ARTIFICIAL NEURAL NETWORKS

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RECAP:
NONLINEAR METHODS

A NONLINEAR PROBLEM

x1	0	1	1	0
x2	0	0	1	1
y	0	0	1	0

$$y = f(x_1, x_2)$$

what is *f* ?

RECAP:
NONLINEAR METHODS

* **Volterra series**

  * Generic, *expensive*

* **Kernel regression** *(samples, not features!)*

  * Generic (w/ RBF or poly. kernel),
    ~linear regression (w/ linear kernel),
    ~Volterra series (w/ Volterra kernel)

  * *Not expensive!*

RECAP:
KERNEL REGRESSION

$$\hat{f}(z) = \sum_{i=1}^{n} \alpha_i k(z, X_i)$$

n ← sum across datapoints

weight — α_i

kernel function — $k(z, X_i)$

$$\hat{\alpha} = \underset{\alpha}{\operatorname{argmin}} \left[||Y - K\alpha||_2^2 + \lambda \alpha^\top K \alpha \right]$$

where: $K_{ij} = k(X_i, X_j)$

ARTIFICIAL NEURAL NETWORK

* Simplest version: a *perceptron*

$$y_i \in \{0, 1\}$$

$$X_i \in \mathcal{R}^p$$

$$\hat{y}_i = H(X_i w)$$

h/t http://ataspinar.com/2016/12/22/the-perceptron/

PERCEPTRON LEARNING

* Due to Frank Rosenblatt (1958)

* Usually defined as online learning rule (assuming each example will be fed in one-by-one)

PERCEPTRON LEARNING

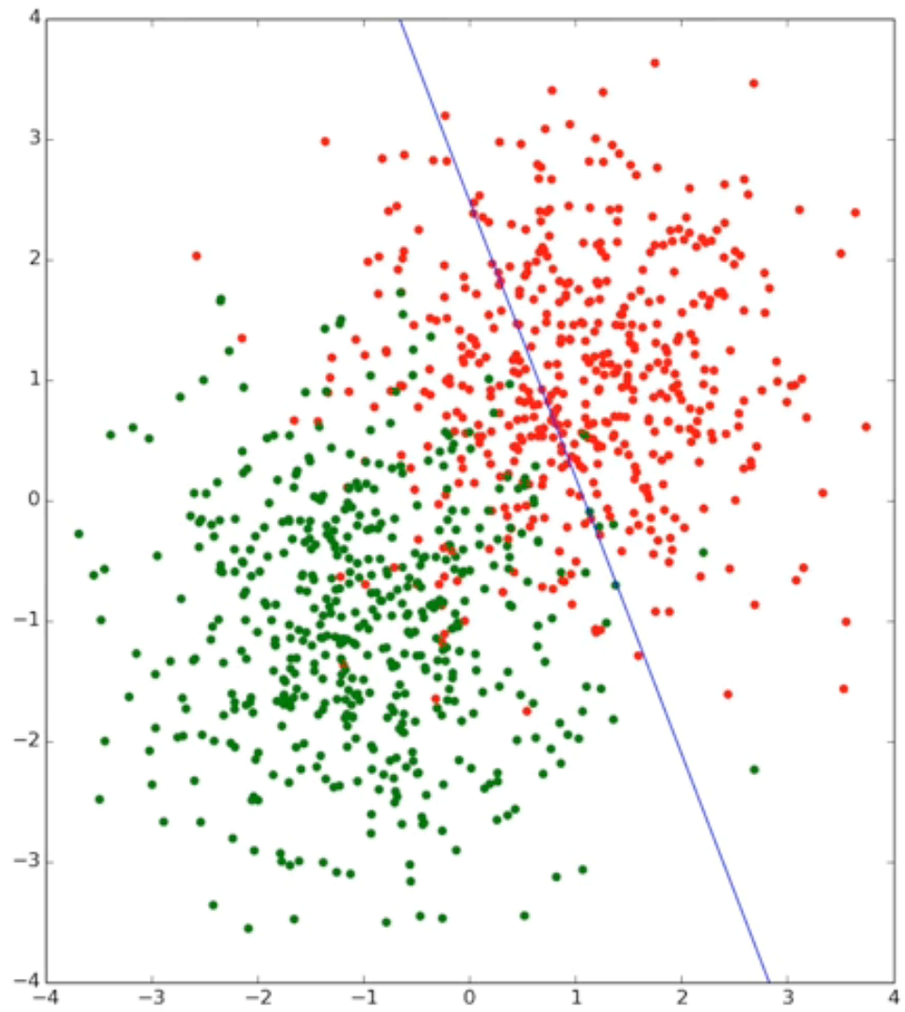
At iteration t in the learning process:

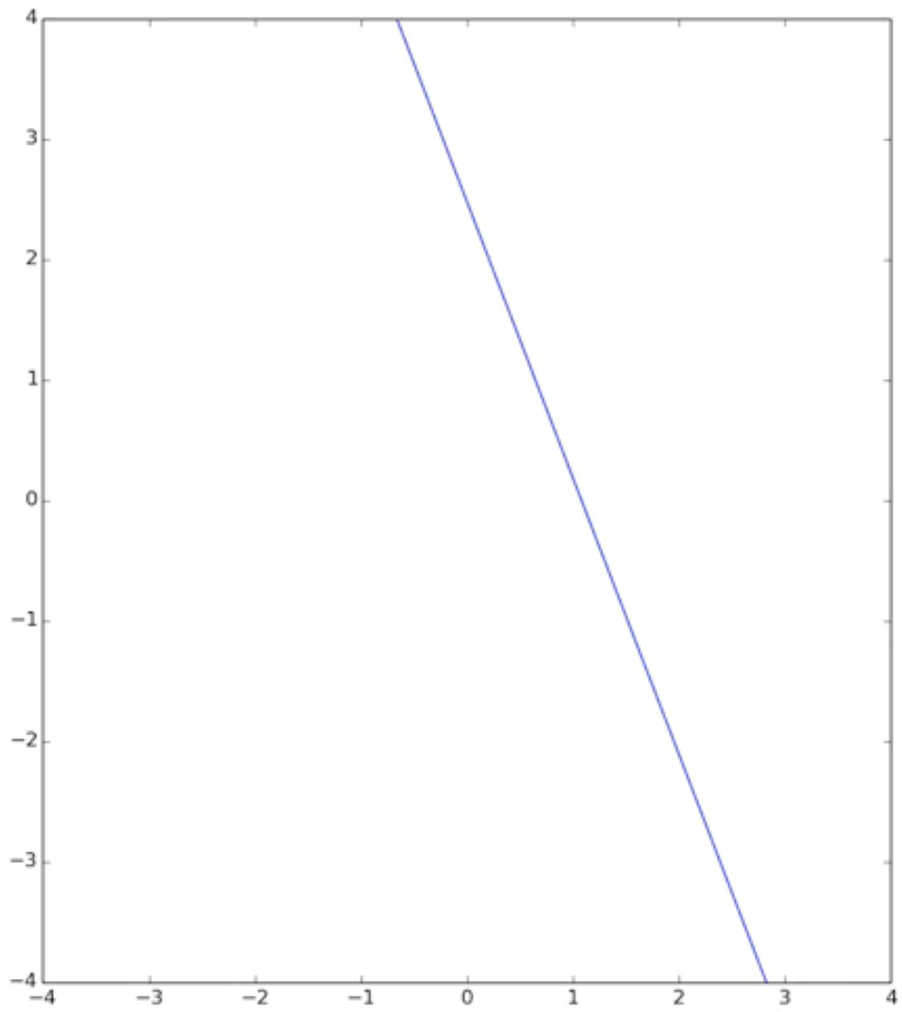
$$\hat{y}_i^{(t)} = H(X_i w^{(t)})$$

\hat{y}_i^{(t)} = H(X_i w^{(t)})
w_j^{(t+1)} = w_j^{(t)} + (y_i - \hat{y}_i^{(t)})X_{ij}

$$w_j^{(t+1)} = w_j^{(t)} + (y_i - \hat{y}_i^{(t)})X_{ij}$$

PERCEPTRON LEARNING





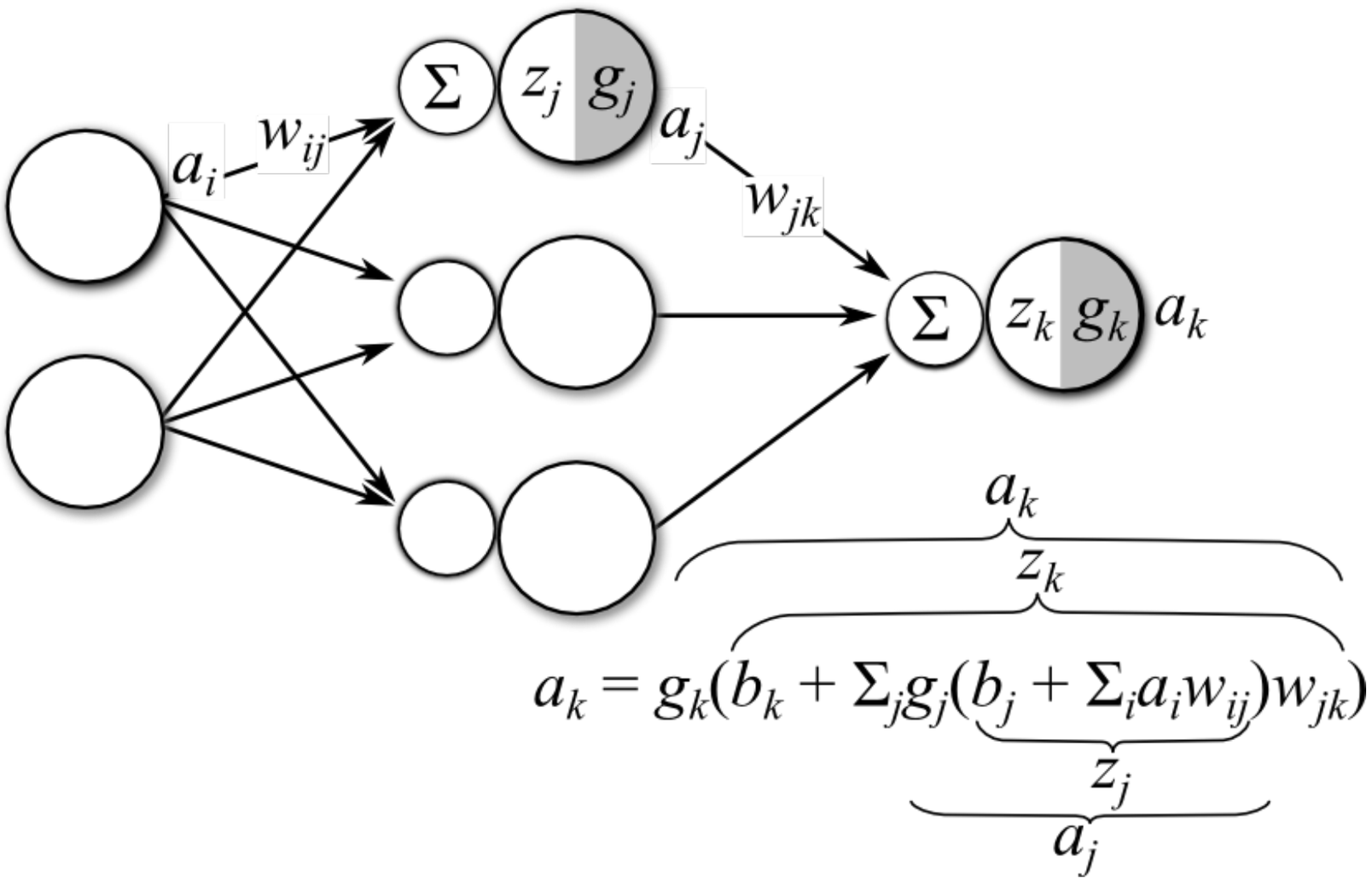
h/t https://github.com/ayusek/Perceptron-Animation

PERCEPTRONS

* “You dumdums, single perceptrons can’t even solve something as simple as XOR, how could they possibly recognize images or walk or talk or be conscious?!”
  — Minsky & Papert, basically, 1969

* —> “AI winter” of 1974-1980

MULTILAYER ARTIFICIAL NEURAL NETWORKS



w = weights

a = activations

z = total input

g = activ. fxn

b = bias

h/t Dustin Stansbury

MULTILAYER ARTIFICIAL NEURAL NETWORKS

* Let y-hat = a_k (the output),
  X_i=a_i (the input)

* Suppose g's are fixed

* How do we learn the w's and b's?

MULTILAYER ARTIFICIAL NEURAL NETWORKS

* Backpropagation!

MULTILAYER ARTIFICIAL NEURAL NETWORKS

* Suppose number of hidden units = number of training samples

* Suppose $w_{ij} = X_j$

* *Suddenly*.. a kernel regression neural network, with k(a,b) = tanh(a.b)

h/t Michael Oliver

NEXT TIME

* Seminar-style paper discussion:

  “Seeing it all: Convolutional network layers map the function of the human visual system”

  by Eickenberg, Gramfort, Varoquaux, & Thirion (Neuoroimage, 2017)

  (PDF on github)

* Who will lead discussion?