Neural networks through ice cream sales

Objectives:

- To ***fluently*** use the ***vocabulary*** of neural networks
- To connect ***familiar past algorithms*** to ***neural networks***, and therefore demystify the math
- To practice ***drawing*** and ***specifying*** the parameters of a neural net
- To list the ***parameters*** one can ***adjust*** when building a neural net

Scenario

You own a chain of ice cream stores.

You want to build a model that will predict the sales numbers of a store, given the store's location, pricing of product, and perceived quality of the product.

Simpler models haven't produced great results, so you want to try a neural network. Plus, neural networks sound fancy. You like fancy.

Problem summary

Variables

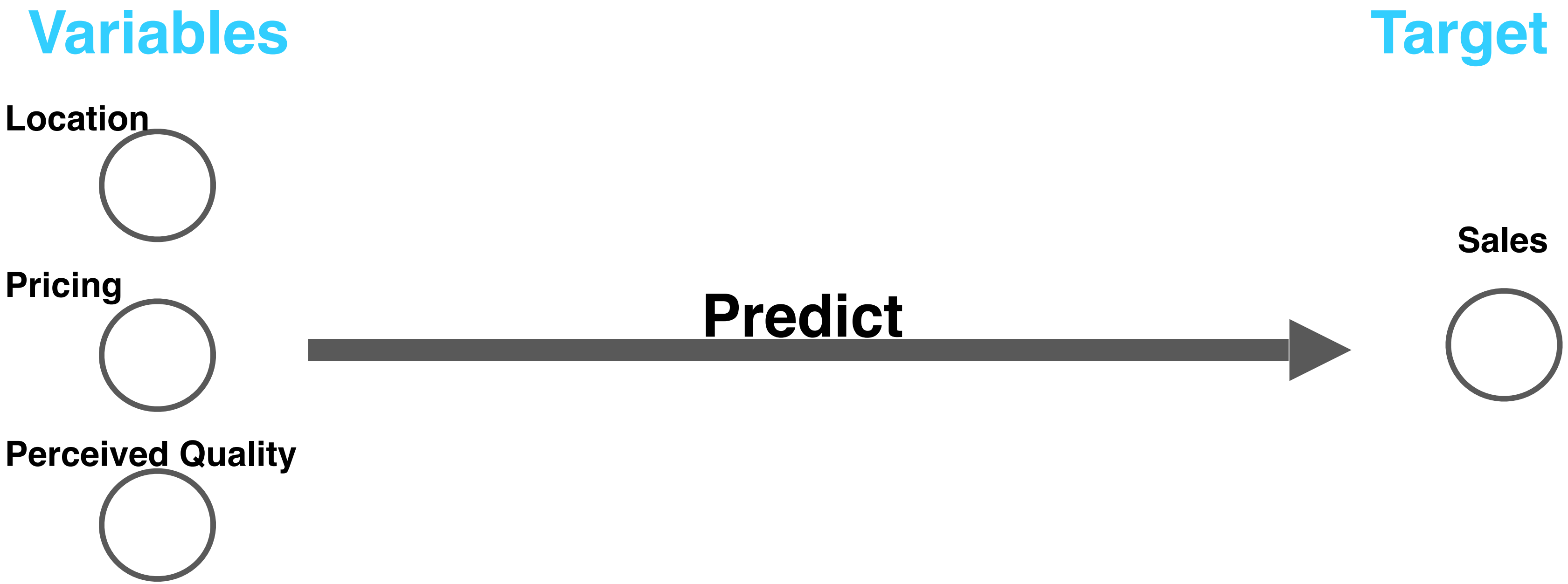
Location

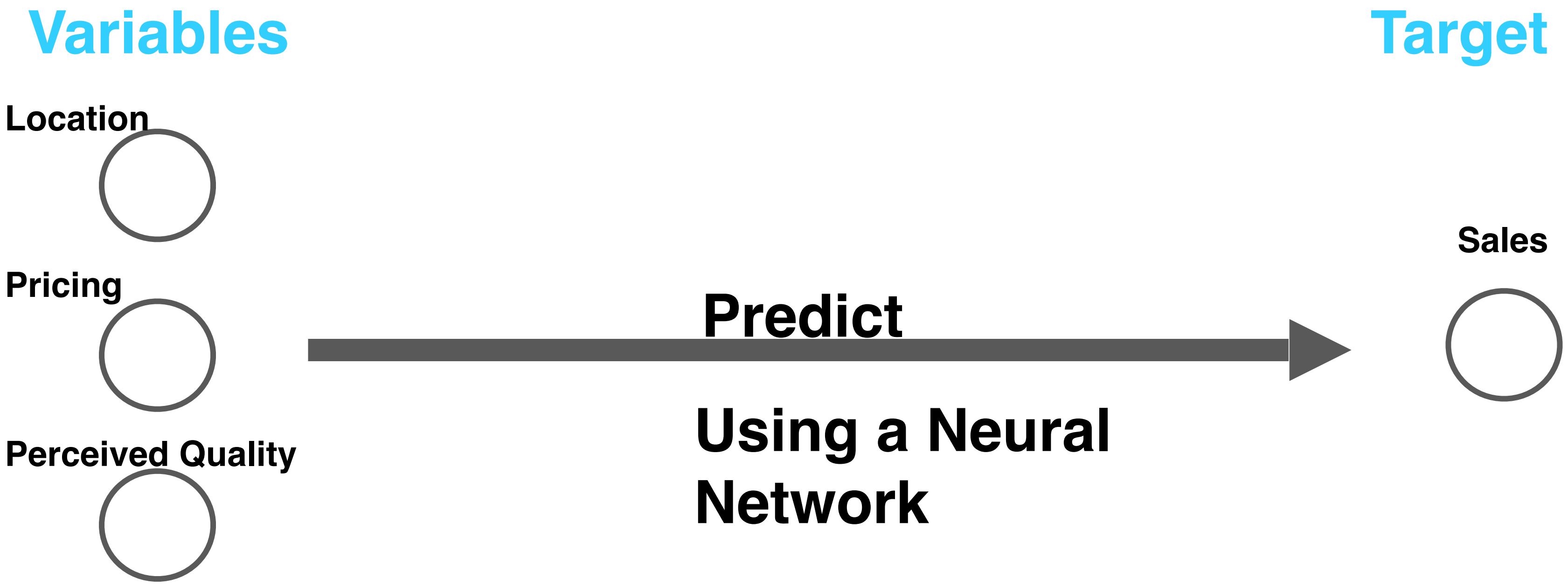
Pricing

Perceived Quality


Variables
Target
Location
Pricing
Perceived Quality
Sales

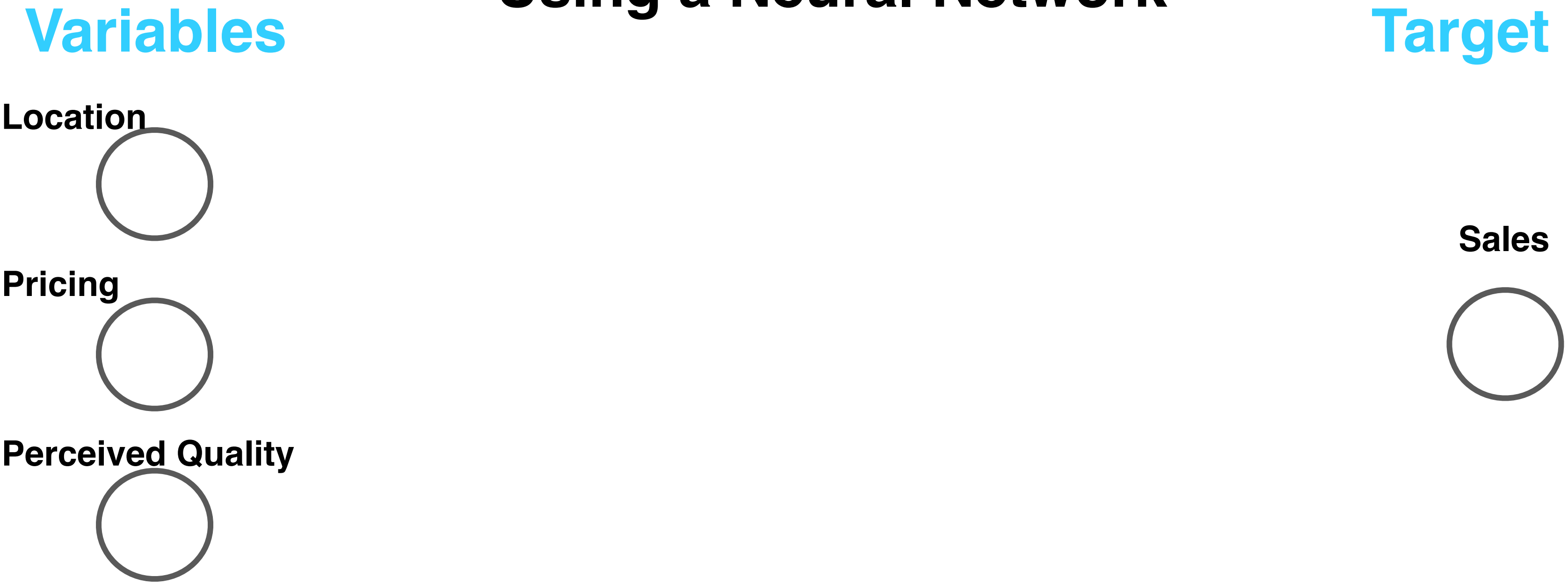

Variables
Target
Location
Pricing
Perceived Quality
Sales


Variables
Target
Location
Pricing
Perceived Quality
Predict
Sales


Variables
Target
Location
Pricing
Perceived Quality
Sales
Predict
Using a Neural Network

Vocabulary

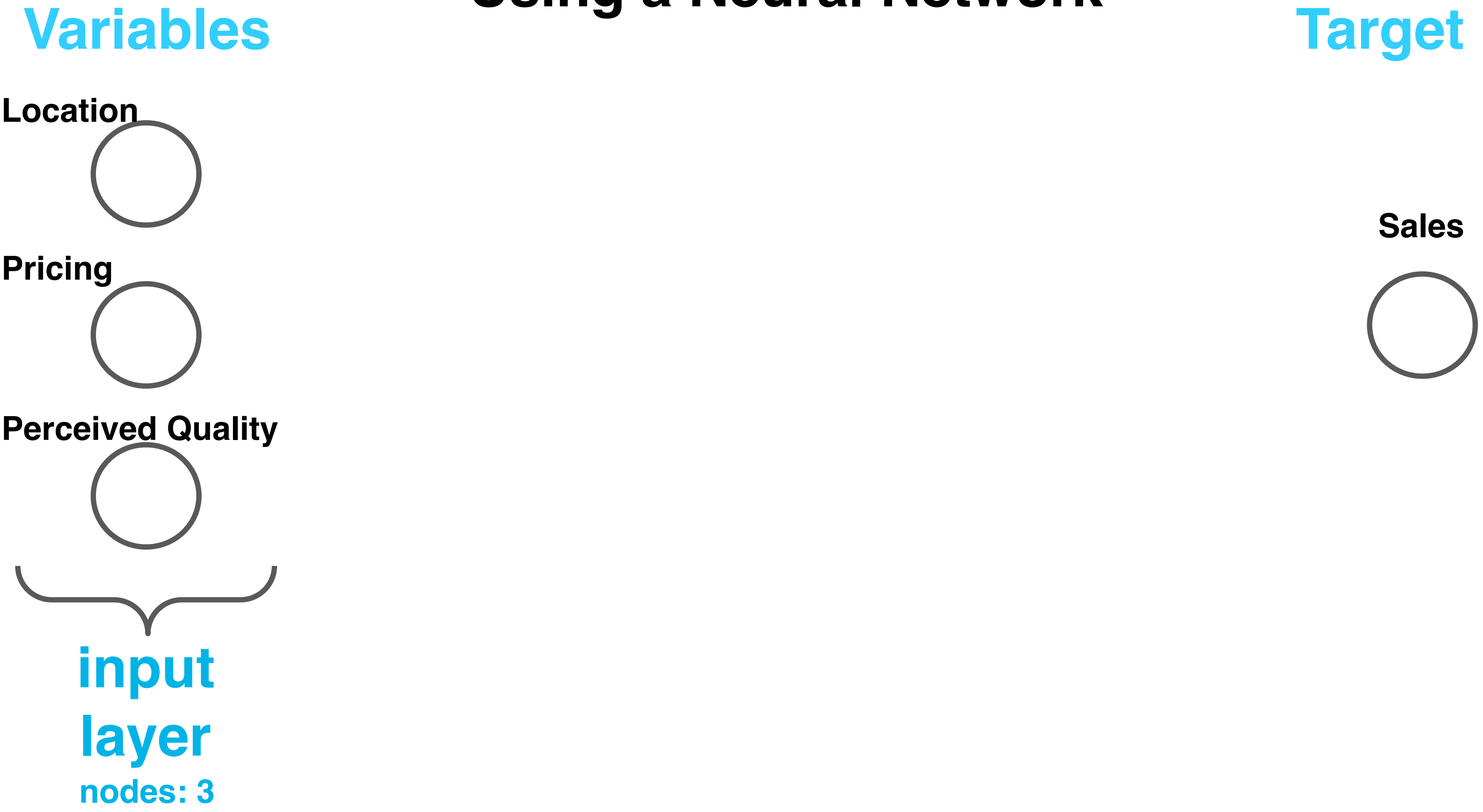
Using a Neural Network



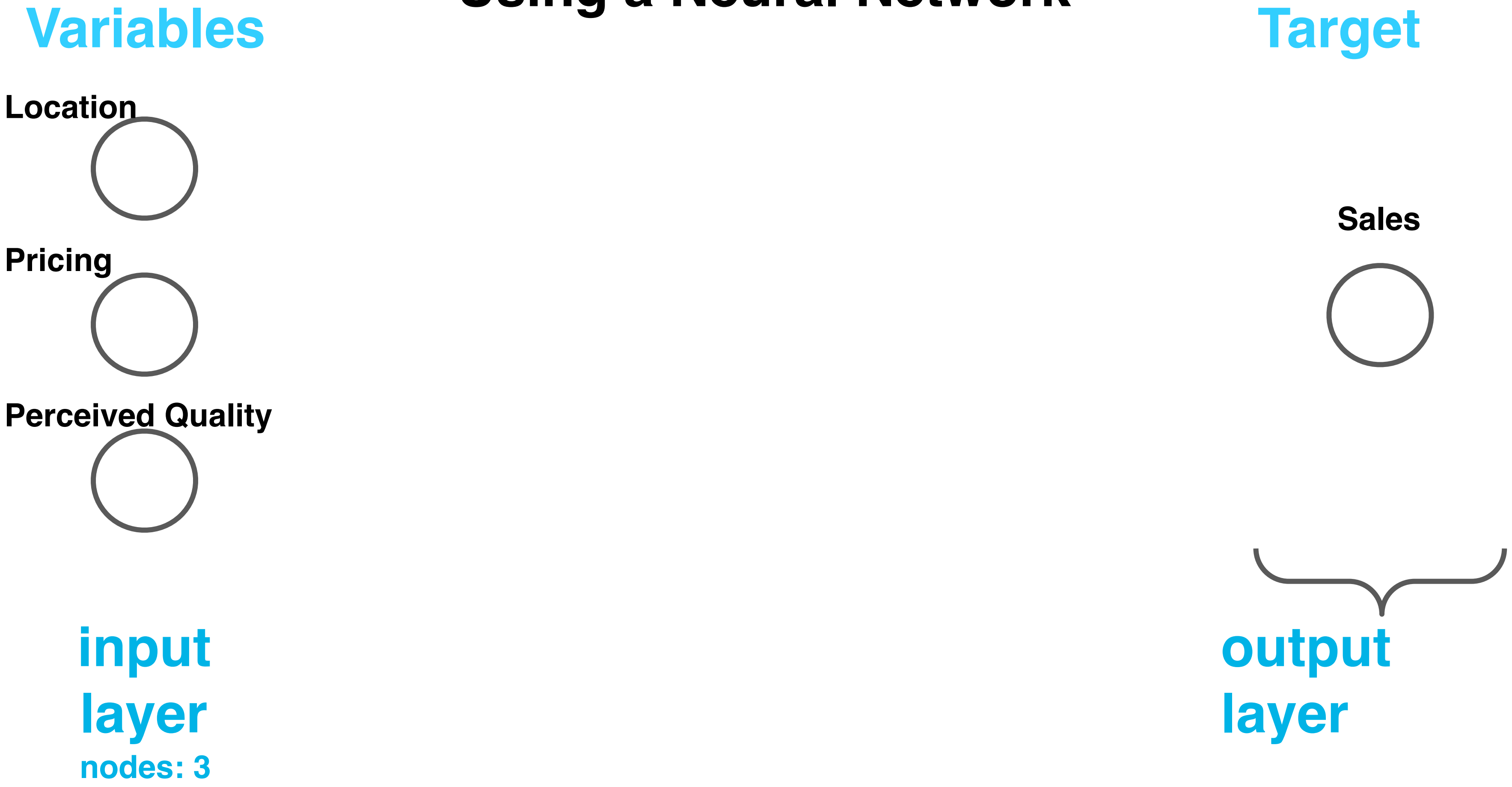
Using a Neural Network

Variables **Target**

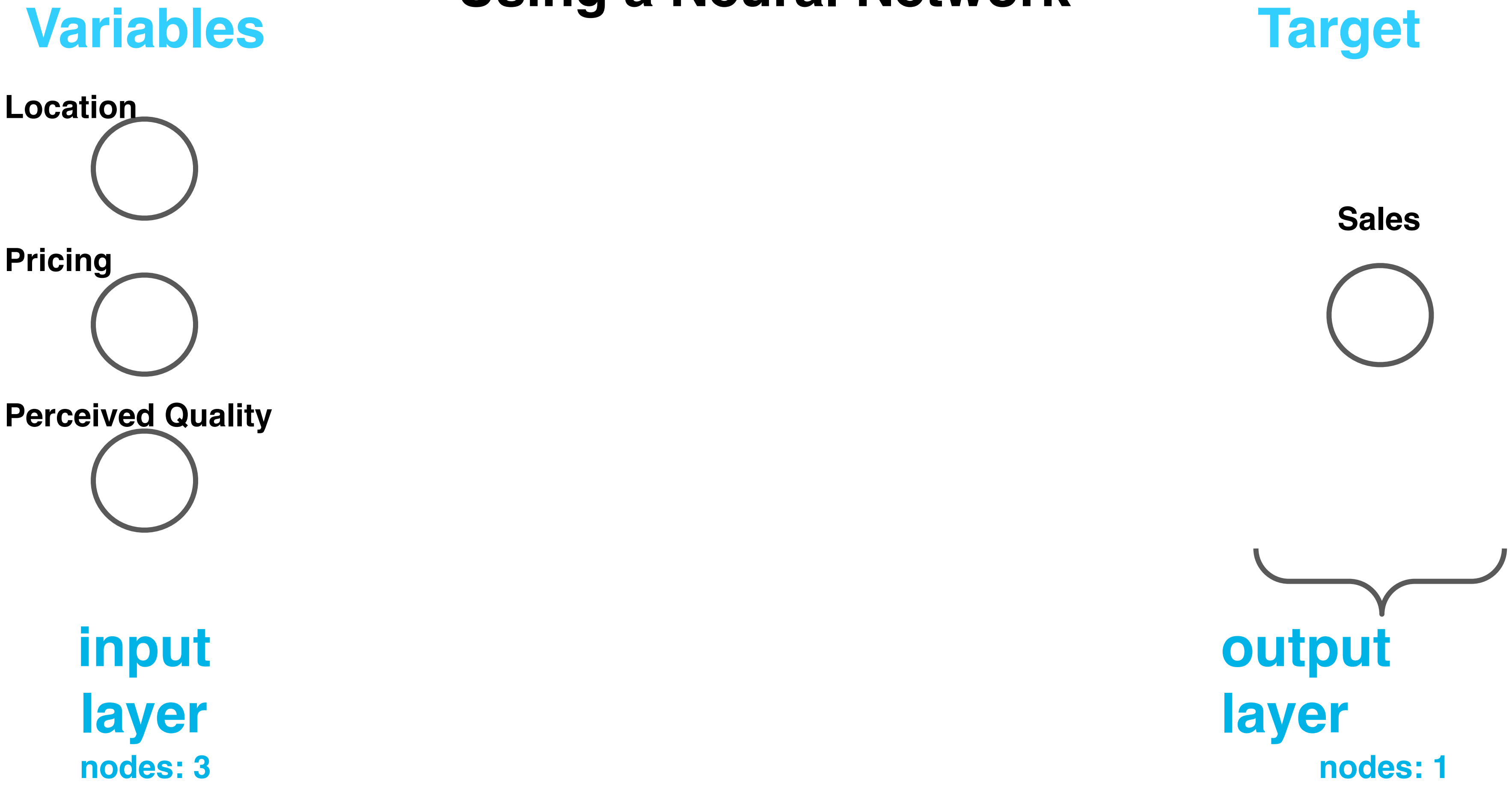
Using a Neural Network



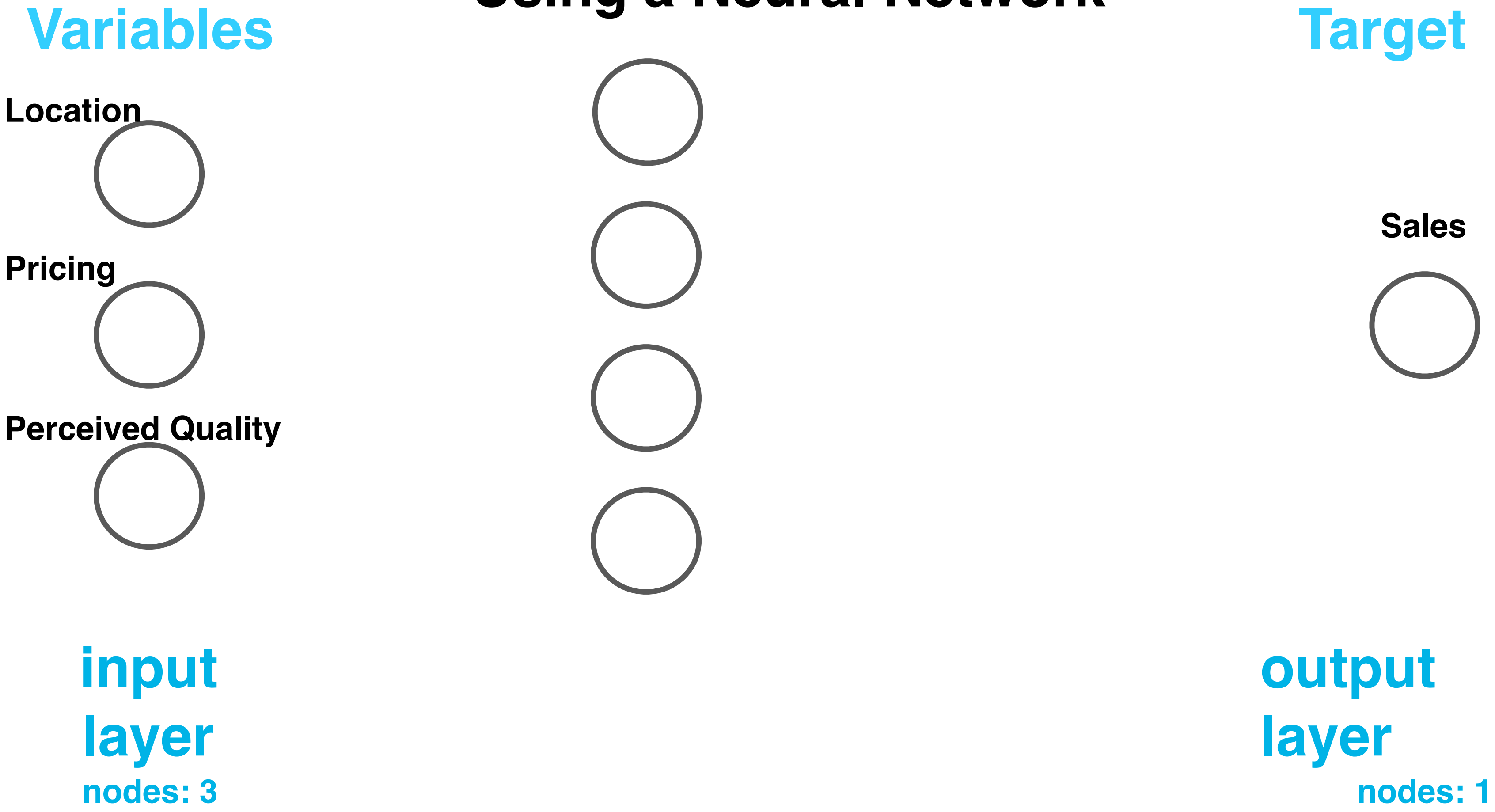
Using a Neural Network



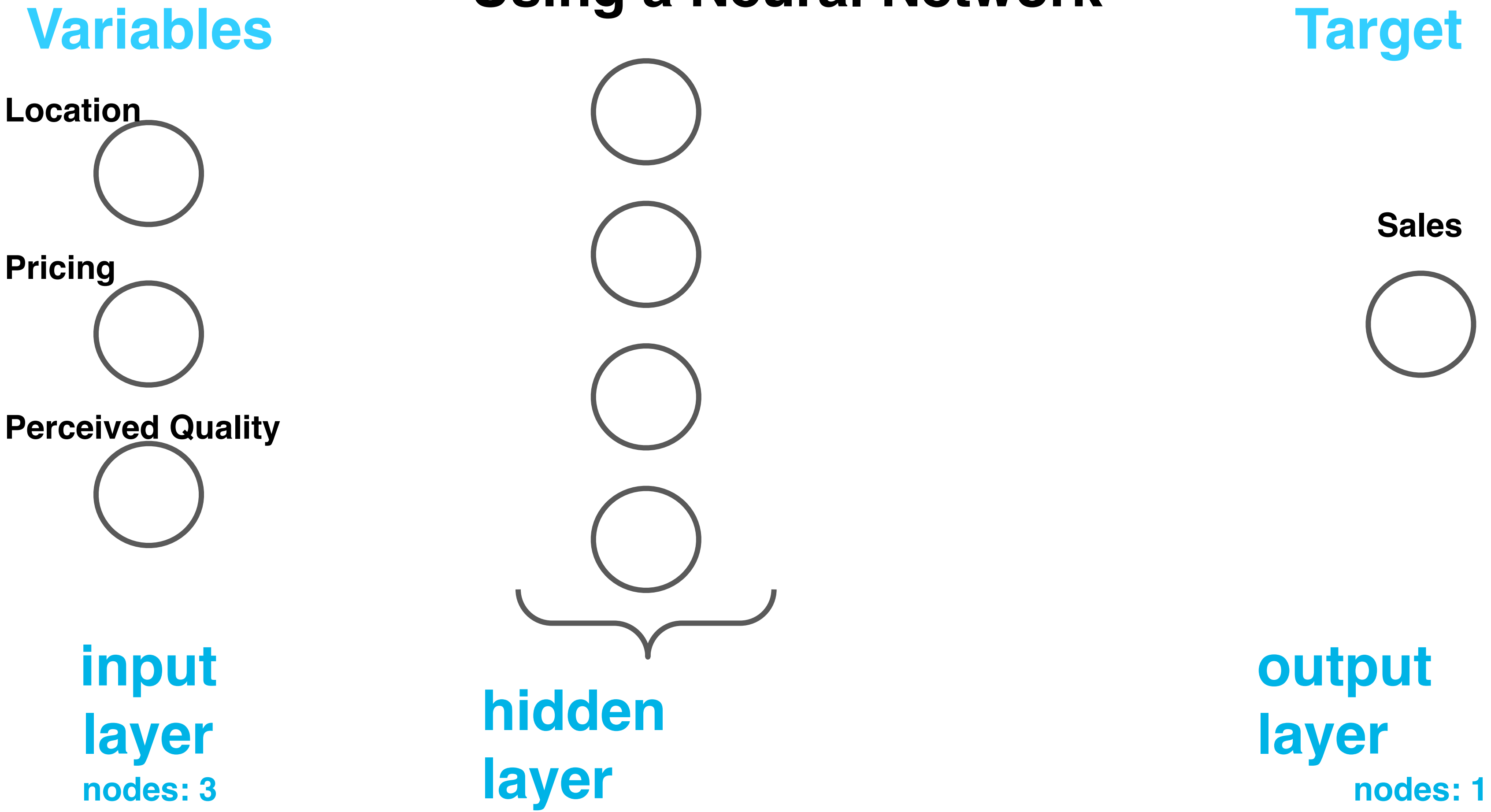
Using a Neural Network



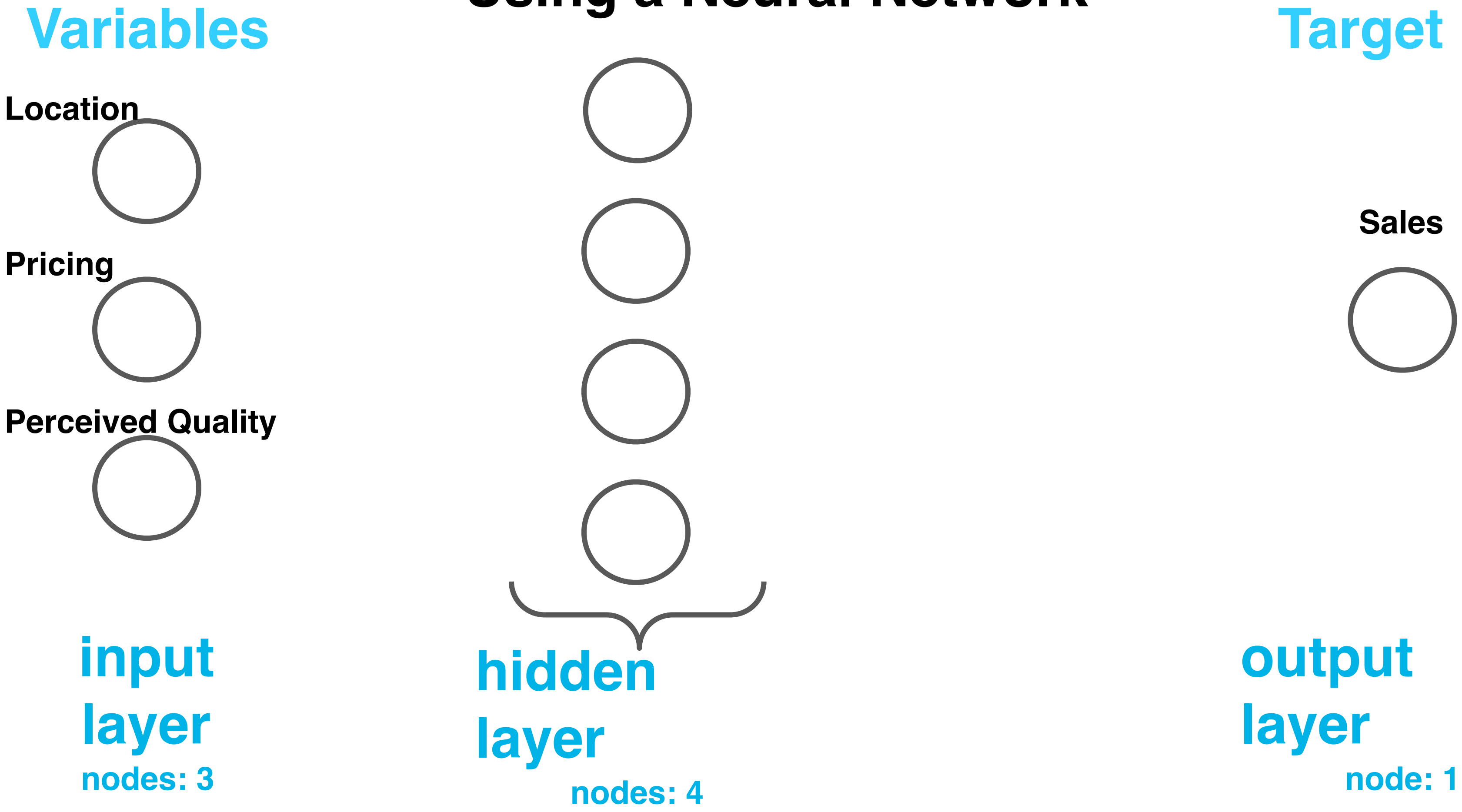
Using a Neural Network



Using a Neural Network



Using a Neural Network



How many layers in our neural network?

Keep this in mind as we build neural networks

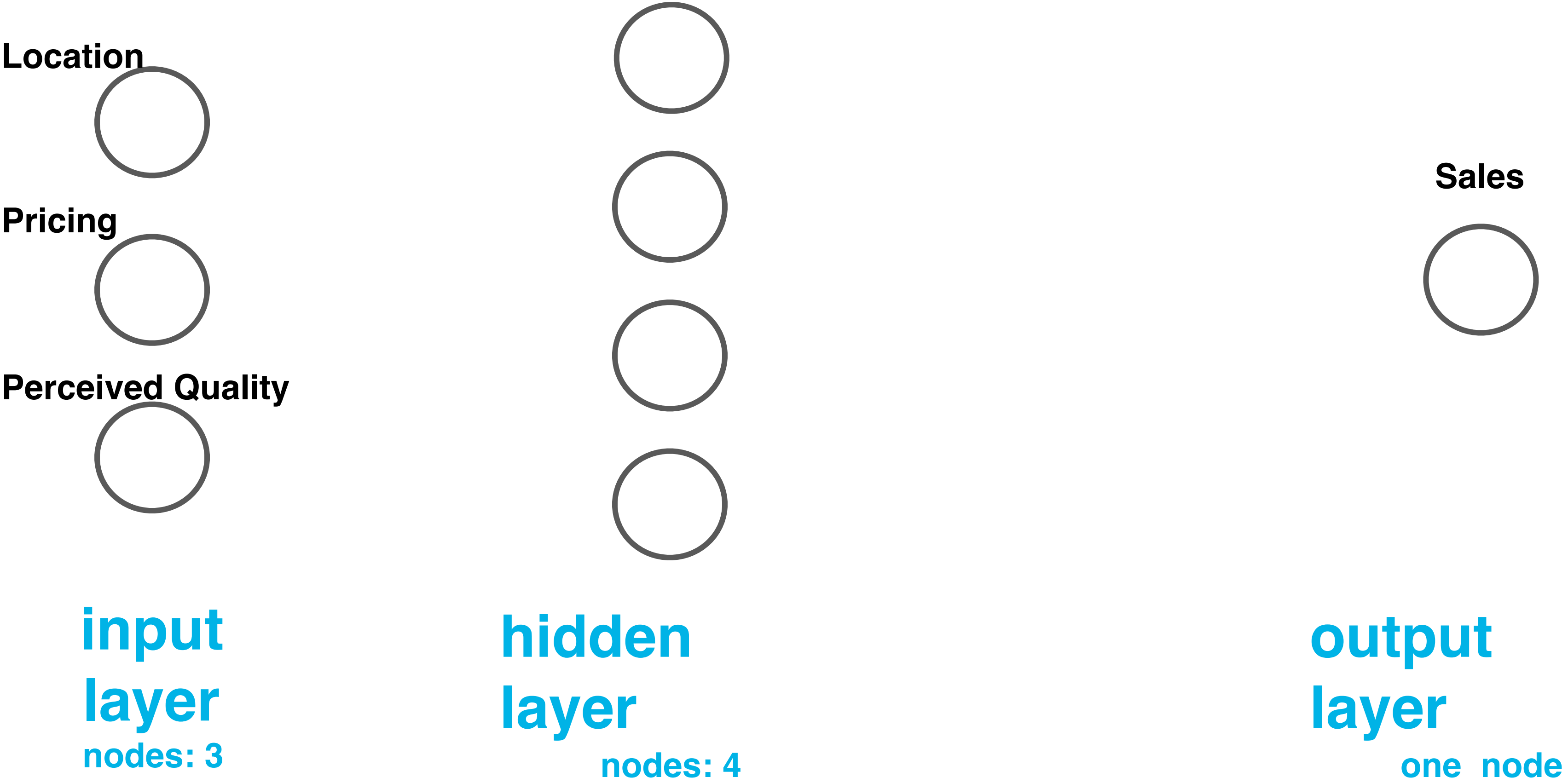
Draw this out:

We want to build a neural network using gender(assume binary), years of education, marital status(single vs wed), and years of employment to predict income.

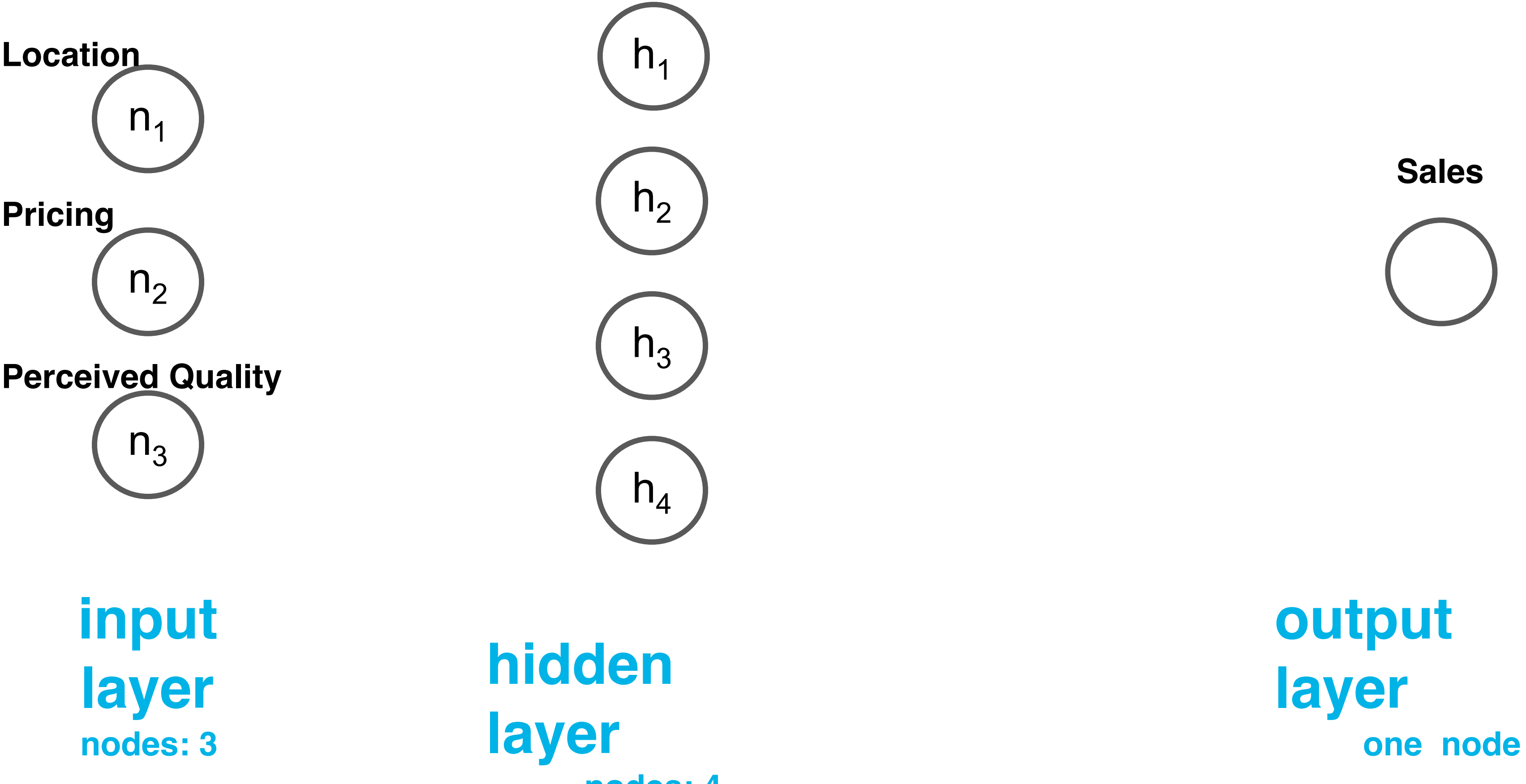
We are going to use two hidden layers. The first one will have three nodes and the second will have 5.

Draw and compare w neighbors.

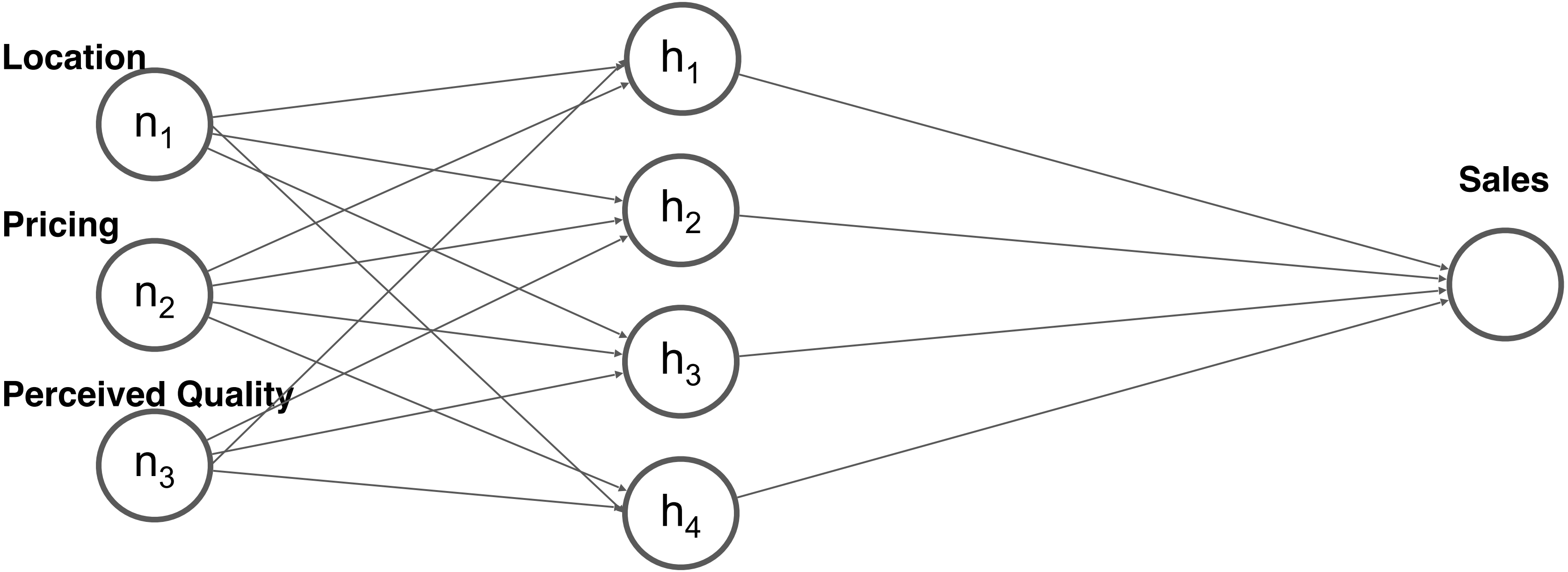
The math behind networks is not that scary



We need some notation to make this work



May have seen diagrams like this

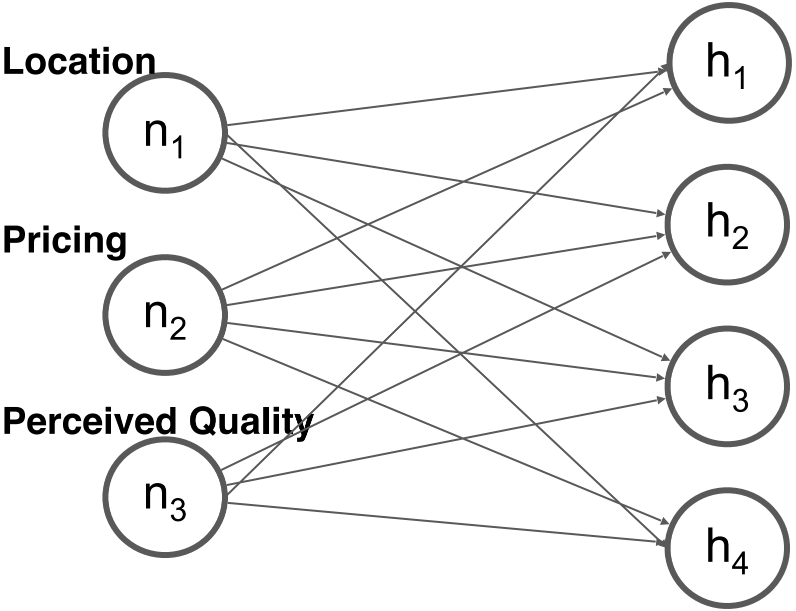


input layer
nodes: 3

hidden layer

output layer
one node

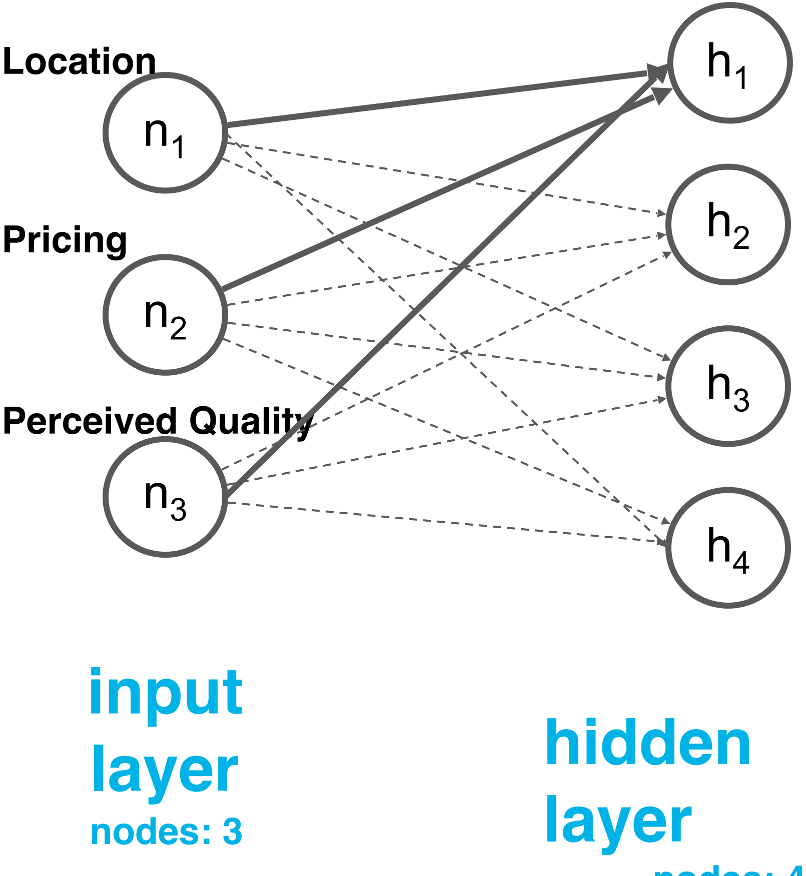
For simplicity we are only going to focus on one layer



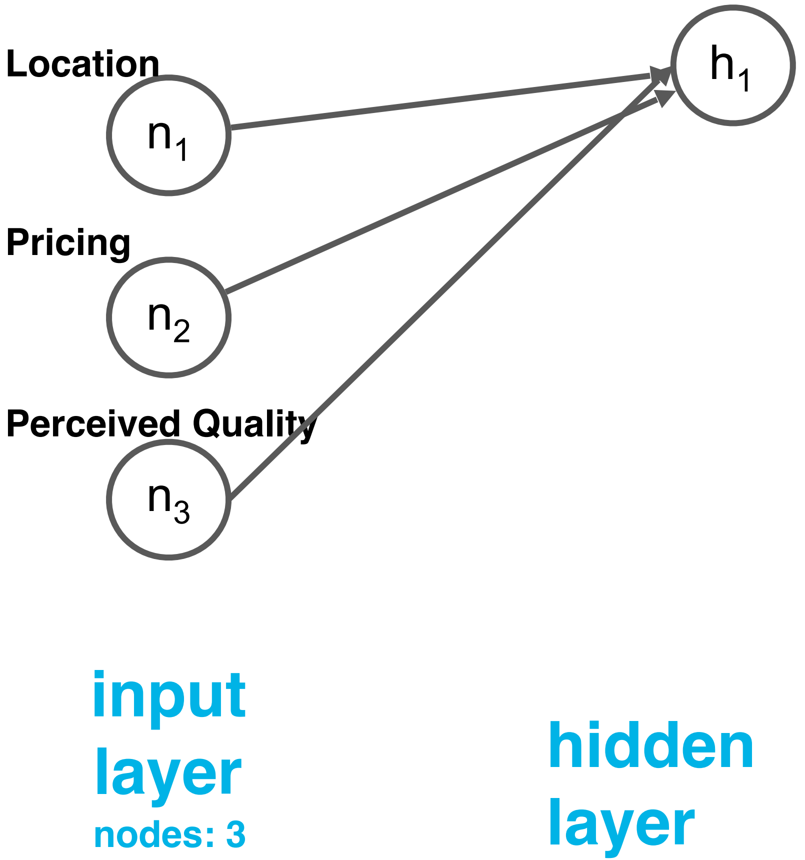
input layer
nodes: 3

hidden layer
nodes: 4

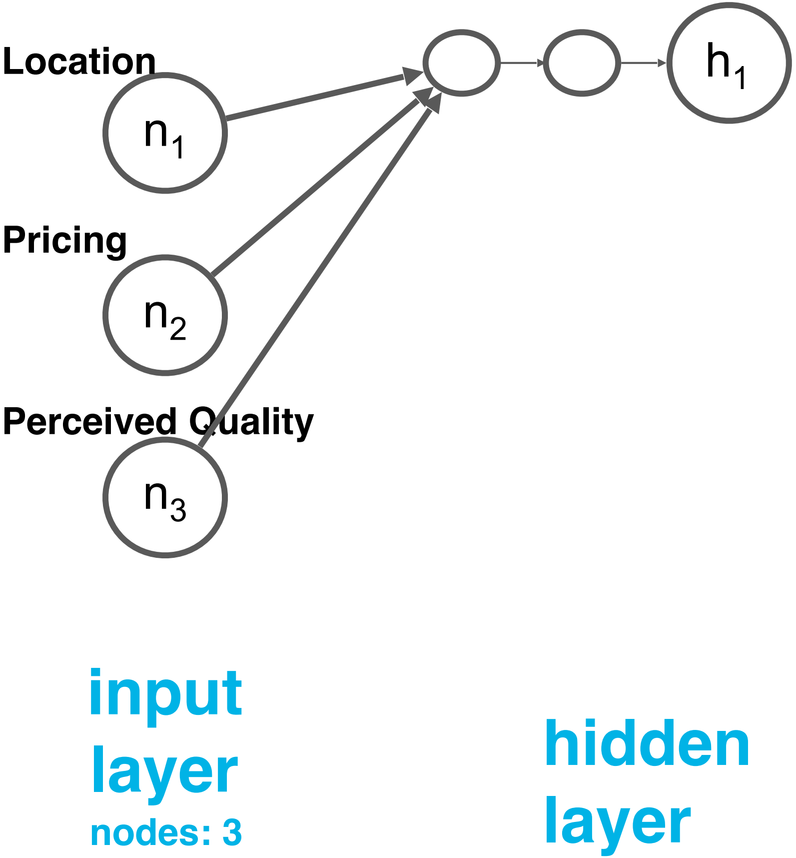
And specifically the first node in the hidden layer



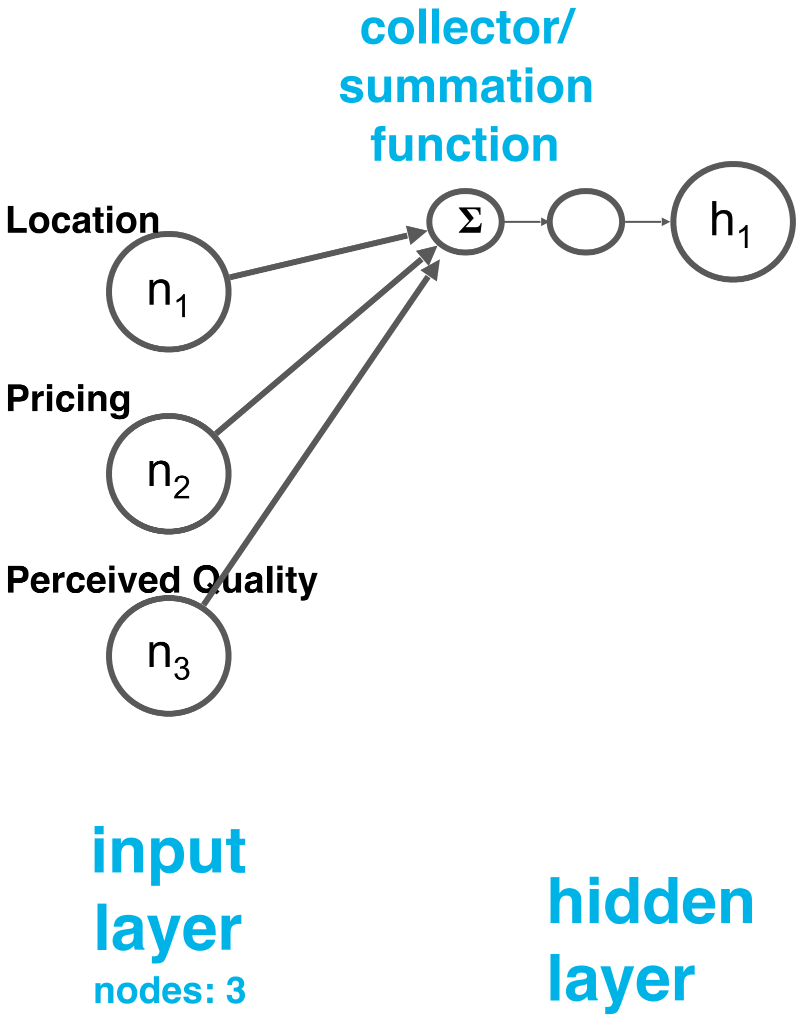
Problem: this common diagram isn't representative



What is shown as one is really three



Each node that receives input from previous nodes actually has **three** parts



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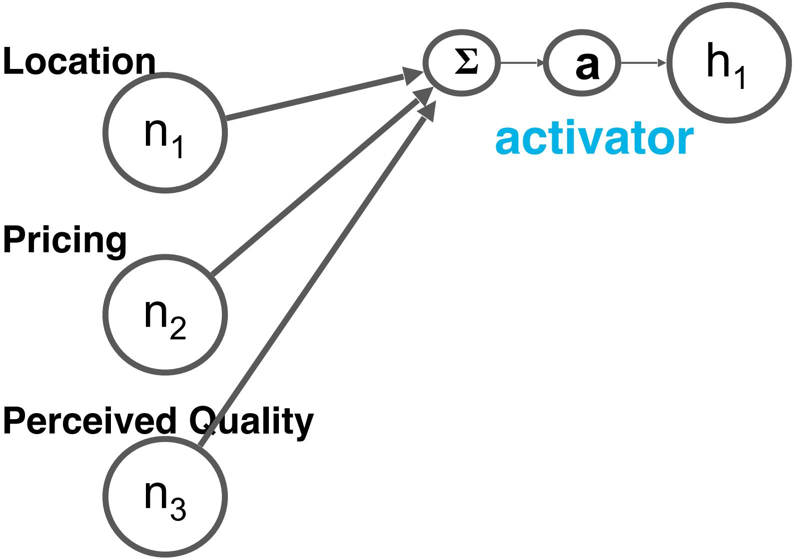
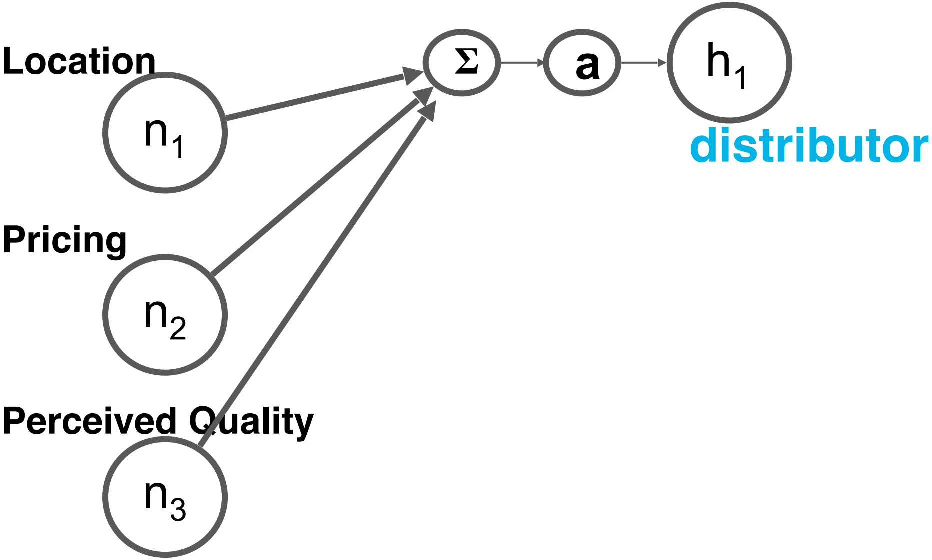


input
layer
nodes: 3

hidden
layer

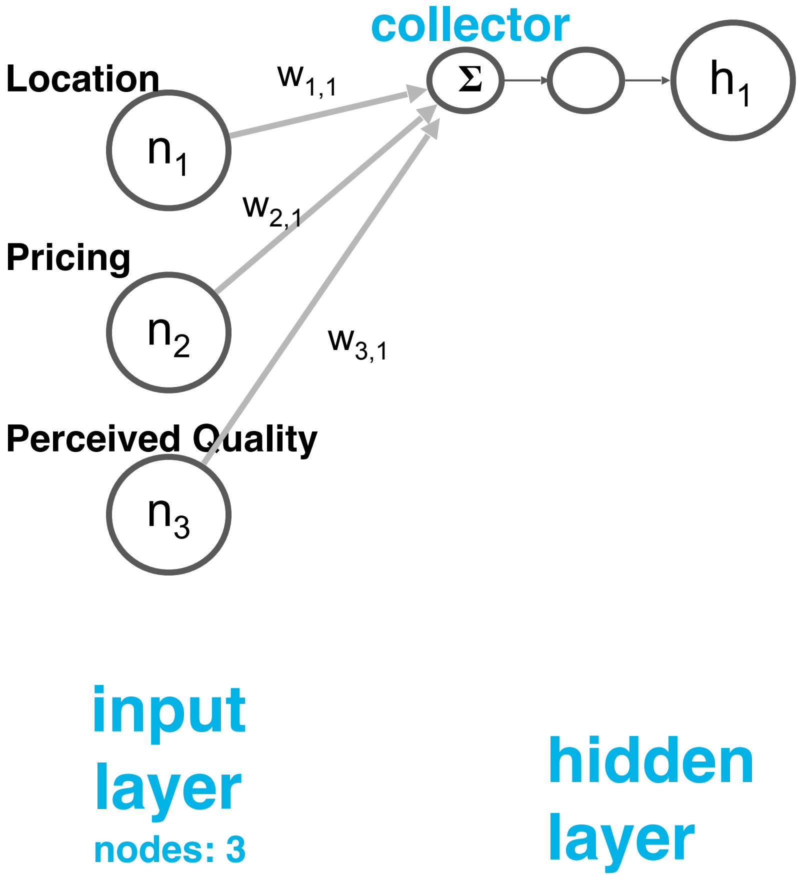
Each node that receives input from previous nodes actually has **three** parts



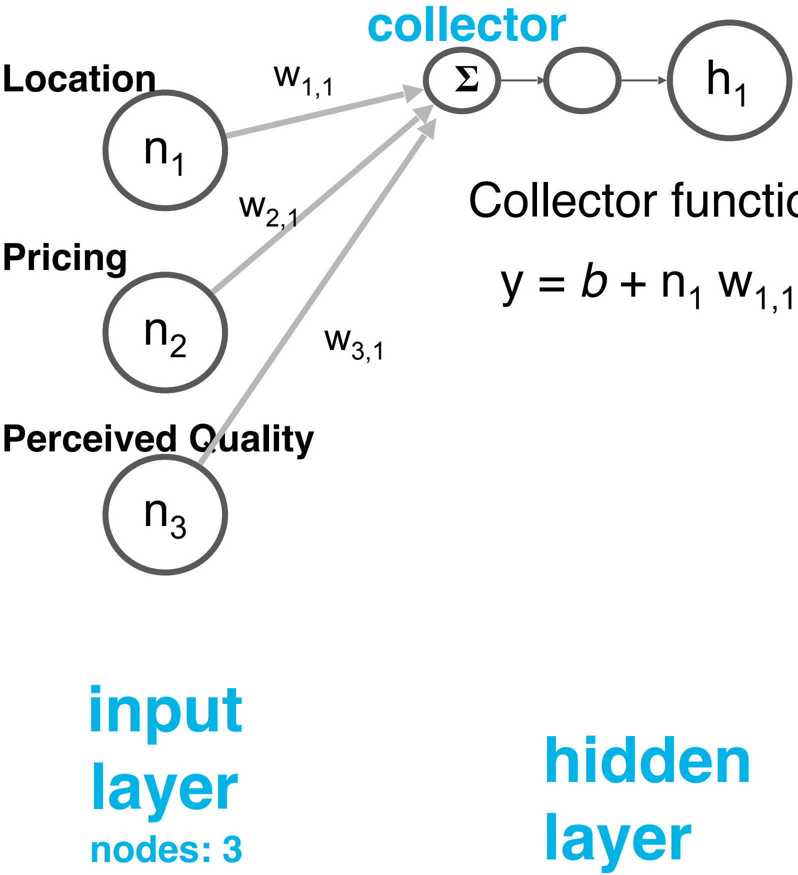
input layer
nodes: 3

hidden layer

Each node that receives input from previous nodes actually has **three** parts

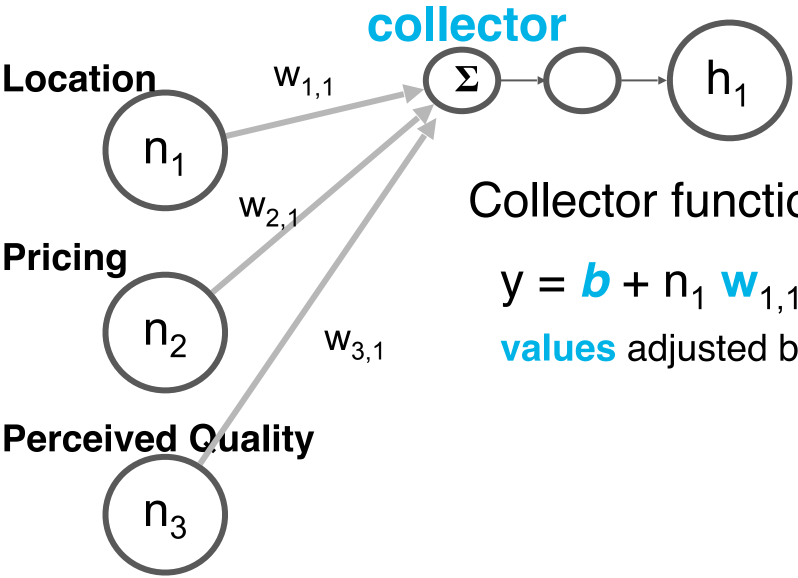

collector
Location
Pricing
Perceived Quality
n_1
n_2
n_3
$w_{1,1}$
$w_{2,1}$
$w_{3,1}$
Σ
h_1
input
layer
nodes: 3
hidden
layer

This function should look familiar



Collector function:

$$y = b + n_1\, w_{1,1} + n_2\, w_{2,1} + n_3\, w_{3,1}$$



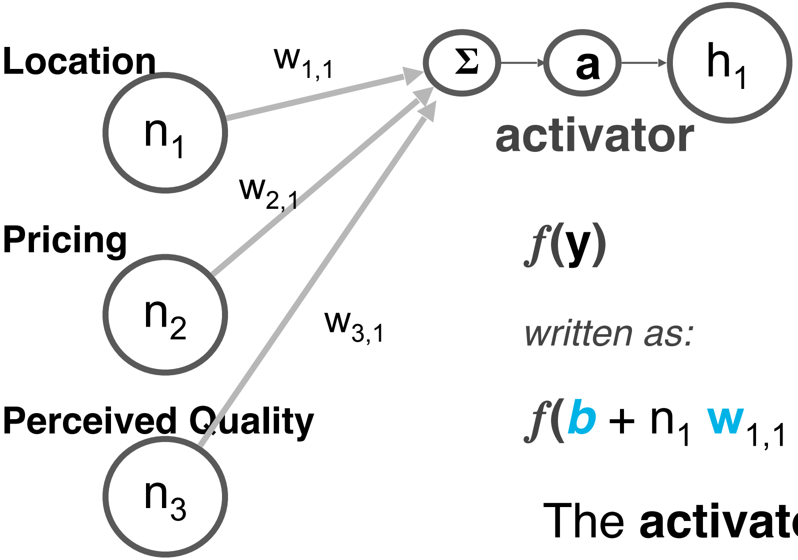
Collector function:

$$y = b + n_1 w_{1,1} + n_2 w_{2,1} + n_3 w_{3,1}$$

values adjusted by the algorithm

input layer
nodes: 3

hidden layer



The **activator** is a function chosen by **you** that takes the output of the collector as input.

$f(\mathbf{y})$

written as:

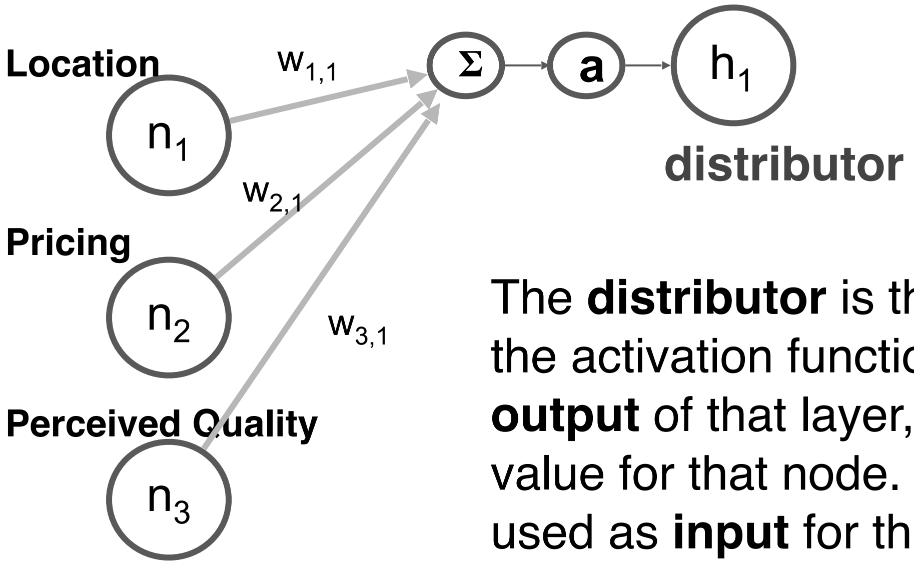
$f(\boldsymbol{b} + n_1\, \mathbf{w}_{1,1} + n_2\, \mathbf{w}_{2,1} + n_3\, \mathbf{w}_{3,1})$

The **activator** is specified for **each** layer. Nodes within a layer all use the same activation function

input layer

nodes: 3

hidden layer

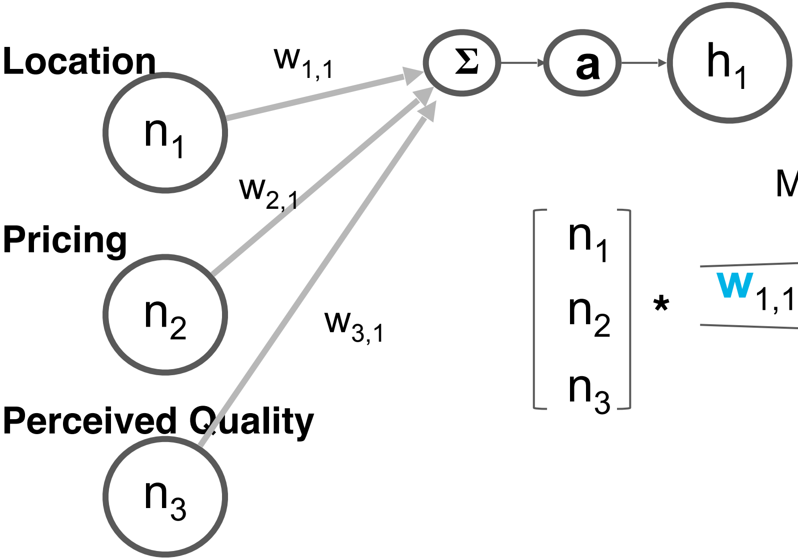


The **distributor** is the **output** of the activation function. It is the **output** of that layer, the final value for that node. It is then used as **input** for the next layer.

input layer
nodes: 3

hidden layer

For the math lovers in the room:



Matrix notation for one hidden node

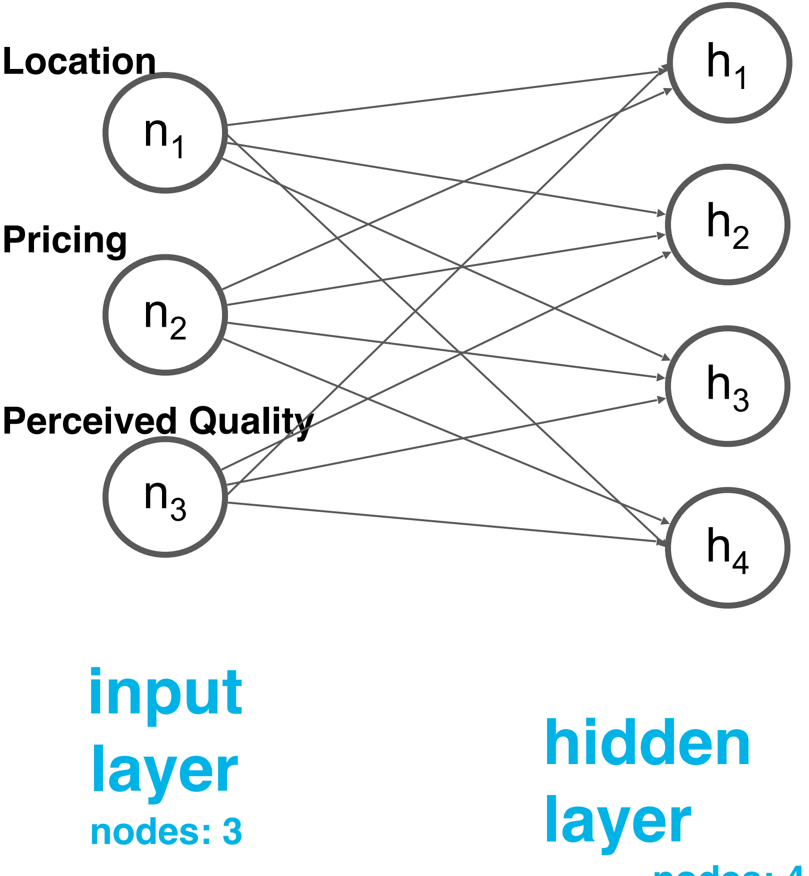
$$\begin{bmatrix} n_1 \\ n_2 \\ n_3 \end{bmatrix} * \begin{bmatrix} w_{1,1} & w_{2,1} & w_{3,1} \end{bmatrix} + b_1 = z_1 \rightarrow f_{a1}(\, y_1 \,) \rightarrow h_1$$

input layer

nodes: 3

hidden layer

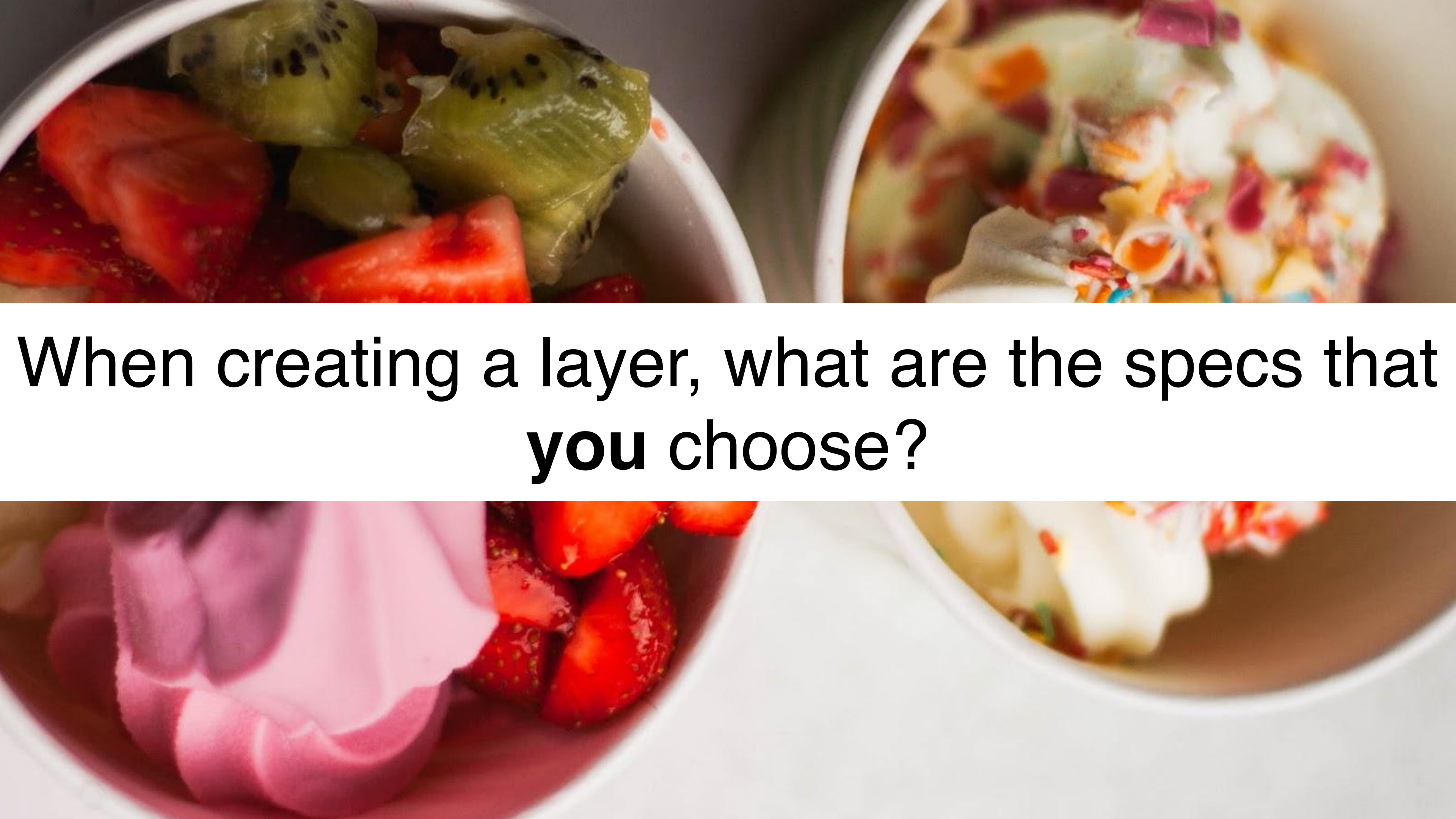
The full math for a layer:



Matrix notation for one hidden layer

$$\begin{bmatrix} n_1 \\ n_2 \\ n_3 \end{bmatrix} * \begin{bmatrix} w_{1,1} & w_{2,1} & w_{3,1} \\ w_{1,2} & w_{2,2} & w_{3,2} \\ w_{1,3} & w_{2,3} & w_{3,3} \\ w_{1,4} & w_{2,4} & w_{3,4} \end{bmatrix}^T + \begin{bmatrix} b_1 \\ b_2 \\ b_3 \\ b_4 \end{bmatrix} = \begin{bmatrix} y_1 \\ y_2 \\ y_3 \\ y_4 \end{bmatrix}$$

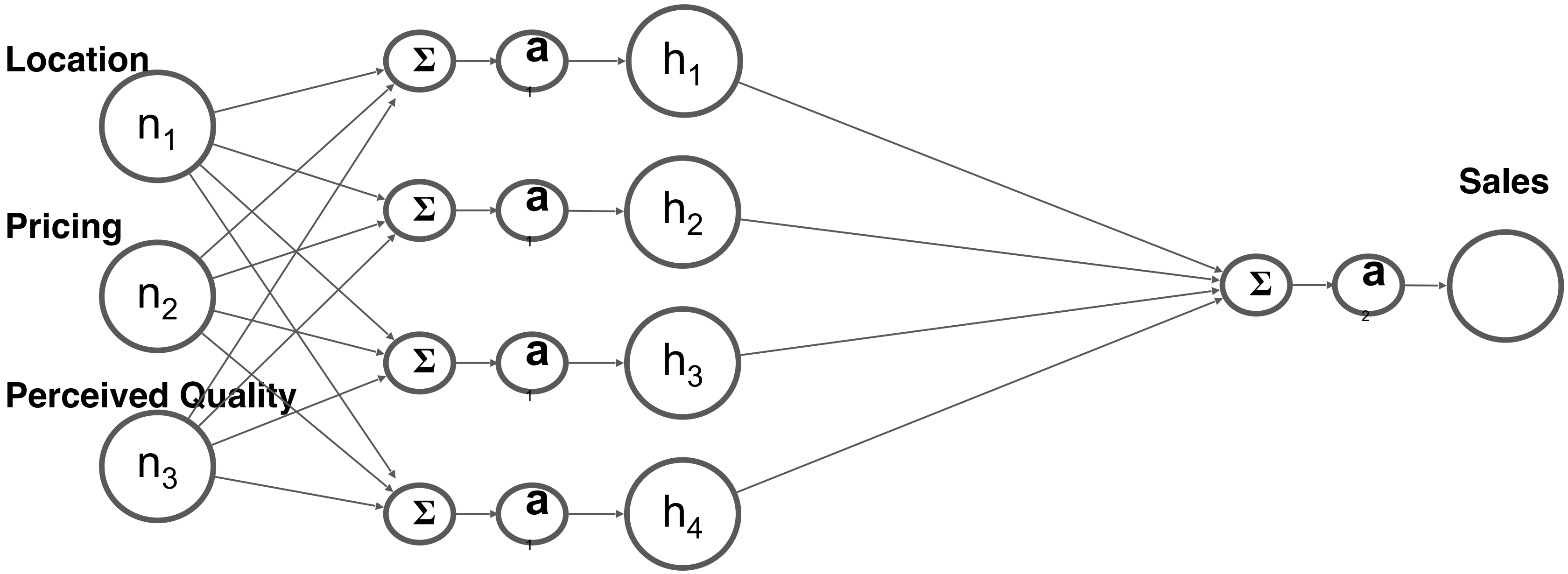
$$\begin{bmatrix} f(y_1) \\ f(y_2) \\ f(y_3) \\ f(y_4) \end{bmatrix} = \begin{bmatrix} h_1 \\ h_2 \\ h_3 \\ h_4 \end{bmatrix}$$



When creating a layer, what are the specs that **you** choose?

Summary

Hidden layer variables	**You define**	**Computer figures out**
weights		✔
activation function	✔	
bias		✔
number of nodes	✔	



input layer

nodes: 3

hidden layer

nodes: 4

output layer

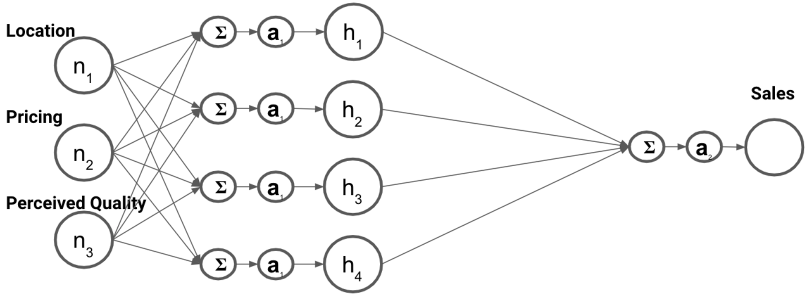
one node

Summary so far:

What you choose when building a neural network:

At the ***network*** level:
- Number of input variables
- Number of hidden layers
- If it is a classification or regression problem

At the ***layer*** level:
- The number of nodes
- The activation function



What else can we adjust?

What you choose when building a neural network:

At the ***network*** level:

- Number of input variables
- Number of hidden layers
- If it is a classification or regression problem
- **Batch size**
- **Number of epochs**
- **Learning rate & optimizer**
- **Regularization type and lambda**

At the ***layer*** level:

- The number of nodes
- The activation function

Batches and Epochs are about data processing

That’s a lot of math and a lot of data. The dataset is split into chunks and passed through the network one chunk at a time.

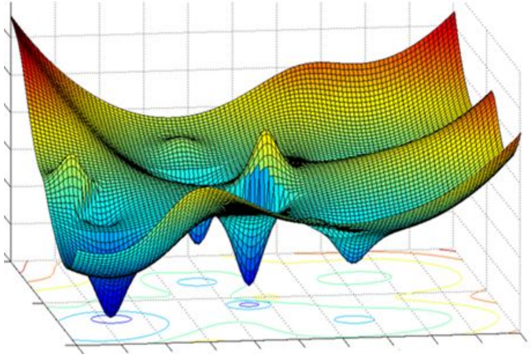
Batch defines the number of observations in each “chunk”.

Epochs are how many times you want the whole dataset to go through the network.

All the **batches** = one **epoch**.

Learning rate is from gradient descent

Scenario	Cost/Loss Function
Regression	MSE
Binary classification	Cross-Entropy (Logarithmic loss)
Multi-class classification	Softmax of Cross-Entropy



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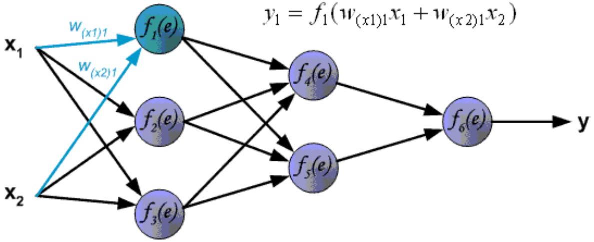
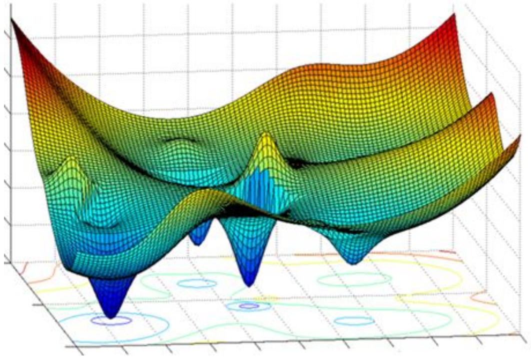
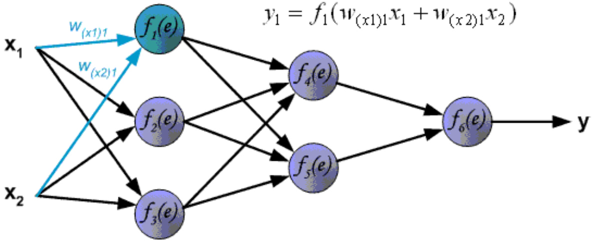


Optimizer is how the gradient is calculated

Options
sgd
rmsprop
Adagrad
Adadelta
Adam
And more!



FP



Regularization - adjusts the weights by layer

Adding a set penalization term at each collector node.

You can choose no regularization, lasso, or ridge.

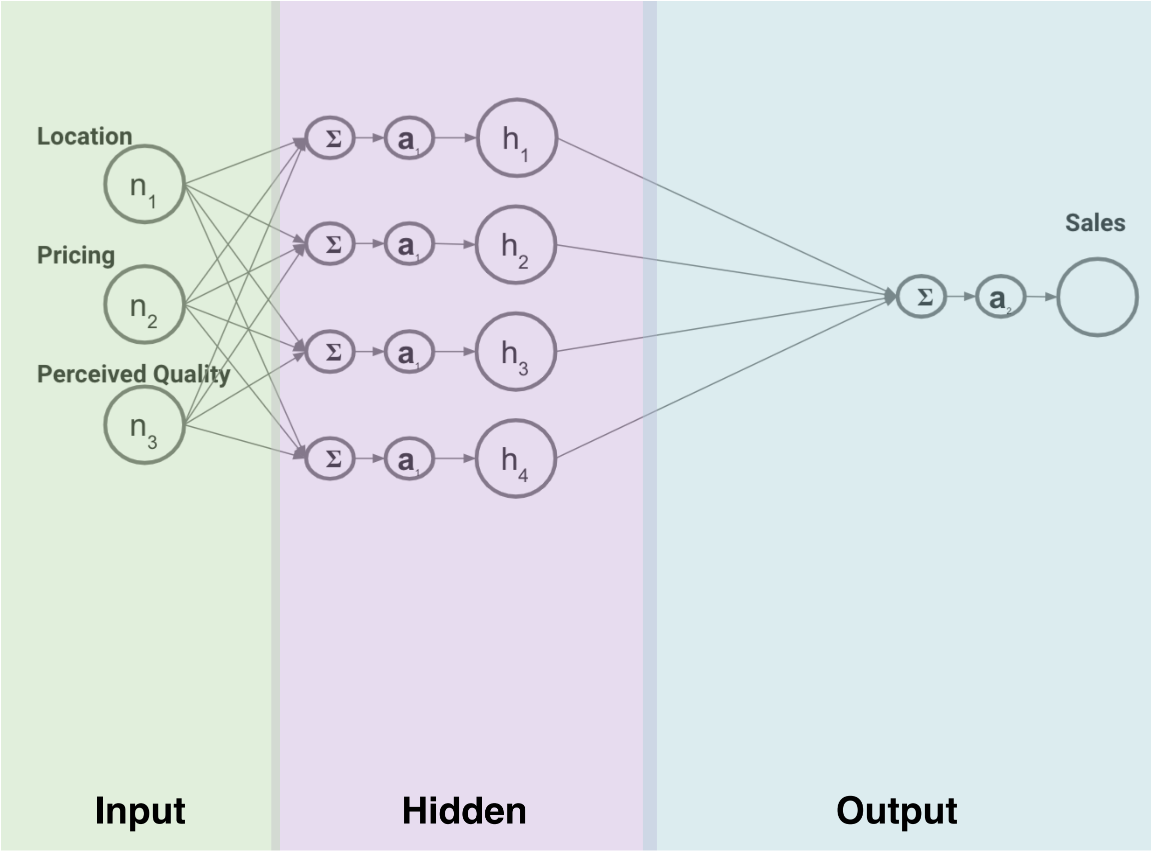
Write in sentences what this code does

```
model = Sequential()
model.add(Dense(32, activation='relu', input_dim=100))
model.add(Dense(1, activation='sigmoid'))
model.compile(optimizer='rmsprop',
              loss='binary_crossentropy',
              metrics=['accuracy'])

# Generate dummy data
import numpy as np
data = np.random.random((1000, 100))
labels = np.random.randint(2, size=(1000, 1))

# Train the model, iterating on the data in batches of 32 samples
model.fit(data, labels, epochs=10, batch_size=32)
```

Even without learning Keras explicitly, you should be able to recognize keywords and concepts based on this review.

Dense = fully connected to all previous nodes

While we have covered this:



Know this is a whole additional area.