An Introduction to Deep Learning with TensorFlow

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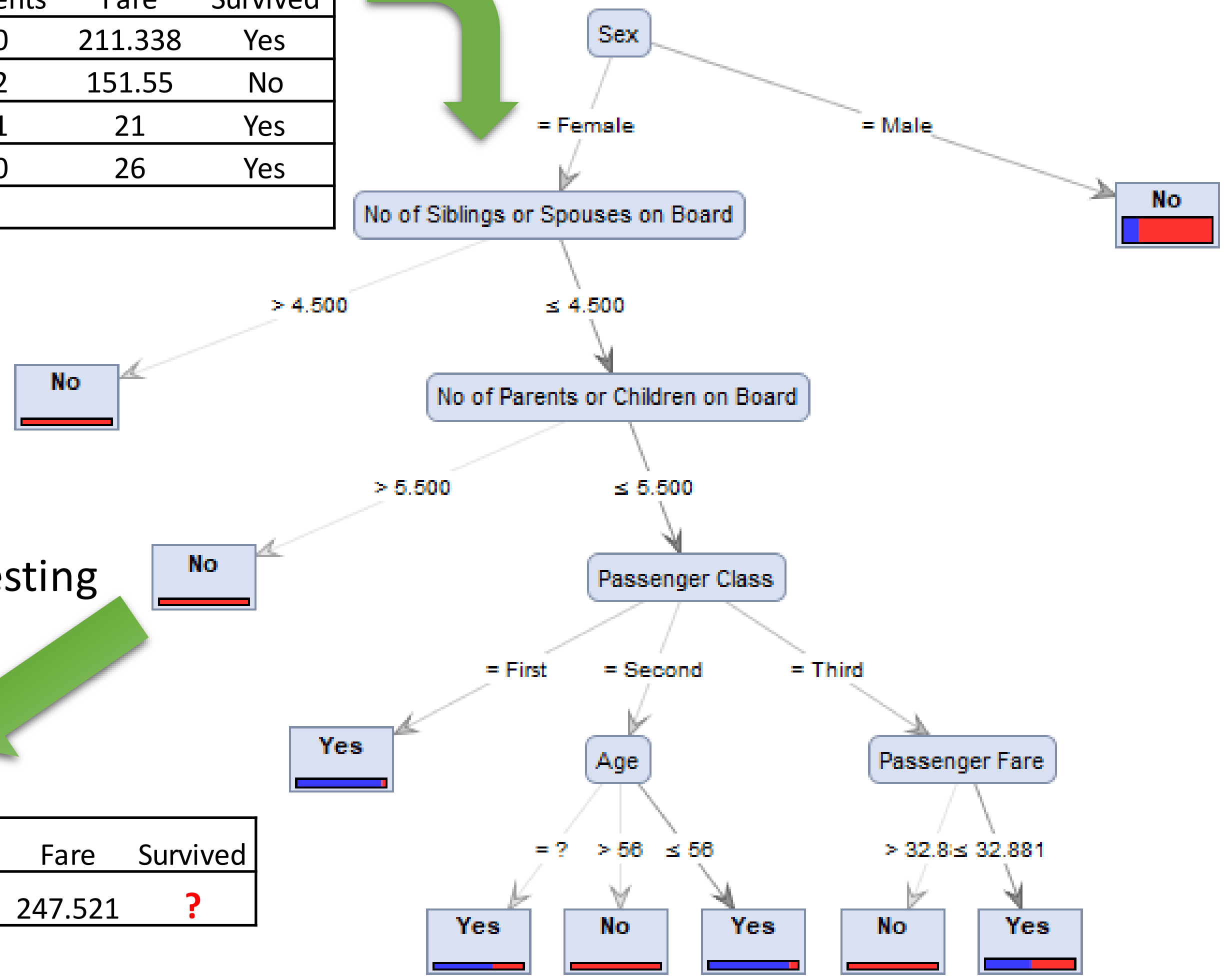
School of Information Studies

Last Workshop - Classification with Decision Tree

Passenger Class	Gender	age	Siblings	Parents	Fare	Survived
First	Female	29	0	0	211.338	Yes
First	Female	2	1	2	151.55	No
Second	Female	21	0	1	21	Yes
Second	Female	19	0	0	26	Yes
...						

Training



Testing

Passenger Class	Gender	age	Siblings	Parents	Fare	Survived
First	Male	24	0	1	247.521	?

So, what is Deep Learning

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Non-linearity

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Feature Learning

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Non-linearity

Auto Encoder

Feature Learning

So, what is Deep Learning

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Recursive Network

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Back Propagation

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Non-linearity

‘Deep Learning’ means using a ***neural network*** with several layers of nodes between input and output.

It's deep if it has more than one stage of non-linear feature transformation.

Agenda

- Logistic Regression
- Neural Network
- Convolutional Neural Network
- Why deep learning works
- Hands-on example using TensorFlow
- Q&A

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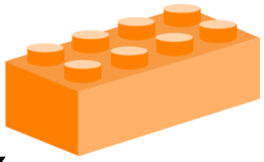

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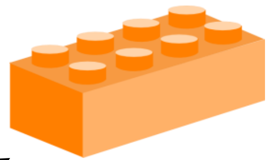

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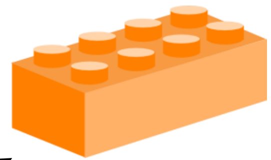

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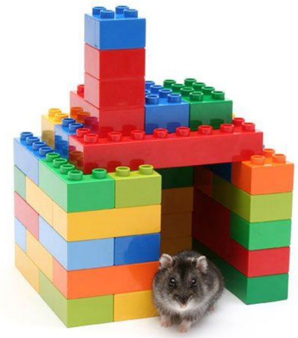

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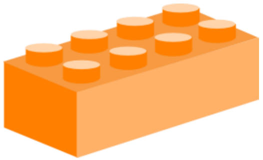
Logistic Regression



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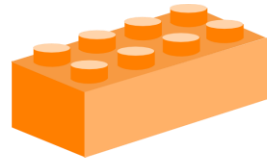

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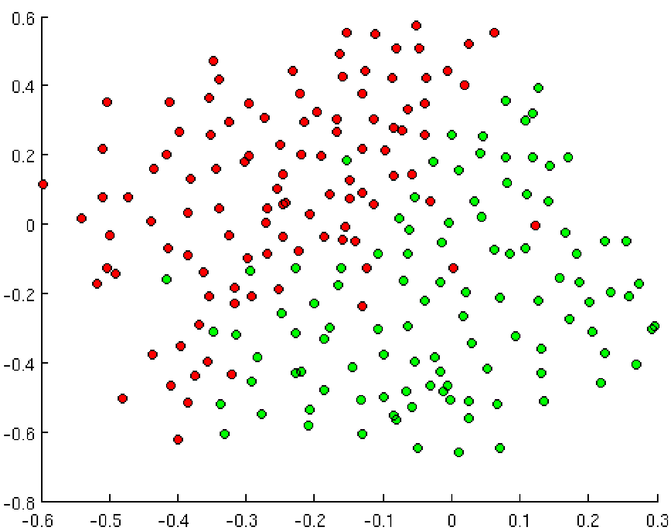

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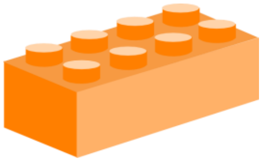

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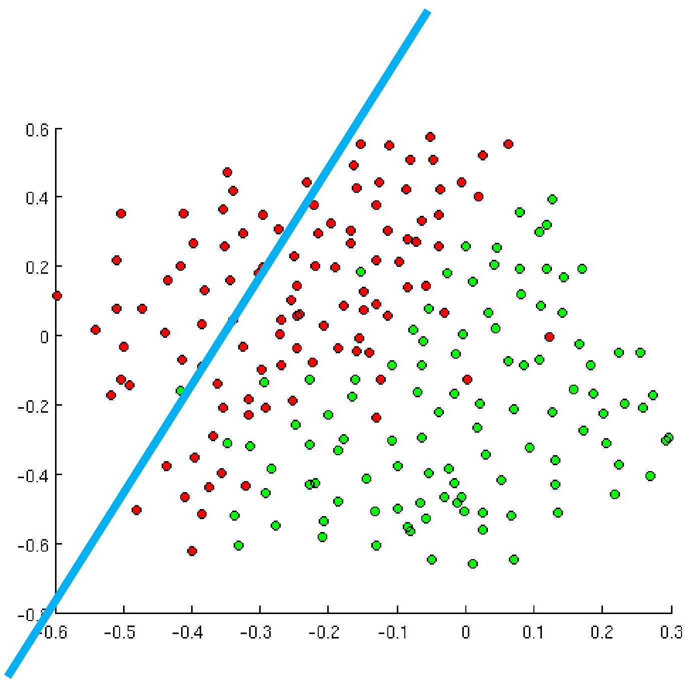

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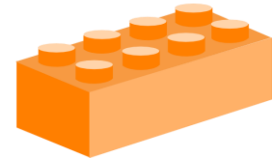

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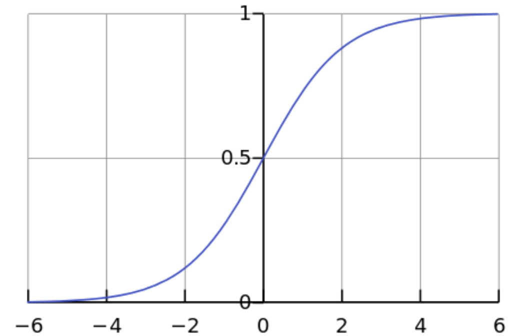

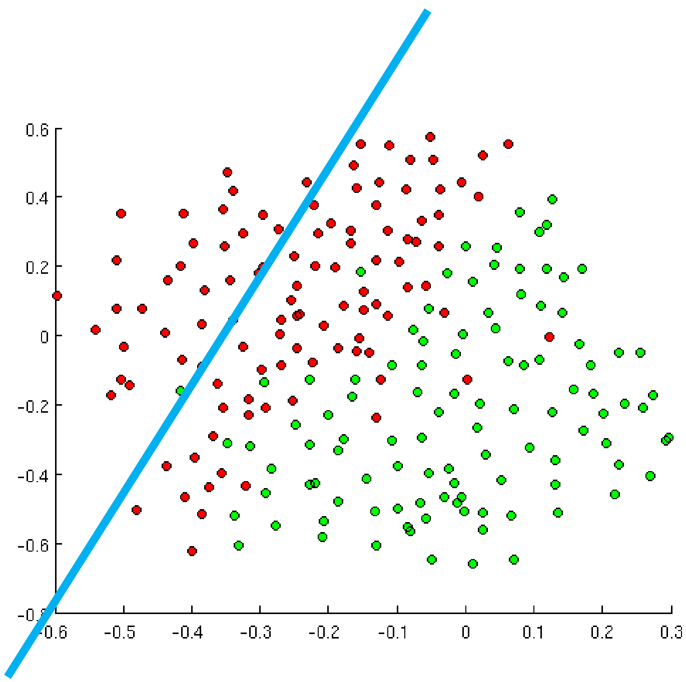

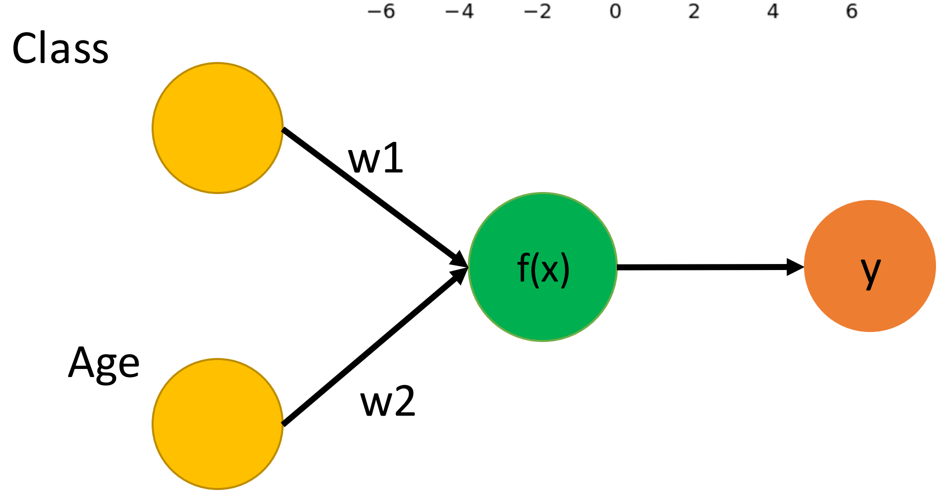

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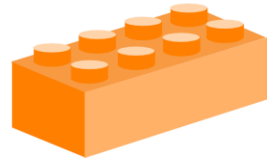
y = f(a)

Logistic Regression



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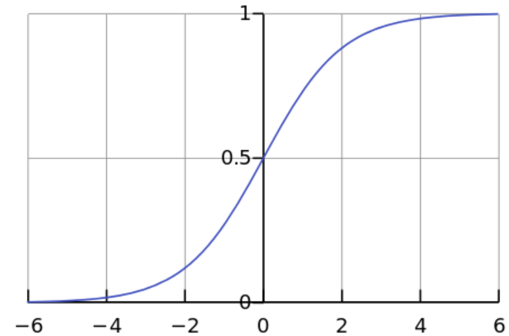

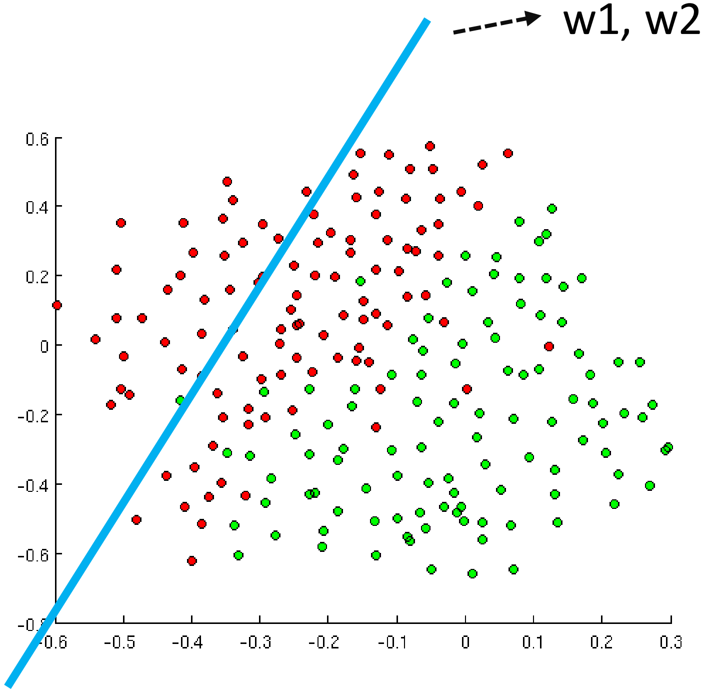

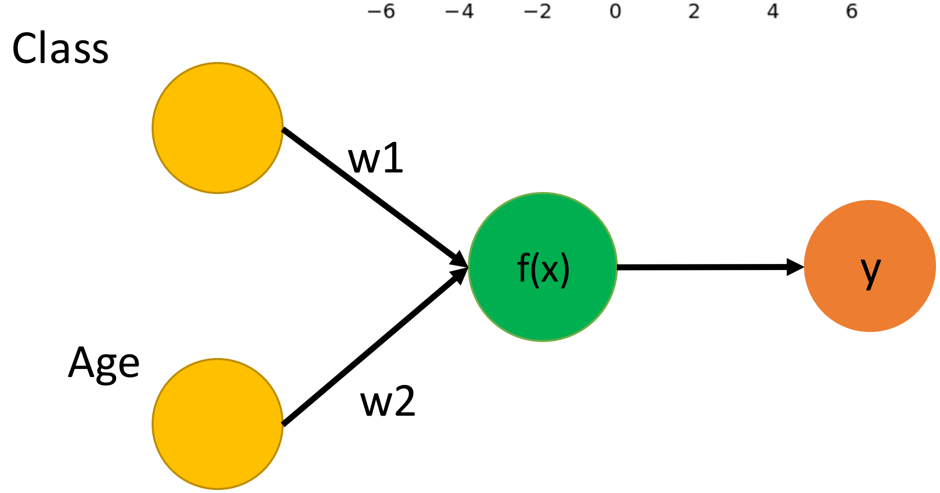

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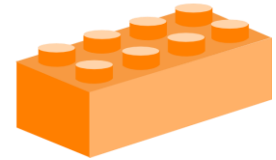

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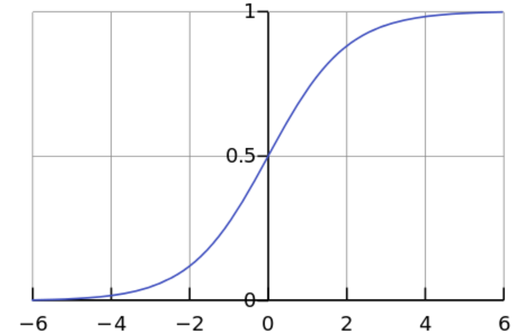

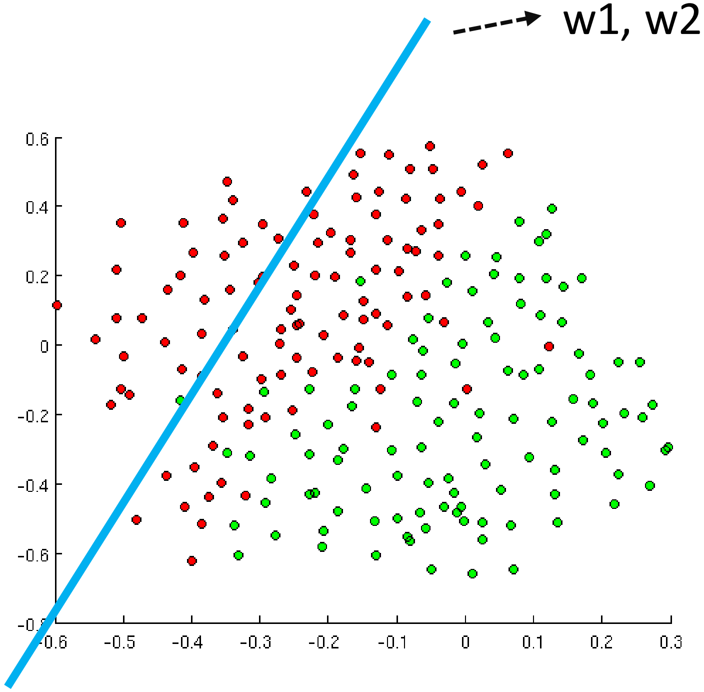

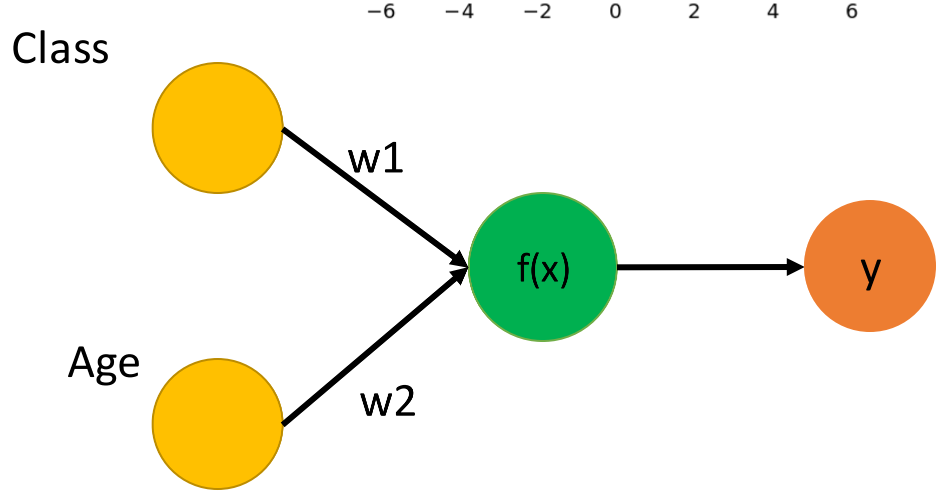

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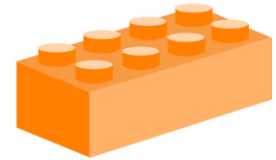

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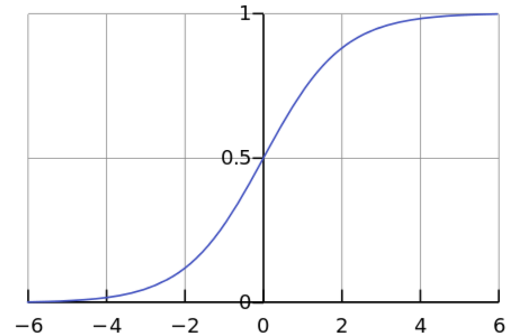

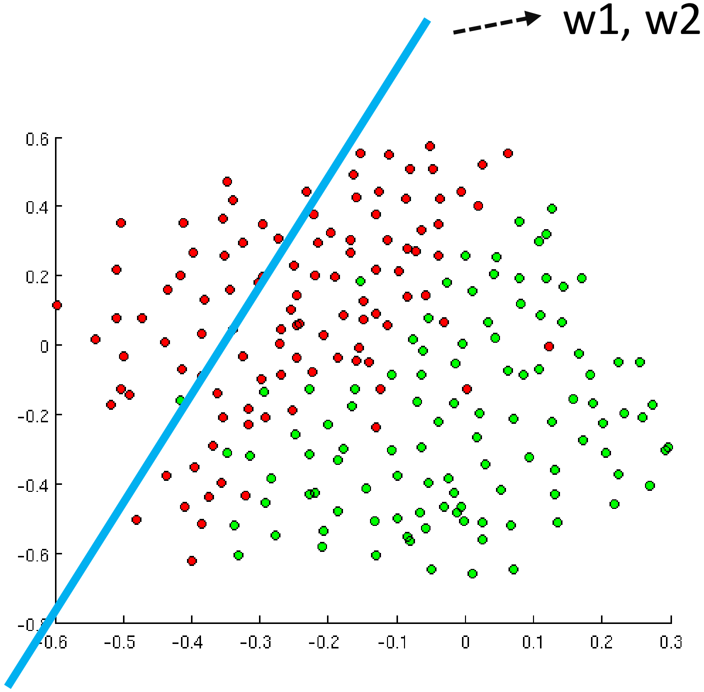

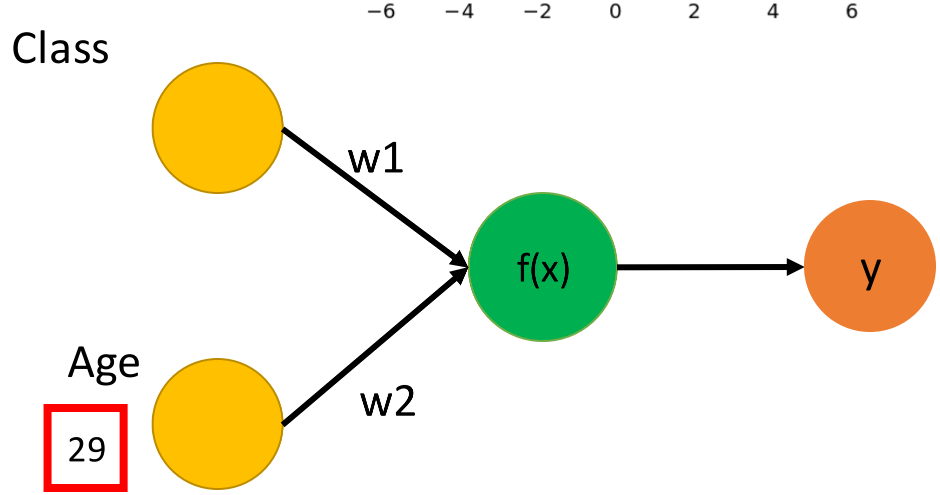

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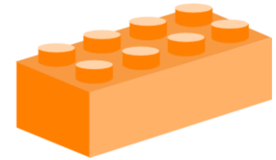

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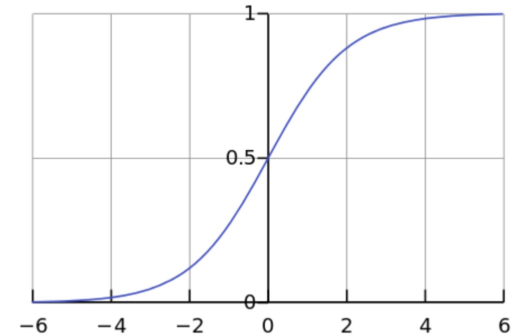

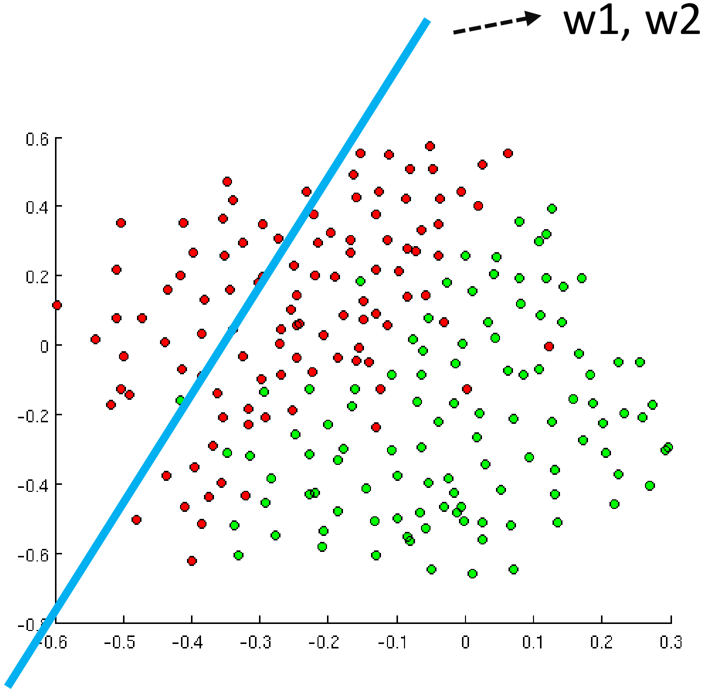

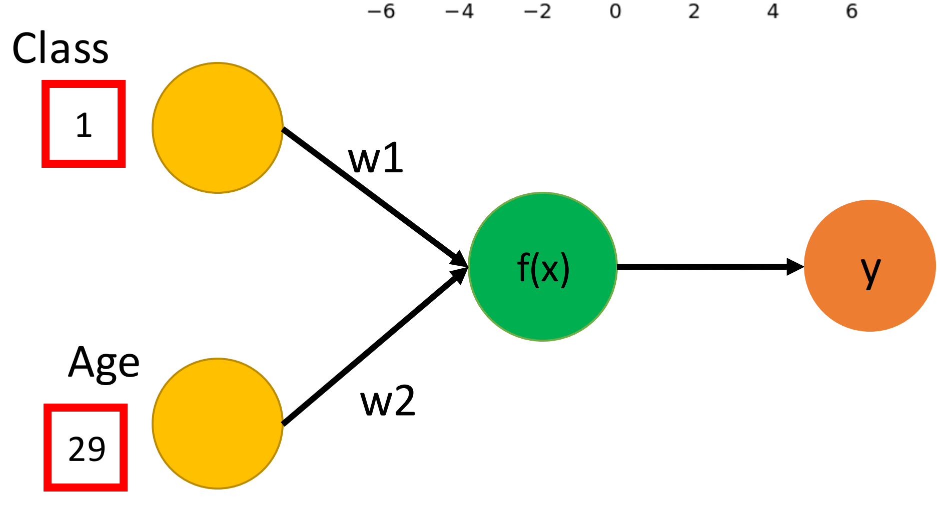

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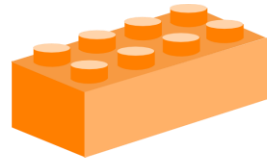

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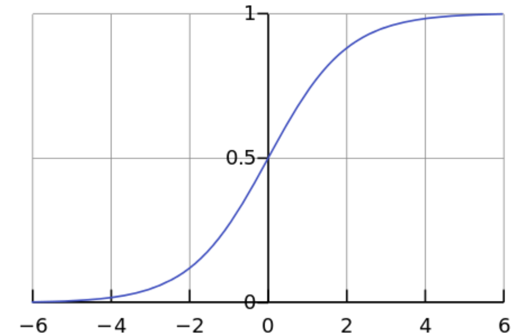
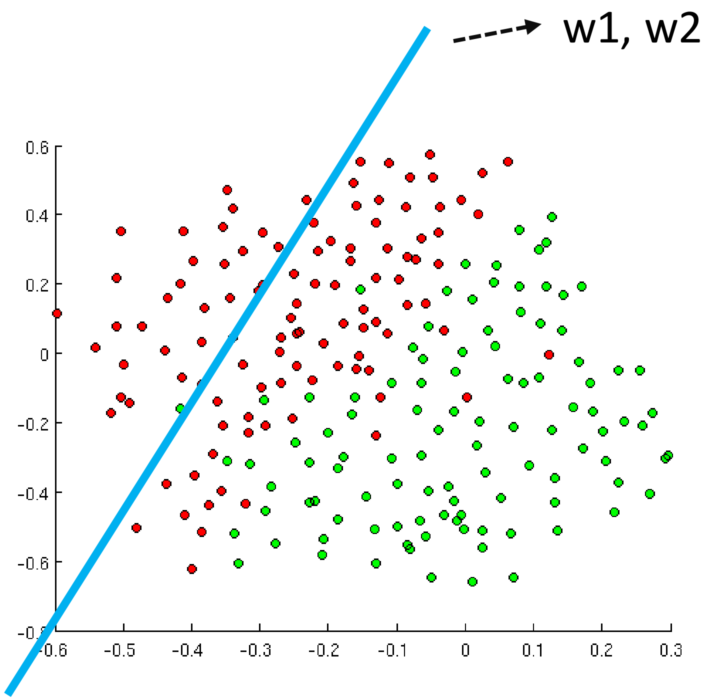
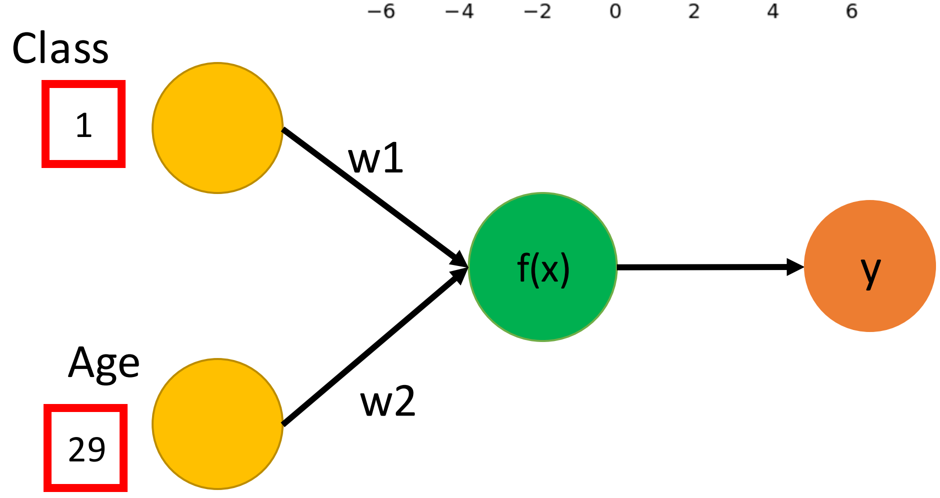




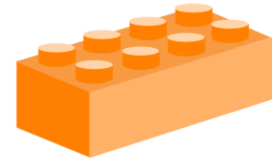


a = w1 * Class + w2 * Age

a' = -2 * 1 + 0.1 * 29 = 0.9

y = f(a)

Logistic Regression



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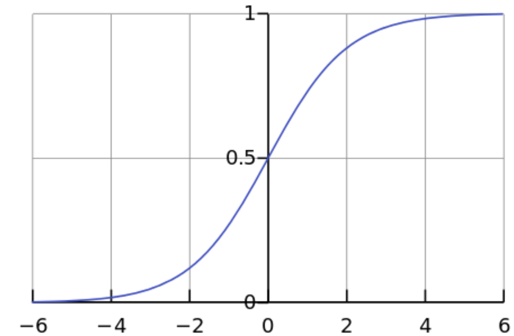

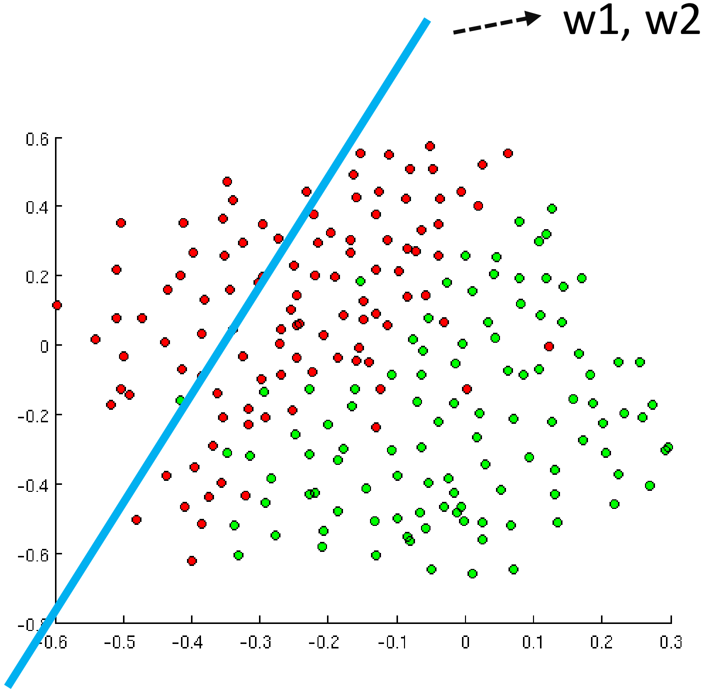

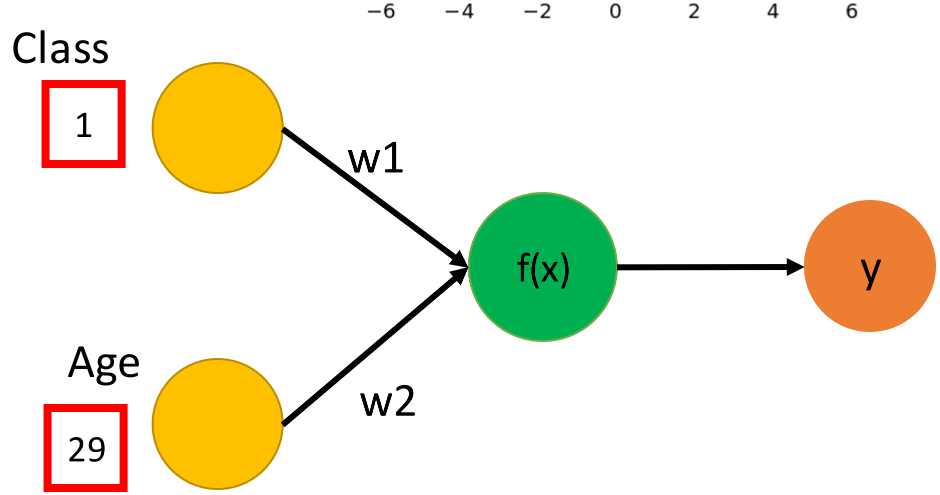

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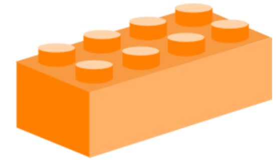

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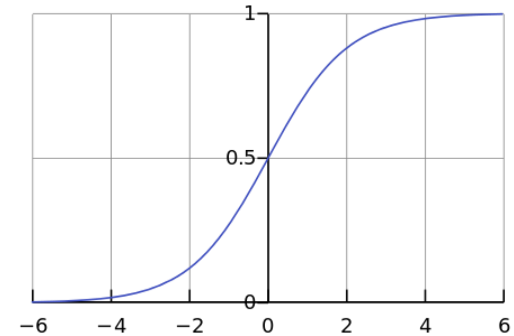

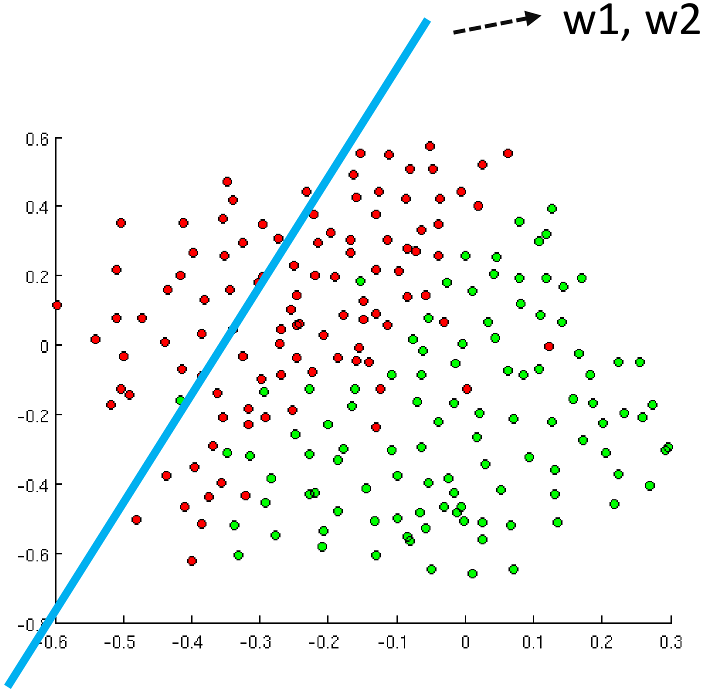

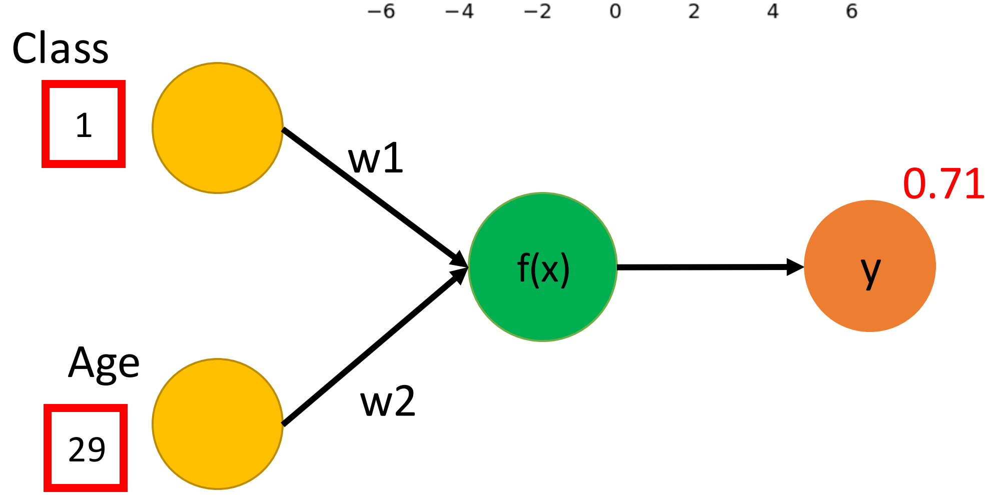

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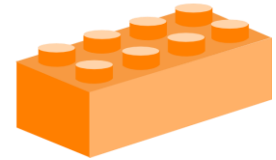

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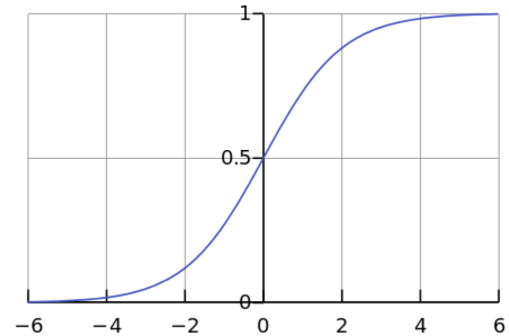

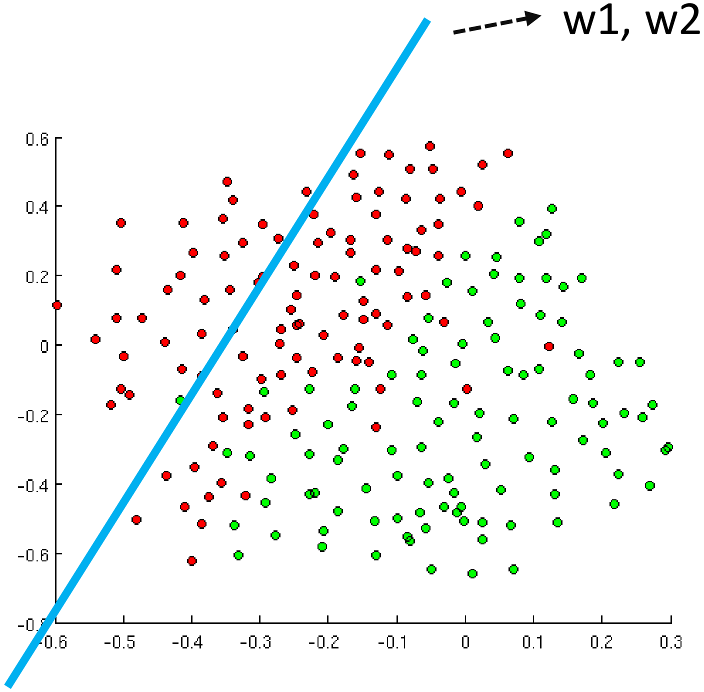

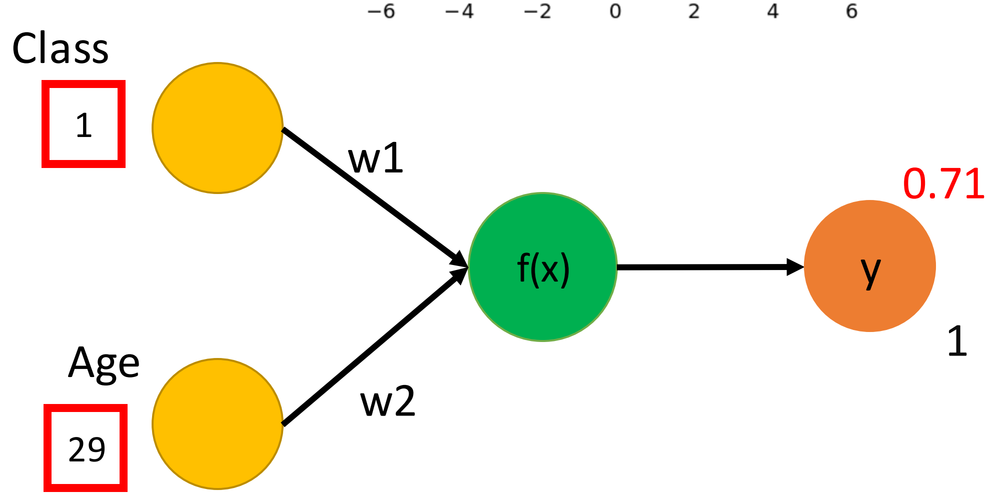

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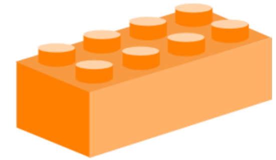

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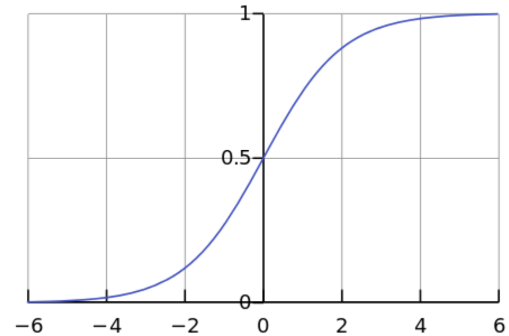

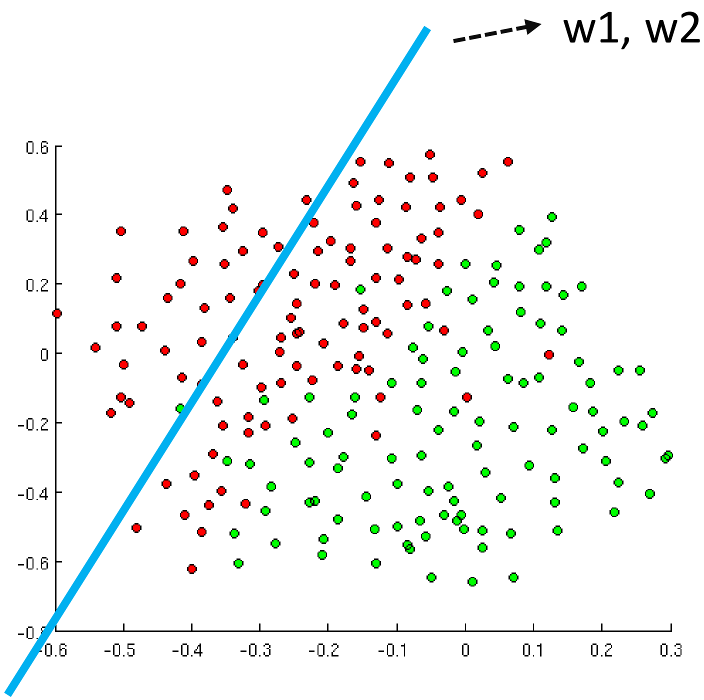

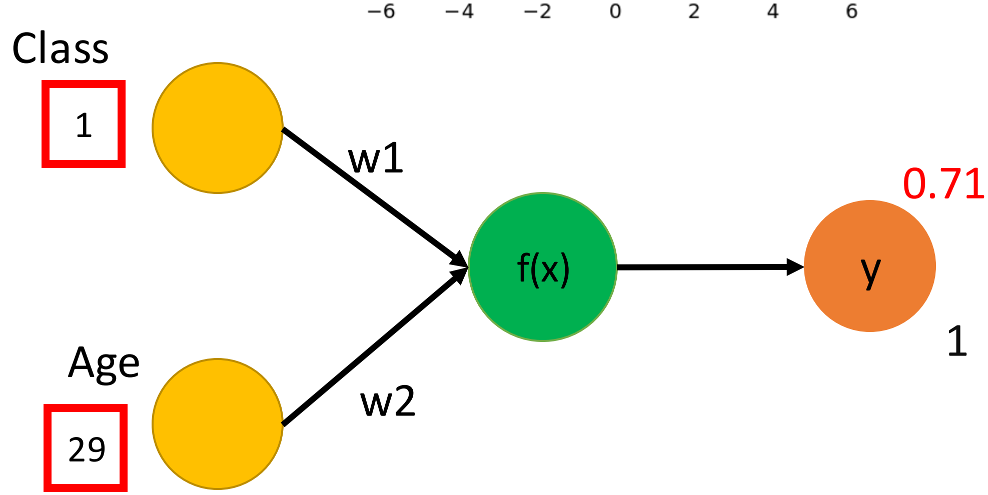

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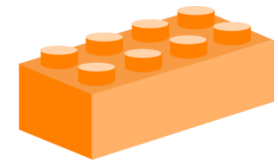
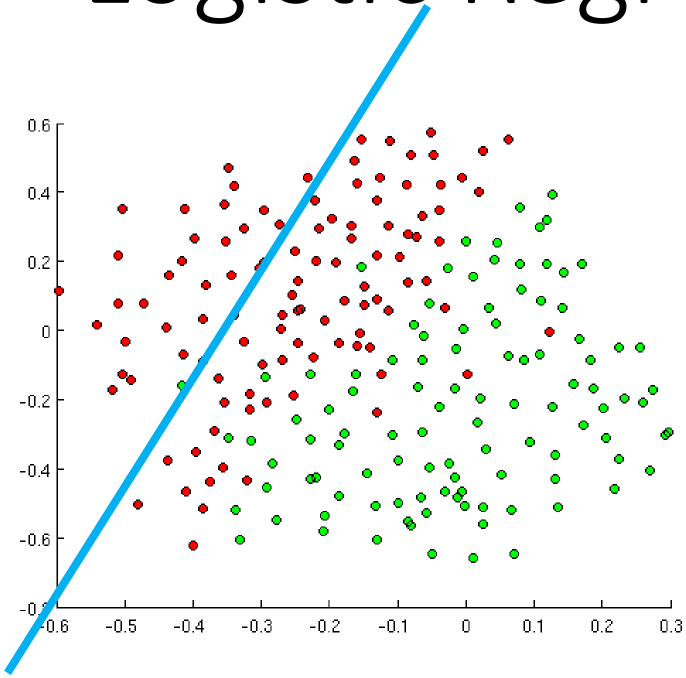
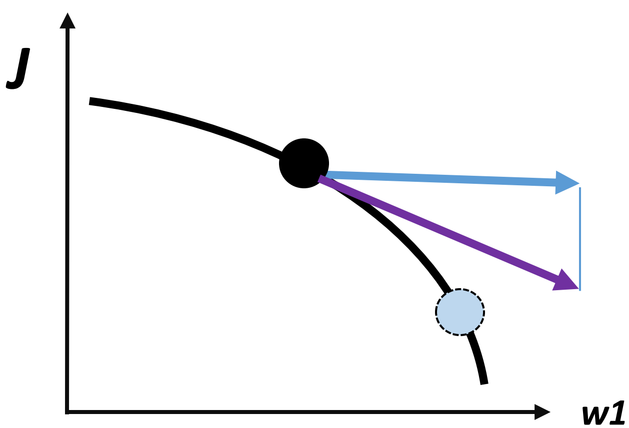
Total cost:

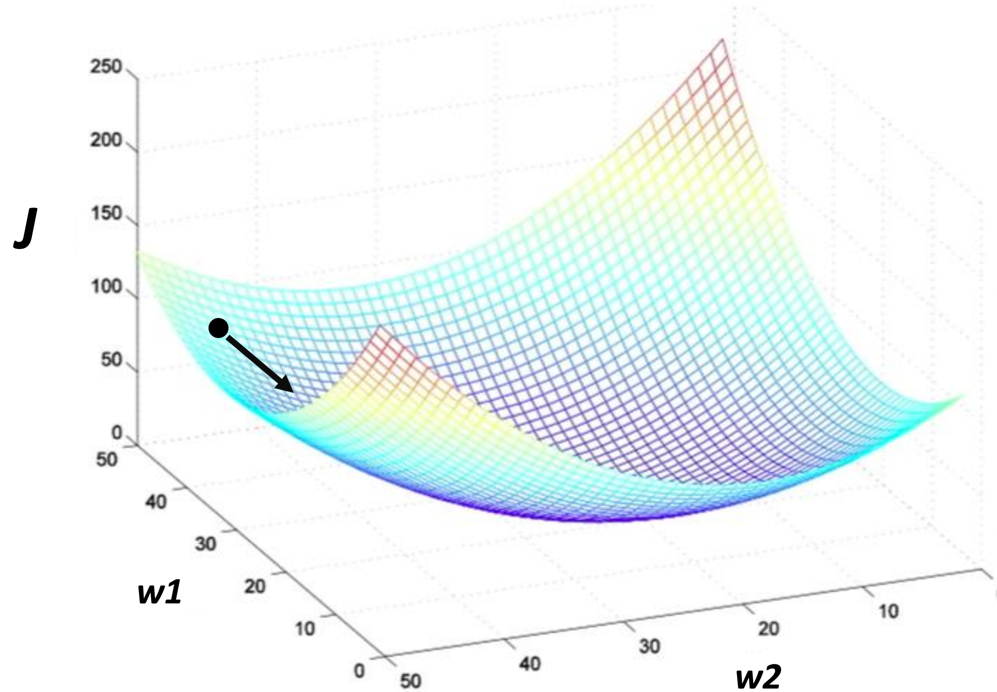
$$J(w) = \Sigma\,(y' - y)^2$$

Logistic Regression cont'd









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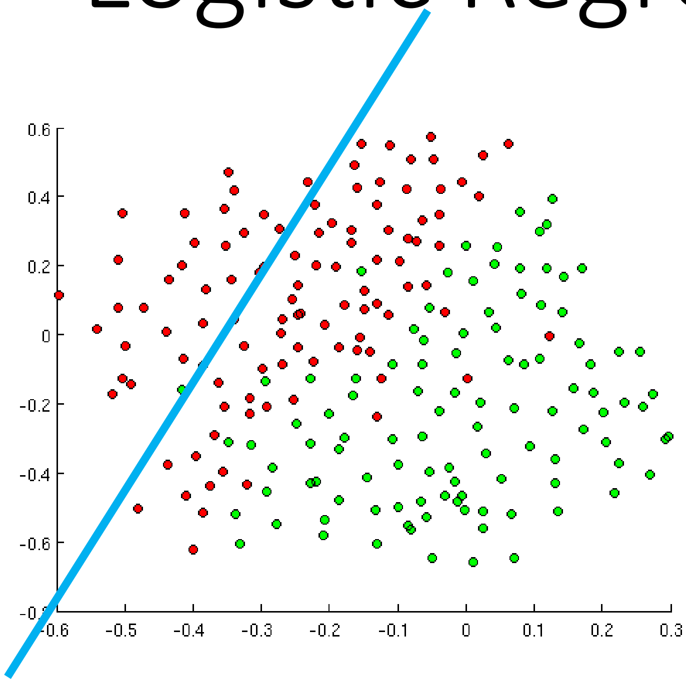

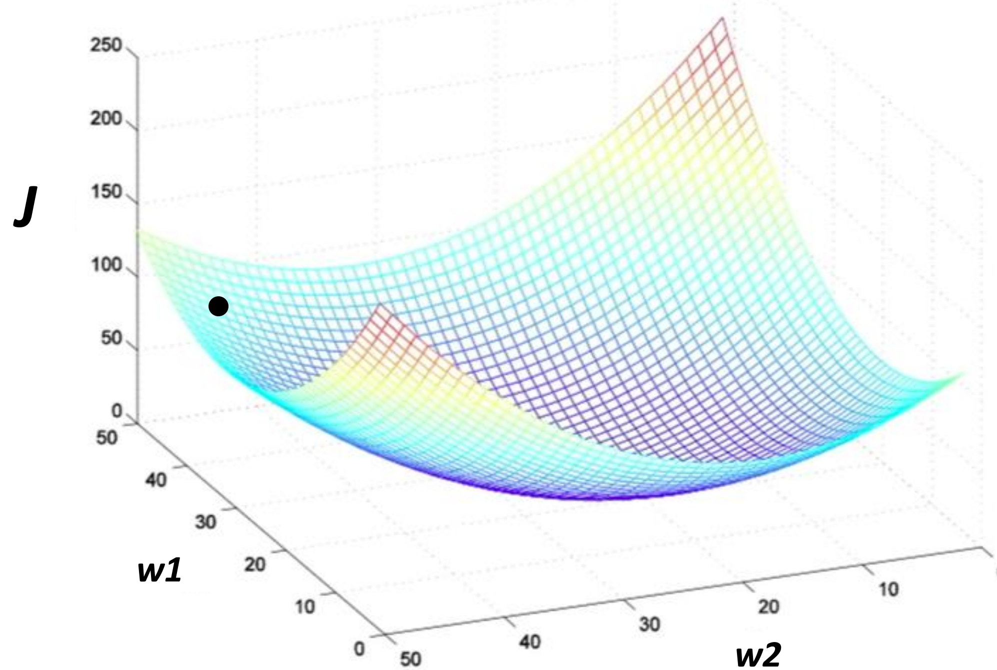

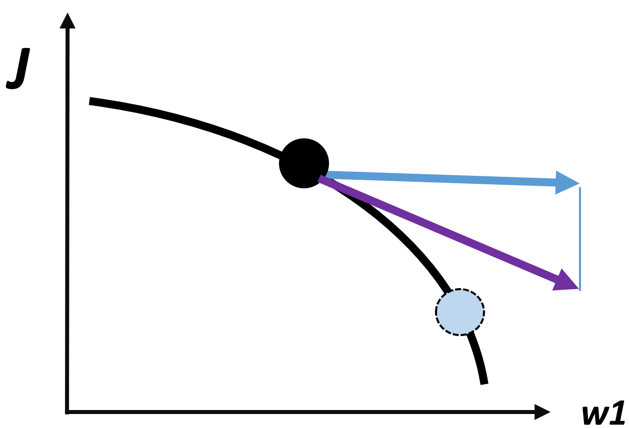

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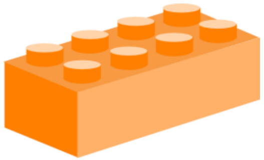
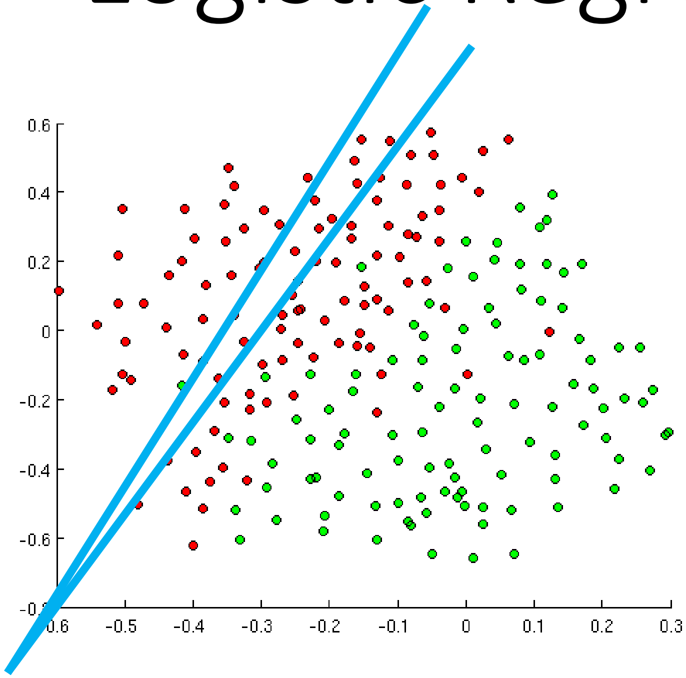
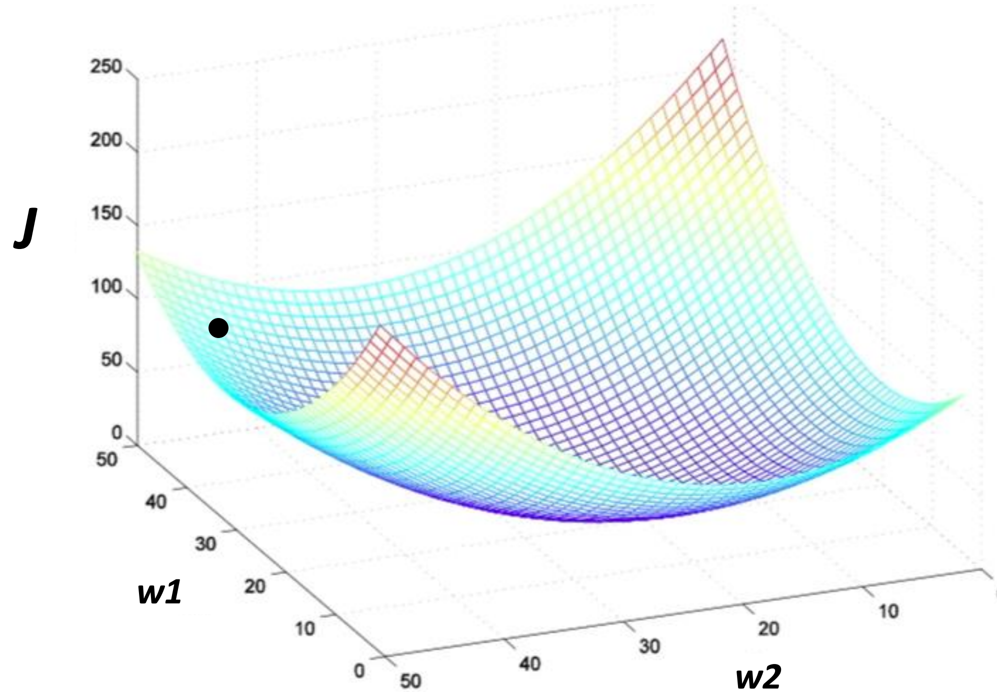
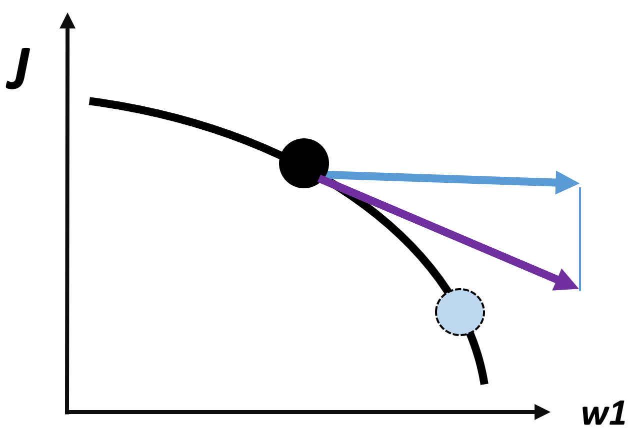
Logistic Regression cont'd





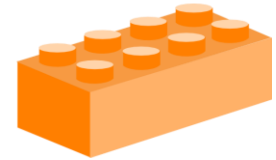


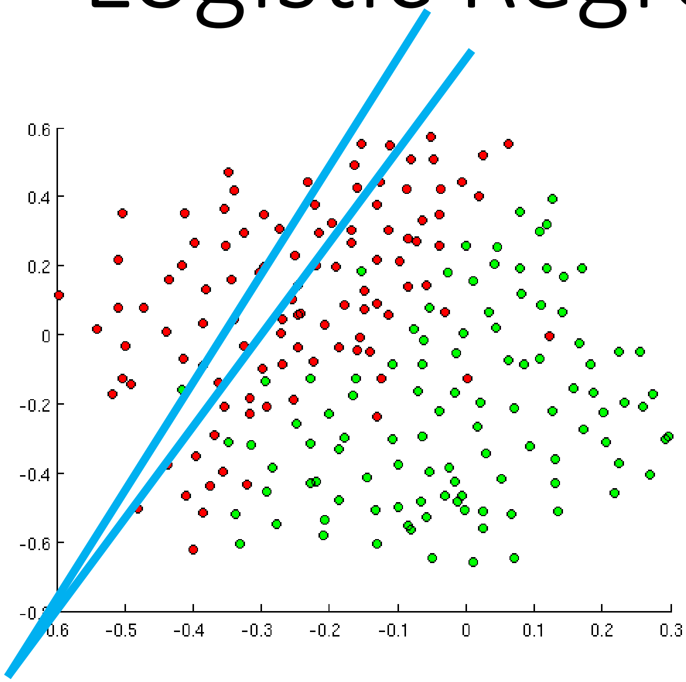


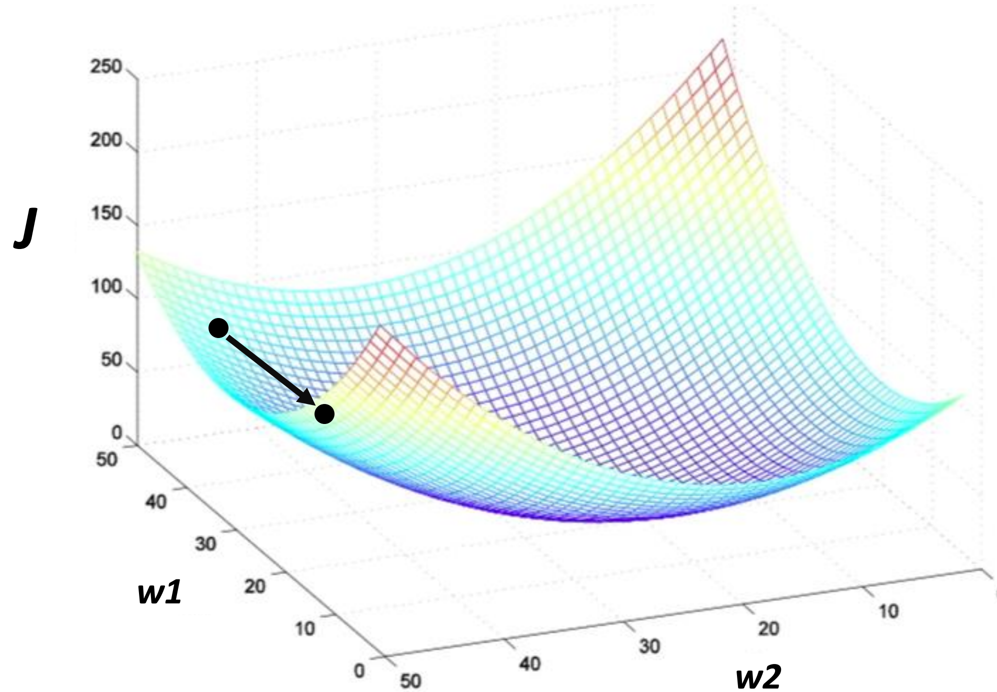
Total cost:

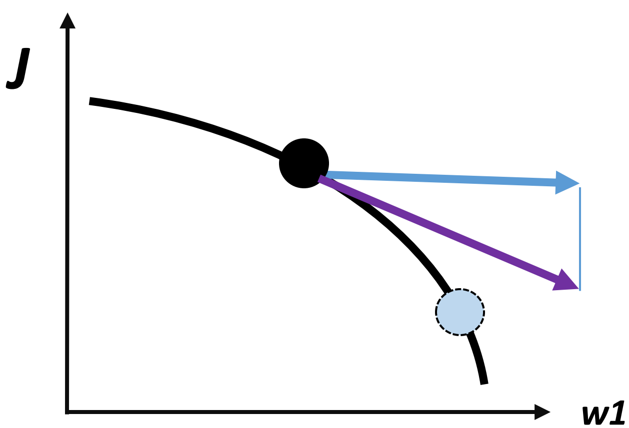
$$J(w) = \Sigma\ (y' - y)^2$$

Logistic Regression cont'd





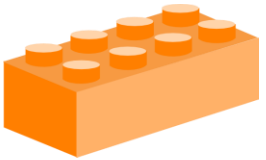


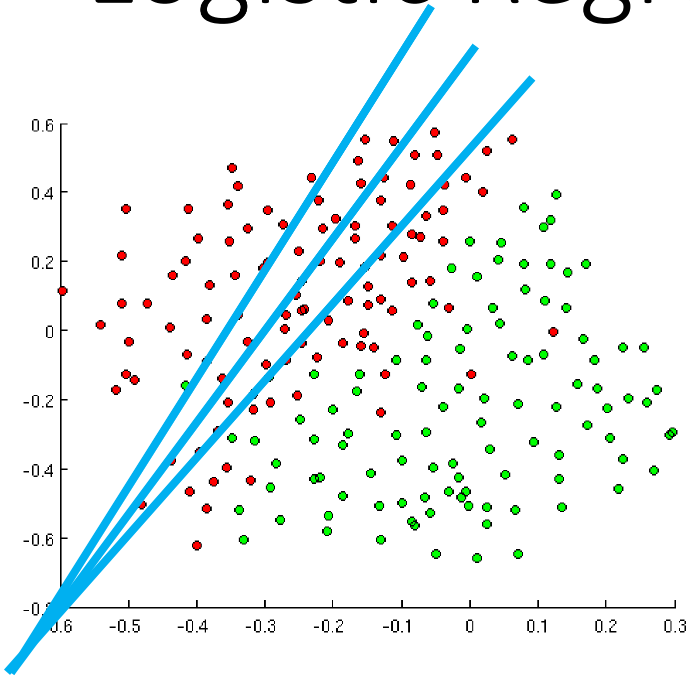


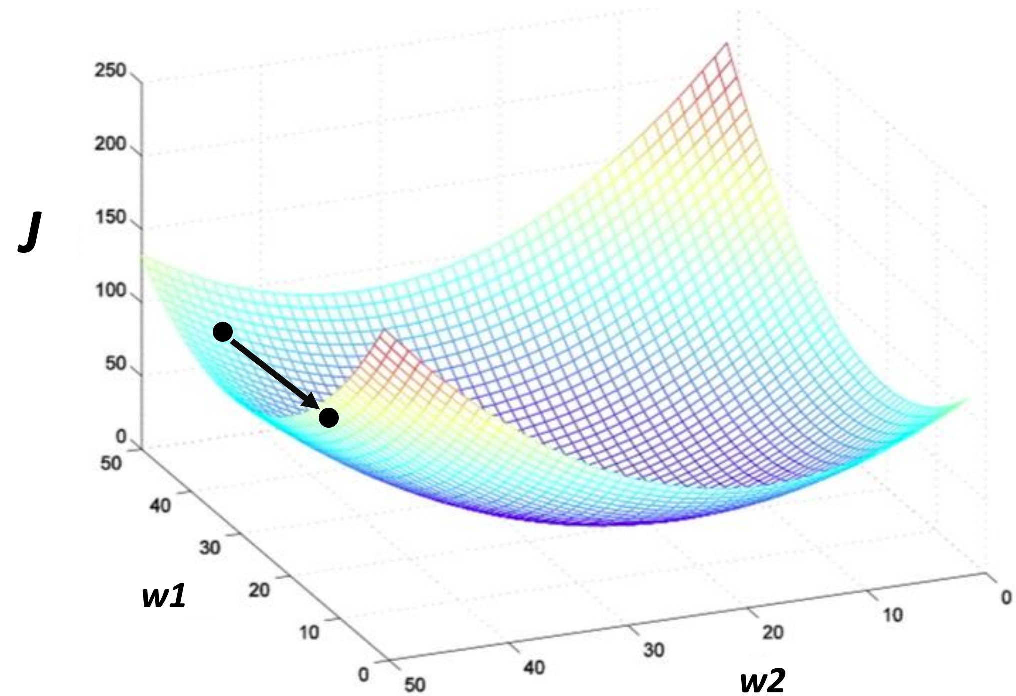
Total cost:

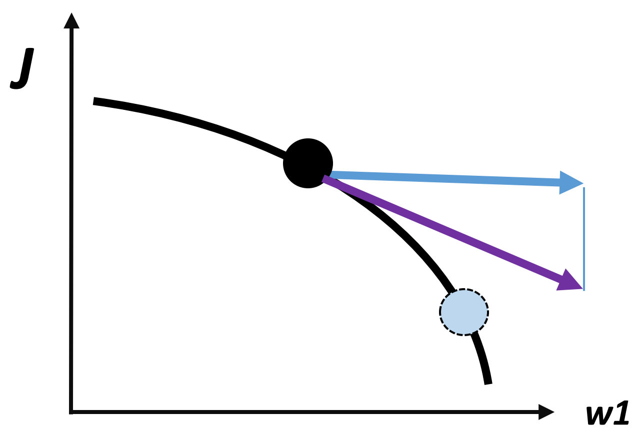
J(w) = Σ (y' - y)^2

Logistic Regression cont'd





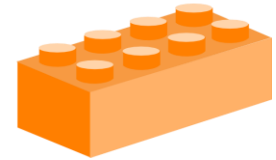


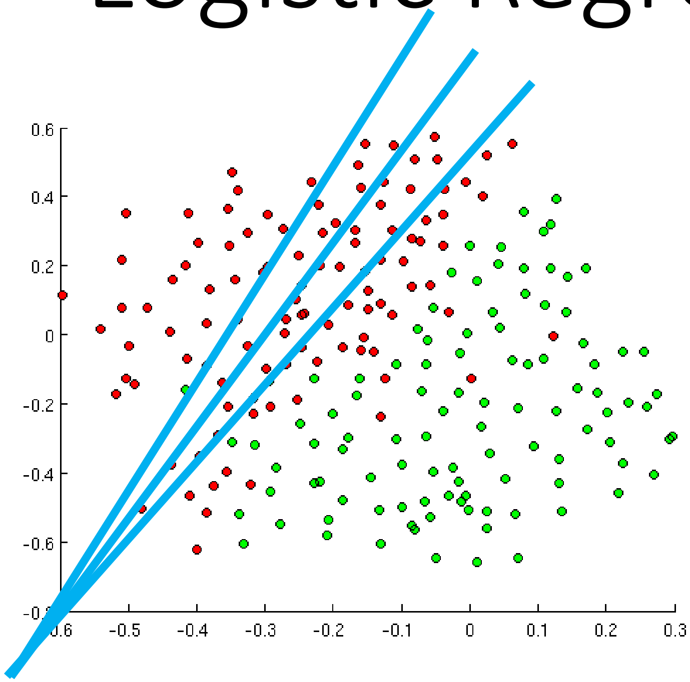


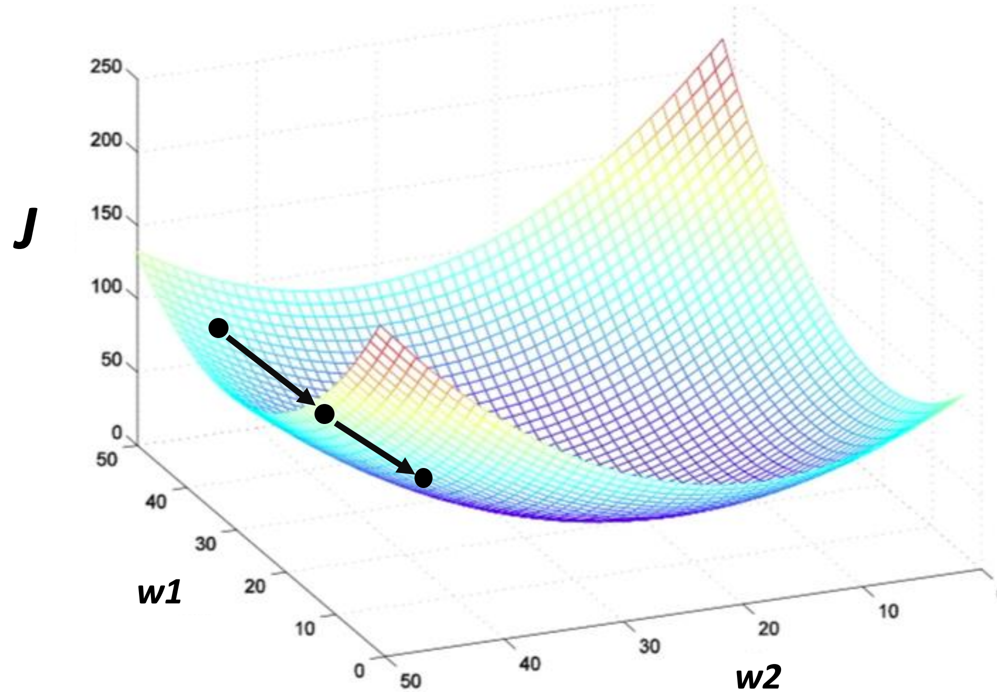
Total cost:

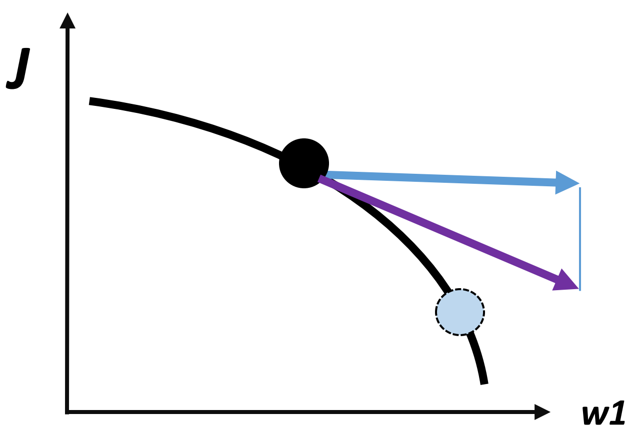
$$J(w) = \Sigma\ (y' - y)^2$$

Logistic Regression cont’d





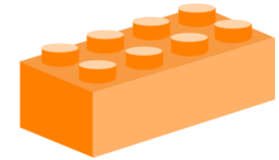


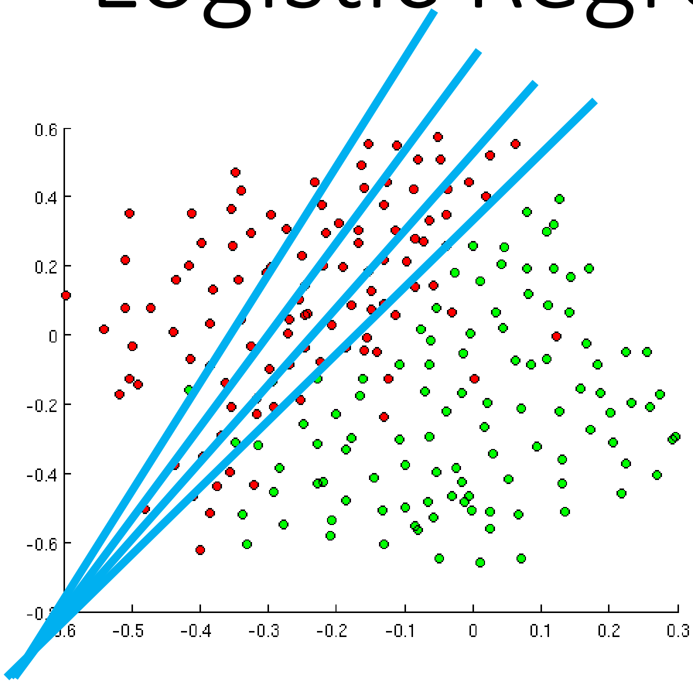


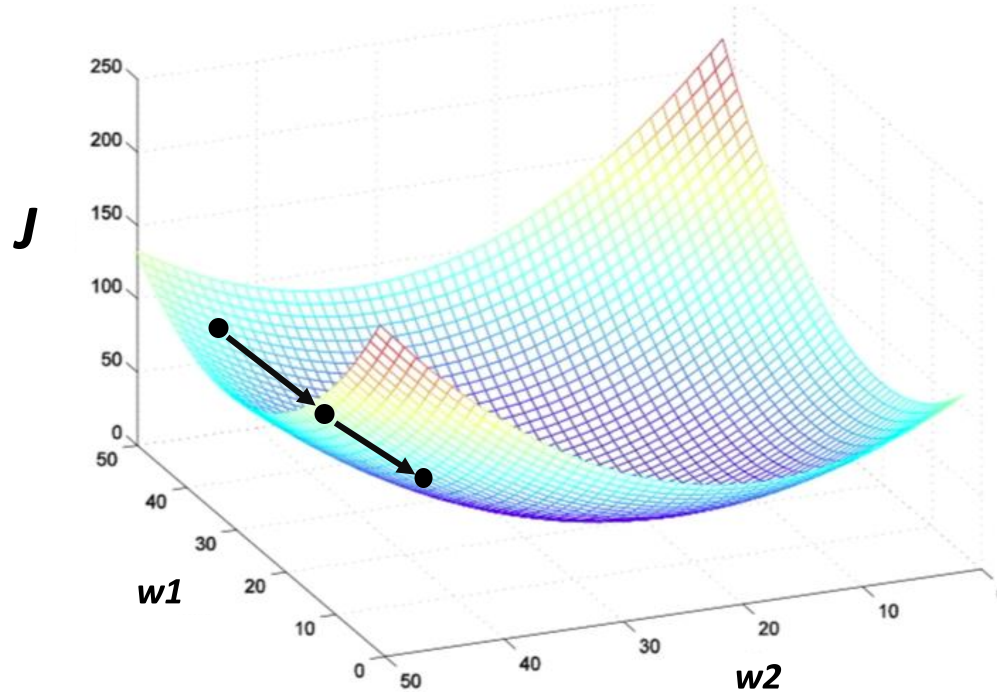
Total cost:

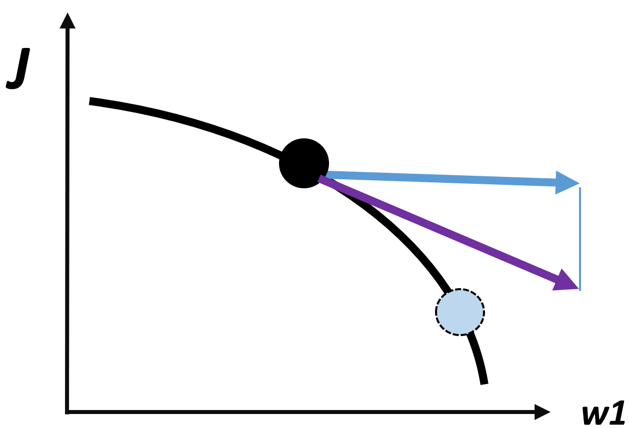
J(w) = *Σ* (y’ - y)^2

Logistic Regression cont'd





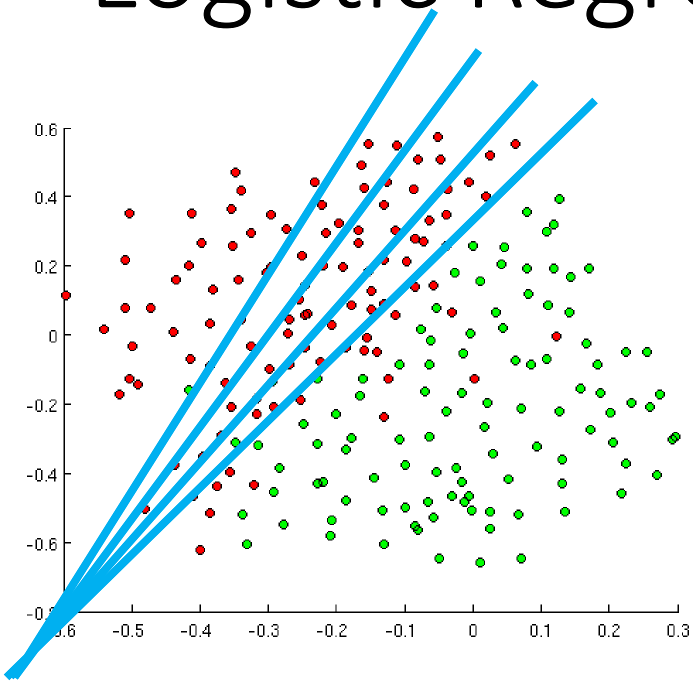


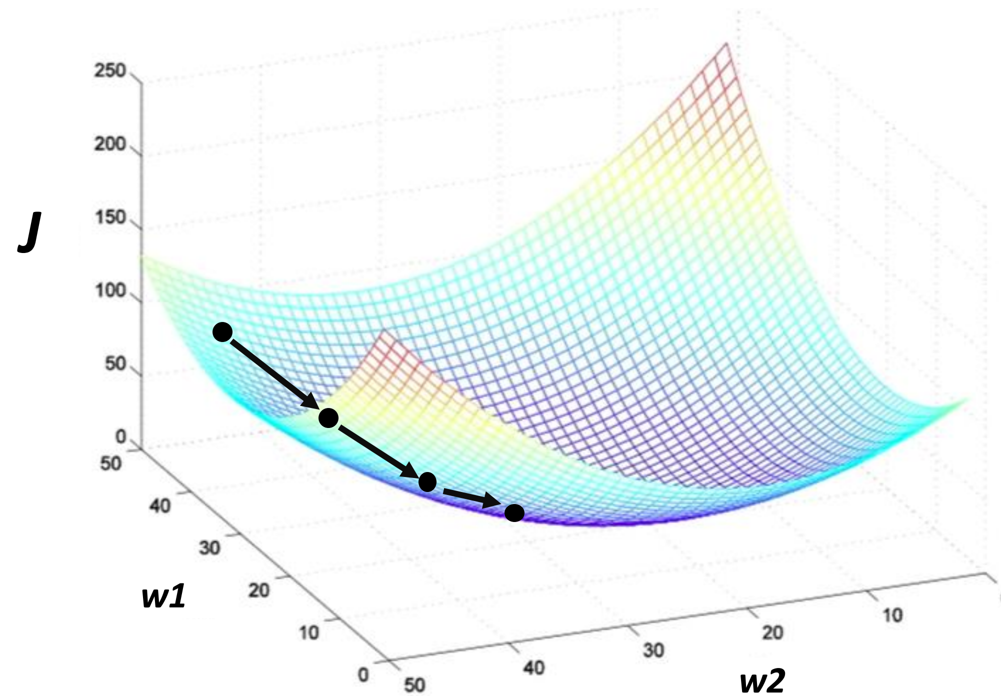


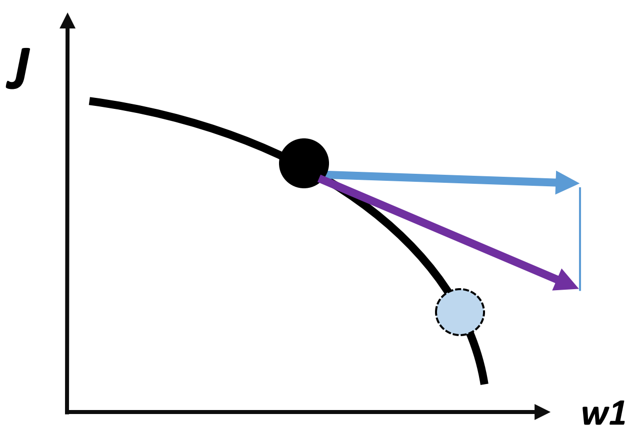
Total cost:

$$\boldsymbol{J(w)} = \Sigma\ (y' - y)^2$$

Logistic Regression cont'd



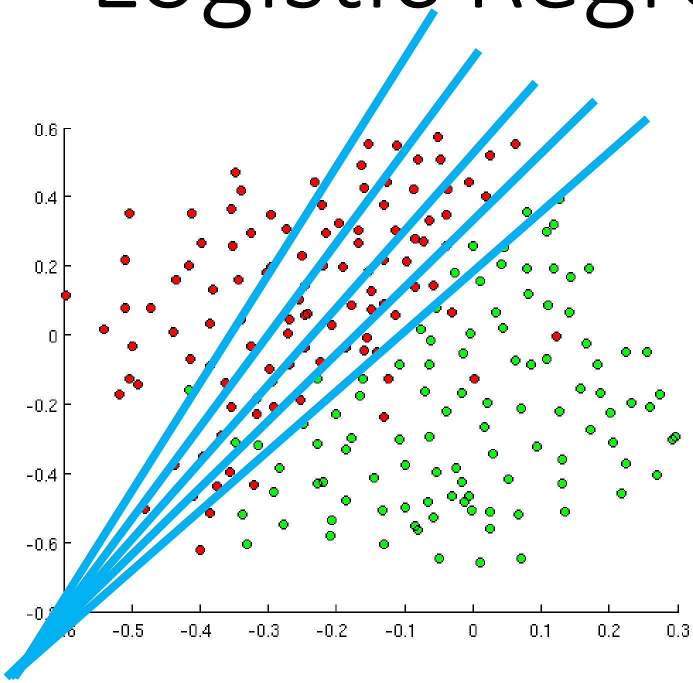


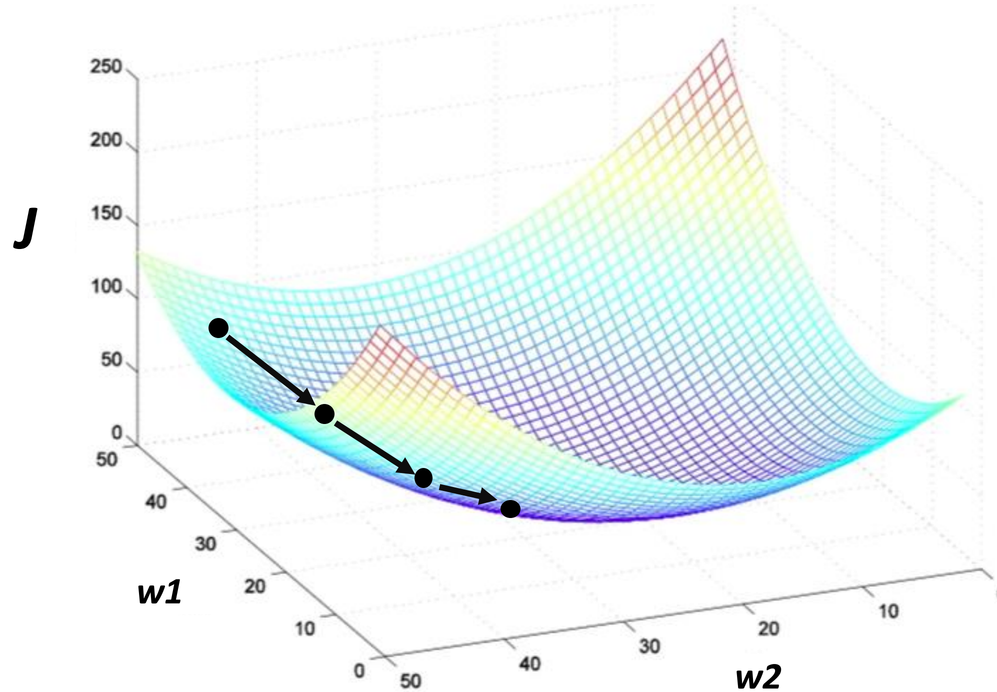


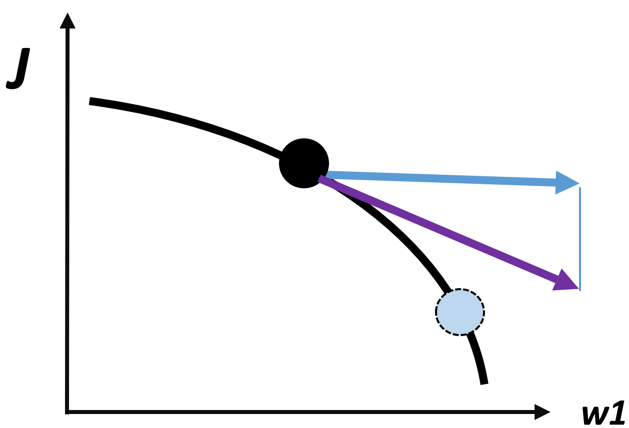
Total cost:

$$J(w) = \Sigma\ (y' - y)^2$$

Logistic Regression cont’d



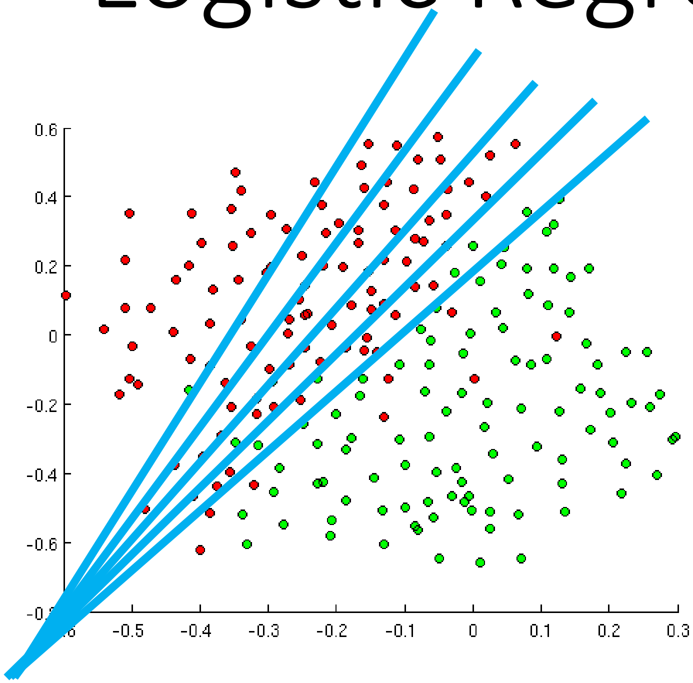


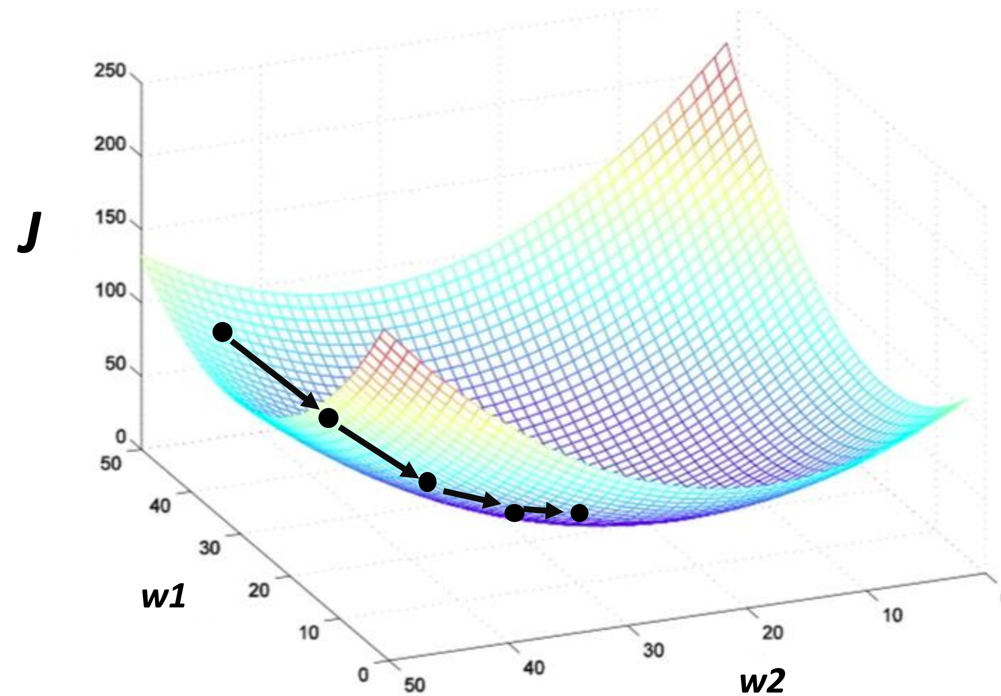


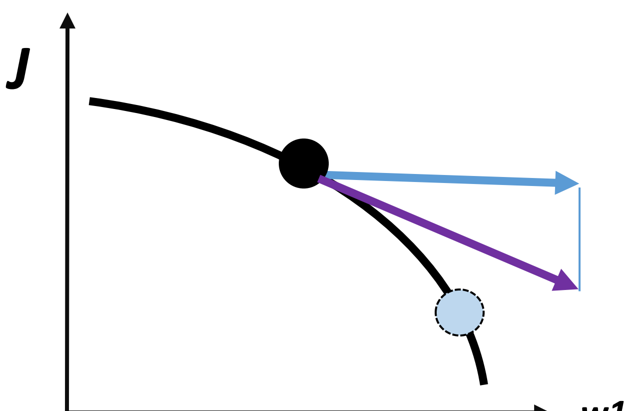
Total cost:

$$J(w) = \Sigma\ (y' - y)^2$$

Logistic Regression cont'd



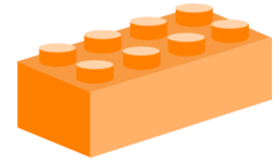


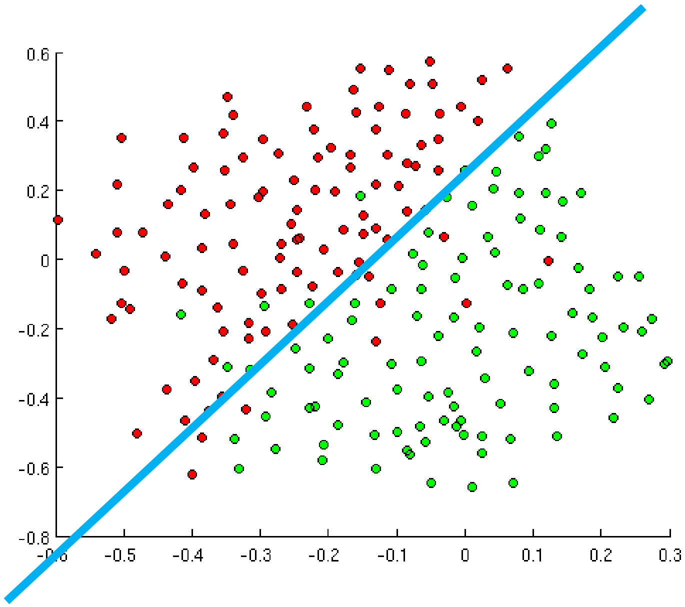


Total cost:

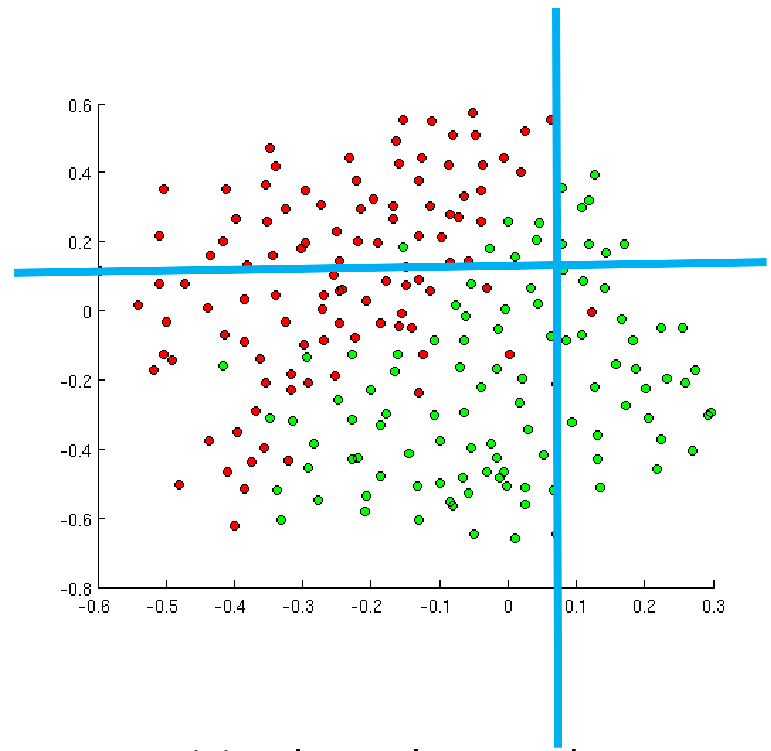
$$J(w) = \Sigma\,(y' - y)^2$$

Logistic Regression cont’d





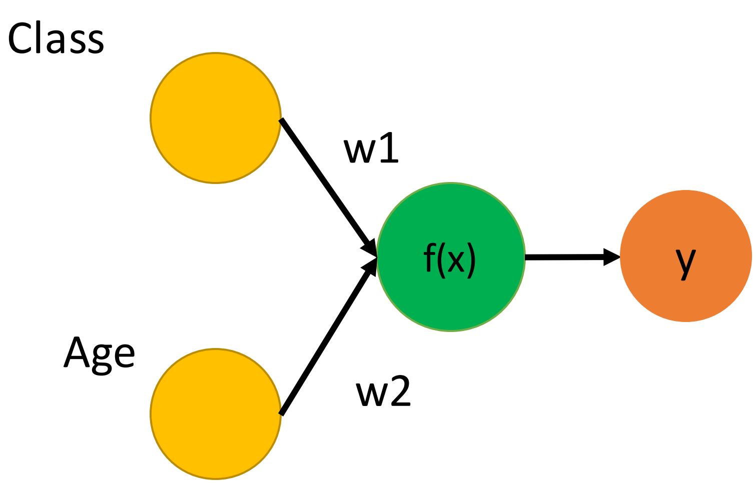
Decision boundary made by a linear model (logistic regression)



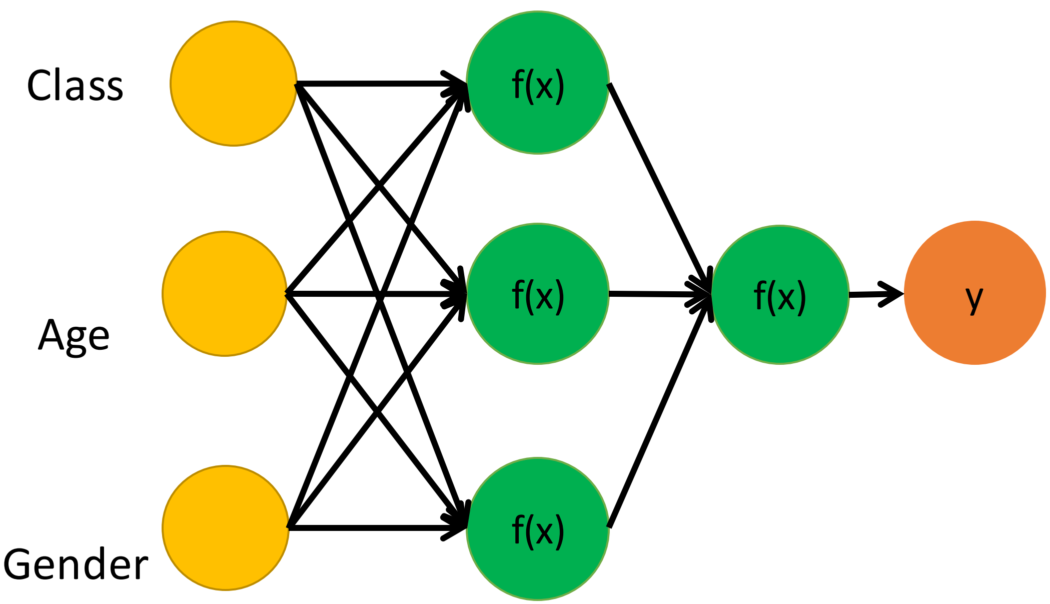
Decision boundary made by a decision tree.

Neural Network

- Adds multiple layer of interconnected regression node.
- Following the same way of training.



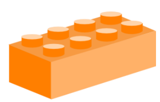
A logistic regression model.

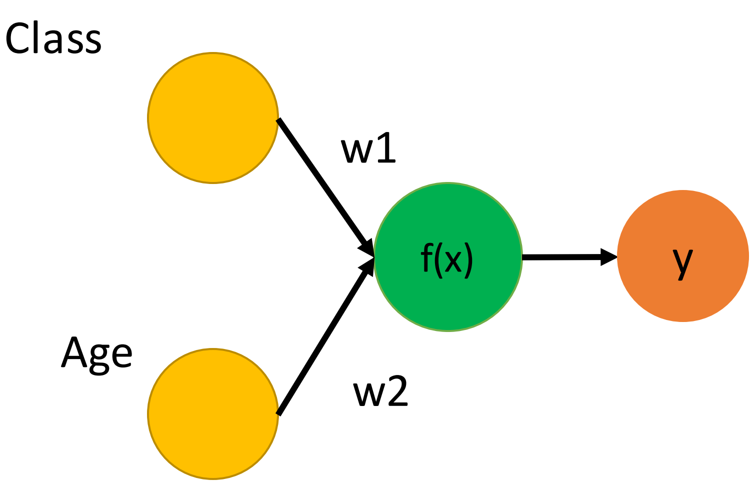


A neural network model.

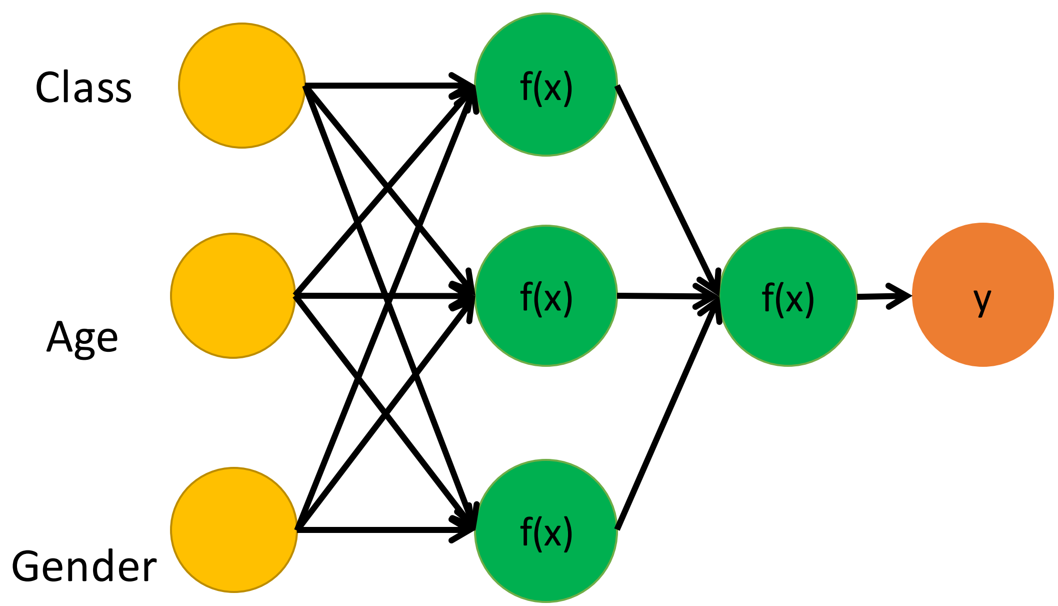
Neural Network

- Adds multiple layer of interconnected regression node.
- Following the same way of training.





A logistic regression model.



A neural network model.

Neural Network

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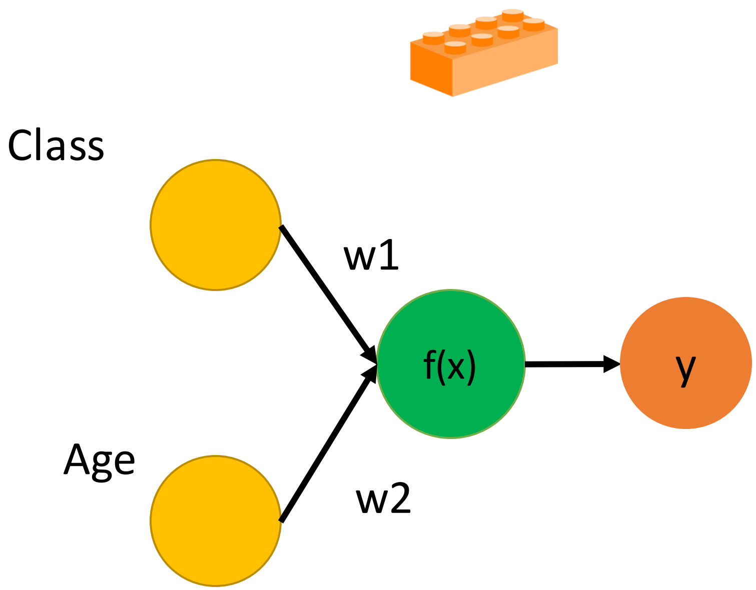
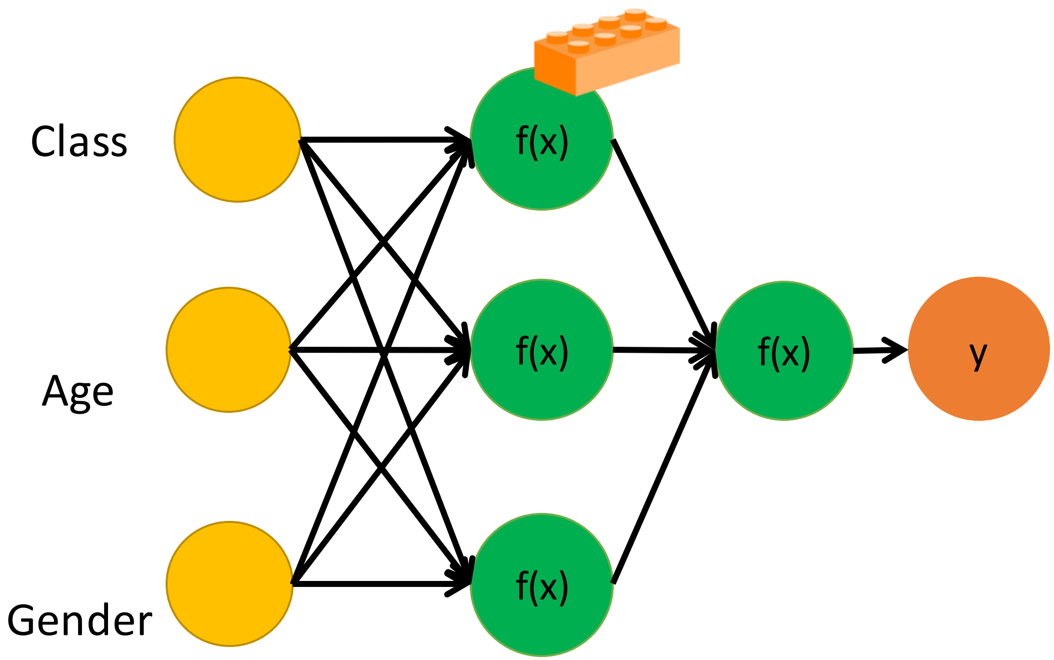


A logistic regression model.



A neural network model.

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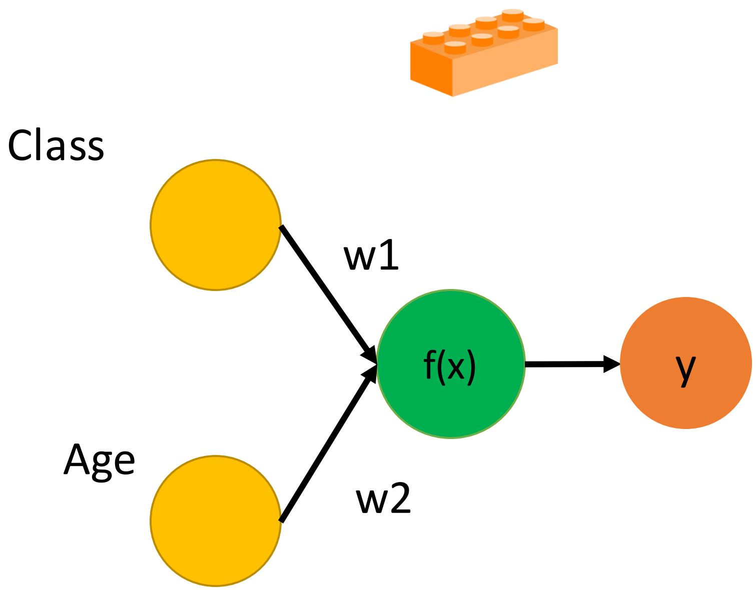
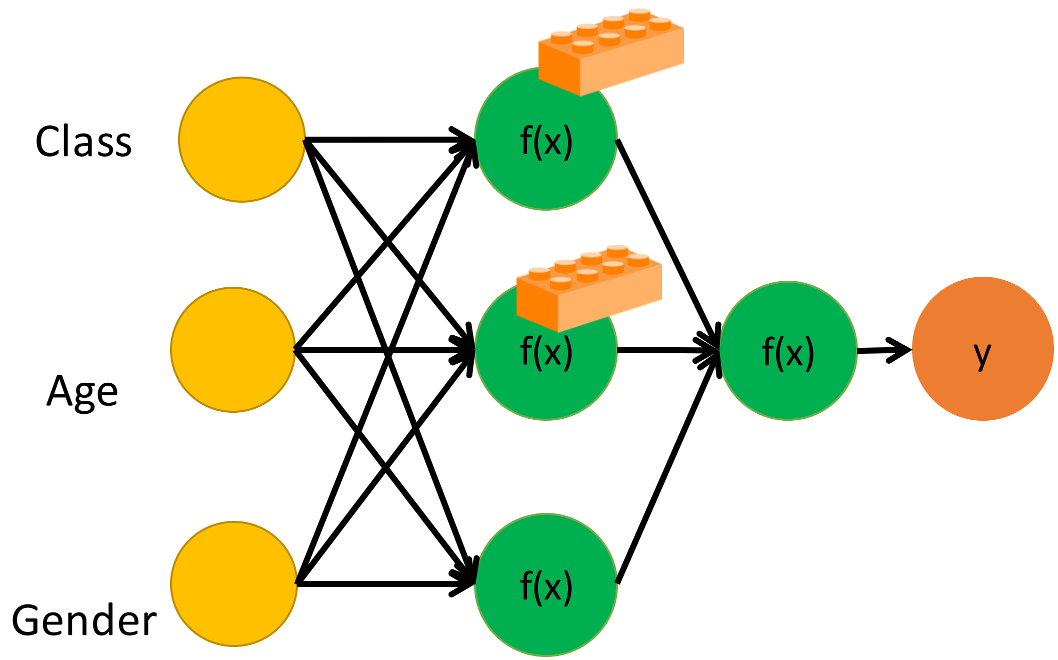


A logistic regression model.



A neural network model.

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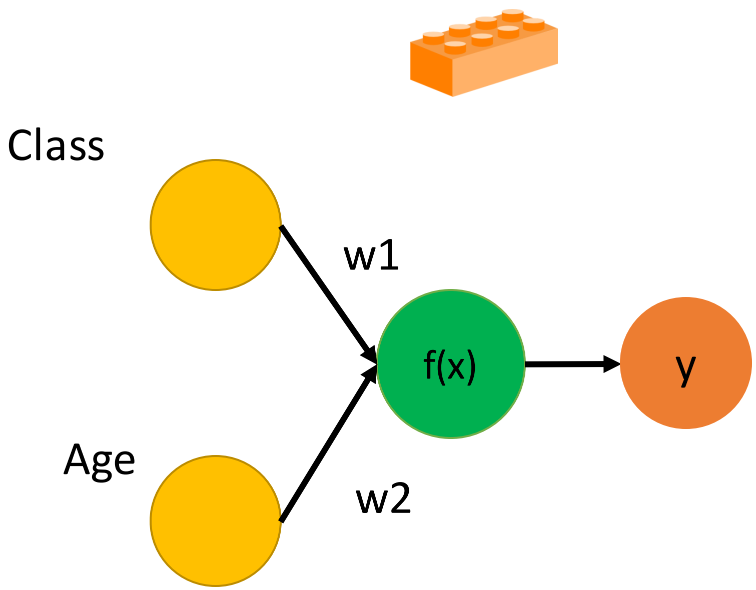
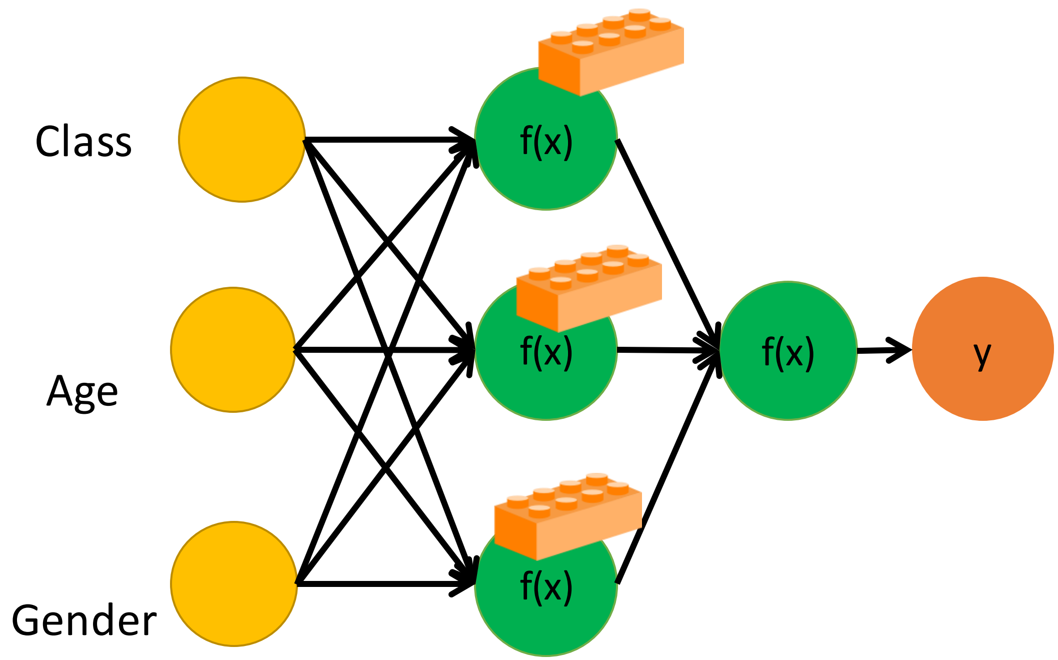


A logistic regression model.



A neural network model.

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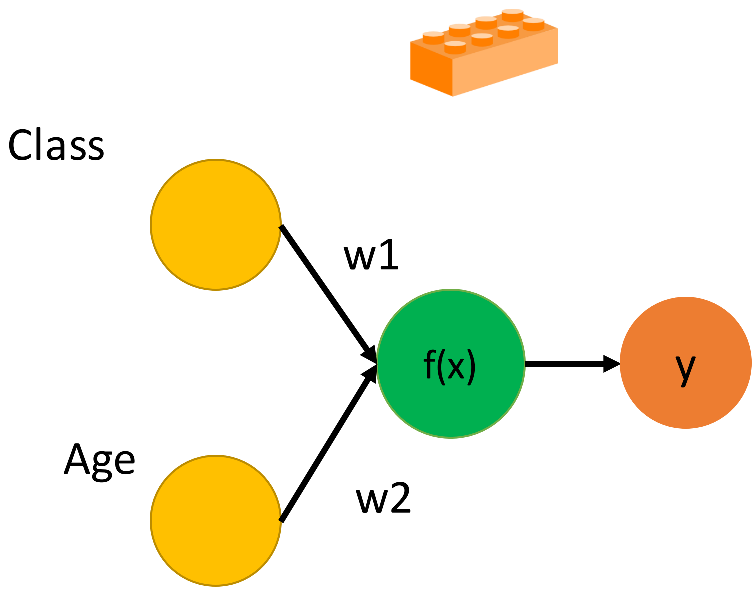
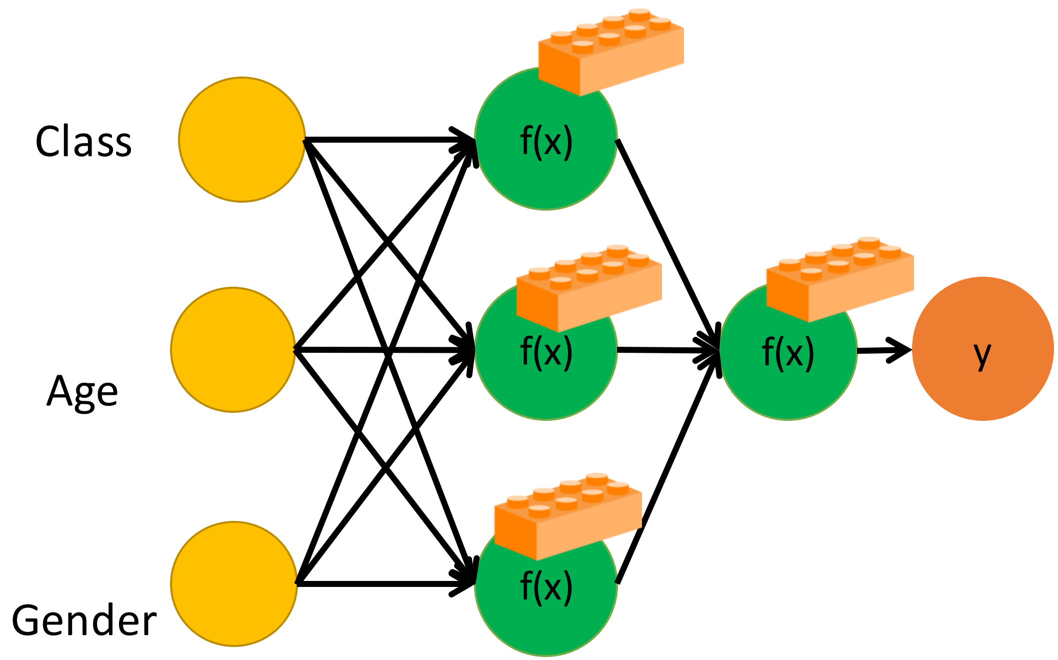


A logistic regression model.

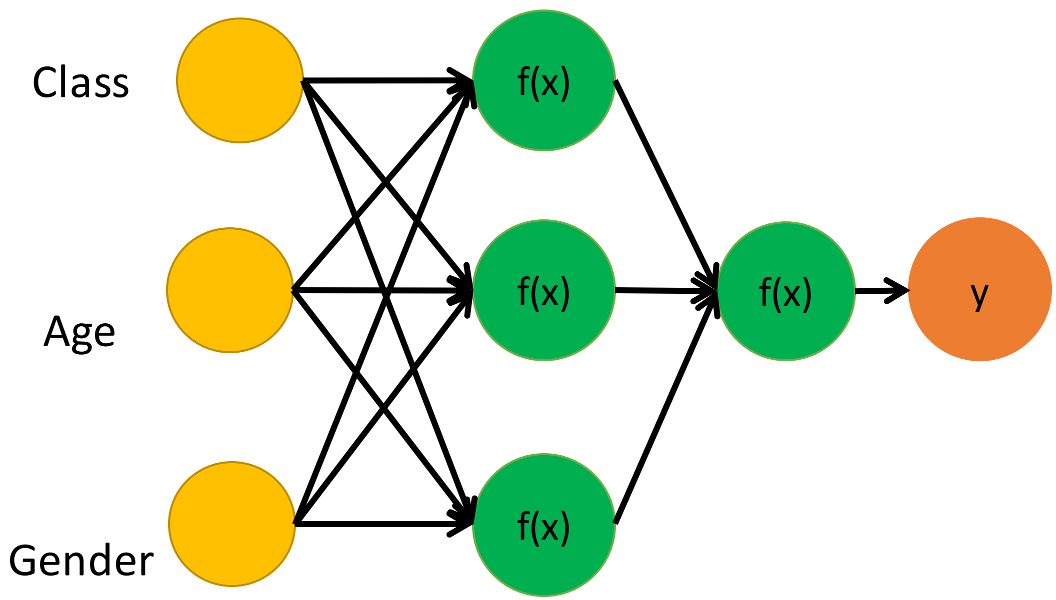


A neural network model.

Neural Network

Passenger Class	Gender	age	Survived
1	1	29	1
1	2	2	0
2	2	21	1
2	1	19	1

Randomly initialize weights.



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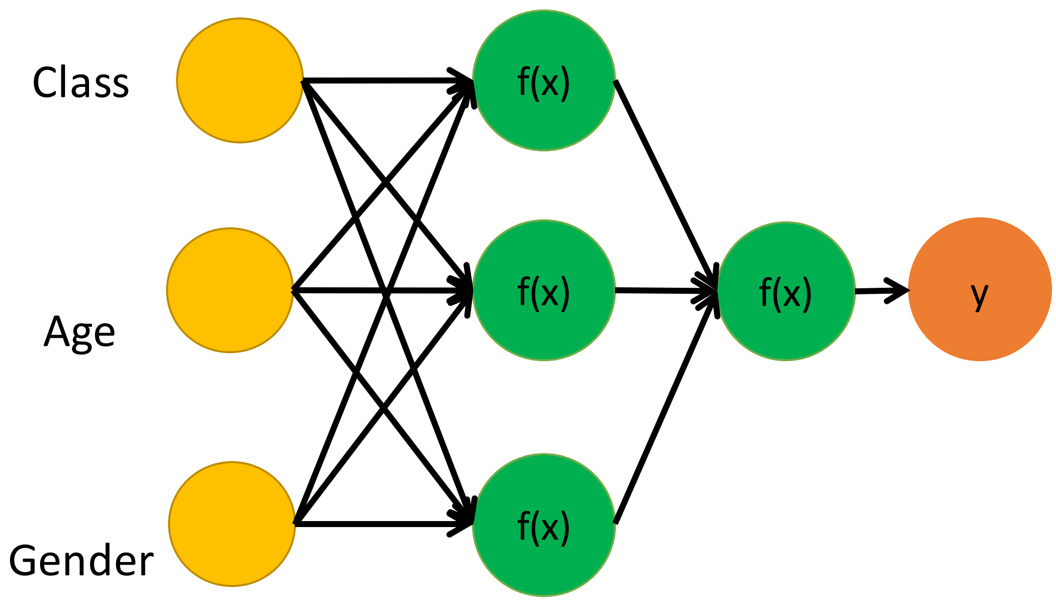

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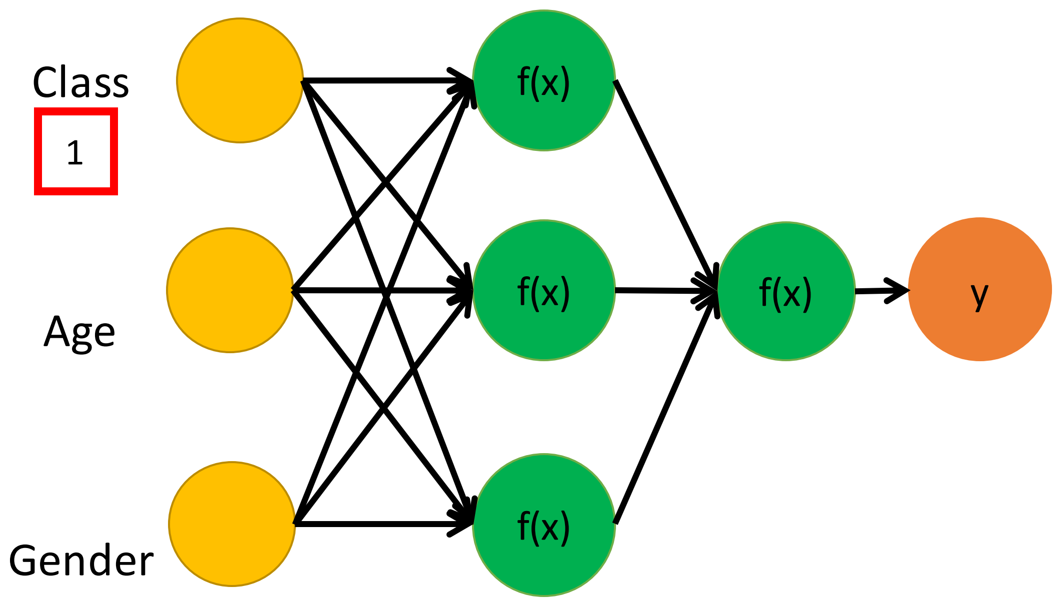

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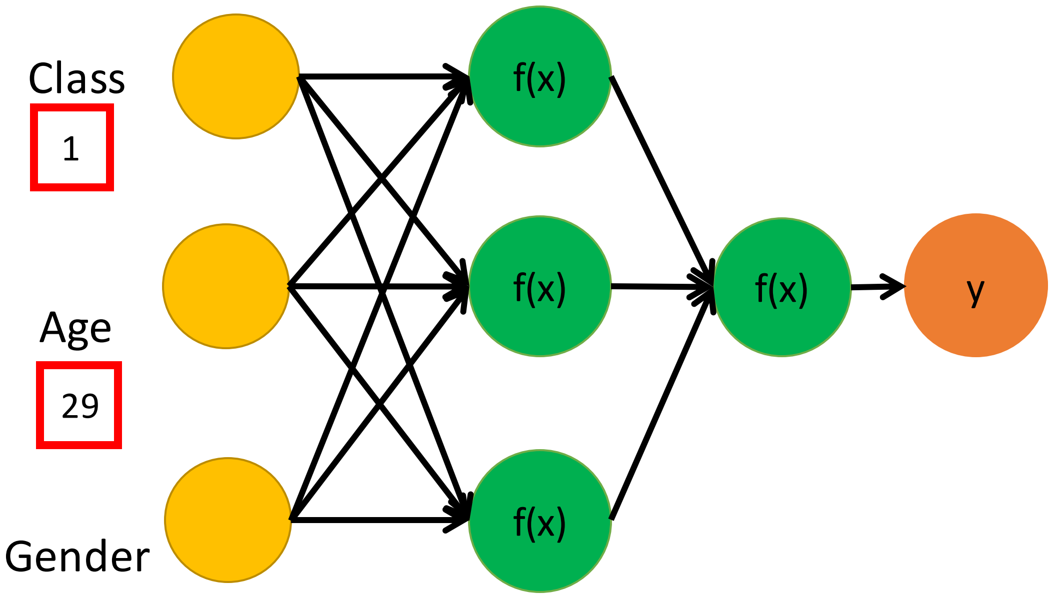

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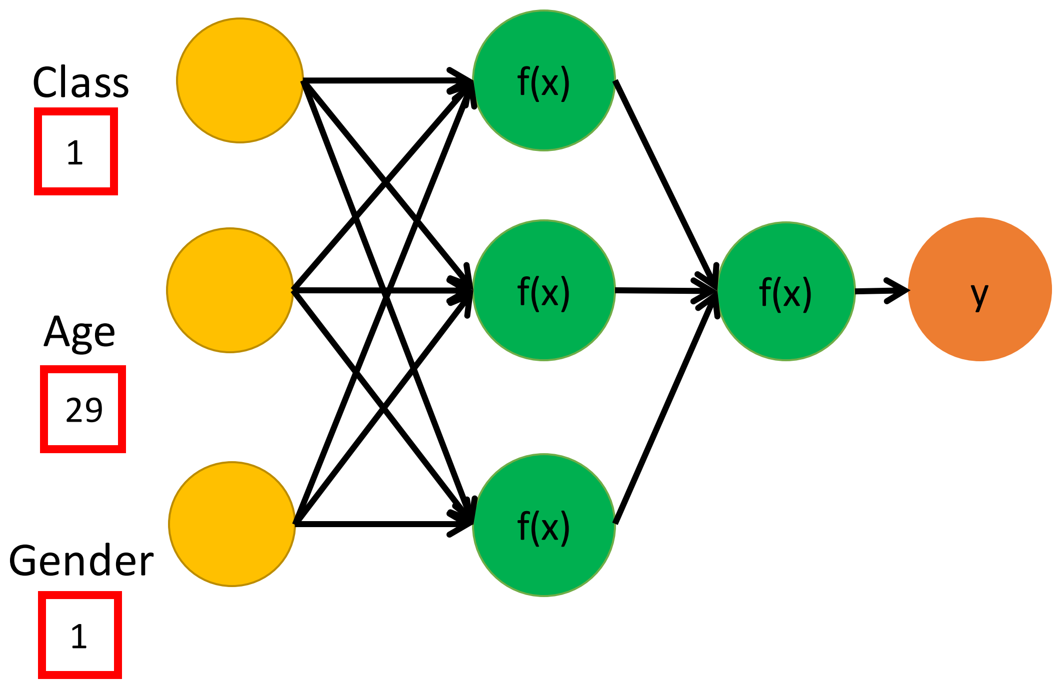

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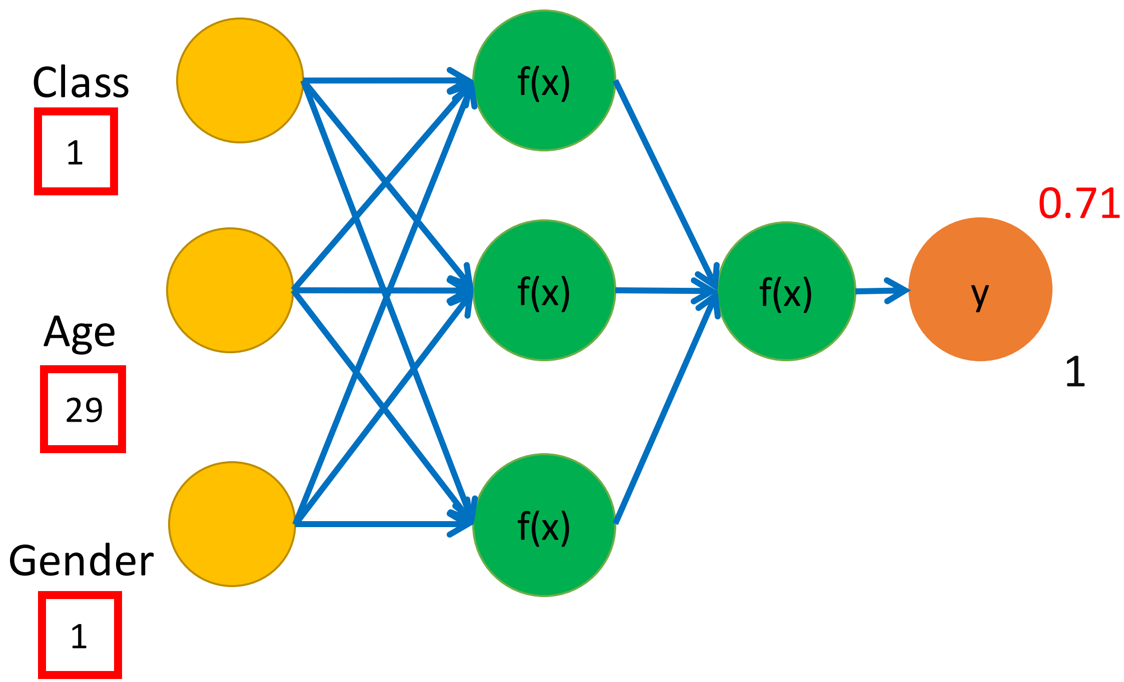

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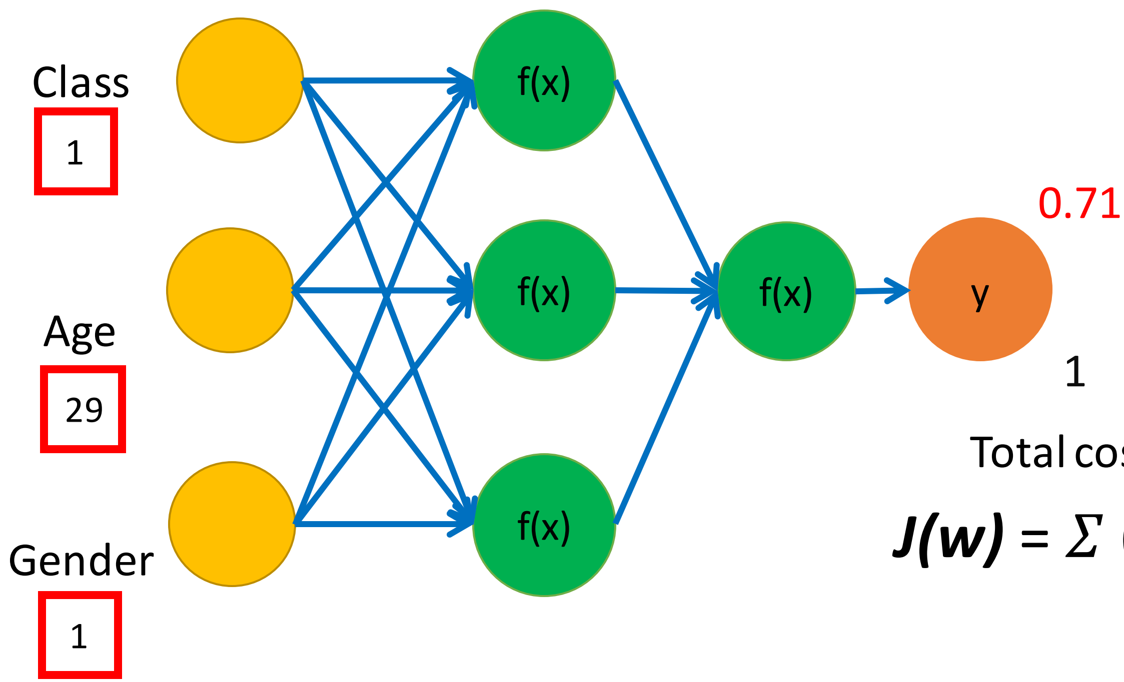

Total cost:

$$J(w) = \Sigma\,(y' - y)^2$$

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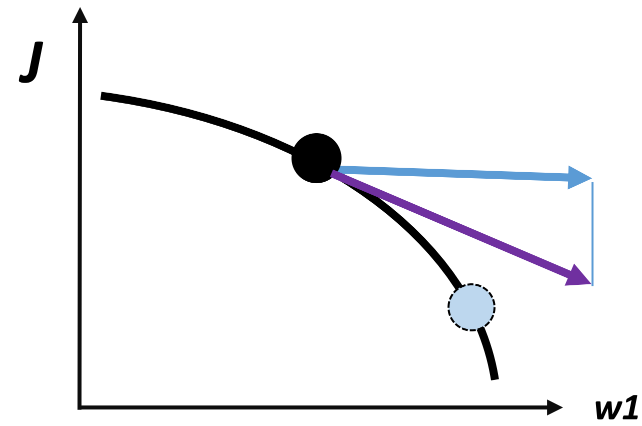

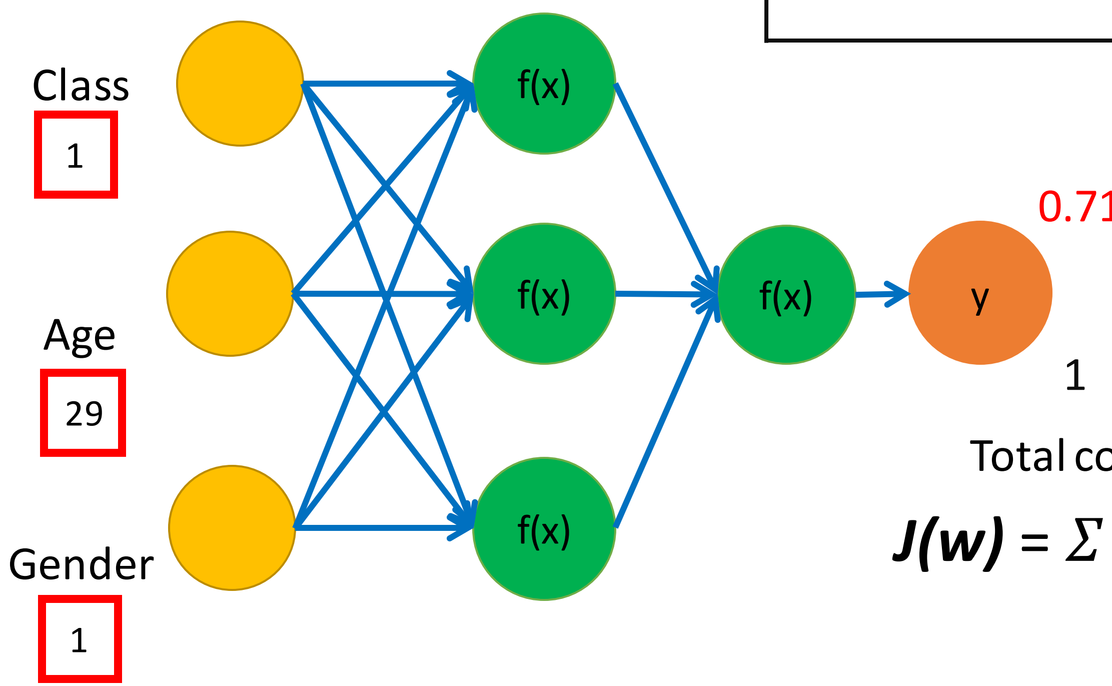

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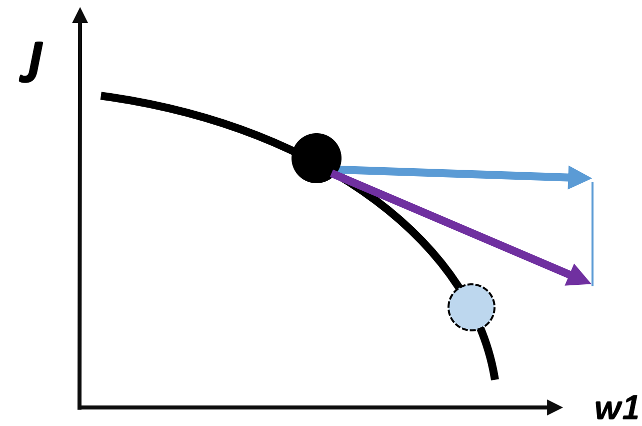

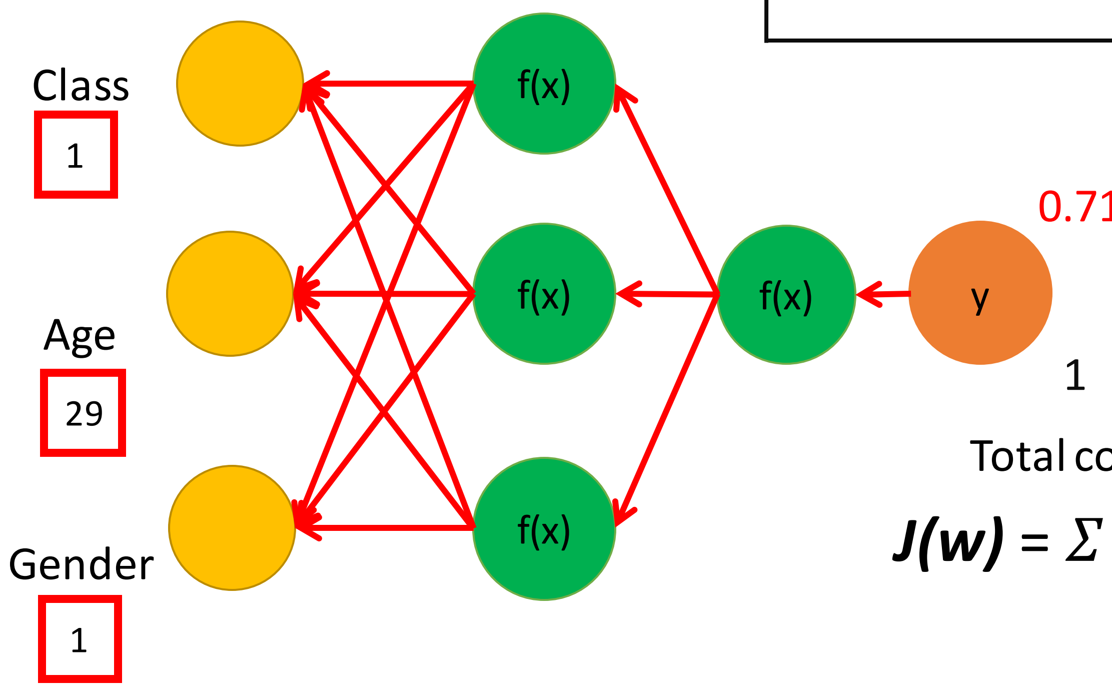

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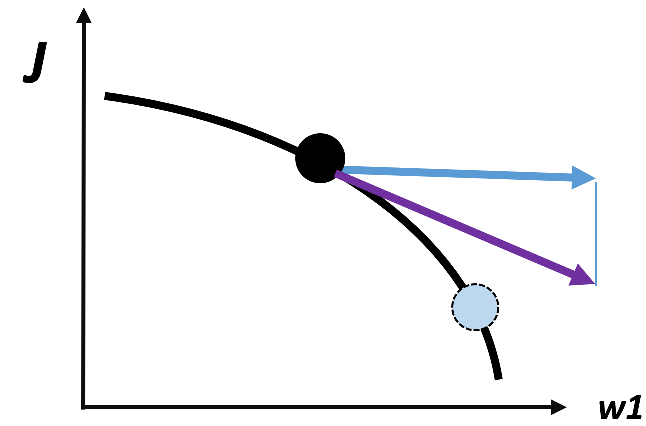

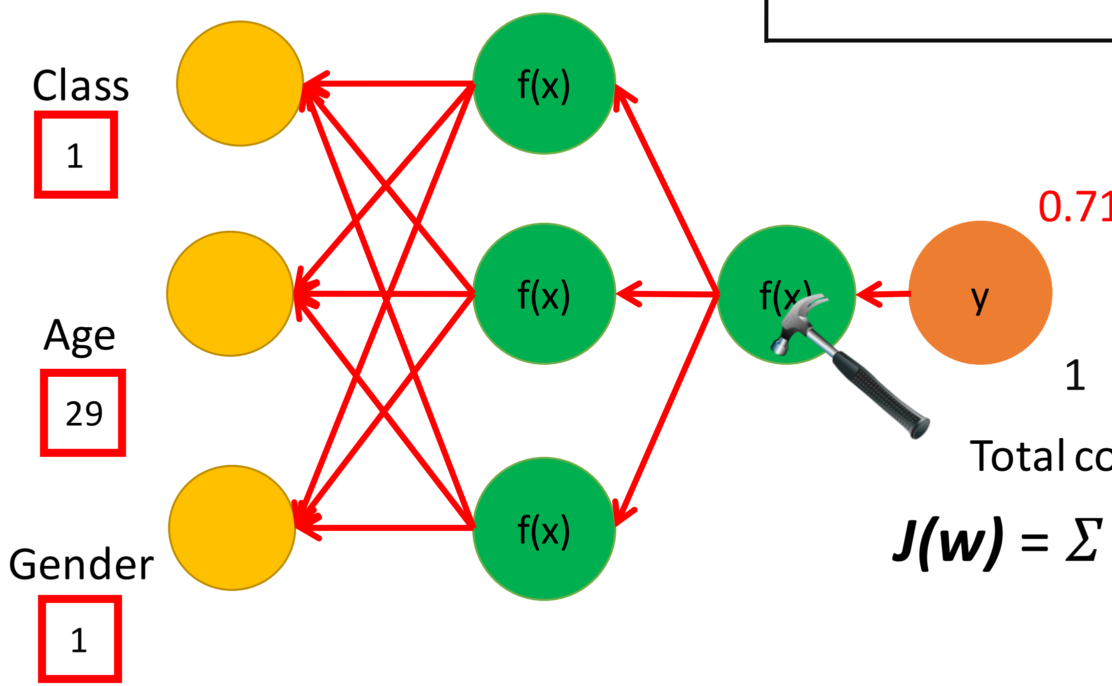

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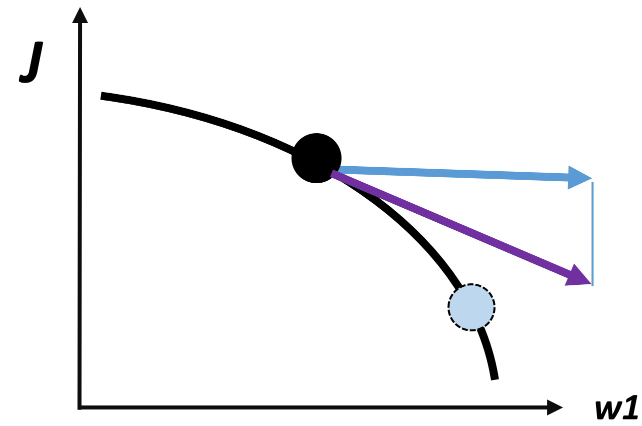

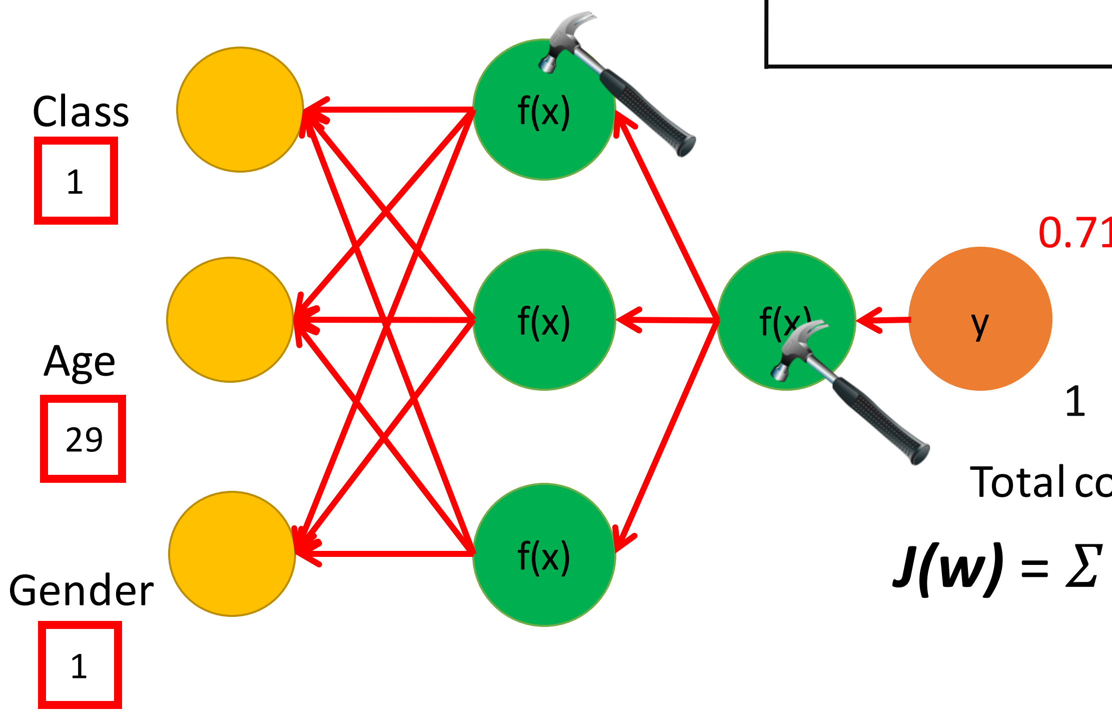

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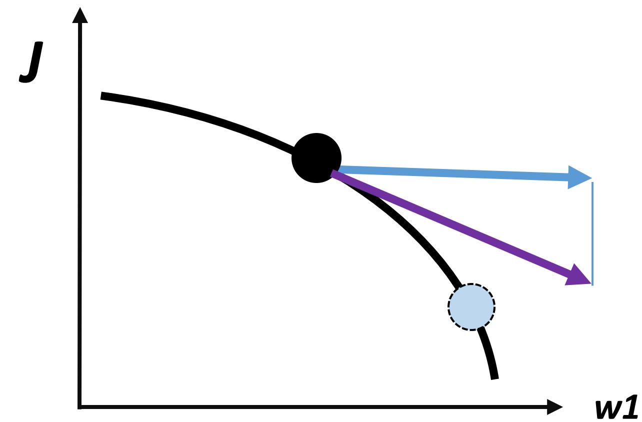

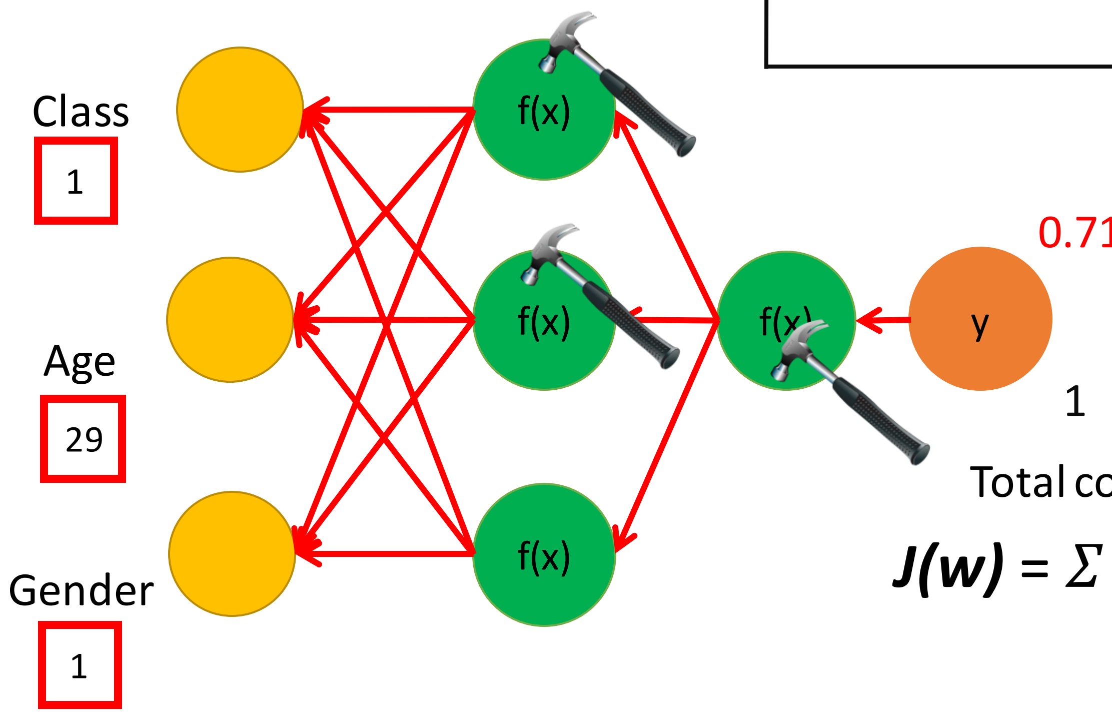

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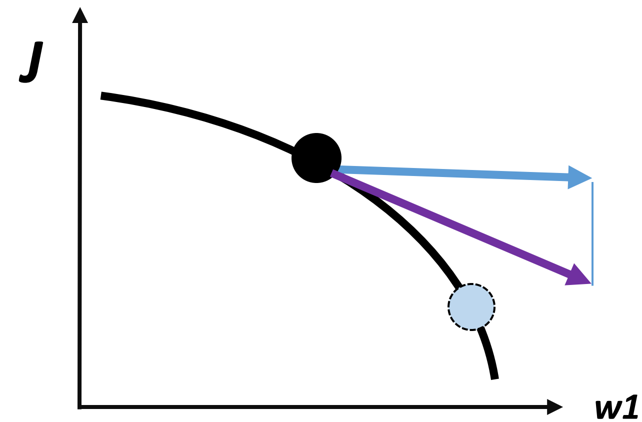

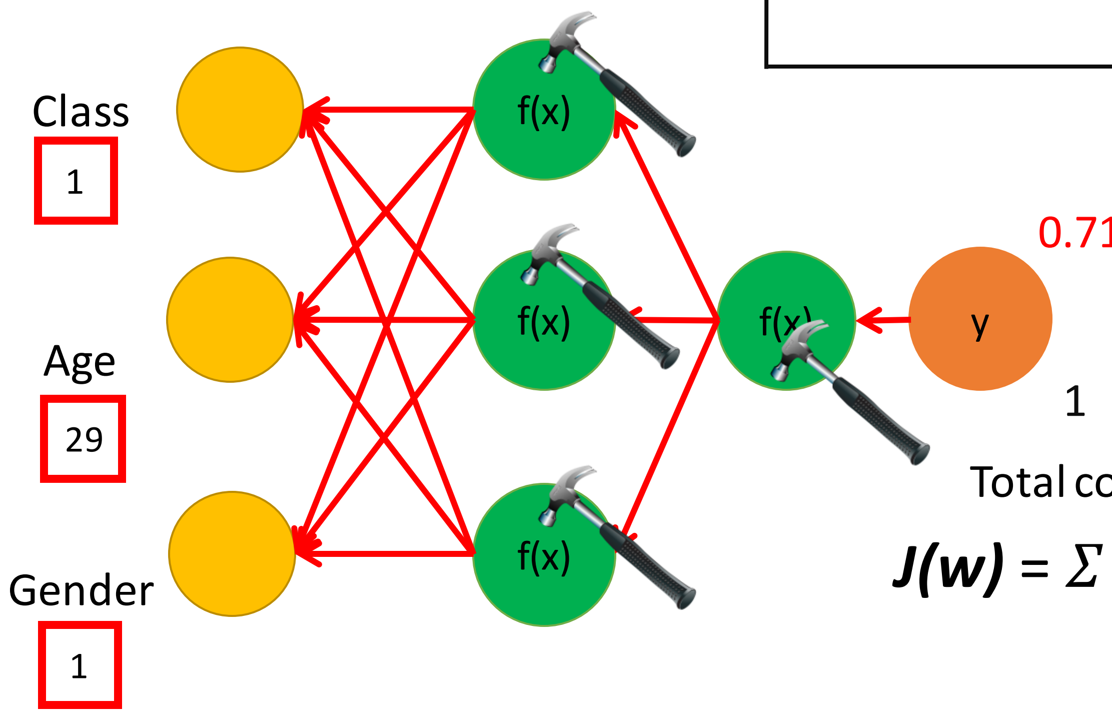

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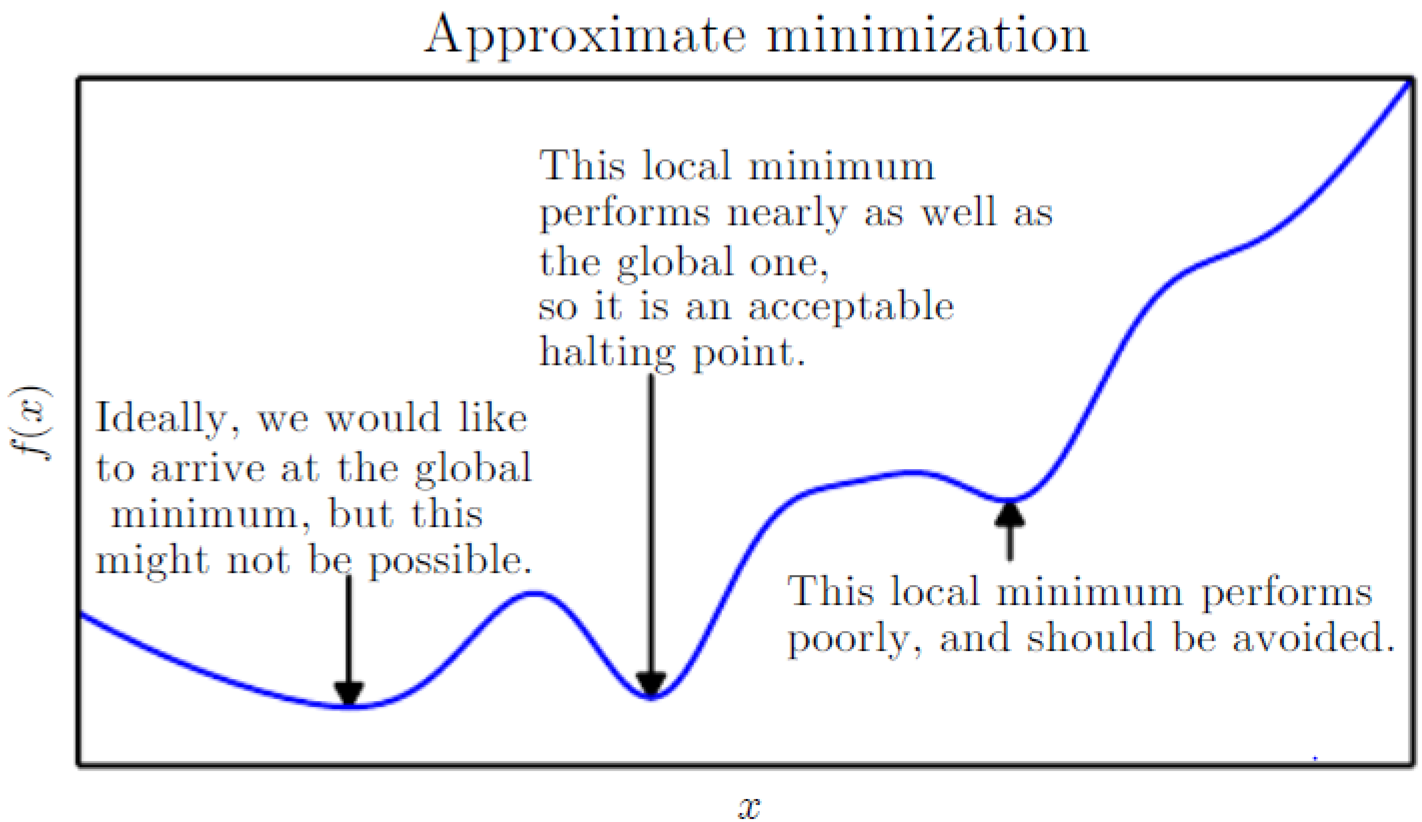
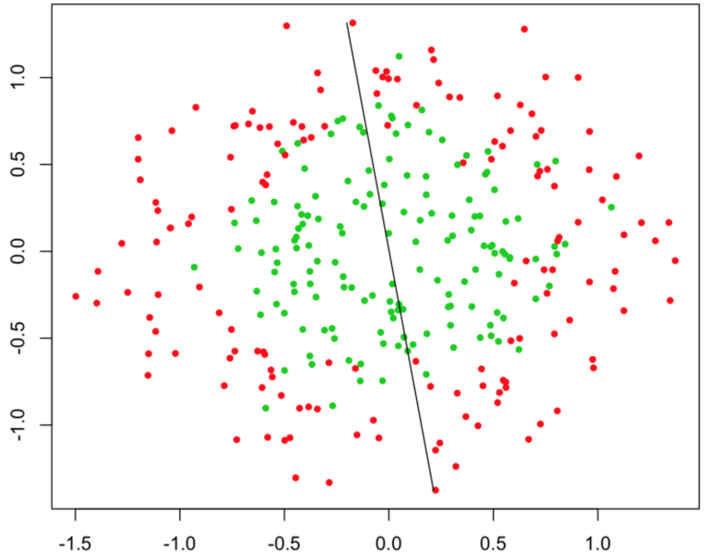
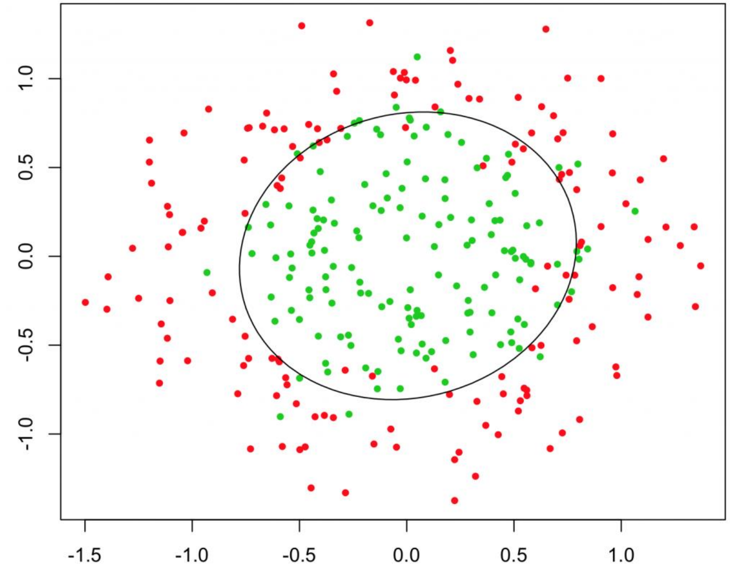
Neural Network



Neural Network cont'd

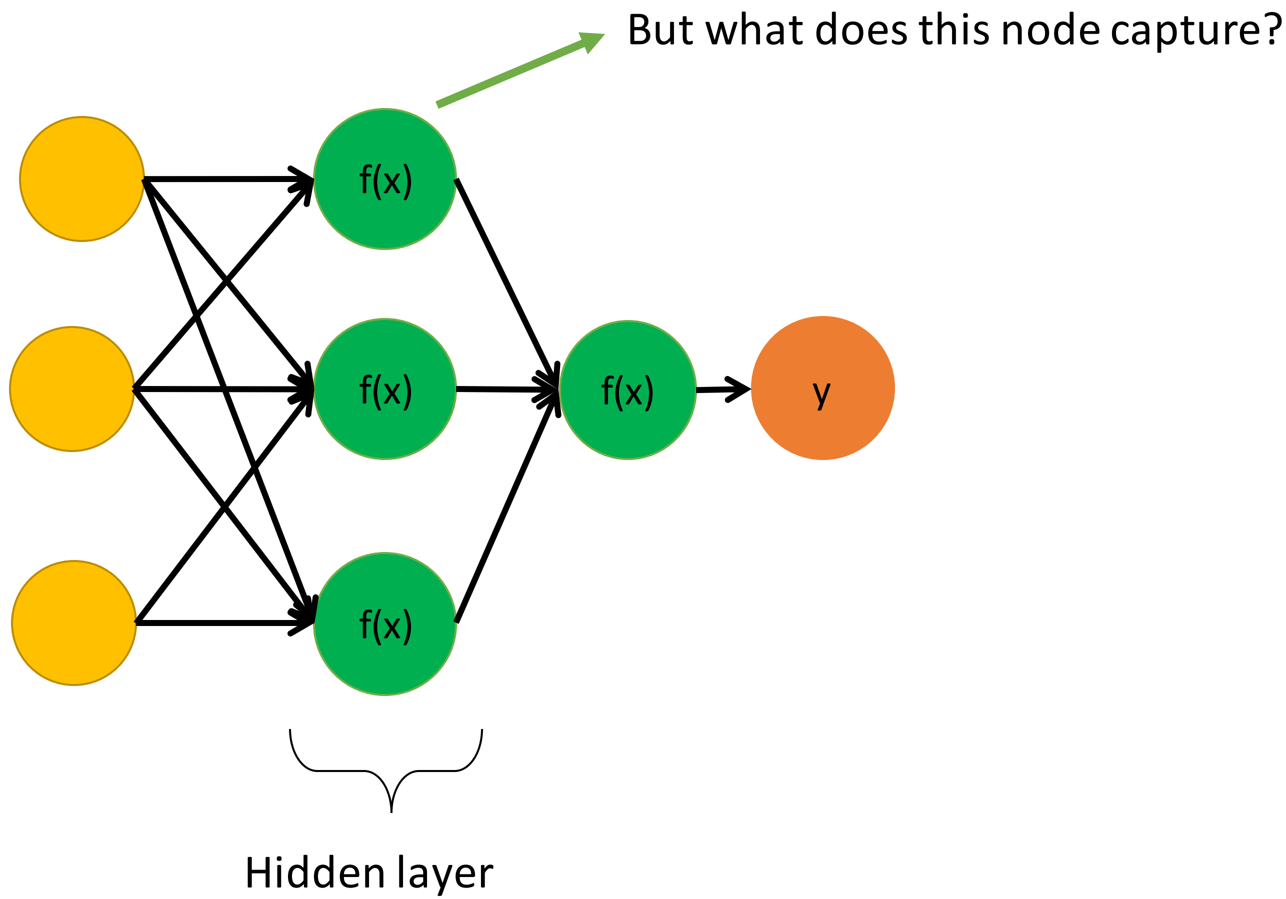


Decision boundary made by a linear model (logistic regression)



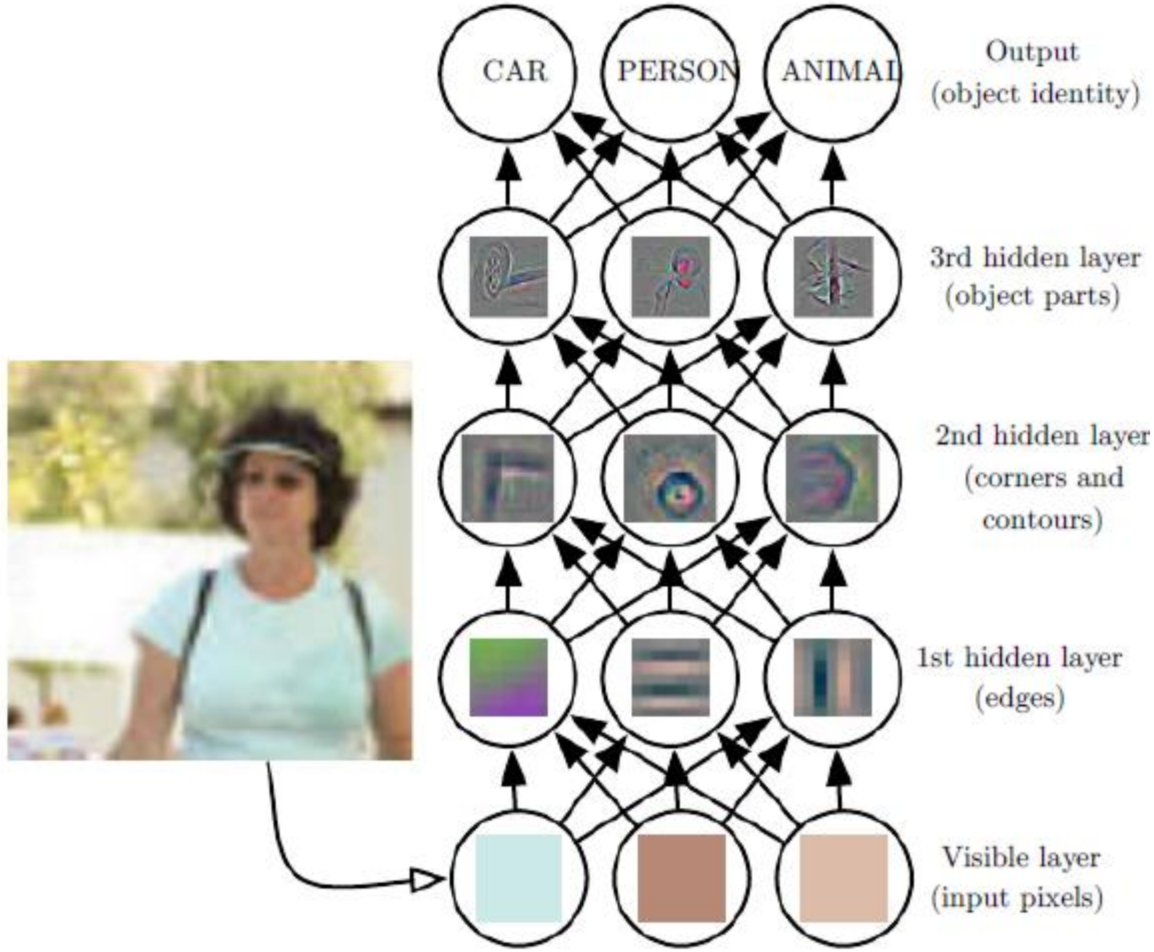
Decision boundary made by a neural network

Neural Network cont'd



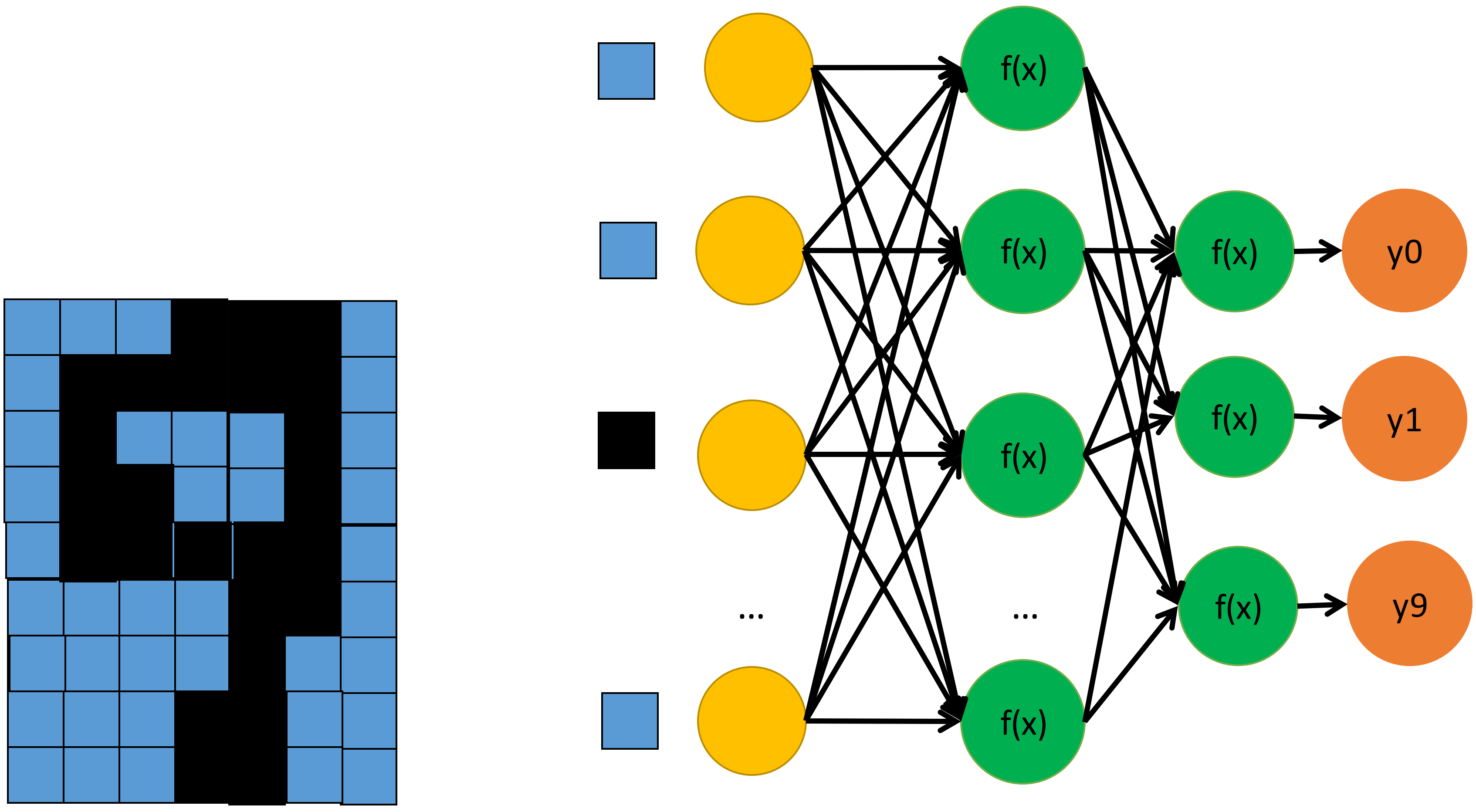
Neural Network cont’d

successive layers can learn higher-level features

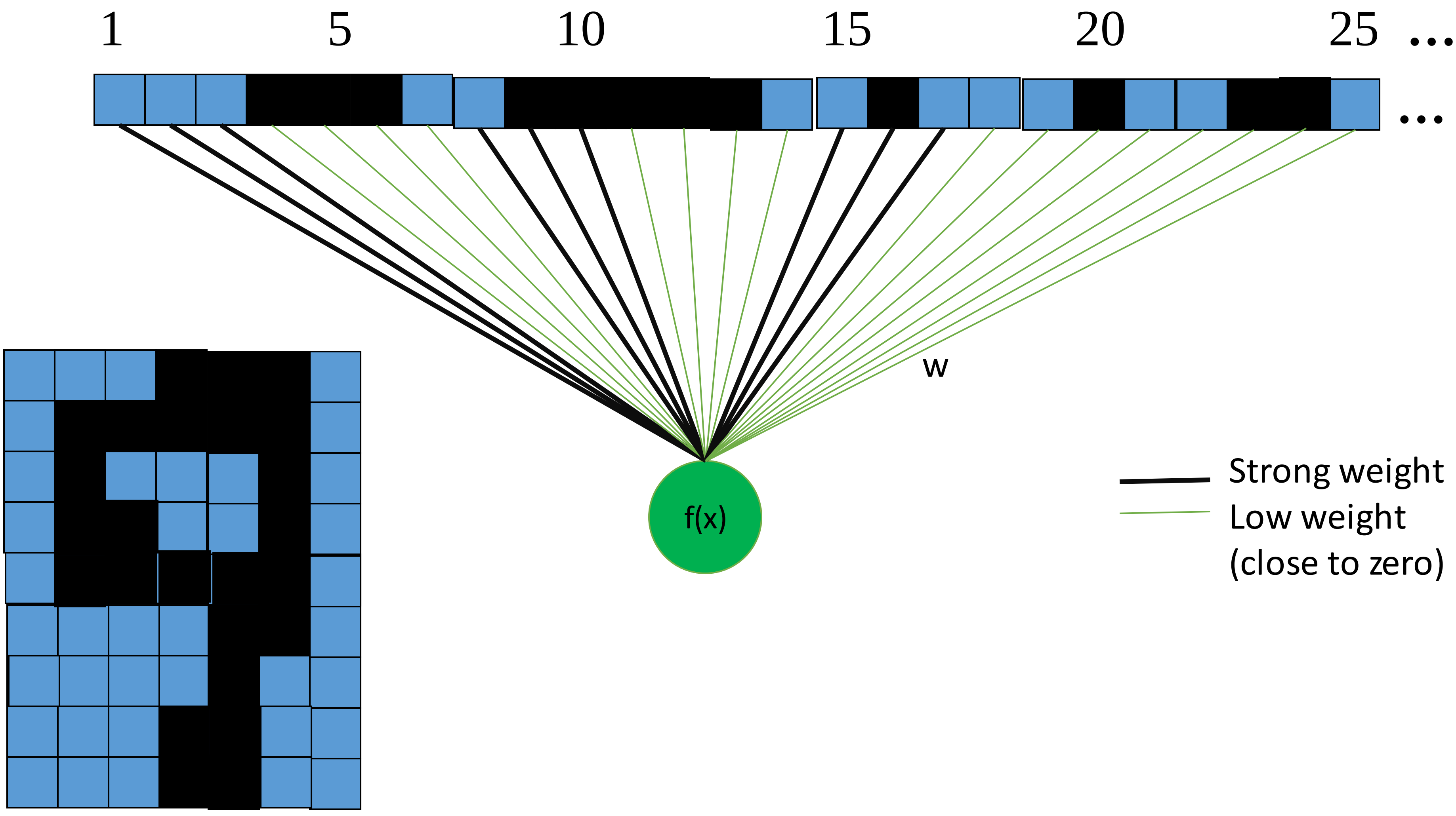


Neural Network cont'd

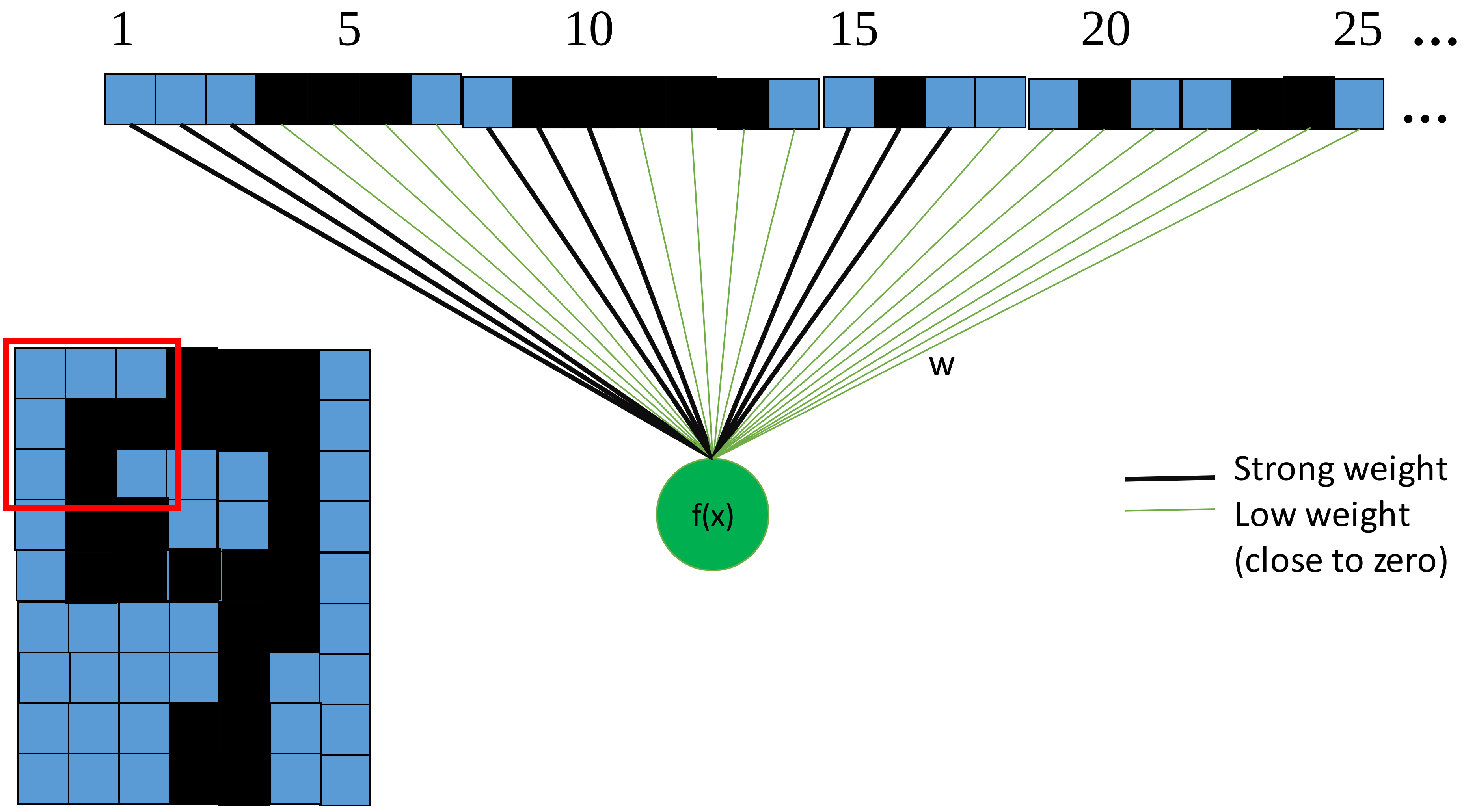
Neural Network cont'd



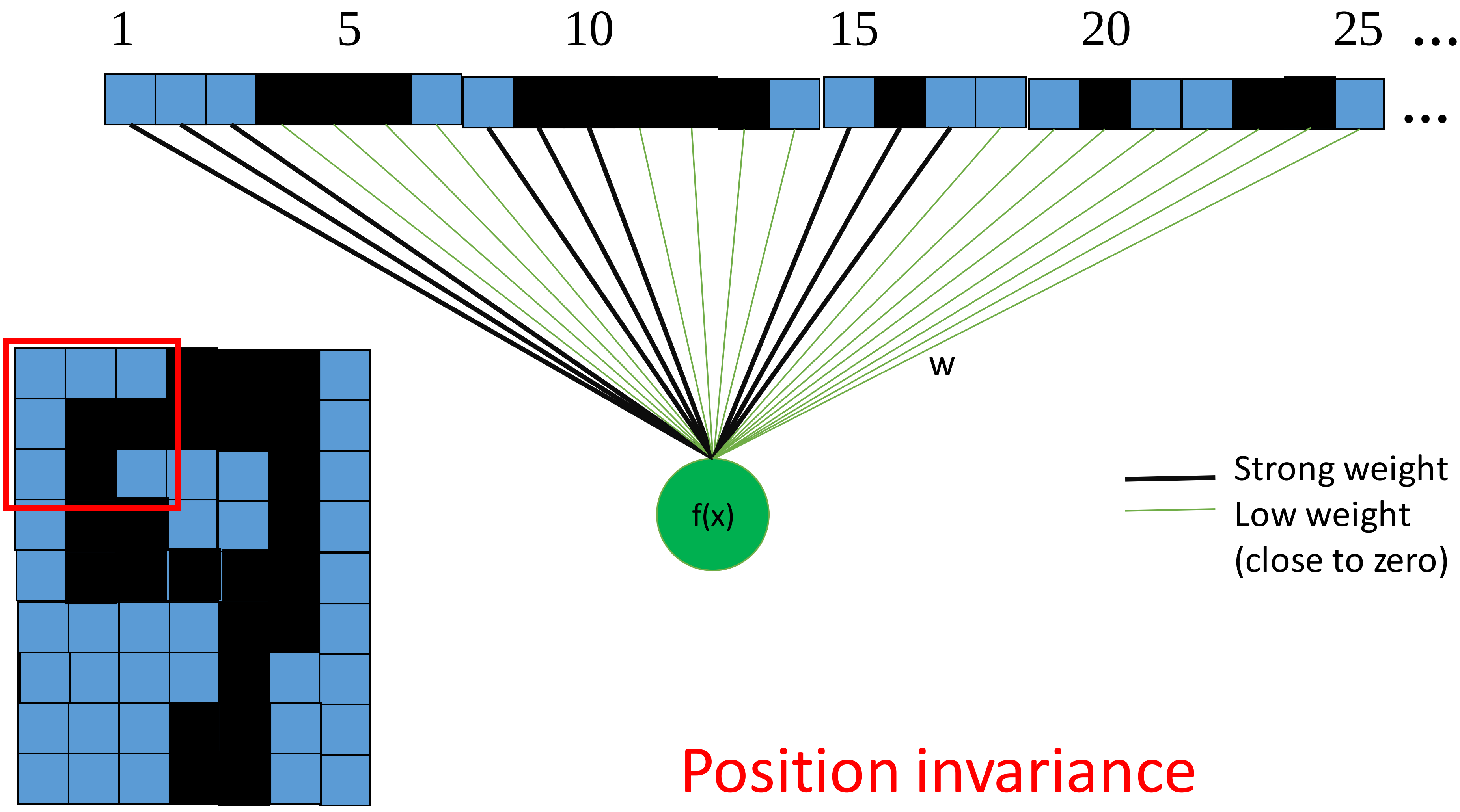
Neural Network cont’d



Neural Network cont’d

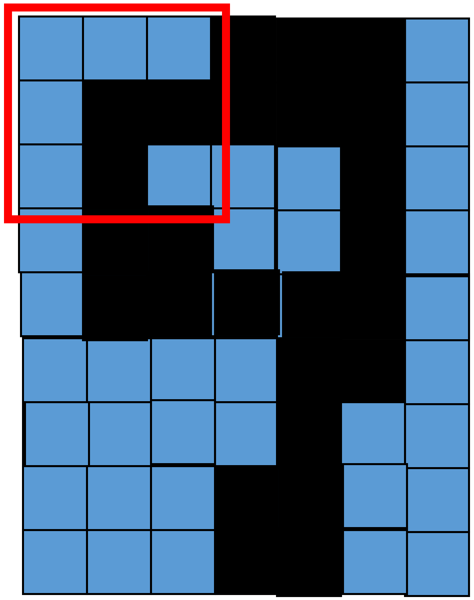


Neural Network cont'd

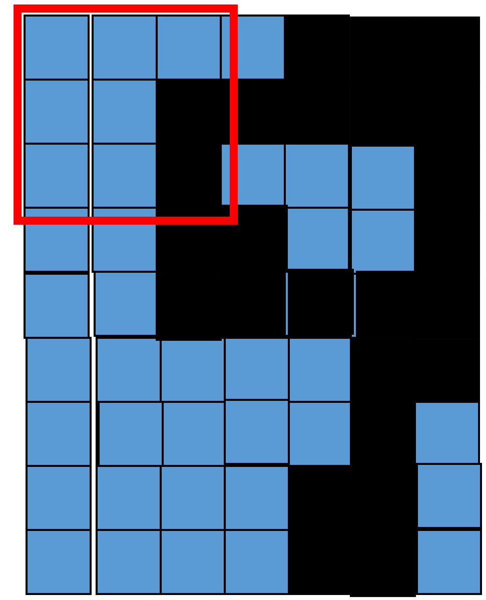


Position invariance

Neural Network cont'd



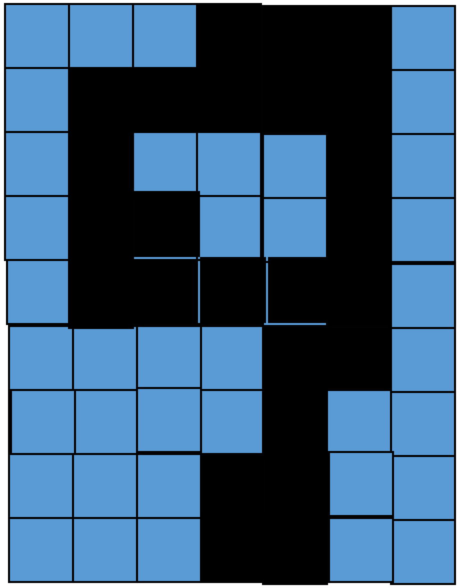
A training sample.



A testing sample. The old hidden unit failed to find the curve.

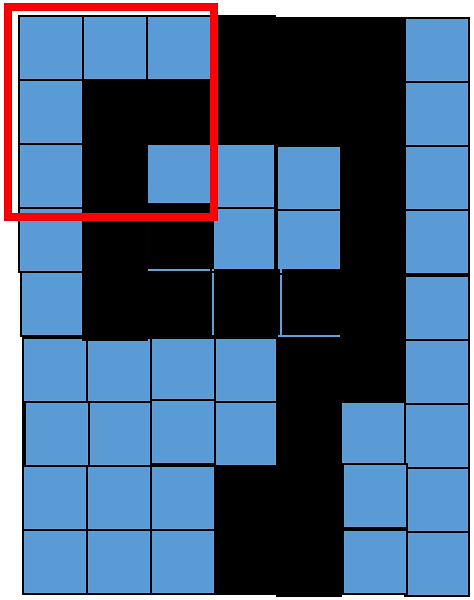
Position invariance

Convolutional Neural Network



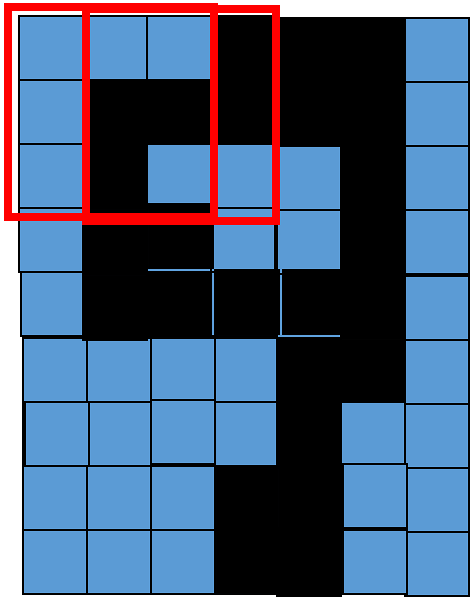
A training sample.

Convolutional Neural Network



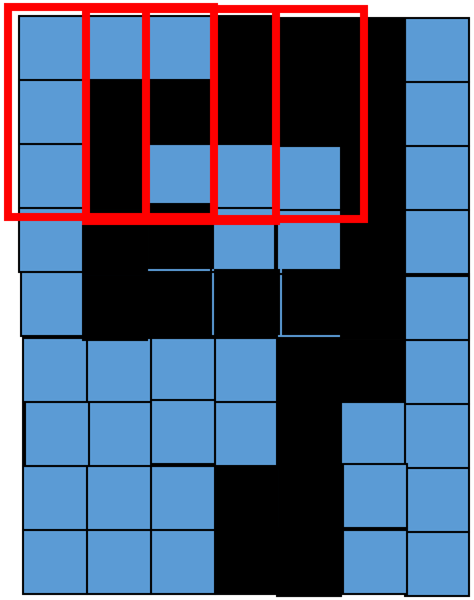
A training sample.

Convolutional Neural Network



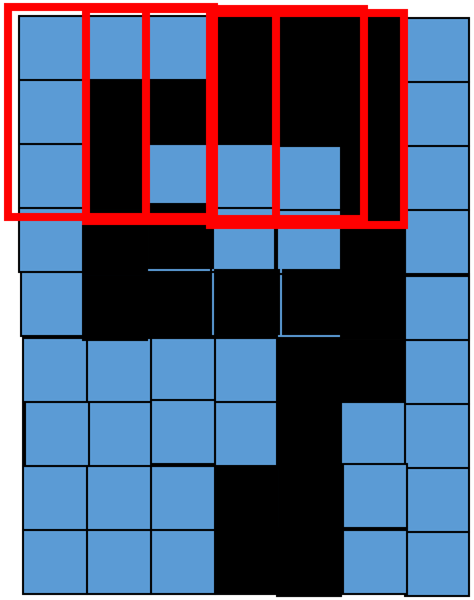
A training sample.

Convolutional Neural Network



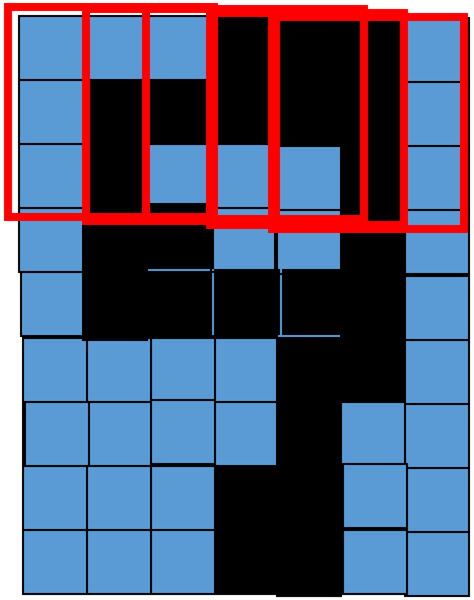
A training sample.

Convolutional Neural Network



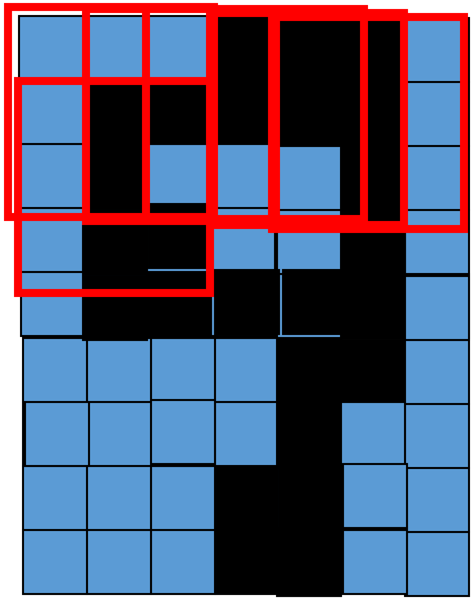
A training sample.

Convolutional Neural Network



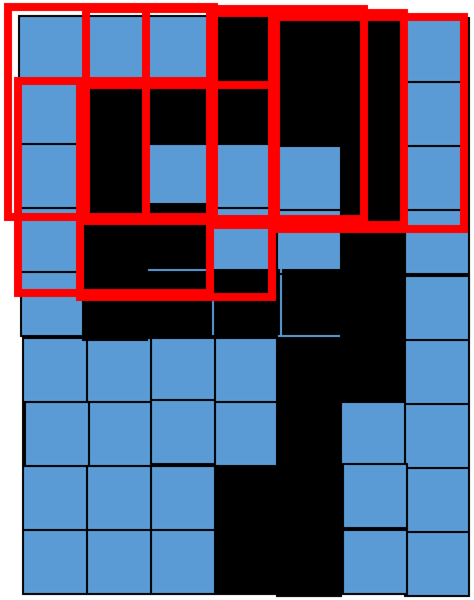
A training sample.

Convolutional Neural Network



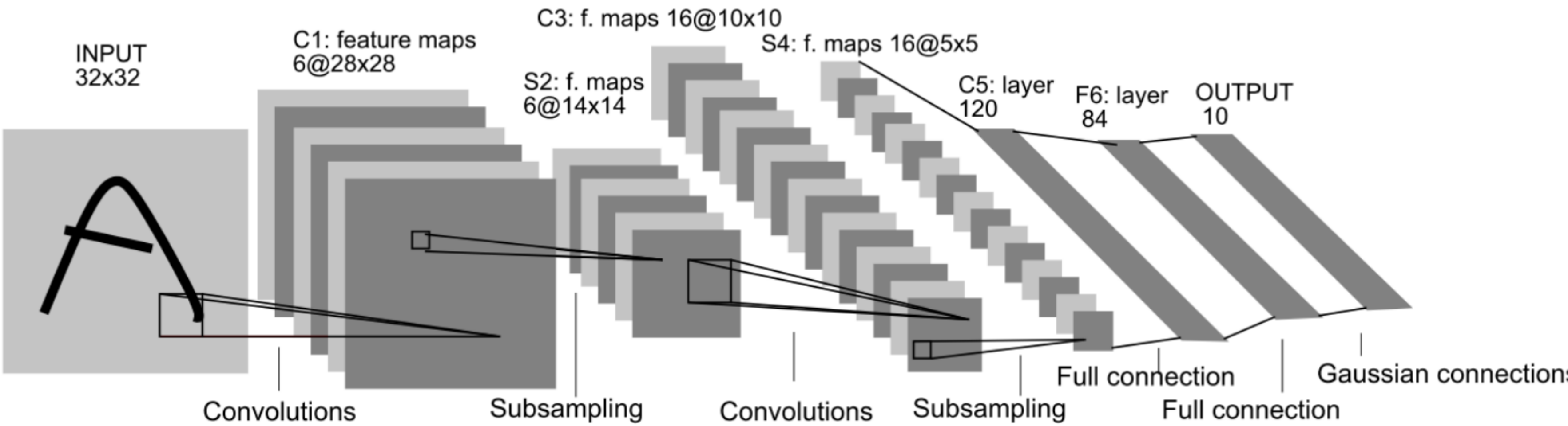
A training sample.

Convolutional Neural Network



A training sample.

Convolutional Neural Network

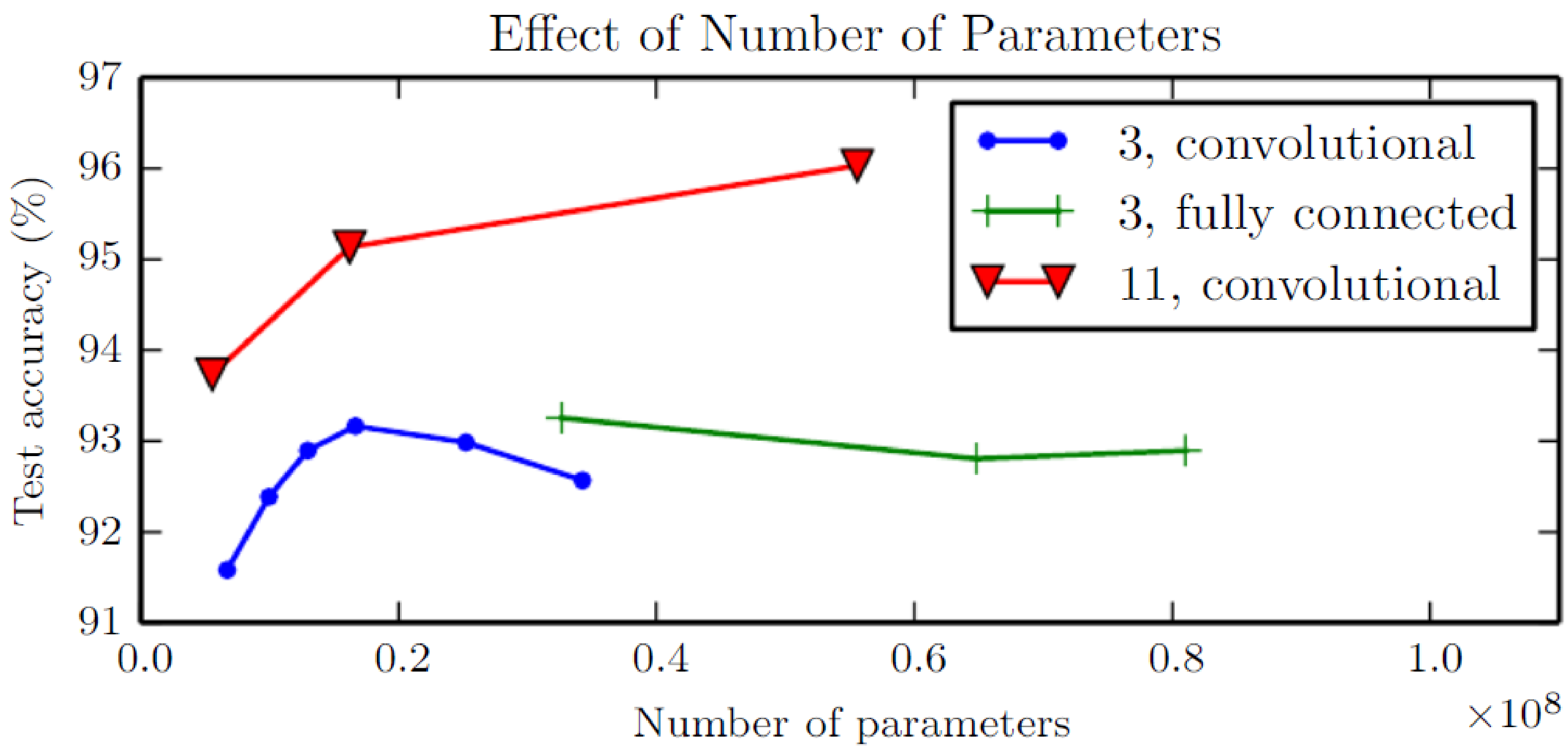


LeNet 5, Layer C5

Why going deep?

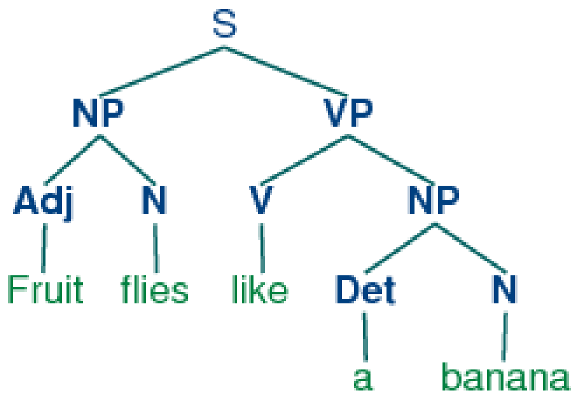
- Most deep learning models have been around for more than 25 years.
    - Theoretically even a NN with a single hidden layer can fit any function.
    - Gradient vanishing problem solved by new set of training algorithms and models.
- Deep structure:
    - Successive layers can learn higher-level features (latent factors)
    - Replace manual feature engineering.
    - Better generalizability. Can represent more complex functions with less parameters.

Why going deep?



What else?

- Classification
- Regression
- Sequential output
- Structured output



Thank you!