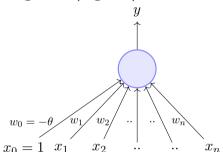
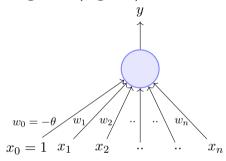
Module 3.2: A typical Supervised Machine Learning Setup

Sigmoid (logistic) Neuron

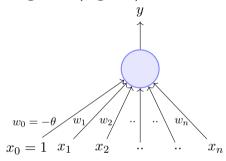


Sigmoid (logistic) Neuron

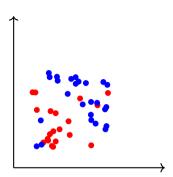


- What next?
- Well, just as we had an algorithm for learning the weights of a perceptron, we also need
 a way of learning the weights of a sigmoid
 neuron

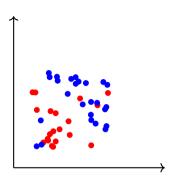
Sigmoid (logistic) Neuron



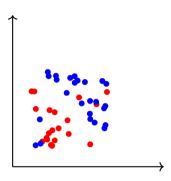
- What next?
- Well, just as we had an algorithm for learning the weights of a perceptron, we also need
 a way of learning the weights of a sigmoid
 neuron
- Before we see such an algorithm we will revisit the concept of **error**



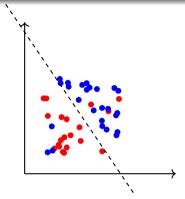
• Earlier we mentioned that a single perceptron cannot deal with this data because it is not linearly separable



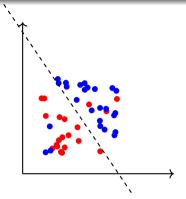
- Earlier we mentioned that a single perceptron cannot deal with this data because it is not linearly separable
- What does "cannot deal with" mean?



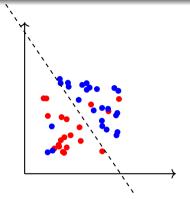
- Earlier we mentioned that a single perceptron cannot deal with this data because it is not linearly separable
- What does "cannot deal with" mean?
- What would happen if we use a perceptron model to classify this data?



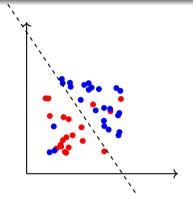
- Earlier we mentioned that a single perceptron cannot deal with this data because it is not linearly separable
- What does "cannot deal with" mean?
- What would happen if we use a perceptron model to classify this data?
- We would probably end up with a line like this ...



- Earlier we mentioned that a single perceptron cannot deal with this data because it is not linearly separable
- What does "cannot deal with" mean?
- What would happen if we use a perceptron model to classify this data?
- We would probably end up with a line like this ...
- This line doesn't seem to be too bad



- Earlier we mentioned that a single perceptron cannot deal with this data because it is not linearly separable
- What does "cannot deal with" mean?
- What would happen if we use a perceptron model to classify this data?
- We would probably end up with a line like this ...
- This line doesn't seem to be too bad
- Sure, it misclassifies 3 blue points and 3 red points but we could live with this error in **most** real world applications



- Earlier we mentioned that a single perceptron cannot deal with this data because it is not linearly separable
- What does "cannot deal with" mean?
- What would happen if we use a perceptron model to classify this data?
- We would probably end up with a line like this ...
- This line doesn't seem to be too bad
- Sure, it misclassifies 3 blue points and 3 red points but we could live with this error in **most** real world applications
- From now on, we will accept that it is hard to drive the error to 0 in most cases and will instead aim to reach the minimum possible error

• Data: $\{x_i, y_i\}_{i=1}^n$

- Data: $\{x_i, y_i\}_{i=1}^n$
- Model: Our approximation of the relation between x and y. For example,

- Data: $\{x_i, y_i\}_{i=1}^n$
- Model: Our approximation of the relation between x and y. For example,

$$\hat{y} = \frac{1}{1 + e^{-(w^T x)}}$$

- Data: $\{x_i, y_i\}_{i=1}^n$
- Model: Our approximation of the relation between x and y. For example,

$$\hat{y} = \frac{1}{1 + e^{-(w^T x)}}$$
or
$$\hat{y} = w^T x$$

- Data: $\{x_i, y_i\}_{i=1}^n$
- Model: Our approximation of the relation between x and y. For example,

$$\hat{y} = \frac{1}{1 + e^{-(w^T x)}}$$
or
$$\hat{y} = w^T x$$
or
$$\hat{y} = \mathbf{x}^T \mathbf{w} \mathbf{x}$$

- Data: $\{x_i, y_i\}_{i=1}^n$
- Model: Our approximation of the relation between x and y. For example,

$$\hat{y} = \frac{1}{1 + e^{-(w^T x)}}$$
or
$$\hat{y} = w^T x$$
or
$$\hat{y} = \mathbf{x}^T \mathbf{w} \mathbf{x}$$

- Data: $\{x_i, y_i\}_{i=1}^n$
- Model: Our approximation of the relation between x and y. For example,

$$\hat{y} = \frac{1}{1 + e^{-(w^T x)}}$$
or
$$\hat{y} = w^T x$$
or
$$\hat{y} = \mathbf{x}^T \mathbf{w} \mathbf{x}$$

or just about any function

• Parameters: In all the above cases, w is a parameter which needs to be learned from the data

• Data: $\{x_i, y_i\}_{i=1}^n$

• Model: Our approximation of the relation between x and y. For example,

$$\hat{y} = \frac{1}{1 + e^{-(w^T x)}}$$
or
$$\hat{y} = w^T x$$
or
$$\hat{y} = \mathbf{x}^T \mathbf{w} \mathbf{x}$$

- Parameters: In all the above cases, w is a parameter which needs to be learned from the data
- Learning algorithm: An algorithm for learning the parameters (w) of the model (for example, perceptron learning algorithm, gradient descent, etc.)



• Data: $\{x_i, y_i\}_{i=1}^n$

• Model: Our approximation of the relation between x and y. For example,

$$\hat{y} = \frac{1}{1 + e^{-(w^T x)}}$$
or
$$\hat{y} = w^T x$$
or
$$\hat{y} = \mathbf{x}^T \mathbf{w} \mathbf{x}$$

- Parameters: In all the above cases, w is a parameter which needs to be learned from the data
- Learning algorithm: An algorithm for learning the parameters (w) of the model (for example, perceptron learning algorithm, gradient descent, etc.)
- Objective/Loss/Error function: To guide the learning algorithm



• Data: $\{x_i, y_i\}_{i=1}^n$

• Model: Our approximation of the relation between x and y. For example,

$$\hat{y} = \frac{1}{1 + e^{-(w^T x)}}$$
or
$$\hat{y} = w^T x$$
or
$$\hat{y} = \mathbf{x}^T \mathbf{w} \mathbf{x}$$

- Parameters: In all the above cases, w is a parameter which needs to be learned from the data
- Learning algorithm: An algorithm for learning the parameters (w) of the model (for example, perceptron learning algorithm, gradient descent, etc.)
- Objective/Loss/Error function: To guide the learning algorithm the learn-

• Data: $\{x_i = movie, y_i = like/dislike\}_{i=1}^n$

- Data: $\{x_i = movie, y_i = like/dislike\}_{i=1}^n$
- Model: Our approximation of the relation between x and y (the probability of liking a movie).

- Data: $\{x_i = movie, y_i = like/dislike\}_{i=1}^n$
- Model: Our approximation of the relation between x and y (the probability of liking a movie).

$$\hat{y} = \frac{1}{1 + e^{-(w^T x)}}$$

- Data: $\{x_i = movie, y_i = like/dislike\}_{i=1}^n$
- Model: Our approximation of the relation between x and y (the probability of liking a movie).

$$\hat{y} = \frac{1}{1 + e^{-(w^T x)}}$$

• Parameter: w

- Data: $\{x_i = movie, y_i = like/dislike\}_{i=1}^n$
- Model: Our approximation of the relation between x and y (the probability of liking a movie).

$$\hat{y} = \frac{1}{1 + e^{-(w^T x)}}$$

- Parameter: w
- Learning algorithm: Gradient Descent [we will see soon]

- Data: $\{x_i = movie, y_i = like/dislike\}_{i=1}^n$
- Model: Our approximation of the relation between x and y (the probability of liking a movie).

$$\hat{y} = \frac{1}{1 + e^{-(w^T x)}}$$

- Parameter: w
- Learning algorithm: Gradient Descent [we will see soon]
- Objective/Loss/Error function:

- Data: $\{x_i = movie, y_i = like/dislike\}_{i=1}^n$
- Model: Our approximation of the relation between x and y (the probability of liking a movie).

$$\hat{y} = \frac{1}{1 + e^{-(w^T x)}}$$

- \bullet Parameter: w
- Learning algorithm: Gradient Descent [we will see soon]
- Objective/Loss/Error function: One possibility is

$$\mathscr{L}(w) = \sum_{i=1}^{n} (\hat{y}_i - y_i)^2$$

- Data: $\{x_i = movie, y_i = like/dislike\}_{i=1}^n$
- Model: Our approximation of the relation between x and y (the probability of liking a movie).

$$\hat{y} = \frac{1}{1 + e^{-(w^T x)}}$$

- Parameter: w
- Learning algorithm: Gradient Descent [we will see soon]
- Objective/Loss/Error function: One possibility is

$$\mathscr{L}(w) = \sum_{i=1}^{n} (\hat{y}_i - y_i)^2$$

The learning algorithm should aim to find a w which minimizes the above function (squared error between y and \hat{y})