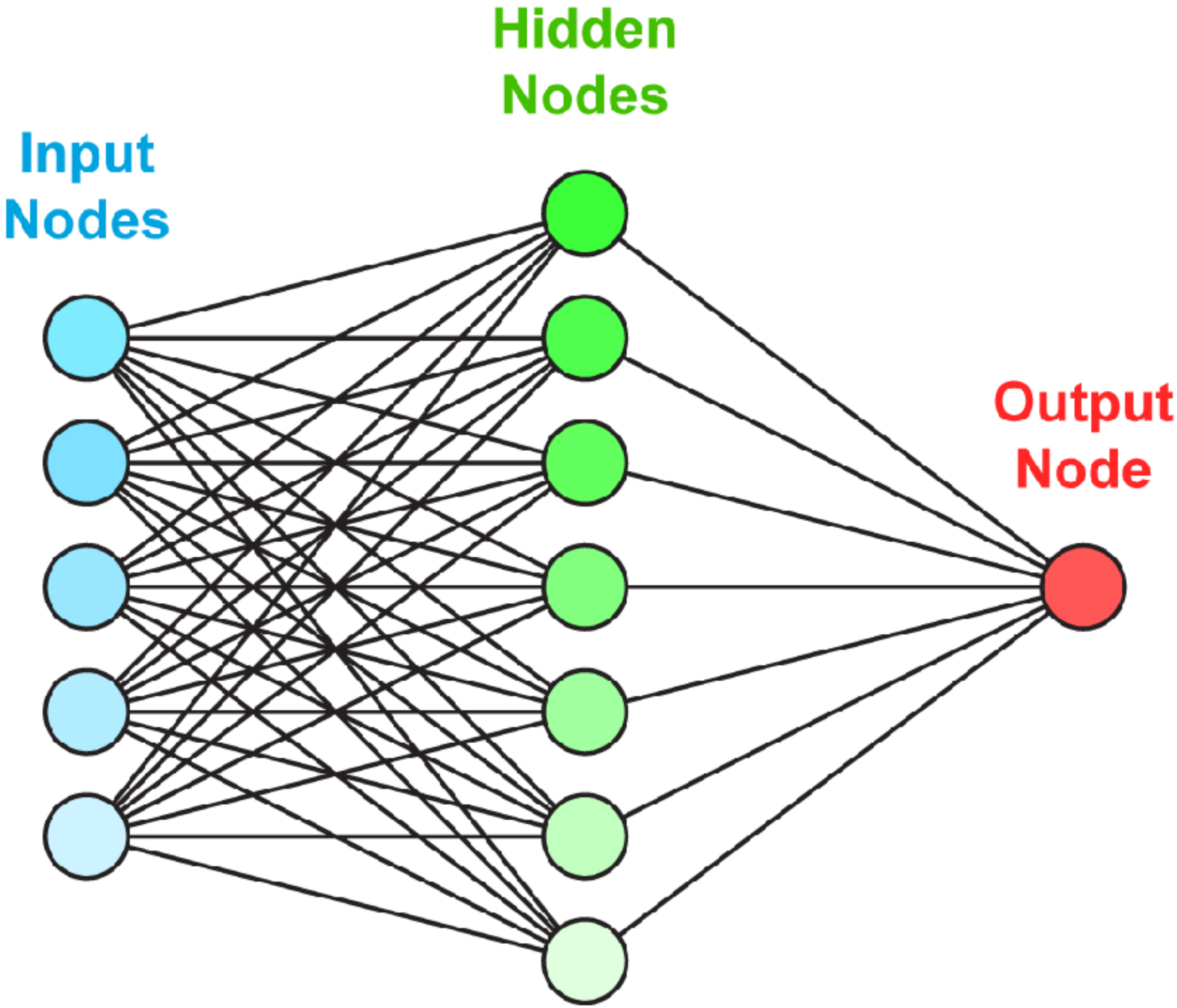
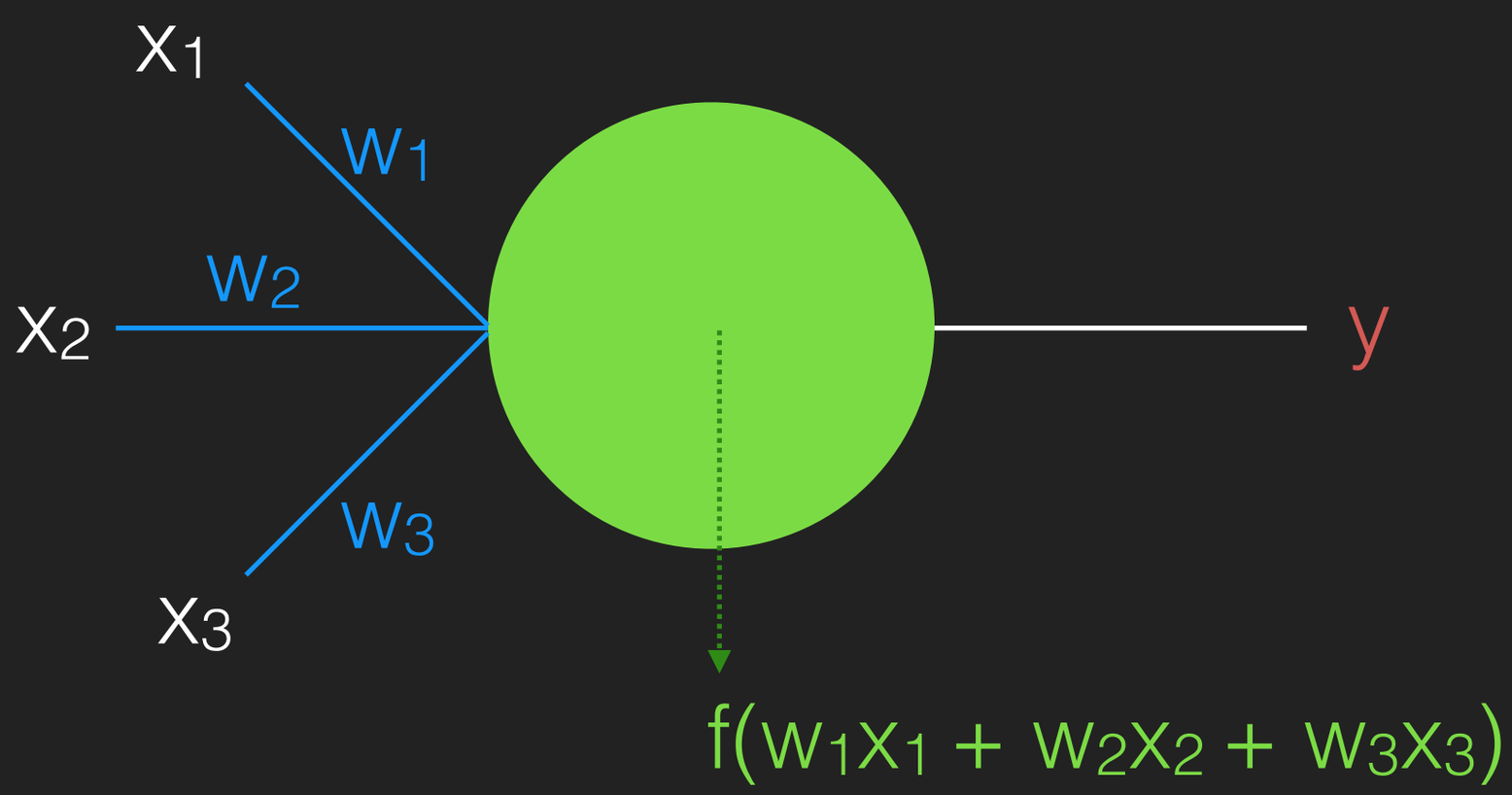
course reviews

Neural Networks

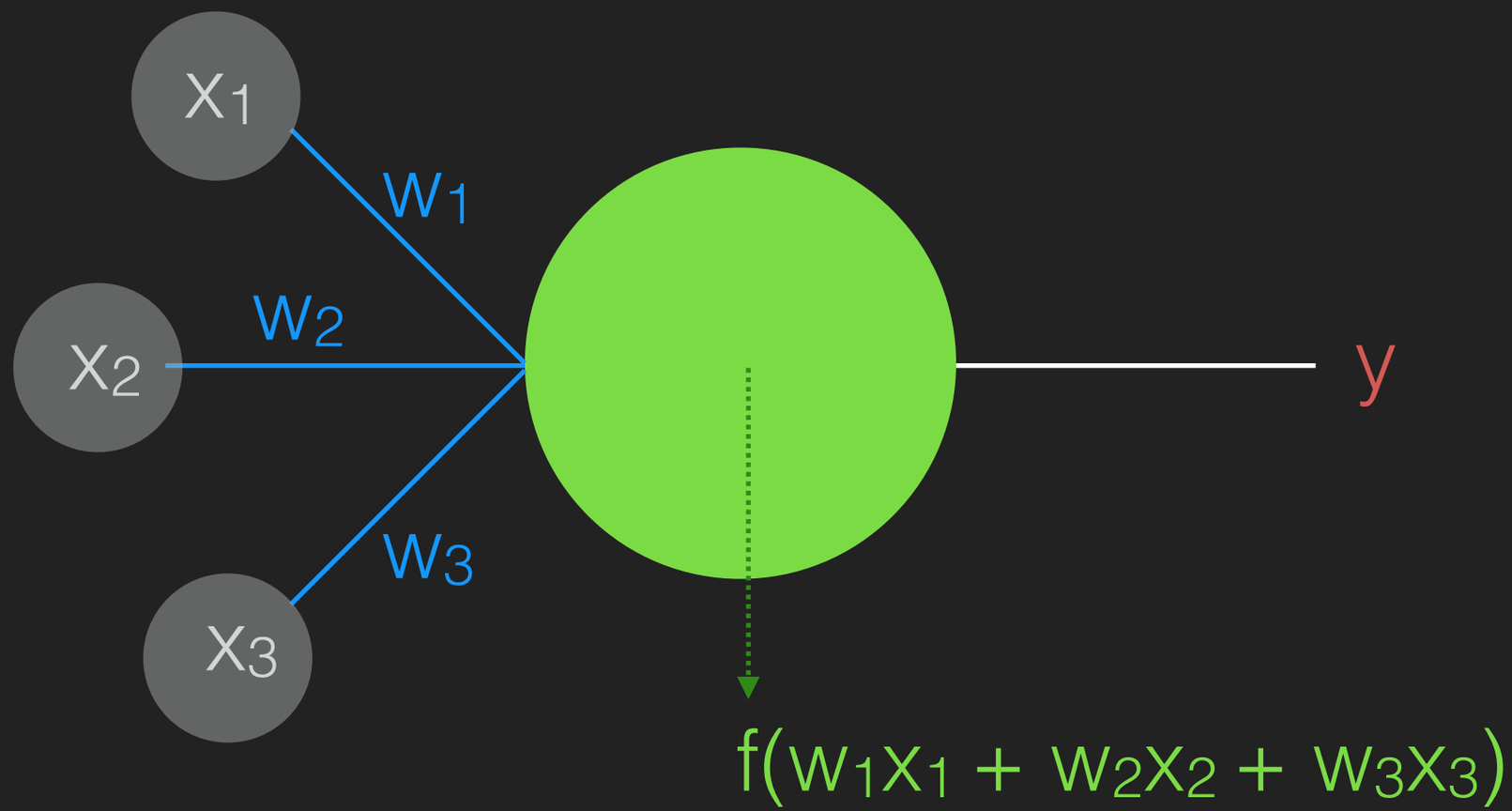
An artificial network consists of a pool of simple processing units which communicate by sending signals to each other over a large number of weighted connections.


Hidden
Nodes
Input
Nodes
Output
Node

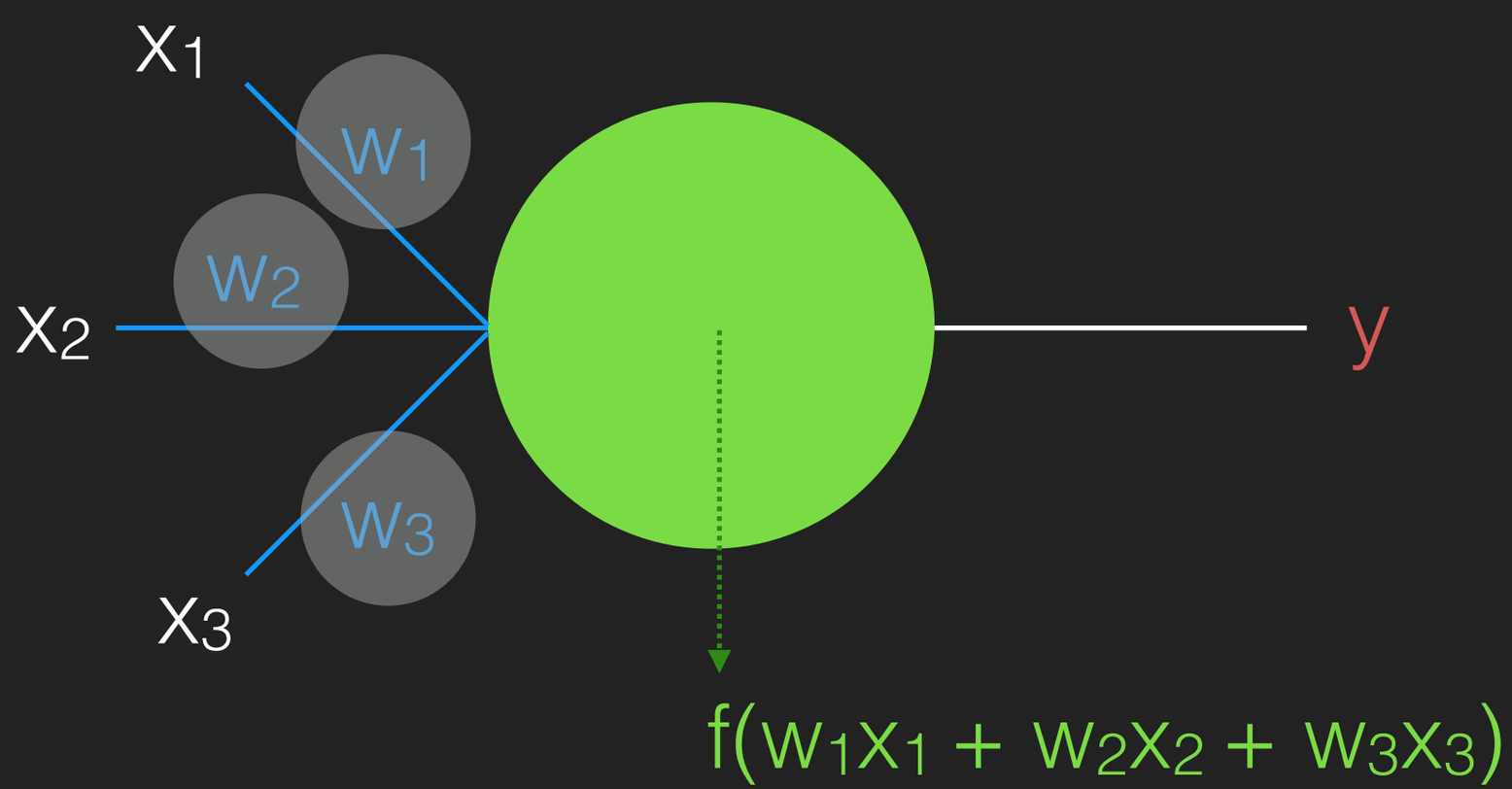
input weights computation output



input weights computation output

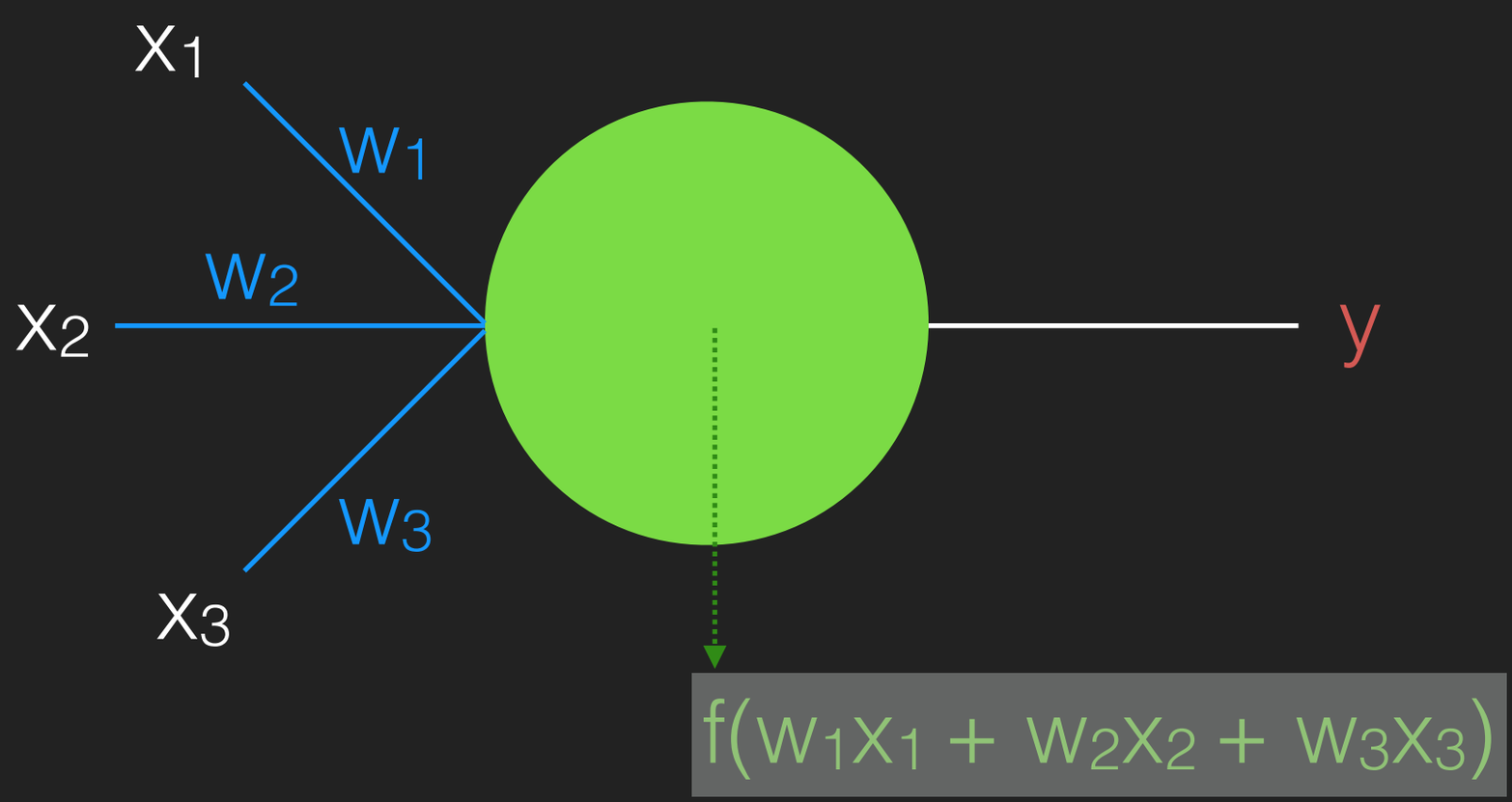


input weights computation output



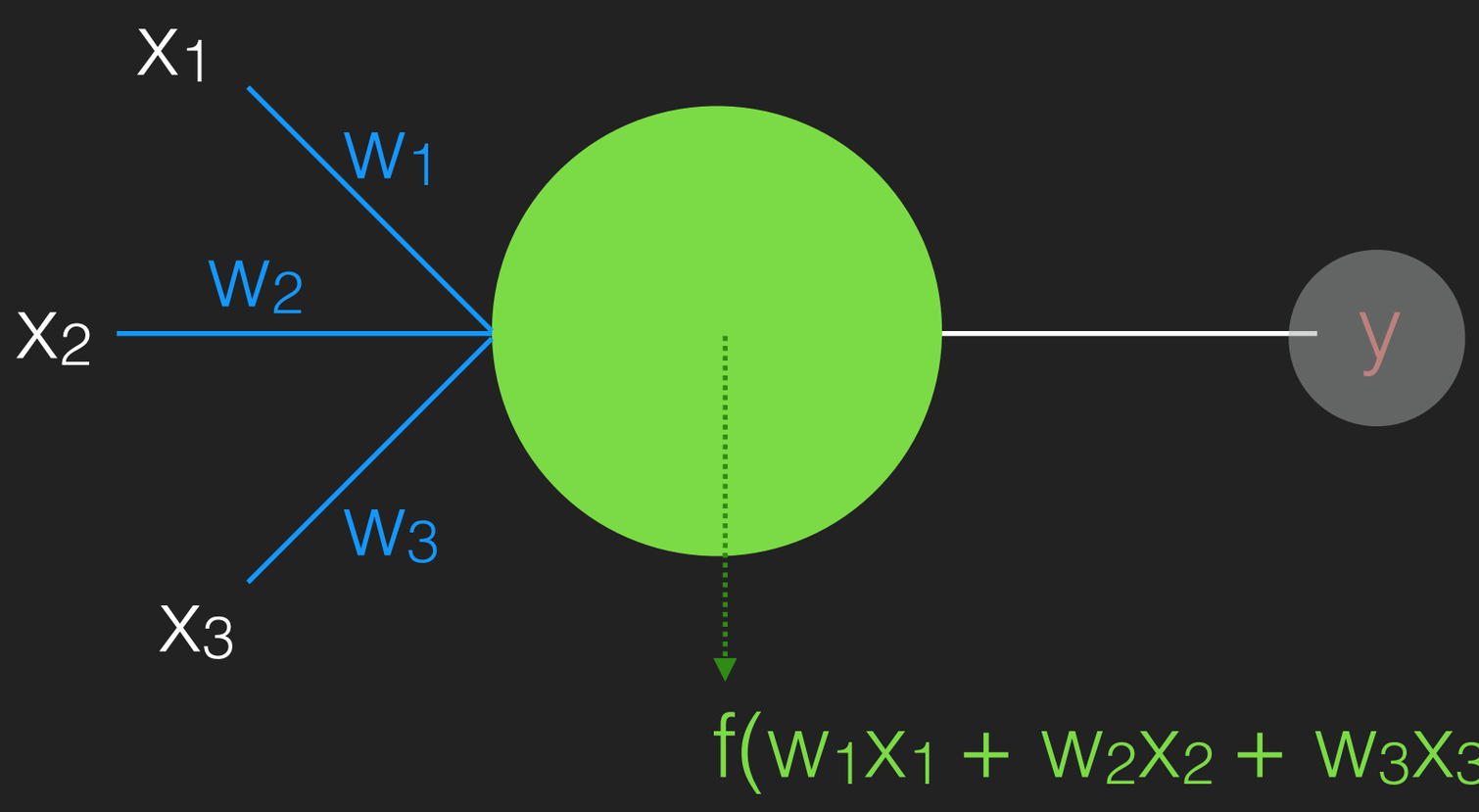
these weights are “learned”

input weights computation output

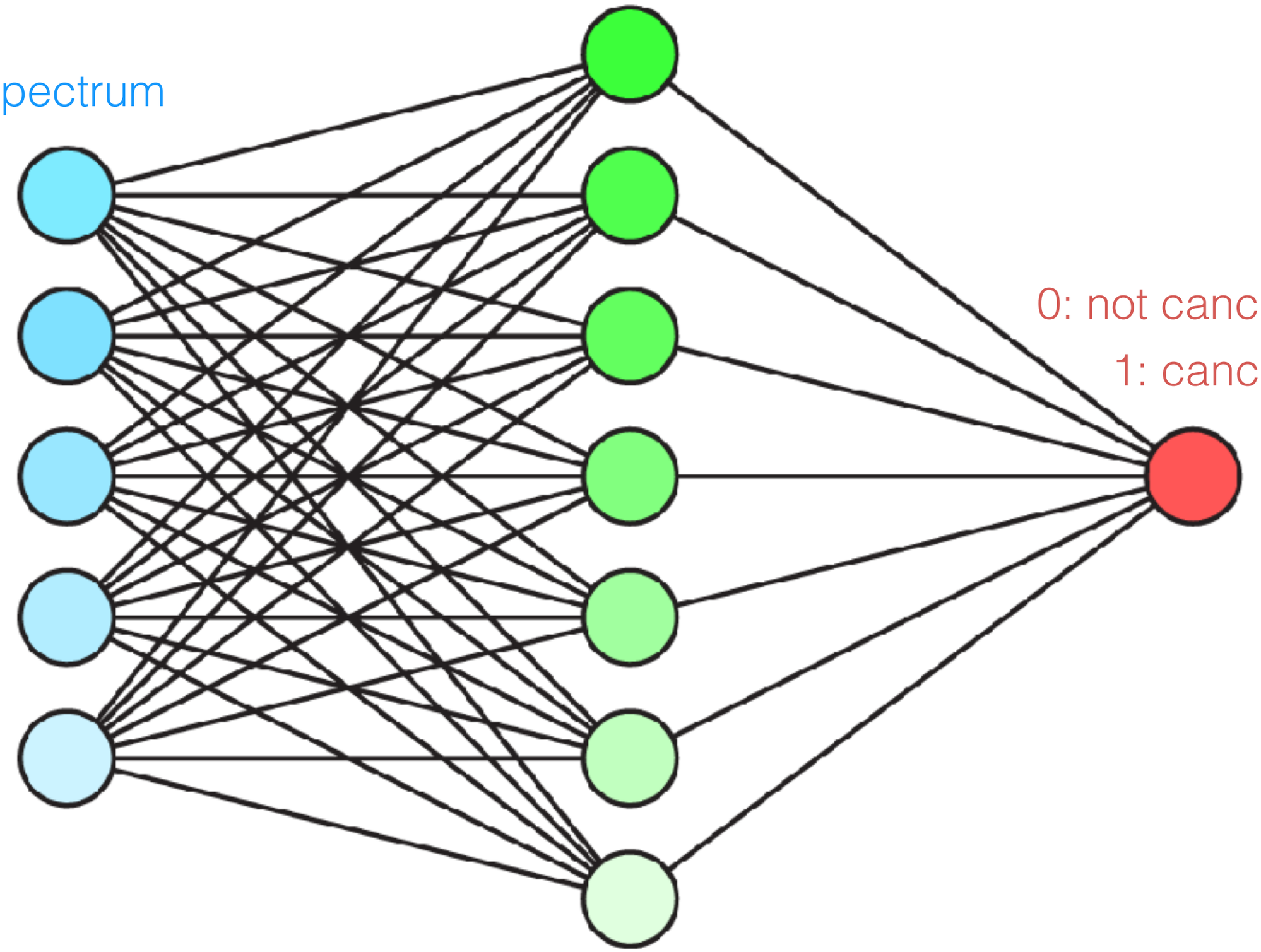


many choices for function f()

input weights computation output



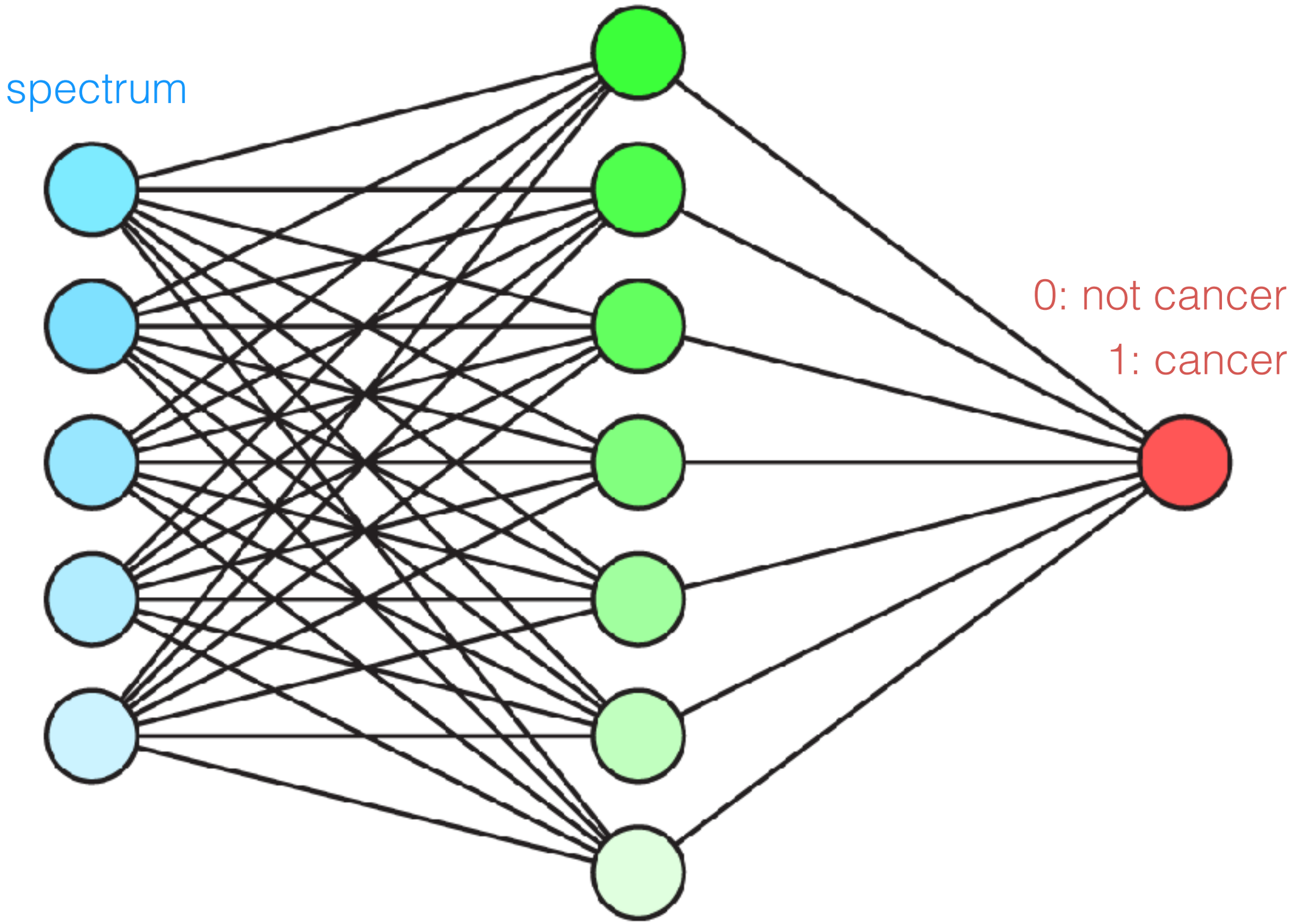
spectrum



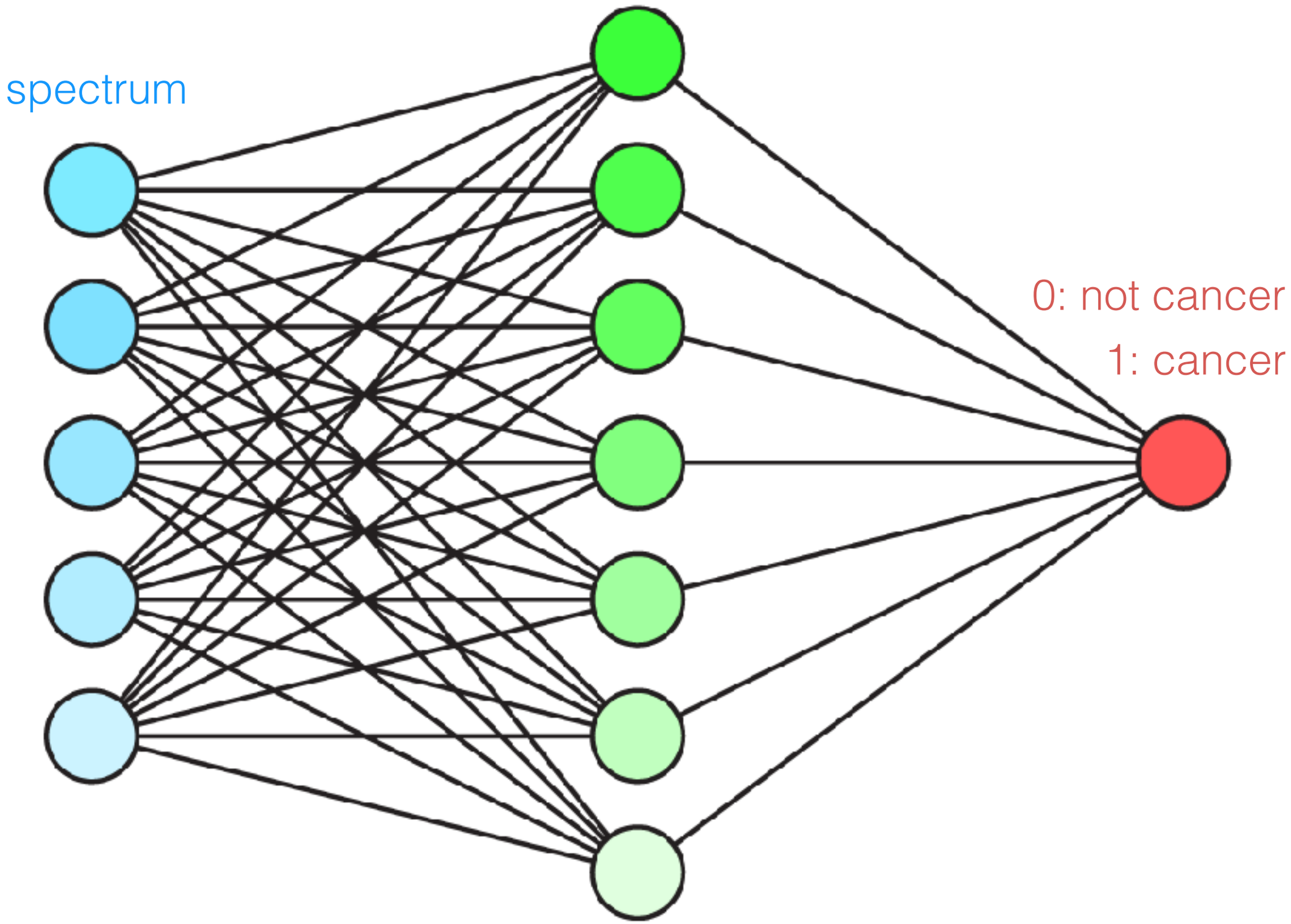
0: not cancer

1: cancer

learn weights (w) that yield correct output for (large) training set



classify using learned weights



Classifiers

Linear Discriminant Analysis (LDA)

+ easy to implement
+ easy/fast to “train”
+ doesn’t require a lot of data
+ robust
+ easy/fast to classify

- only works if data is linearly separable

Classifiers

Linear Support Vector Machine (SVM)

+ easy to implement
+ easy/fast to “train”
+ doesn’t require a lot of data
+ robust
+ easy/fast to classify

- only works if data is linearly separable

Classifiers

Non-Linear Support Vector Machine (SVM)

+ works if data is not linearly separable
+ easy/fast to classify

- harder to implement
- harder to “train”
- requires a lot of data
- less robust (over-training)

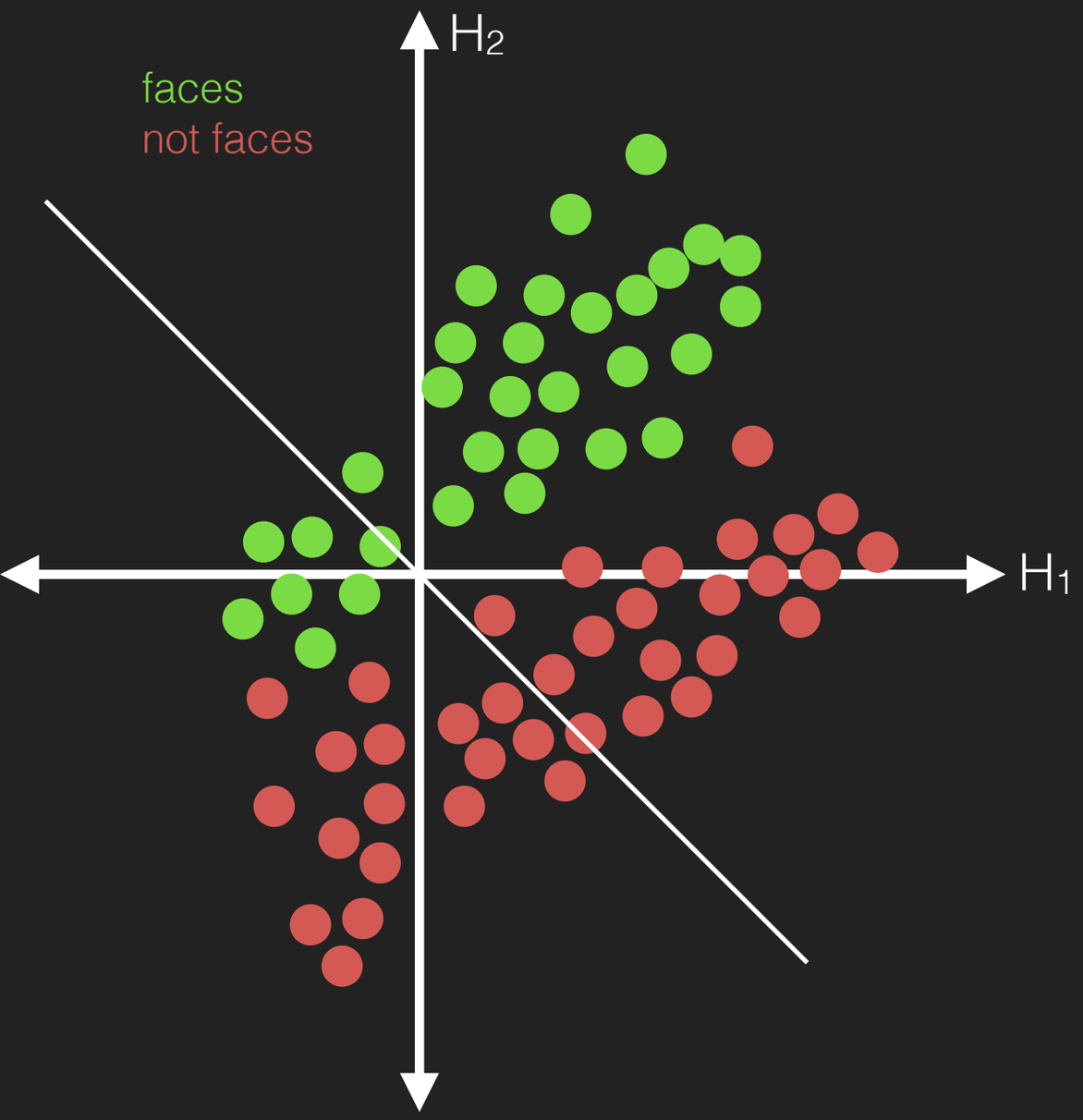
Classifiers

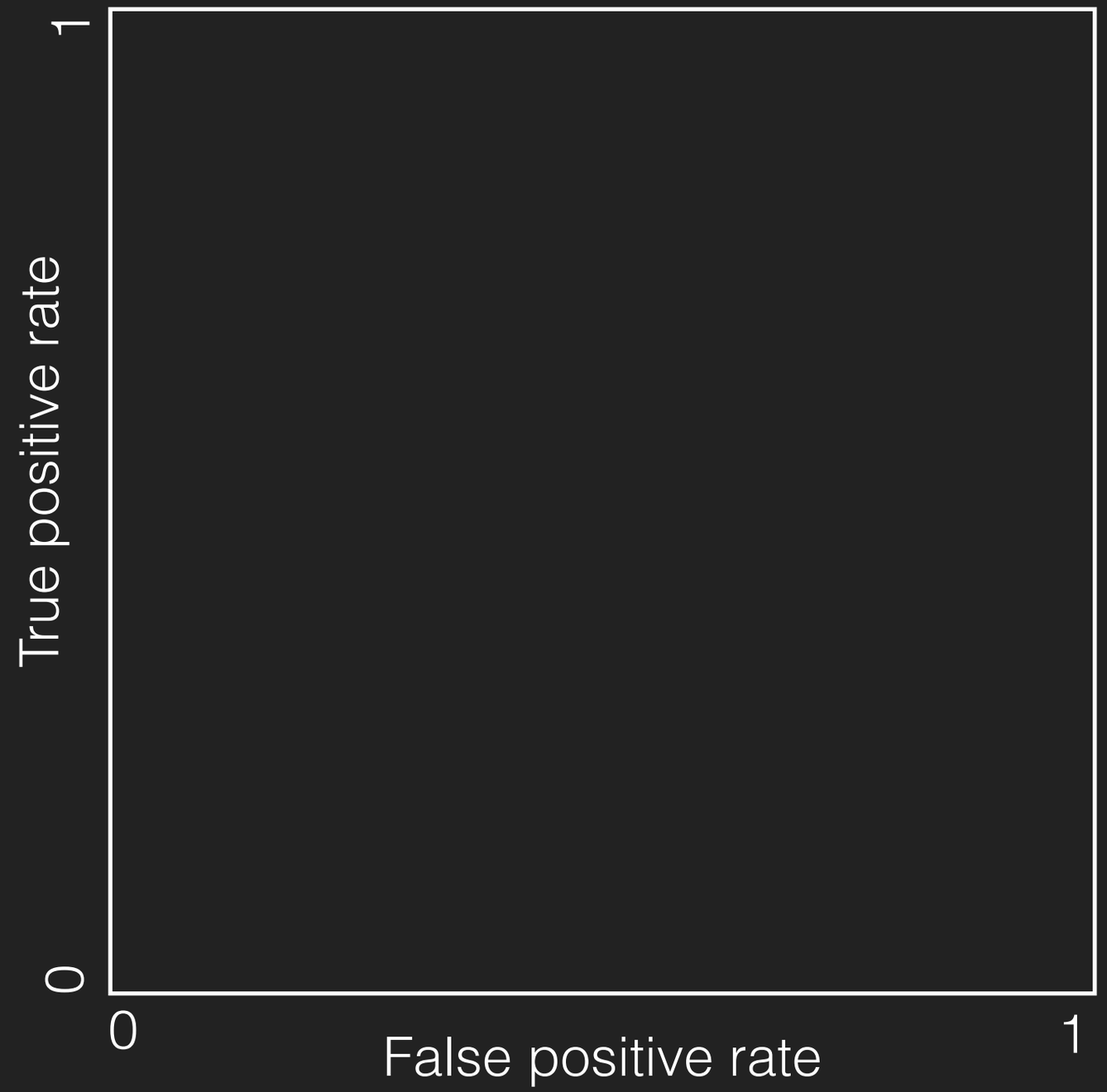
Neural Networks

+ works if data is not linearly separable
+ easy/fast to classify

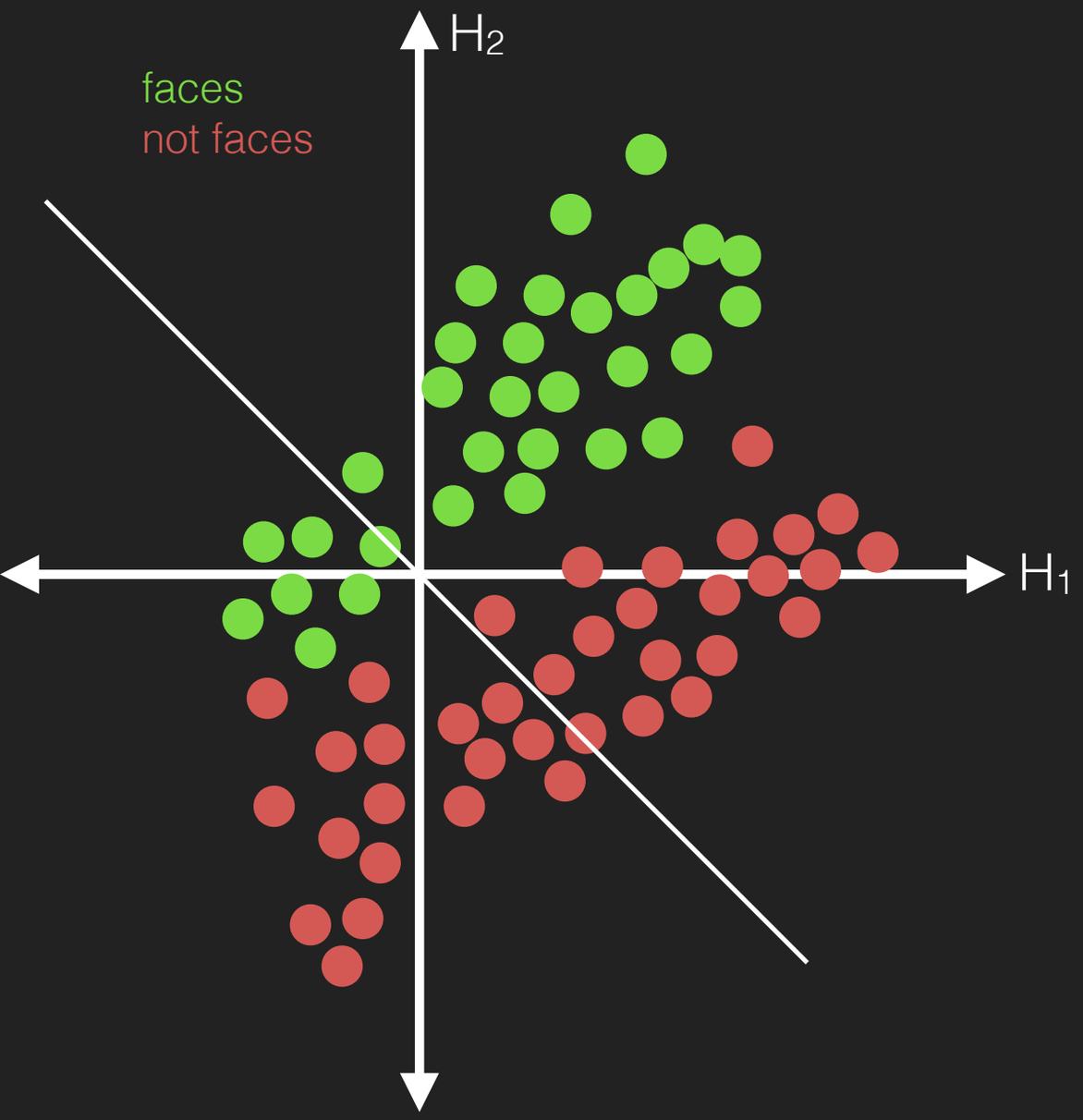
- harder to implement
- harder to “train”
- requires a lot of data
- less robust (over-training)

Receiver Operating Characteristic (ROC)

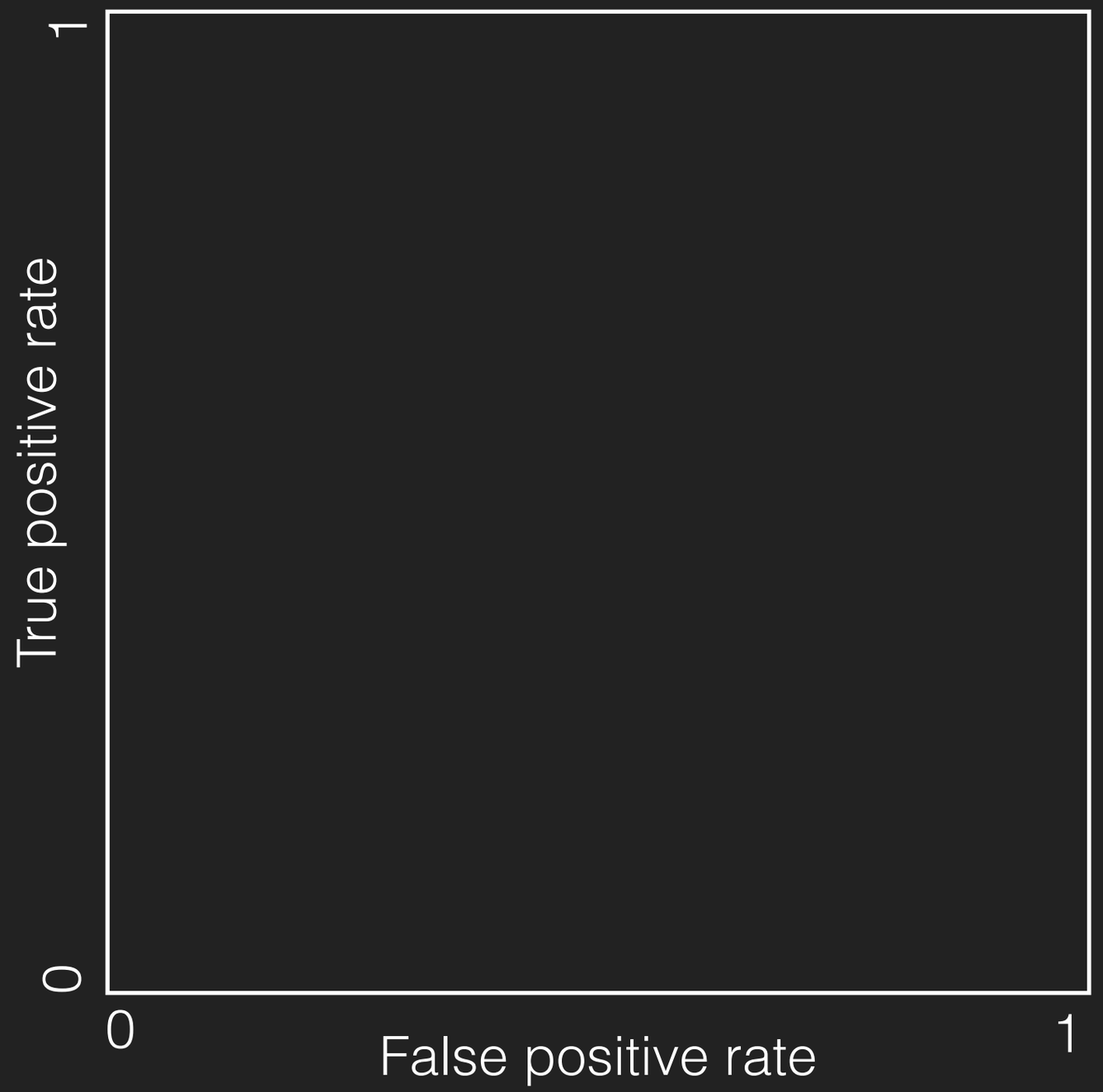




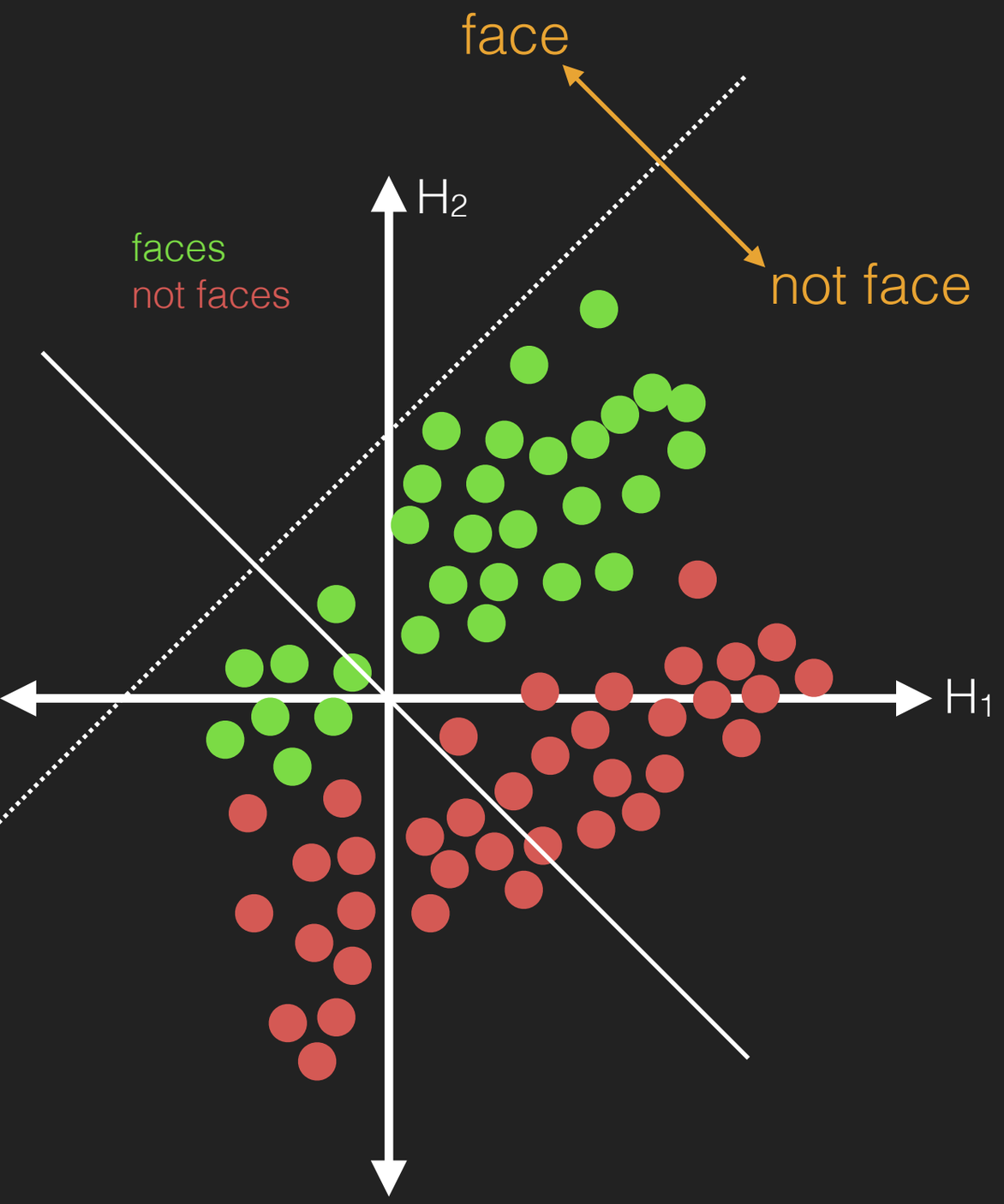
Receiver Operating Characteristic (ROC)



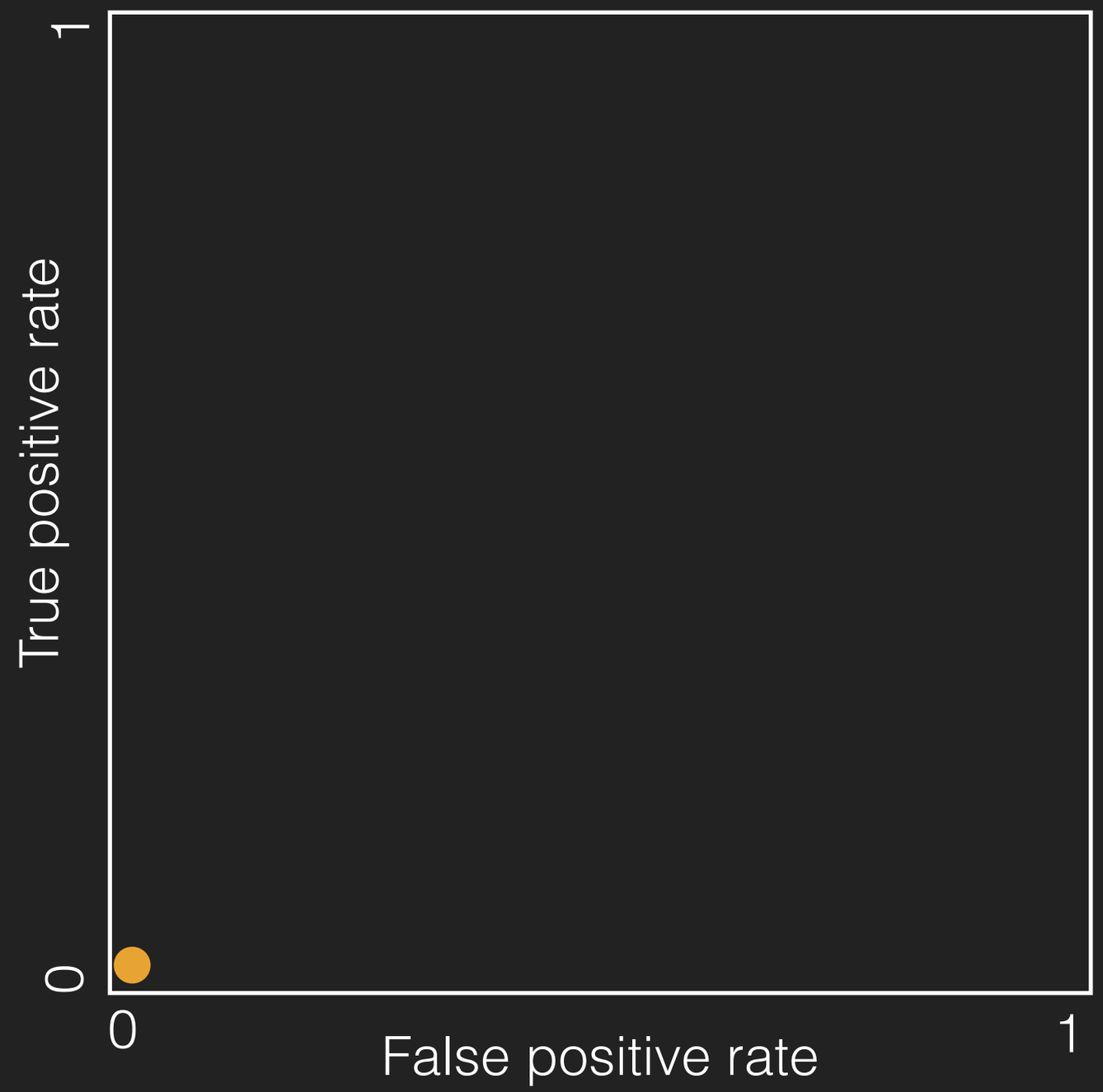
TP: detect face when face is present
FP: detect face when face is not present



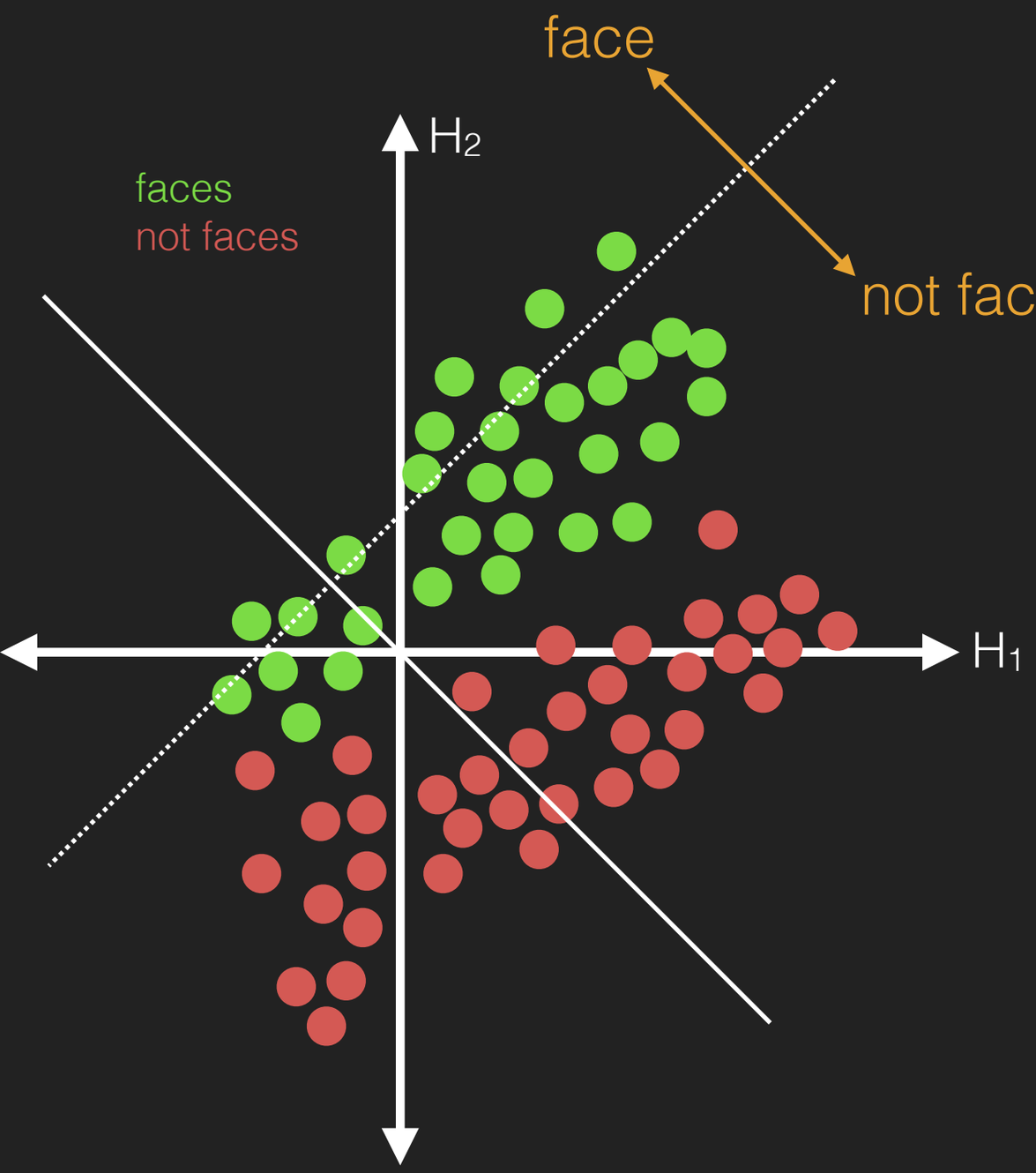
Receiver Operating Characteristic (ROC)



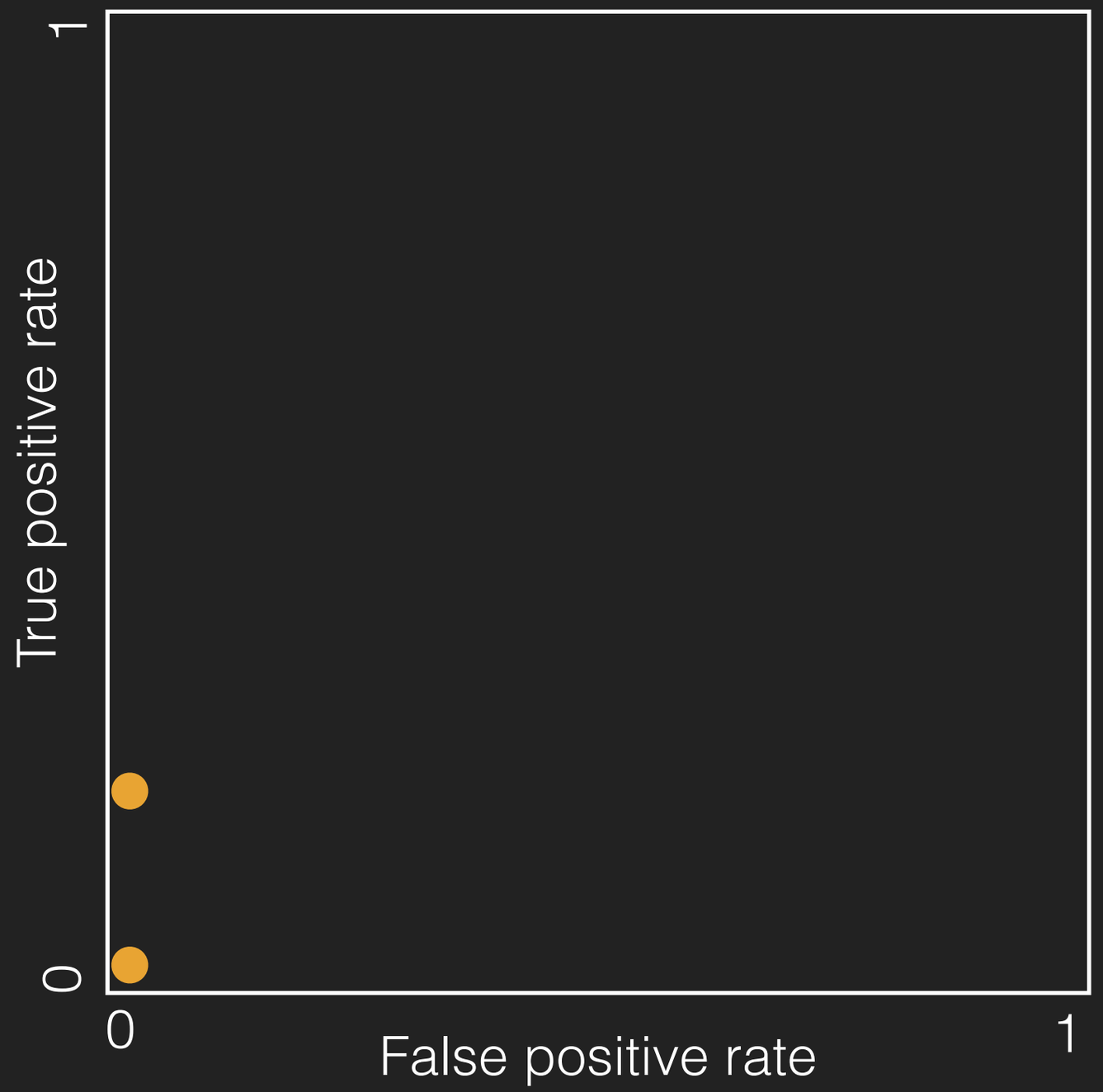
TP: detect face when face is present
FP: detect face when face is not present



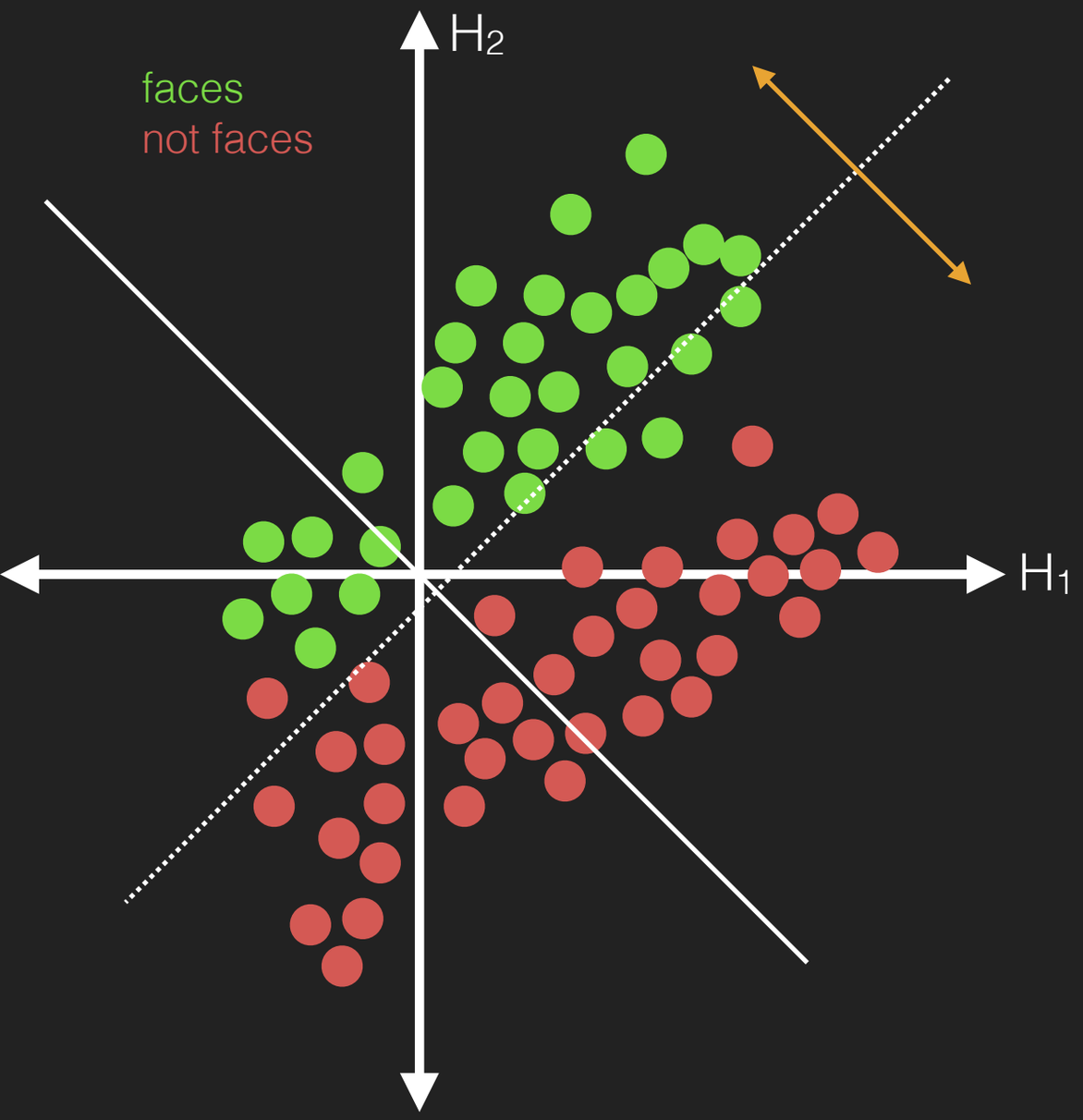
Receiver Operating Characteristic (ROC)



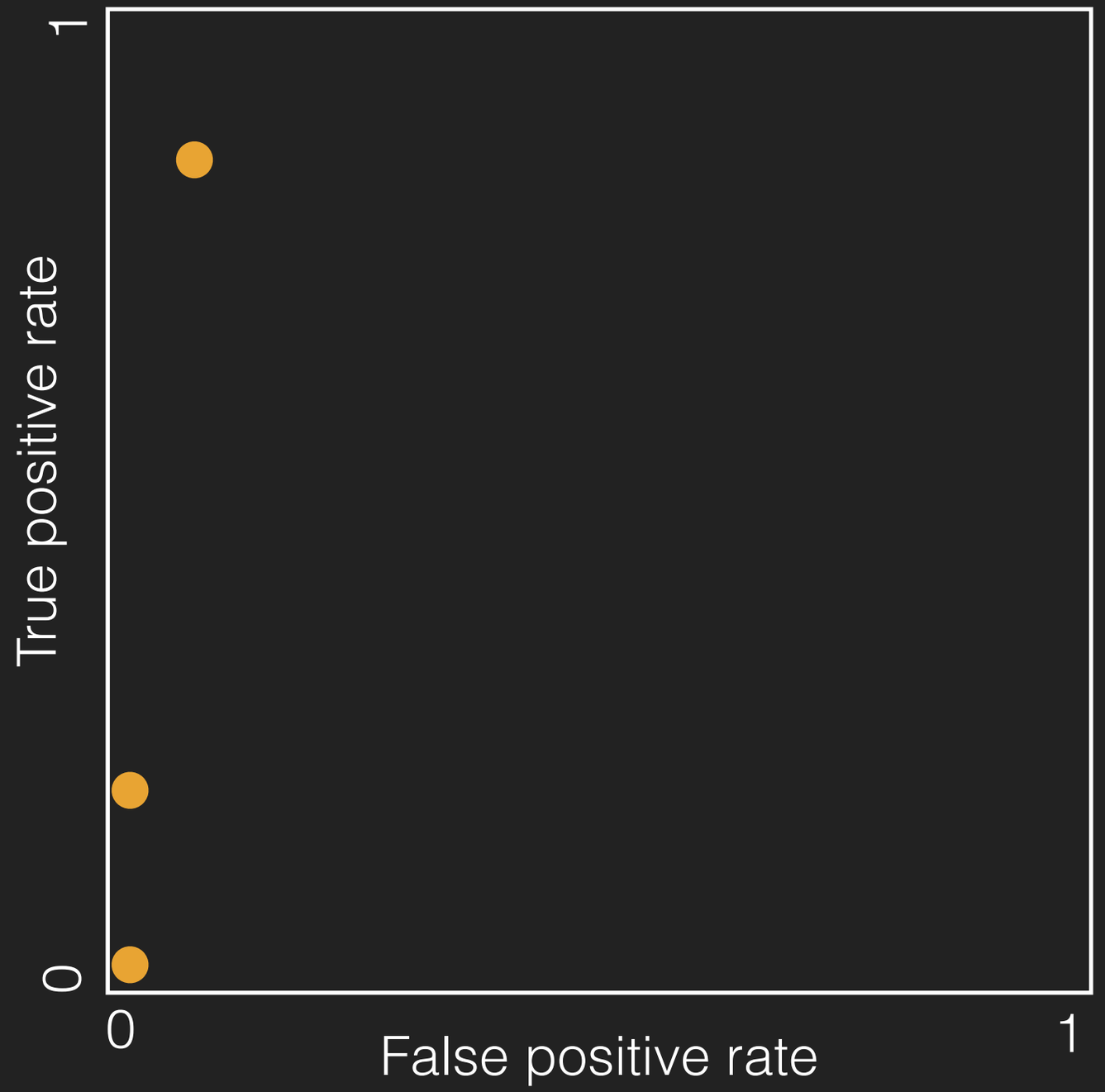
TP: detect face when face is present
FP: detect face when face is not present



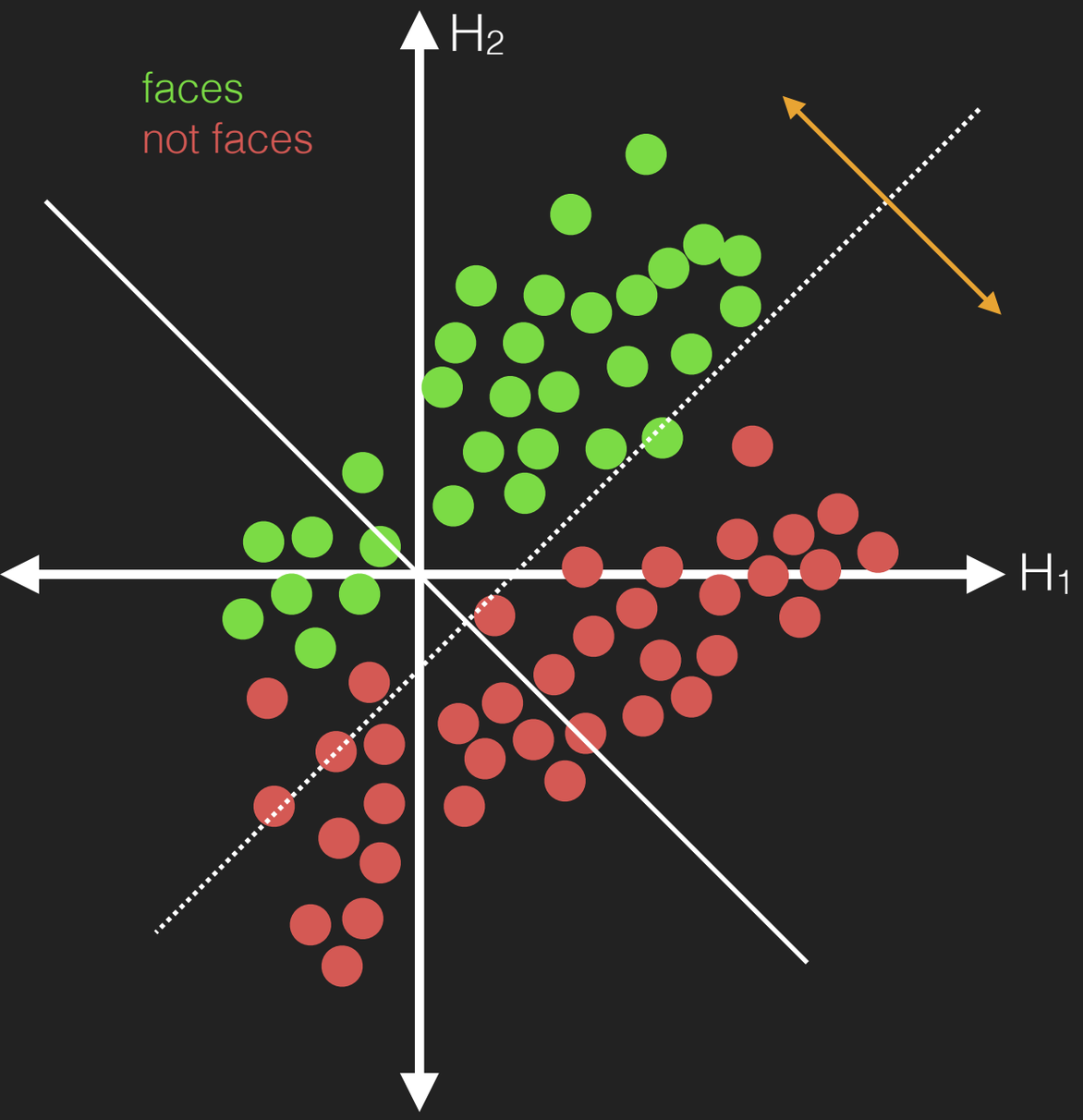
Receiver Operating Characteristic (ROC)



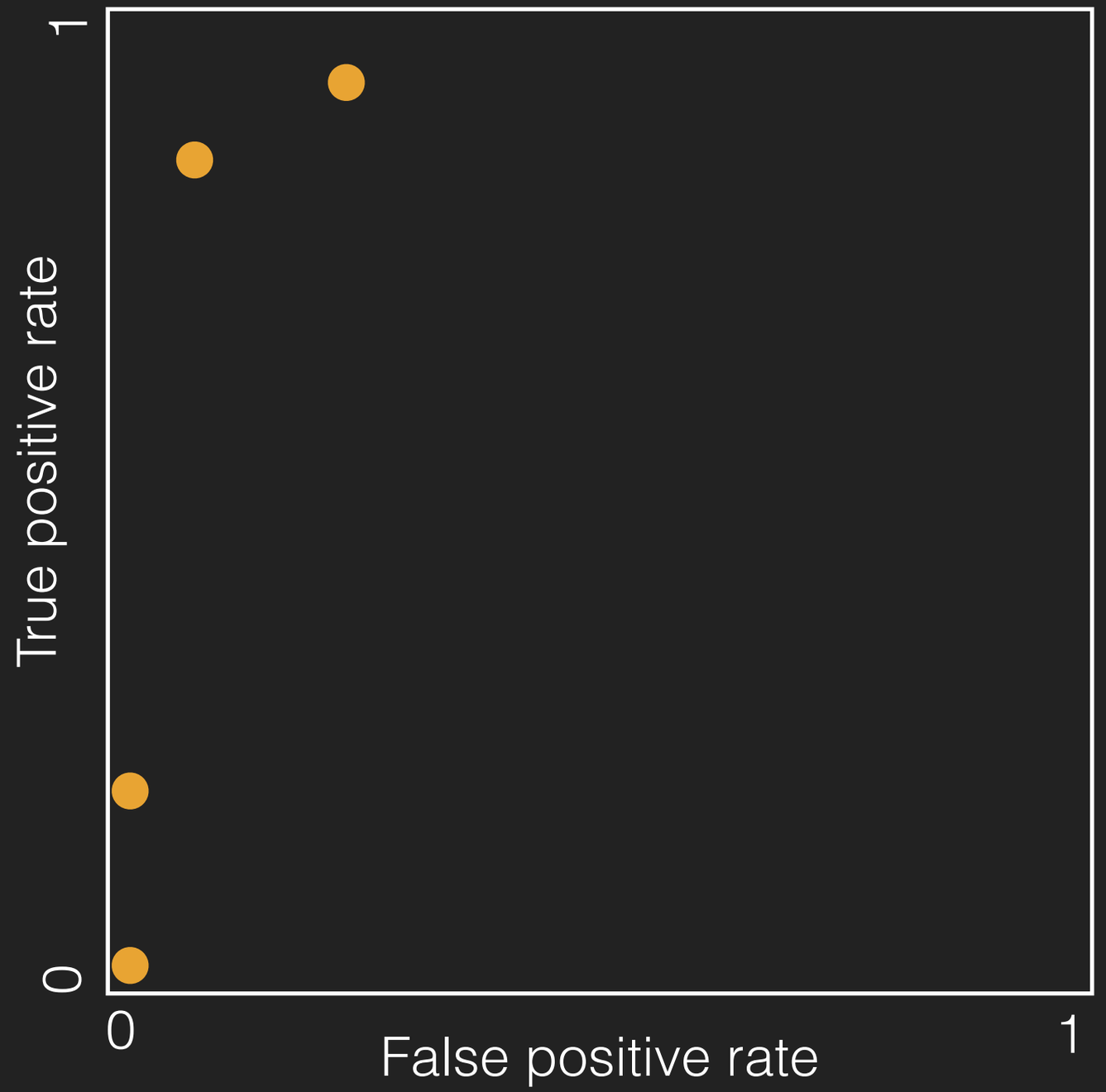
TP: detect face when face is present
FP: detect face when face is not present



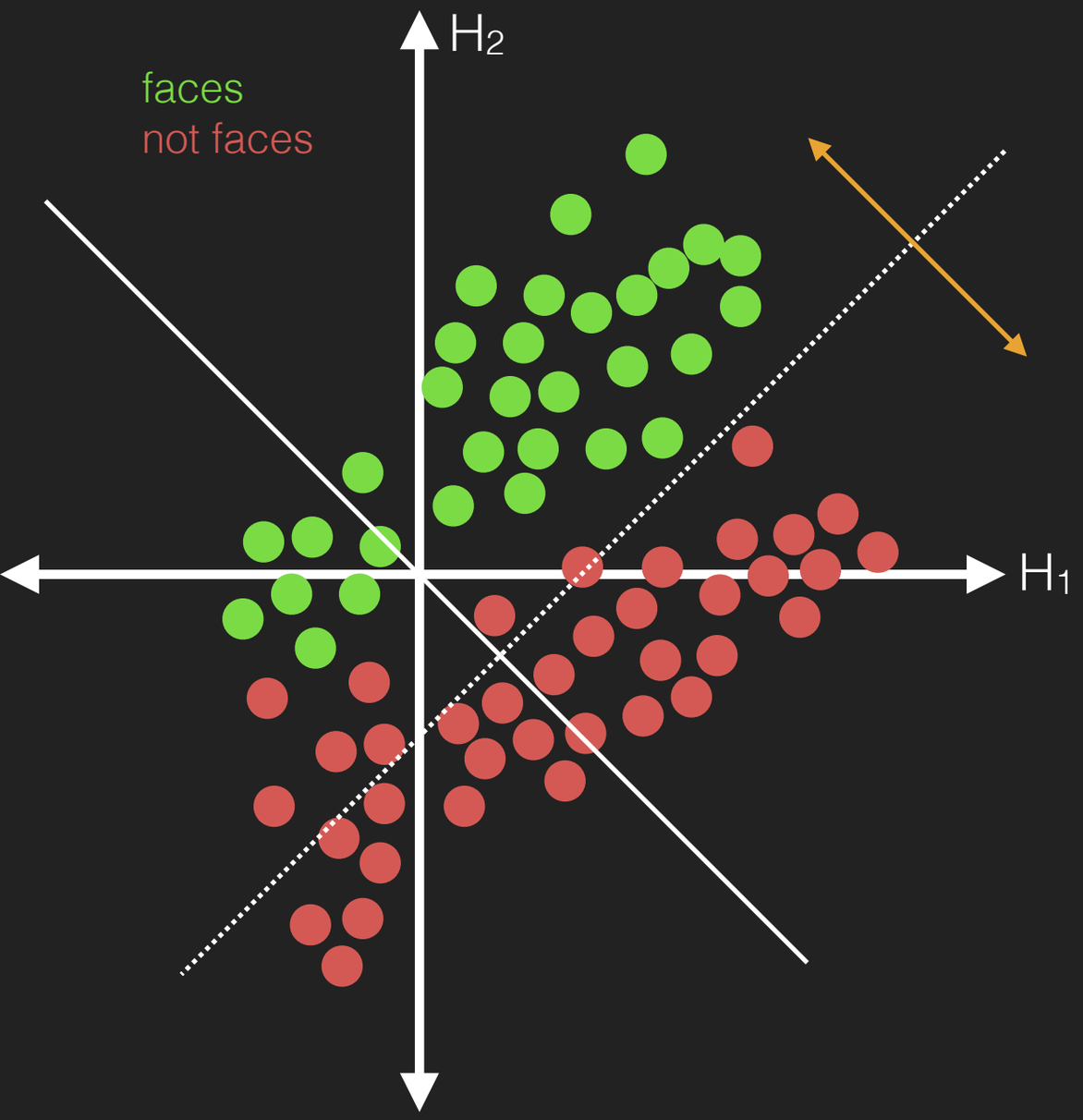
Receiver Operating Characteristic (ROC)



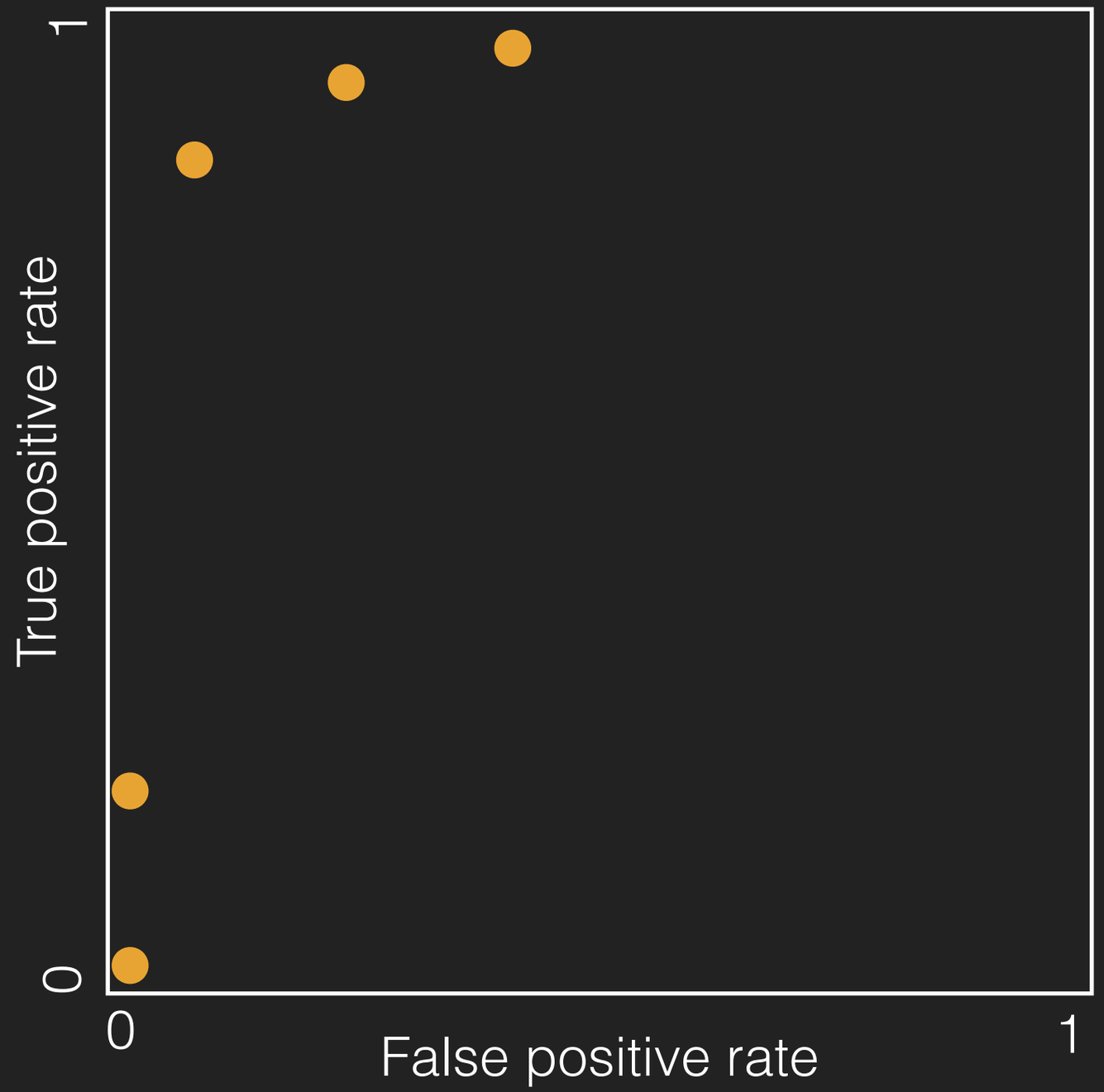
TP: detect face when face is present
FP: detect face when face is not present



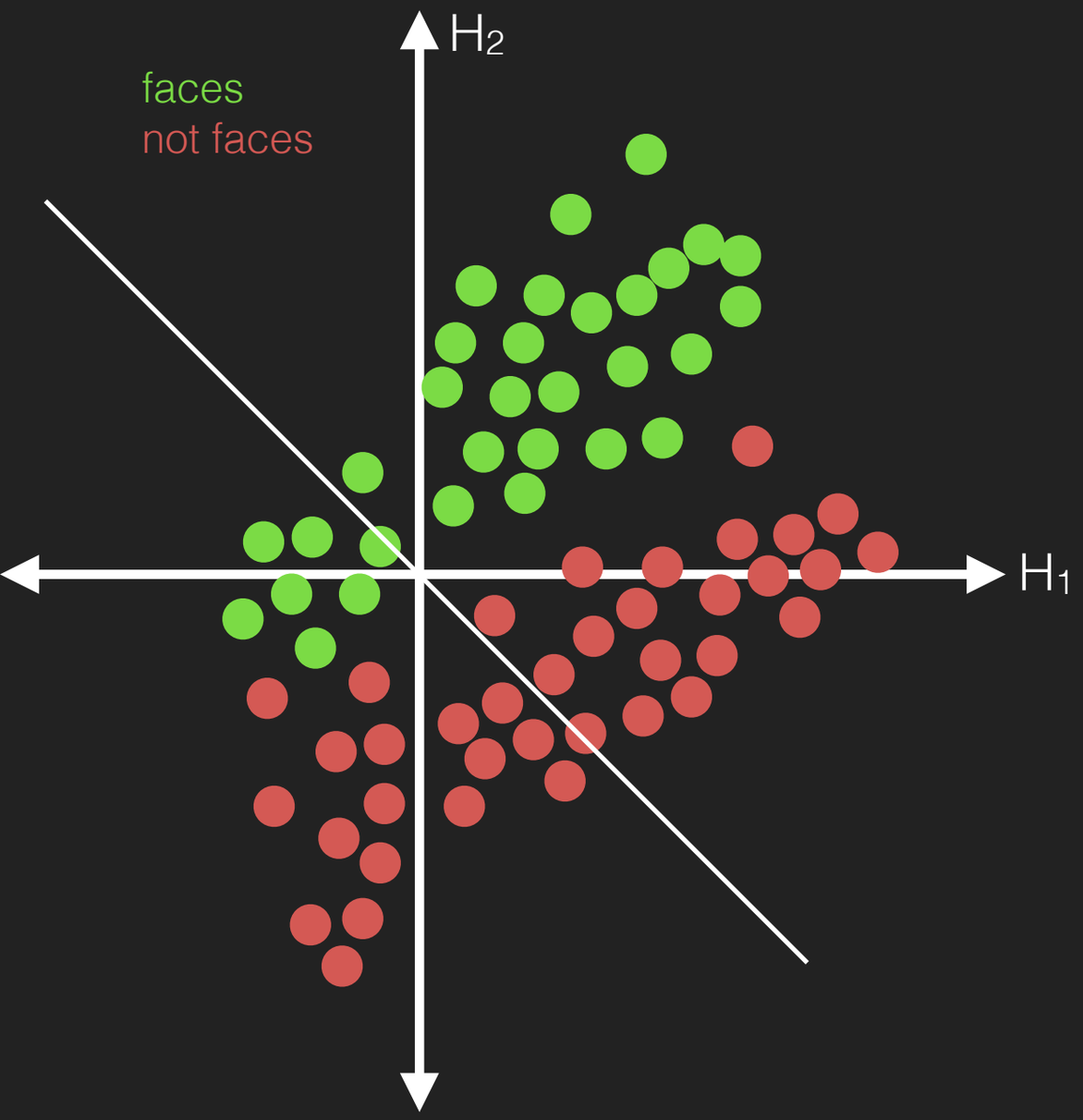
Receiver Operating Characteristic (ROC)



TP: detect face when face is present
FP: detect face when face is not present



Receiver Operating Characteristic (ROC)



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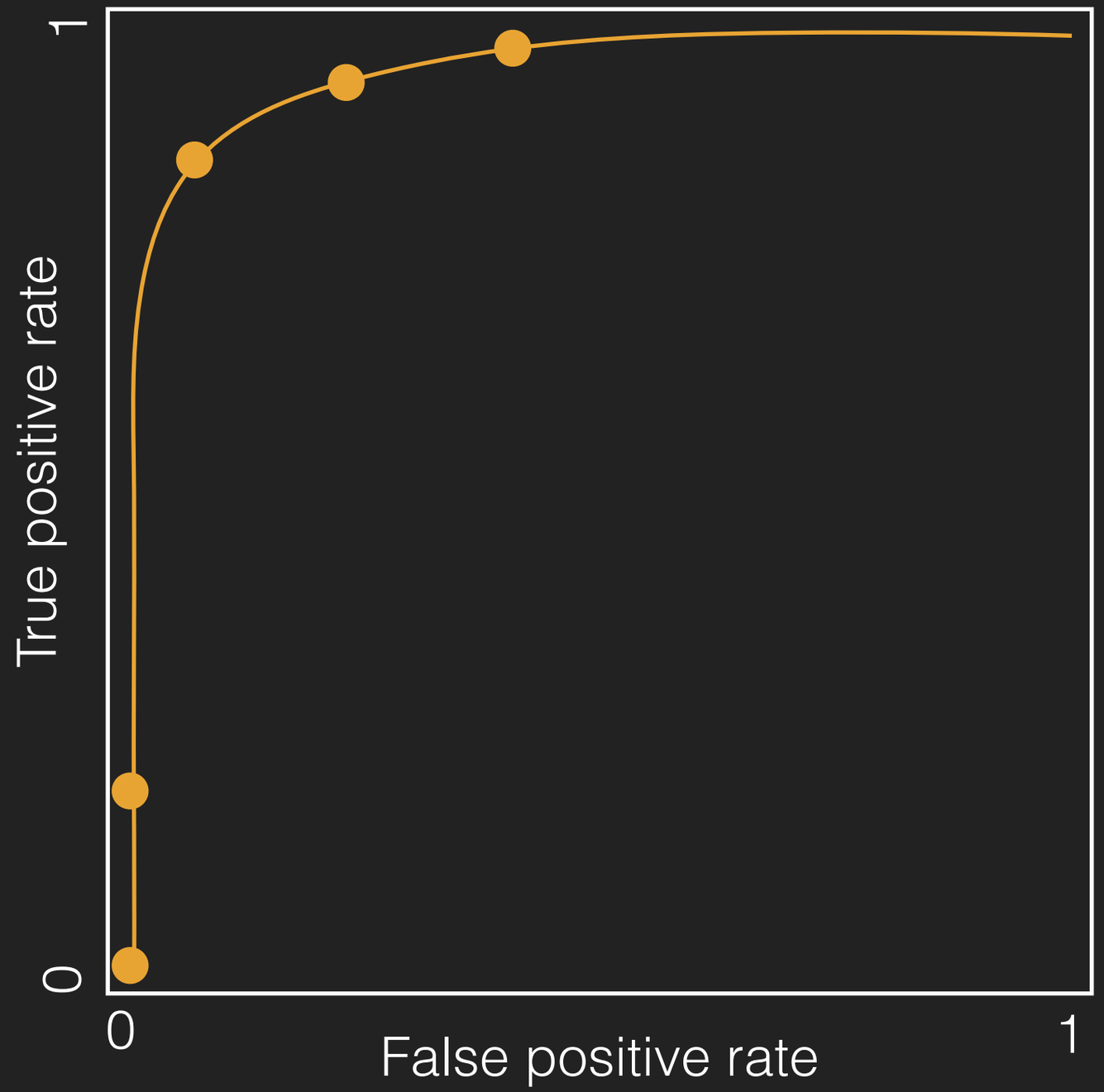
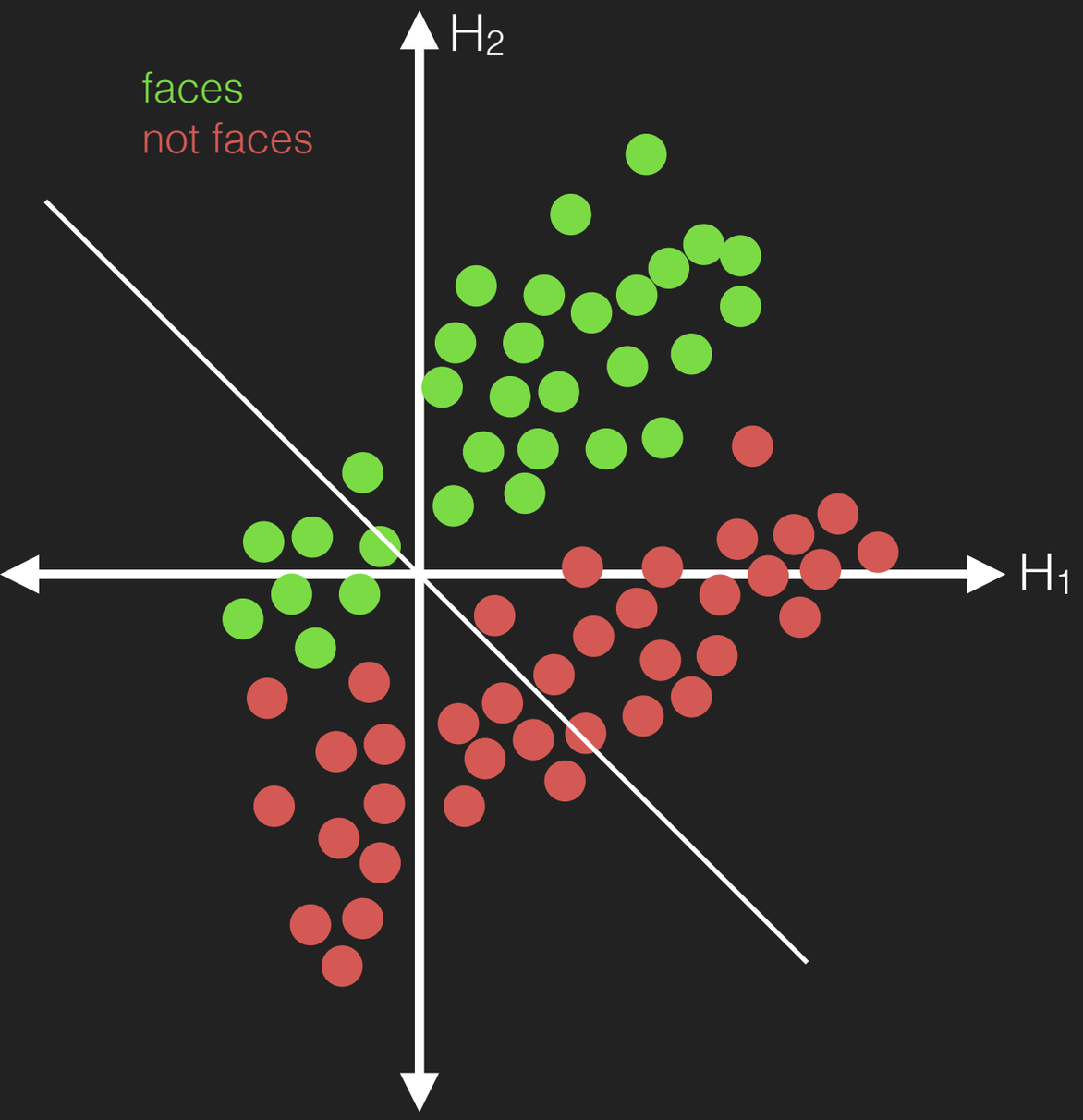


Receiver Operating Characteristic (ROC)



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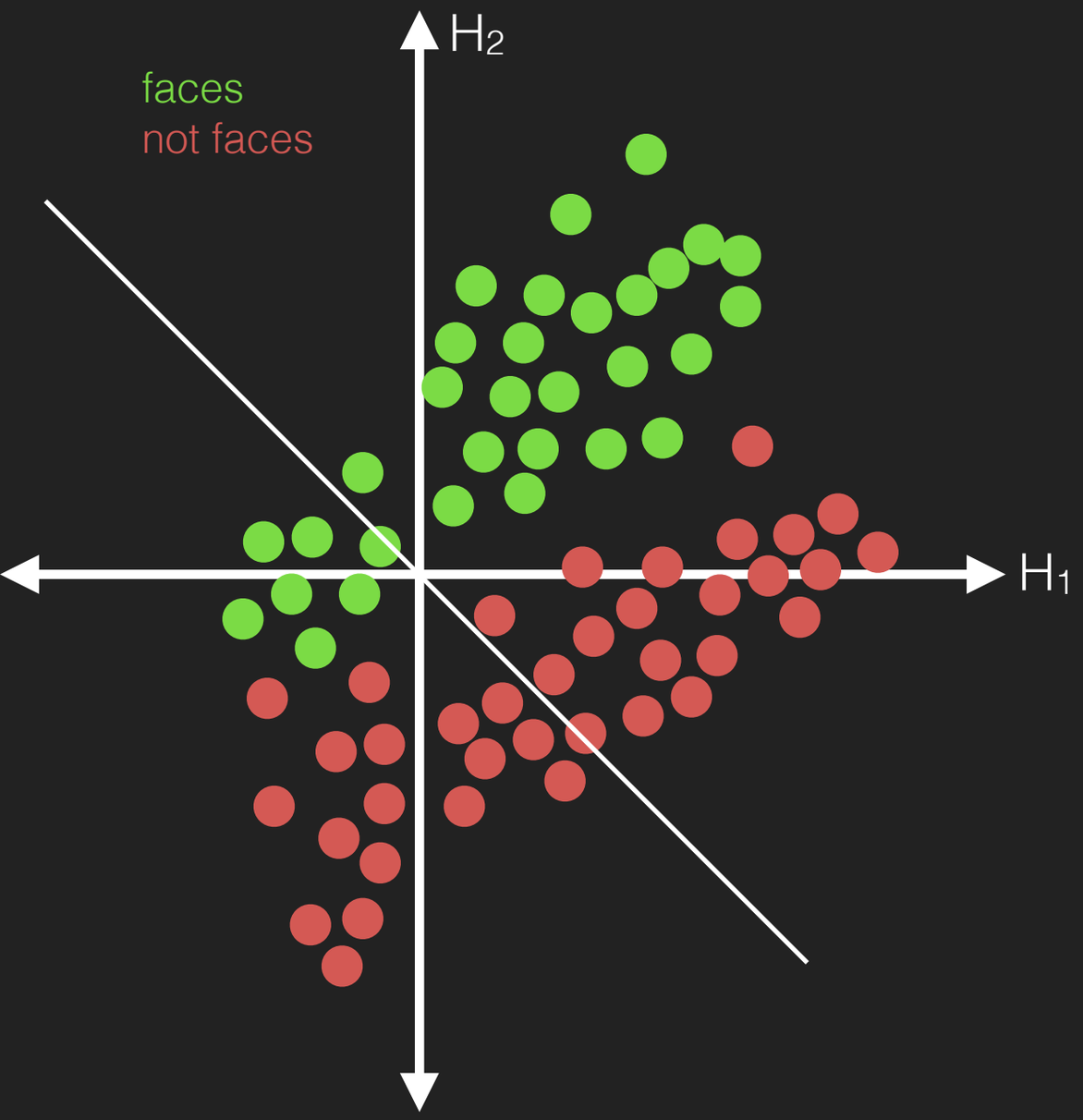
Receiver Operating Characteristic (ROC)



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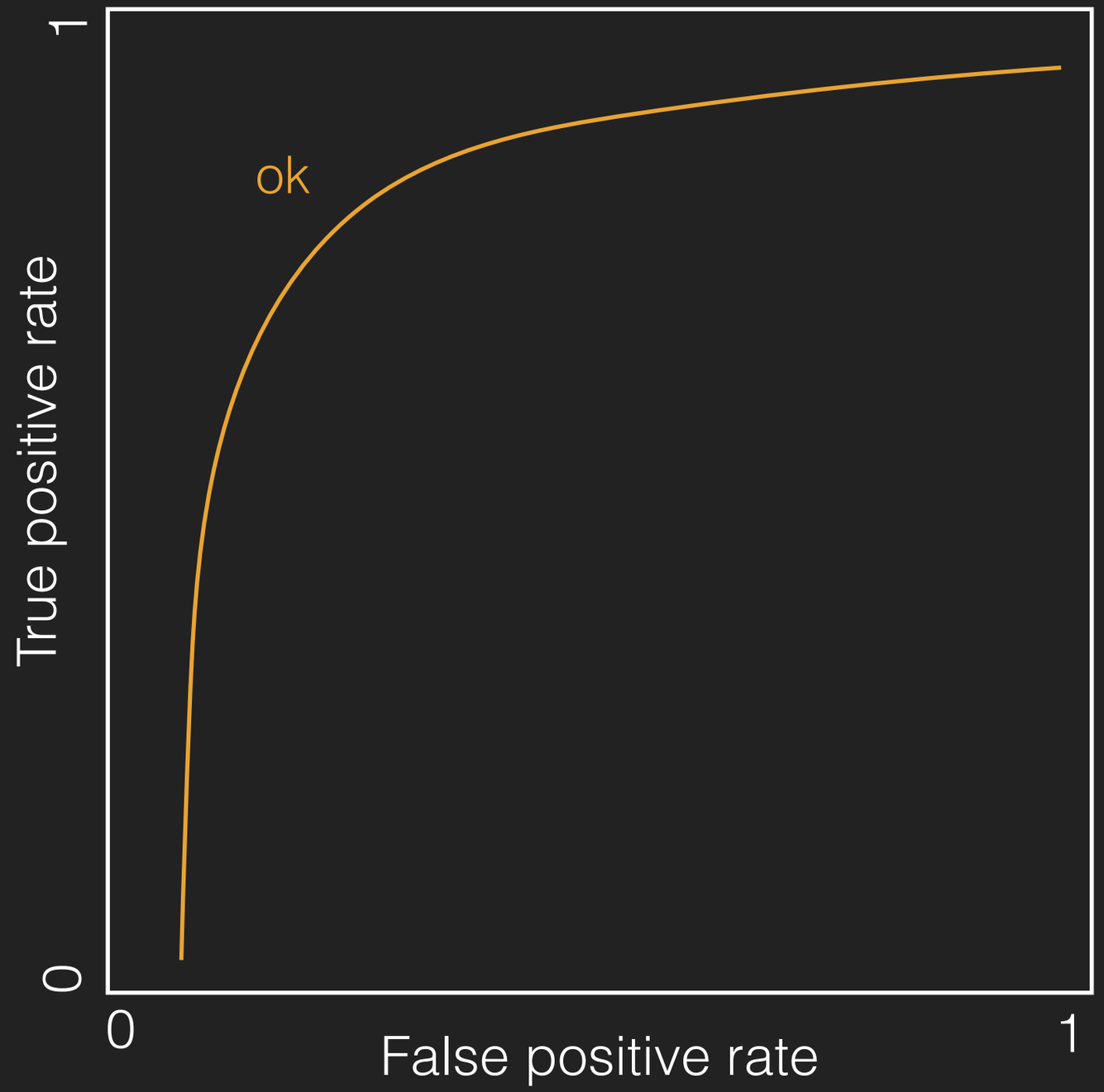
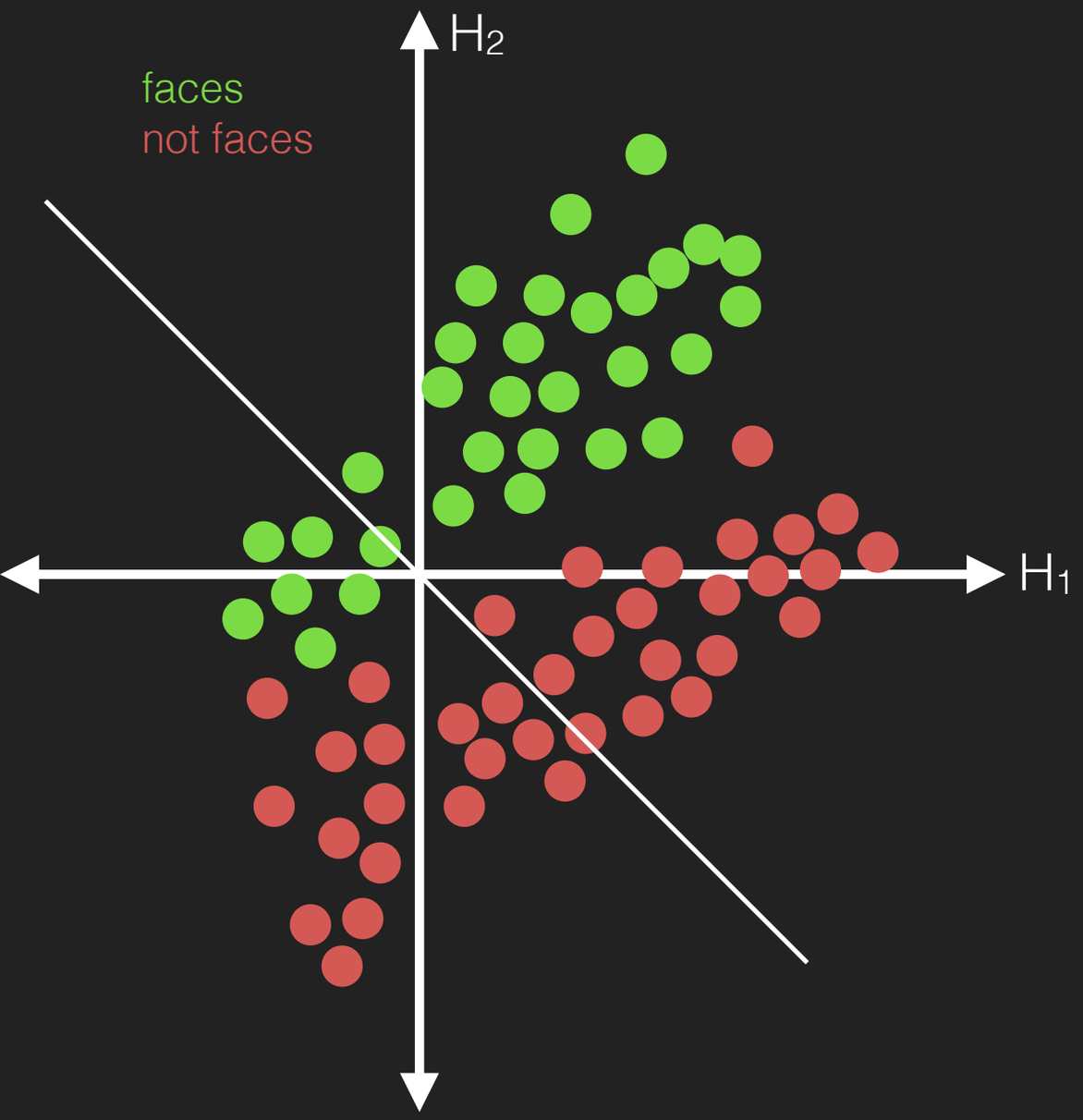


Receiver Operating Characteristic (ROC)



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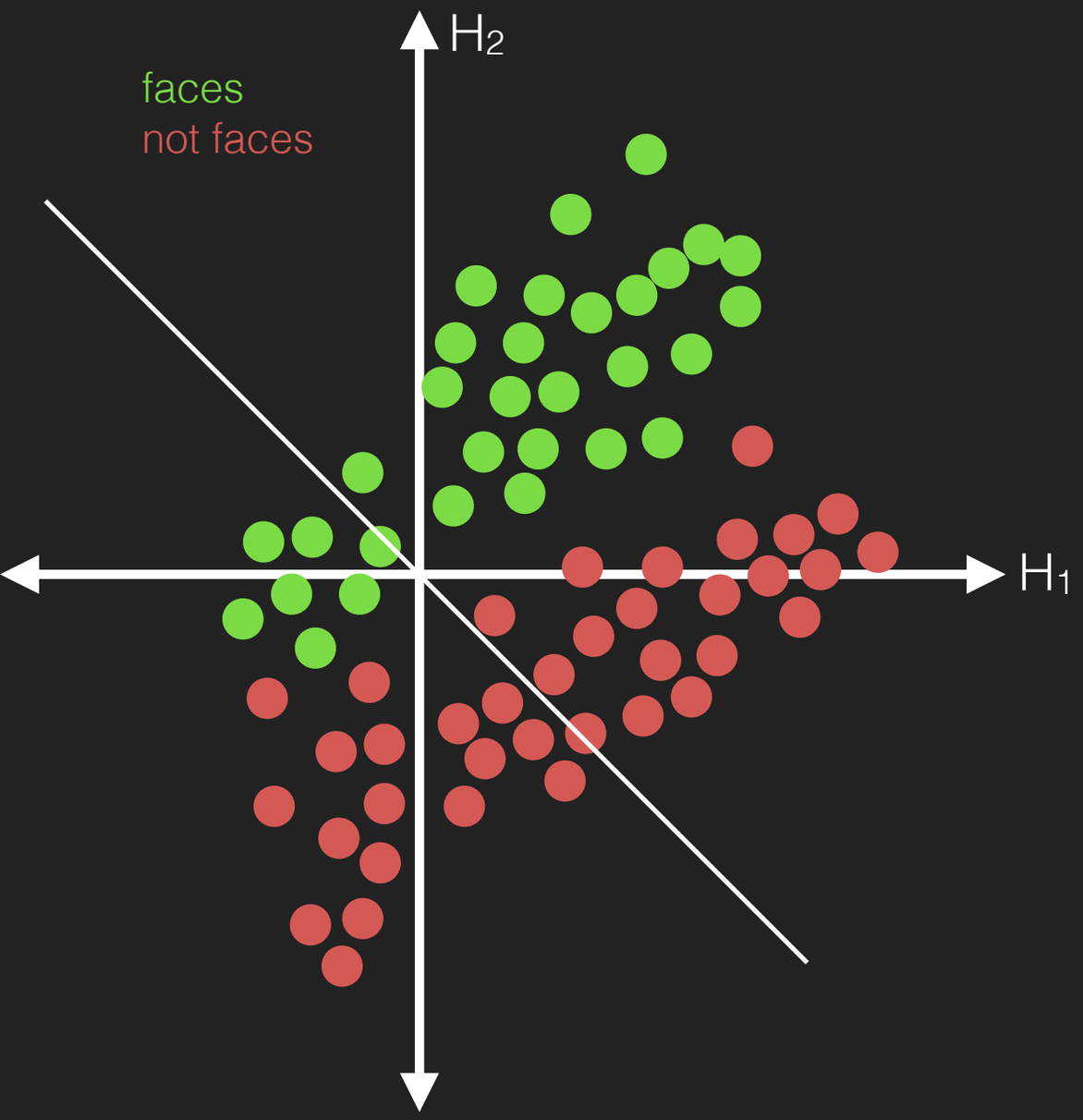
Receiver Operating Characteristic (ROC)

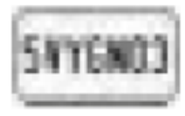


TP: detect face when face is present
FP: detect face when face is not present

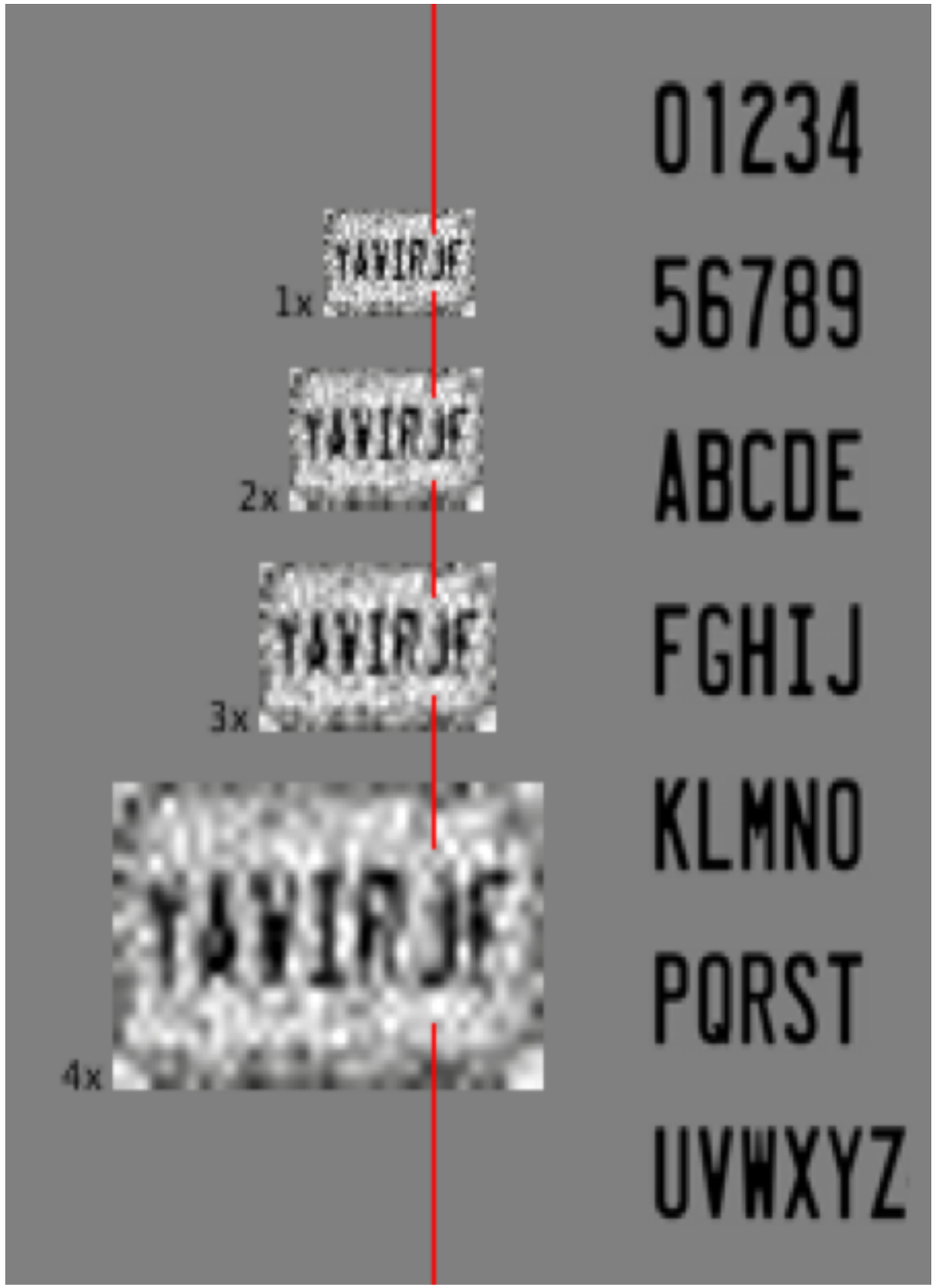
Area Under Curve (AUC)

Reading License Plates using Neural Networks

SNR (db)

width (pixels)	-3.0	0.0	3.0	7.0	20.0
55					
45					
35					
25					
15					
12					

Sample Images



- 6 resolutions
- 5 noise levels
- 12 observers
- 75 images/observer

Human

Width (pixels)	Noise (SNR)				
	-3.0	**0.0**	**3.0**	**7.0**	**20.0**
55	52.8	88.9	97.2	100.0	97.2
45	50.0	75.0	86.1	91.7	100.0
35	33.3	63.9	80.6	80.6	97.2
25	0.0	13.9	33.3	52.8	77.8
15	2.8	2.8	5.6	11.1	2.8
12	-	-	-	-	-

Chance = 2.8%

Human

Width (pixels)	Noise (SNR)				
	-3.0	**0.0**	**3.0**	**7.0**	**20.0**
55	52.8	88.9	97.2	100.0	97.2
45	50.0	75.0	86.1	91.7	100.0
35	33.3	63.9	80.6	80.6	97.2
25	0.0	13.9	33.3	52.8	77.8
15	2.8	2.8	5.6	11.1	2.8
12	-	-	-	-	-

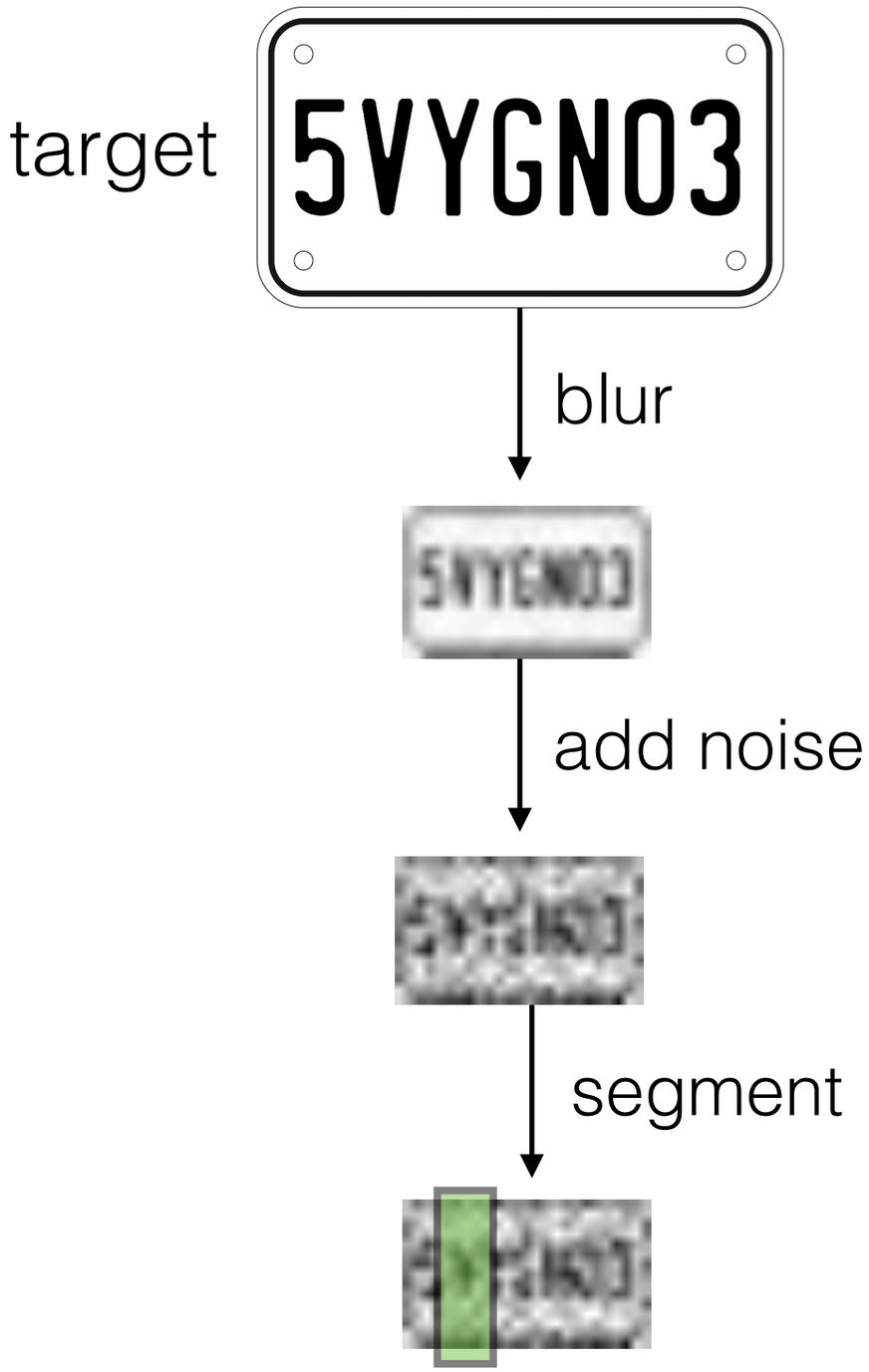
Chance = 2.8%

Human

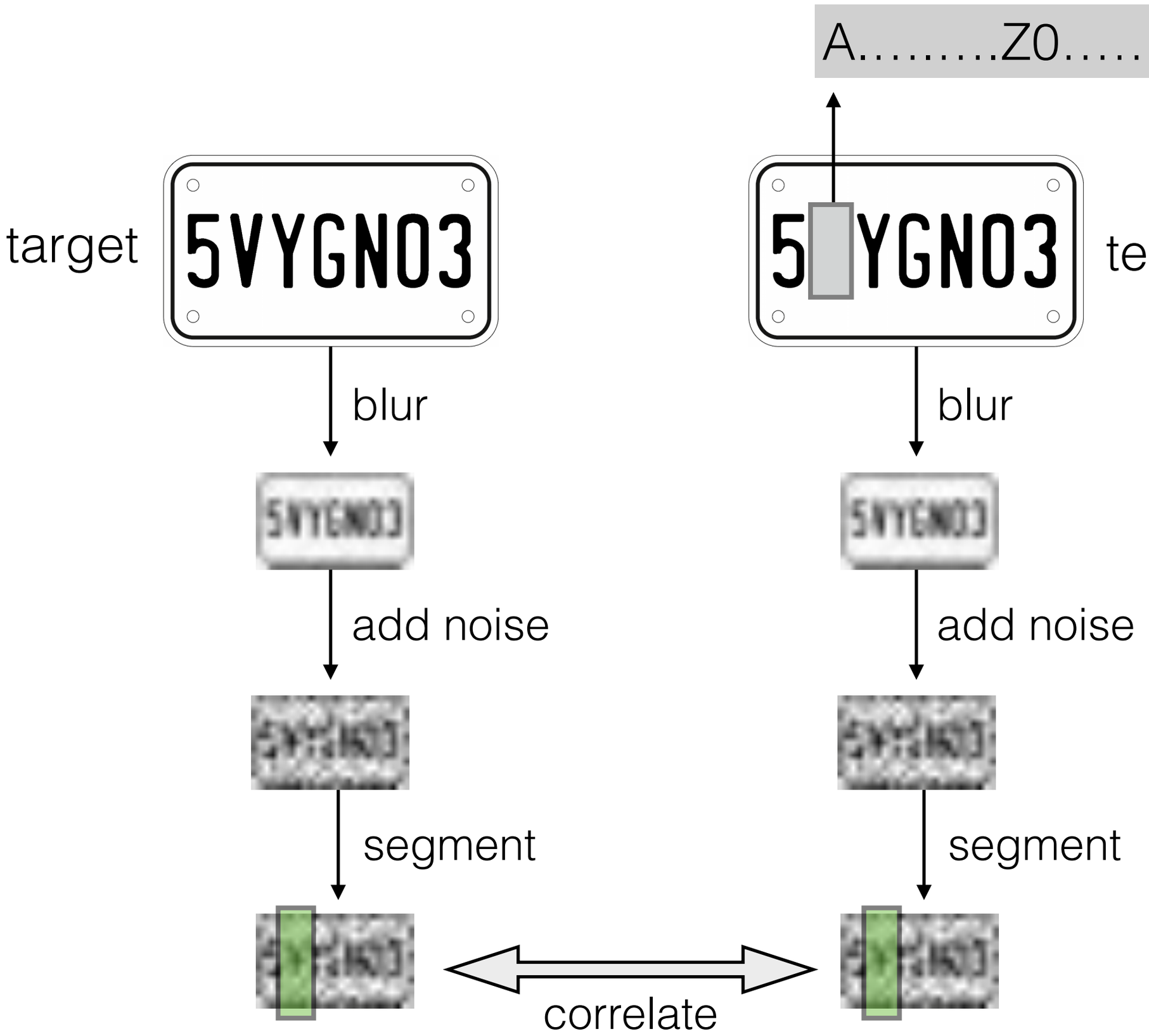
Width (pixels)	Noise (SNR)				
	-3.0	**0.0**	**3.0**	**7.0**	**20.0**
55	52.8	88.9	97.2	100.0	97.2
45	50.0	75.0	86.1	91.7	100.0
35	33.3	63.9	80.6	80.6	97.2
25	0.0	13.9	33.3	52.8	77.8
15	2.8	2.8	5.6	11.1	2.8
12	-	-	-	-	-

Chance = 2.8%

Human



Correlation



Correlation

Width (pixels)	Noise (SNR)				
	-3.0	**0.0**	**3.0**	**7.0**	**20.0**
55	60.9	84.1	95.2	99.0	100.0
45	49.2	74.9	91.6	98.1	100.0
35	33.9	59.2	81.8	95.4	100.0
25	16.4	31.2	53.8	82.5	100.0
15	5.7	8.8	15.3	32.1	98.4
12	5.0	7.1	11.1	22.2	88.7

Chance = 2.8%

Correlation

Width (pixels)	Noise (SNR)				
	-3.0	**0.0**	**3.0**	**7.0**	**20.0**
55	60.9	84.1	95.2	99.0	100.0
45	49.2	74.9	91.6	98.1	100.0
35	33.9	59.2	81.8	95.4	100.0
25	16.4	31.2	53.8	82.5	100.0
15	5.7	8.8	15.3	32.1	98.4
12	5.0	7.1	11.1	22.2	88.7

H	52.8	88.9	97.2	100.0	97.2
H	50.0	75.0	86.1	91.7	100.0

Chance = 2.8%

Correlation

Width (pixels)	Noise (SNR)				
	-3.0	**0.0**	**3.0**	**7.0**	**20.0**
55	60.9	84.1	95.2	99.0	100.0
45	49.2	74.9	91.6	98.1	100.0
35	33.9	59.2	81.8	95.4	100.0
25	16.4	31.2	53.8	82.5	100.0
15	5.7	8.8	15.3	32.1	98.4
12	5.0	7.1	11.1	22.2	88.7

H	0.0	13.9	33.3	52.8	77.8
H	2.8	2.8	5.6	11.1	2.8

Chance = 2.8%

Correlation

low dimensionality
character segmentation

high dimensionality
no character segmentation

medium dimensionality
easier character segmentation

CNN Training

synthetic training (27,993,600)

synthetic testing (20,000)

real testing (132)

CNN Training

Width (pixels)	Noise (SNR)				
	-3.0	**0.0**	**3.0**	**7.0**	**20.0**
55	64.8	83.9	89.7	92.2	93.8
45	43.6	72.4	87.2	91.7	93.7
35	18.3	53.2	77.5	88.7	93.1
25	2.6	14.8	40.9	71.0	88.6
15	0.1	0.3	1.1	4.2	31.1
12	0.1	0.2	0.5	1.2	4.7

Chance = 0.002%

CNN Synthetic Testing Accuracy

Width (pixels)	Noise (SNR)					H	C
	-3.0	0.0	3.0	7.0	20.0		
55	64.8	83.9	89.7	92.2	93.8	100.0	97.0
45	43.6	72.4	87.2	91.7	93.7	77.1	94.4
35	18.3	53.2	77.5	88.7	93.1	52.3	86.8
25	2.6	14.8	40.9	71.0	88.6	14.7	56.2
15	0.1	0.3	1.1	4.2	31.1	0.14	3.3
12	0.1	0.2	0.5	1.2	4.7	-	1.1

Chance = 0.002%

CNN Synthetic Testing Accuracy

Width (pixels)	Noise (SNR)					H	C
	-3.0	0.0	3.0	7.0	20.0		
55	64.8	83.9	89.7	92.2	93.8	70.5	59.3
45	43.6	72.4	87.2	91.7	93.7	42.2	42.0
35	18.3	53.2	77.5	88.7	93.1	26.1	20.7
25	2.6	14.8	40.9	71.0	88.6	0.2	3.0
15	0.1	0.3	1.1	4.2	31.1	0.002	0.07
12	0.1	0.2	0.5	1.2	4.7	-	0.04

Chance = 0.002%

CNN Synthetic Testing Accuracy

Width (pixels)	Noise (SNR)				
	-3.0	**0.0**	**3.0**	**7.0**	**20.0**
55	64.8	83.9	89.7	92.2	93.8
45	43.6	72.4	87.2	91.7	93.7
35	18.3	53.2	77.5	88.7	93.1
25	2.6	14.8	40.9	71.0	88.6
15	0.1	0.3	1.1	4.2	31.1
12	0.1	0.2	0.5	1.2	4.7

H	0.0	0.27	3.6	14.9	47.4

C	0.4	3.0	15.6	56.1	100.0

Chance = 0.002%

CNN Synthetic Testing Accuracy

Width (pixels)	Noise (SNR)				
	-3.0	**0.0**	**3.0**	**7.0**	**20.0**
55	64.8	83.9	89.7	92.2	93.8
45	43.6	72.4	87.2	91.7	93.7
35	18.3	53.2	77.5	88.7	93.1
25	2.6	14.8	40.9	71.0	88.6
15	0.1	0.3	1.1	4.2	31.1
12	0.1	0.2	0.5	1.2	4.7

H	0.002	0.002	0.02	0.13	0.002

C	0.02	0.07	0.4	3.3	95.2

Chance = 0.002%

CNN Synthetic Testing Accuracy

Width (pixels)	Noise (SNR)				
	-3.0	**0.0**	**3.0**	**7.0**	**20.0**
55	53.8	71.5	81.4	85.4	91.2
45	27.7	58.3	75.9	88.2	90.2
35	10.4	40.7	57.4	77.1	87.2
25	2.5	10.3	31.0	52.7	75.2
15	0.0	0.0	1.5	2.8	23.6
12	0.2	0.5	0.0	0.0	1.2

Chance = 0.002%

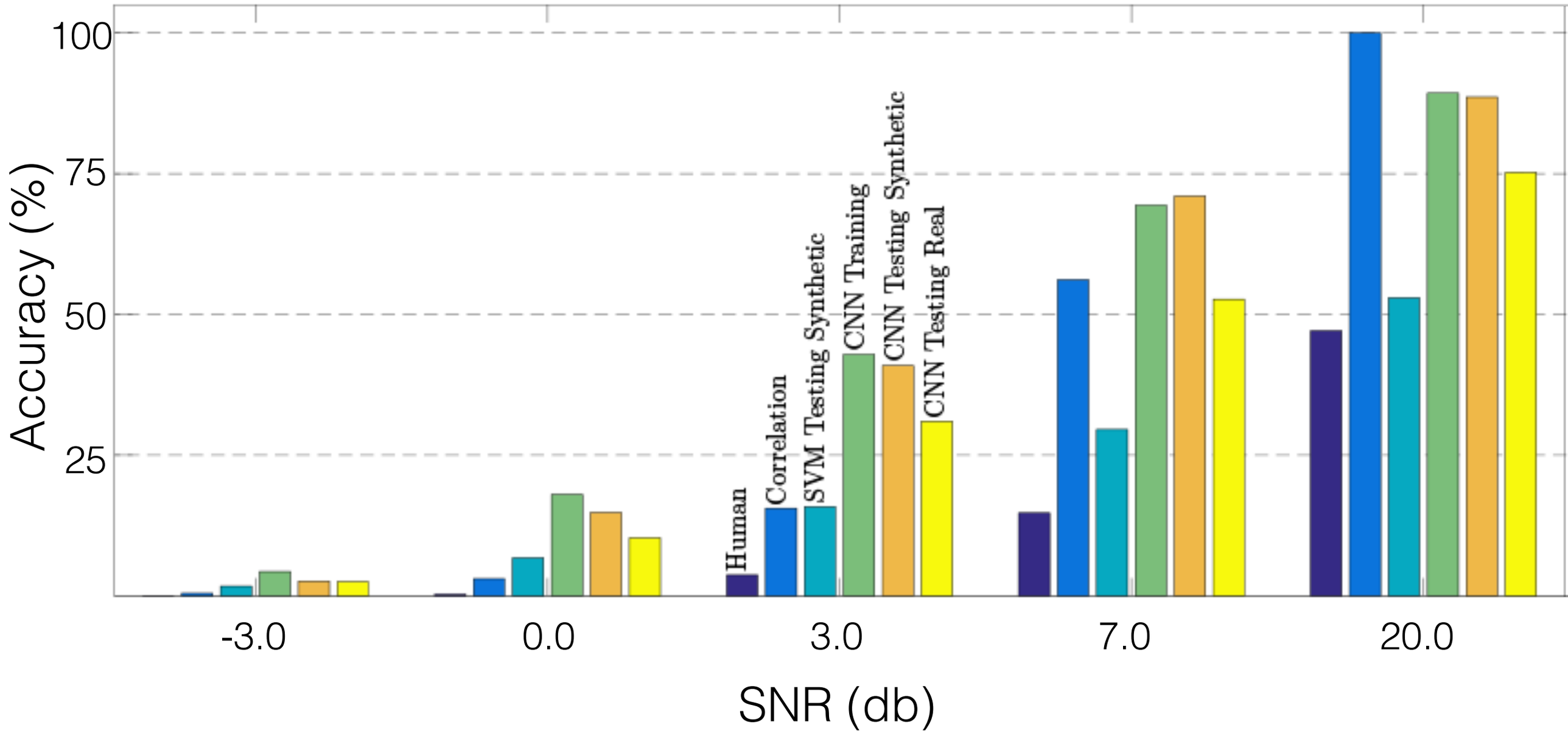
CNN Real Testing Accuracy

Width (pixels)	Noise (SNR)				
	-3.0	**0.0**	**3.0**	**7.0**	**20.0**
55	53.8	71.5	81.4	85.4	91.2
45	27.7	58.3	75.9	88.2	90.2
35	10.4	40.7	57.4	77.1	87.2
25	2.5	10.3	31.0	52.7	75.2
15	0.0	0.0	1.5	2.8	23.6
12	0.2	0.5	0.0	0.0	1.2

CNN	2.6	14.8	40.9	71.0	88.6

Chance = 0.002%

CNN Real Testing Accuracy



Performance Comparison

Most Frequent Matches →

Character

0	O	0	D	U	Q
O	D	O	0	U	Q
8	8	B	H	R	6
B	B	R	8	D	6
D	D	O	0	Q	G

Errors