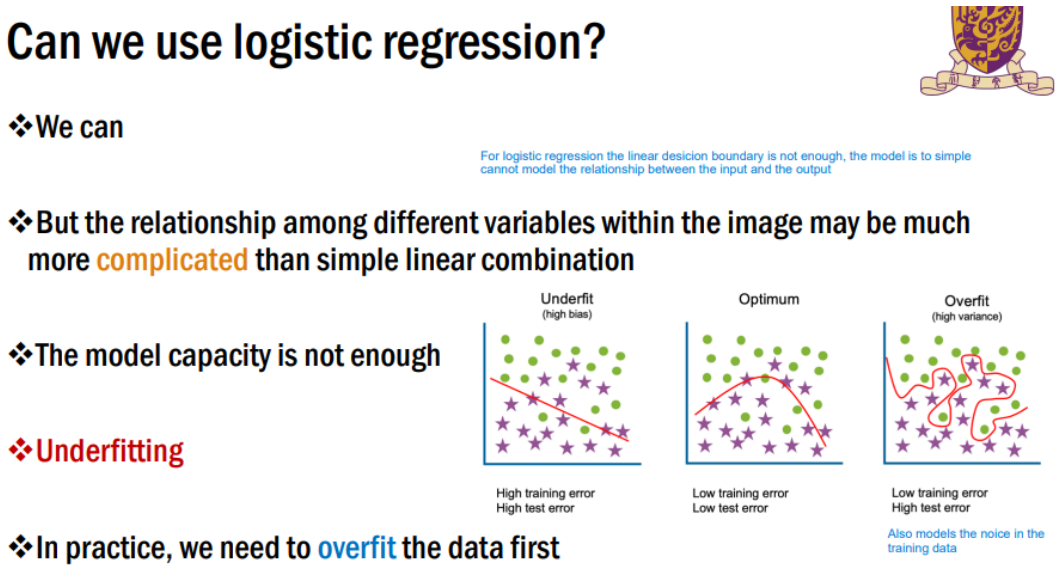
Neural Networks

Neural networks, also known as artificial neural networks (ANNs) or simulated neural networks (SNNs), are a subset of machine learning and are at the heart of deep learning algorithms. Their name and structure are inspired by the human brain, mimicking the way that biological neurons signal to one another.

Each individual node as its own linear regression model, composed of input data, weights, a bias (or threshold), and an output.



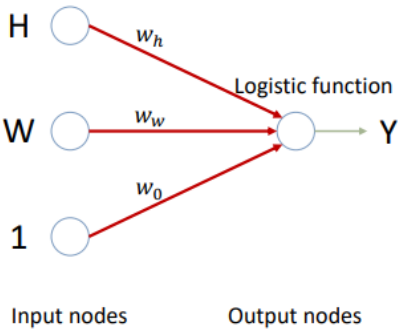
Linear regression analysis is used to predict the value of a variable based on the value of another variable. The variable you want to predict is called the dependent variable. The variable you are using to predict the other variable's value is called the independent variable.

Linear-regression models are relatively simple and provide an easy-to-interpret mathematical formula that can generate predictions. Linear regression can be applied to various areas in business and academic study

Because linear regression is a long-established statistical procedure, the properties of linear-regression models are well understood and can be trained very quickly.

However, it has its limitations.

The problem of logistic regression

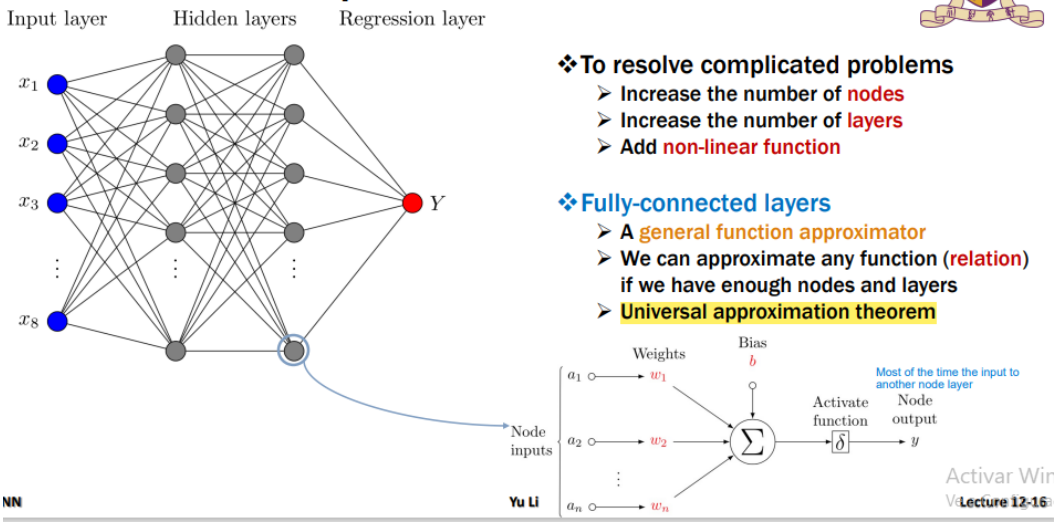


$$Y^{output} = \frac{1}{1 + e^{-(w_h H + w_w W + w_0)}}$$

- The relation between the output and input may be nonlinear
- The relation between the output and input can be very complex

An approach to solve this problem is

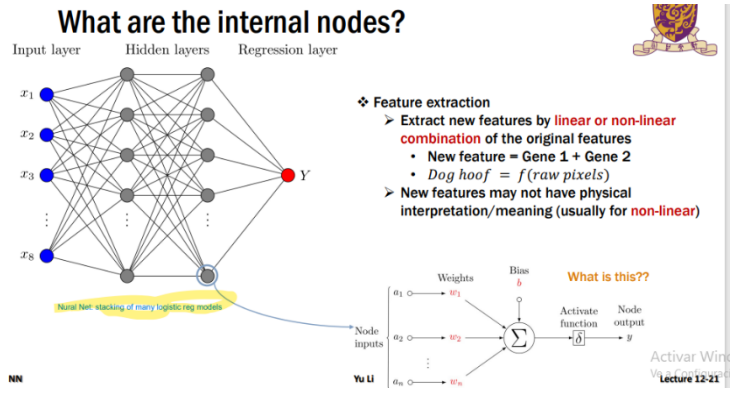
From LR to deep neural networks



- To resolve complicated problems
  - Increase the number of nodes
  - Increase the number of layers
  - Add non-linear function
- Fully-connected layers
  - A general function approximator
  - We can approximate any function (relation) if we have enough nodes and layers
  - Universal approximation theorem

The most common type of layer to construct a basic neural network is the fully connected layer, in which the adjacent layers are fully connected pairwise and neurons in a single layer are not connected to each other.

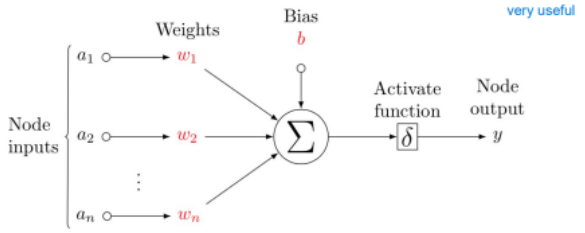
What are the internal nodes?



- Feature extraction
  - Extract new features by linear or non-linear combination of the original features
    - New feature = Gene 1 + Gene 2
    - $Dog\ hoof = f(raw\ pixels)$
  - New features may not have physical interpretation/meaning (usually for non-linear)

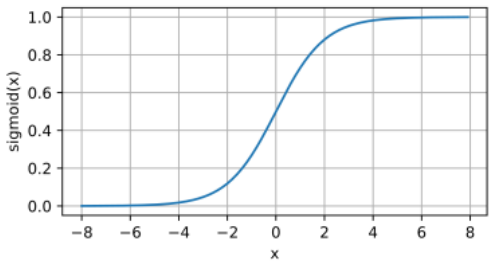
Feature Extraction aims to reduce the number of features in a dataset by creating new features from the existing ones (and then discarding the original features). These new reduced set of features should then be able to summarize most of the information contained in the original set of features.

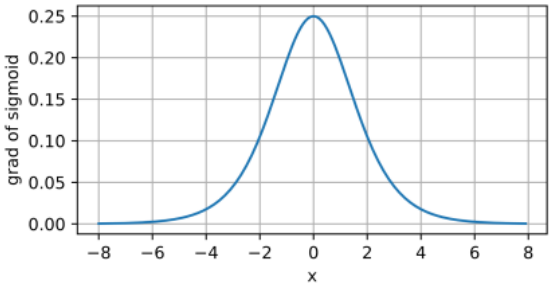
Different activation functions-Sigmoid



$$Sigmoid(x) = \frac{1}{1 + \exp(-x)}$$

$$\frac{d}{dx}\text{sigmoid}(x) = \frac{\exp(-x)}{(1 + \exp(-x))^2}$$
$$= sigmoid(x)\big(1 - sigmoid(x)\big)$$

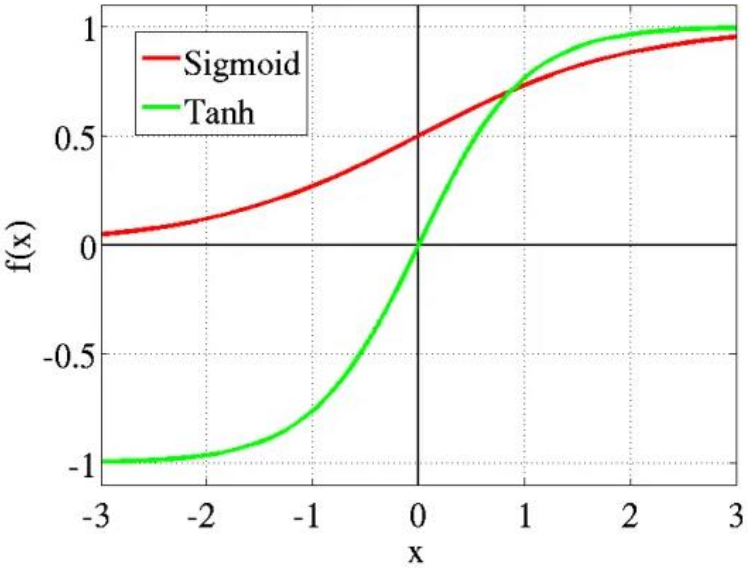




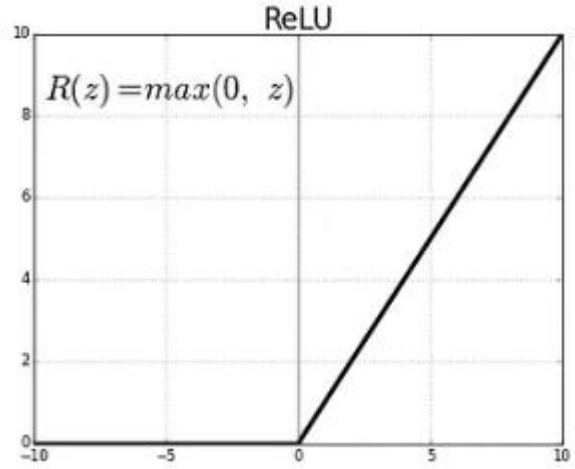
It is used to determine the output of neural network like yes or no. It maps the resulting values in between 0 to 1 or -1 to 1 etc. (depending upon the function).

The Activation Functions can be basically divided into 2 types>

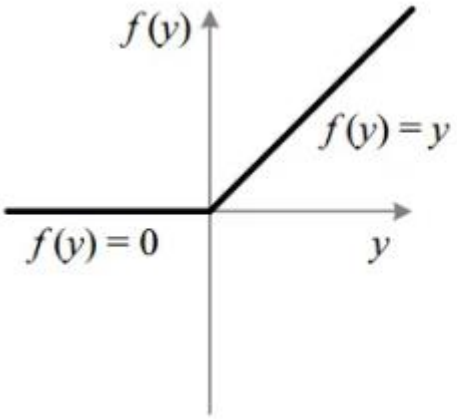
- Linear Activation Function
- Non-linear Activation Functions
    - Sigmoid or Logistic Activation Function: is especially used for models where we must predict the probability as an output. Since probability of anything exists only between the range of 0 and 1, sigmoid is the right choice.
    - Tanh or hyperbolic tangent Activation Function: tanh is also like logistic sigmoid but better. The range of the tanh function is from (-1 to 1). tanh is also sigmoidal (s - shaped).

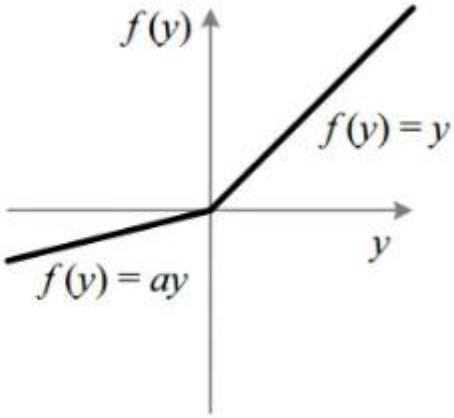


- ReLU (Rectified Linear Unit) Activation Function: The ReLU is the most used activation function in the world right now. Since, it is used in almost all the convolutional neural networks or deep learning.



- Leaky ReLU: It is an attempt to solve the dying ReLU problem



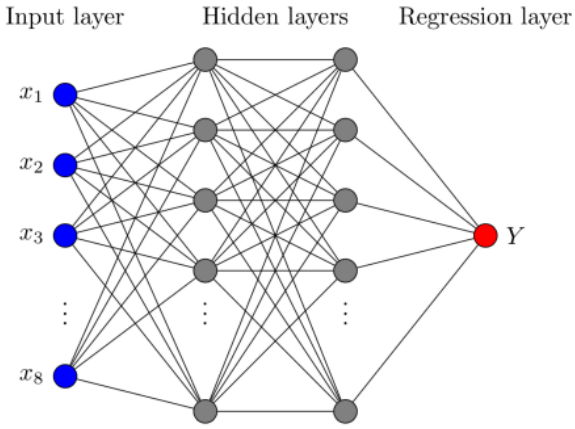


How to choose activation function?

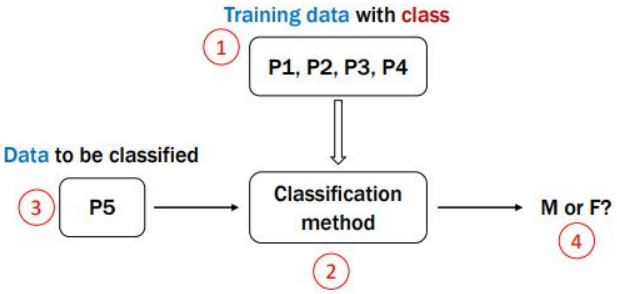
❖ Hidden layers
- ➢ By default, ReLU

very important

❖ Output layer
- ➢ Depends on your task
- ➢ Regression: Sigmoid
- ➢ Binary classification: Sigmoid
- ➢ Multi-class classificaton: Softmax



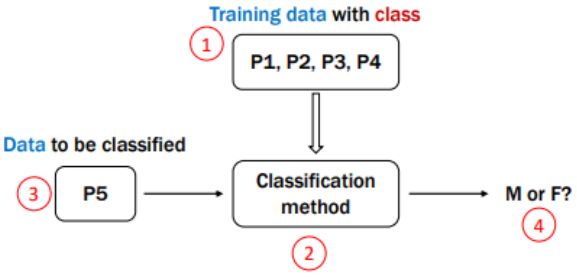
Deep learning for disease screening

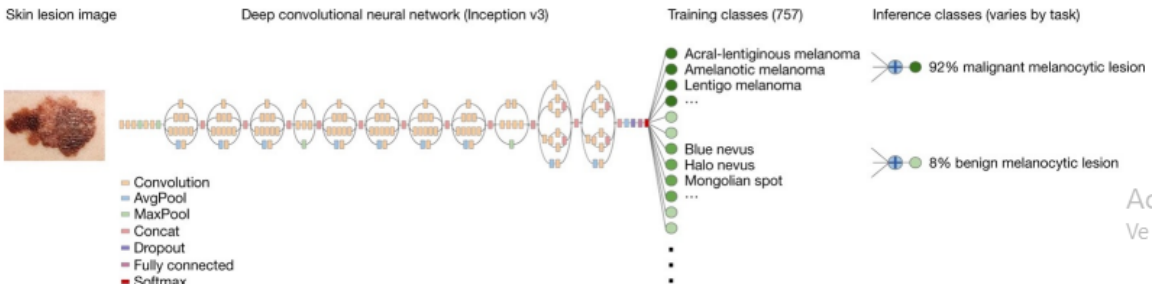


Deep learning: Deep learning is a subset of machine learning, which is essentially a neural network with three or more layers.

- Deep learning drives many artificial intelligence (AI) applications and services that improve automation, performing analytical and physical tasks without human intervention.

Deep learning for disease screening





Logistic regression is also used with deel

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