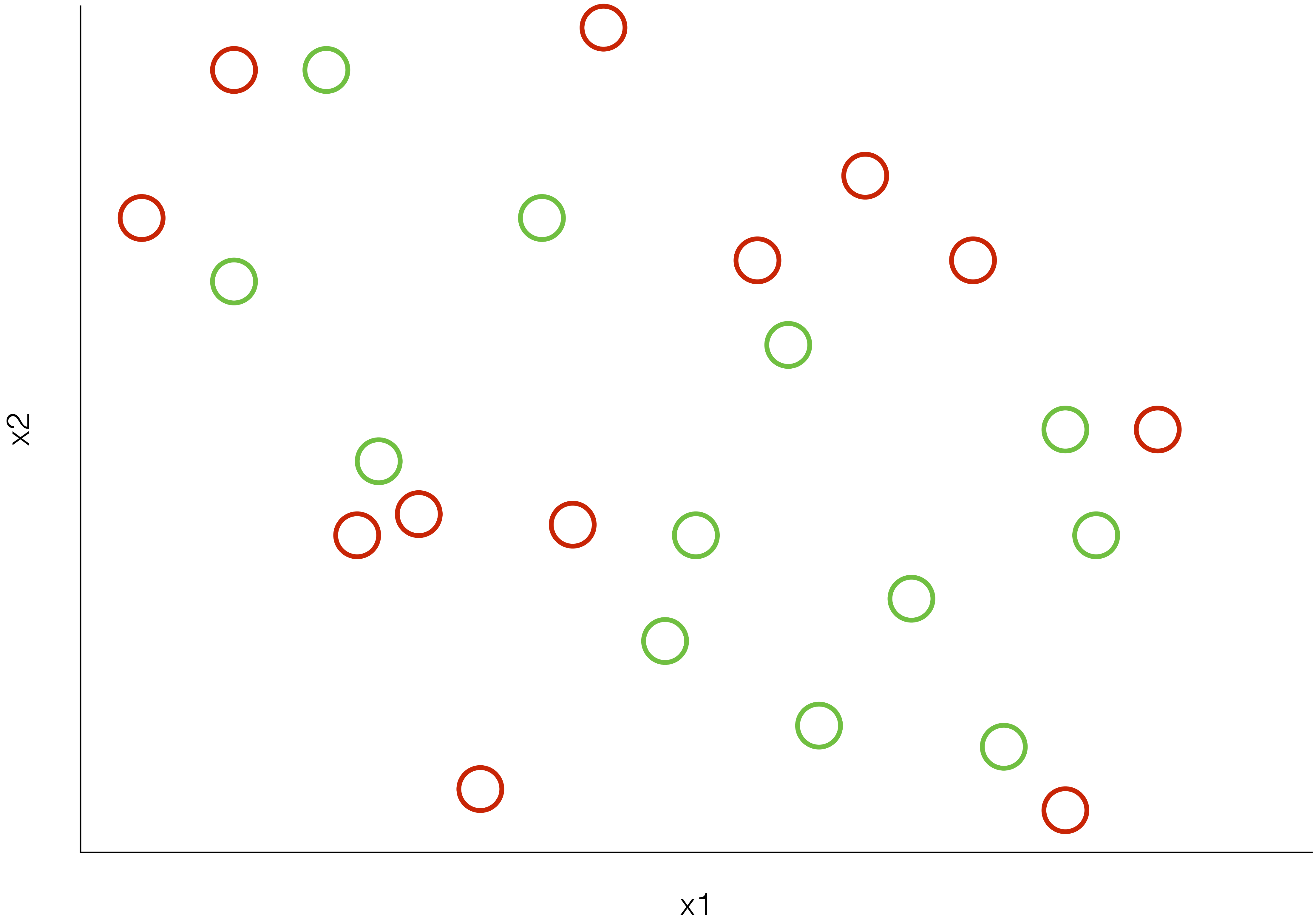
$$\tanh(x)$$

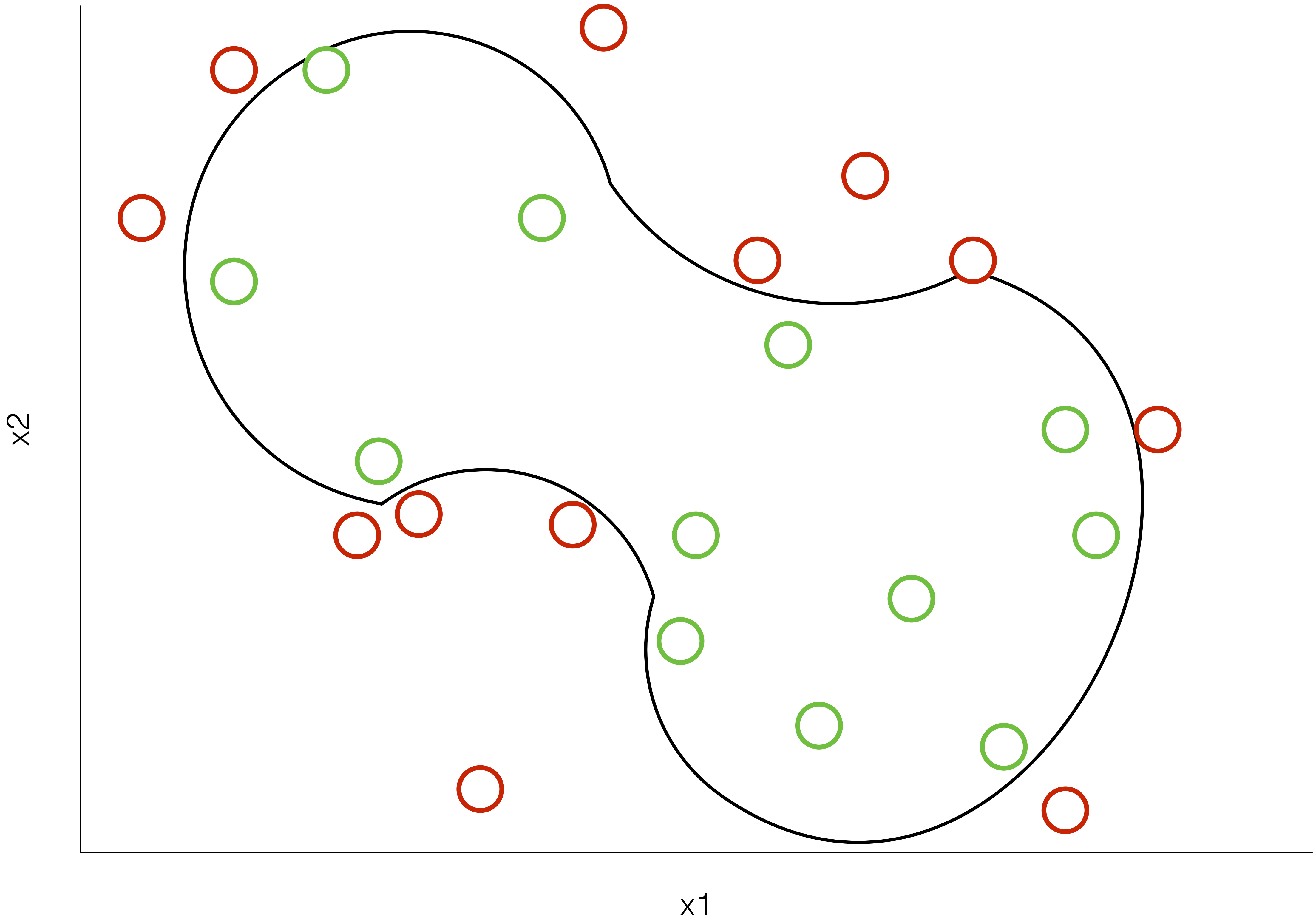


ReLU

$$\max(0, x)$$



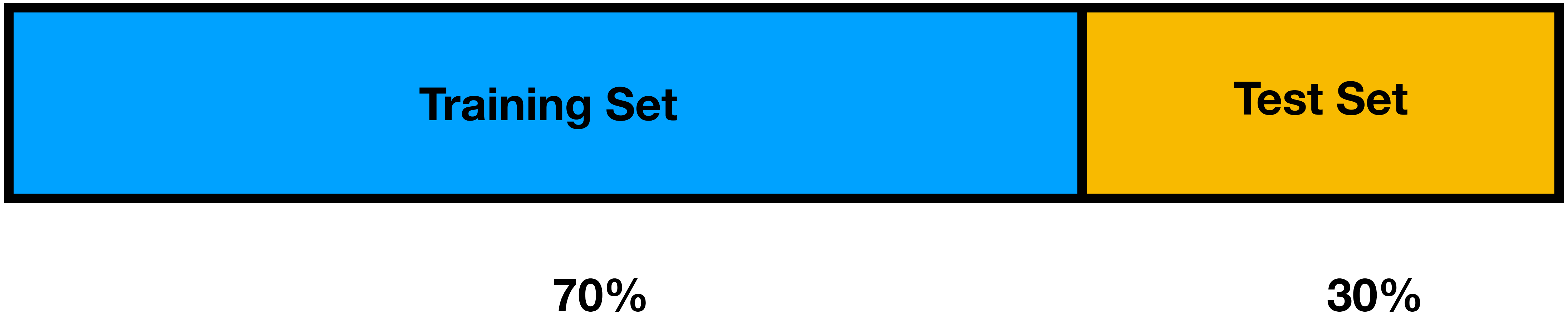

x2
x1


x2
x1

Model Selection

Test/Train Split

DATA SET



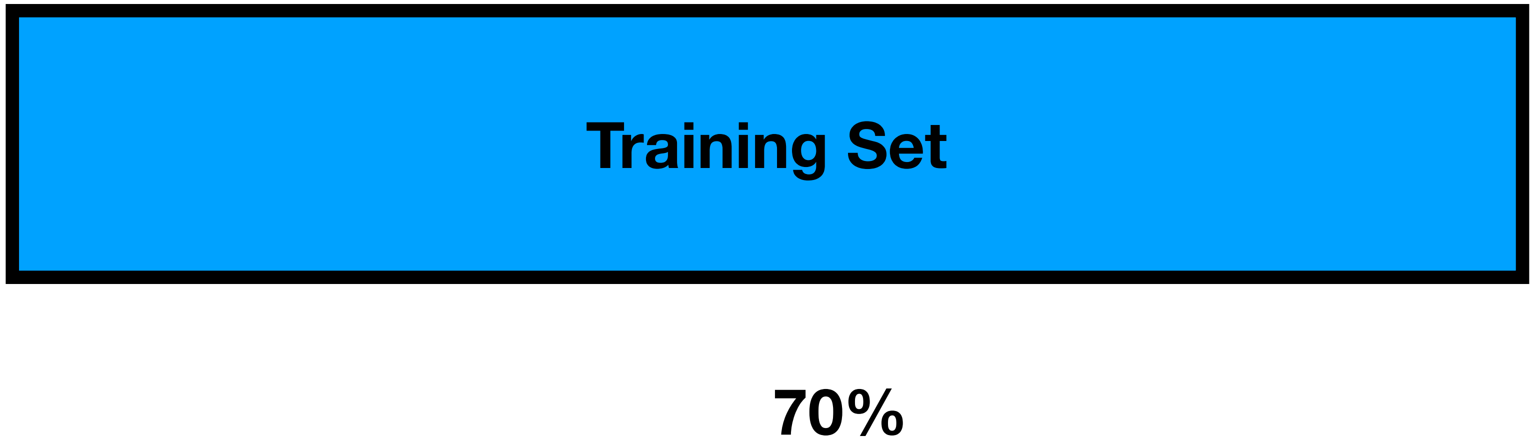
Training Set

Test Set

70%

30%

DATA SET



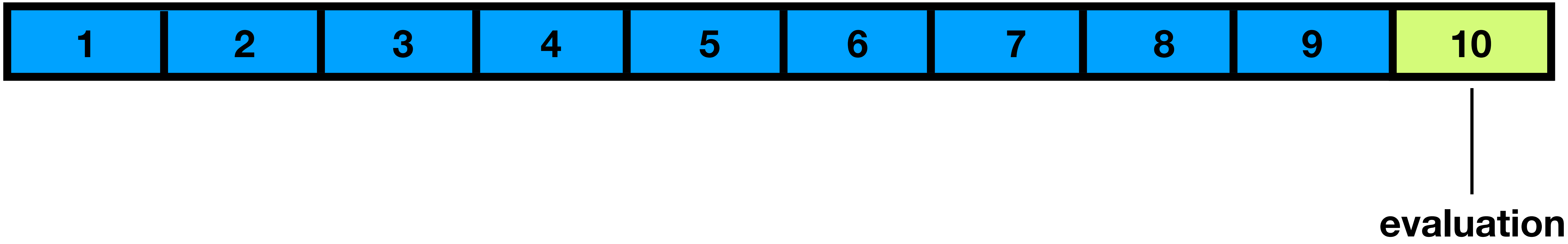
Training Set

70%

K-fold cross validation

10-Fold Cross Validation

Training Set

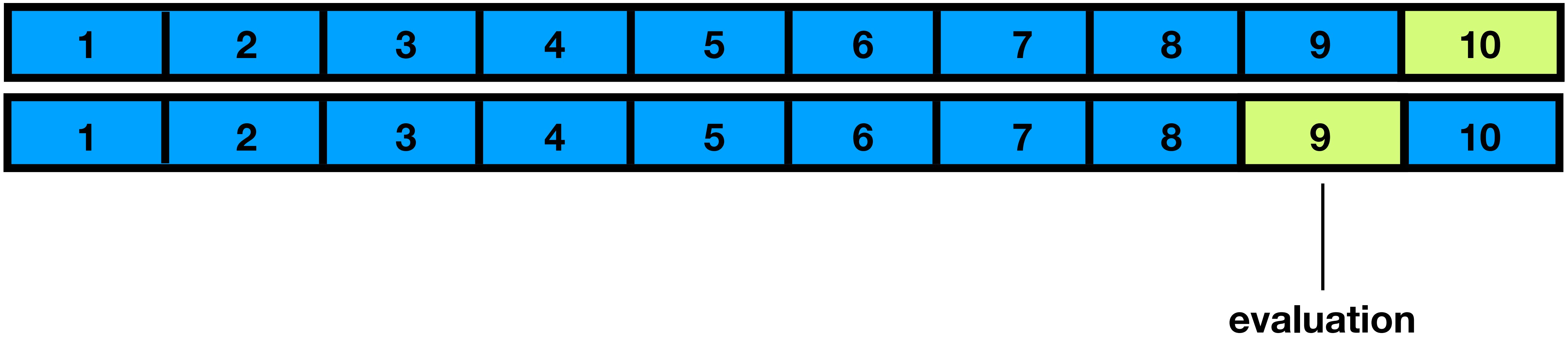


1 2 3 4 5 6 7 8 9 10

evaluation

10-Fold Cross Validation

Training Set



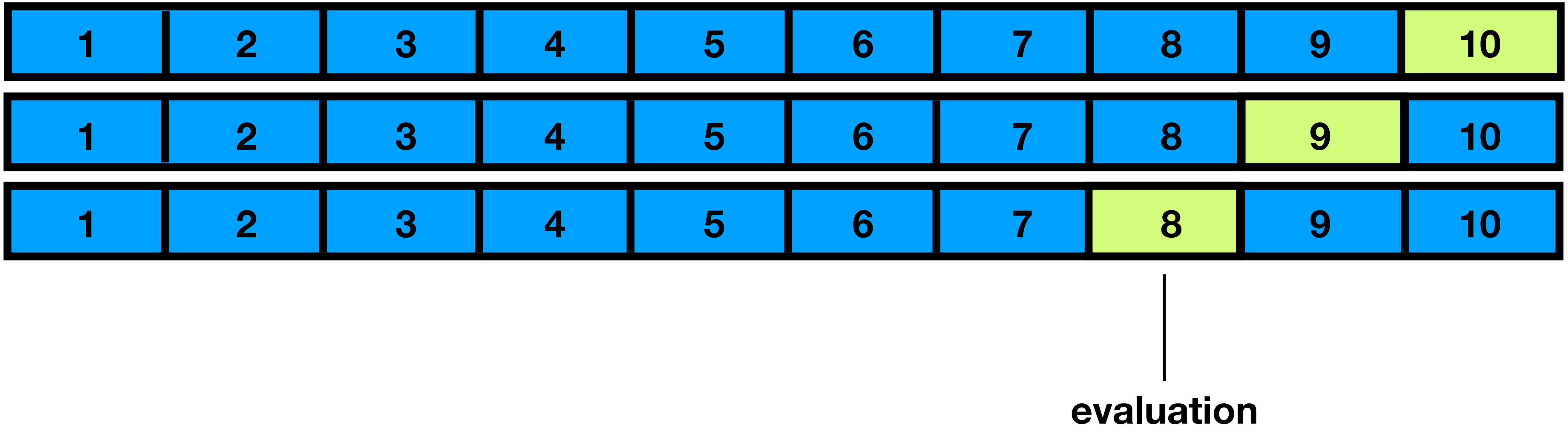
1 2 3 4 5 6 7 8 9 10

1 2 3 4 5 6 7 8 9 10

evaluation

10-Fold Cross Validation

Training Set

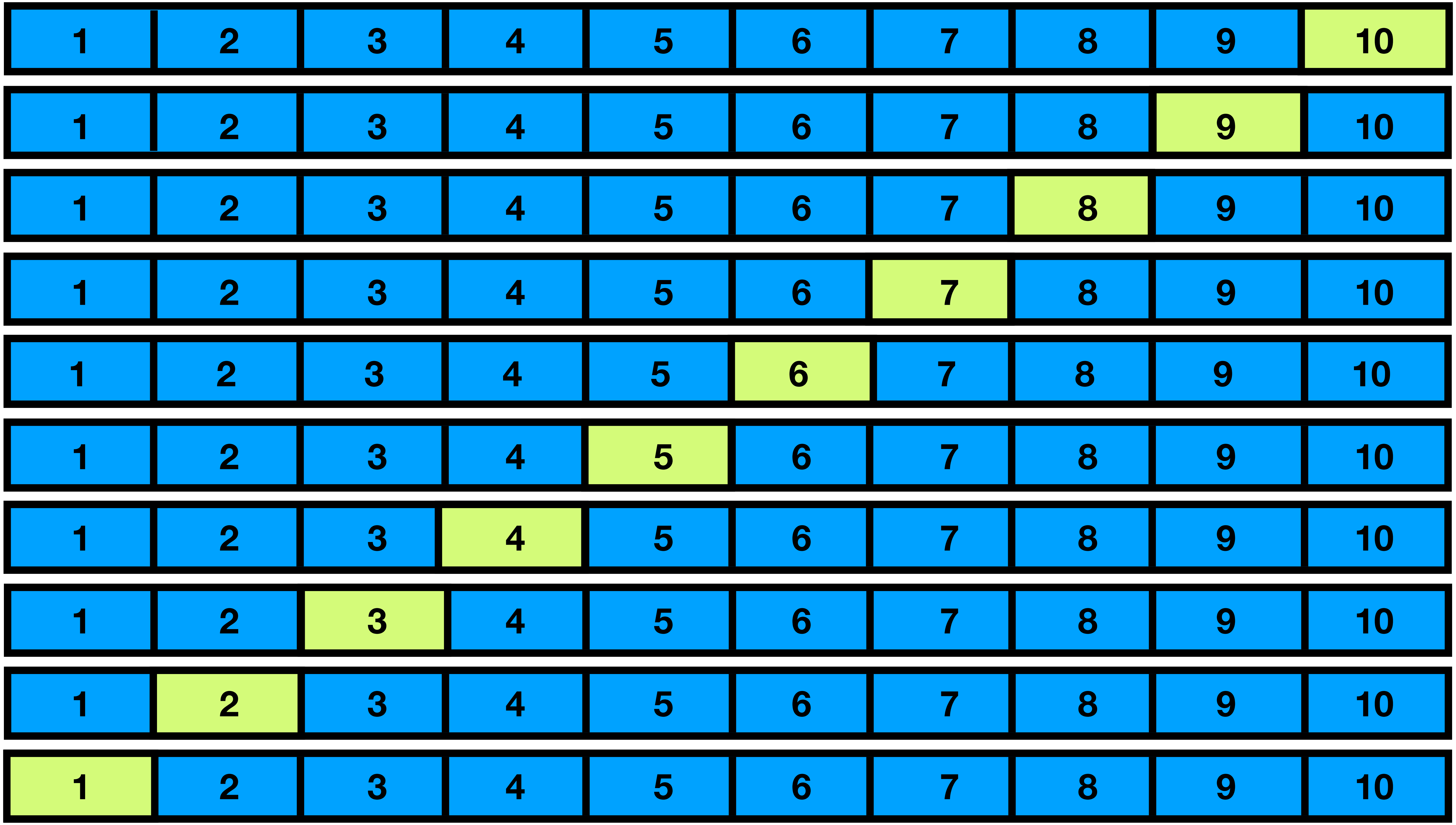


1	2	3	4	5	6	7	8	9	10
1	2	3	4	5	6	7	8	9	10
1	2	3	4	5	6	7	8	9	10

evaluation

10-Fold Cross Validation

Training Set

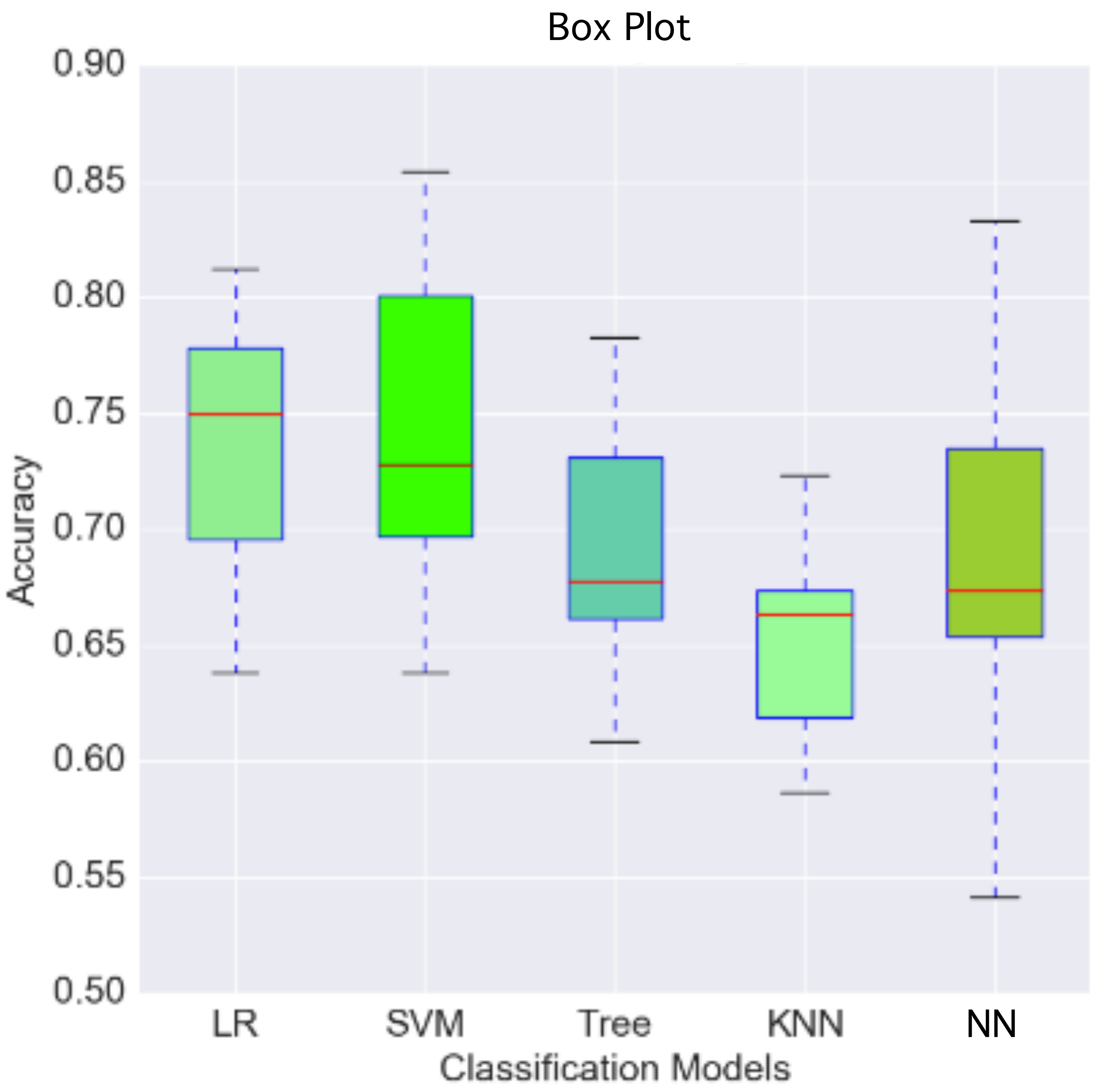


1	2	3	4	5	6	7	8	9	**10**
1	2	3	4	5	6	7	8	**9**	10
1	2	3	4	5	6	7	**8**	9	10
1	2	3	4	5	6	**7**	8	9	10
1	2	3	4	5	**6**	7	8	9	10
1	2	3	4	**5**	6	7	8	9	10
1	2	3	**4**	5	6	7	8	9	10
1	2	**3**	4	5	6	7	8	9	10
1	**2**	3	4	5	6	7	8	9	10
1	2	3	4	5	6	7	8	9	10

Logistic Regression

Fold 1	Fold 2	Fold 3	Fold 4	Fold 5	Fold 6	Fold 7	Fold 8	Fold 9	Fold 10	mean
0.69	0.64	0.73	0.82	0.64	0.70	0.68	0.71	0.70	0.69	**0.70**

Logistic Regression	Support Vector Machine	Decision Tree	K-Nearest Neighbor	Neural Network
0.705	0.722	0.635	0.675	0.607



Hyperparameter Tuning

Logistic Regression

$$\hat{f}(X) = \frac{1}{1+e^{-(\beta_0+\beta_1 X_1+\beta_2 X_2)}}$$

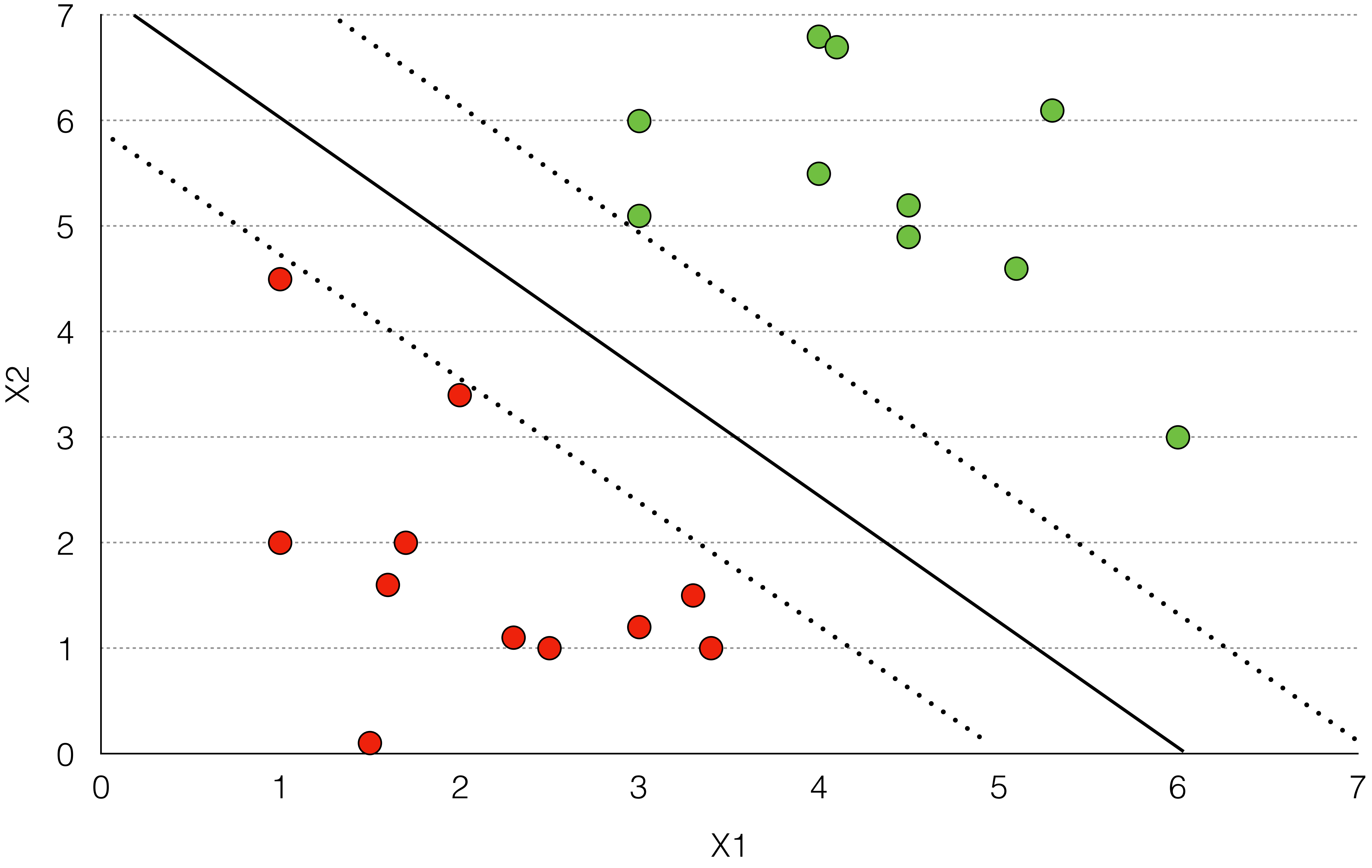
$$\text{LOC} = 227.63 + 9.51x_1 + 2.7x_2 - 7.08x_3$$

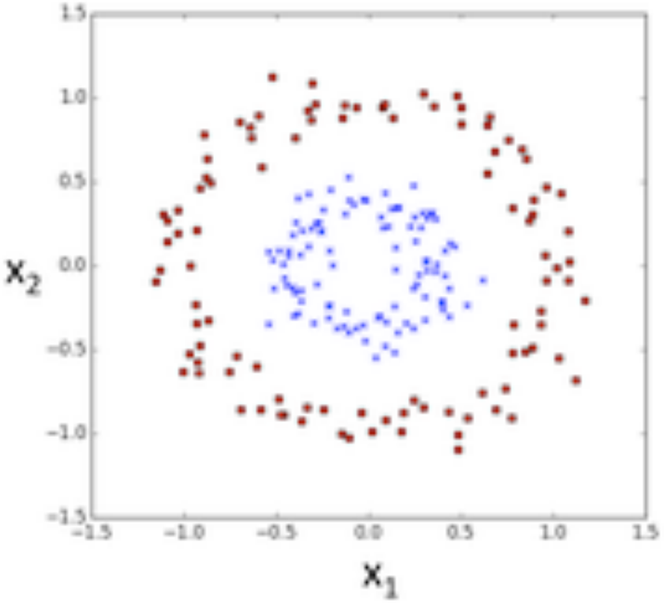
x_1 = hour pair programming

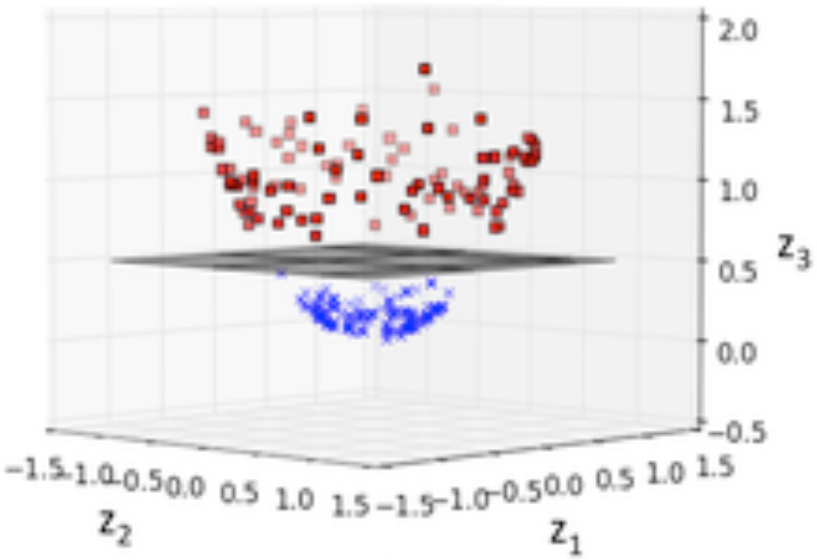
x_2 = gender (m = 0; f = 1)

x_3 = number of social accounts

Support Vector Machine

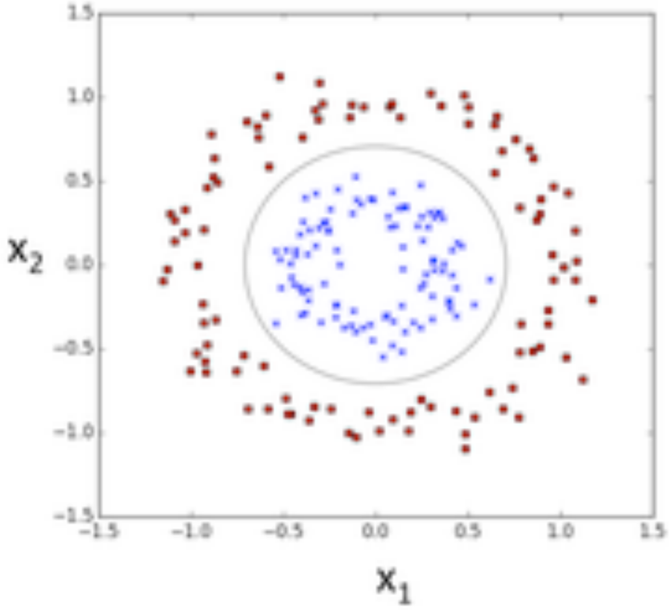




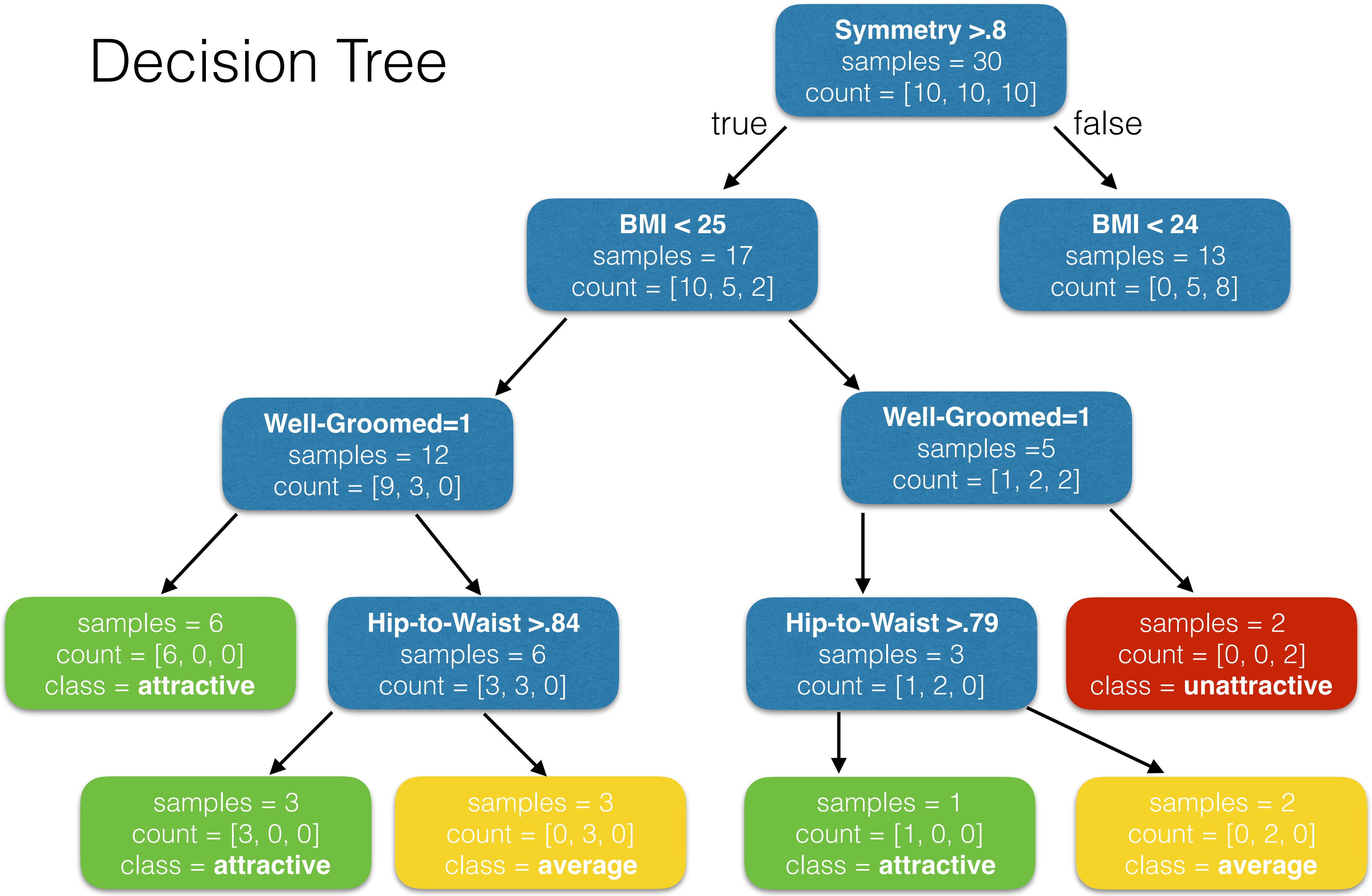


‘rbf’ kernel

Radial Basis Function



Decision Tree



Symmetry >.8
samples = 30
count = [10, 10, 10]

true

false

BMI < 25
samples = 17
count = [10, 5, 2]

BMI < 24
samples = 13
count = [0, 5, 8]

Well-Groomed=1
samples = 12
count = [9, 3, 0]

Well-Groomed=1
samples =5
count = [1, 2, 2]

samples = 6
count = [6, 0, 0]
class = **attractive**

Hip-to-Waist >.84
samples = 6
count = [3, 3, 0]

Hip-to-Waist >.79
samples = 3
count = [1, 2, 0]

samples = 2
count = [0, 0, 2]
class = **unattractive**

samples = 3
count = [3, 0, 0]
class = **attractive**

samples = 3
count = [0, 3, 0]
class = **average**

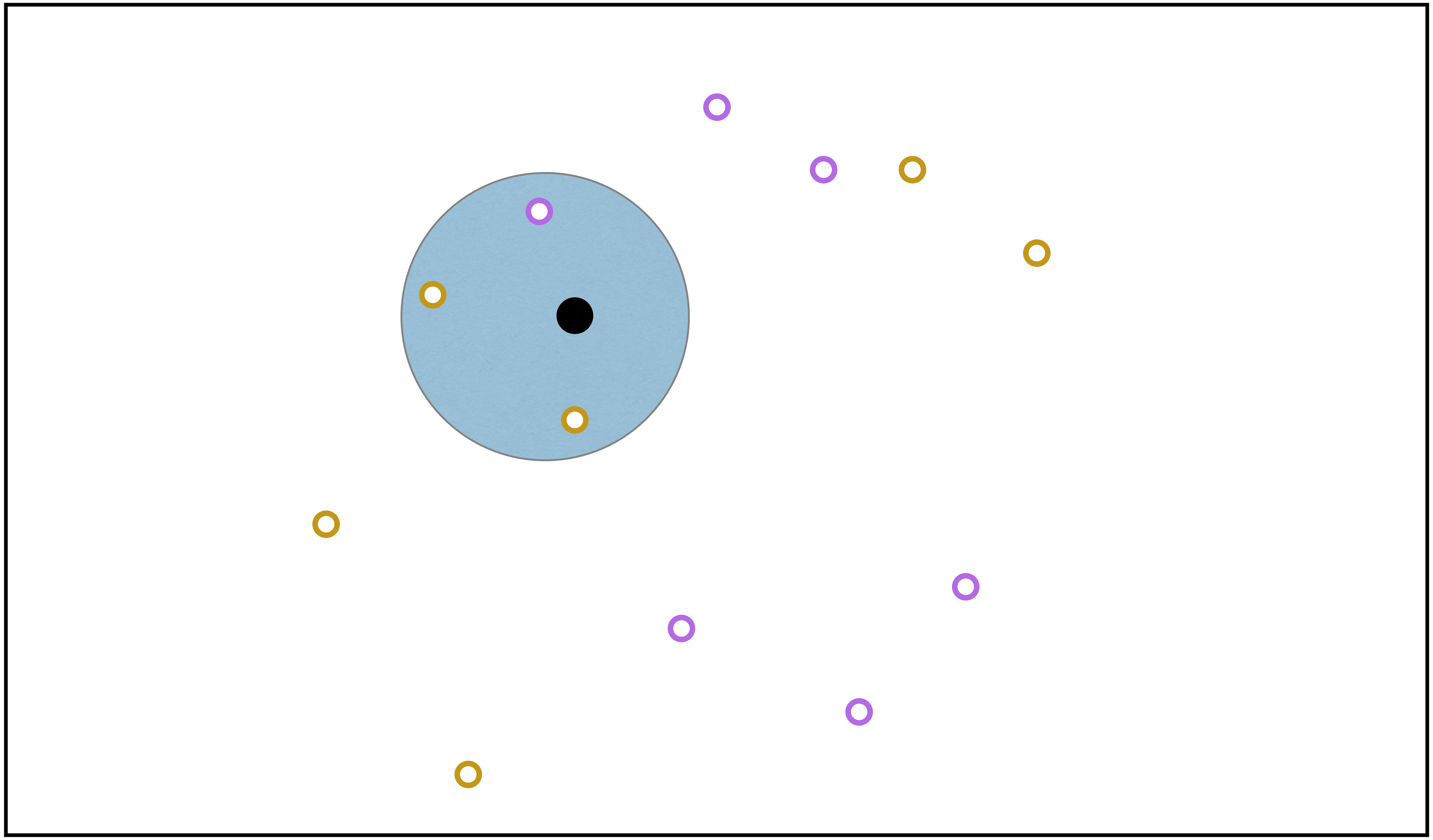
samples = 1
count = [1, 0, 0]
class = **attractive**

samples = 2
count = [0, 2, 0]
class = **average**

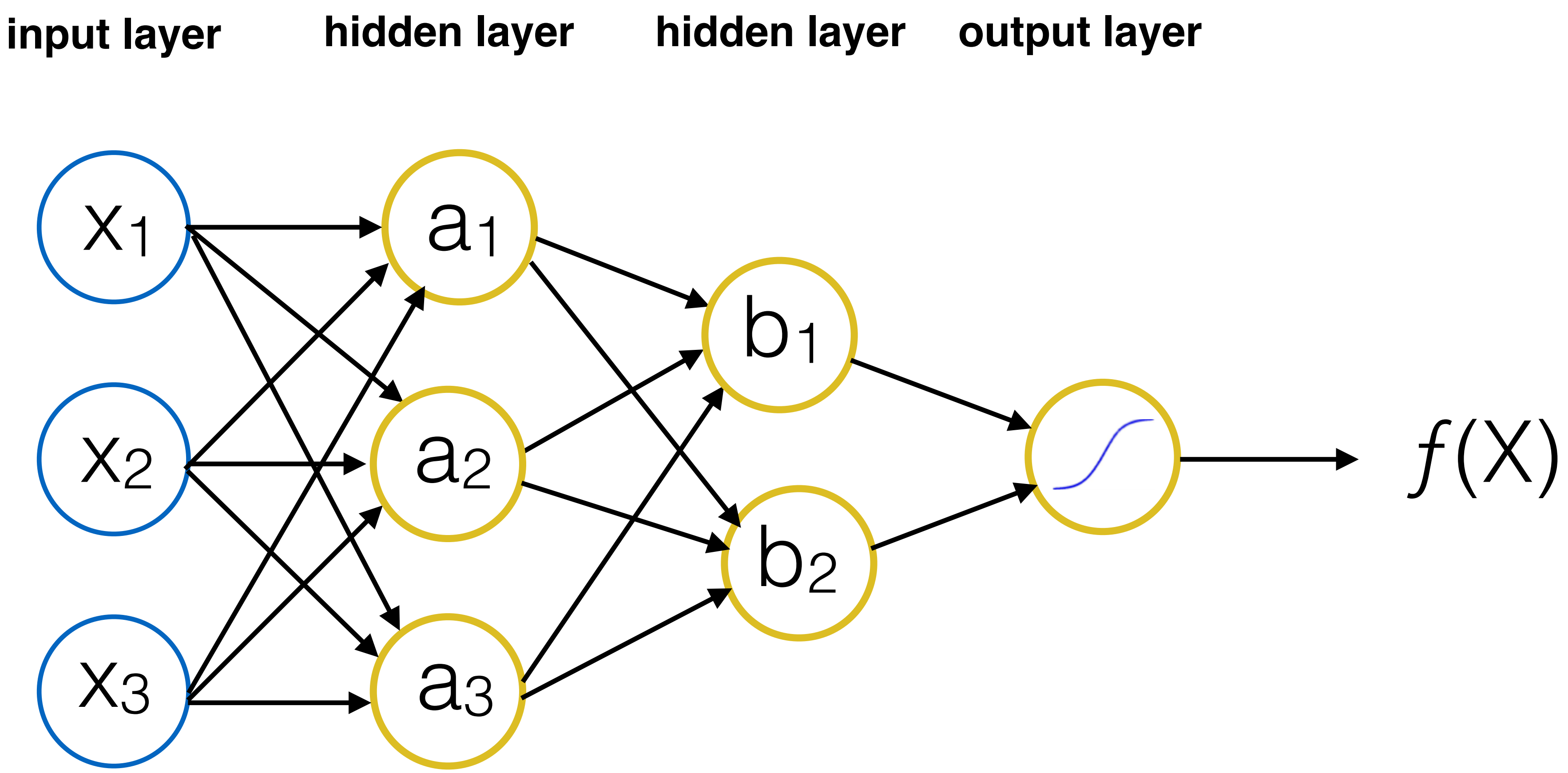
[att, ave, un]

k-Nearest Neighbor

k = 3



Multi-Layer Perceptron (MLP)



input layer

hidden layer

hidden layer

output layer

Grid Search

Grid Search

Support Vector Machine

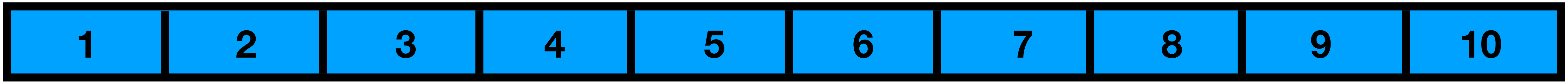
Grid Search

Support Vector Machine

param_grid=[{'C': [.1, 1, 10]}], ‘kernel’: [‘linear’, ‘rbf’], cv=3)}]

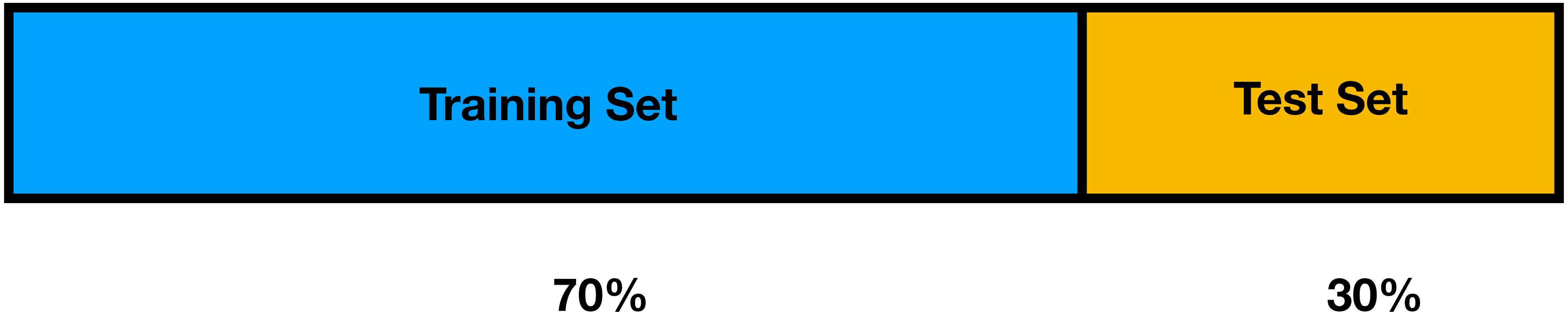
C	kernel
0.1	linear’
1	linear’
10	linear’
0.1	‘rbf’
1	'rbf’
10	‘rbf’

Training Set



1 2 3 4 5 6 7 8 9 10

DATA SET



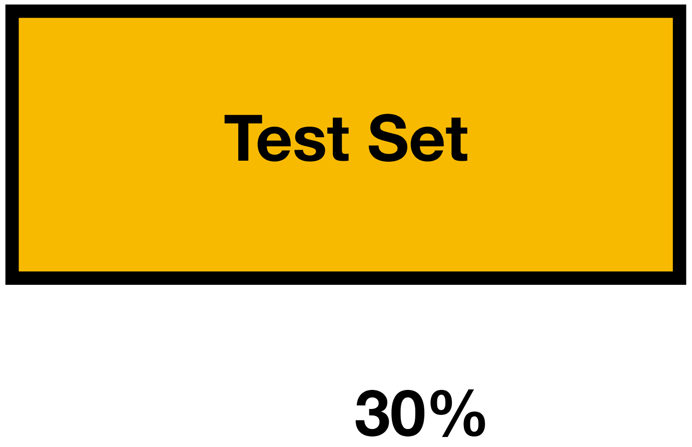
Training Set

Test Set

70%

30%

DATA SET



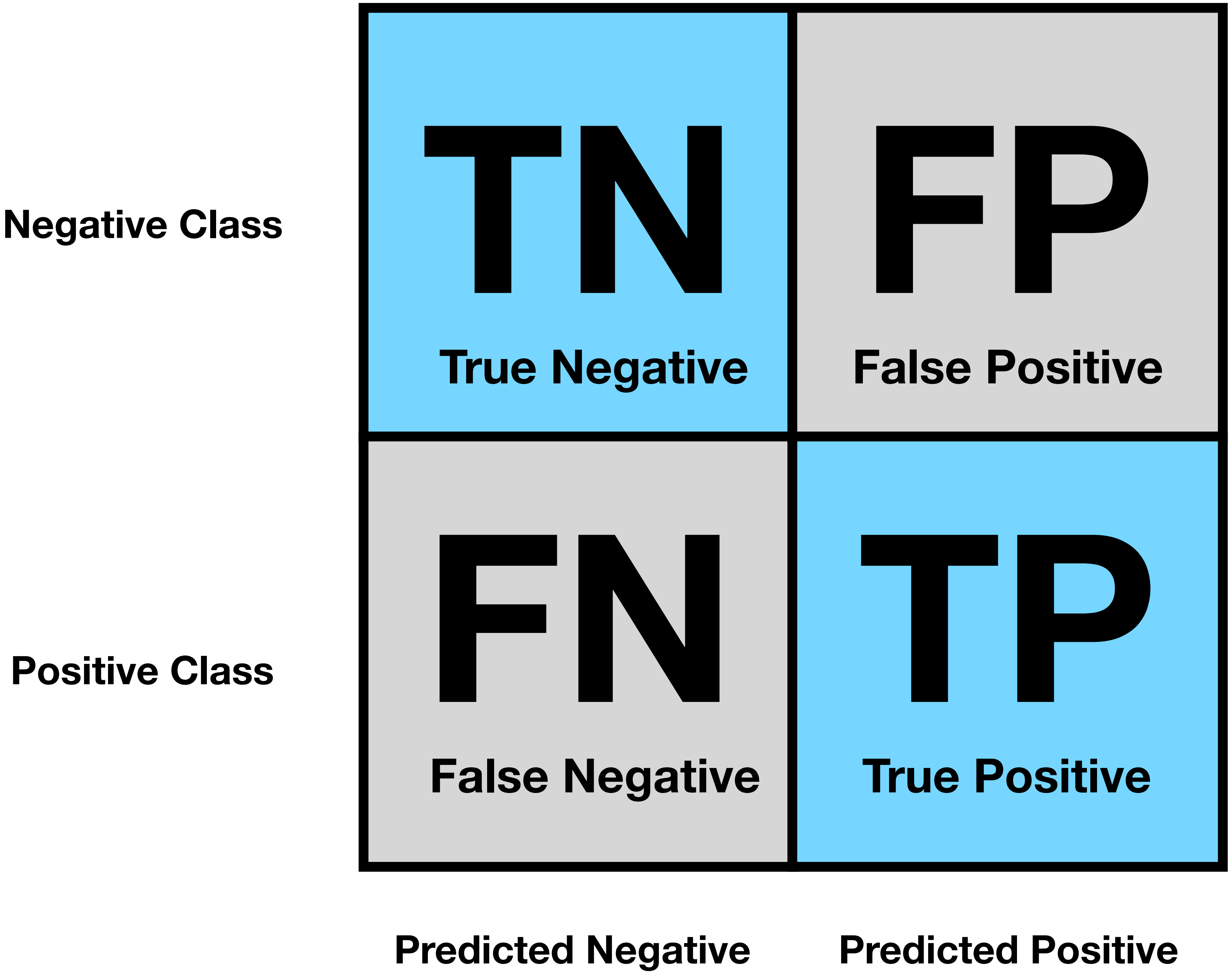
Test Set

30%

Model Evaluation Metrics

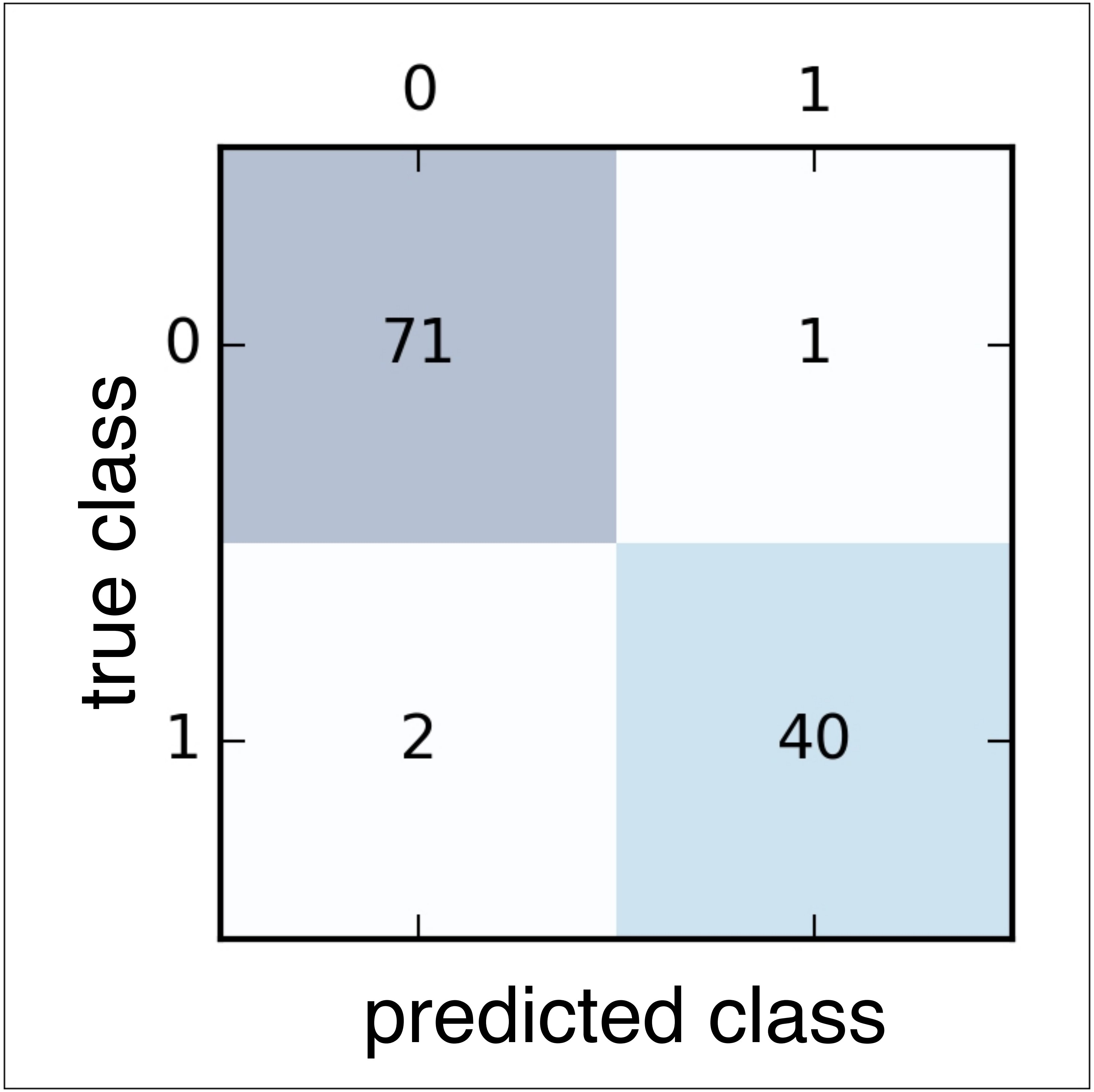
Confusion Matrix

Confusion Matrix



	Predicted Negative	Predicted Positive
Negative Class	TN True Negative	FP False Positive
Positive Class	FN False Negative	TP True Positive

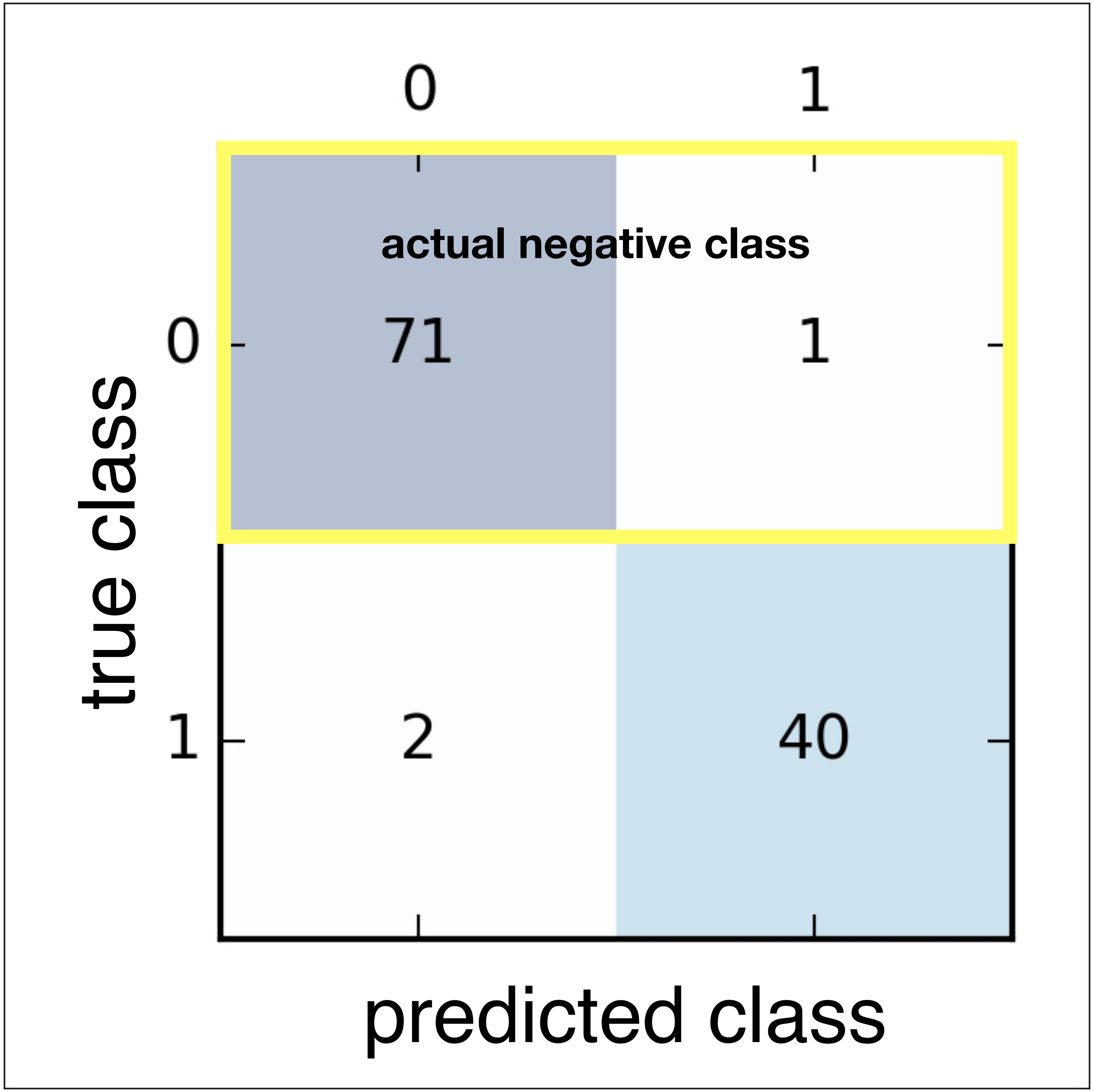
Confusion Matrix



true class \ predicted class	0	1
0	71	1
1	2	40

predicted class
true class

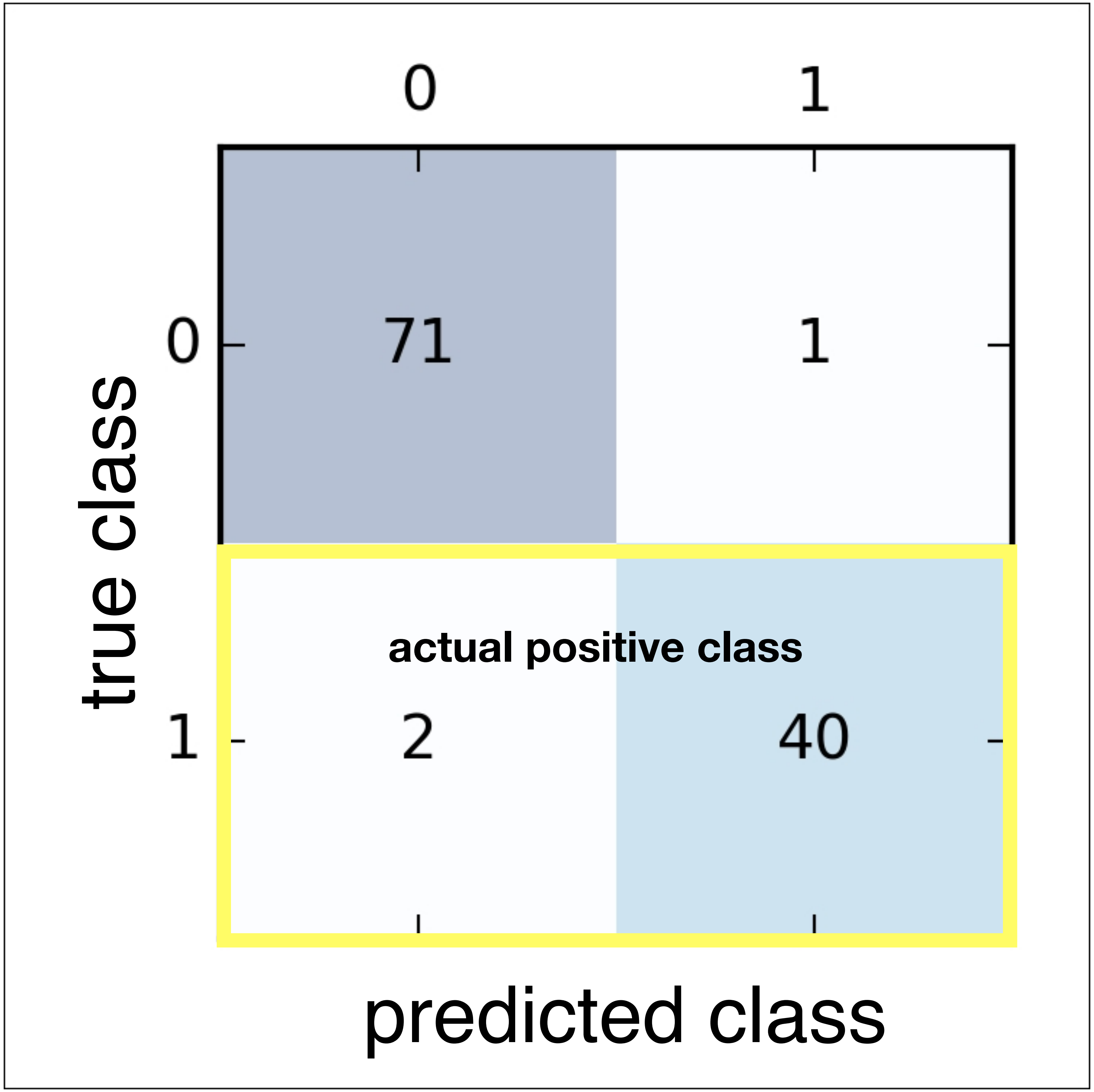
Confusion Matrix



actual negative class

	0	1
0	71	1
1	2	40

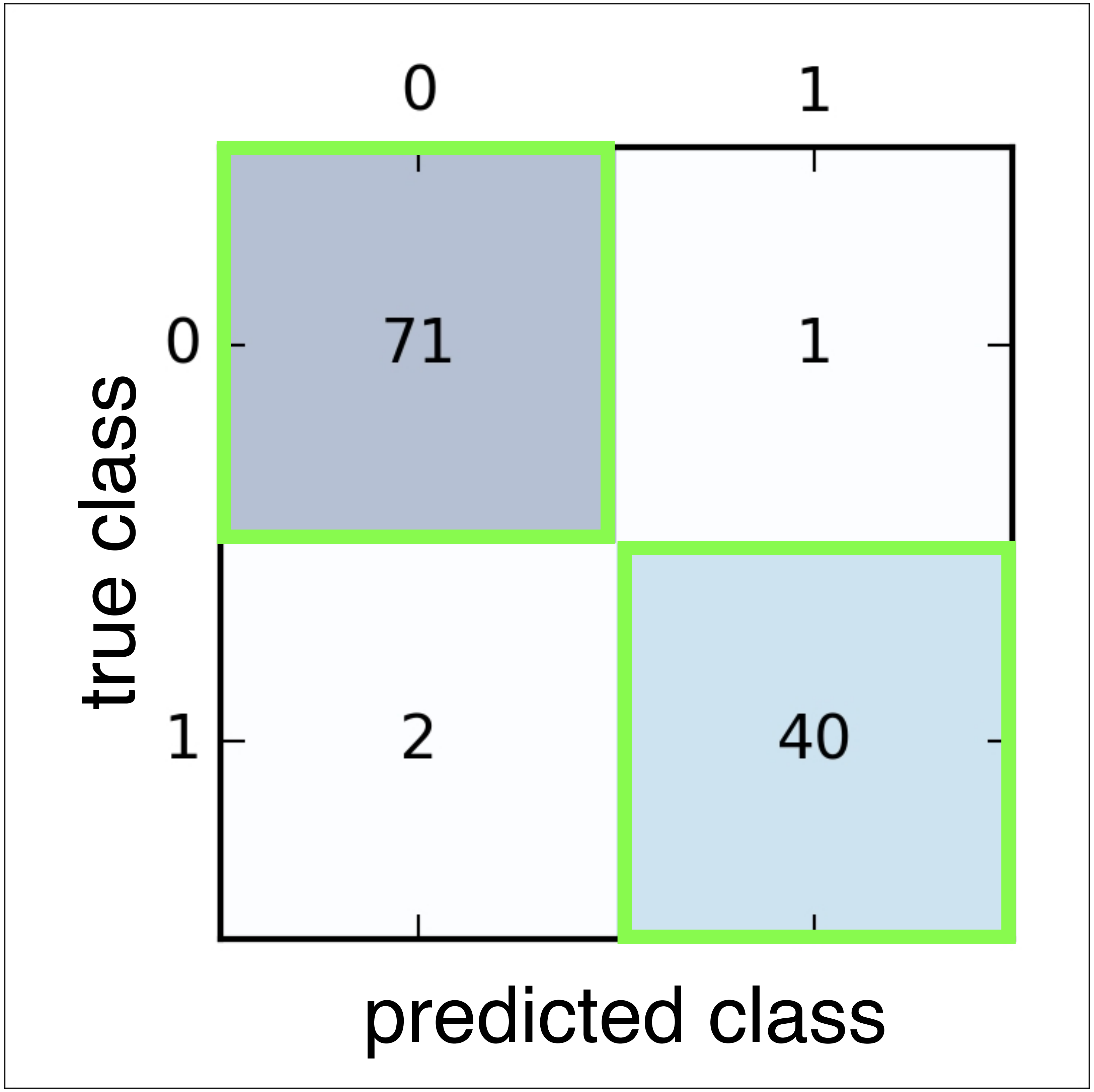
Confusion Matrix



	0	1
0	71	1
1	2	40

actual positive class

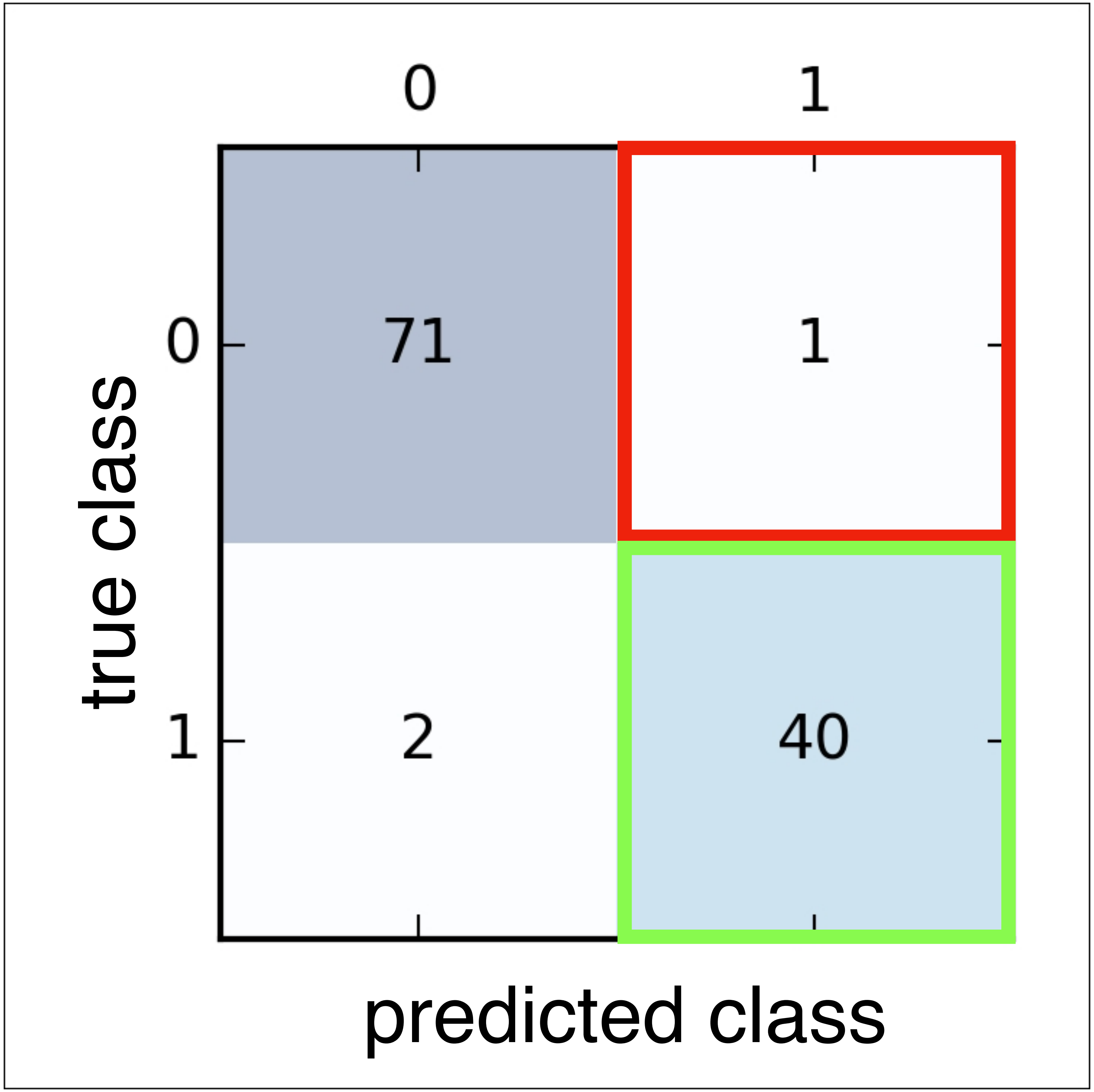
Accuracy



	0	1
0	71	1
1	2	40

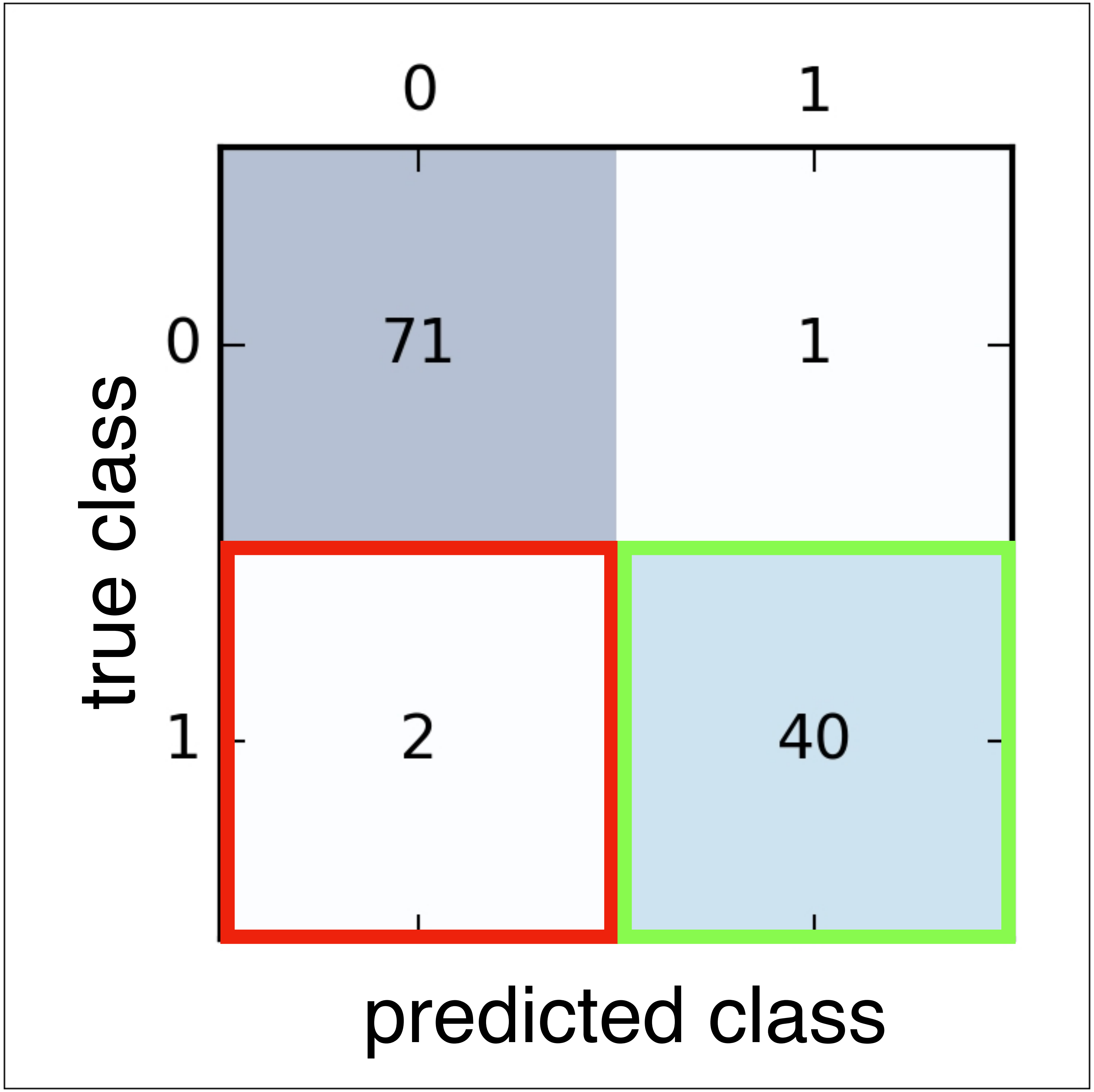
true class
predicted class

Precision



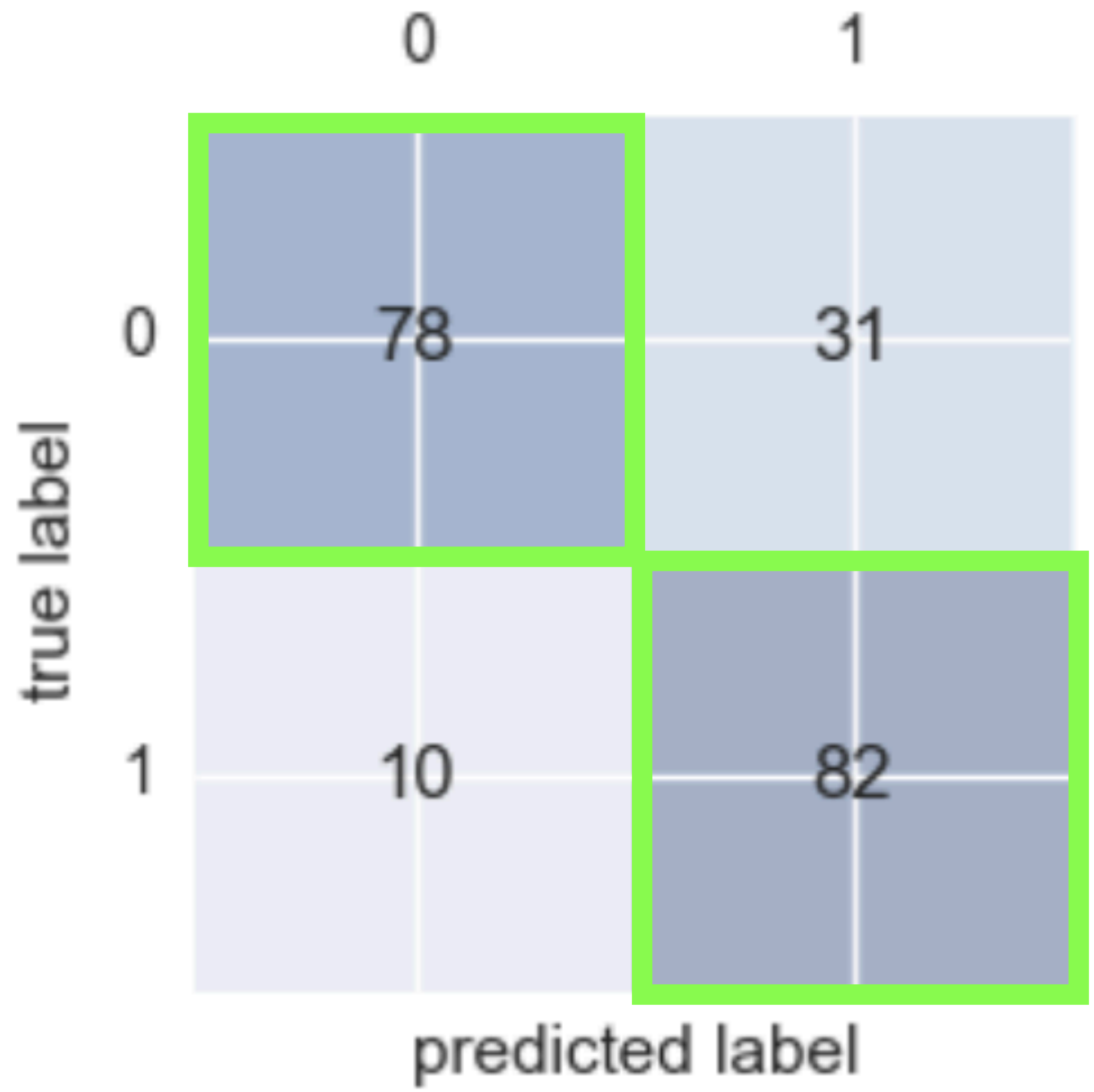
	0	1
0	71	1
1	2	40

Recall



true class \ predicted class	0	1
0	71	1
1	2	40

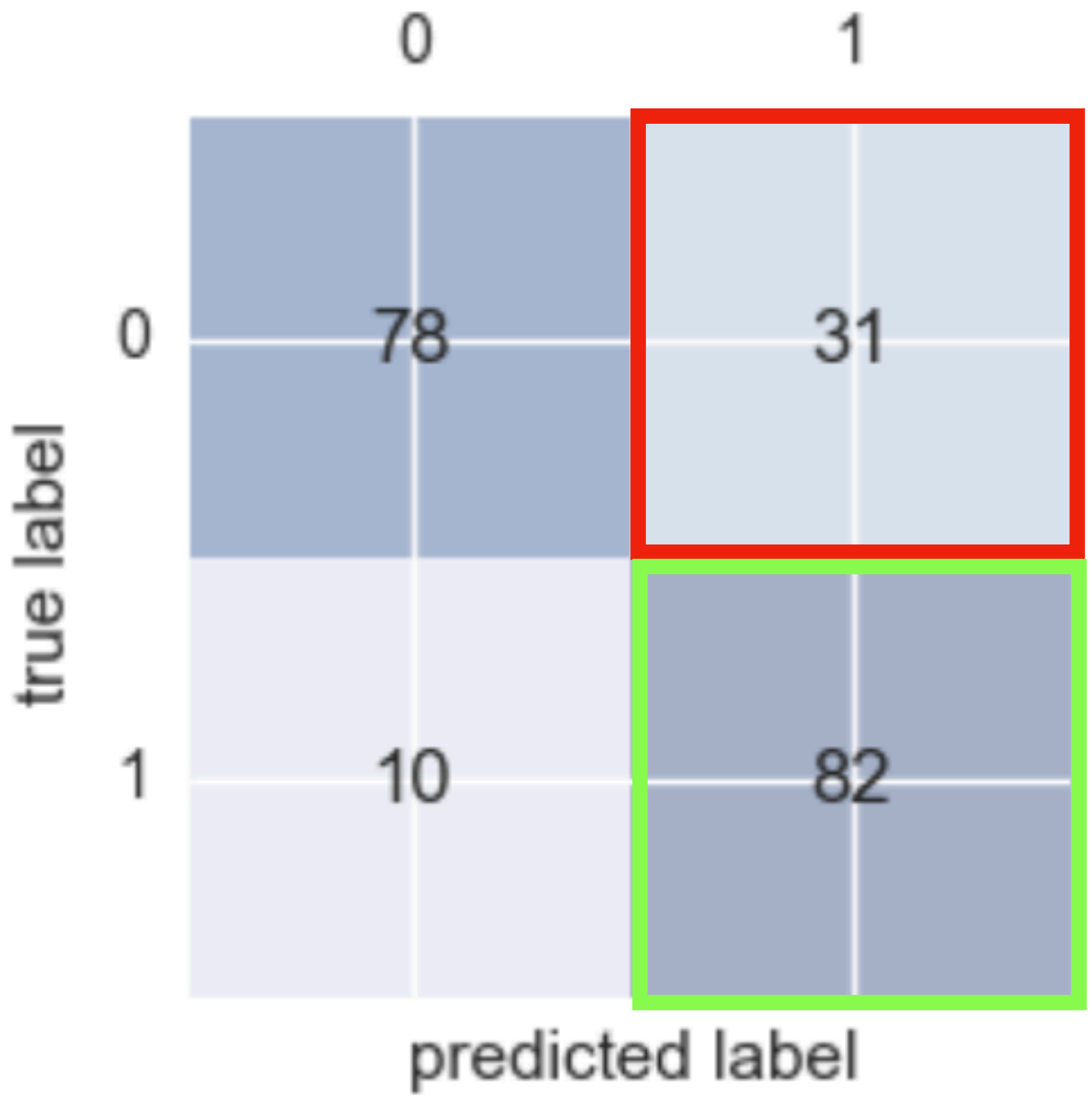
Confusion Matrix



true label \ predicted label	0	1
0	78	31
1	10	82

Accuracy
0.796

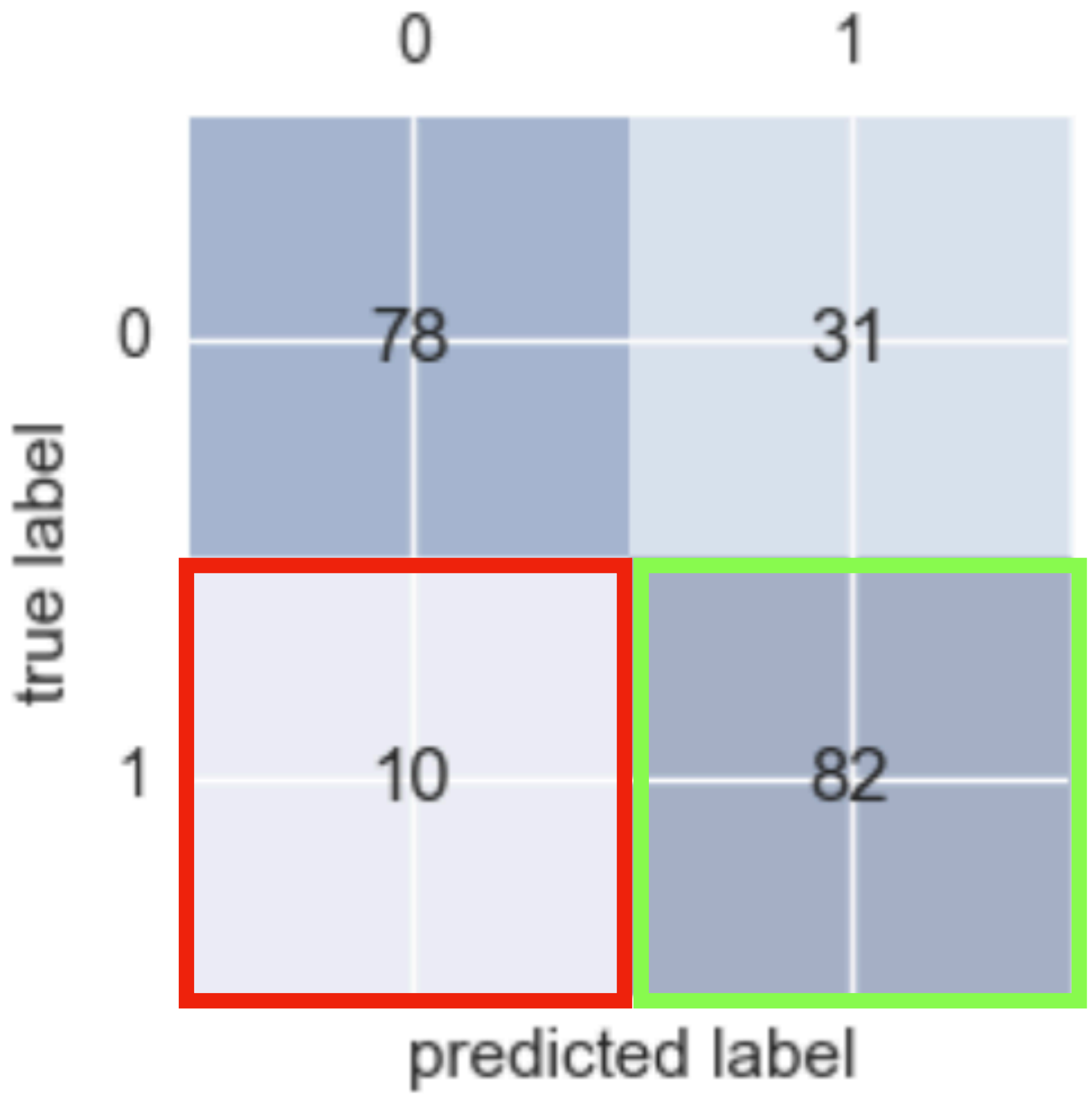
Confusion Matrix



true label \ predicted label	0	1
0	78	31
1	10	82

Precision
0.725

Confusion Matrix

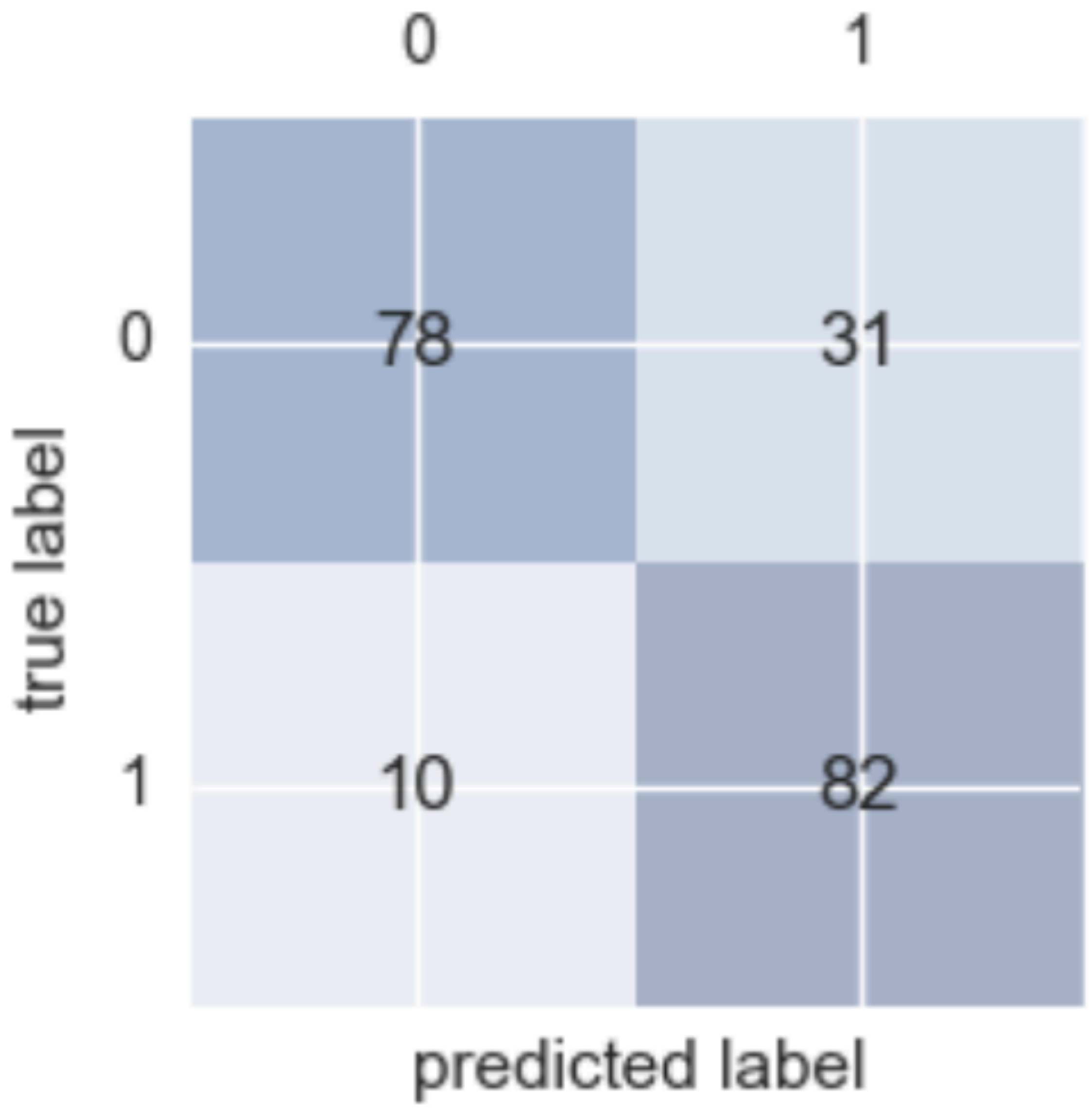


true label \ predicted label	0	1
0	78	31
1	10	82

Recall
0.891

Model Evaluation Metrics

	Precision	Recall	F1-score
Rejected	0.89	0.72	0.79
Liked	0.73	0.89	0.81



Some things to keep in mind:

Get more and/or better data

Feature Engineering

Hyperparameter tuning

Generalization