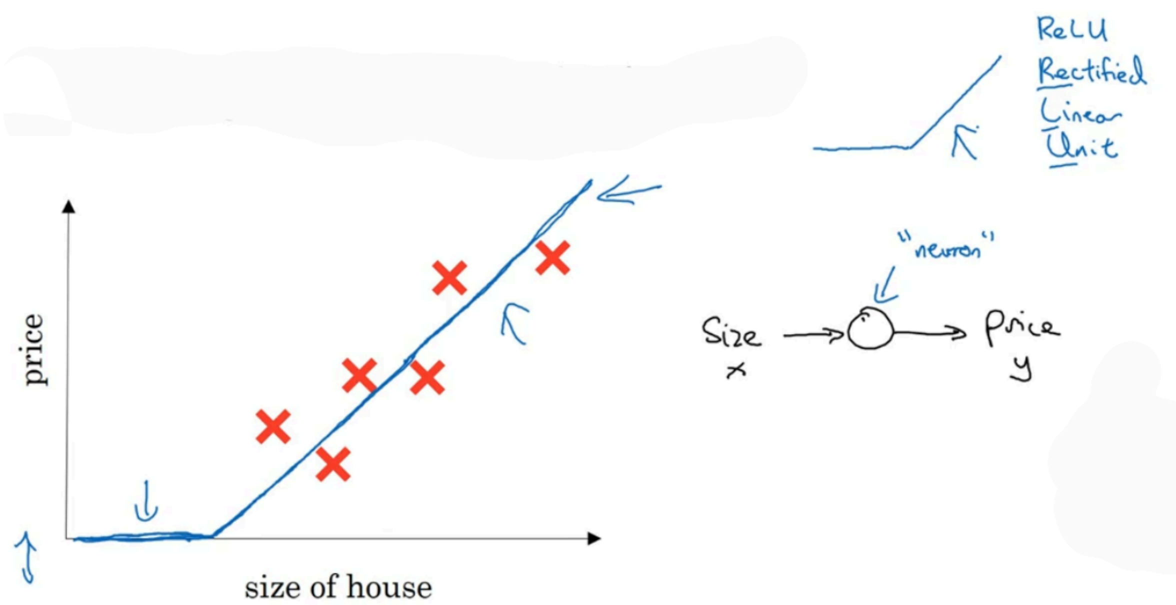
Week 1: Introduction

> AI is the new Electricity —- Andrew Ng

What is a Neural Network?

- A computational model inspired by the human brain's structure and function
- Consists of interconnected nodes (neurons) organized in layers
- Processes information through weighted connections between neurons
- Learns patterns from data through a process called training
- Adjusts connection weights using algorithms like backpropagation
- Can recognize complex patterns and make predictions
- Composed of input layer, hidden layer(s), and output layer
- Uses activation functions to introduce non-linearity
- Capable of solving problems in classification, regression, and pattern recognition
- Forms the foundation of deep learning and many AI applications

1. Housing Price Prediction (Single Feature)

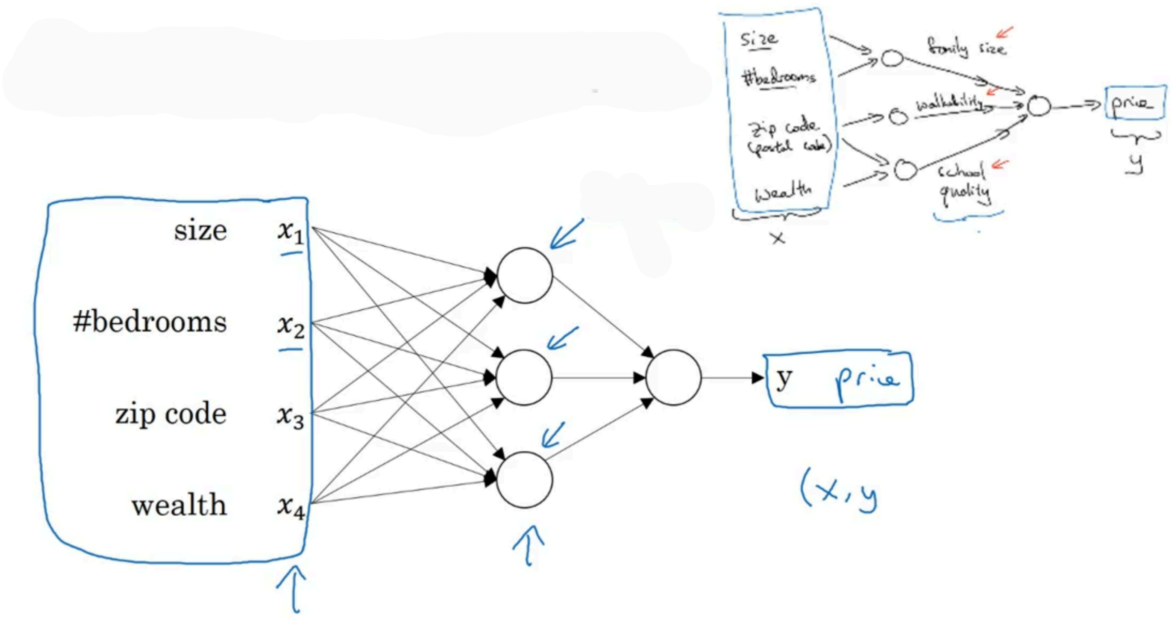


- **Input**: size of house x
- **Output**: price y
- **Model**: $y = wx + b$
- **Neuron**: $Input \rightarrow Neuron \rightarrow Output$
- **Activation**: ReLU

$$f(z) = \max(0, z)$$

- **Takeaway**: Linear regression can predict price, neuron representation generalizes it.

2. Housing Price Prediction (Multiple Features)



- **Inputs**: $x = [\text{size}, \#\text{bedrooms}, \text{zip code}, \text{wealth}]$
- **Hidden layer**: Learns intermediate features (e.g. family size, walkability, school quality).
- **Output**: price y
- **Formulas**:
  - Hidden:

$$a^{[1]} = g(W^{[1]}x + b^{[1]})$$

- Output:

$$\hat{y} = g(W^{[2]}a^{[1]} + b^{[2]})$$

- **Takeaway**: Neural nets extract useful features automatically.

Supervised Learning Examples

General Idea

- **Input (x)** → **Model** → **Output (y)**
- Different tasks = different kinds of inputs/outputs.

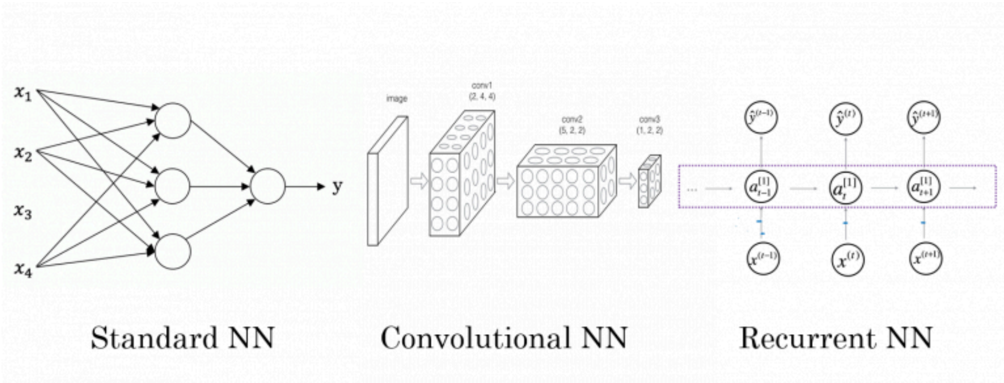
Examples

Input (x)	Output (y)	Application
Home features	Price	Real Estate
Ad, user info	Click on ad? (0/1)	Online Advertising
Image	Object (1,…,1000)	Photo tagging
Audio	Text transcript	Speech recognition
English	Chinese	Machine translation
Image + Radar info	Position of other cars	Autonomous driving

Takeaway

- **Regression**: Output is continuous (e.g., house price).
- **Classification**: Output is discrete (e.g., click = 0/1).
- **Structured prediction**: Output is complex (text, translation, positions).

Types of Neural Networks



1. Standard Neural Network (Fully Connected / Dense NN)

- **Input**: feature vector $x = [x1, x2, ..., xn]$.
- **Connections**: every neuron connected to all neurons in next layer.
- **Output**: prediction y.
- **Applications**: structured data (tabular, simple regression/classification).

2. Convolutional Neural Network (CNN)

- Designed for **images**.
- Uses **convolution filters** to detect patterns (edges, shapes, objects).
- Layers:

$$conv1 \rightarrow conv2 \rightarrow conv3 \rightarrow fullyconnected \rightarrow output$$

- **Applications**:
  - Image recognition
  - Photo tagging
  - Medical image analysis

3. Recurrent Neural Network (RNN)

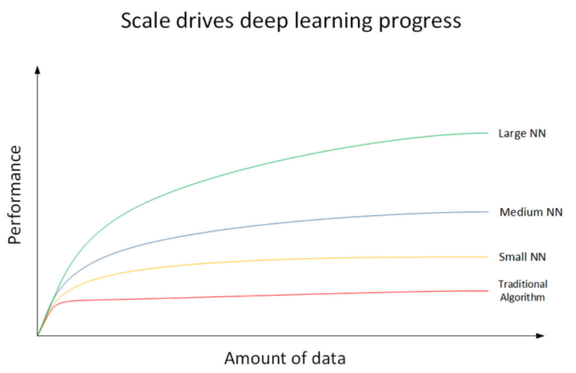
- Designed for **sequential data**.
- Input at time $t : x^{(t)}$.
- Hidden state $a^{(t)}$ carries information from previous steps.
- Output at time $t : \hat{y}^{(t)}$.
- **Applications**:

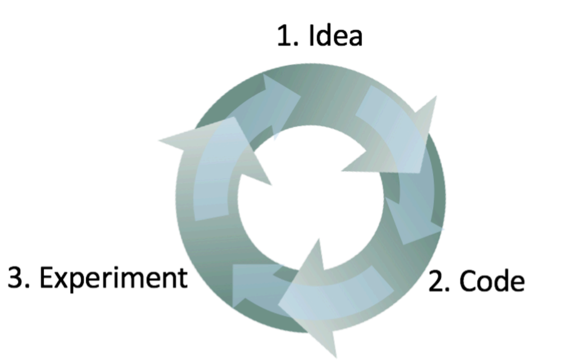
- Speech recognition
- Language modeling & translation
- Time-series forecasting

Takeaway

- **Standard NN** → Structured/tabular data.
- **CNN** → Image/video data.
- **RNN** → Sequential/text/audio data.

Why is Deep Learning taking off?





- **X-axis**: Amount of data.
- **Y-axis**: Performance.
- Curves:
  - 🔴 Traditional algorithms → saturate early.
  - 🟡 Small NN → better, but limited.
  - 🔵 Medium NN → improves more with data.
  - 🟢 Large NN → best scaling with huge data.

Key Insight

- **Performance = Algorithm + Data + Compute**.
- Larger NNs continue to learn from massive datasets, unlike traditional ML.

Takeaway

- Scale (data + bigger networks) is the **key driver** of deep learning's success.
- like shifting from sigmoid function to ReLU significantly improved the computation

> "More data beats clever algorithms."

Geoffrey Hinton Interview

Geoffrey Hinton's Key Points:

- Deep learning represents a revolutionary approach to AI where machines learn representations rather than being explicitly programmed
- The importance of backpropagation as a key algorithm for training neural networks
- The significance of distributed representations in neural networks
- The breakthrough of using ReLU activation functions to address the vanishing gradient problem
- How dropout techniques help prevent overfitting in neural networks
- The development of capsule networks to better handle spatial hierarchies
- The future potential of unsupervised learning approaches

Andrew Ng's Key Points:

- The role of large-scale data in the success of modern deep learning
- The importance of computational resources in enabling complex neural network architectures
- How algorithmic innovations have accelerated neural network training
- The concept of transfer learning to leverage pre-trained models
- Practical strategies for structuring machine learning projects
- The importance of hyperparameter tuning and optimization
- How deep learning is transforming various industries including healthcare, autonomous vehicles, and natural language processing
- The ethical considerations and societal impacts of AI