A Machine Learning Primer

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Silicon Valley Code Camp
October 1, 2016

Linear Regression

Logistic Regression

Support Vector Machine

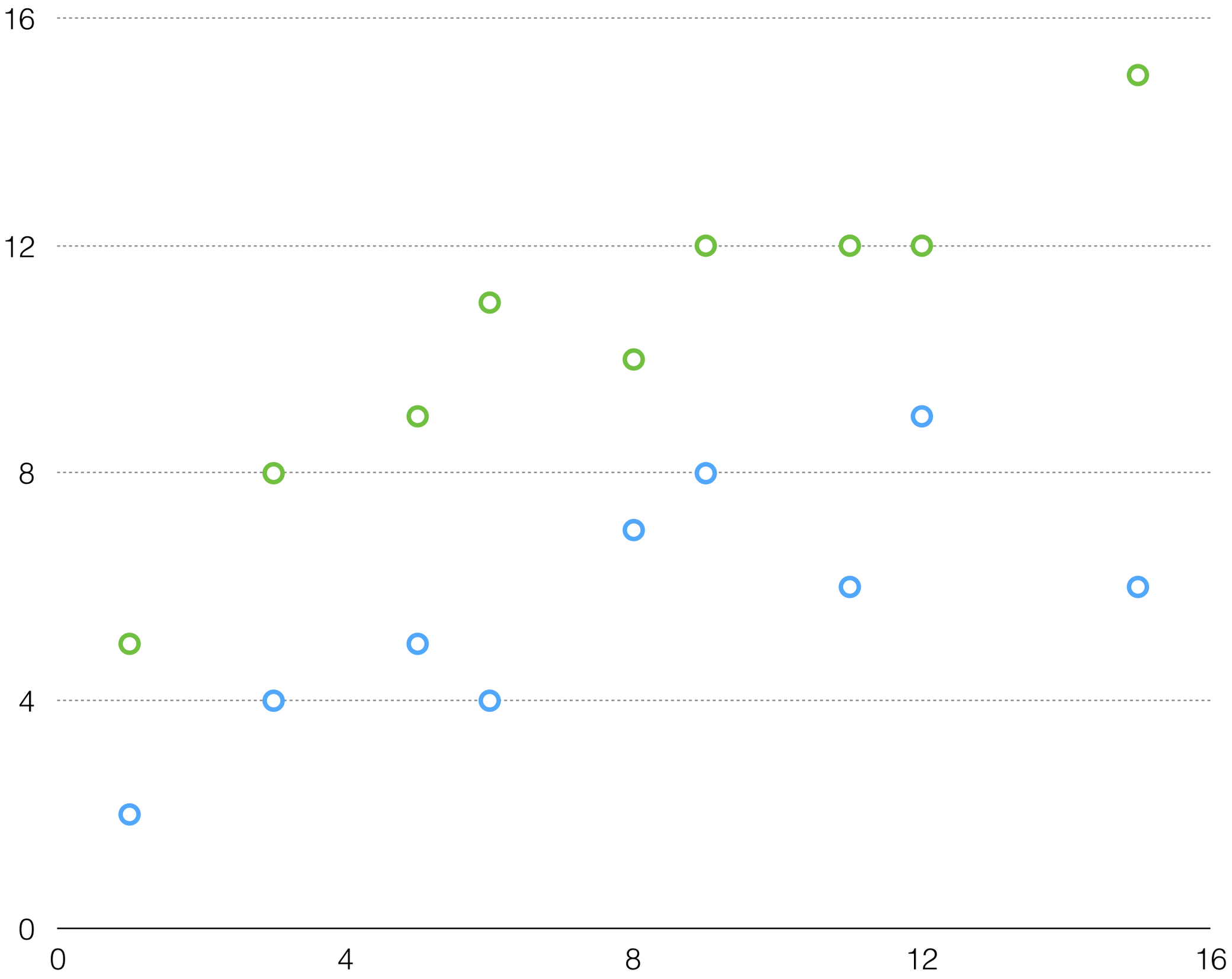
Decision Tree

K-Nearest Neighbor

K-Means

Neural Network

$$\hat{f}(X)$$


16
12
8
4
0
0
4
8
12
16

input output

$$\hat{f}(X) = y$$

Linear Regression

equation of a line

$$y = mx + b$$

Linear Regression

$$y = \beta_0 + \beta_1 x$$

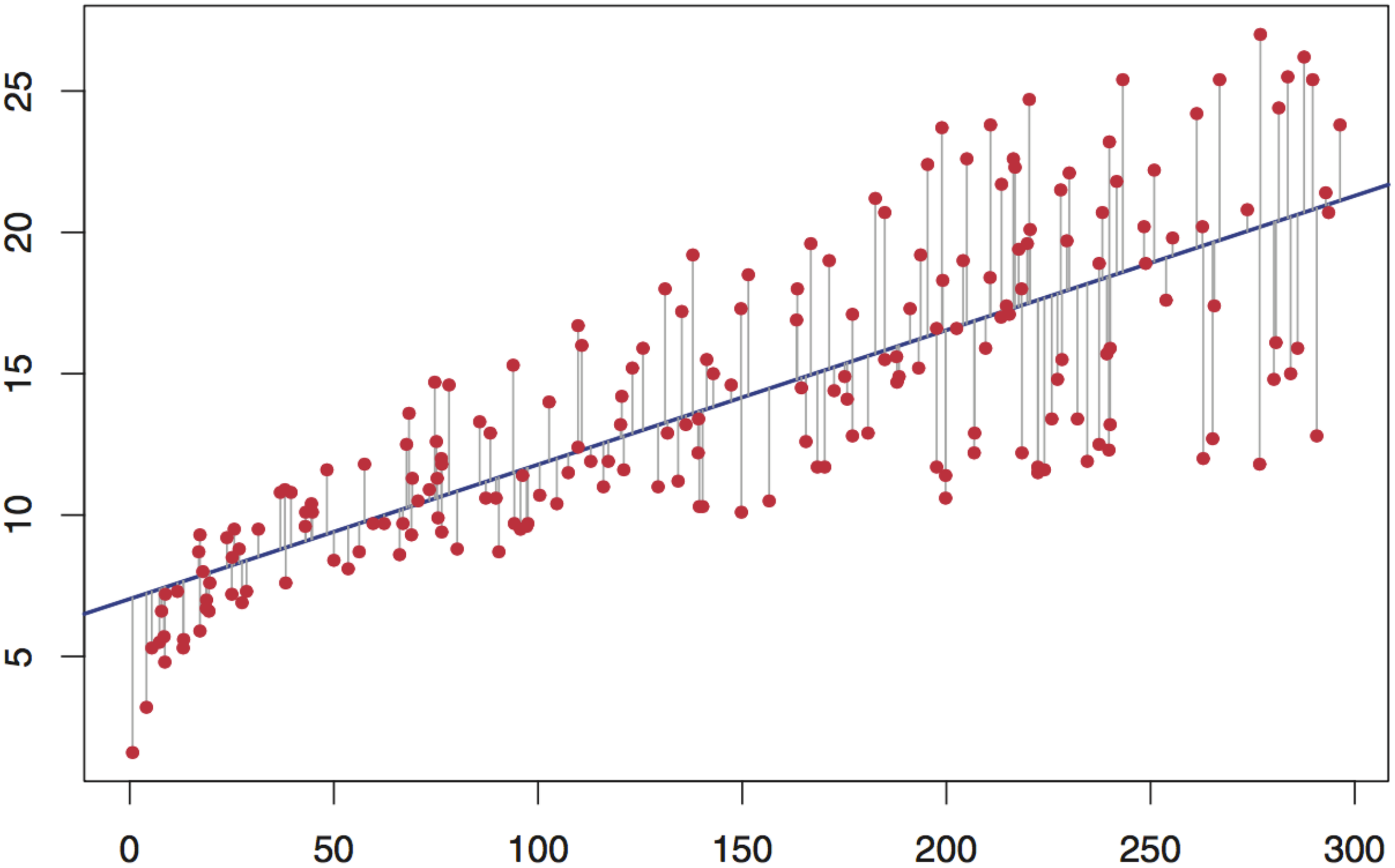
equation of a line

$$y = mx + b$$

Simple Linear Regression

Input	learned coefficients (weights)	Output
x_1	β_0, β_1	y

$$y = \beta_0 + \beta_1 x_1$$


25
20
15
10
5
0
50
100
150
200
250
300

Lines of Code

Gender	Pair Programming	Social Accounts	LOC
Female	3	2	309
Male	2	3	276
Male	2	1	353
Male	4	2	285
Female	4	2	220
Female	2	2	347
Male	3	1	244
Female	2	3	312
Female	4	2	239
Male	4	2	307

Lines of Code

features (X) →

Gender	Pair Programming	Social Accounts	LOC
Female	3	2	309
Male	2	3	276
Male	2	1	353
Male	4	2	285
Female	4	2	220
Female	2	2	347
Male	3	1	244
Female	2	3	312
Female	4	2	239
Male	4	2	307

Lines of Code

Gender	Pair Programming	Social Accounts	LOC
Female	3	2	309
Male	2	3	276
Male	2	1	353
Male	4	2	285
Female	4	2	220
Female	2	2	347
Male	3	1	244
Female	2	3	312
Female	4	2	239
Male	4	2	307

output/target (y)

Lines of Code

sample →

Gender	Pair Programming	Social Accounts	LOC
Female	3	2	309
Male	2	3	276
Male	2	1	353
Male	4	2	285
Female	4	2	220
Female	2	2	347
Male	3	1	244
Female	2	3	312
Female	4	2	239
Male	4	2	307

Lines of Code

Gender	Pair Programming	Social Accounts	LOC
Female	3	2	309
Male	2	3	276
Male	2	1	353
Male	4	2	285
Female	4	2	220
Female	2	2	347
Male	3	1	244
Female	2	3	312
Female	4	2	239
Male	4	2	307

Lines of Code

Gender	Pair Programming	Social Accounts	LOC
1	3	2	309
0	2	3	276
0	2	1	353
0	4	2	285
1	4	2	220
1	2	2	347
0	3	1	244
1	2	3	312
1	4	2	239
0	4	2	307

$$
\mathbf{X} = \begin{bmatrix}
1 & 3 & 2 \\
0 & 2 & 3 \\
0 & 2 & 1 \\
0 & 4 & 2 \\
1 & 4 & 2 \\
1 & 2 & 2 \\
0 & 3 & 1 \\
1 & 2 & 3 \\
1 & 4 & 2 \\
0 & 4 & 2
\end{bmatrix}
\quad
\mathbf{y} = \begin{bmatrix}
309 \\
276 \\
353 \\
285 \\
220 \\
347 \\
244 \\
312 \\
239 \\
307
\end{bmatrix}
$$

Multiple Linear Regression

$$LOC = 227.63 + 9.51x_1 + 2.7x_2 - 3.08x_3$$

x_1 = hour pair programming

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

x_3 = number of social accounts

Multiple Linear Regression

$$\text{Apps sold} = 46.55 + 35.03x_1 + 27.11x_2 + 52.48x_3$$

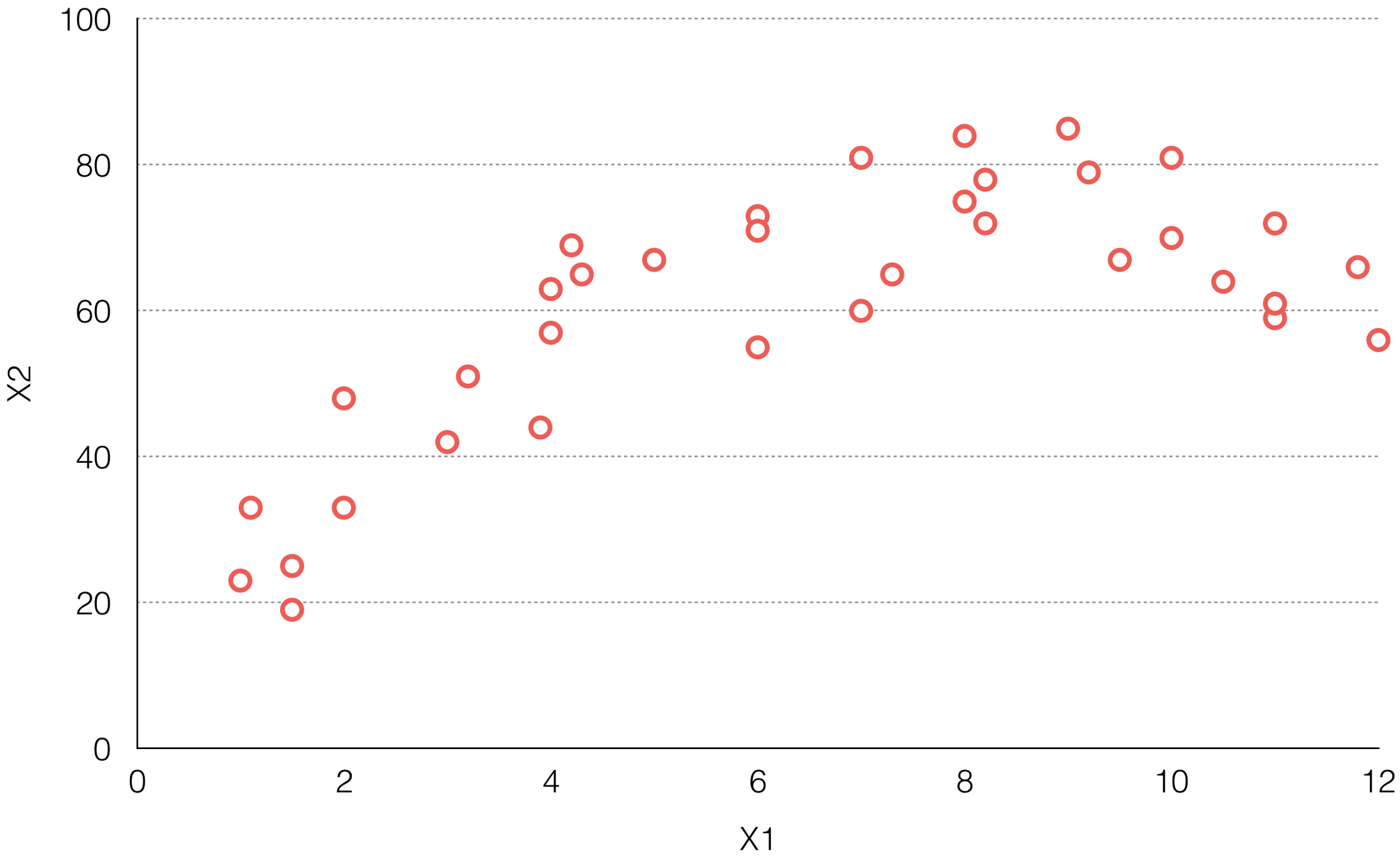
x_1 = per $100 advertising

x_2 = per public talk

x_3 = per targeted podcast

Polynomial Regression

$$f(X) = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_1 x_2 + \beta_4 x_1^2 + \beta_5 x_2^2$$


100
80
60
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20
0
X2
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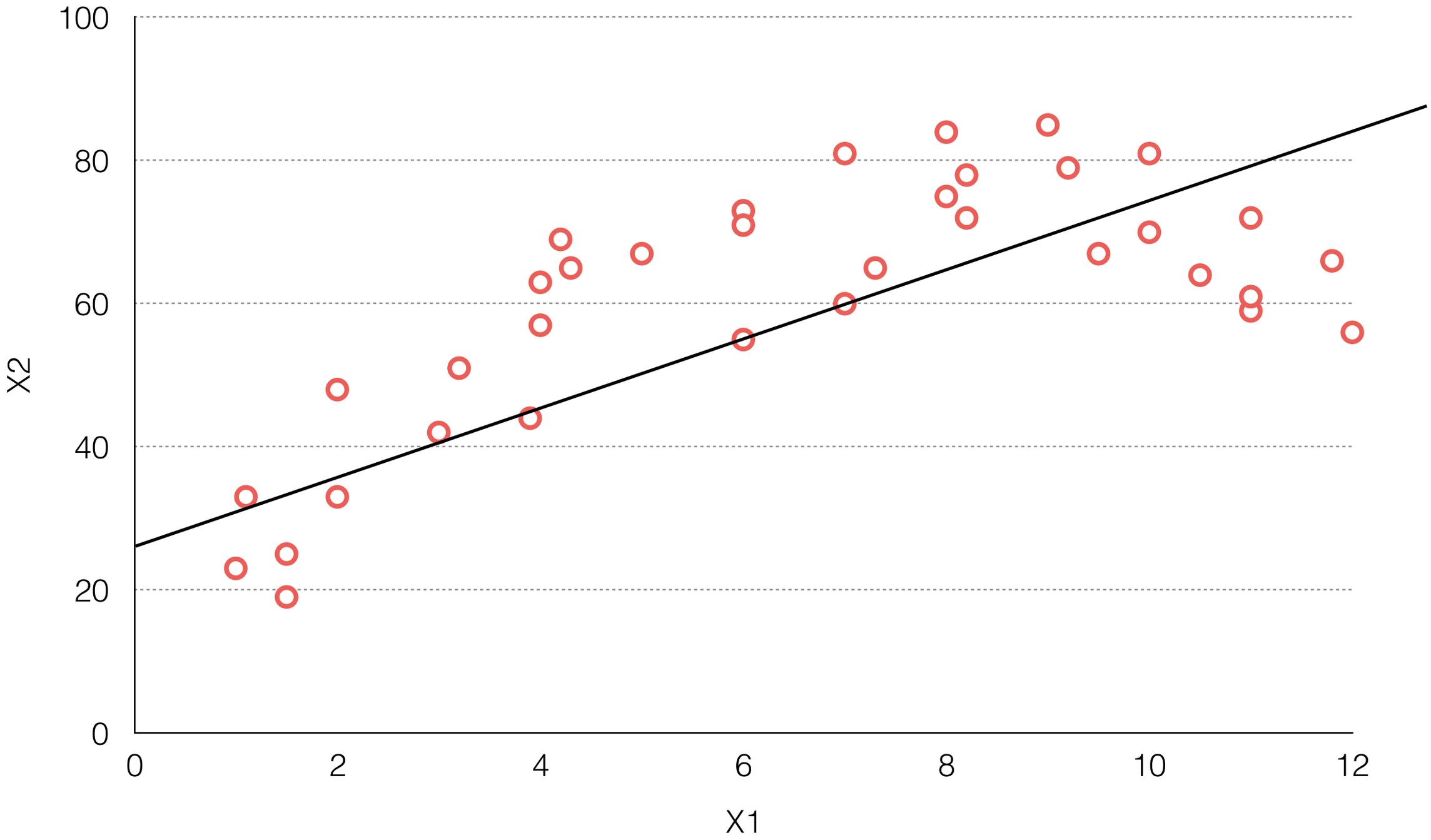
4
6
8
10
12
X1


100
80
60
40
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0
X2
0
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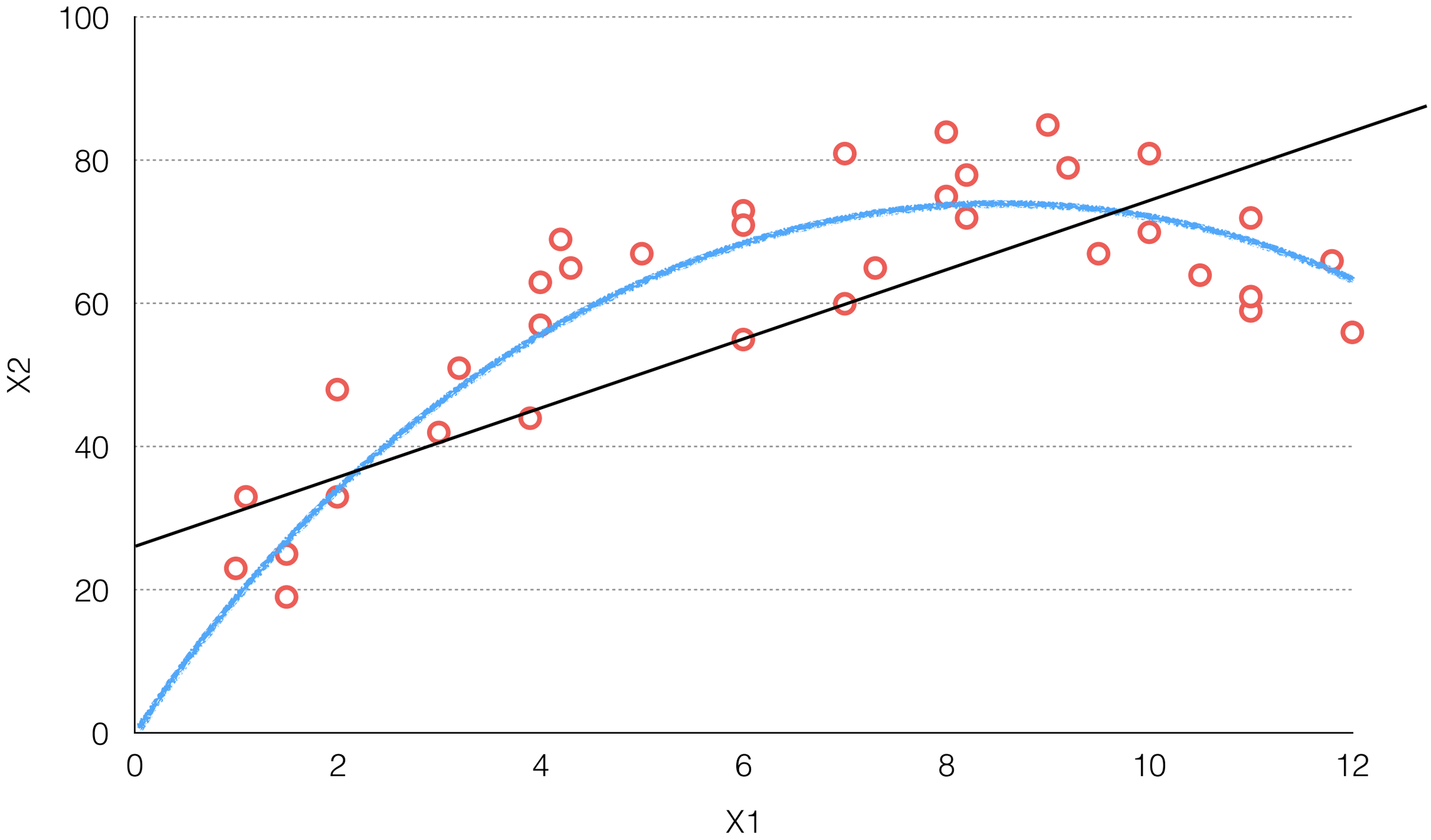
4
6
8
10
12
X1


100
80
60
40
20
0
X2
0
2
4
6
8
10
12
X1

CLASSIFICATION

Logistic Regression

Logistic Regression

$$\beta_0 + \beta_1 x + \beta_2 x + \beta_3 x$$

positive class = 1

negative class = 0

if probability >= 0.5: predict 1

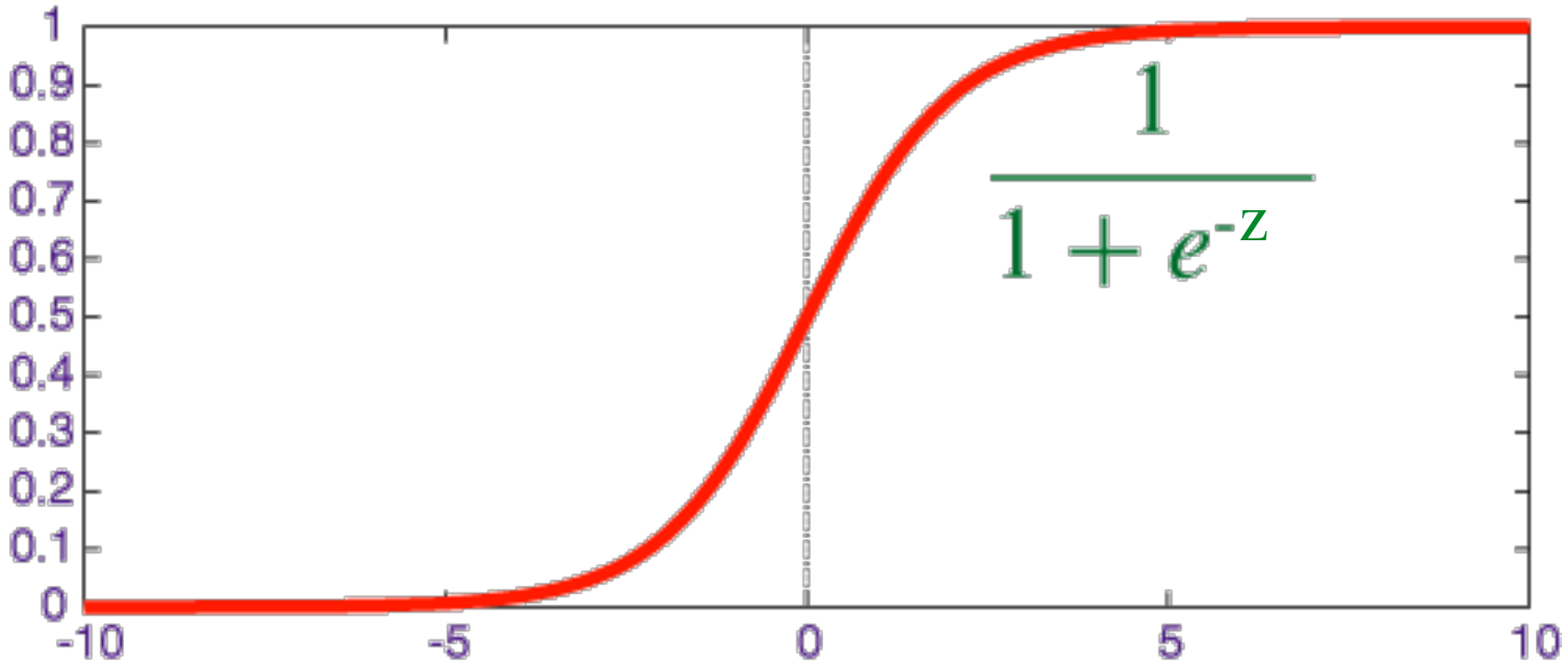
else: predict 0

Logistic Regression

intermediate step

$$z = \beta_0 + \beta_1 x + \beta_2 x + \beta_3 x$$

Logistic (Sigmoid) Function



Logistic Regression

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

DEBORAH HILL

Highly motivated C# Software Develo
programming languages, including M
device drivers and applications. Ex
within Fortune 100, small start-up co
software project and subcontract ma
mentoring, and training. Proven a
Demonstrated leadership abilities a
supervision. Hold a current Departm

Programming Languages:
C#, SQL, HTML, XML, CSS, C+

.NET Skill Set:
.NET Framework 4.0 and Com
Web Services

Databases:
MS SQL Server 2008, MySQ

Software:
Visual Studio 2010, Dream
Clear Case, Clear Quest,

Operating Systems:
Windows 7/NT/XP/2003/

Department of Defen
Secret

Certified Manager
James Madison Un

.Net Master's Pr
SetFocus, LLC -

The SetFocus
knowledge of a

- Devel
  encap
- User
  envi
  Ser
- Cre
  Consumed
- Created business com
  multi-tier environment suitable for
  issues associated with building scalable enterp
- Developed ASP.NET n-tiered "Public Library Manageme
  middle tier data access components. Non-public web pages secured

Deborah Hill

Steven Barnes

55 Blue Way, New City, CT, 55555. Tel: (203) 555-5555. email: sbarnes@jupiter.com

OBJECTIVE

Seeking a challenging software development opportunity in a dynamic environment where innovation, education and sense of ownership are valued and encouraged.

SKILL SUMMARY

- Platforms: UNIX/Solaris, Windows
- Languages: Java/J2EE (concurrency, socket level, NIO, JSP, Servlets, EJB, RMI, Swing), C/C++ (STL, Win32 SDK, MFC)
- Scripting: JPython, UNIX shell, sed, awk
- Networking: TCP/IP, UDP, HTML, XML, Apache & Tomcat
- Databases: Oracle, PL/SQL, JDBC
- Methodologies: OOP/D, UML, Design Patterns, Extreme Programming
- Tools: CodeWarrior, VisualStudio, ClearCase, SourceSafe, RationalRose, OptimizeIt

WORK EXPERIENCE

NETWORK INTERACTIVE

Software Engineer — *New York, NY* — *Jan 1998 – July 2004*

- Contributed to the development and continuous enhancement of the company's proprietary server-side/platform framework.
- Designed and implemented the room server - a Java game matchmaking application that serves as the main backbone of the system. This high-availability multithreaded server maintains persistent TCP/IP connections with all players on the system, provides an interface for creating and running games, acts as a communication hub and enforces data integrity between clients and game-specific business logic.
- Participated in the implementation of several key platform services such as user account management, player ratings, game prizes and tournaments. Each service is a multi-tiered system consisting of a database component, server application and at least one client API.
- Developed several new features of the web site including intelligent method of routing players to optimal games based on player preferences, player statistics and the current load on the system.
- Assisted third-party partners as well as internal engineers in developing and customizing games for deployment on the system.
- Developed web-based and command line tools that allowed administrators to configure and monitor system components.
- Assumed ownership of the source code and developed regular updates to a Windows game matchmaking application.
- Served as a technical lead to junior team members and as a link to other teams by providing assistance and training.
- Assumed management responsibilities by evaluating upcoming and ongoing projects, assigning tasks to team members and reporting project status in the manager's absence.

PRESENTATION PUBLISHING CORPORATION

Software Engineer — *Stamford, CT* — *March 1996 – Jan 1997*

- Took part in developing a lightweight, graphically rich business presentation application.
- Created several installation programs for various packaging options of the product.
- Managed the build and release process of the company's product line.
- Administered the company's version control system.

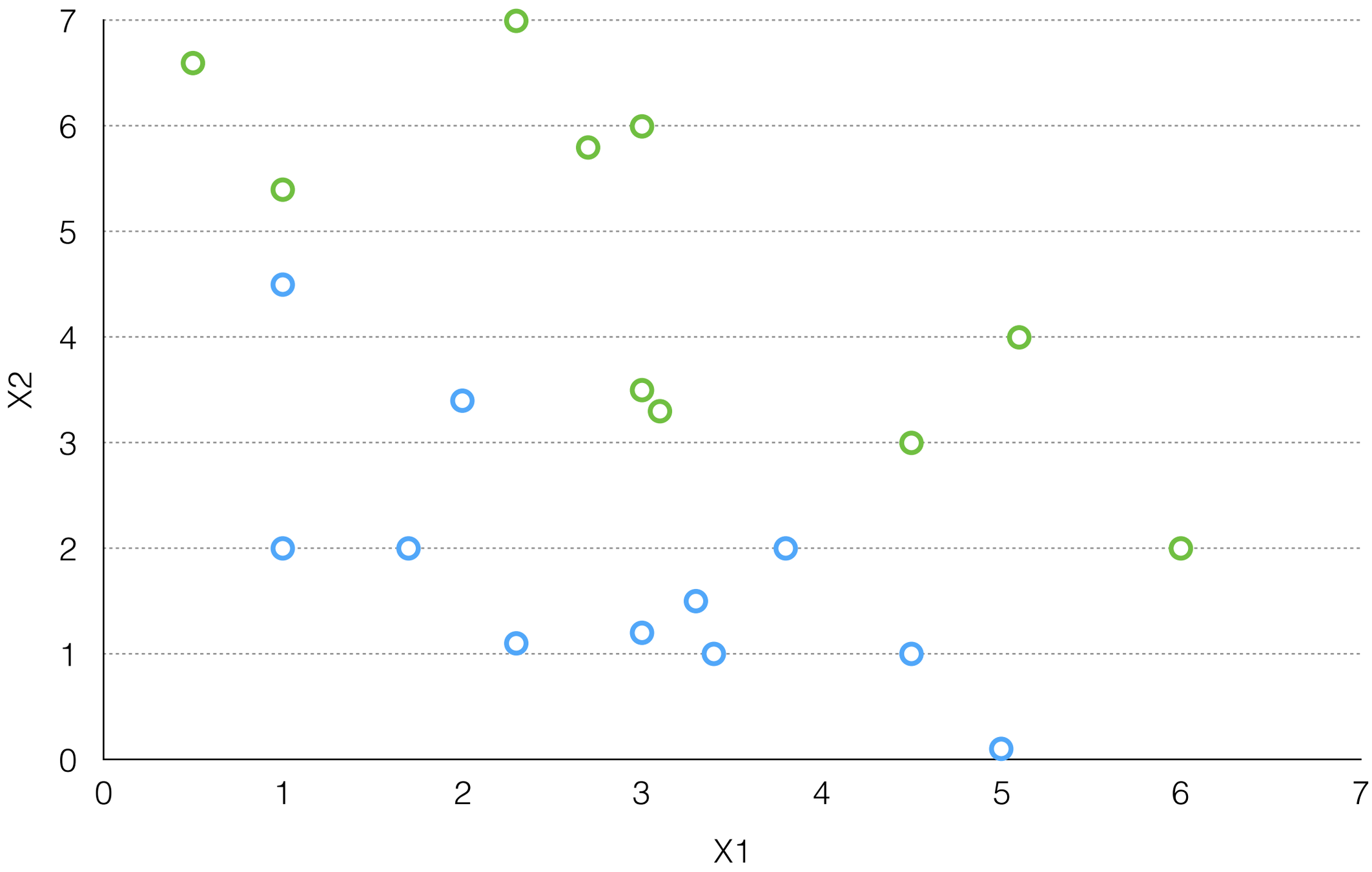
Gender	Years Exp.	Interview Source	Phone Screen	On-site Interview
Female	3	2	9	Yes
Male	2	3	7.5	No
Male	2	1	7	No
Male	4	2	8.5	Yes
Female	4	2	9.5	Yes
Female	2	2	6.5	No
Male	3	1	8	No
Female	2	3	8	No
Female	4	2	9	Yes
Male	4	2	7	Yes

Gender	Years Exp.	Interview Source	Phone Screen	On-site Interview
1	3	2	9	Yes
0	2	3	7.5	No
0	2	1	7	No
0	4	2	8.5	Yes
1	4	2	9.5	Yes
1	2	2	6.5	No
0	3	1	8	No
1	2	3	8	No
1	4	2	9	Yes
0	4	2	7	Yes

One-Hot Encoding

Gender	Years Exp.	Source 1	Source 2	Source 3	Phone Screen	On-site Interview
1	3	0	1	0	9	Yes
0	2	0	0	1	7.5	No
0	2	1	0	0	7	No
0	4	0	1	0	8.5	Yes
1	4	0	1	0	9.5	Yes
1	2	0	1	0	6.5	No
0	3	1	0	0	8	No
1	2	0	0	1	8	No
1	4	0	1	0	9	Yes
0	4	0	1	0	7	Yes

Gender	Years Exp.	Source 1	Source 2	Source 3	Phone Screen	On-site Interview
1	3	0	1	0	9	1
0	2	0	0	1	7.5	0
0	2	1	0	0	7	0
0	4	0	1	0	8.5	1
1	4	0	1	0	9.5	1
1	2	0	1	0	6.5	0
0	3	1	0	0	8	0
1	2	0	0	1	8	0
1	4	0	1	0	9	1
0	4	0	1	0	7	1


7
6
5
4
3
2
1
0
X2
0
1
2
3
4
5
6
7
X1

Decision Boundary

$$\text{On-site Interview} = \beta_0 + \beta_1 x_1 + \beta_2 x_2$$

Decision Boundary

$$\text{On-site Interview} = -6 + 1x_1 + 1x_2$$

Decision Boundary

On-site Interview = $-6 + 1x_1 + 1x_2$

predict 1 when $-6 + 1x_1 + 1x_2 >= 0$

predict 0 when $-6 + 1x_1 + 1x_2 < 0$

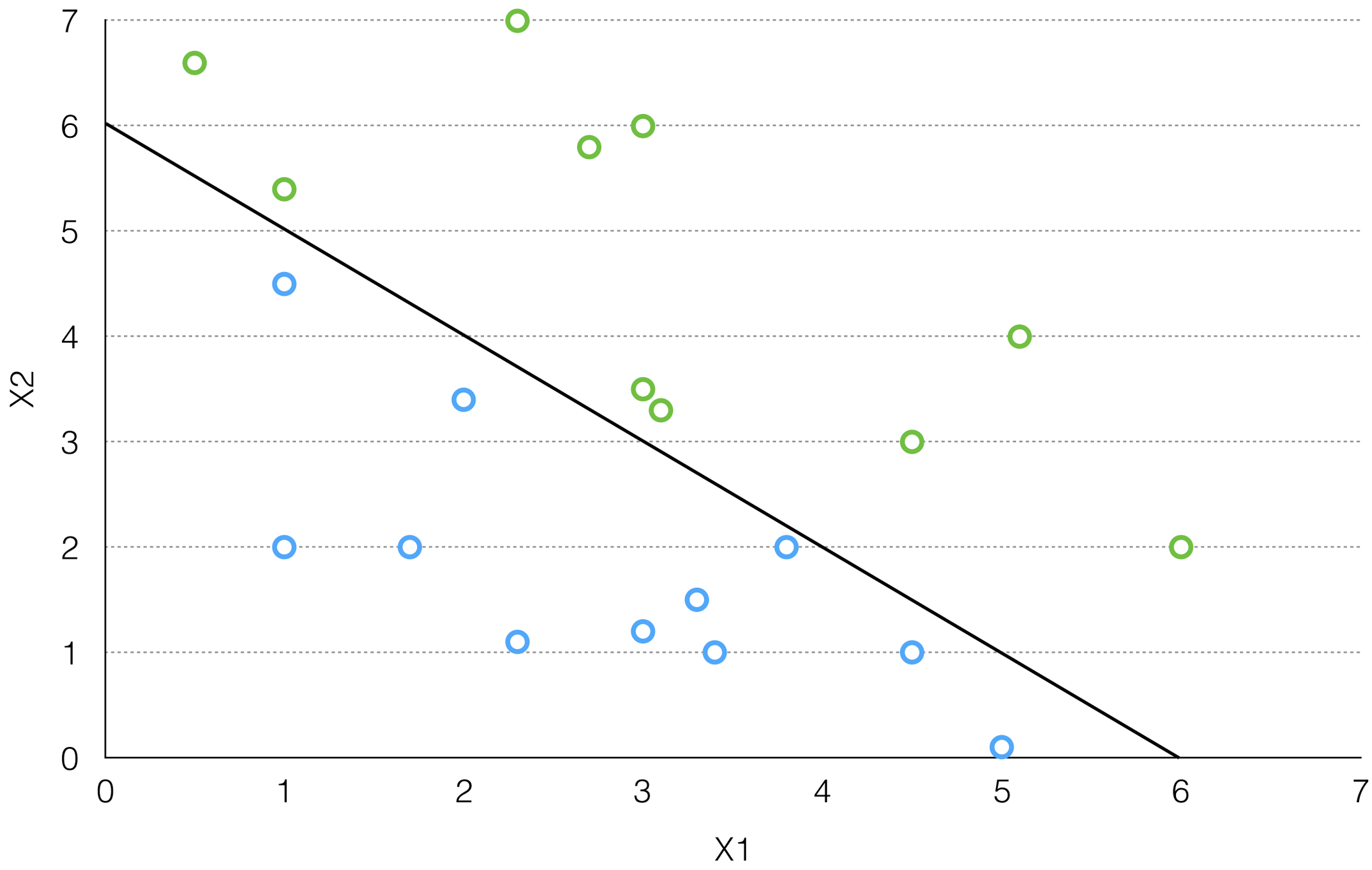
Decision Boundary

On-site Interview = $-6 + 1x_1 + 1x_2$

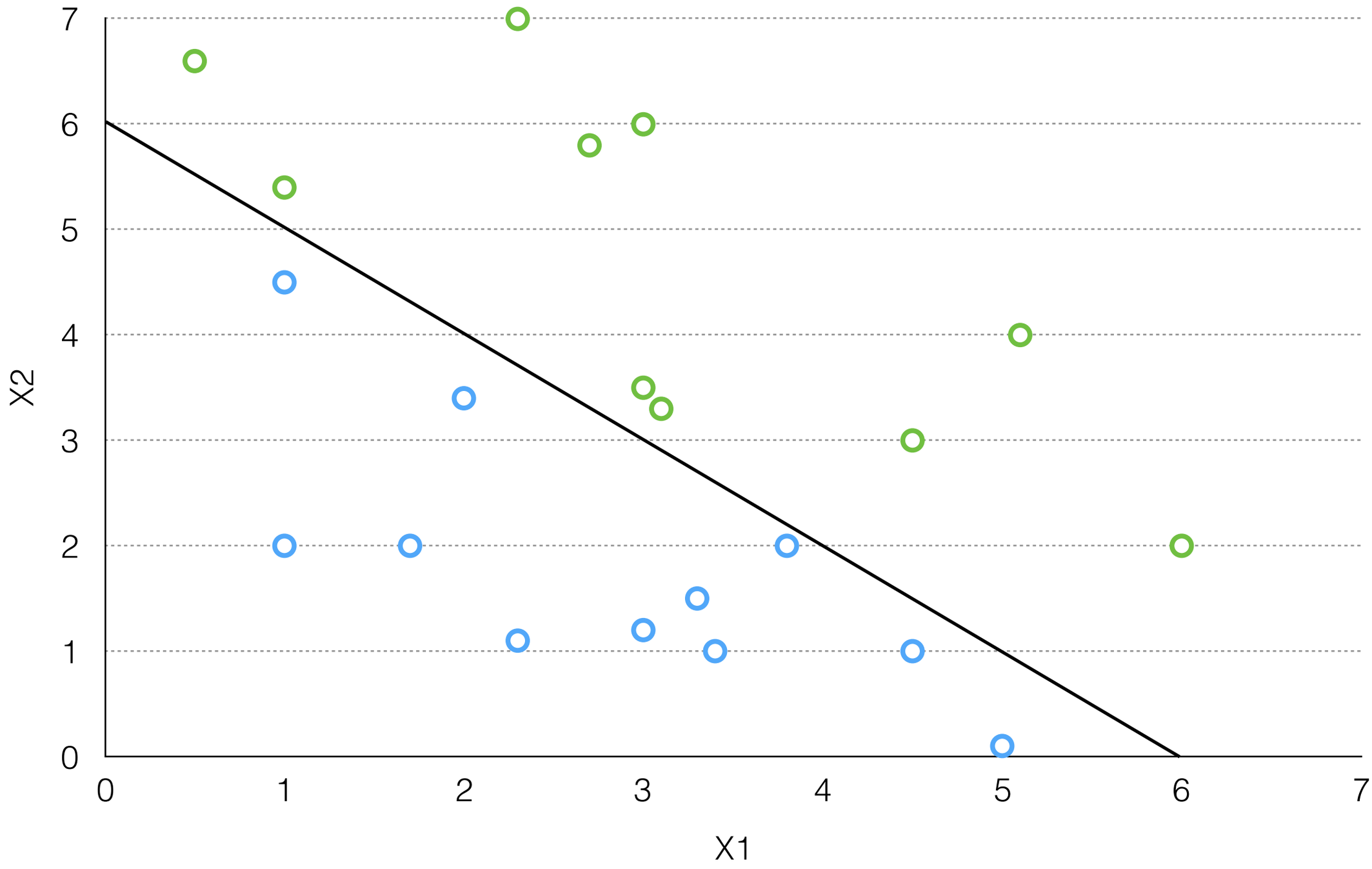
predict 1 when $x_1 + x_2 >= 6$

predict 0 when $x_1 + x_2 < 6$

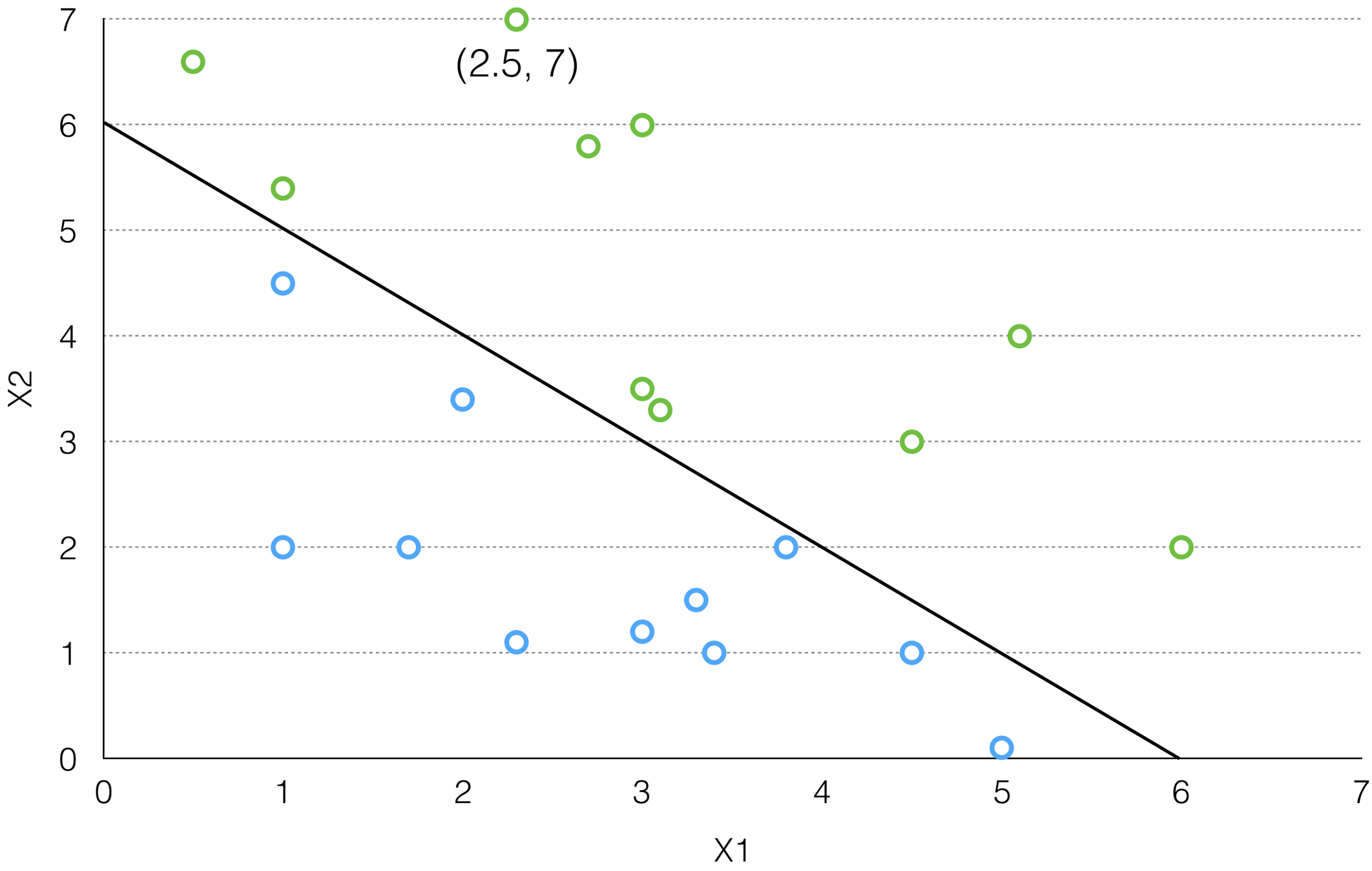
Decision Boundary = -6 + $1x_1$ + $1x_2$



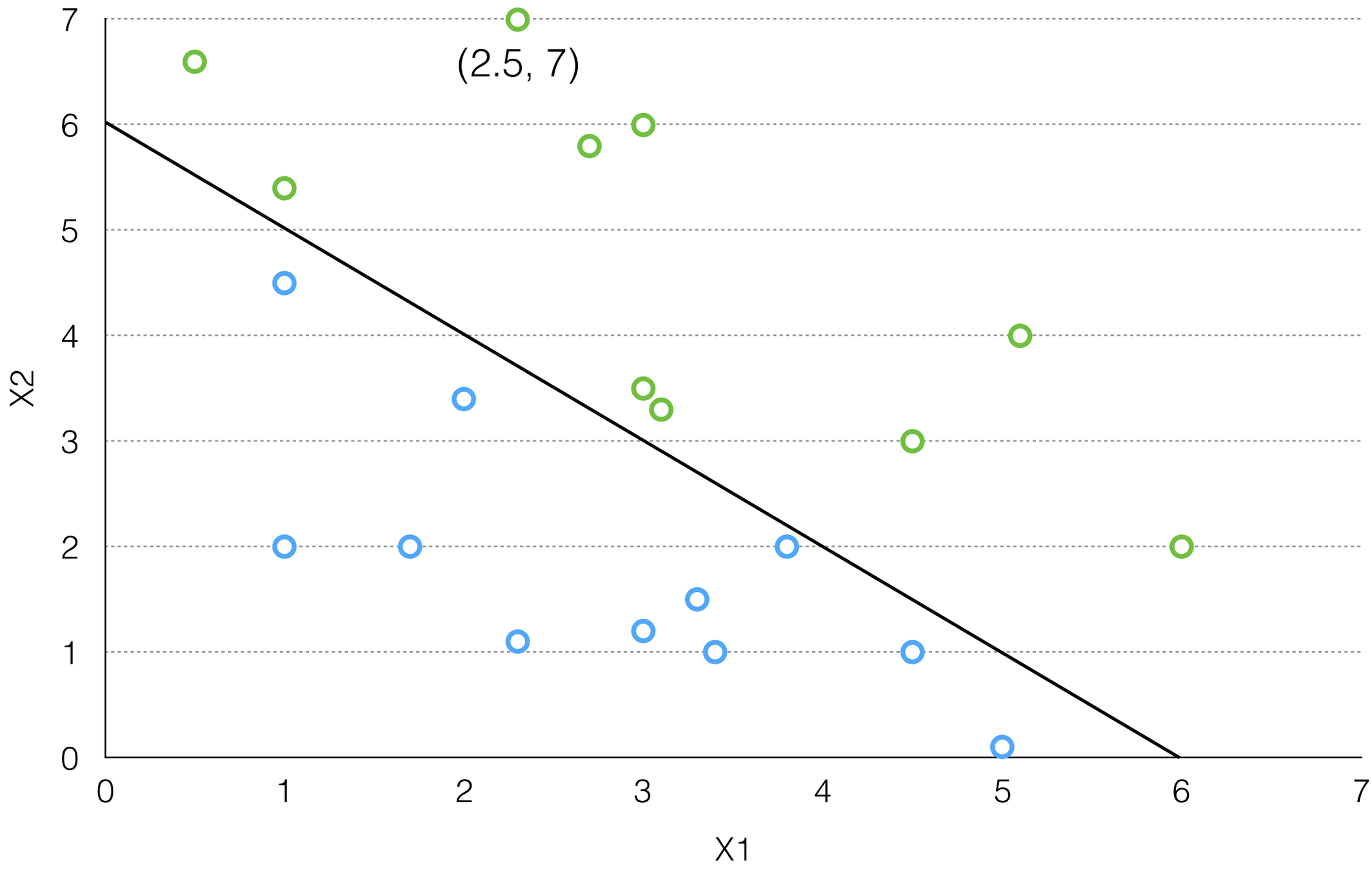
$$\hat{f}(X) = \frac{1}{1+e^{-(-6 + 1x_1 + 1x_2)}}$$



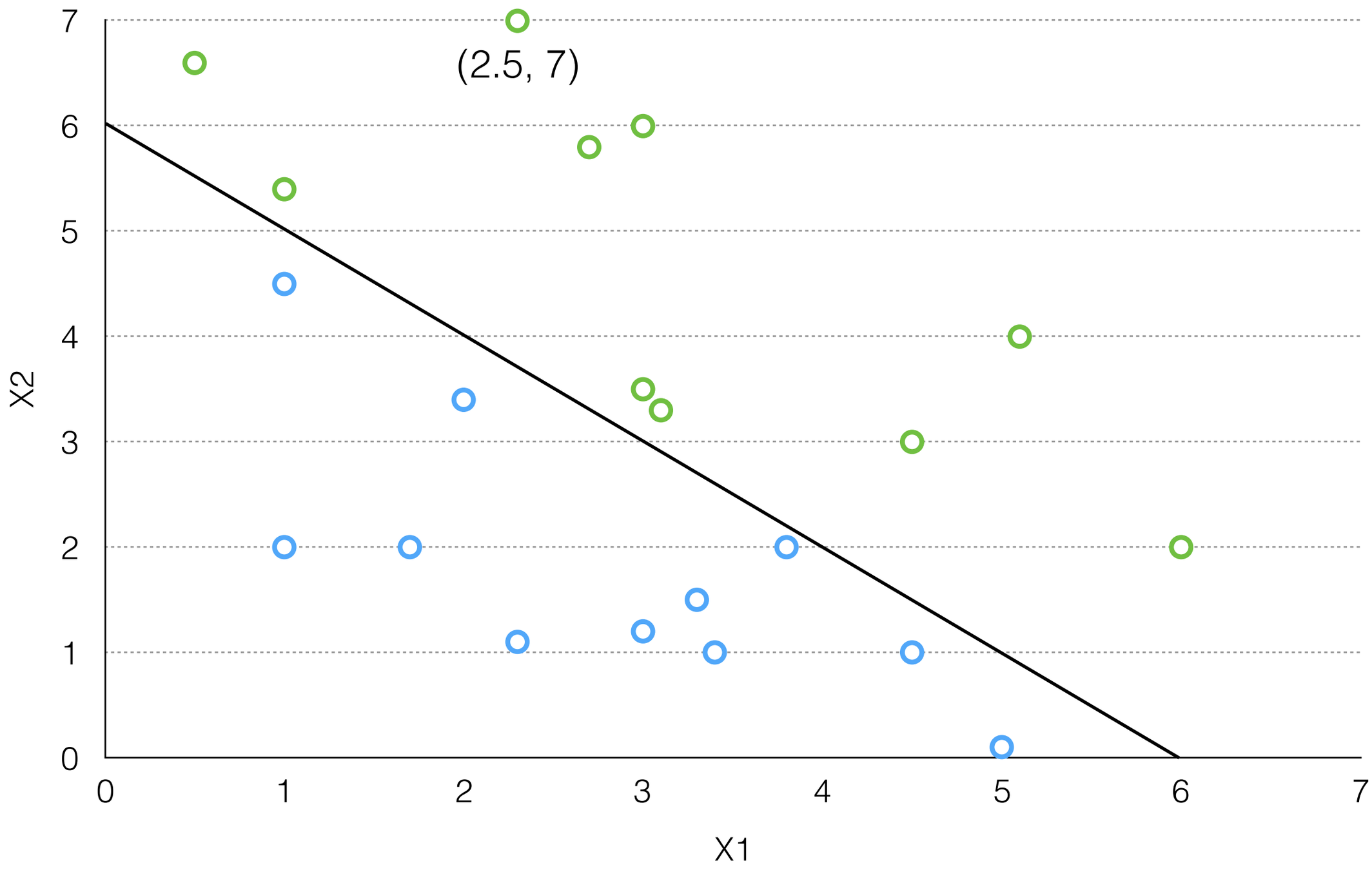
$$\frac{1}{1+e^{-(-6 + 1x_1 + 1x_2)}}$$



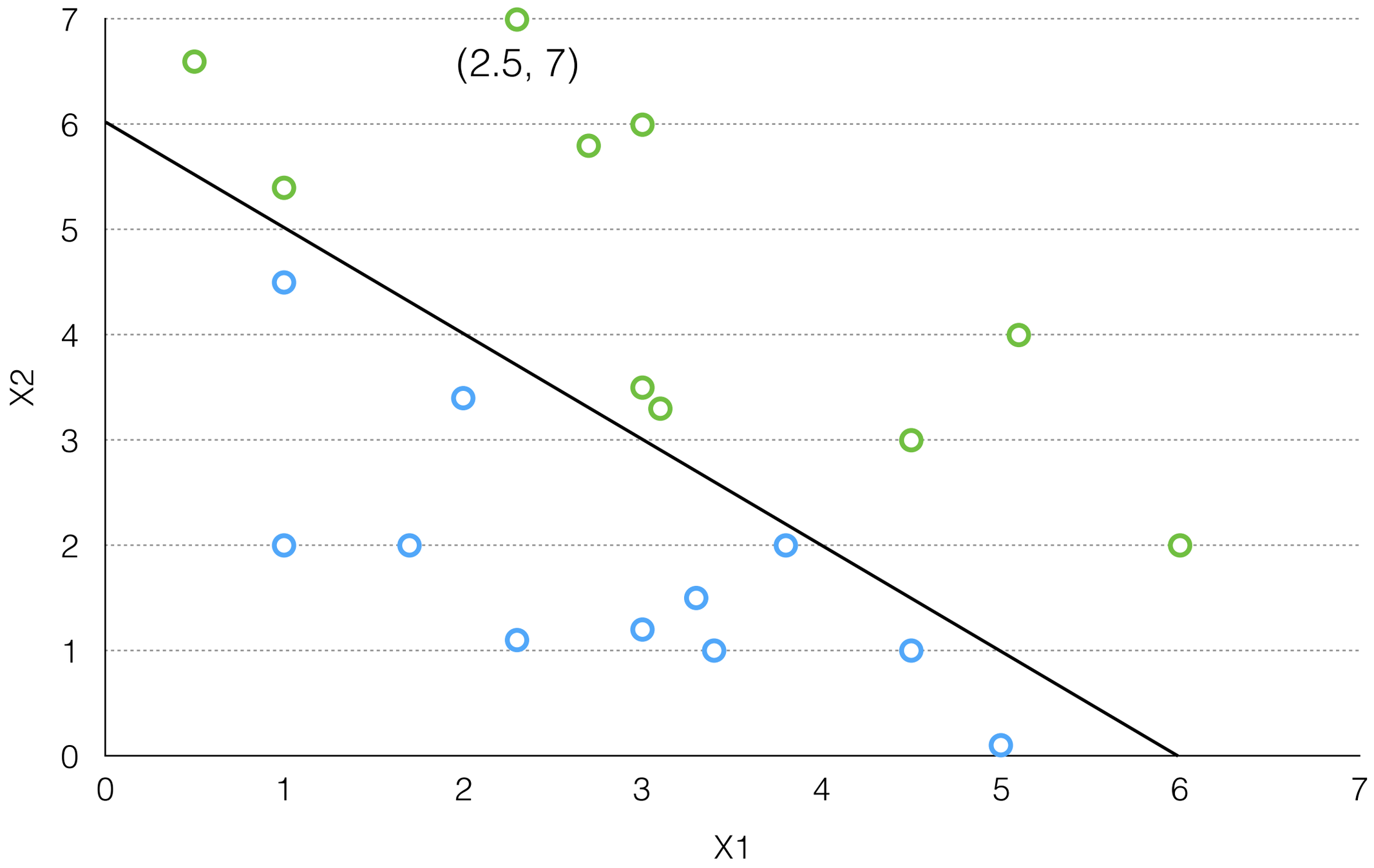
$$\frac{1}{1+e^{-(-6+2.5+7)}}$$



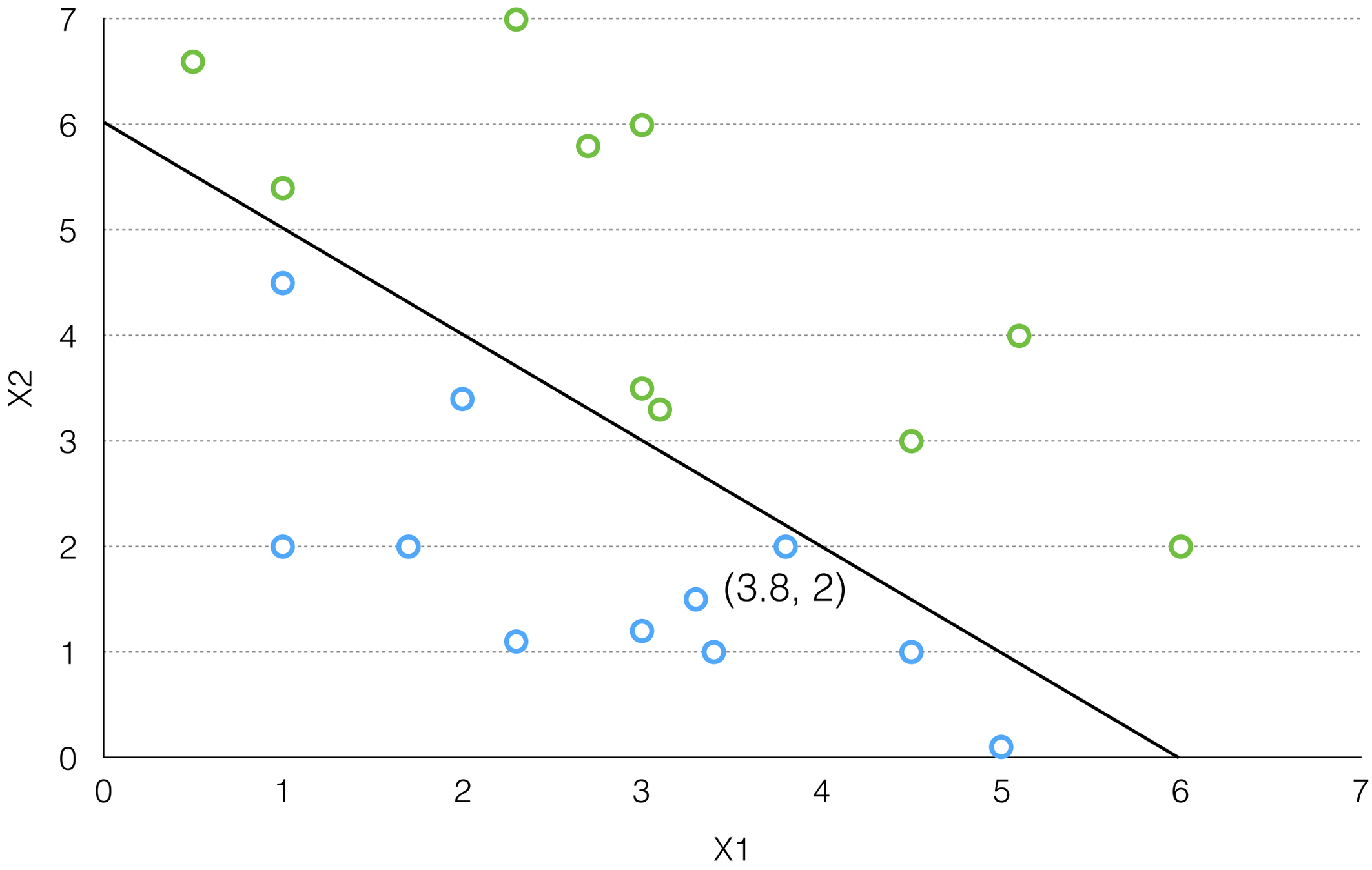
$$\frac{1}{1+e^{-(-6+9.5)}}$$



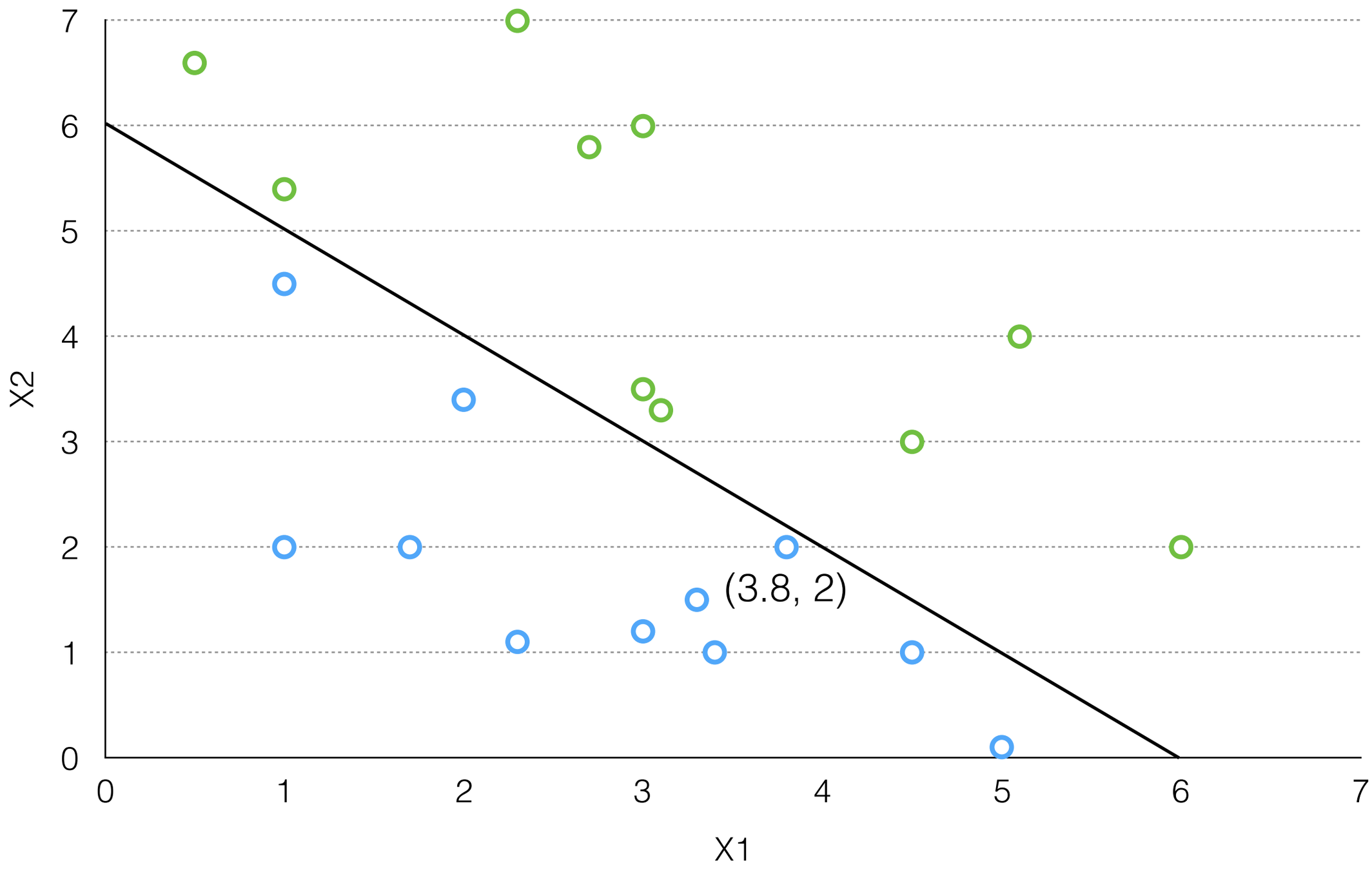
$$\frac{1}{1+e^{-(3.5)}} = .97 \text{ (probability)}$$



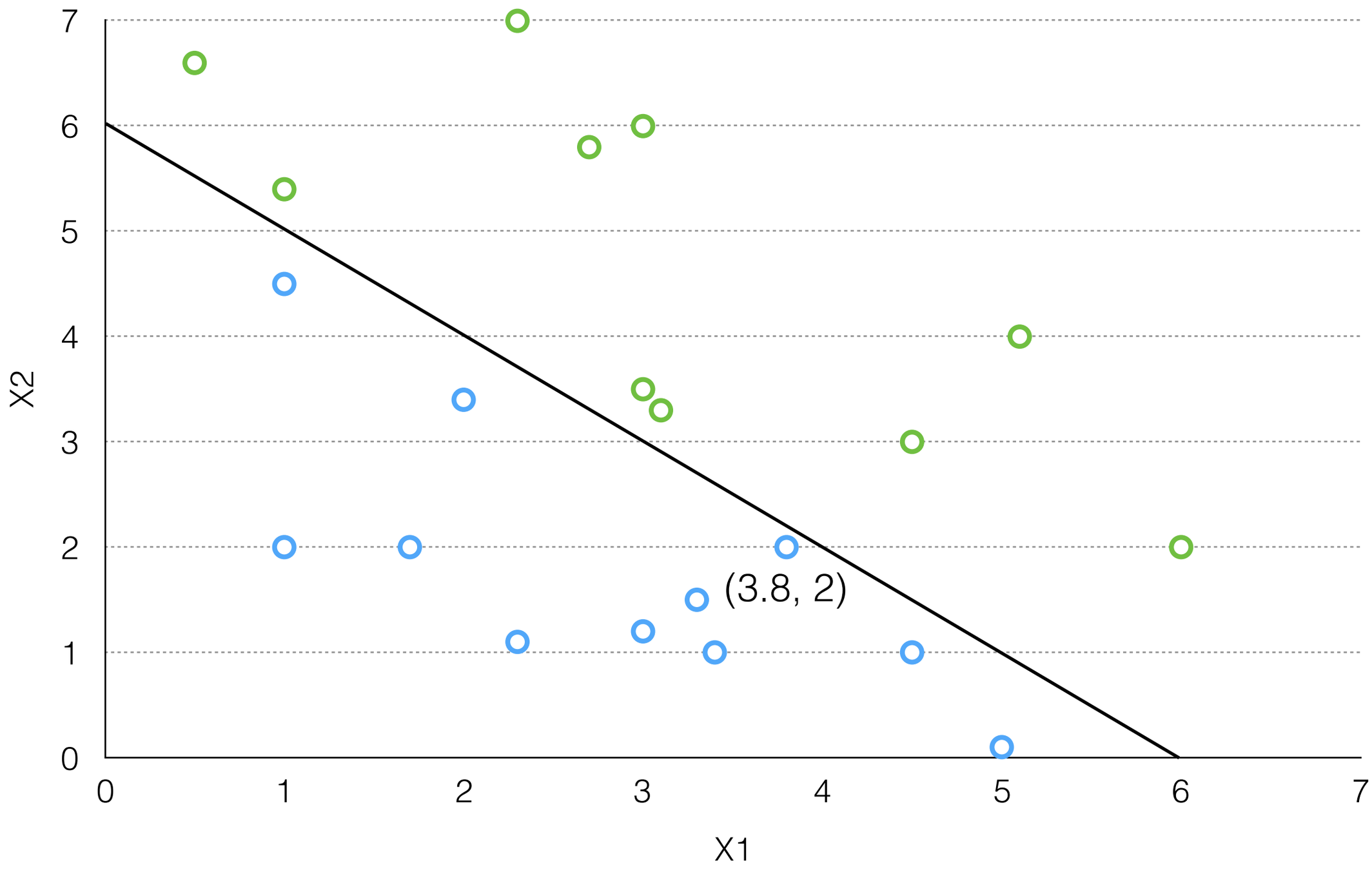
$$\frac{1}{1+e^{-(-6 + 1x_1 + 1x_2)}}$$



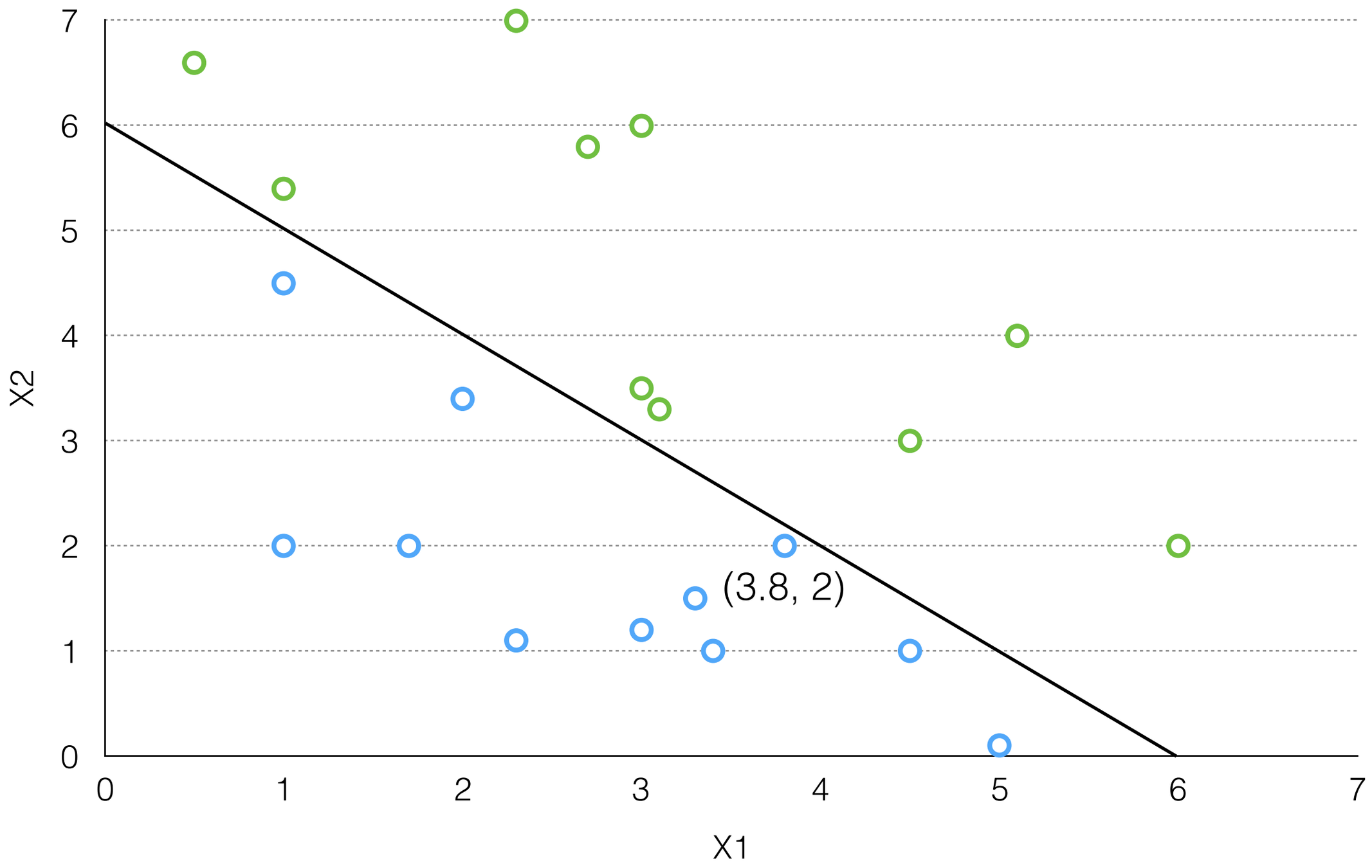
$$\frac{1}{1+e^{-(-6+3.8+2)}}$$



$$\frac{1}{1+e^{-(-6+5.8)}}$$



$$\frac{1}{1+e^{-(-0.2)}} = .45 \text{ probability}$$



Support Vector Machine

Support Vector Machine

$$\beta_0 + \beta_1 x + \beta_2 x + \beta_3 x$$

Support Vector Machine

predict 1 when $\beta_0 + \beta_1 x_1 + \beta_2 x_2 >= 0$

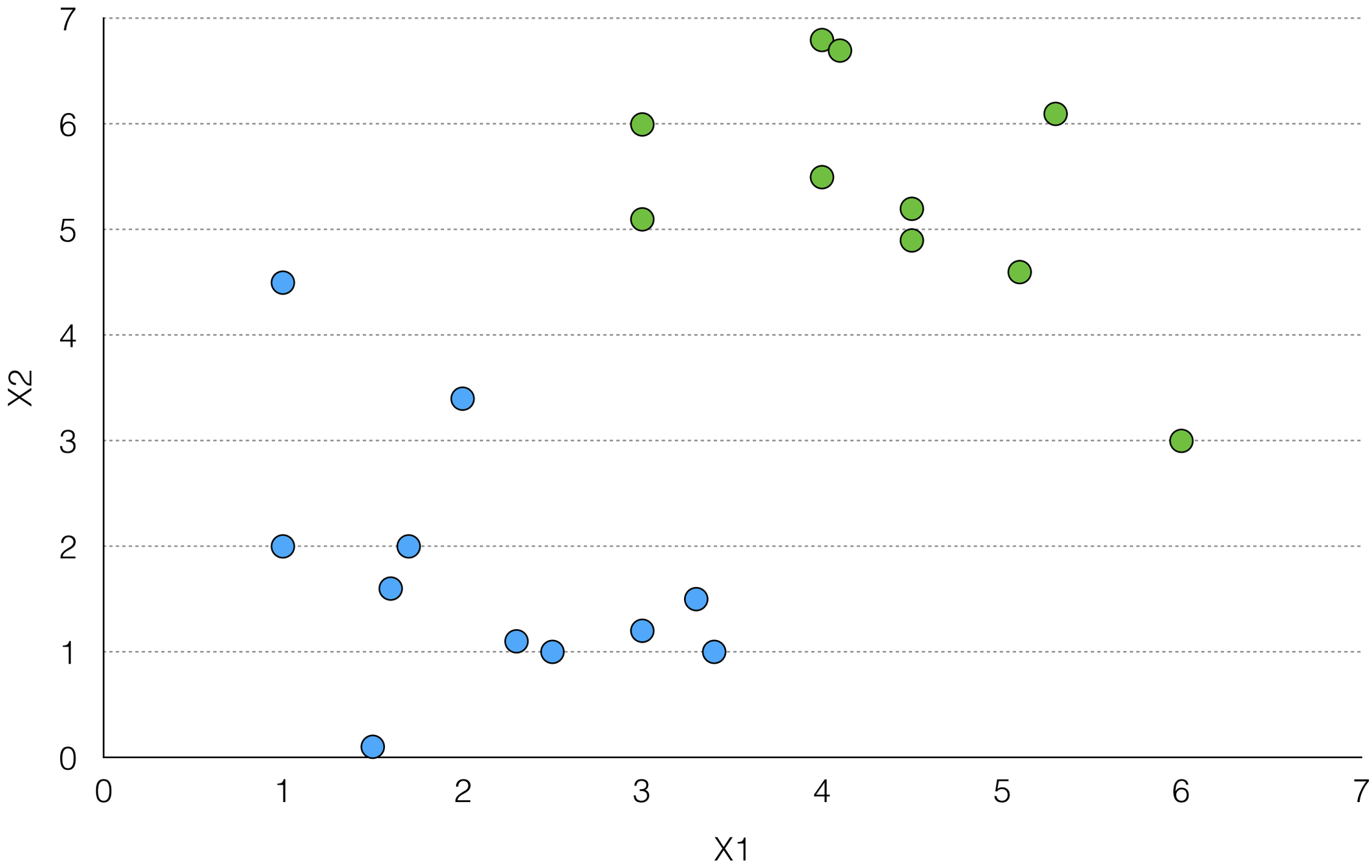
predict 0 when $\beta_0 + \beta_1 x_1 + \beta_2 x_2 < 0$

Support Vector Machine

Large Margin Classifier

predict 1 when $\beta_0 + \beta_1 x_1 + \beta_2 x_2 >= 1$

predict 0 when $\beta_0 + \beta_1 x_1 + \beta_2 x_2 < -1$


7
6
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X2
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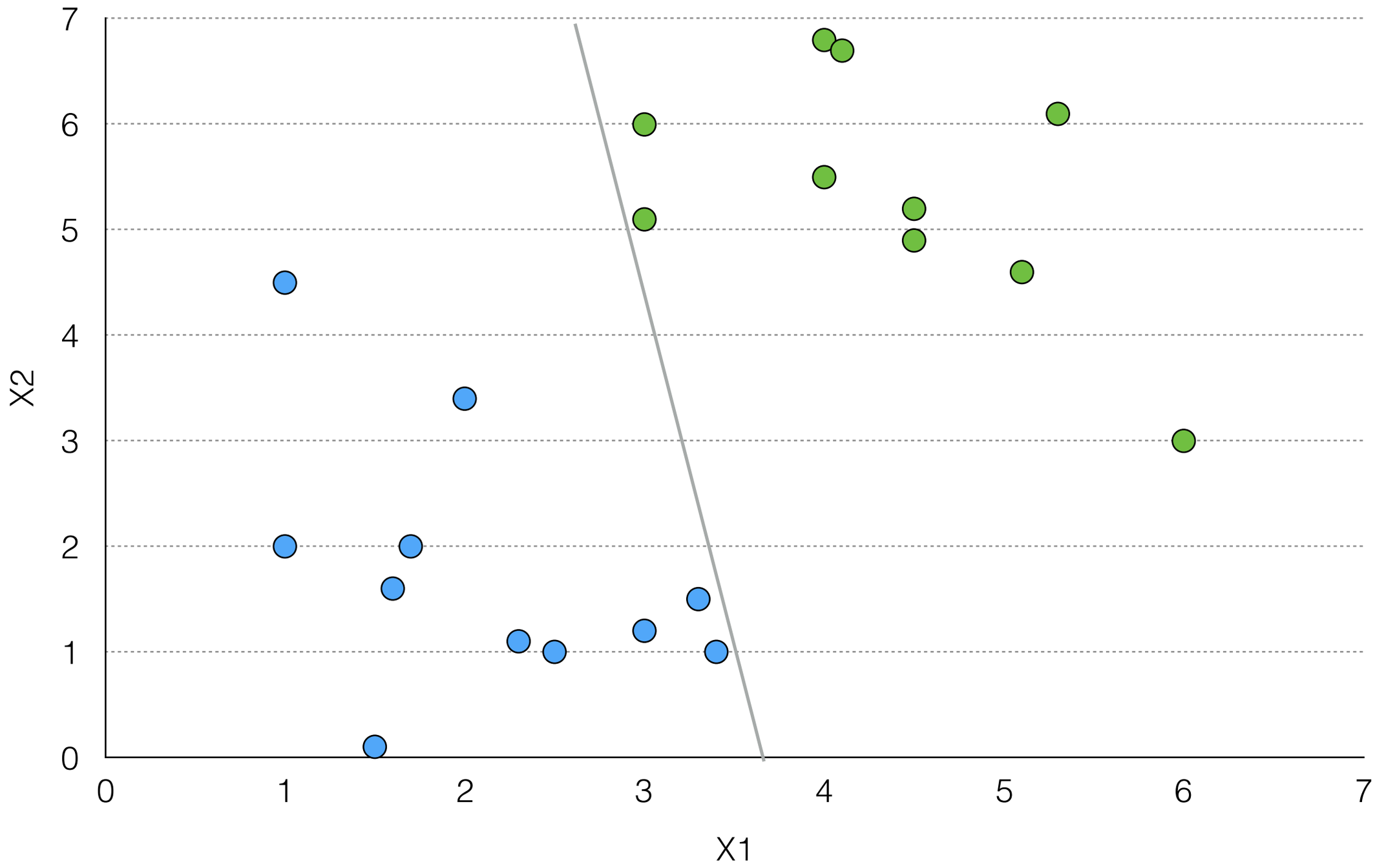
6
7
X1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X2
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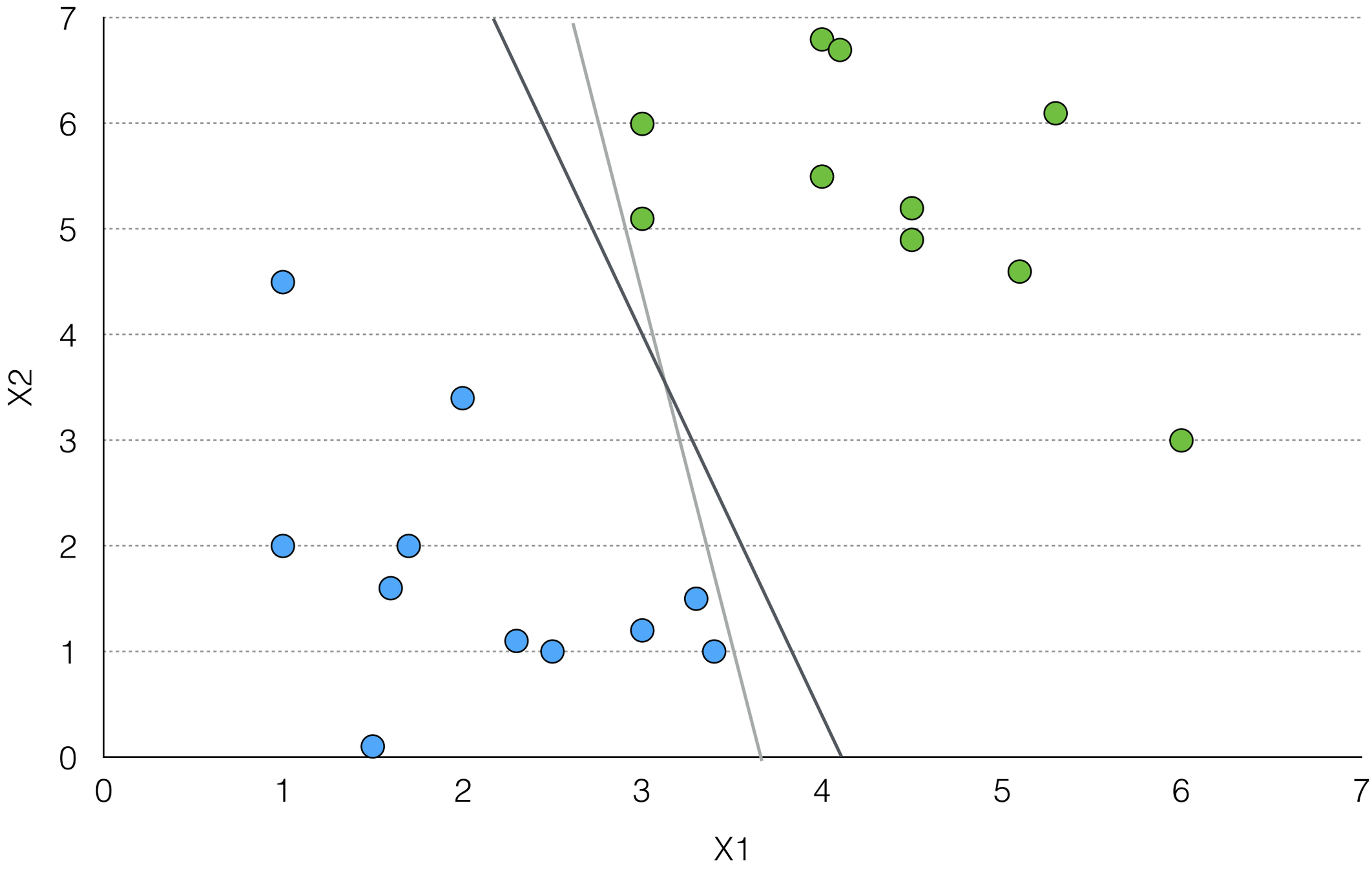
7
X1


7
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X2
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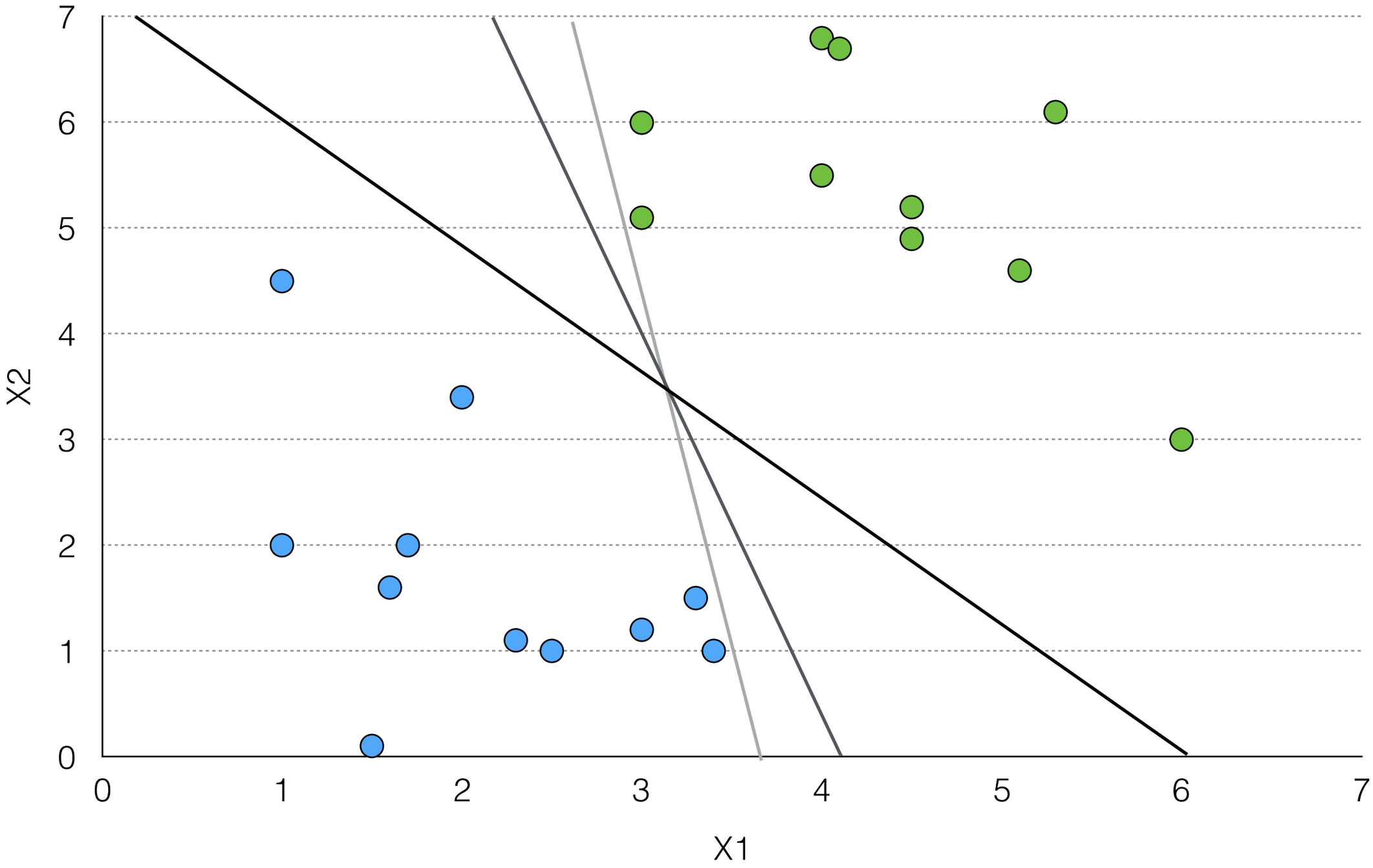
X1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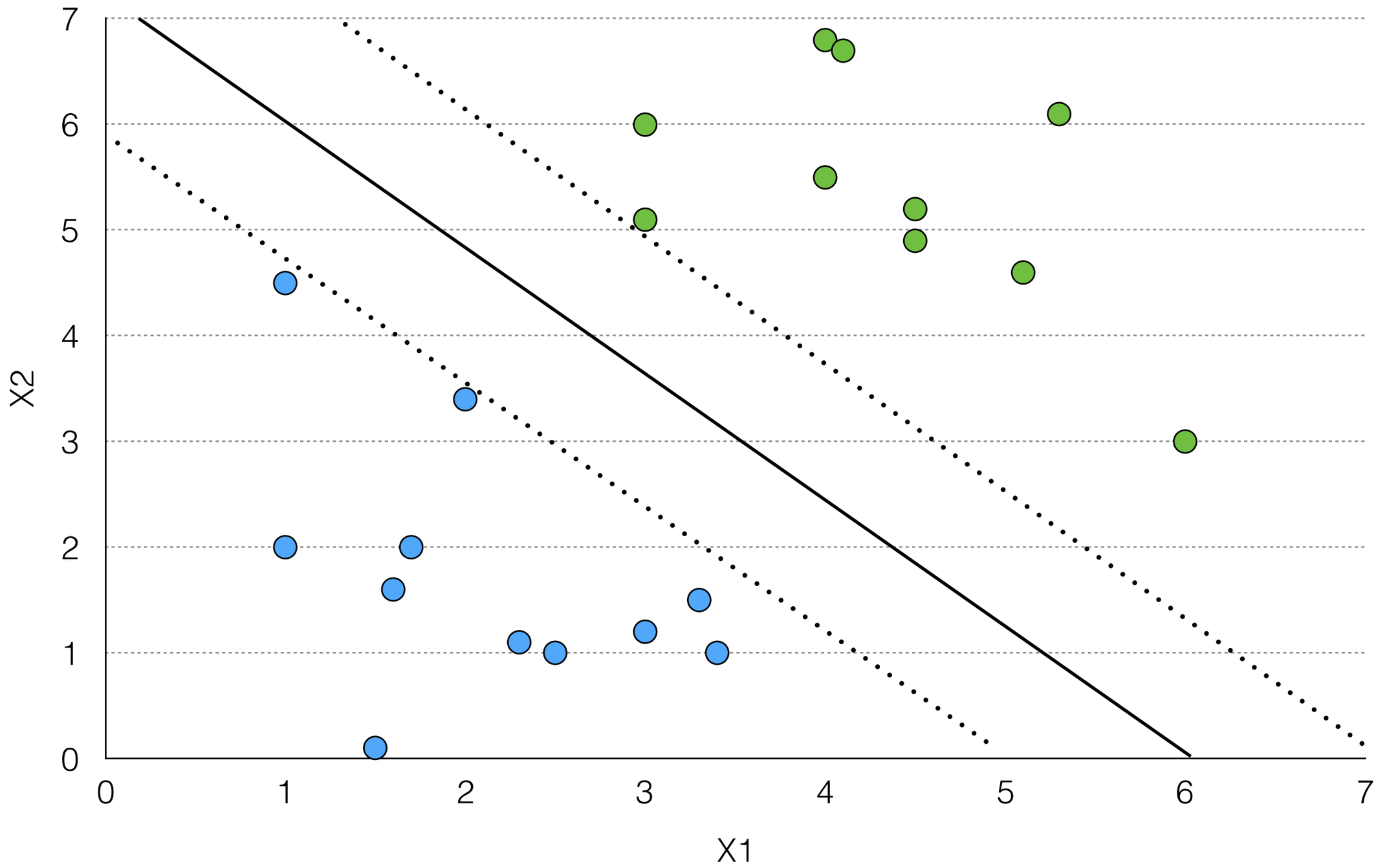
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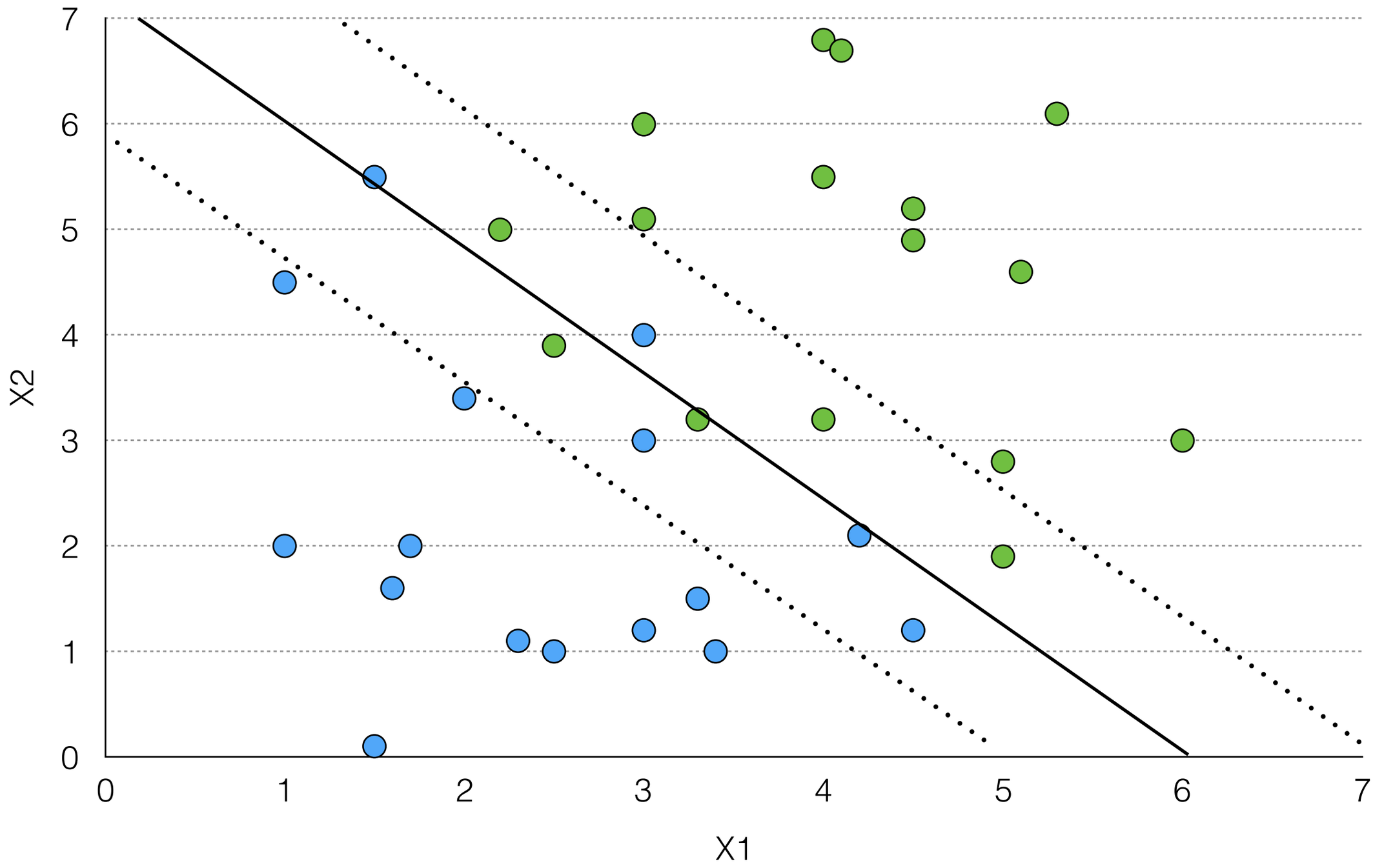
X1


7
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X2
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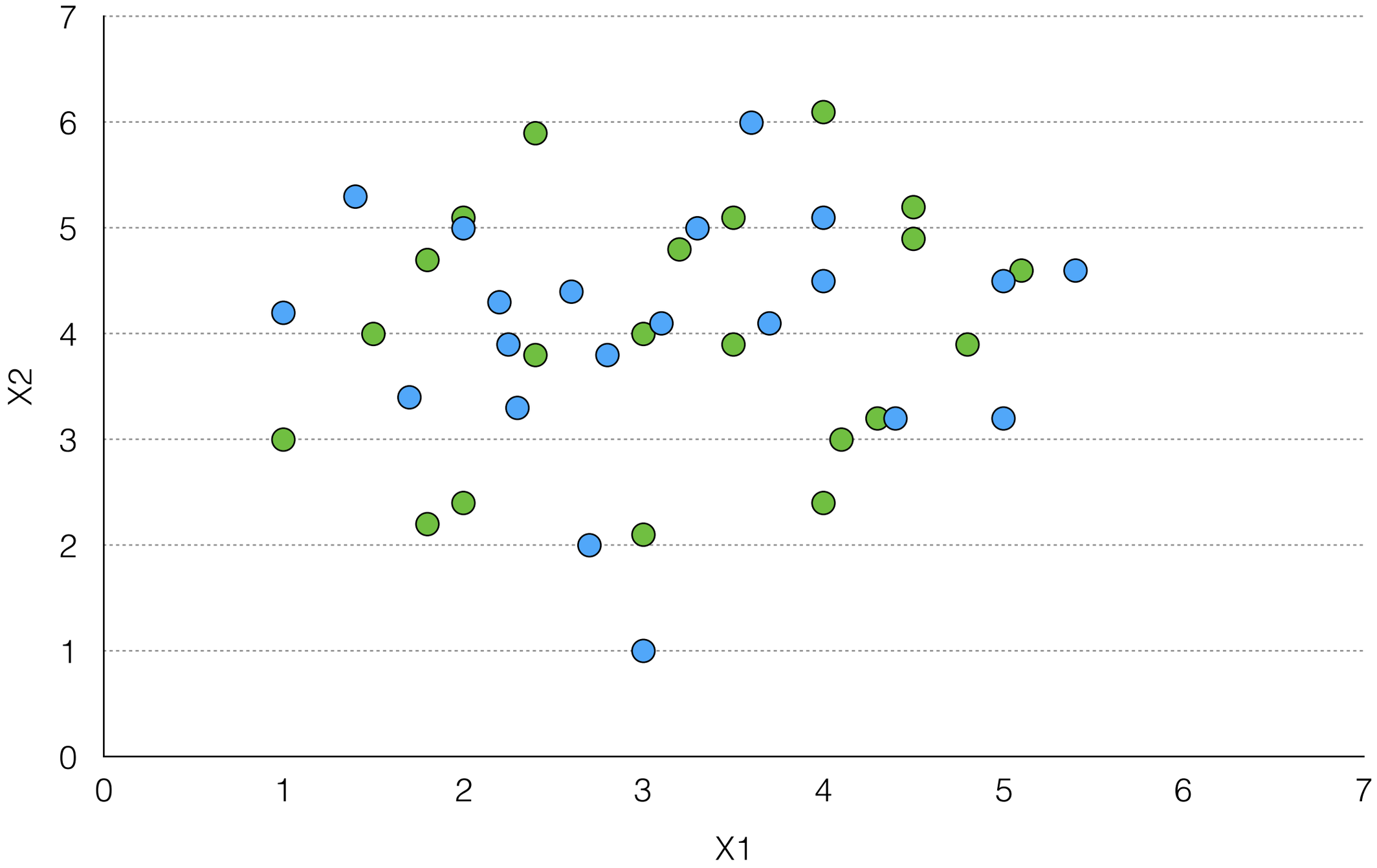
6
7
X1


NFL
SCOUTING
COMBINE
2016

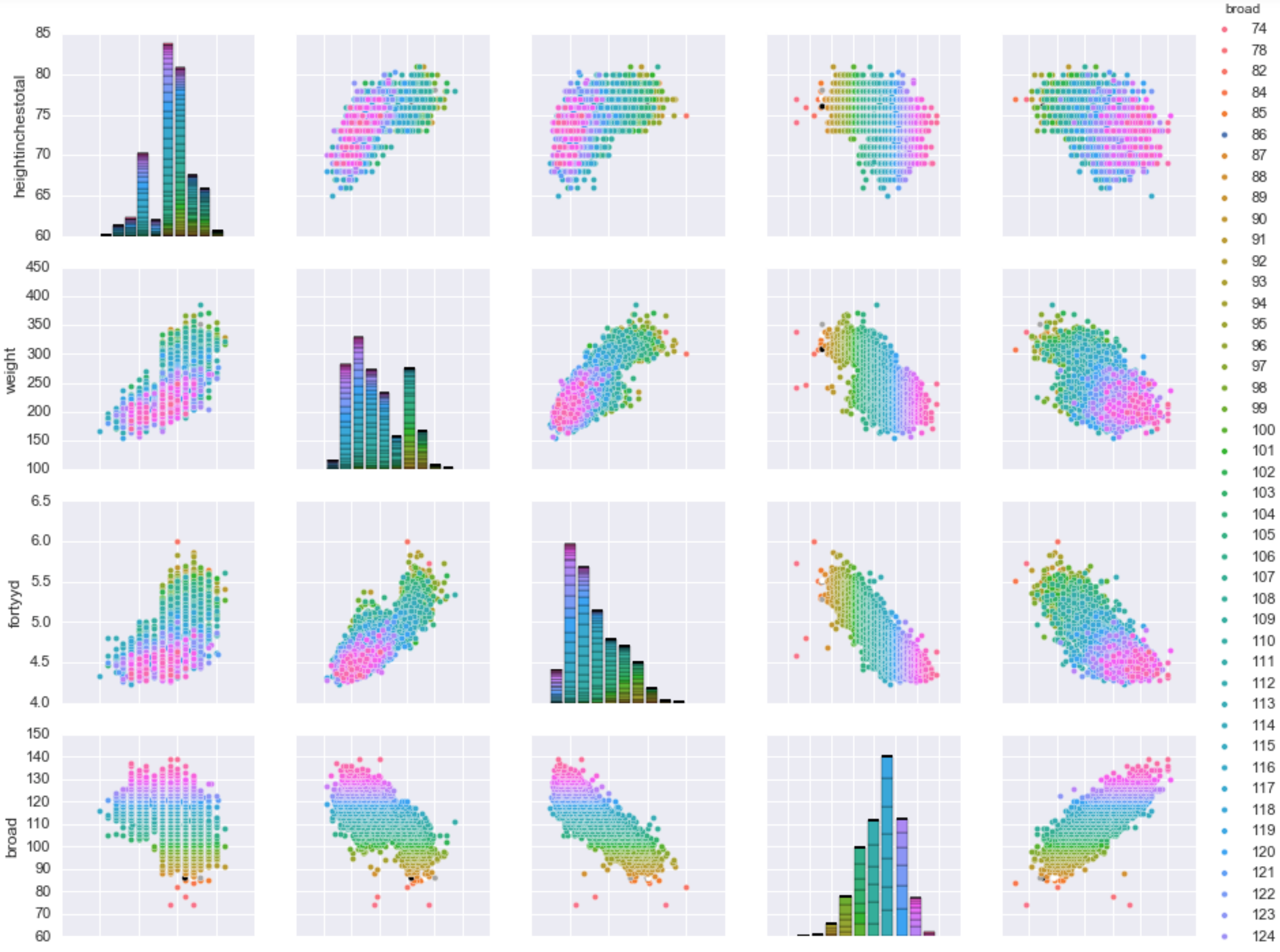
NFL Combine Dataframe

	year	name	position	heightinchestotal	weight	fortyyd	vertical	broad	bench	round	college
520	2014	Tre Mason	RB	68.0	207	4.50	38.5	126	0	3	Auburn
521	2014	Jeff Mathews	QB	76.0	223	5.26	25.5	105	0	0	Cornell
522	2014	Jake Matthews	OT	77.0	308	5.07	30.5	105	24	1	Texas A&M
523	2014	Jordan Matthews	WR	75.0	212	4.46	35.5	120	21	2	Vanderbilt
524	2014	Josh Mauro	DE	78.0	271	5.21	32.0	116	21	0	Stanford
525	2014	AJ McCarron	QB	75.0	220	4.94	28.0	99	0	6	Alabama
526	2014	Daniel McCullers	DT	79.0	352	0.00	20.5	97	27	7	Tennessee
527	2014	Dexter McDougle	CB	70.0	196	0.00	0.0	0	0	3	Maryland
528	2014	Keith McGill	CB	75.0	211	4.51	39.0	129	0	4	Utah
529	2014	Jerick McKinnon	RB	69.0	209	4.41	40.5	132	32	3	Georgia Southern

40-yard dash	Weight	Height	Drafted
5.10	290	74	1
4.92	275	75.5	1
4.43	178	69	0
4.62	221	74.5	1
4.91	248	75	0
5.53	303	77	0
4.47	189	71	1
4.56	205	71	1
4.75	267	73	0
4.84	261	74	1


7
6
5
4
3
2
1
0
X2
0
1
2
3
4
5
6
7
X1

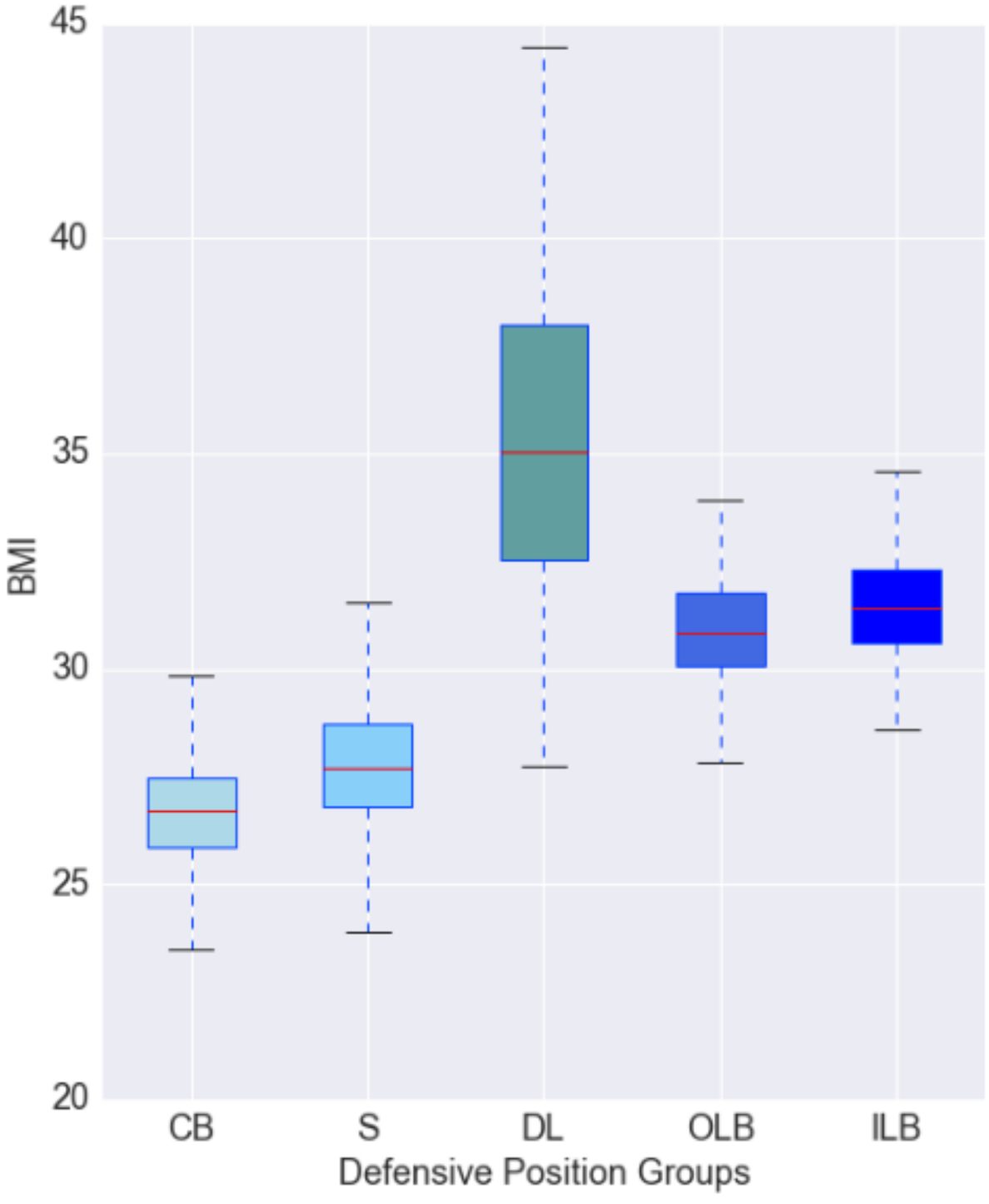
40-yard dash	Weight	Height	Drafted
5.10	290	74	1
4.92	275	75.5	1
4.43	178	69	0
4.62	221	74.5	1
4.91	248	75	0
5.53	303	77	0
4.47	189	71	1
4.56	205	71	1
4.75	267	73	0
4.84	261	74	1

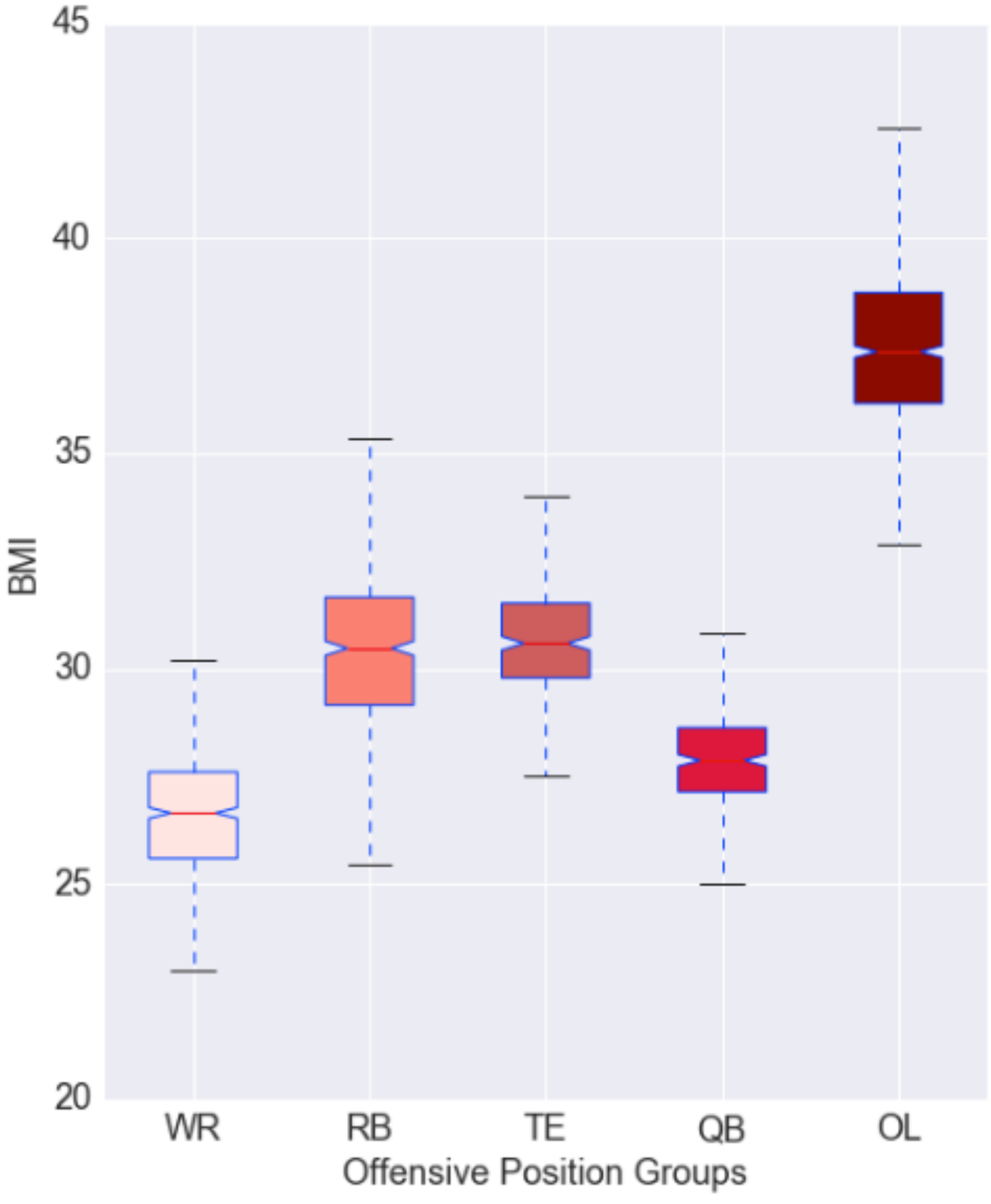

heightinchestotal
85
80
75
70
65
60
weight
450
400
350
300
250
200
150
100
fortyyd
6.5
6.0
5.5
5.0
4.5
4.0
broad
150
140
130
120
110
100
90
80
70
60
broad
74
78
82
84
85
86
87
88
89
90
91
92
93
94
95
96
97
98
99
100
101
102
103
104
105
106
107
108
109
110
111
112
113
114
115
116
117
118
119
120
121
122
123
124

40-yard dash	Weight	Height	Drafted
5.10	290	74	1
4.92	275	75.5	1
4.43	178	69	0
4.62	221	74.5	1
4.91	248	75	0
5.53	303	77	0
4.47	189	71	1
4.56	205	71	1
4.75	267	73	0
4.84	261	74	1

Feature Engineering

40-yard dash	BMI (wt/ht^2)	Drafted
5.10	37.2	1
4.92	33.9	1
4.43	26.3	0
4.62	28	1
4.91	31	0
5.53	35.9	0
4.47	26.4	1
4.56	28.6	1
4.75	35.2	0
4.84	33.5	1


45
40
35
30
25
20
BMI
CB
S
DL
OLB
ILB
Defensive Position Groups


45
40
35
30
25
20
BMI
WR
RB
TE
QB
OL
Offensive Position Groups

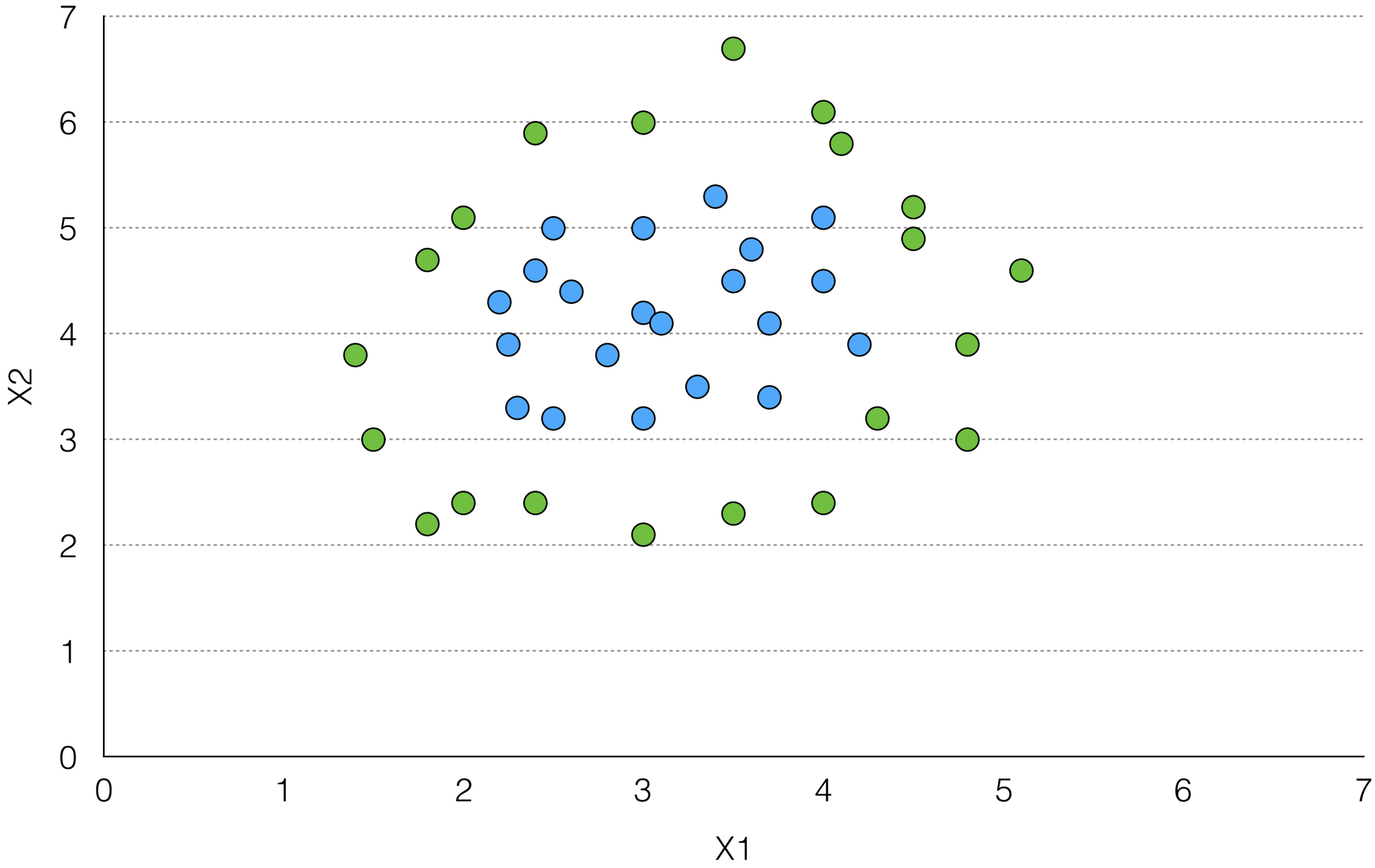

44
OL

Feature Engineering

40-yard dash	BMI (wt/ht^2)	Drafted
5.10	37.2	1
4.92	33.9	1
4.43	26.3	0
4.62	28	1
4.91	31	0
5.53	35.9	0
4.47	26.4	1
4.56	28.6	1
4.75	35.2	0
4.84	33.5	1

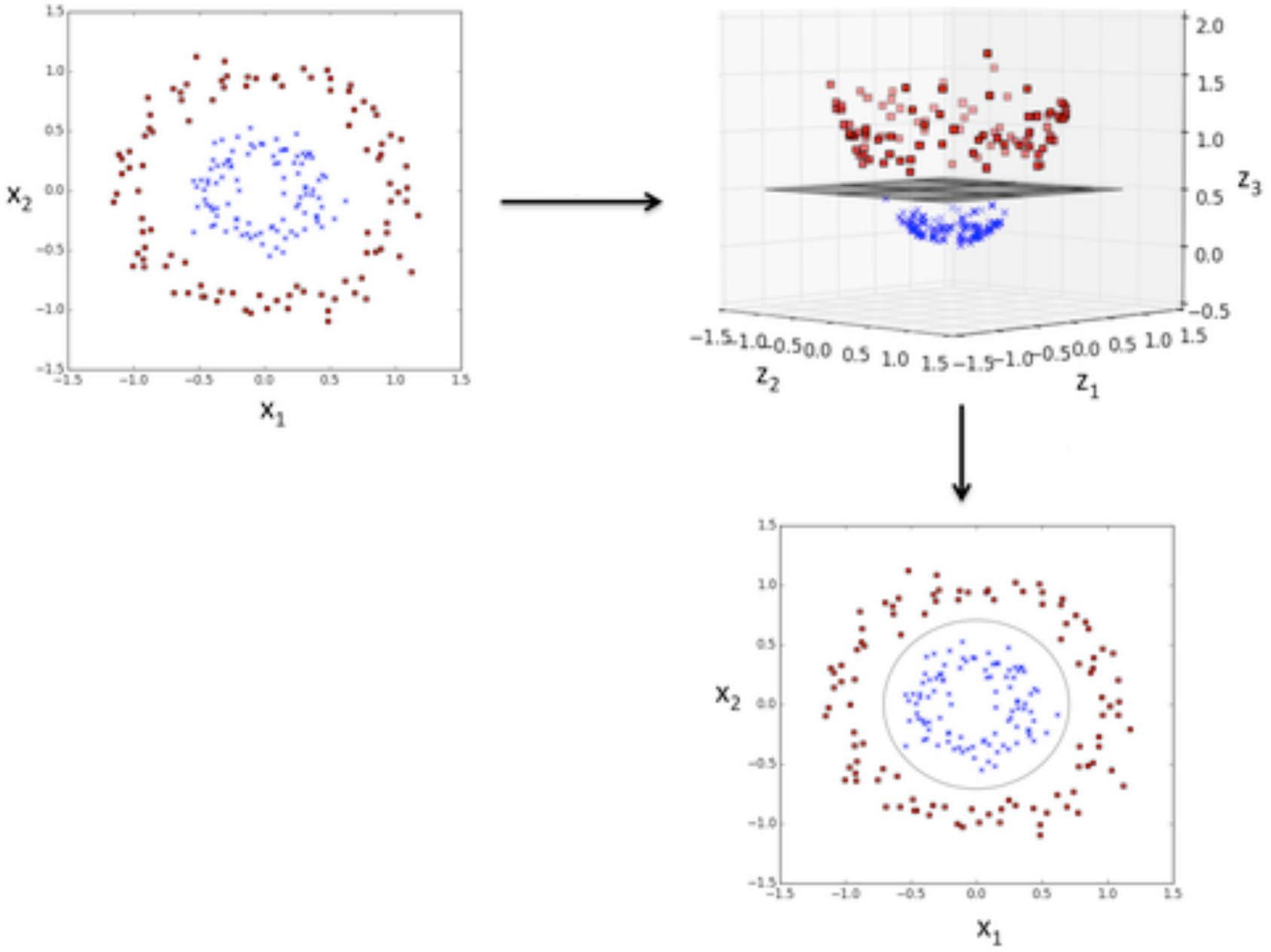
Feature Engineering

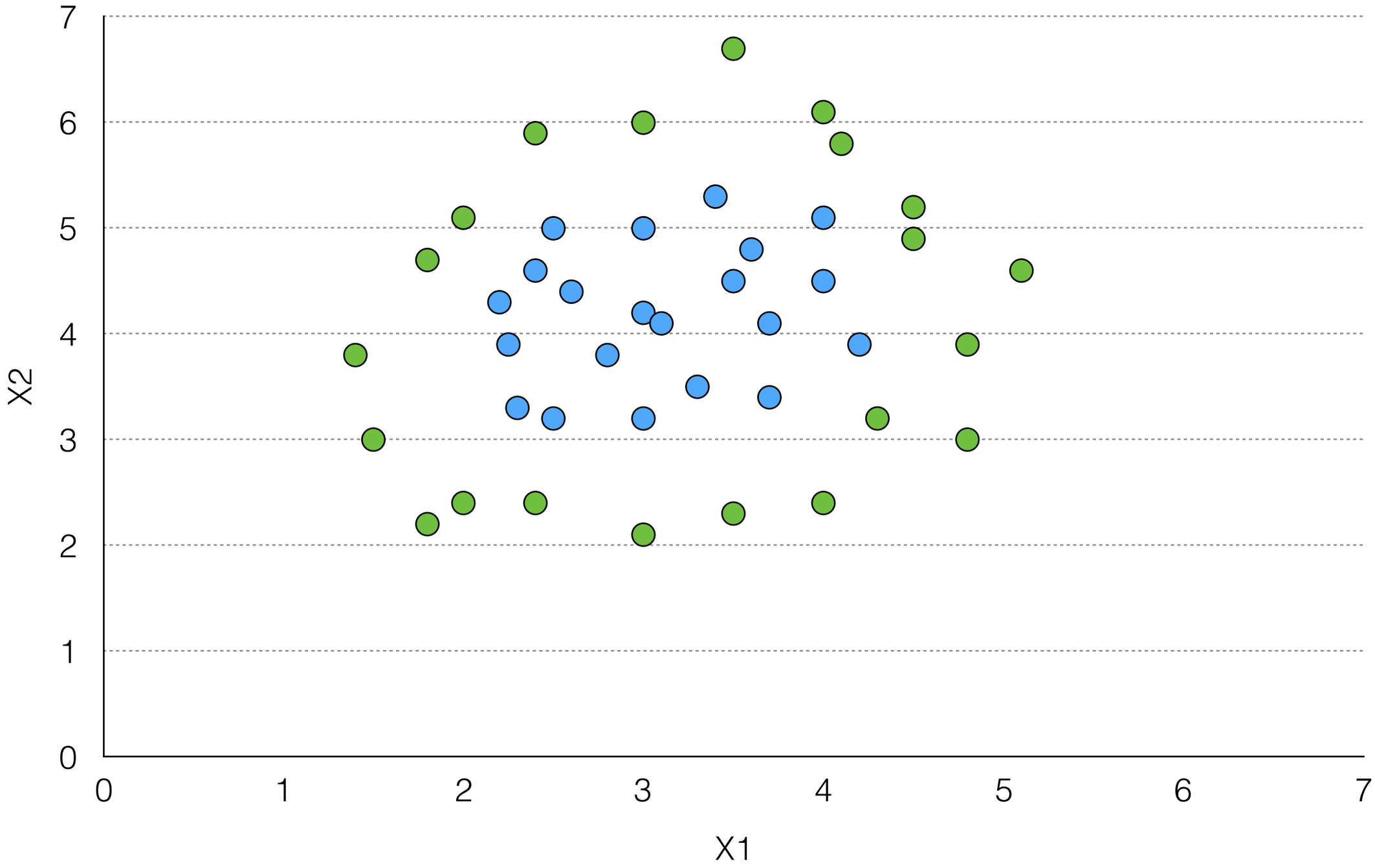
Size-to-Speed (40-yd/bsa)	BMI (wt/ht^2)	Drafted
2.16	37.2	1
2.06	33.9	1
2.02	26.3	0
1.97	28	1
2.23	31	0
2.00	35.9	0
2.03	26.4	1
1.99	28.6	1
1.85	35.2	0
2.03	33.5	1

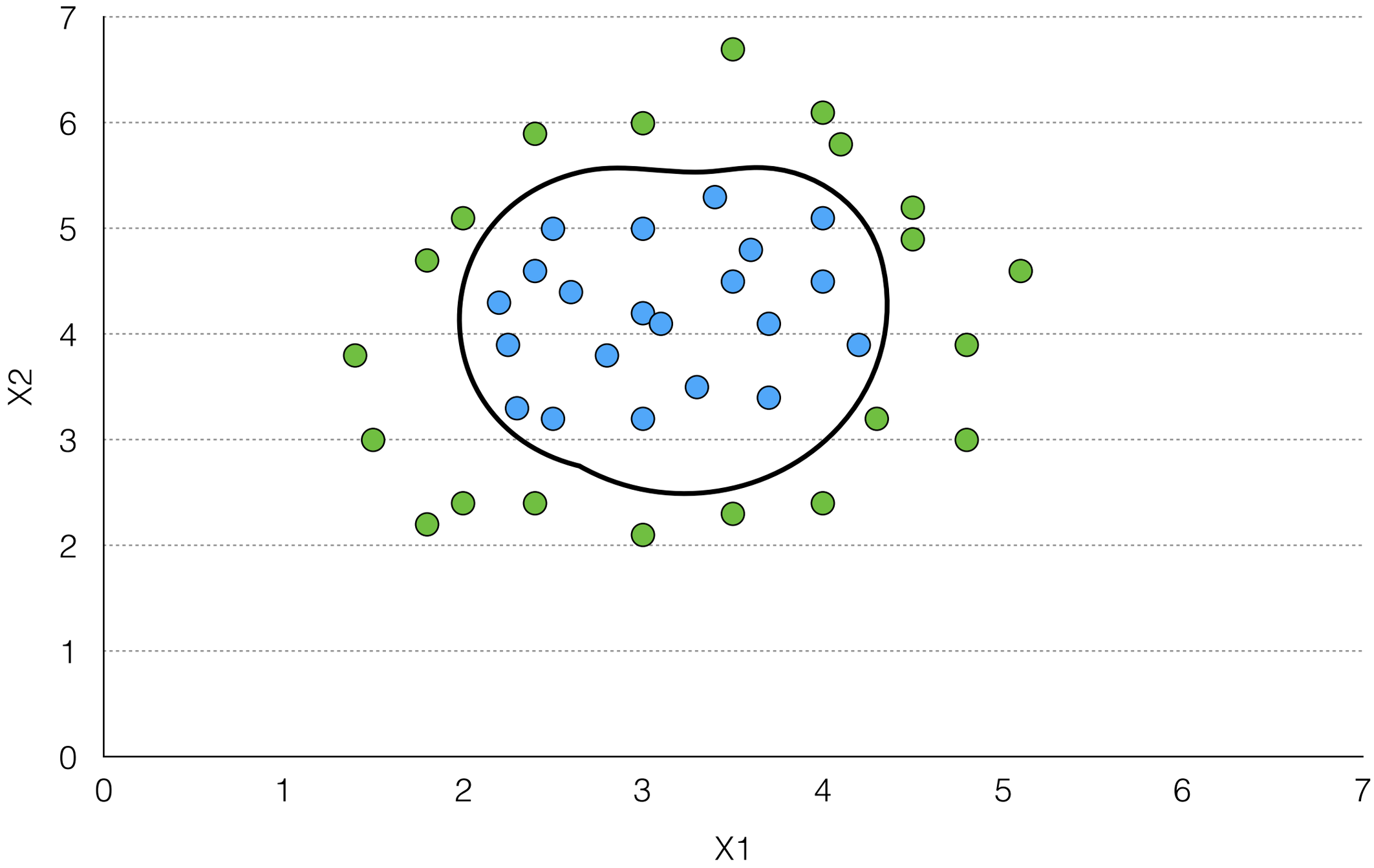

7
6
5
4
3
2
1
0
X2
0
1
2
3
4
5
6
7
X1

Kernel

non-linear classification

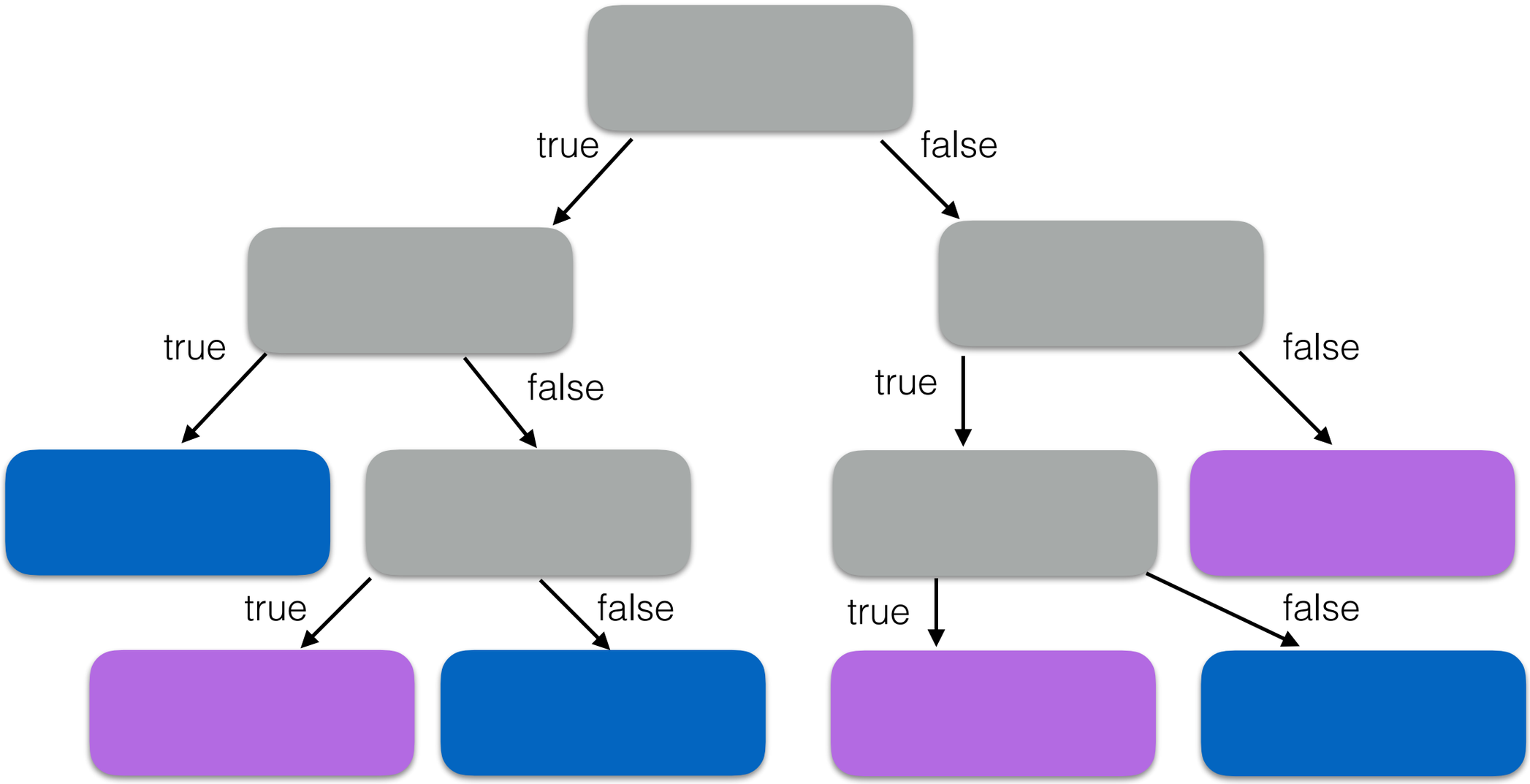

x_2
x_1
z_3
z_2
z_1
x_2
x_1


7
6
5
4
3
2
1
0
X2
0
1
2
3
4
5
6
7
X1


7
6
5
4
3
2
1
0
X2
0
1
2
3
4
5
6
7
X1

Decision Tree

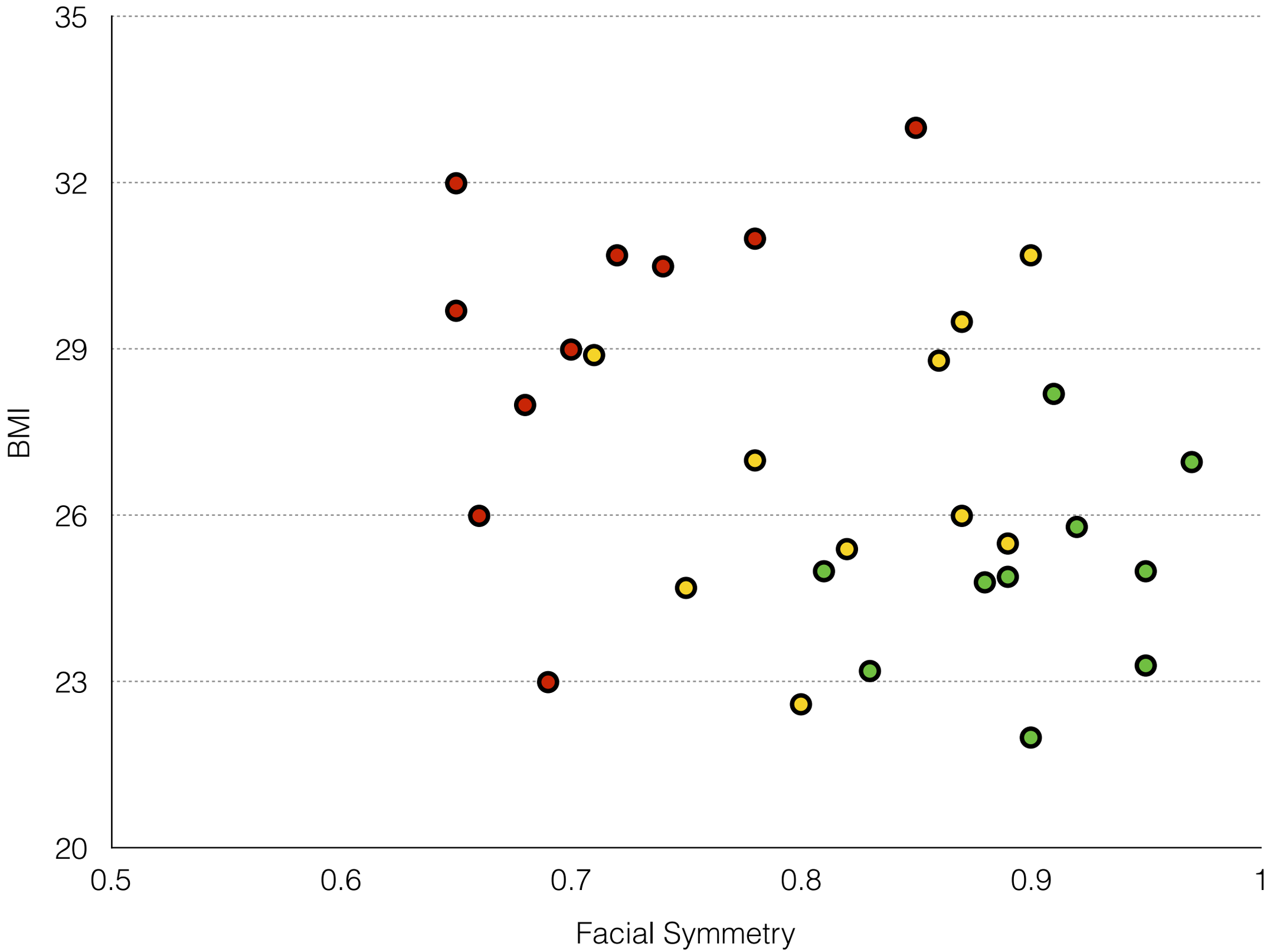
Decision Tree



Short-term Attractiveness

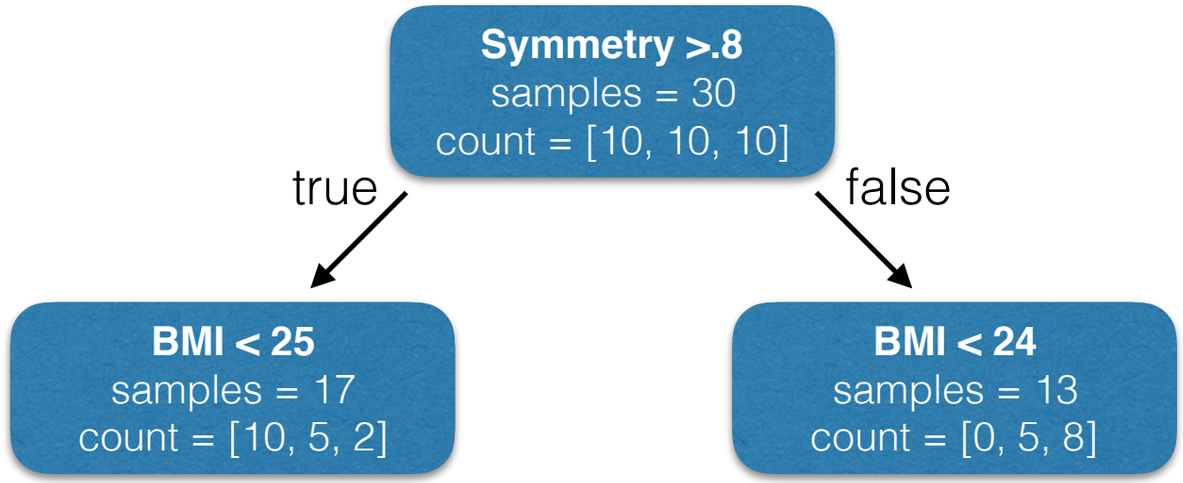
Short-term Attractiveness

Facial Symmetry	BMI	Waist-to-Hip	Well-Groomed
0.9	23.4	0.93	1
0.85	27.9	0.87	0
0.65	27.1	0.79	1
0.85	22.6	0.91	1
0.9	30.3	0.82	0
0.75	29.0	0.82	0
0.85	22.3	0.89	1
0.7	37.6	0.73	0
0.85	24.2	0.85	0

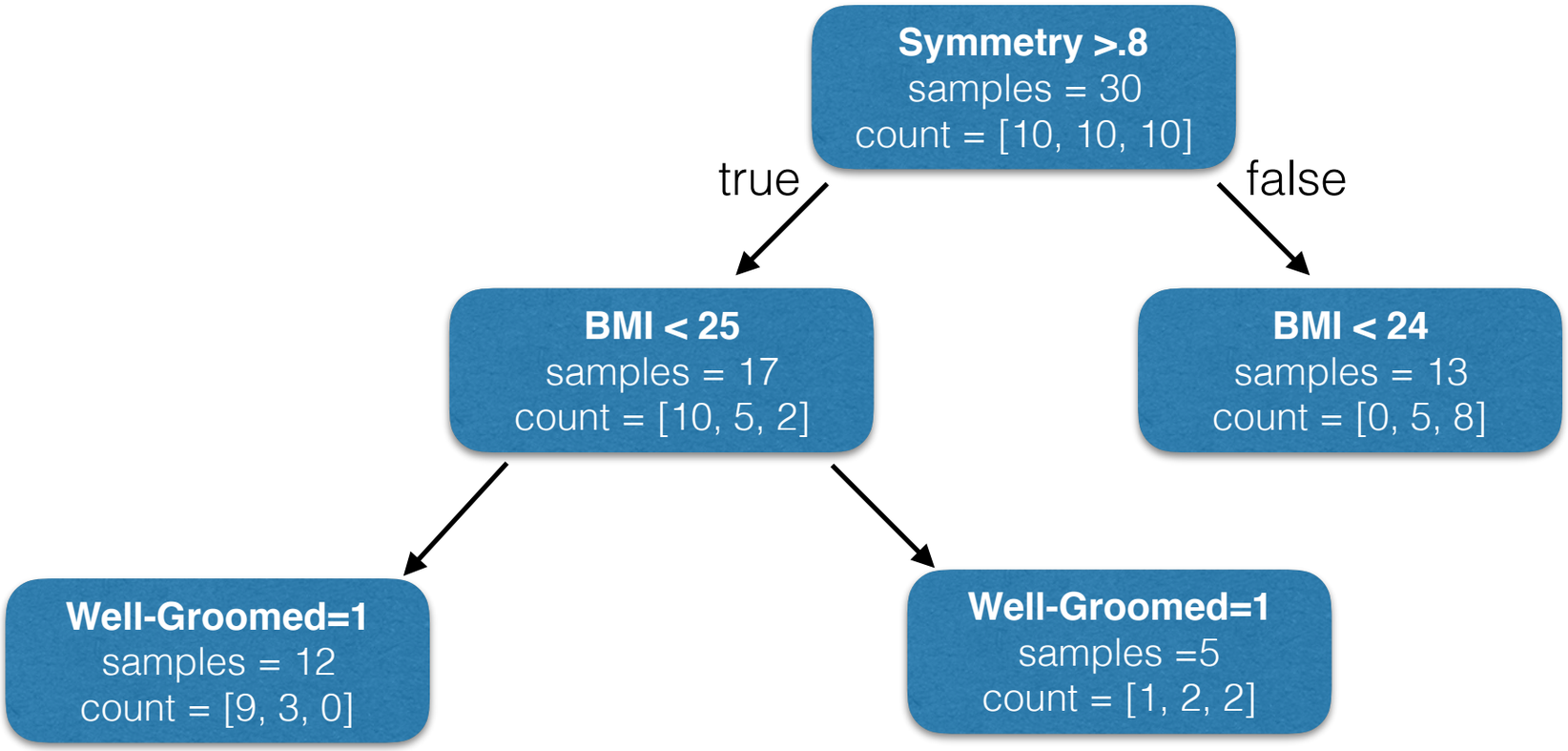

35
32
29
26
23
20
BMI
0.5
0.6
0.7
0.8
0.9
1
Facial Symmetry

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

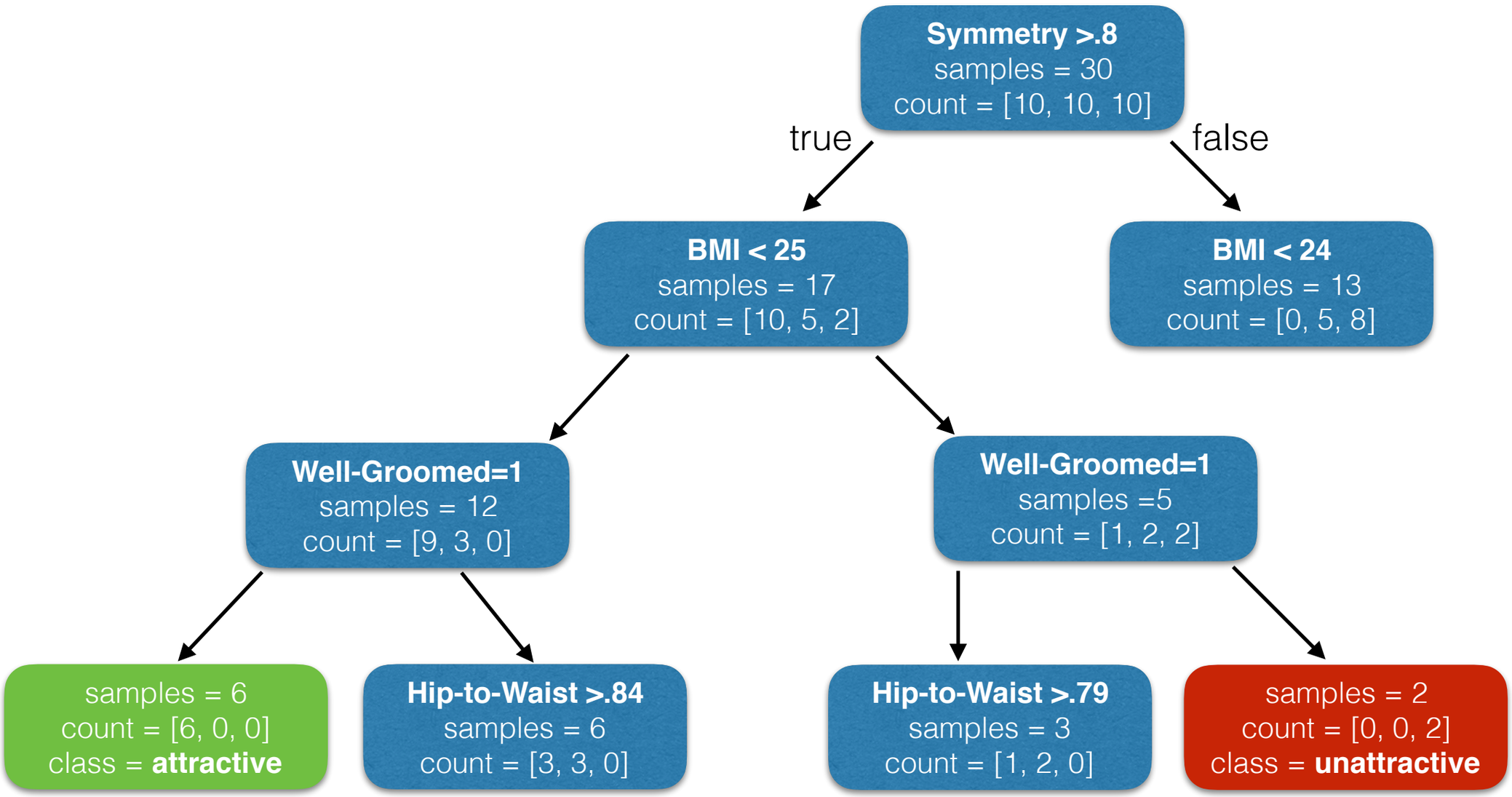
[att, ave, un]


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]

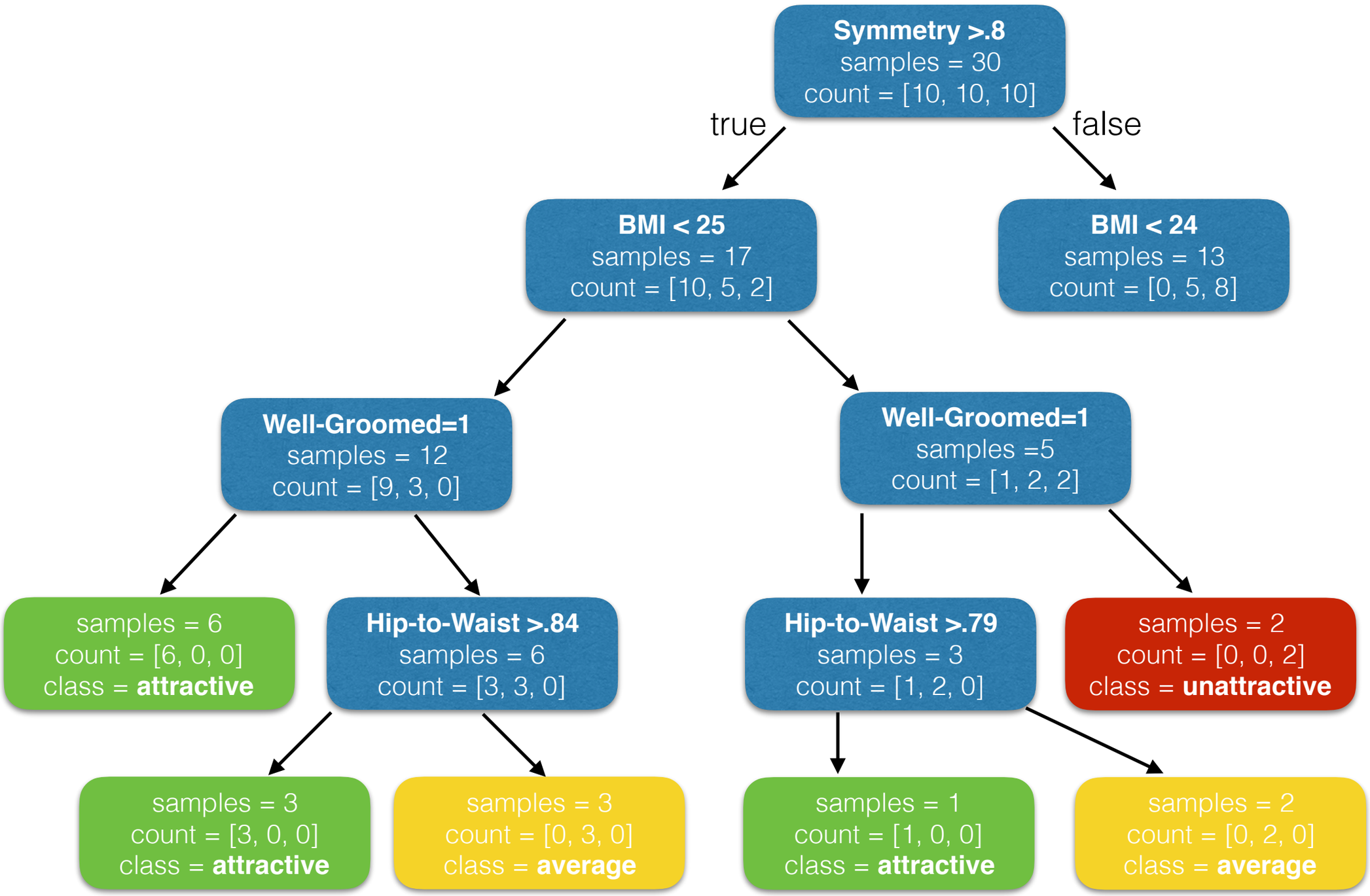
[att, ave, un]


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]

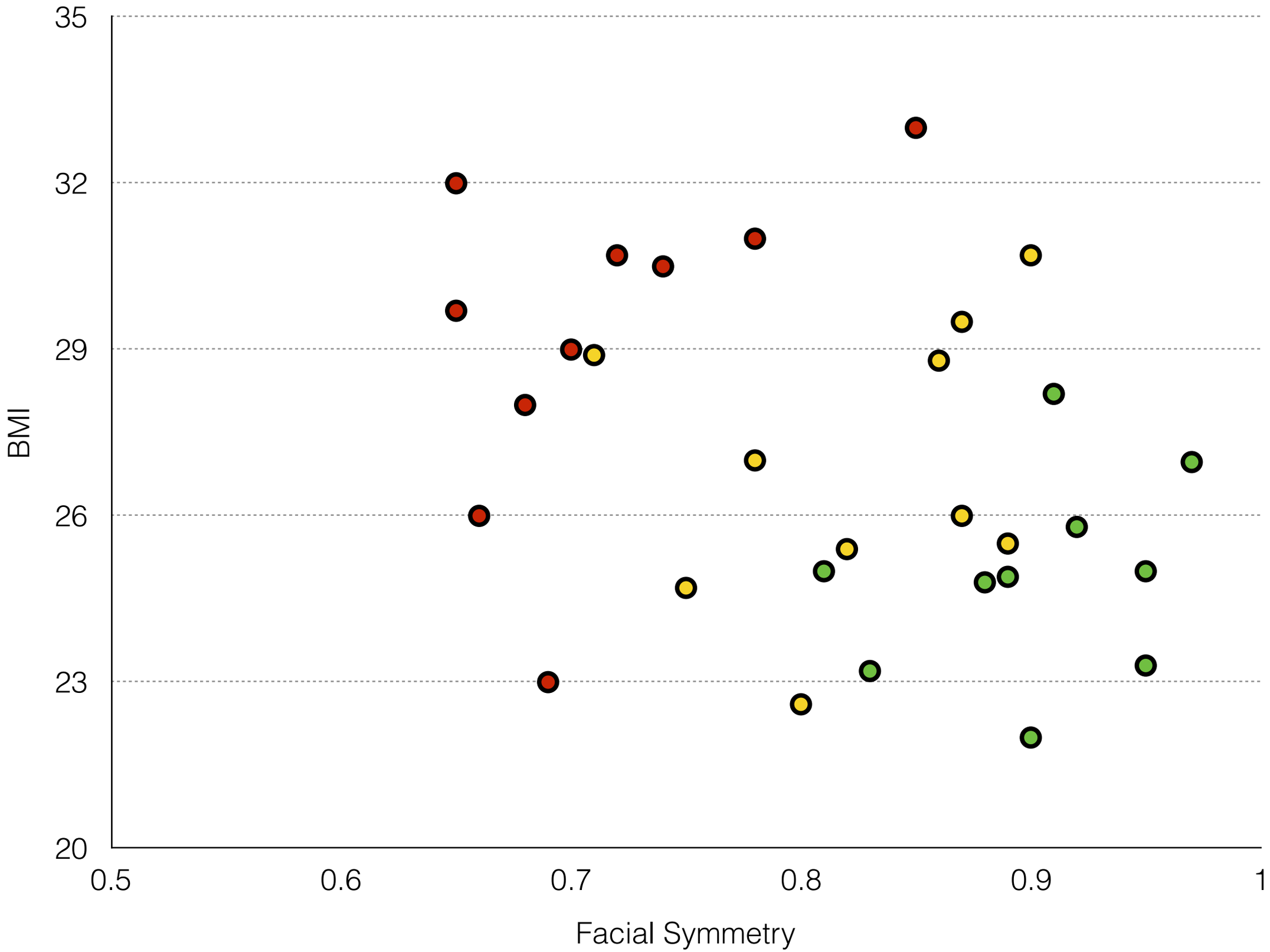
[att, ave, un]

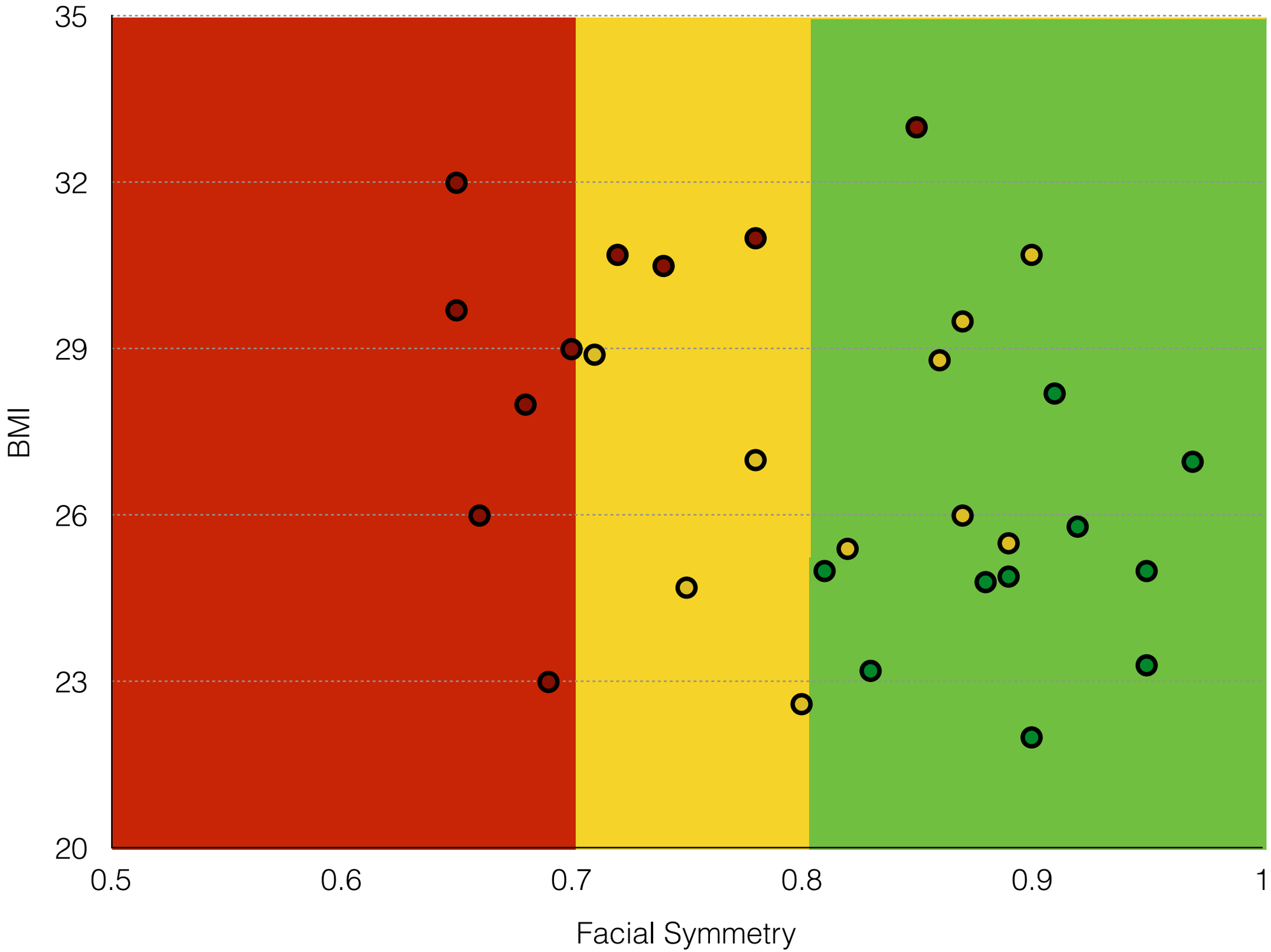

Symmetry >.8
samples = 30
count = [10, 10, 10]
true
false
BMI < 25
samples = 17
count = [10, 5, 2]
BMI < 24
samples = 13
count = [0, 5, 8]
Well-Groomed=1
samples = 12
count = [9, 3, 0]
Well-Groomed=1
samples =5
count = [1, 2, 2]
samples = 6
count = [6, 0, 0]
class = attractive
Hip-to-Waist >.84
samples = 6
count = [3, 3, 0]
Hip-to-Waist >.79
samples = 3
count = [1, 2, 0]
samples = 2
count = [0, 0, 2]
class = unattractive

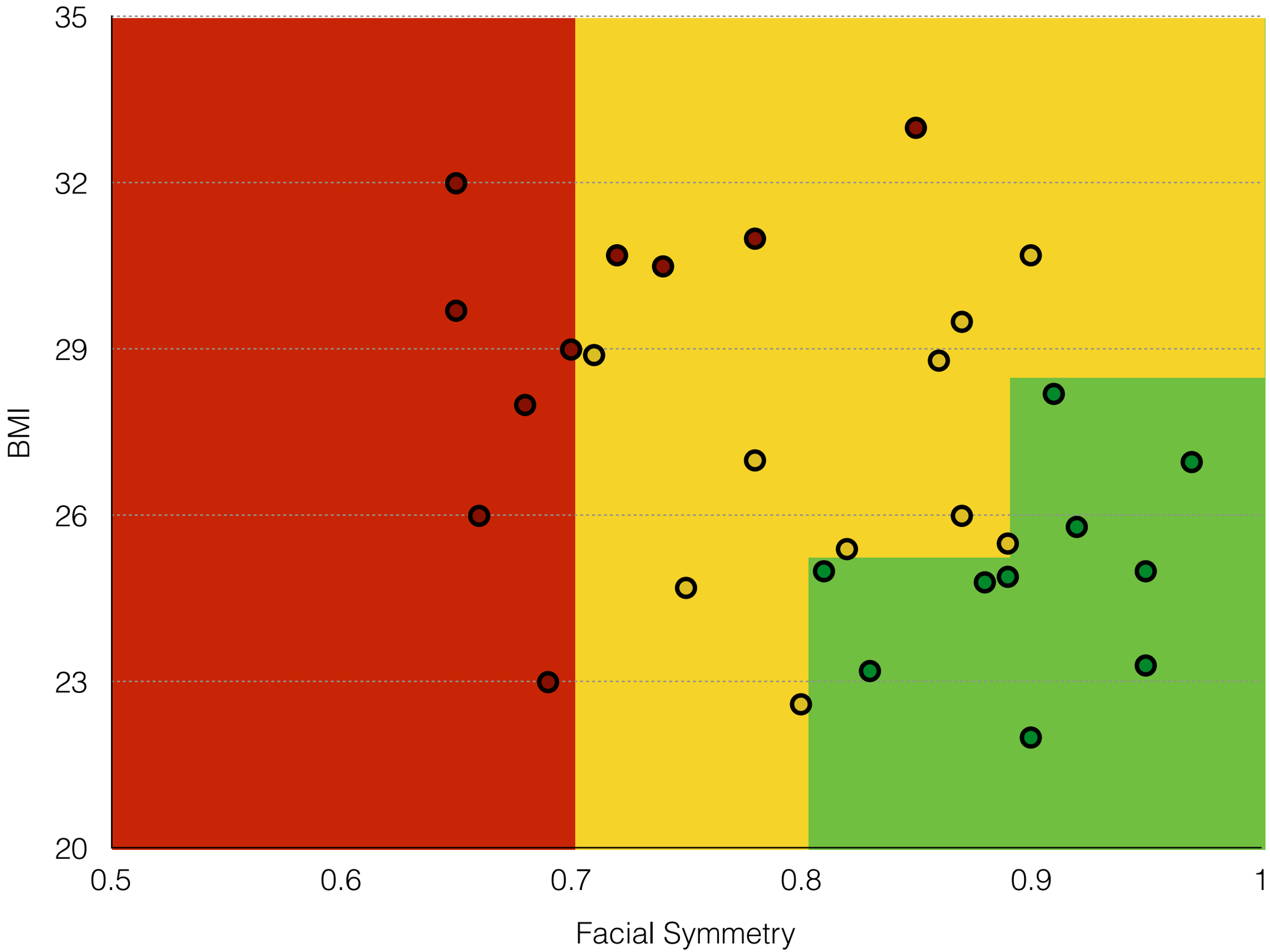
[att, ave, un]

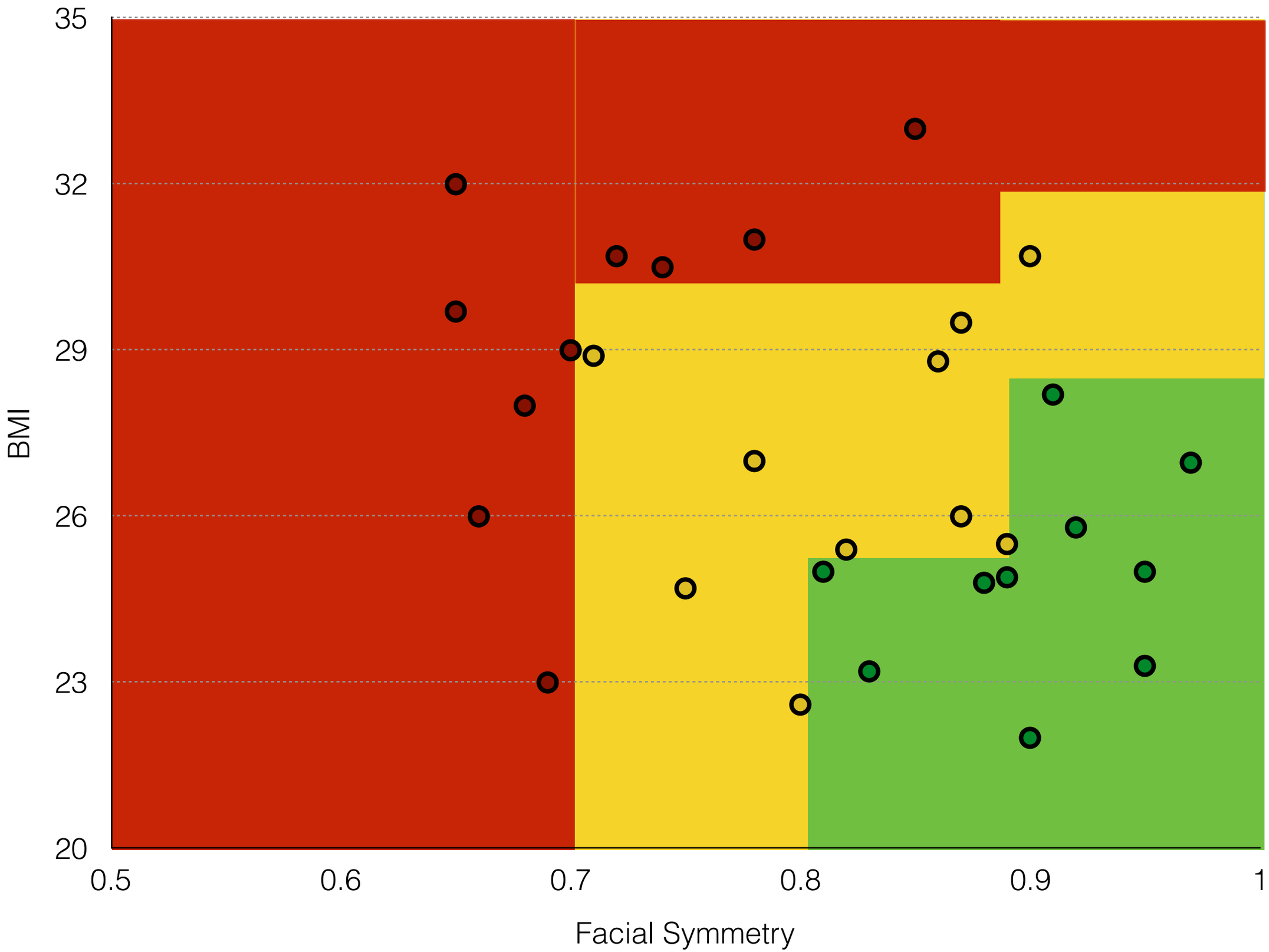

Symmetry >.8
samples = 30
count = [10, 10, 10]
true
false
BMI < 25
samples = 17
count = [10, 5, 2]
BMI < 24
samples = 13
count = [0, 5, 8]
Well-Groomed=1
samples = 12
count = [9, 3, 0]
Well-Groomed=1
samples =5
count = [1, 2, 2]
samples = 6
count = [6, 0, 0]
class = attractive
Hip-to-Waist >.84
samples = 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]


35
32
29
26
23
20
BMI
0.5
0.6
0.7
0.8
0.9
1
Facial Symmetry


35
32
29
26
23
20
BMI
0.5
0.6
0.7
0.8
0.9
1
Facial Symmetry


35
32
29
26
23
20
BMI
0.5
0.6
0.7
0.8
0.9
1
Facial Symmetry


35
32
29
26
23
20
BMI
0.5
0.6
0.7
0.8
0.9
1
Facial Symmetry

K-nearest Neighbor

Euclidean Distance

point a = [a1, a2]

point b = [b1, b2]

Euclidean Distance

point a = [a1, a2]

point b = [b1, b2]

Two dimensions (features)

$$\sqrt{(a_1-b_1)^2+(a_2-b_2)^2}$$

	Number of Relationships	Grade of First Relationship
sample a	3	7
sample b	6	11
sample c	3	9
sample d	5	10

Euclidean Distance

Feature Vector

a = [3, 7]

b = [6, 11]

Euclidean Distance

$$\sqrt{(3-6)^2+(7-11)^2}$$

Feature Vector

a = [3, 7]

b = [6, 11]

Euclidean Distance

$$\sqrt{(3-6)^2+(7-11)^2}$$

$$\sqrt{(-3)^2+(-4)^2}$$

Feature Vector

a = [3, 7]

b = [6, 11]

Euclidean Distance

$$\sqrt{(3-6)^2+(7-11)^2}$$

Feature Vector

a = [3, 7]

b = [6, 11]

$$\sqrt{(-3)^2+(-4)^2}$$

$$\sqrt{9+16}$$

Euclidean Distance

Feature Vector

a = [3, 7]

b = [6, 11]

$$\sqrt{(3-6)^2+(7-11)^2}$$

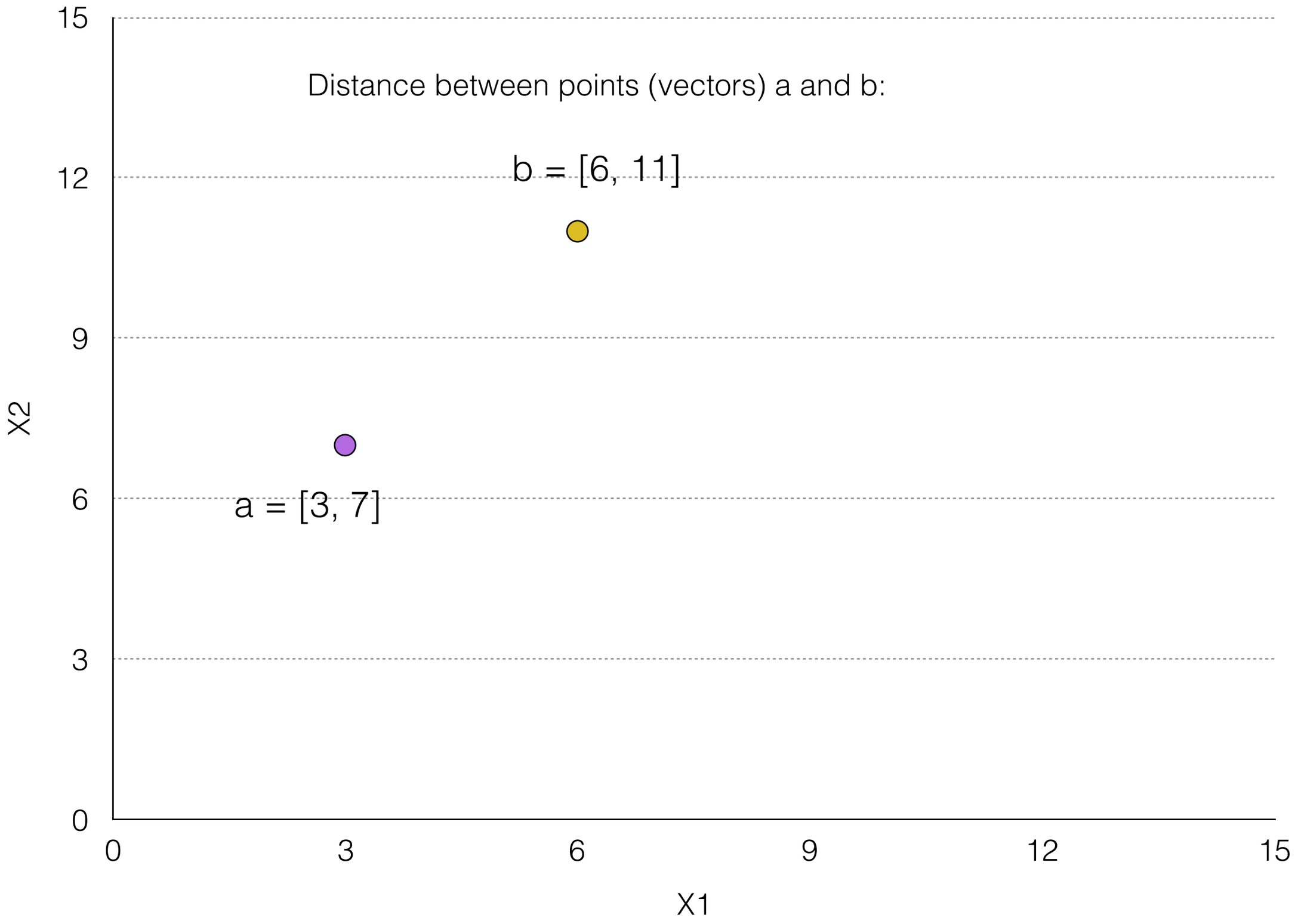
$$\sqrt{(-3)^2+(-4)^2}$$

$$\sqrt{9+16}$$

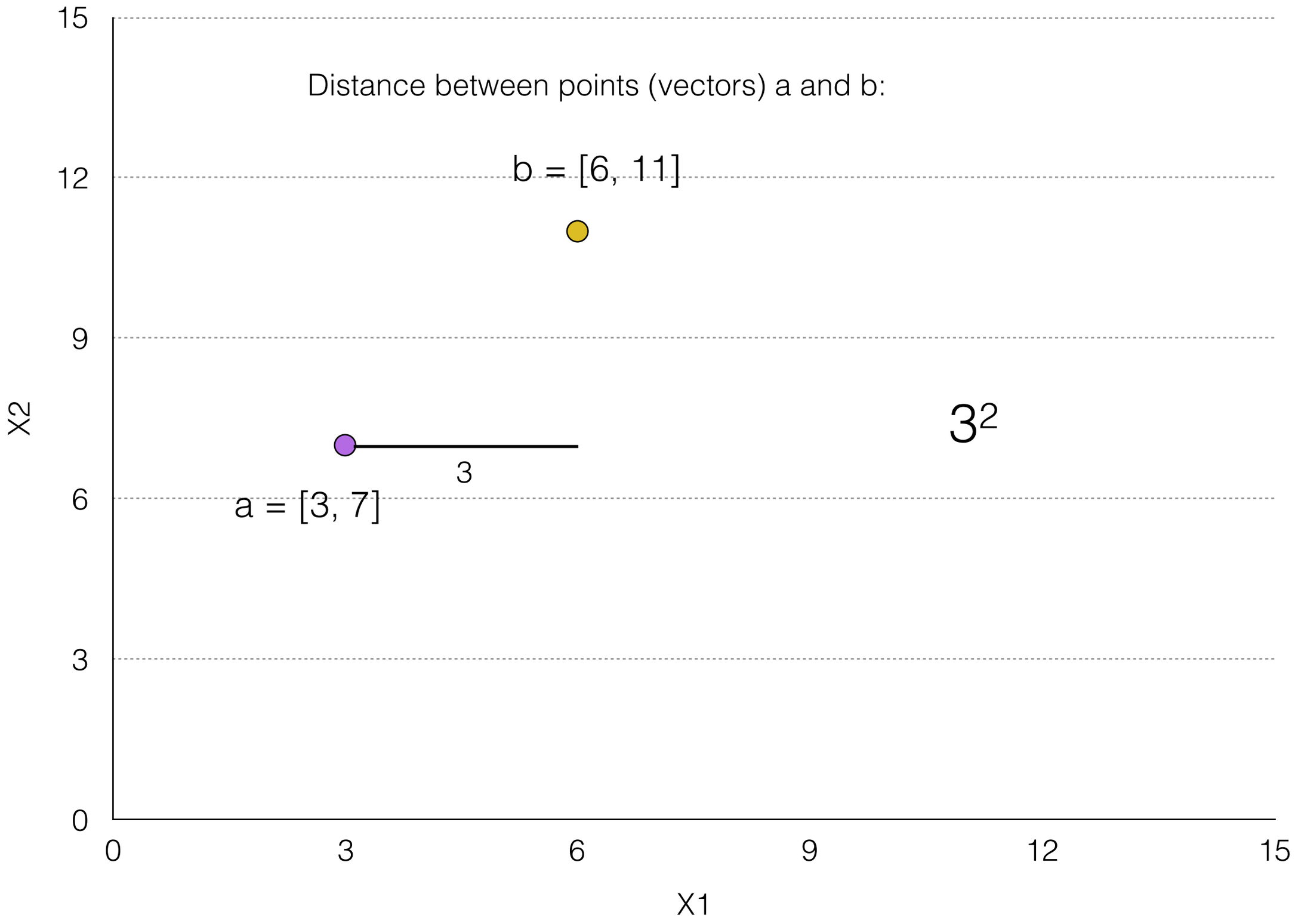
Distance between points (vectors) a and b:

$$\sqrt{25}=5$$

Euclidean Distance



Euclidean Distance



Euclidean Distance

Distance between points (vectors) a and b:

b = [6, 11]

a = [3, 7]

4

3

$3^2 + 4^2$

15
12
9
6
3
0

X2

0 3 6 9 12 15

X1

Euclidean Distance

Distance between points (vectors) a and b:

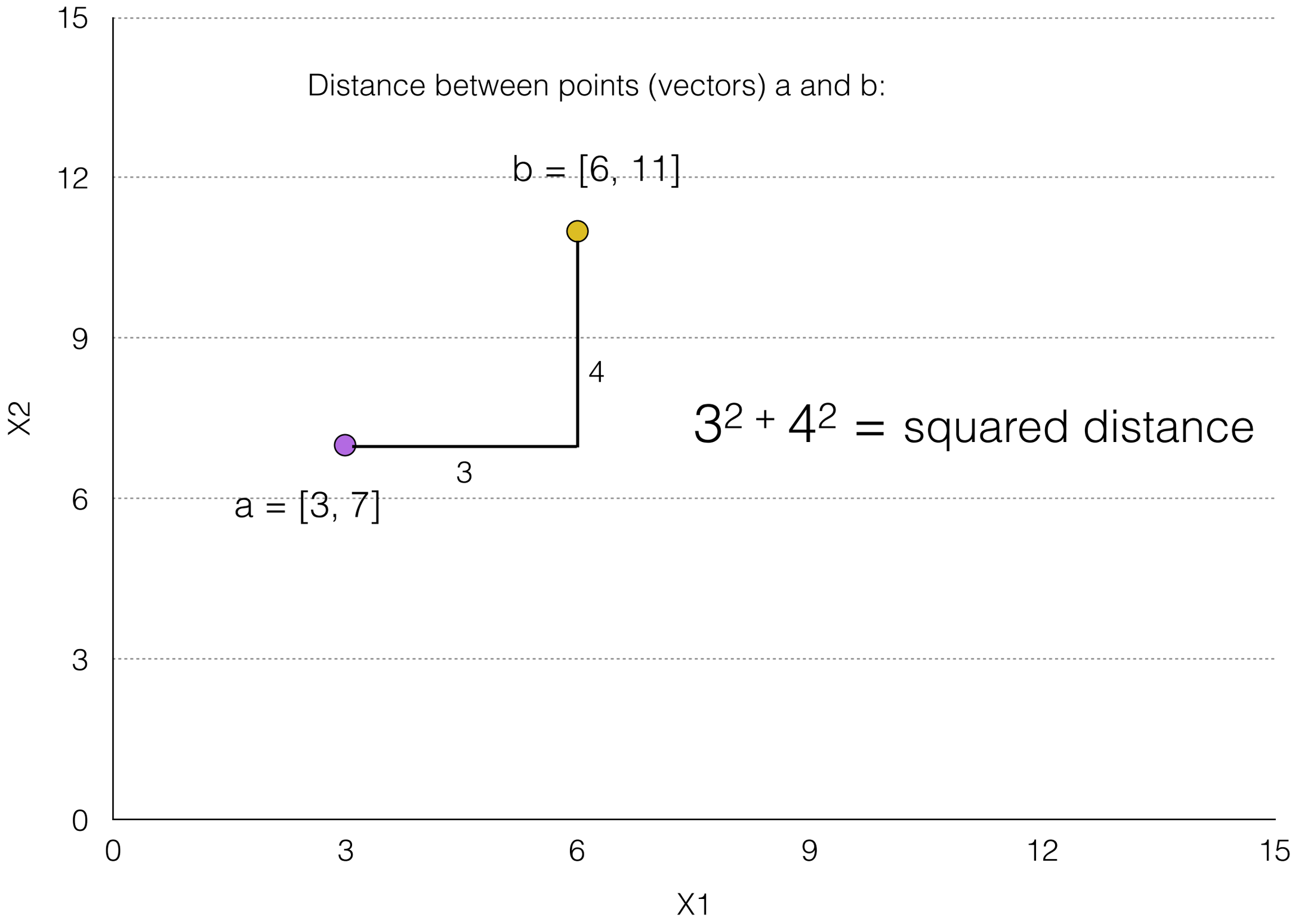
b = [6, 11]

a = [3, 7]

4

3

$3^2 + 4^2$ = squared distance



Euclidean Distance

Distance between points (vectors) a and b:

b = [6, 11]

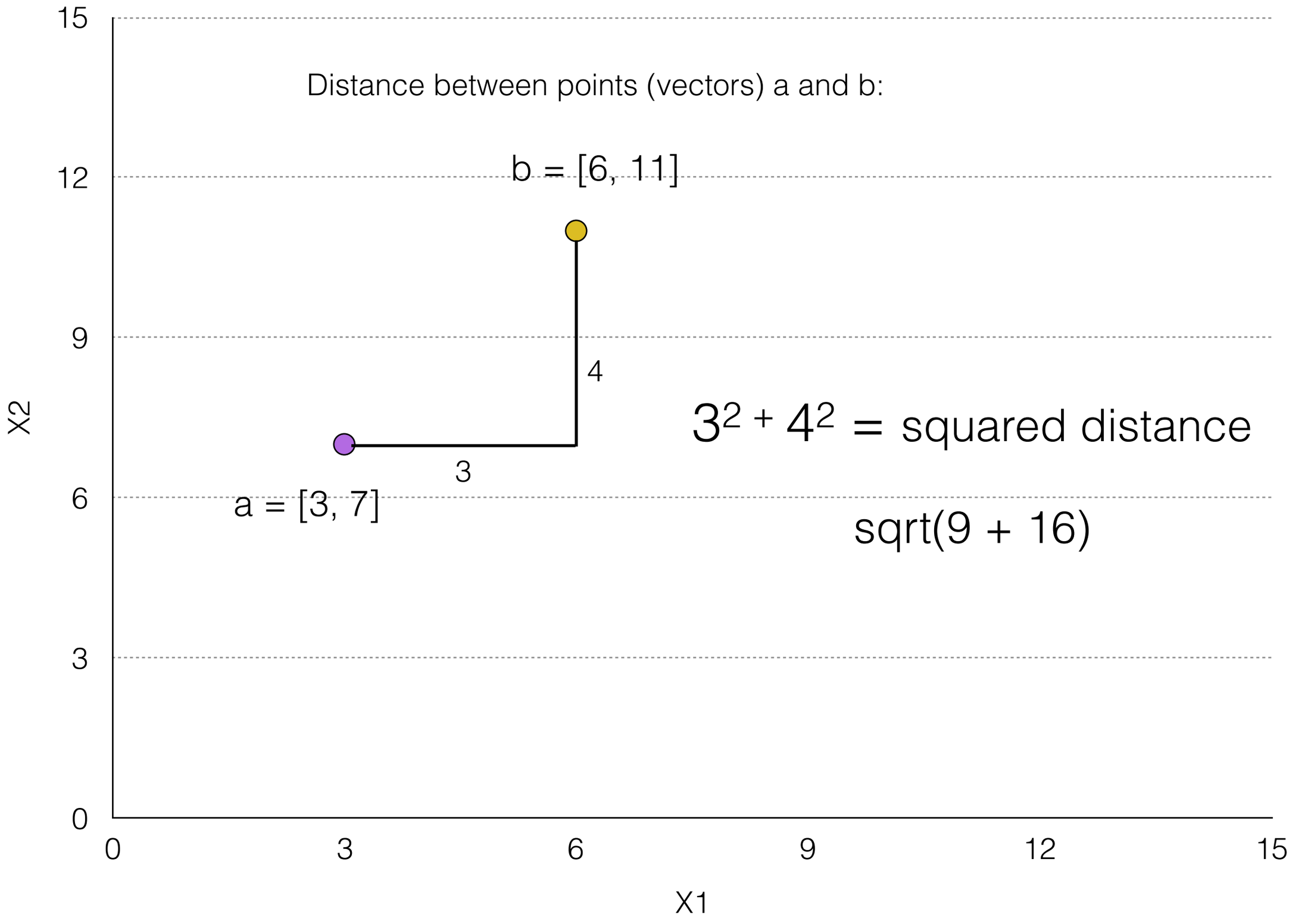
a = [3, 7]

4

3

$3^2 + 4^2$ = squared distance

sqrt(9 + 16)



Euclidean Distance

Distance between points (vectors) a and b:

b = [6, 11]

distance = **5**

a = [3, 7]

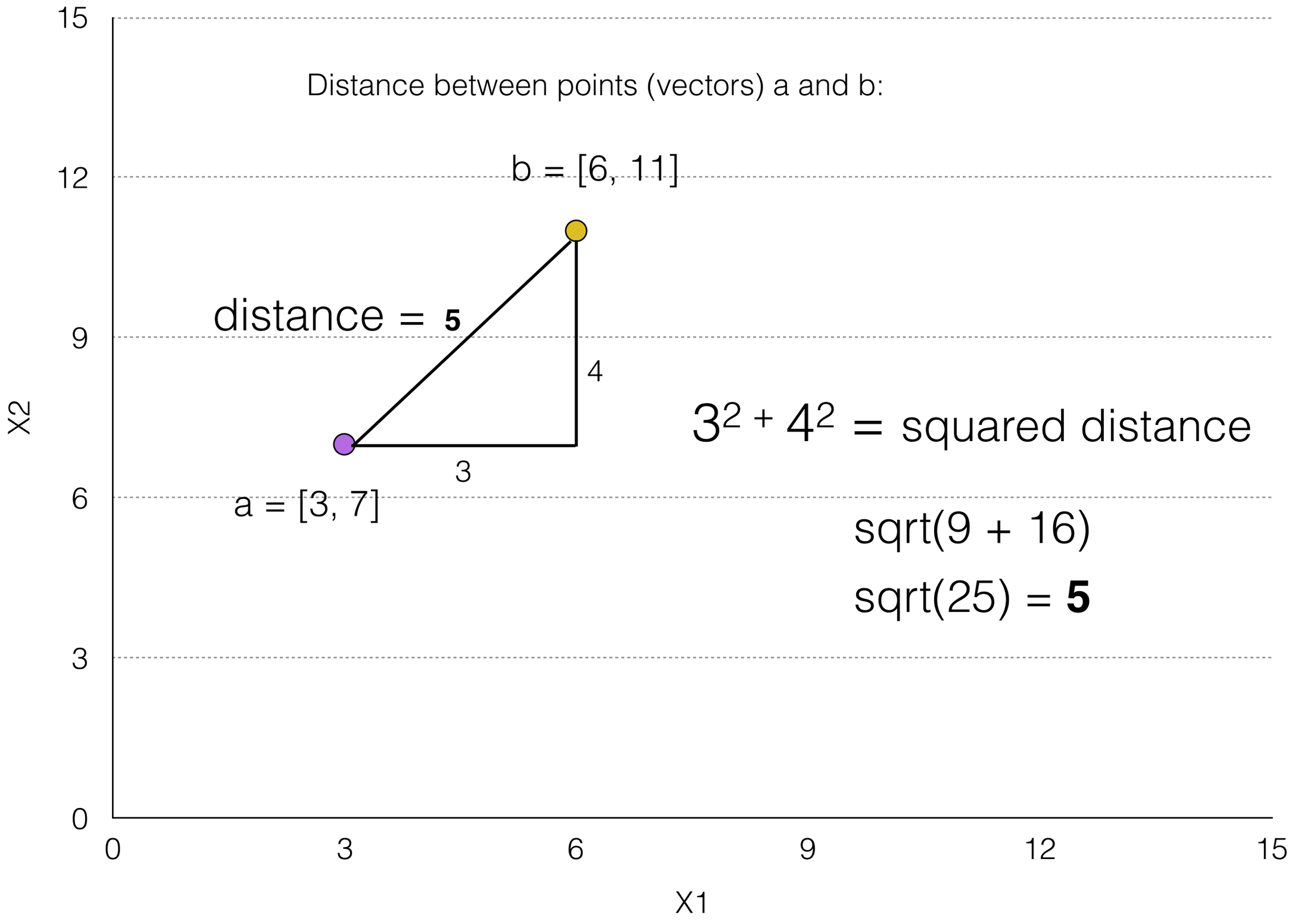
4

3

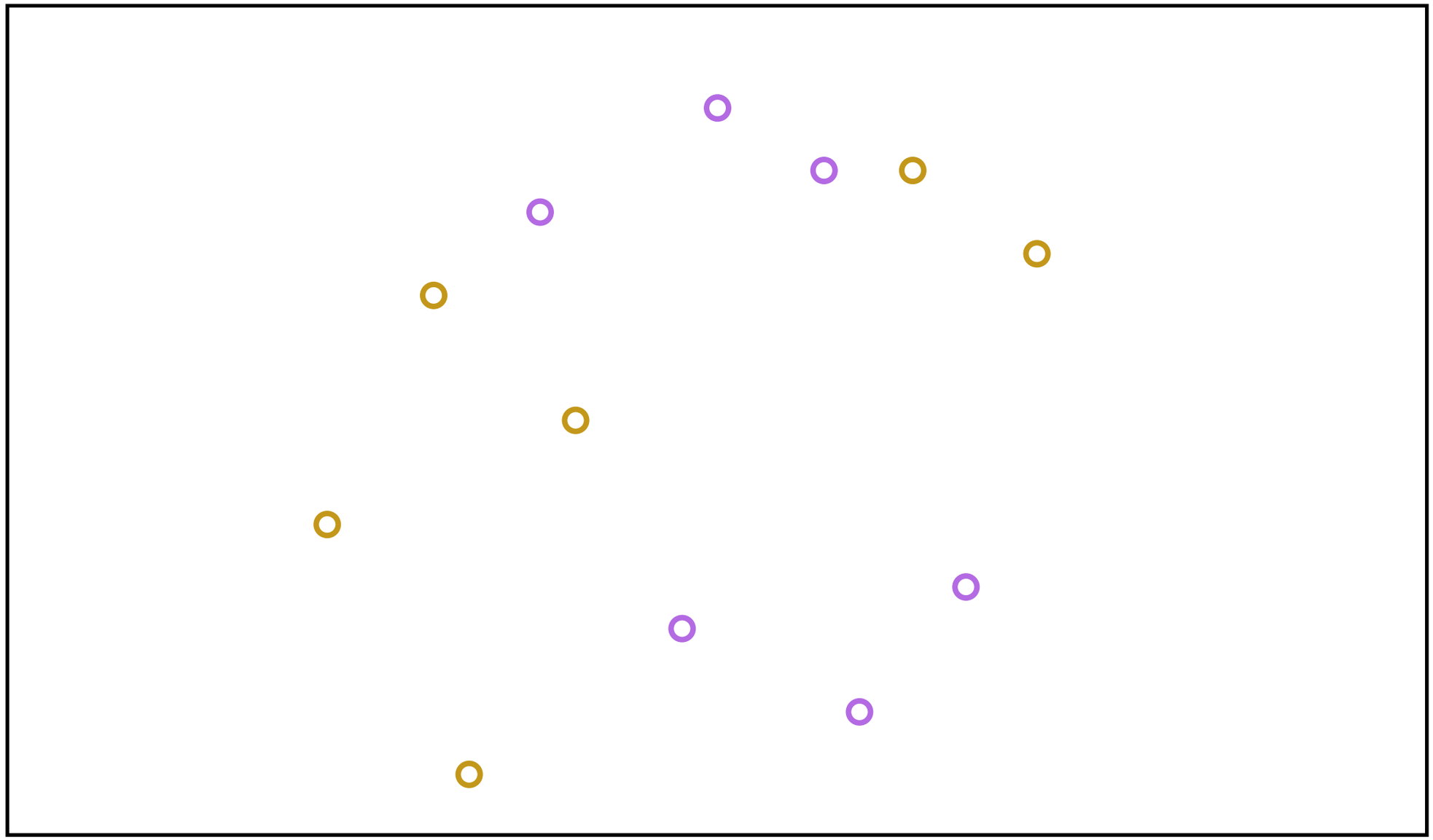
$3^2 + 4^2$ = squared distance

sqrt(9 + 16)

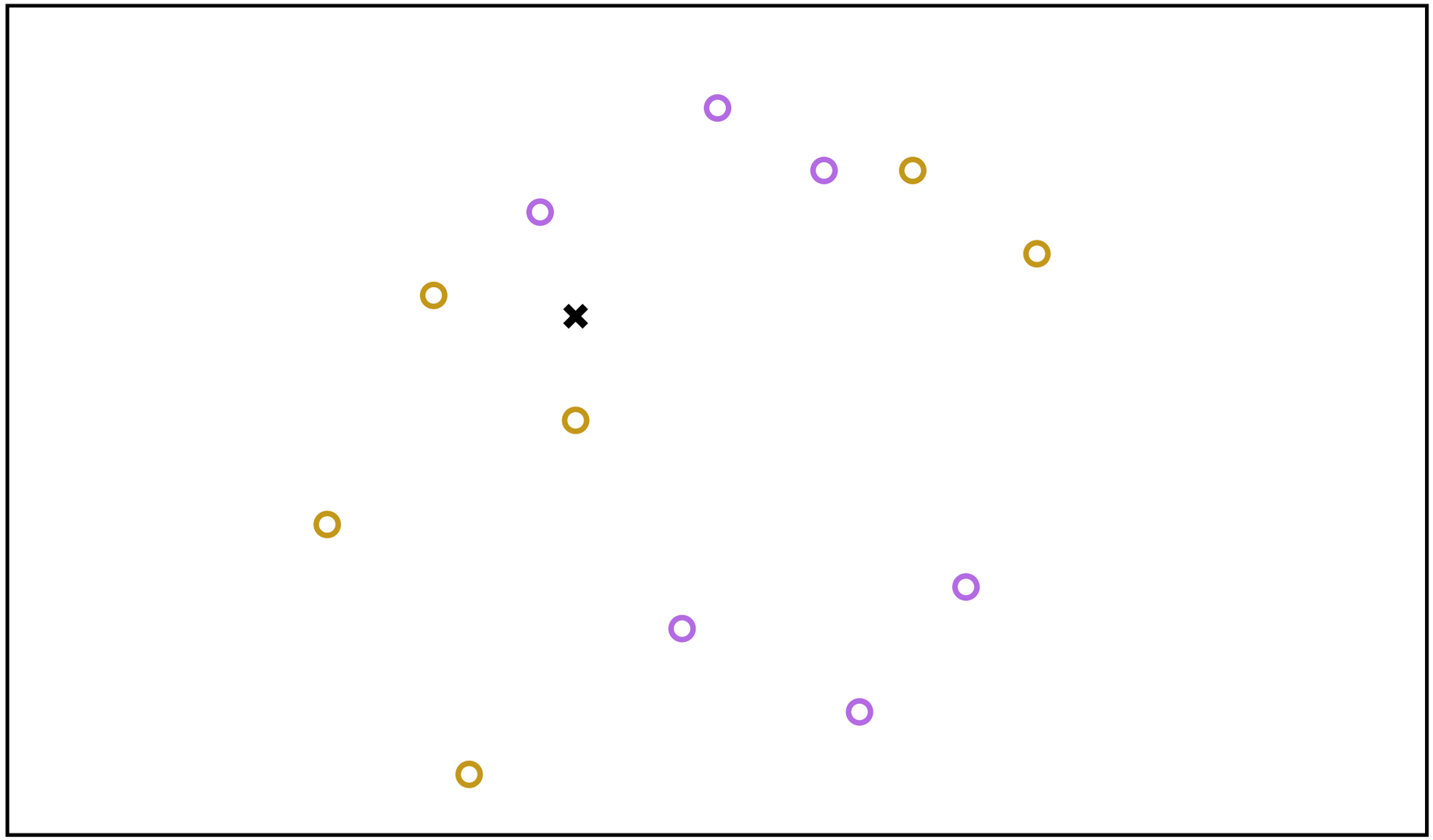
sqrt(25) = **5**



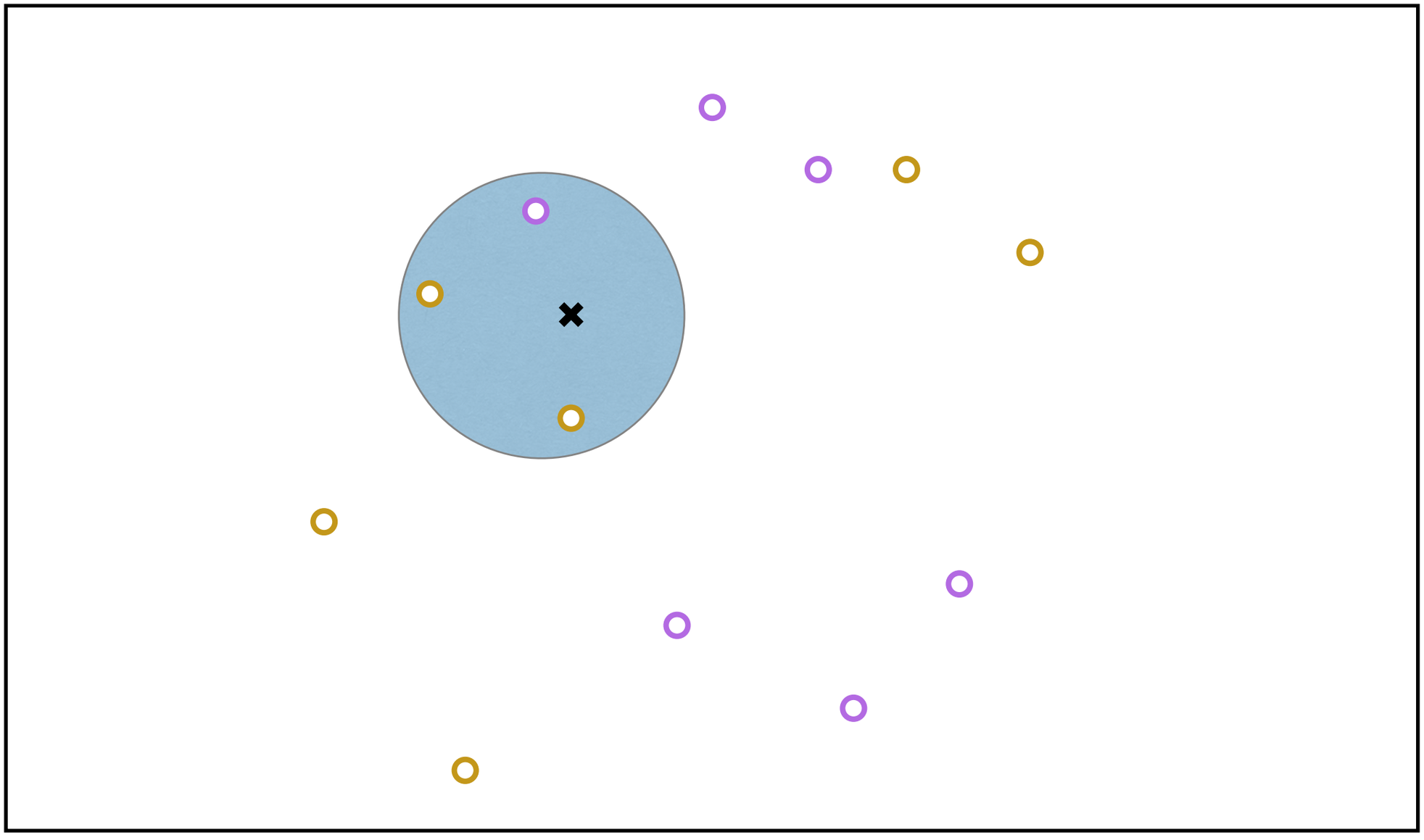
K-nearest Neighbor



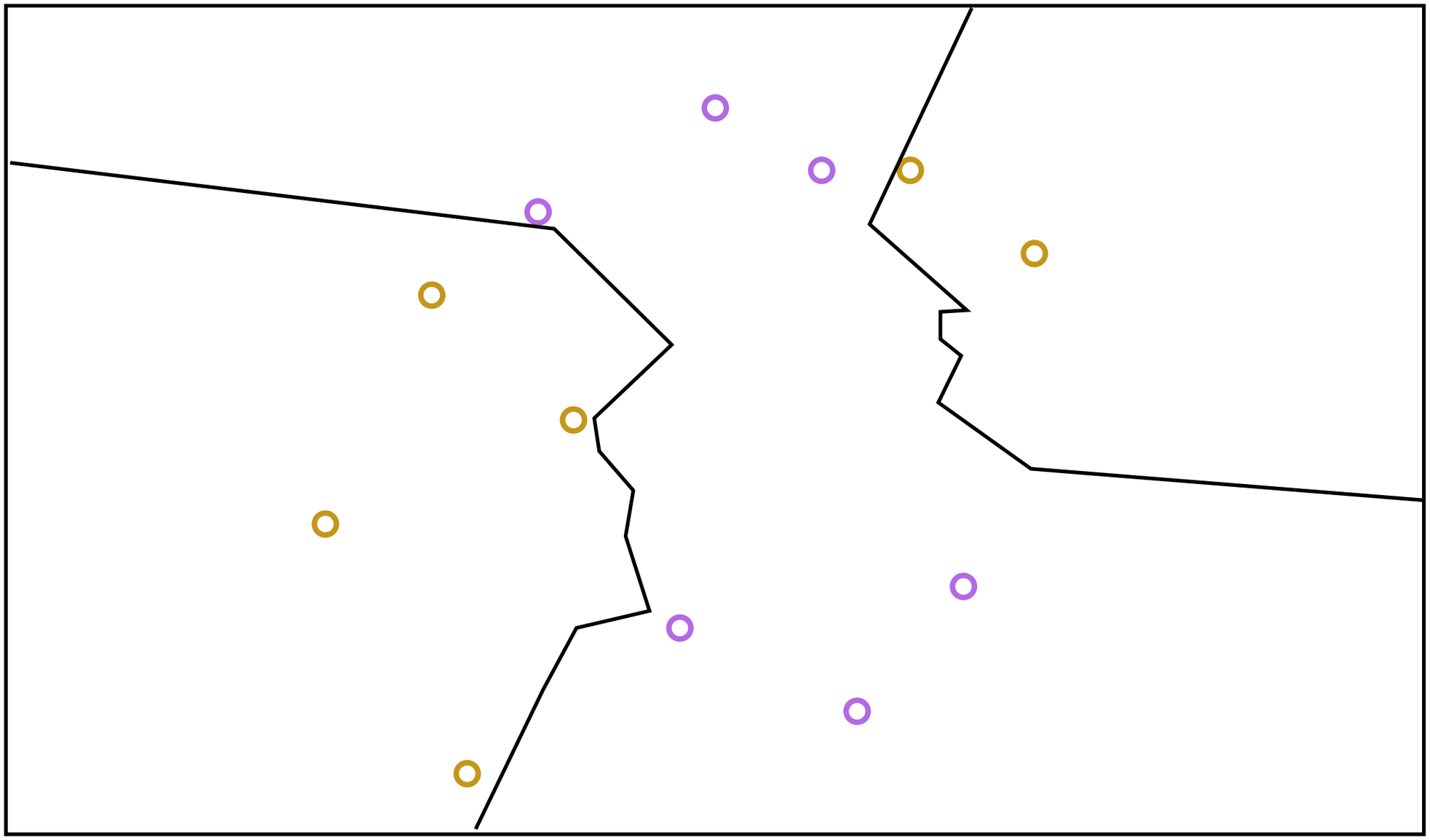
K-nearest Neighbor



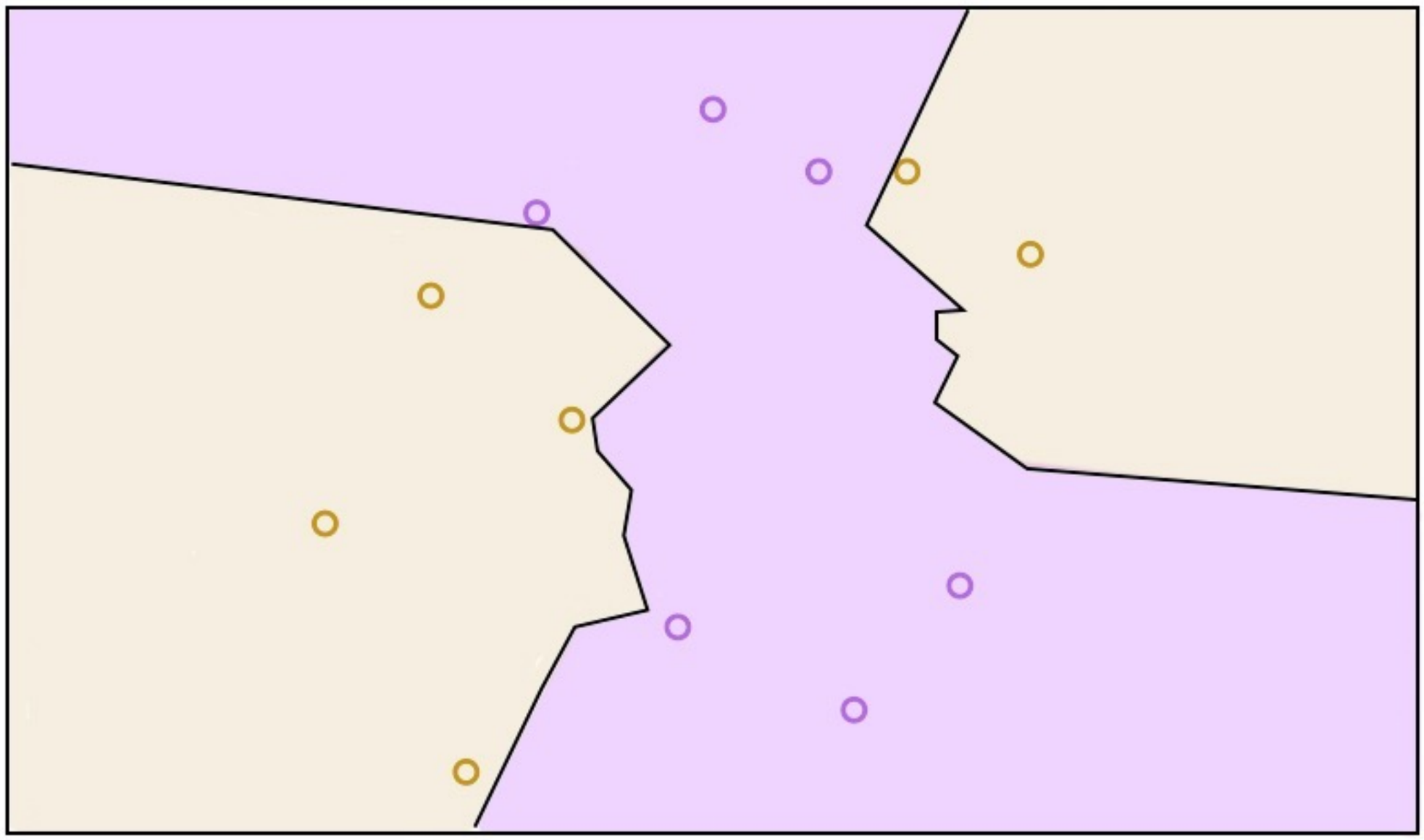
K = 3



K = 3



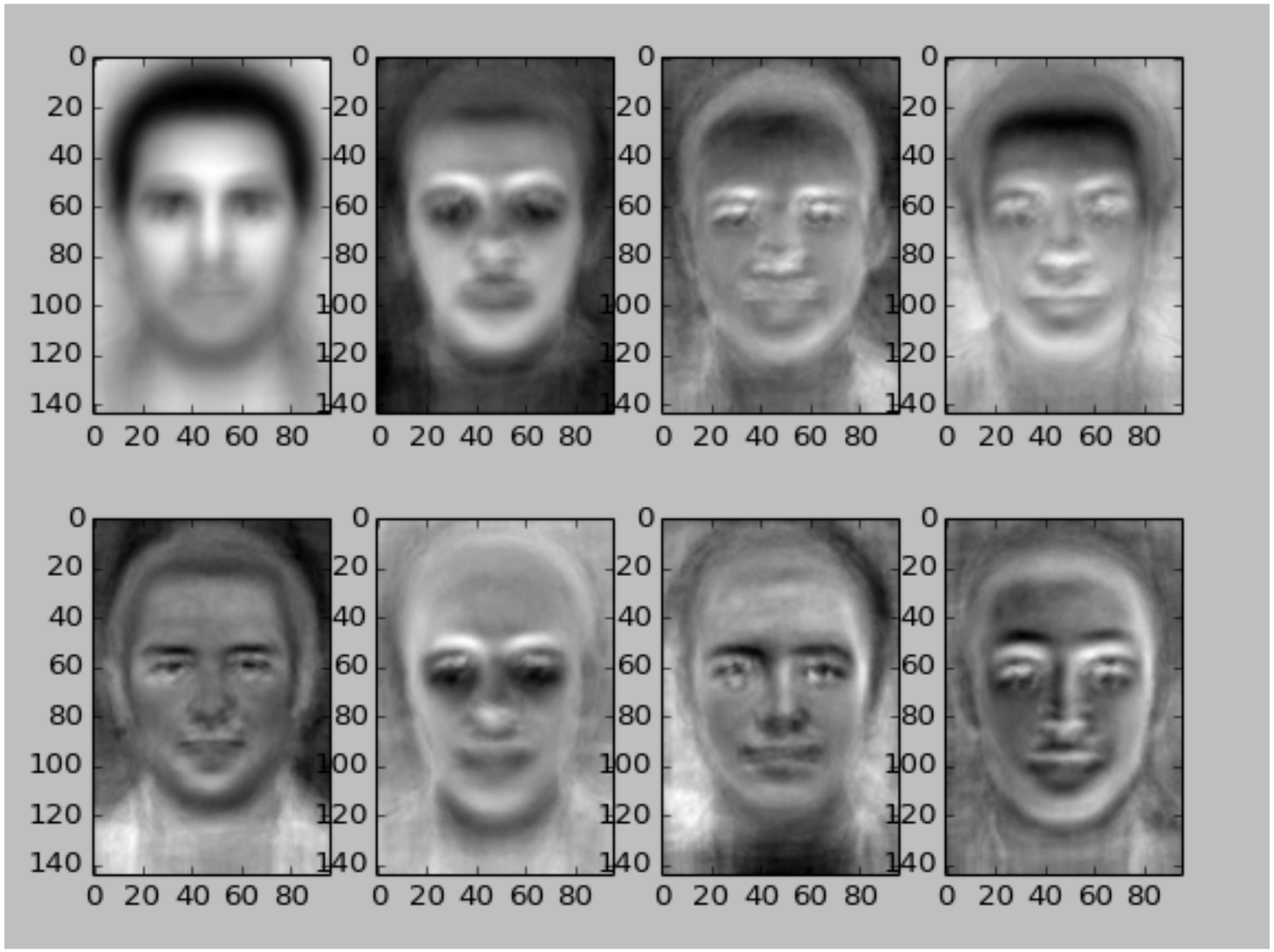
K = 3

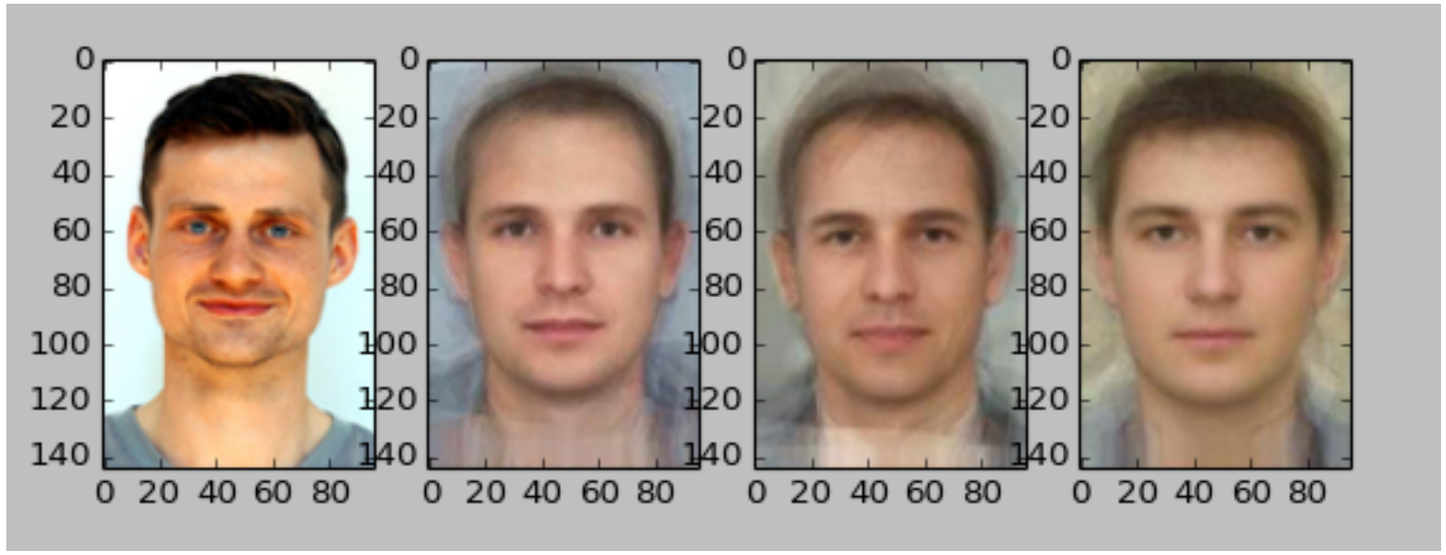


Face Recognition

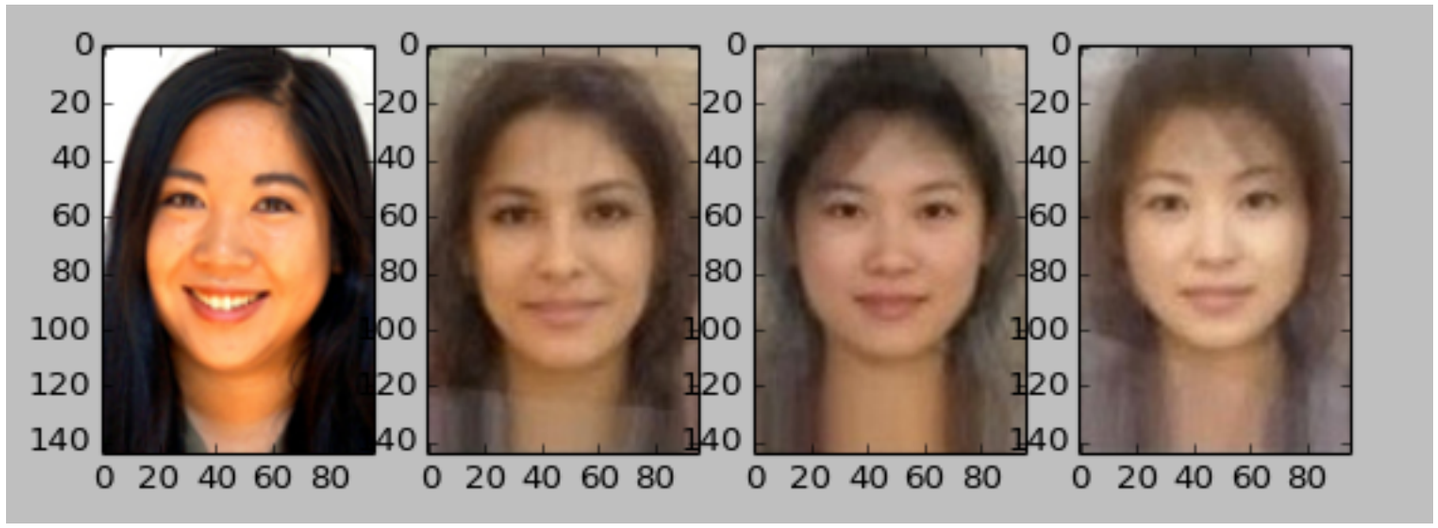
Face Recognition

Eigenfaces





Lithuanian Czech Republic Austria Ukraine

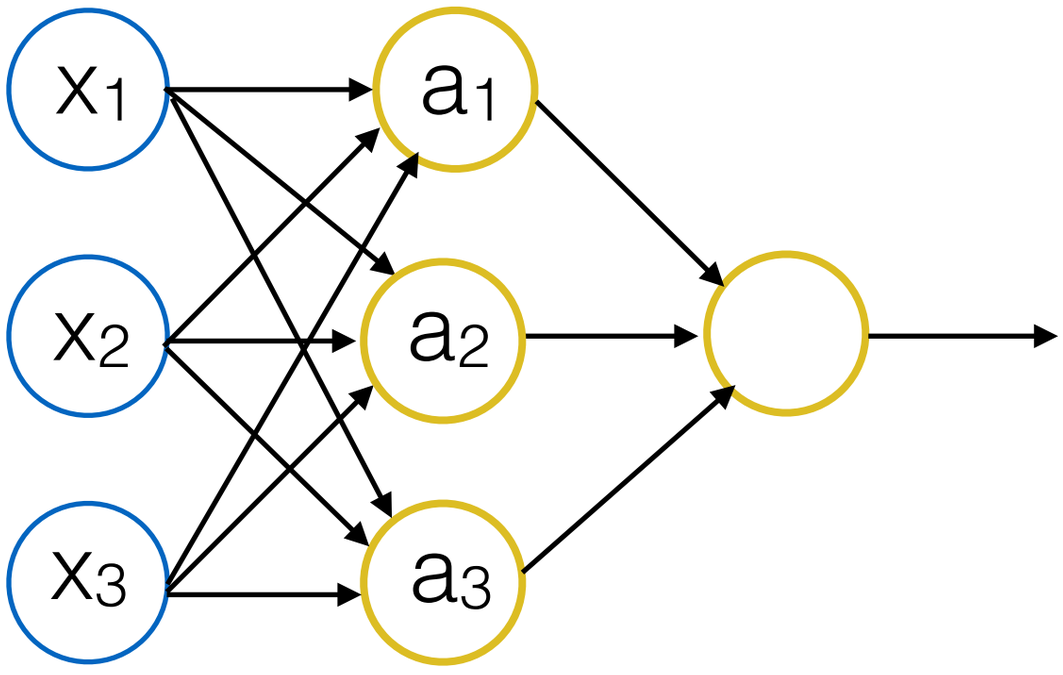


Chinese Peruvian Chinese Japanese

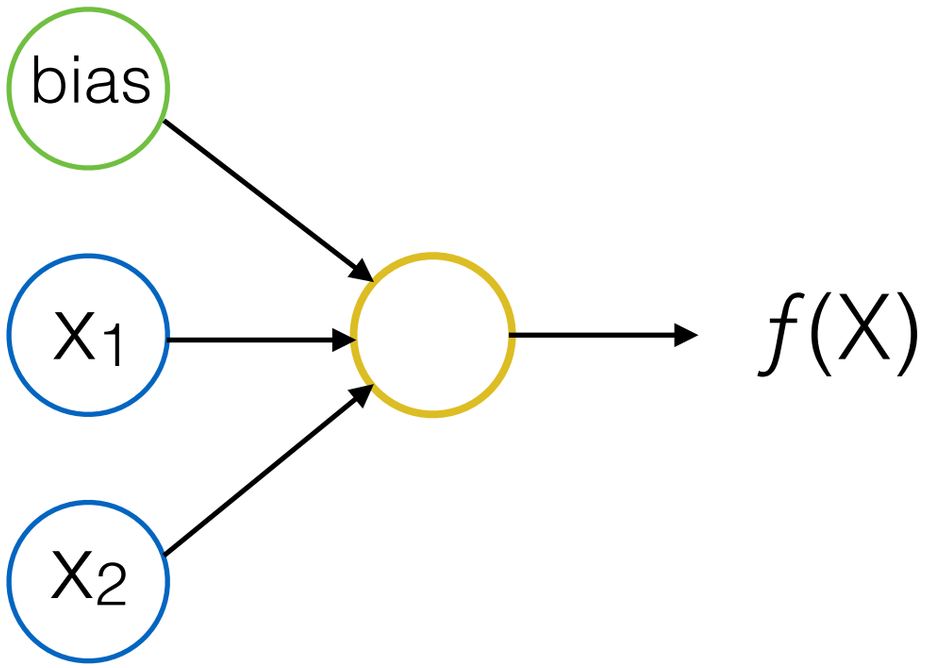
K-Means

Neural Network

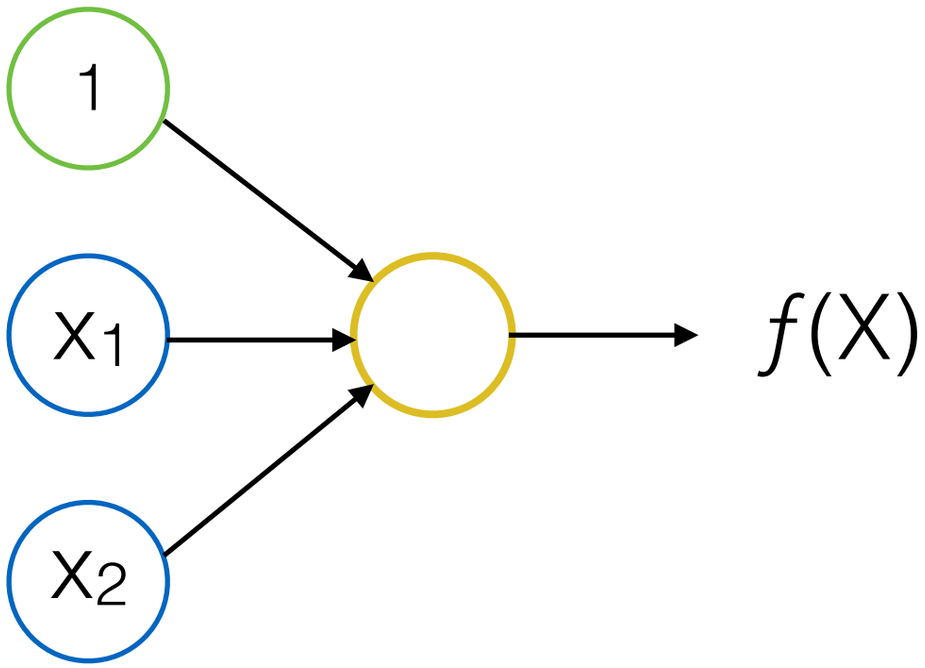
Neural Network



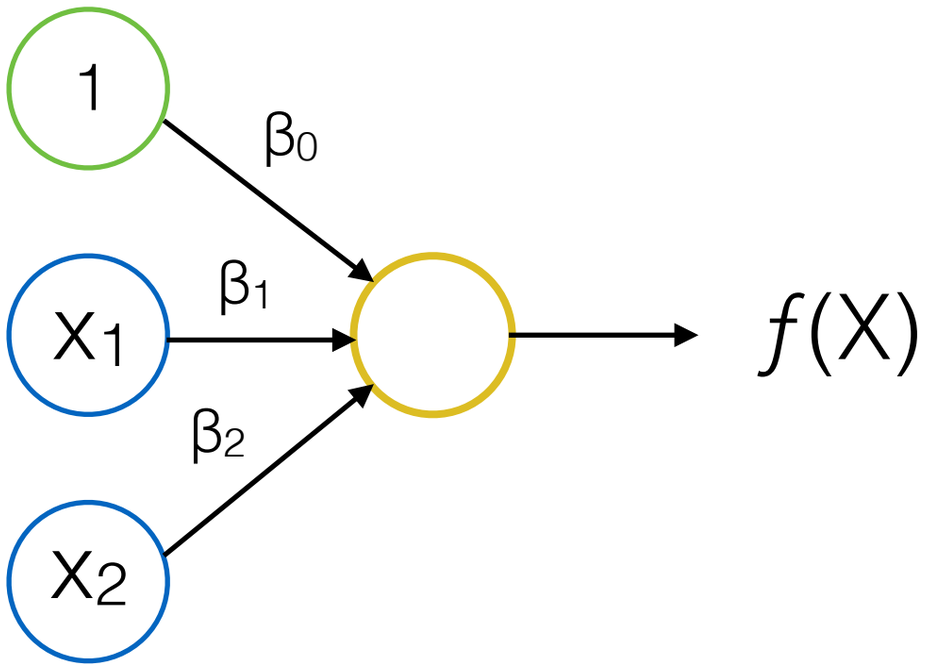
Perceptron



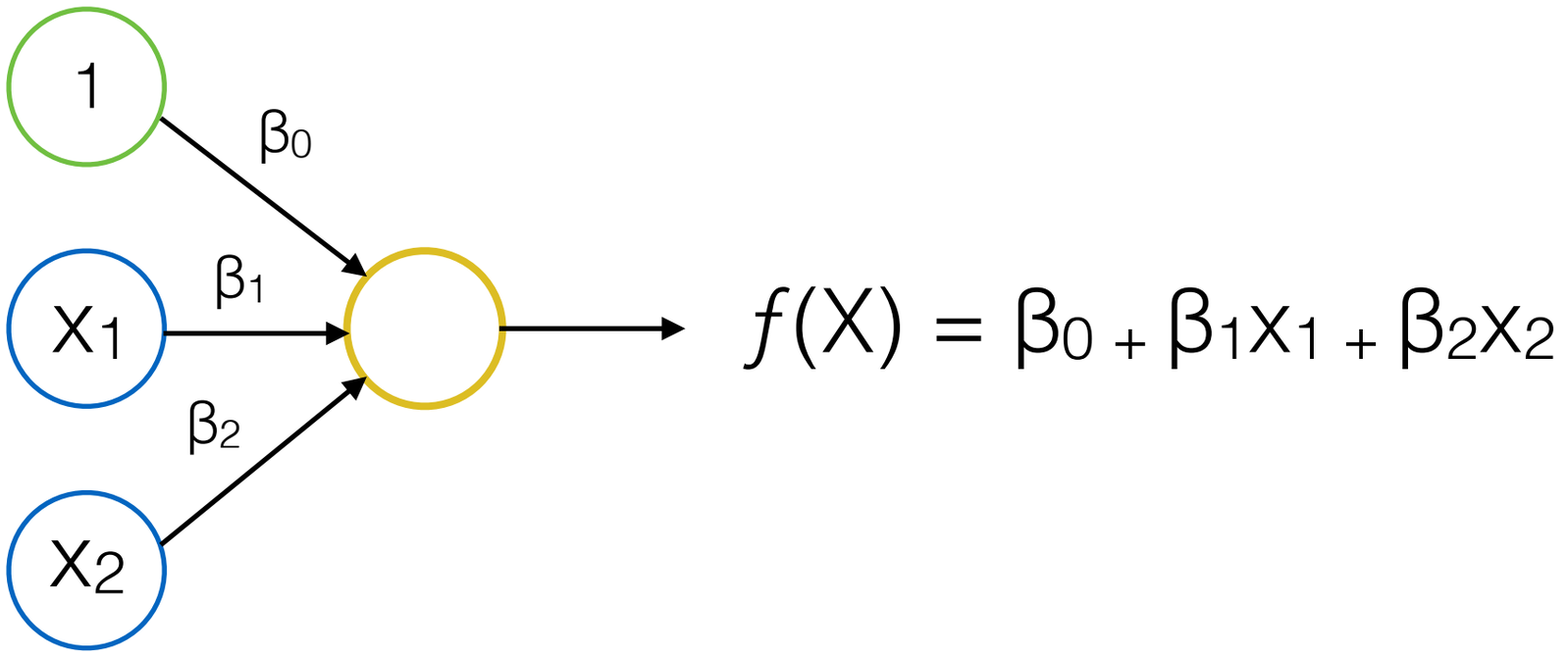
Perceptron



Perceptron



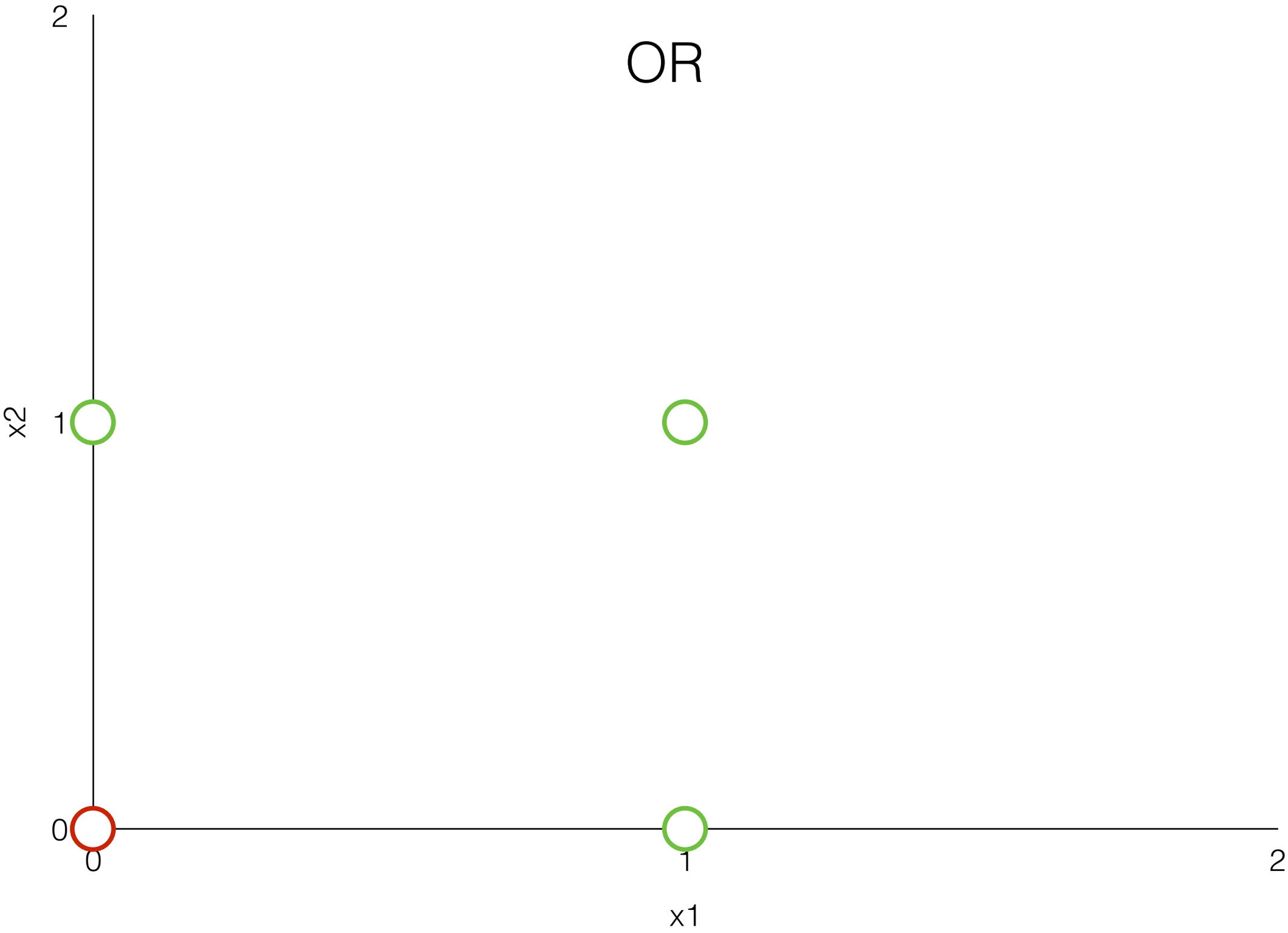
Perceptron



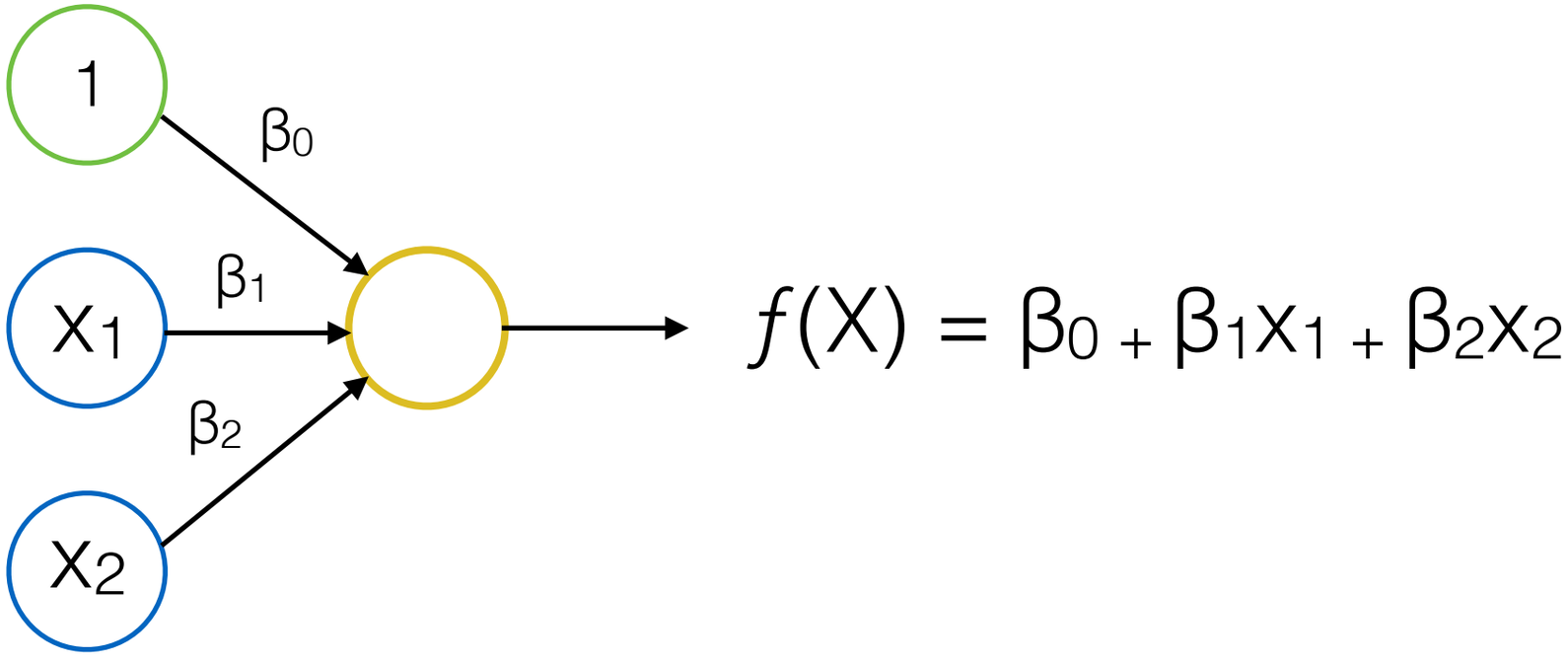
OR

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



Activation Function: Threshold

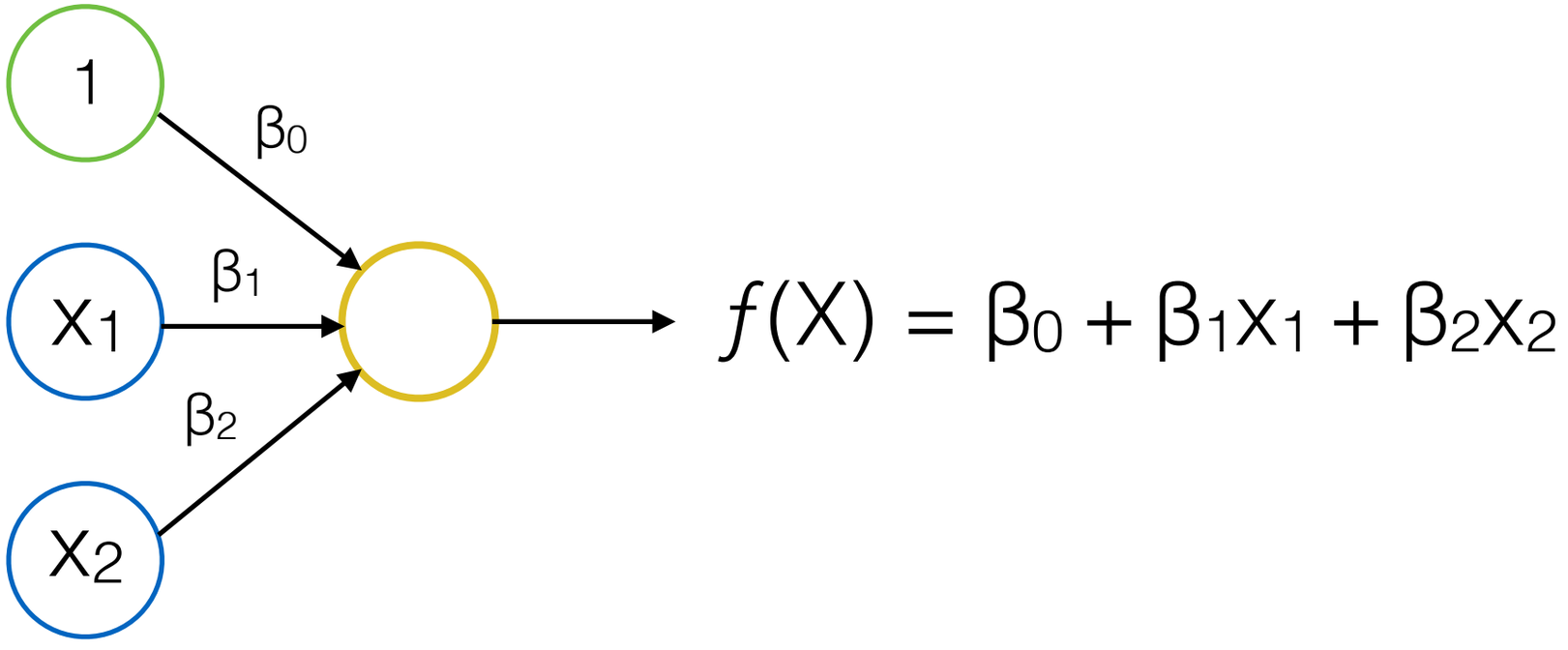
if $\beta_0 + \beta_1 x_1 + \beta_2 x_2 > 0$: 1

Else: 0

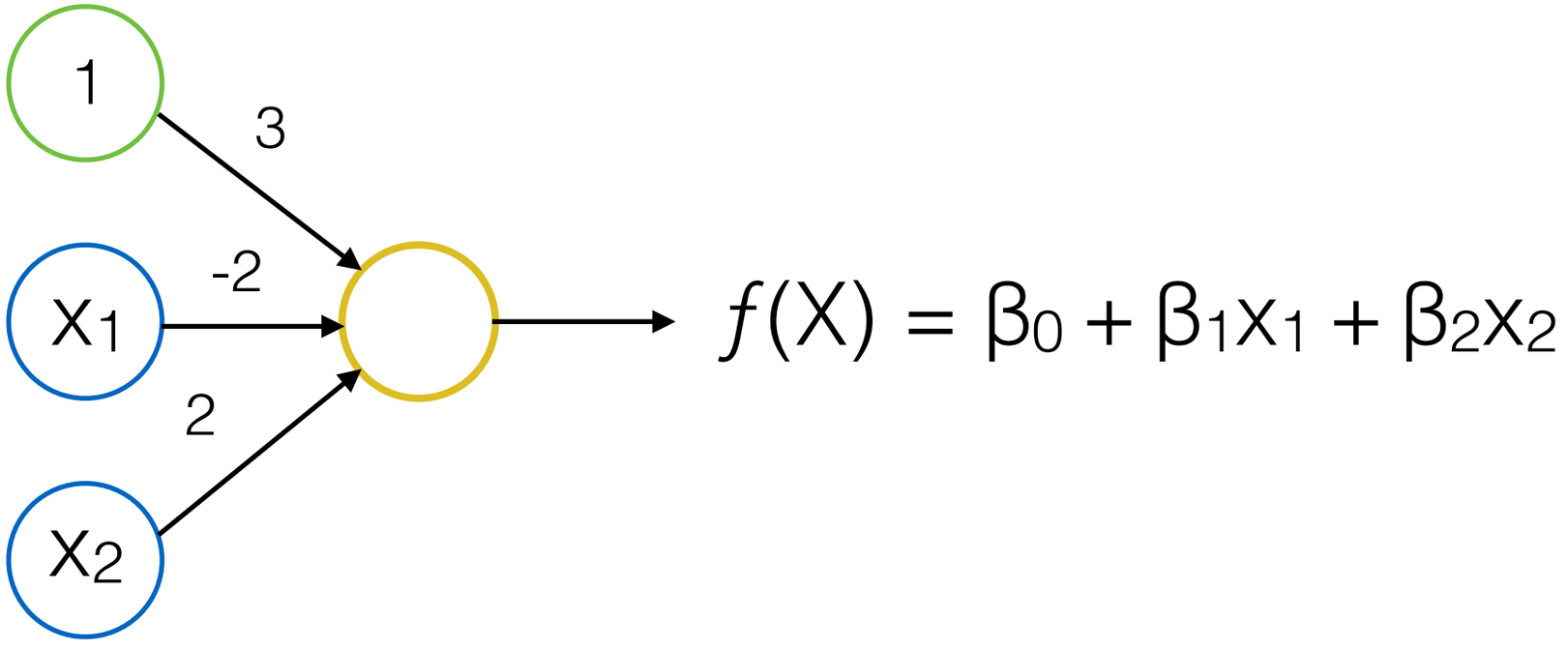
Update Rule:

updated weight_i = weight_i - (output - target) * input_i

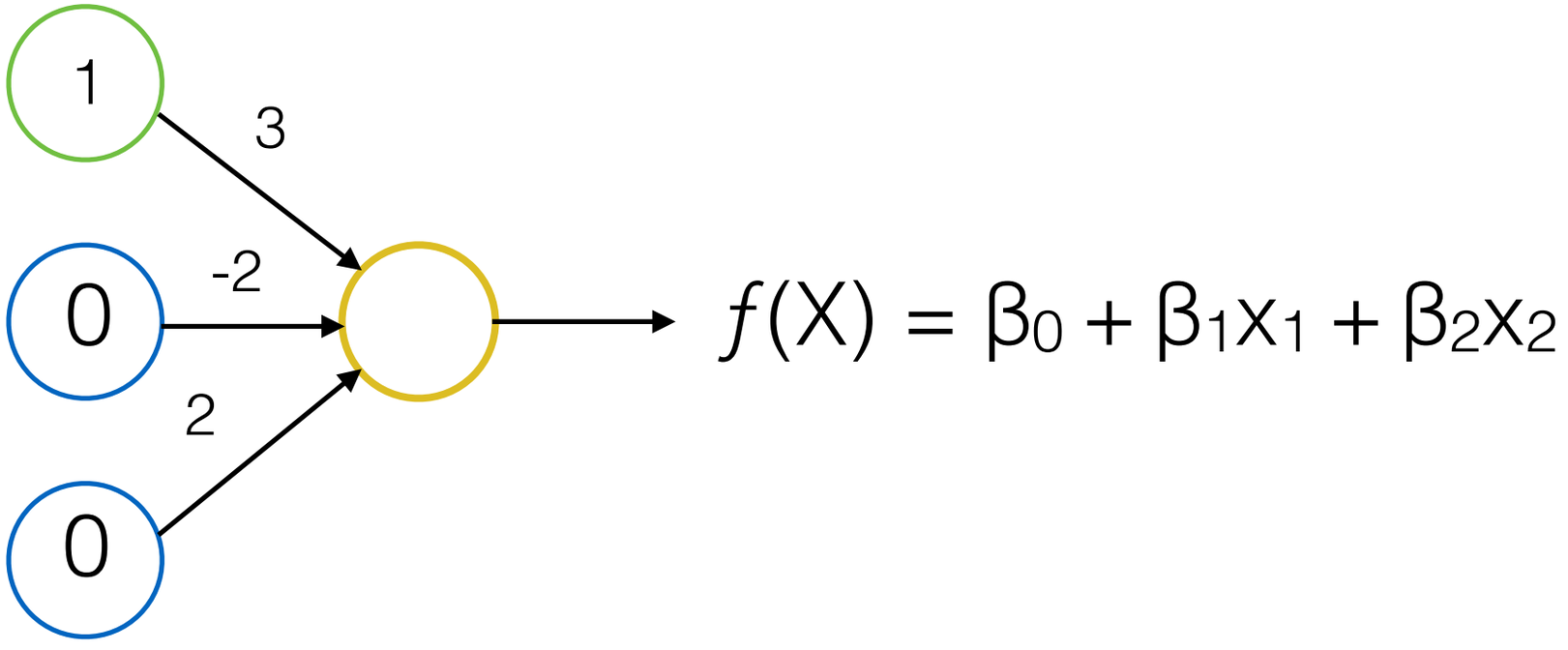
Feature 1	Feature 2	Target
0	0	0
1	0	1
0	1	1
1	1	1



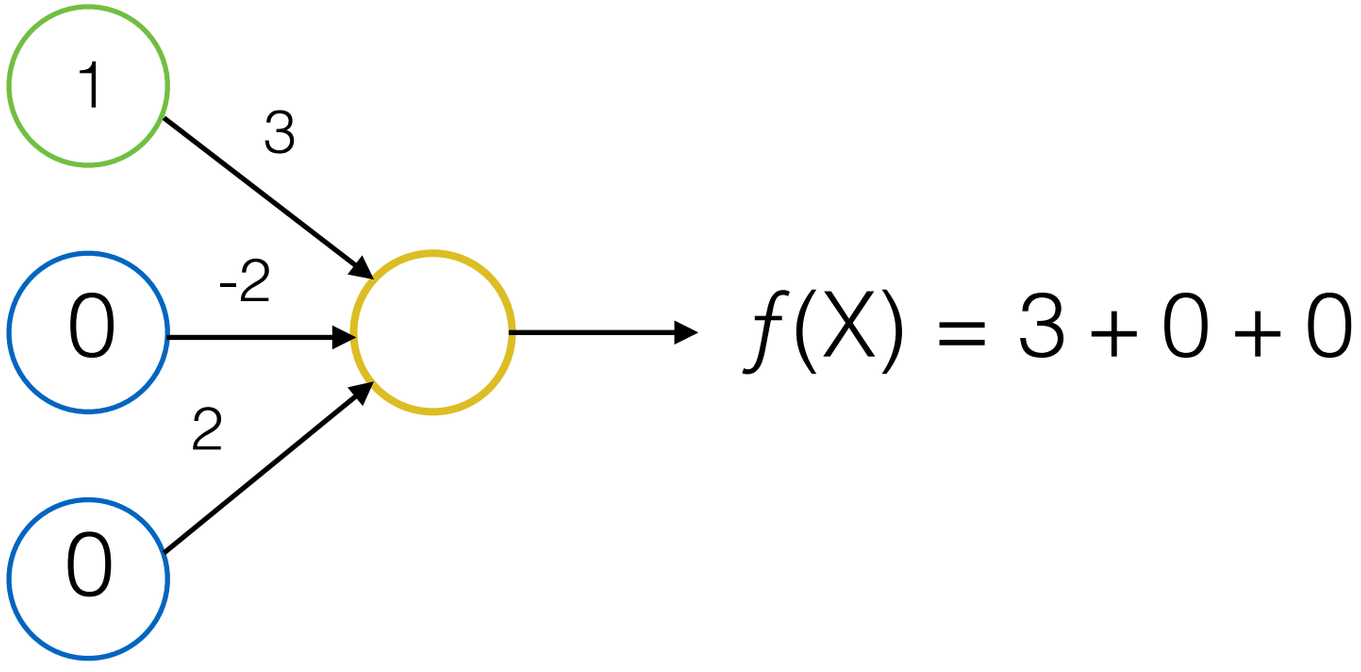
Feature 1	Feature 2	Target
0	0	0
1	0	1
0	1	1
1	1	1



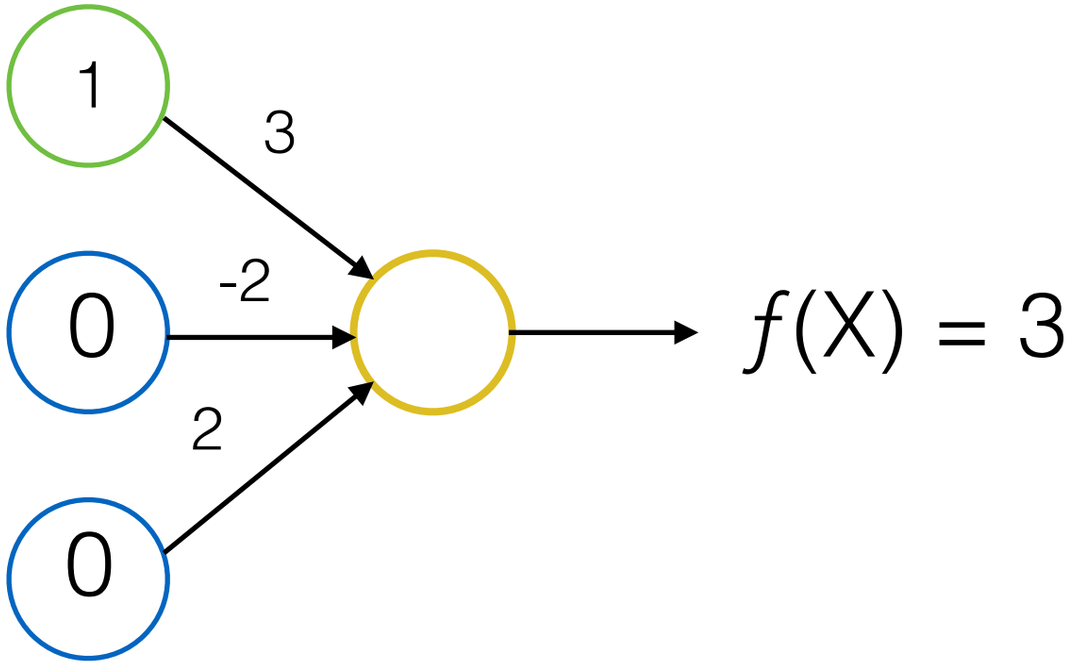
Feature 1	Feature 2	Target
0	0	0
1	0	1
0	1	1
1	1	1



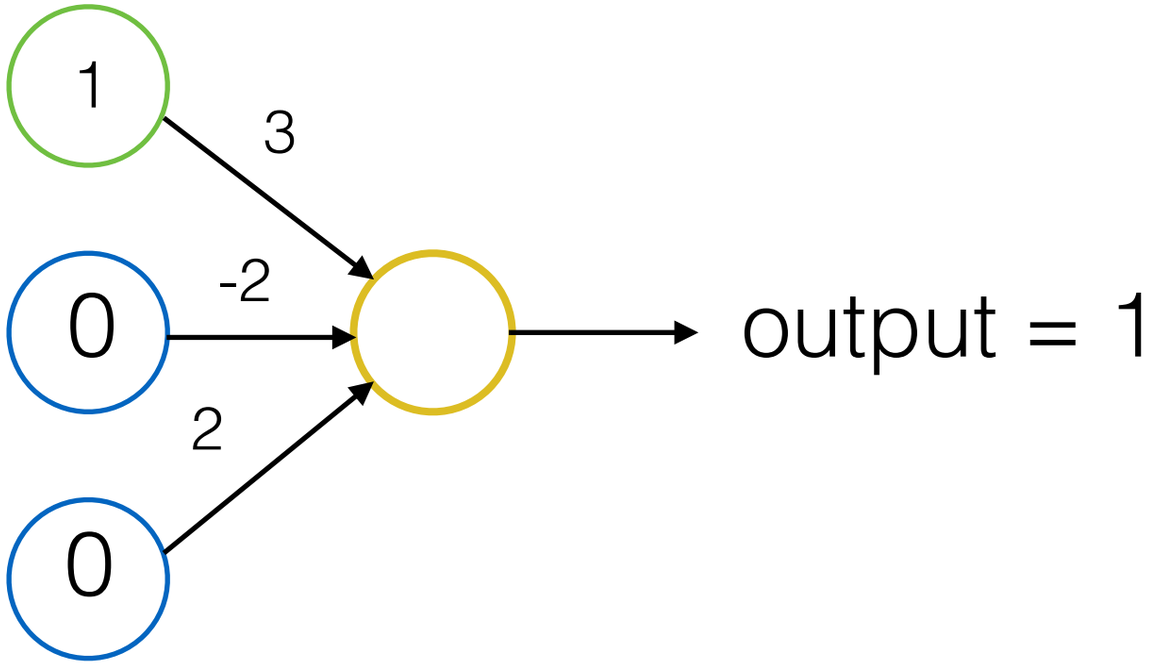
Feature 1	Feature 2	Target
0	0	0
1	0	1
0	1	1
1	1	1



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



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 $\text{weight}_0 = 3 - (\text{output} - \text{target}) * \text{input}_0$

updated $\text{weight}_1 = -2 - (\text{output} - \text{target}) * \text{input}_1$

updated $\text{weight}_2 = 2 - (\text{output} - \text{target}) * \text{input}_2$

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

input: 1, 0, 0

output: 1

target: 0

$$\text{updated weight}_0 = 3 - (1 - 0) * \text{input}_0$$

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

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

weights: 3, -2, 2 **output**: 1

input: 1, 0, 0 **target**: 0

$$\text{updated weight}_0 = 3 - (1 - 0) * 1$$

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

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

weights: 3, -2, 2

input: 1, 0, 0

output: 1

target: 0

updated $\text{weight}_0 = 3 - 1$

updated $\text{weight}_1 = -2 - 0$

updated $\text{weight}_2 = 2 - 0$

weights: 3, -2, 2

input: 1, 0, 0

output: 1

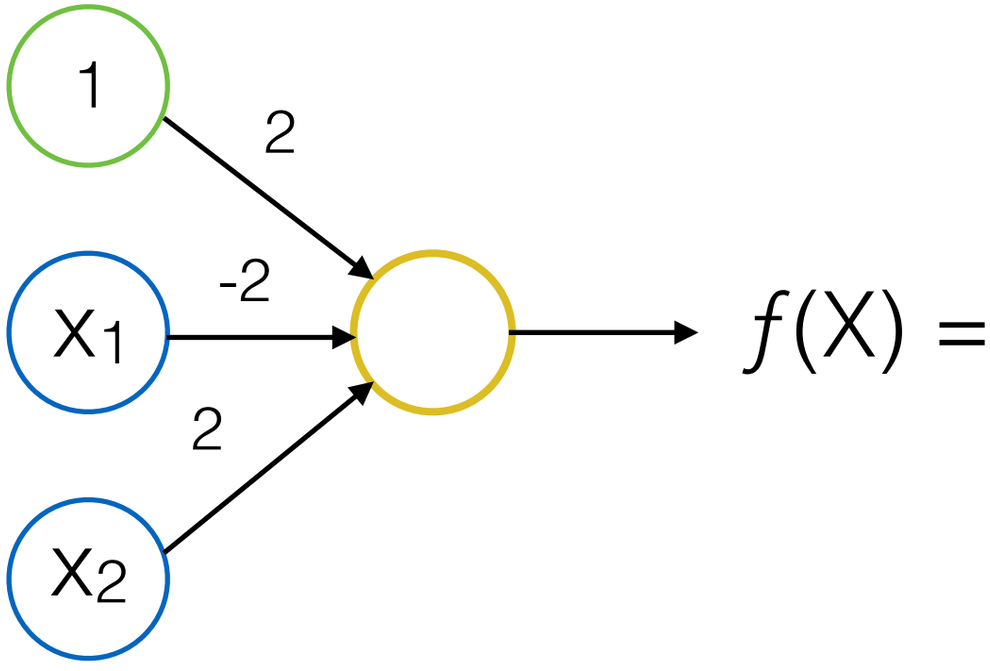
target: 0

updated $\text{weight}_0 = 2$

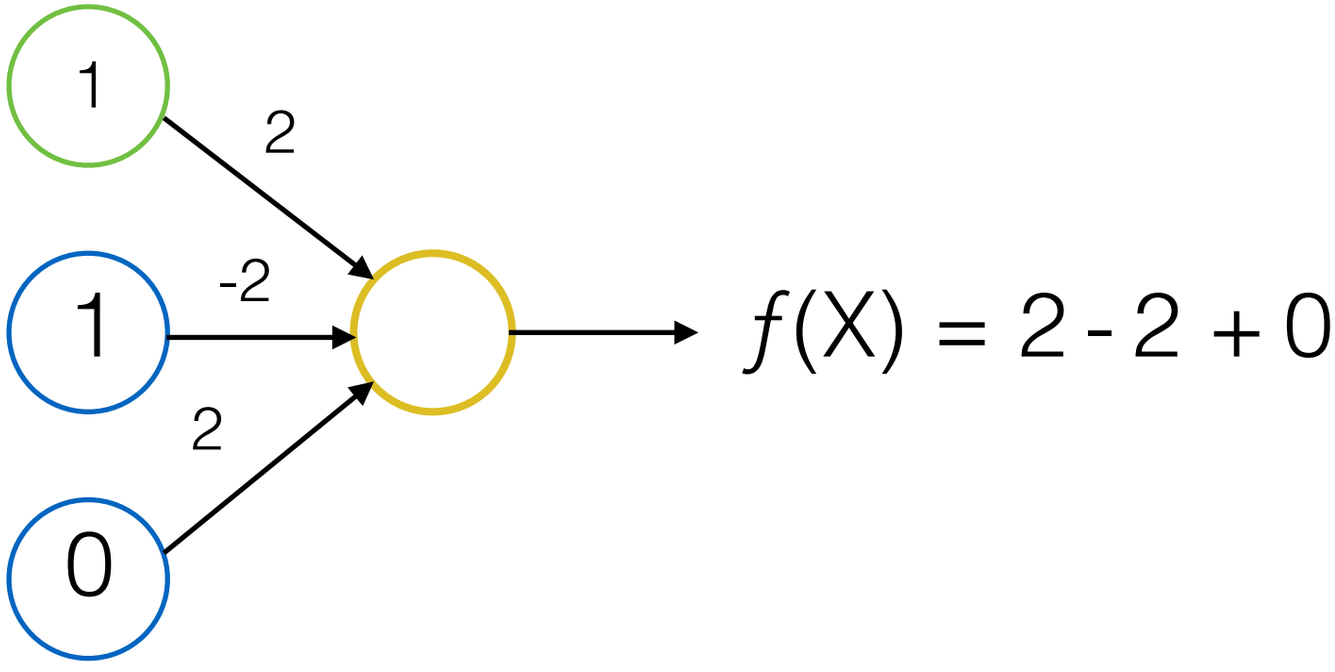
updated $\text{weight}_1 = -2$

updated $\text{weight}_2 = 2$

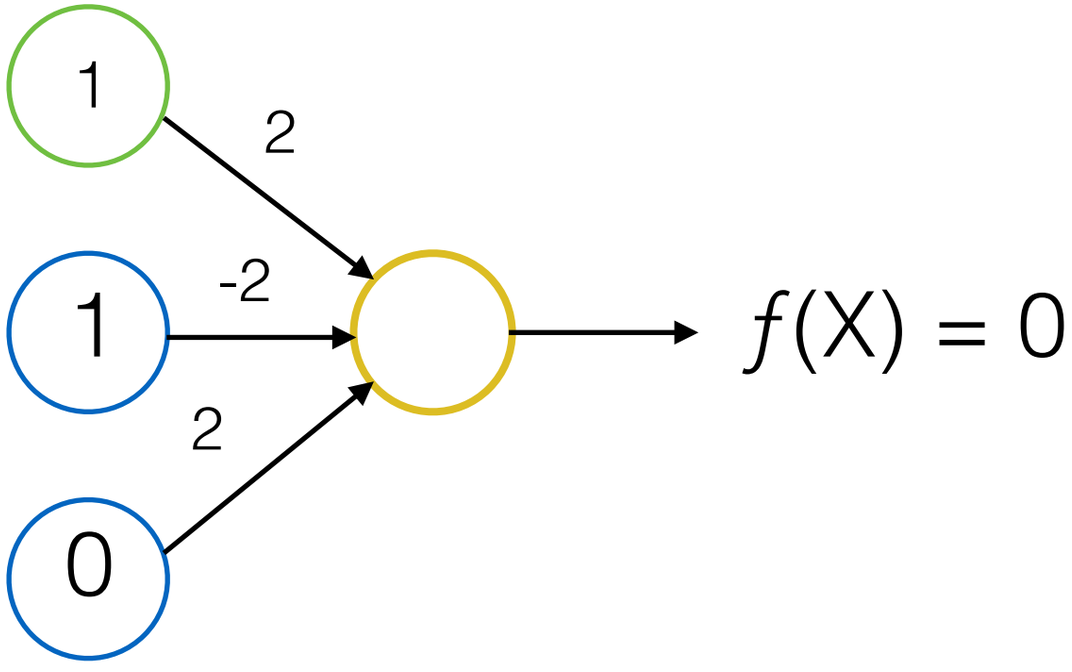
Feature 1	Feature 2	Target
0	0	0
1	0	1
0	1	1
1	1	1



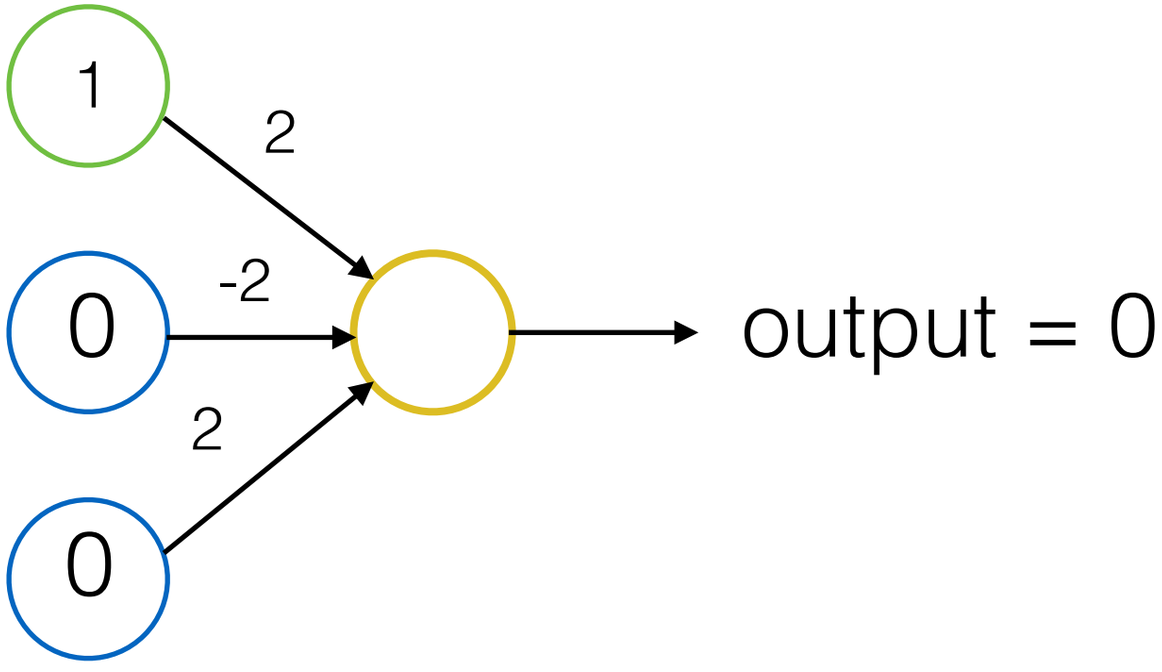
Feature 1	Feature 2	Target
0	0	0
1	0	1
0	1	1
1	1	1



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 $\text{weight}_0 = 2 - (\text{output} - \text{target}) * \text{input}_0$

updated $\text{weight}_1 = -2 - (\text{output} - \text{target}) * \text{input}_1$

updated $\text{weight}_2 = 2 - (\text{output} - \text{target}) * \text{input}_2$

weights: 2, -2, 2

input: 1, 1, 0

output: 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

input: 1, 1, 0

output: 0

target: 1

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

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

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

weights: 2, -2, 2 **output**: 0

input: 1, 1, 0 **target**: 1

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

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

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

weights: 2, -2, 2

output: 0

input: 1, 1, 0

target: 1

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

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

$$\text{updated weight}_2 = 2 - 0$$

weights: 2, -2, 2

input: 1, 1, 0

output: 0

target: 1

$$\text{updated weight}_0 = 2 + 1$$

$$\text{updated weight}_1 = -2 + 1$$

$$\text{updated weight}_2 = 2 - 0$$

weights: 2, -2, 2

input: 1, 1, 0

output: 0

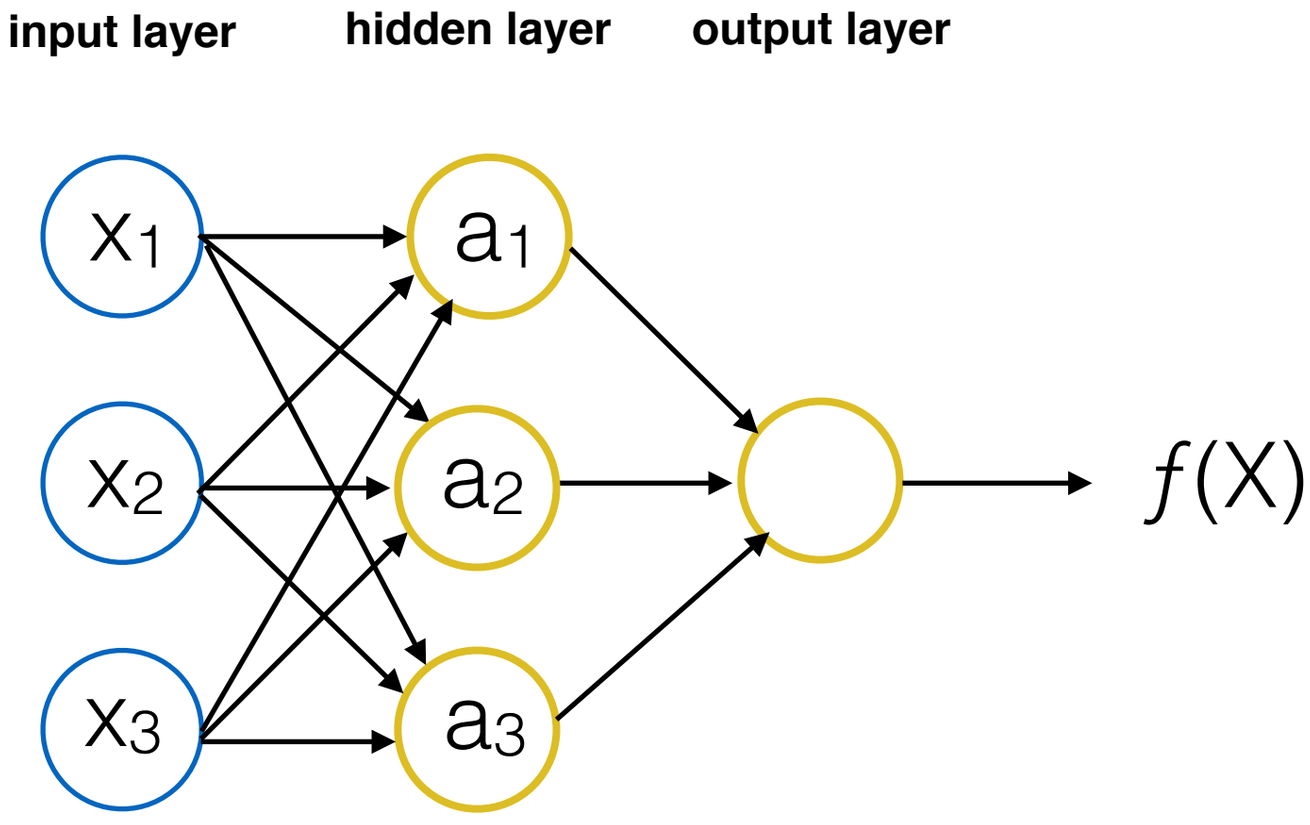
target: 1

updated $\text{weight}_0 = 3$

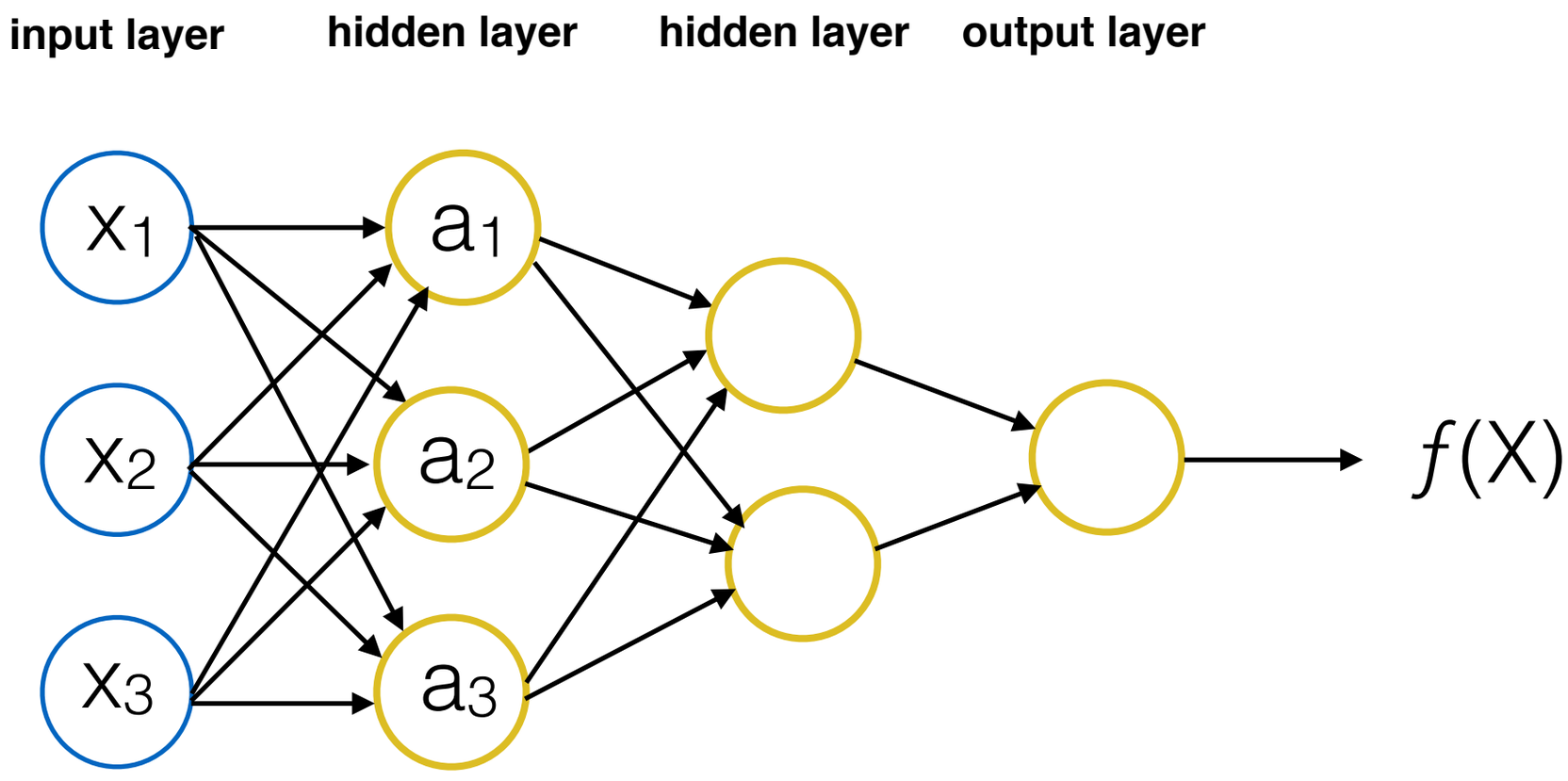
updated $\text{weight}_1 = -1$

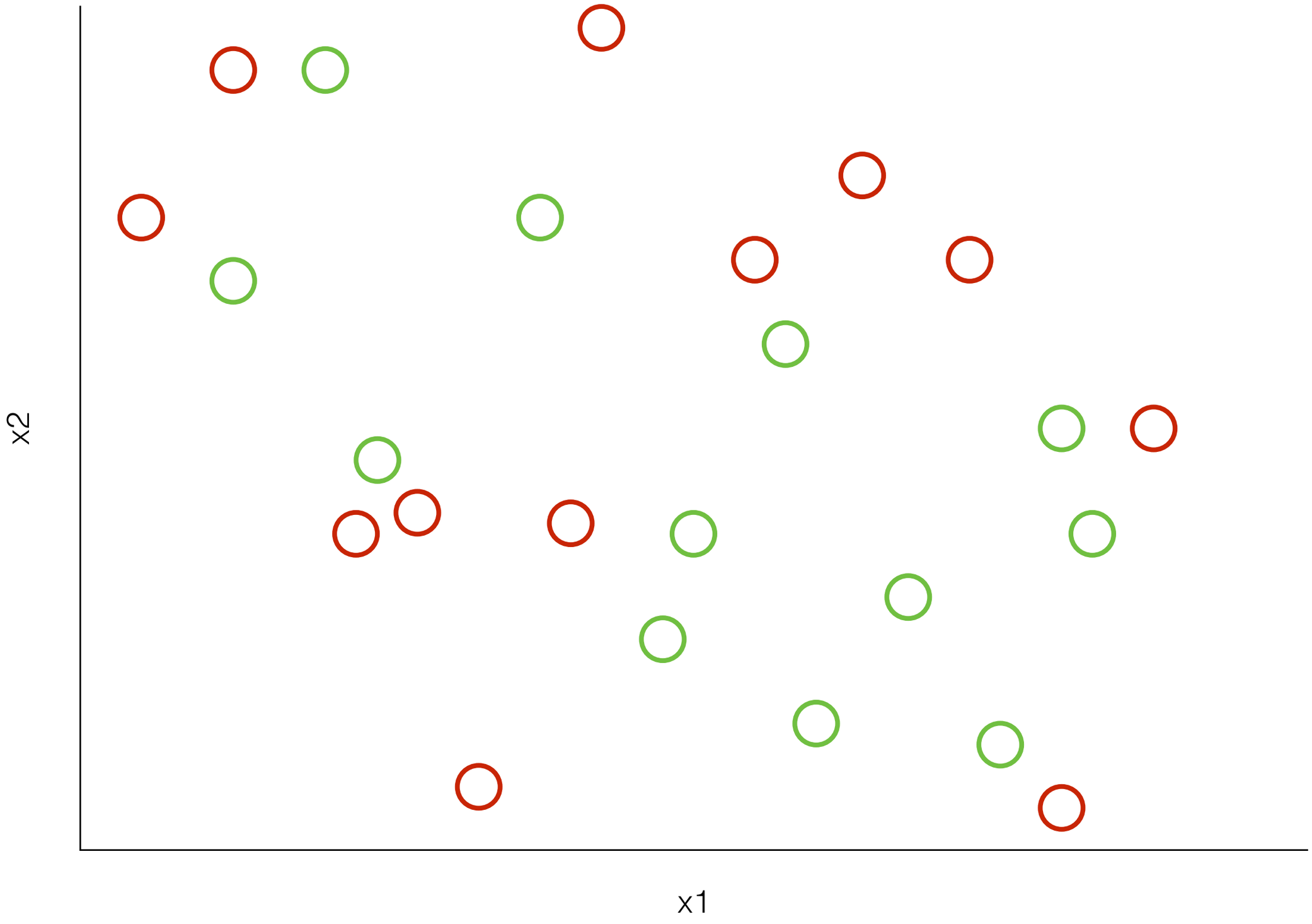
updated $\text{weight}_2 = 2$

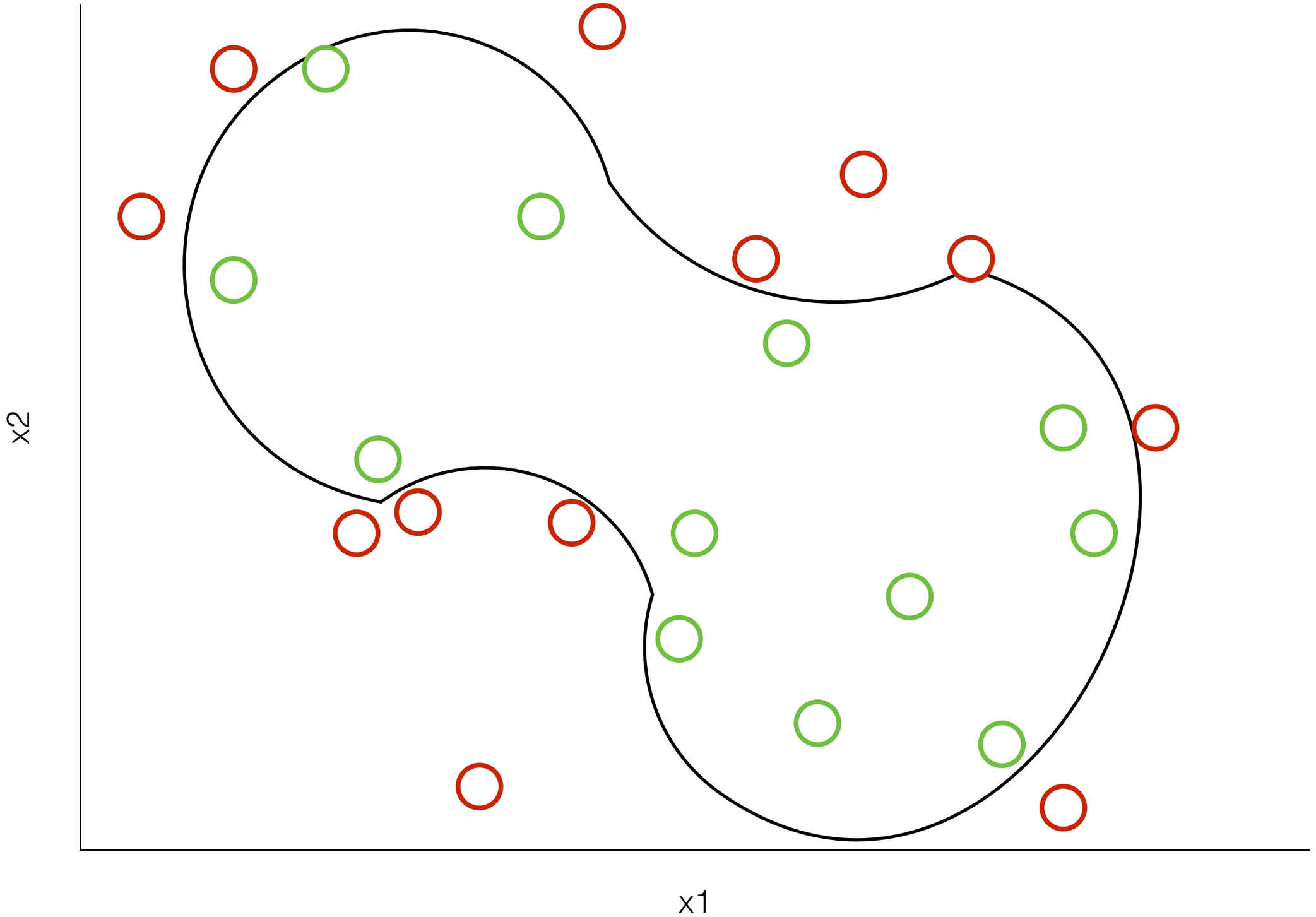
Multi-Layer Perceptron (MLP)



Multi-Layer Perceptron (MLP)




x2
x1


x2
x1

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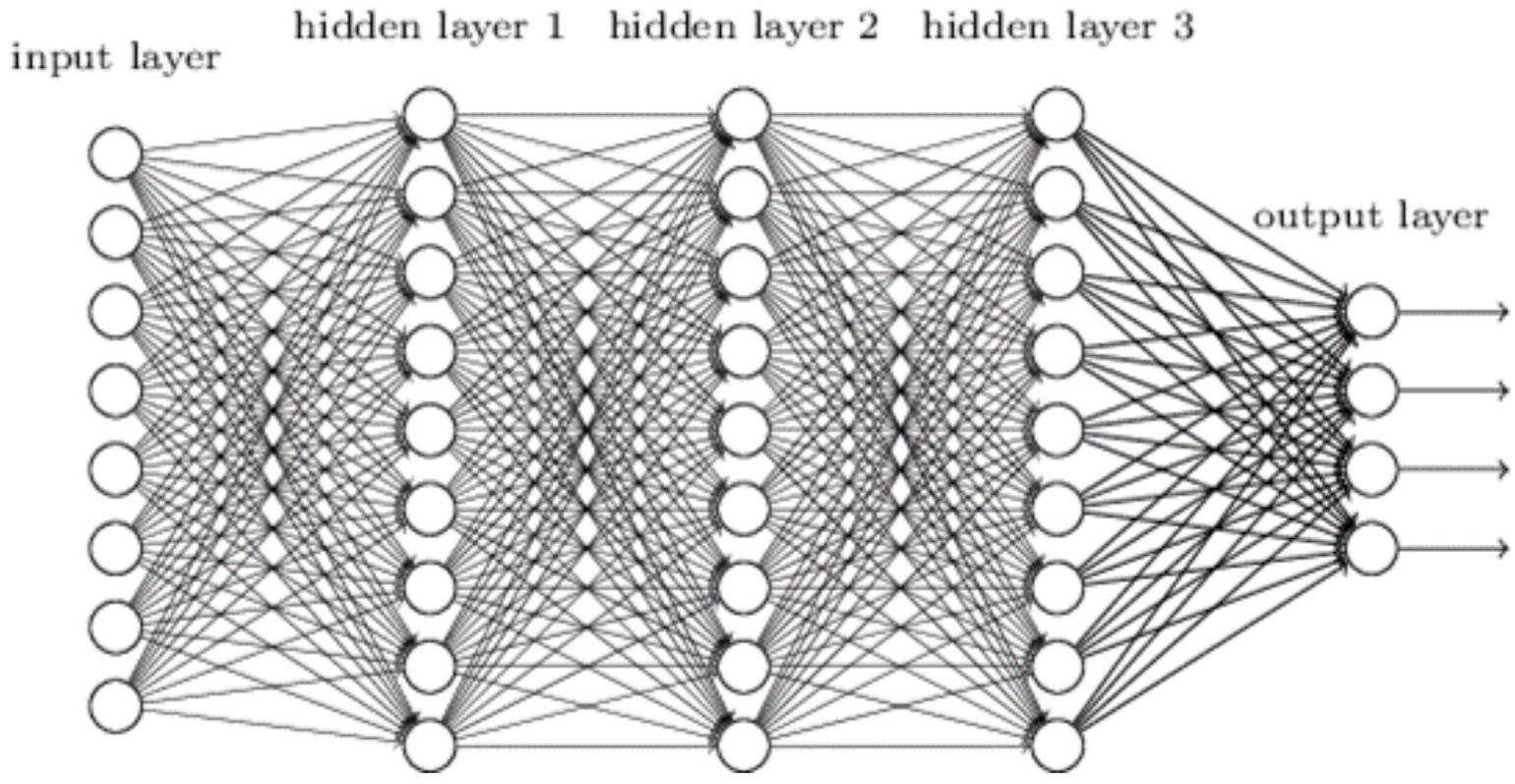
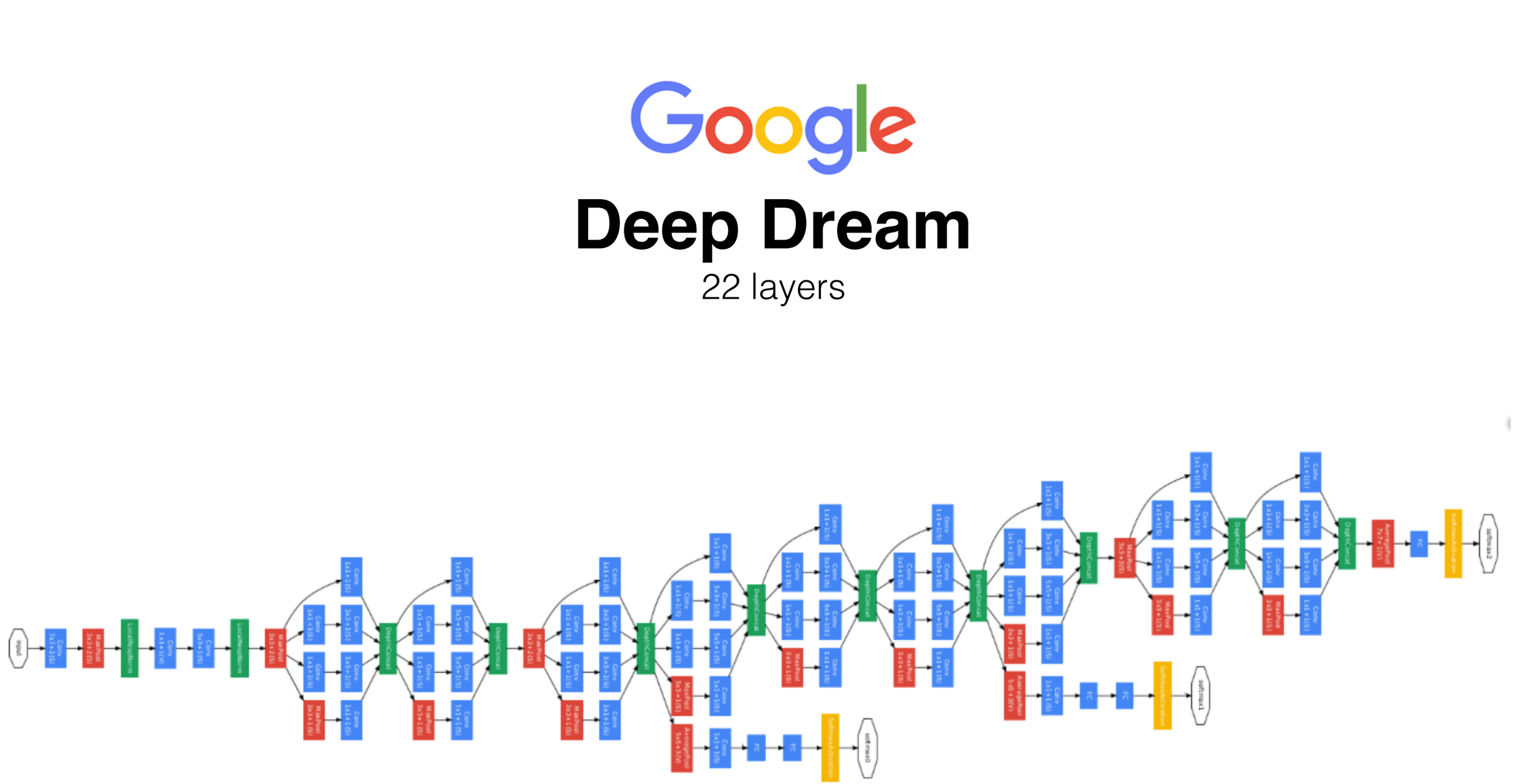
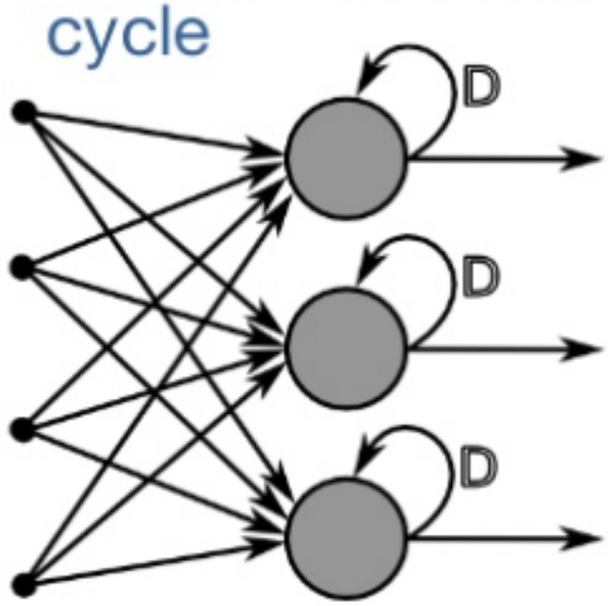
Deep Neural Network

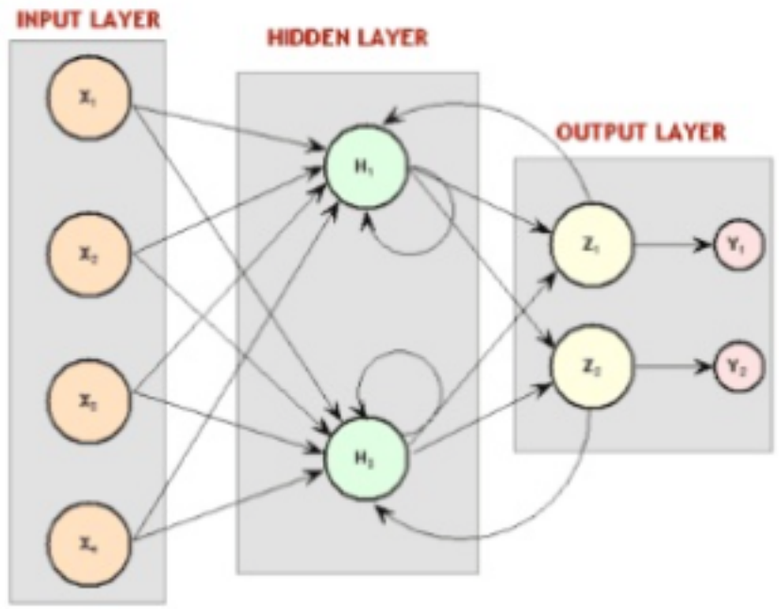



Google
Deep Dream
22 layers

Recurrent neural network

- A class of artificial neural network where connections between units form a directed cycle





Harry Potter: Written by Artificial Intelligence

I trained an LSTM Recurrent Neural Network (a deep learning algorithm) on the first four Harry Potter books. I then asked it to produce a chapter based on what it learned. Here's the chapter. (I added a bit of formatting to aid readability)

Part 1

"The Malfoys!" said Hermione.

Harry was watching him. He looked like Madame Maxime. When she strode up the wrong staircase to visit himself.

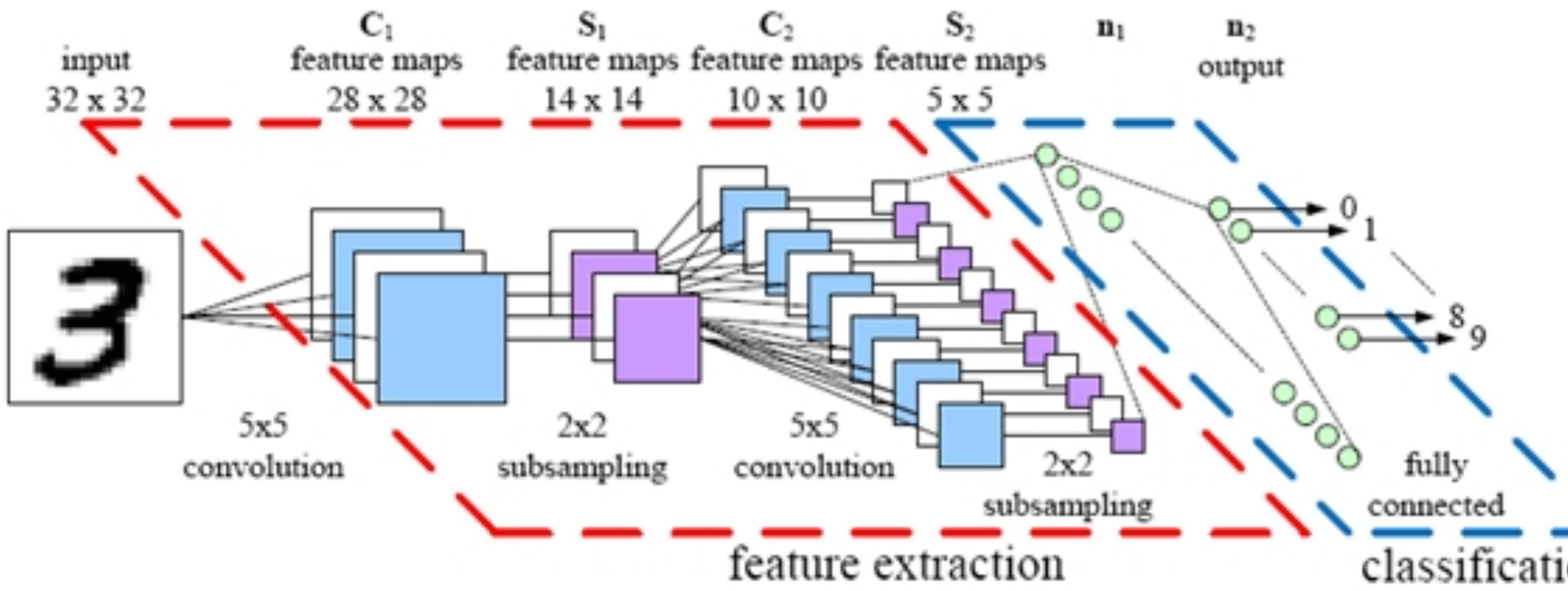
"I'm afraid I've definitely been suspended from power, no chance—indeed?" said Snape. He put his head back behind them and read groups as they crossed a corner and fluttered down onto their ink lamp, and picked up his spoon. The doorbell rang. It was a lot cleaner down in London.

Hermione yelled. The party must be thrown by Krum, of course.

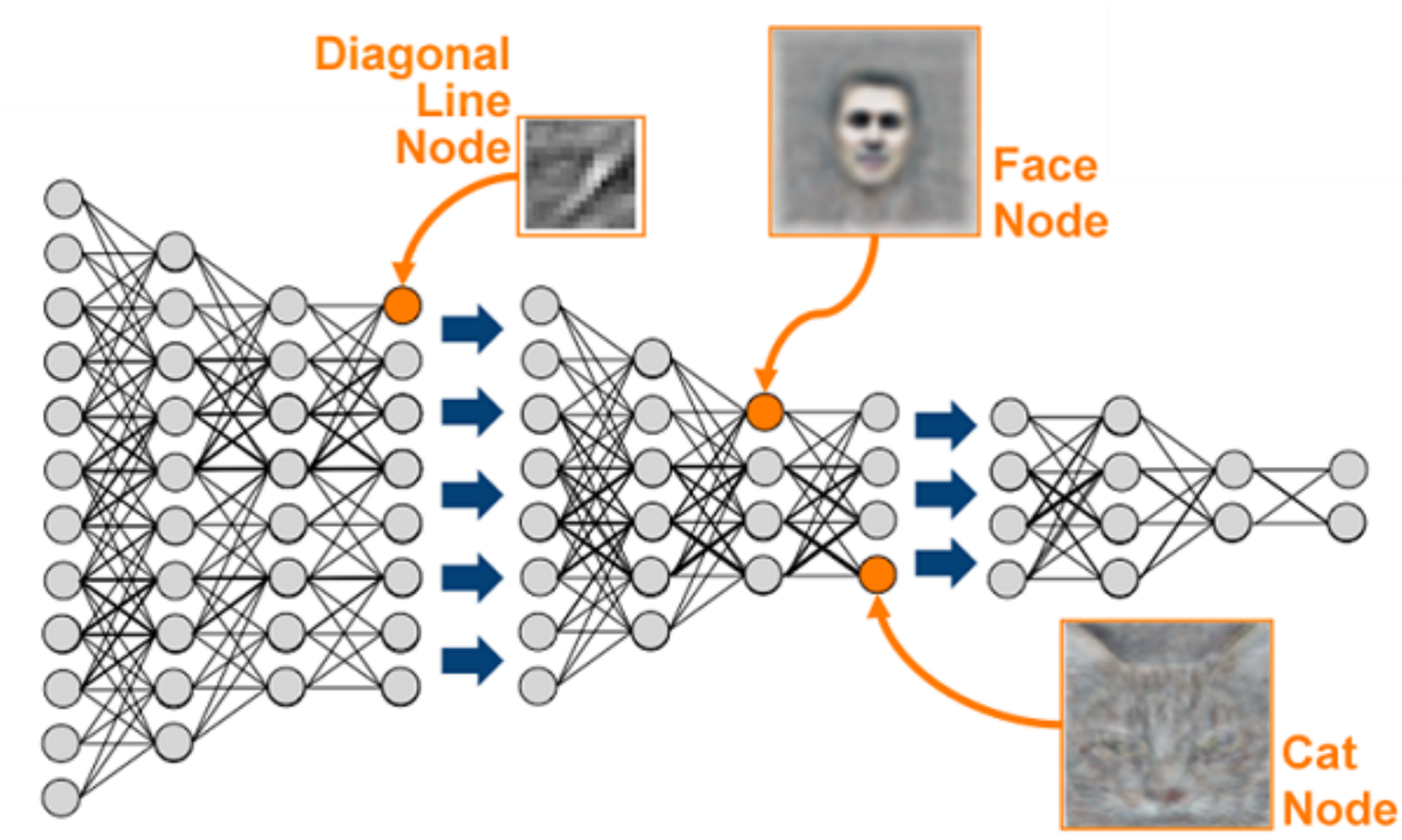
Harry collected fingers once more, with Malfoy. "Why, didn't she never tell me. …" She vanished. And then, Ron, Harry noticed, was nearly right.

"Now, be off," said Sirius, "I can't trace a new voice."

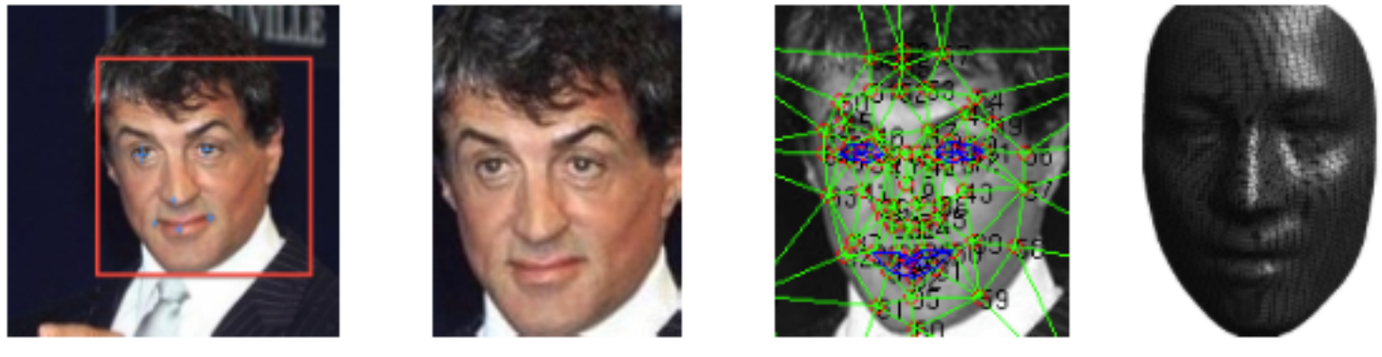
Convolutional Neural Network



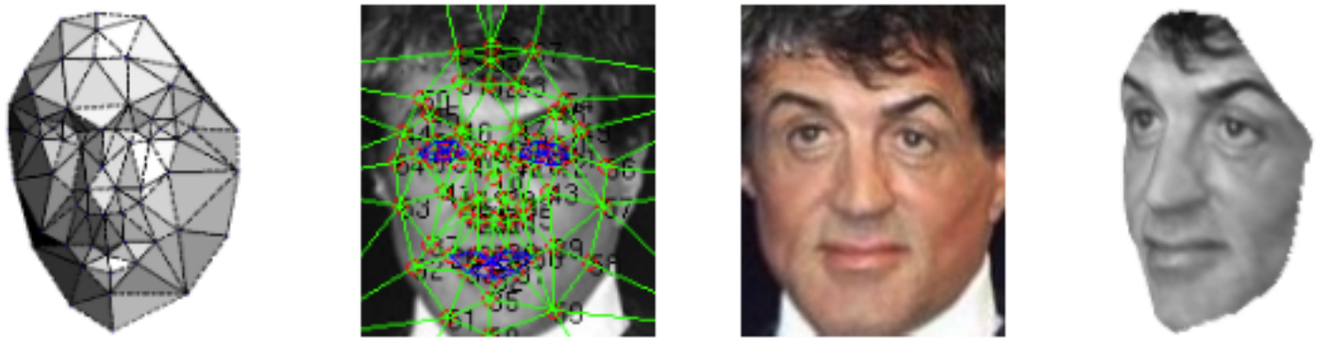
Convolutional Neural Network



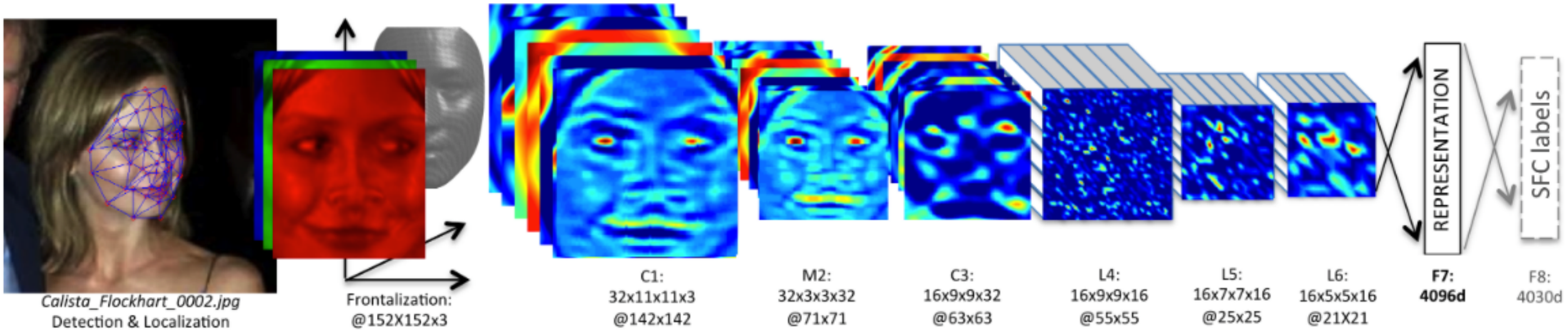
Facebook - DeepFace



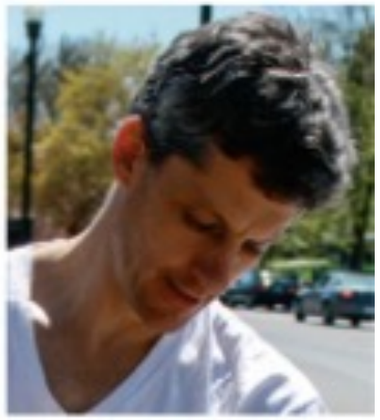
(a) (b) (c) (d)



(e) (f) (g) (h)


Calista_Flockhart_0002.jpg
Detection & Localization
Frontalization:
@152X152x3
C1:
32x11x11x3
@142x142
M2:
32x3x3x32
@71x71
C3:
16x9x9x32
@63x63
L4:
16x9x9x16
@55x55
L5:
16x7x7x16
@25x25
L6:
16x5x5x16
@21X21
F7:
4096d
REPRESENTATION
F8:
4030d
SFC labels



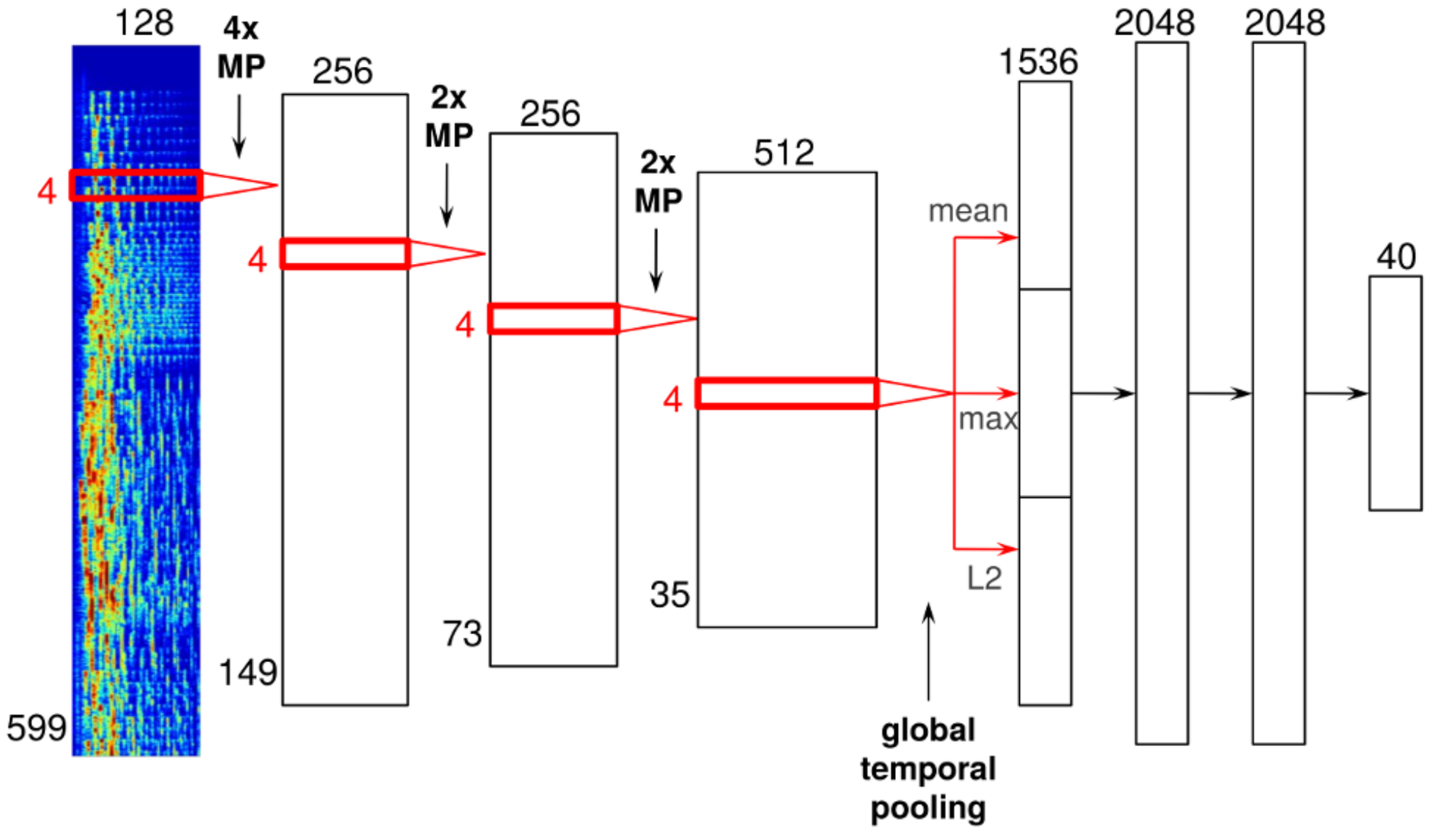









Spotify


128
599
4x
MP
256
149
4
2x
MP
256
73
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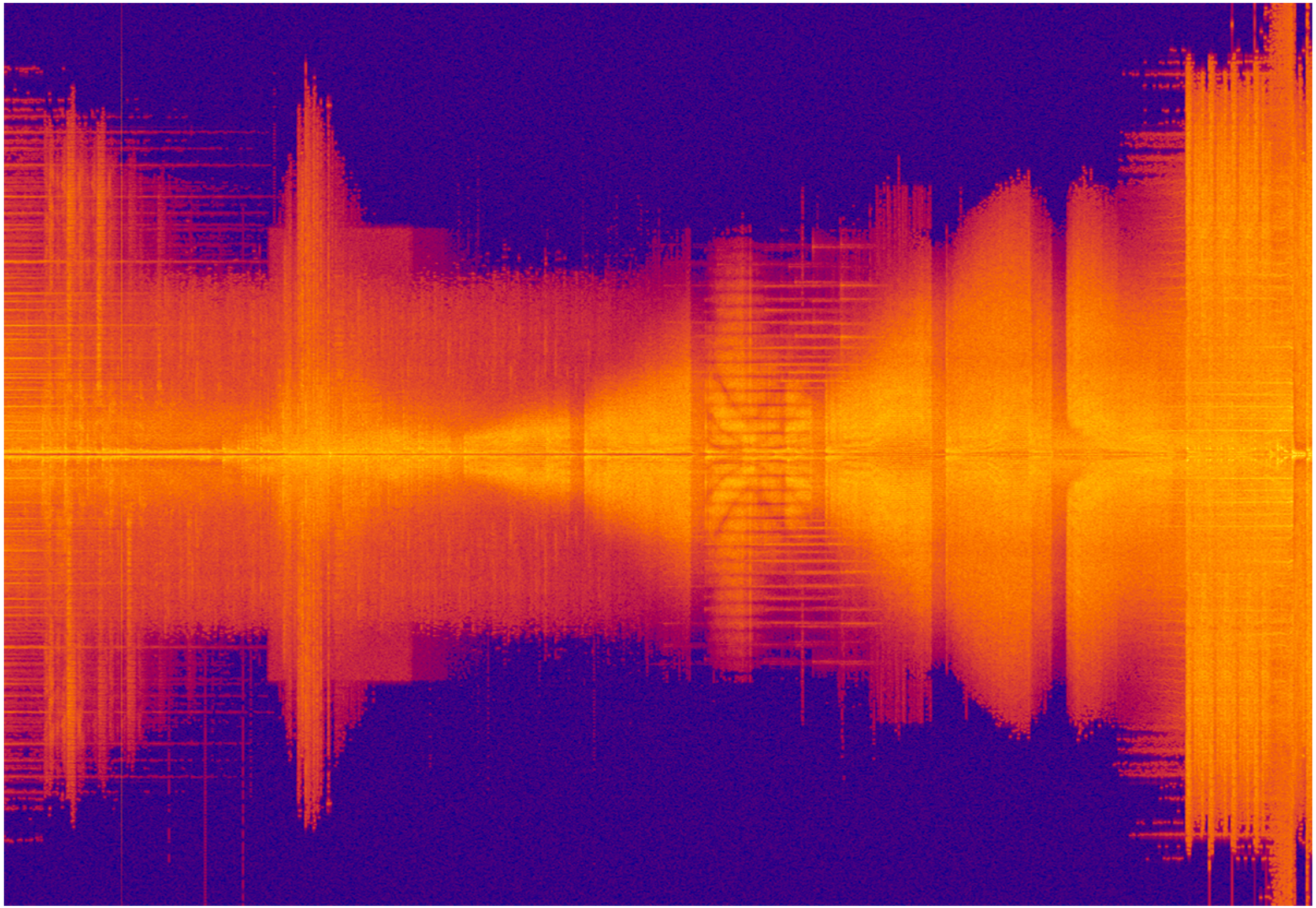
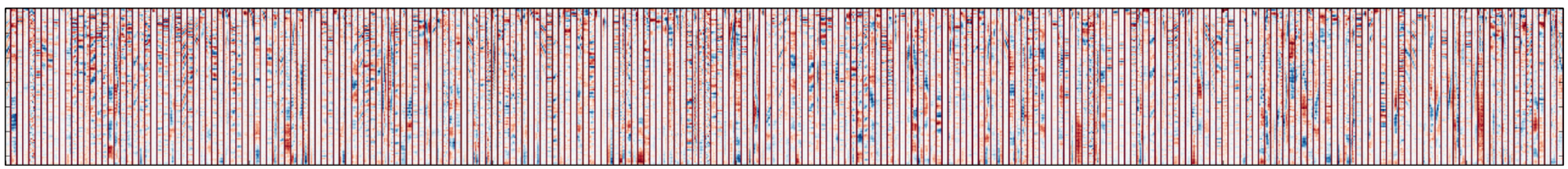
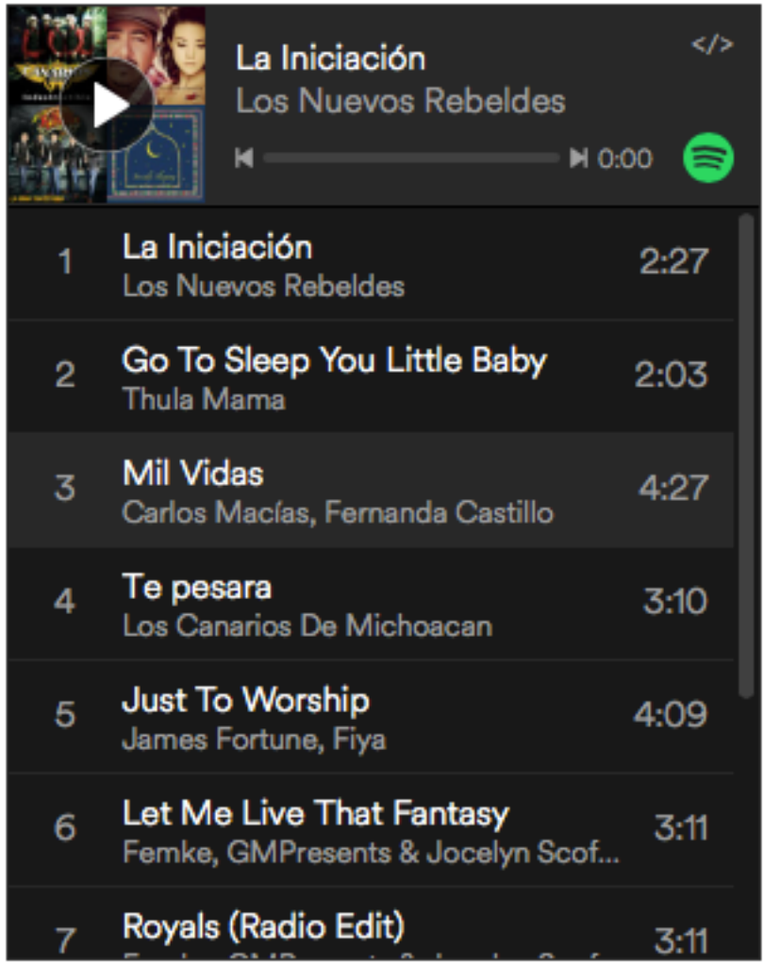
2x
MP
512
35
4
mean
max
L2
1536
2048
2048
40
global
temporal
pooling





Filter 250: vocal thirds



Filter 253: bass drums