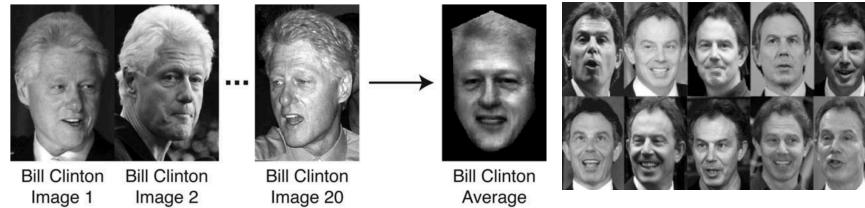


## 100% Accuracy in Automatic Face Recognition Jenkins & Burton (2008)



### Big challenge for face recognition:

coping with variation in facial appearance due to changing illumination, pose, expression, age, hair, etc.

Store *average face* for each person??

## Artificial Neural Networks (ANNs)

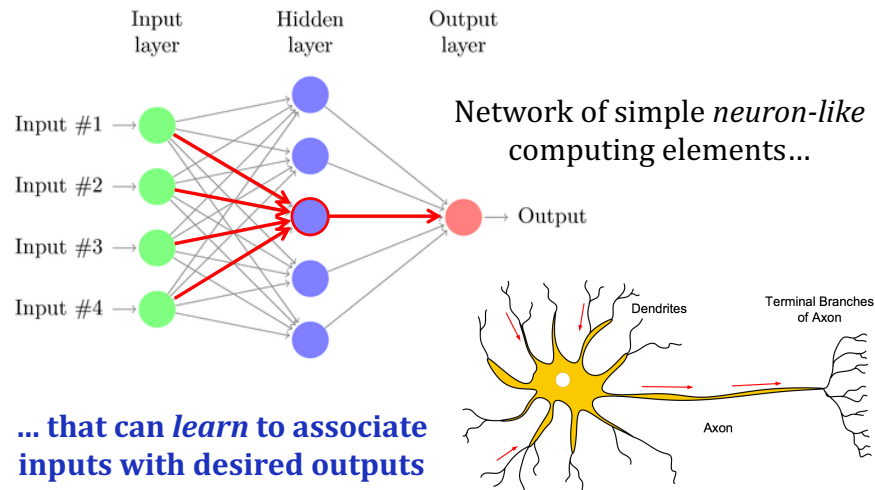
➔ What is an artificial neural network?

What can an artificial neural network *learn to do*?  
early success: ALVINN, handwritten zip codes, NETtalk

A (very!) simple neural network

Training a neural network with *backpropagation*

## What is an artificial neural network?



## Artificial Neural Networks (ANNs)

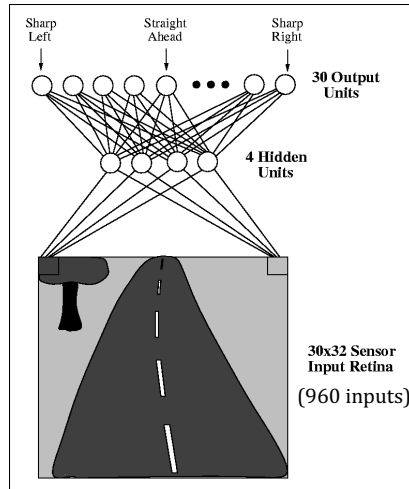
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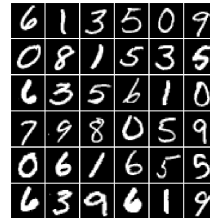
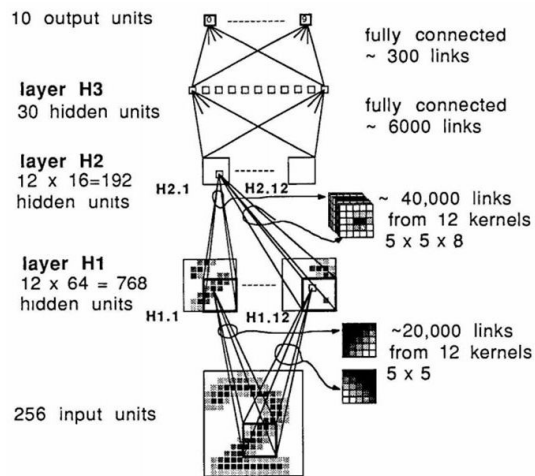
Training a neural network with *backpropagation*

## ALVINN learned to control steering actions Pomerleau (1991)

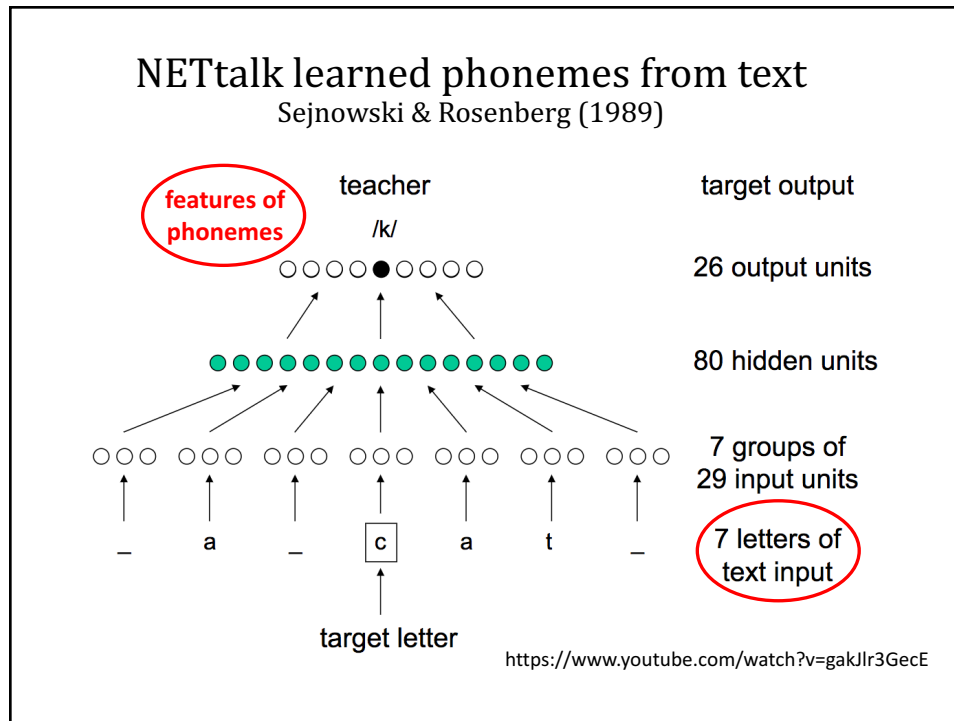


- ALVINN learned to steer by *observing a human driver*
- Multiple networks for different roads (e.g. dirt road, two-lane road, highway (up to 70mph!))

## Learning to recognize handwritten zip codes LeCun et al. (1989)



System could recognize image samples provided by the US postal service, with high accuracy



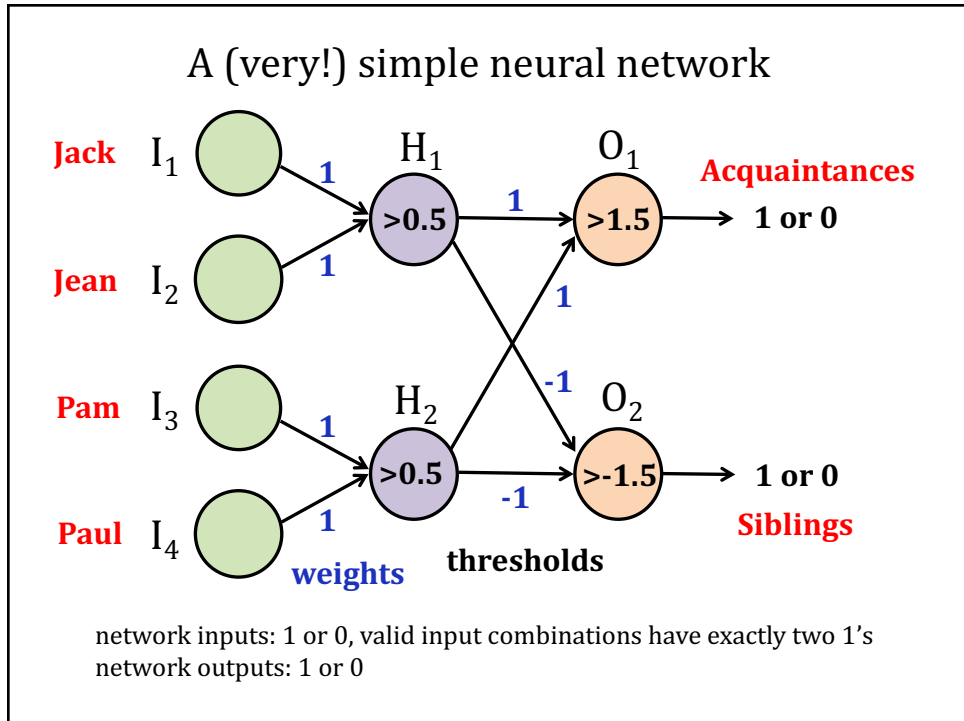
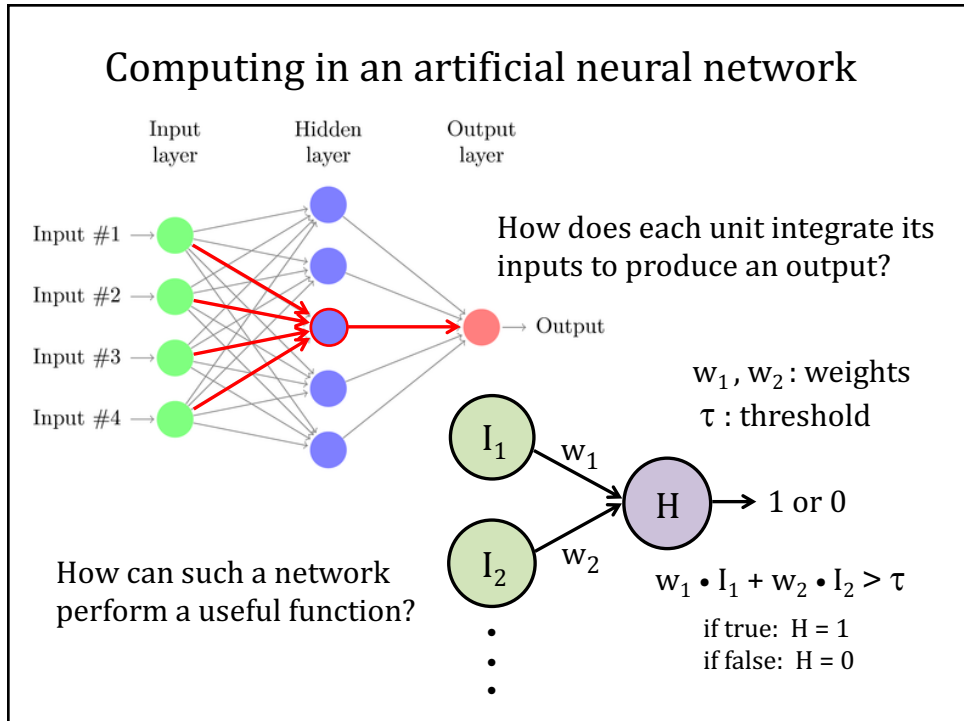
## Artificial Neural Networks (ANNs)

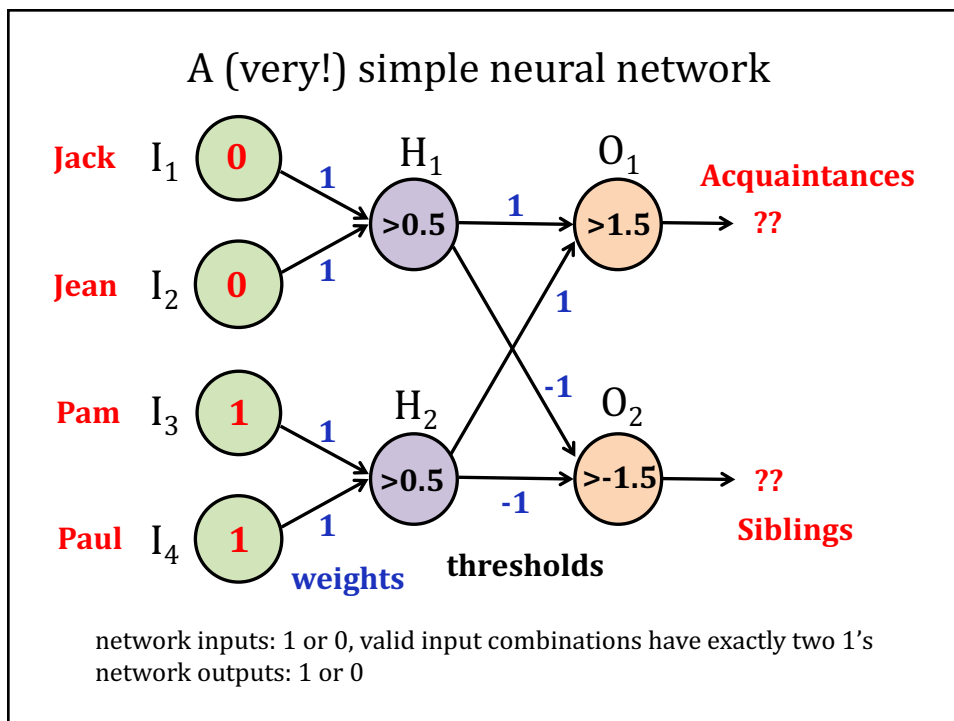
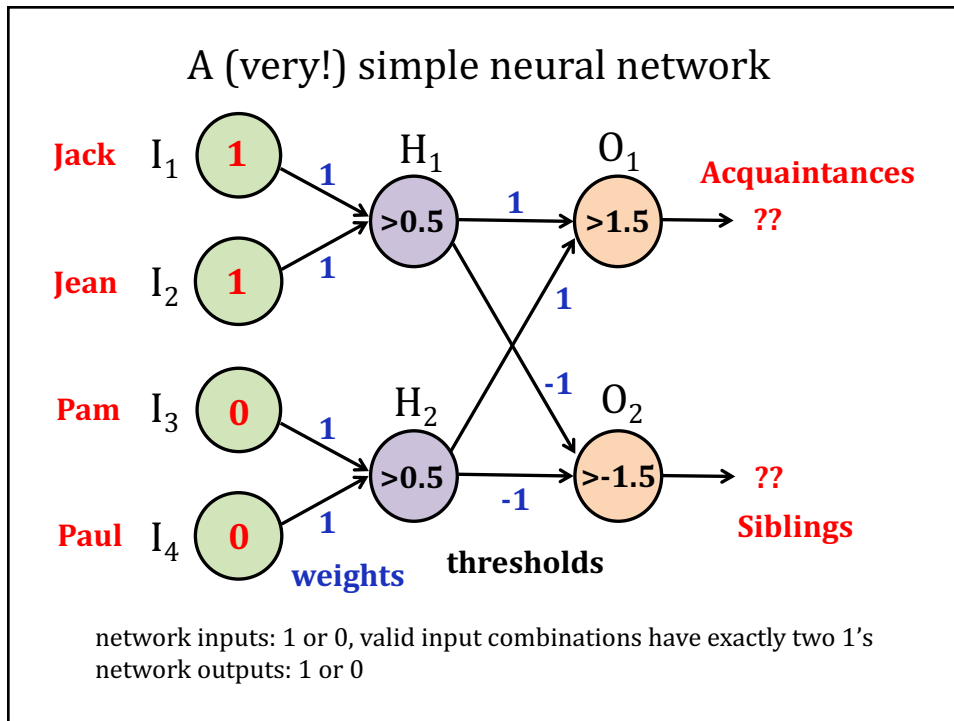
What is an artificial neural network?

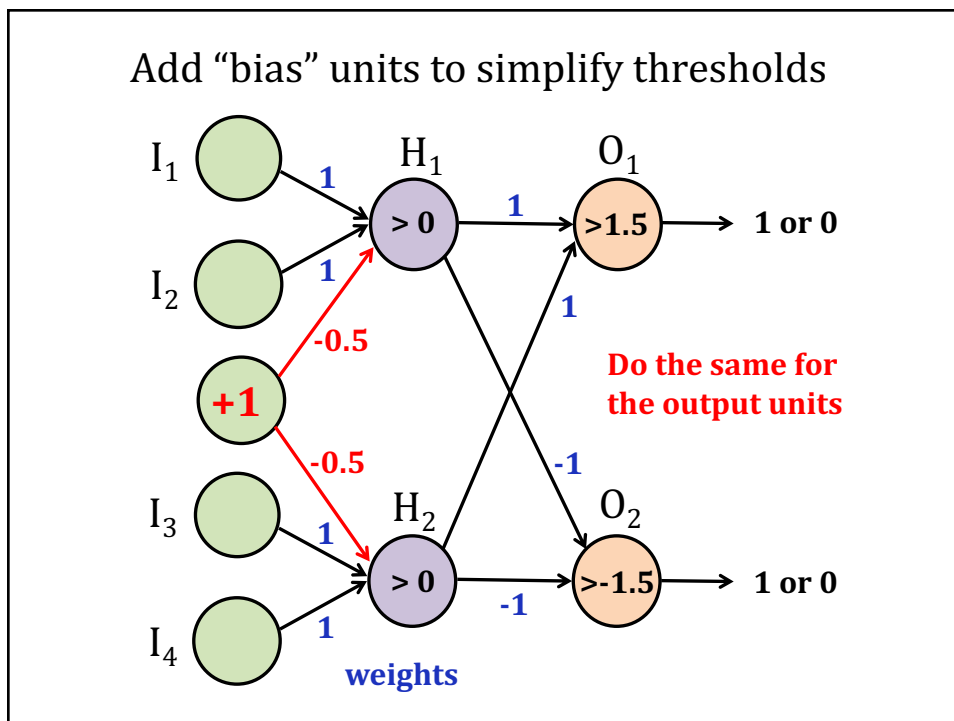
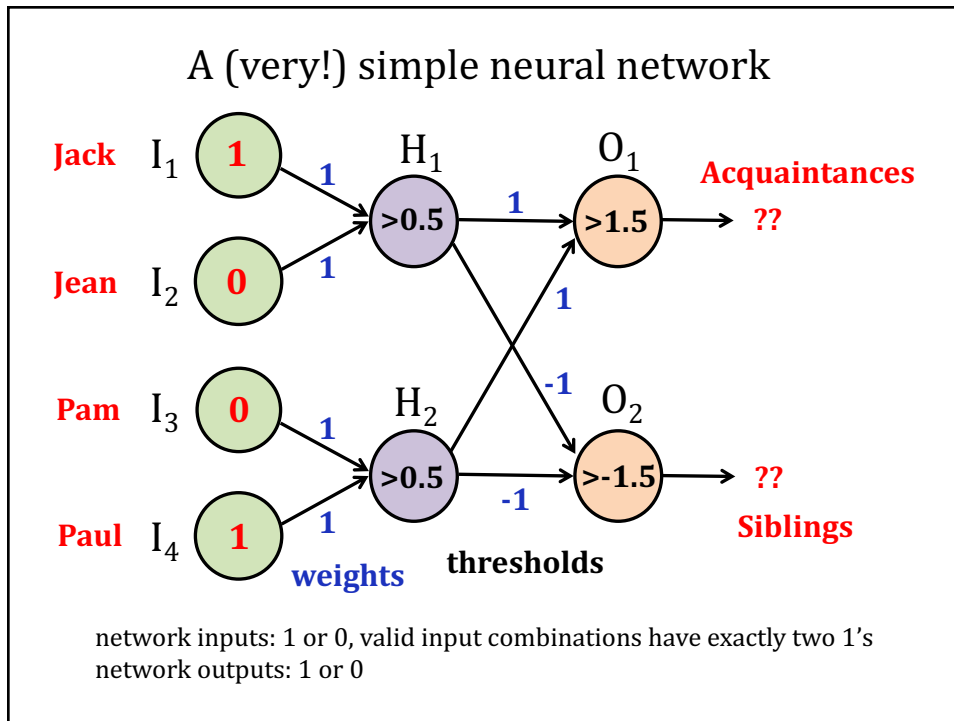
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early success: ALVINN, handwritten zip codes,  
NETtalk

➔ A (very!) simple neural network

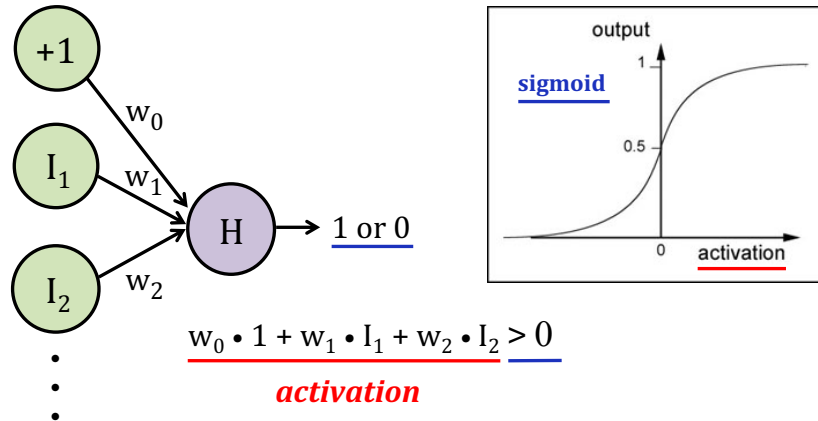
Training a neural network with *backpropagation*







## Computing in a "typical" neural network



How does each unit integrate its inputs to produce an output?

sum of weighted inputs  $\rightarrow$  sigmoid function  $\rightarrow$  output *between 0 and 1*

## Artificial Neural Networks (ANNs)

What is an artificial neural network?

What can an artificial neural network learn to do?

early success: ALVINN, handwritten zip codes,  
NETtalk

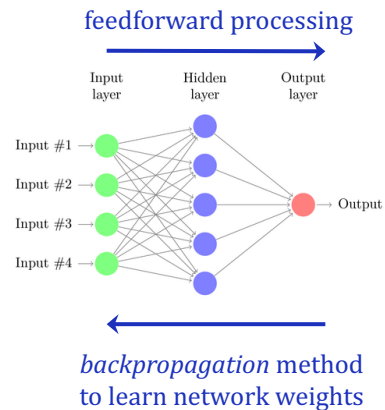
A (very!) simple neural network

**→** Training a neural network with *backpropagation*



## Learning in an artificial neural network

network weights can be *learned* from training examples



What's in a set of training examples?

### Backpropagation method:

- compute output for each input training sample, using current network
- compute errors between actual and desired outputs
- work backwards from output layer to input to determine how each weight can be adjusted to reduce errors
- update network **and repeat**