

Introduction to Deep Learning

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About myself

- + Dean FAST NUCES
- + iParhai (startup)
- + Previously
 - + Director Campus
 - + HoD Computer Science
- + Education
 - + PhD. Computer Science
 - + Wayne State Univ, MI, USA

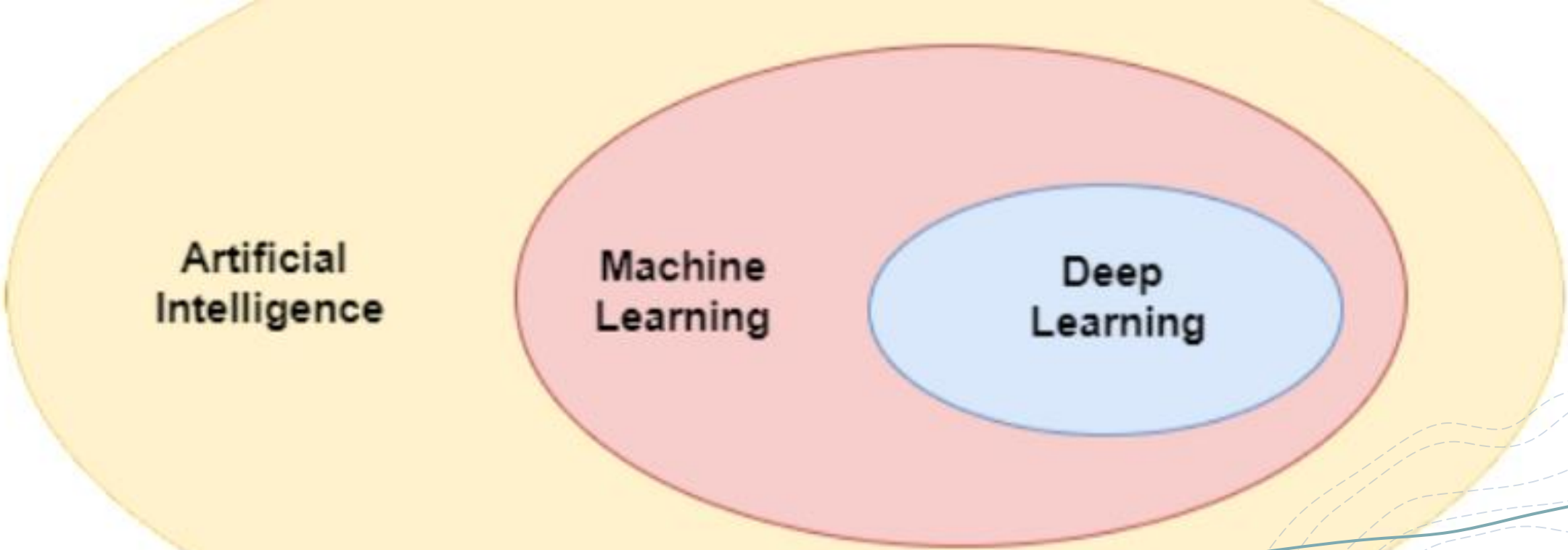


Topics

- + Introductory Lecture on Deep Learning
- + AI vs ML DL
- + Features
- + Neural Networks
- + Activation Functions
- + MLP
- + Applications
- + Types of DNNs
- + Hands-on

AI vs ML and DL

- + AI: Train Machines so they mimic humans
- + ML: A subset of Artificial Intelligence that uses statistical learning algorithms. Has the ability to automatically learn and improve from experiences
- + DL: Subset of ML. Feature selection is integrated with classification.



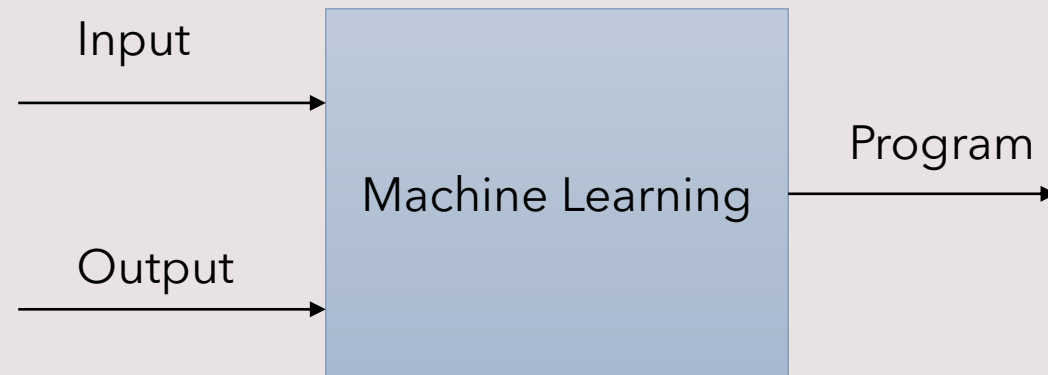
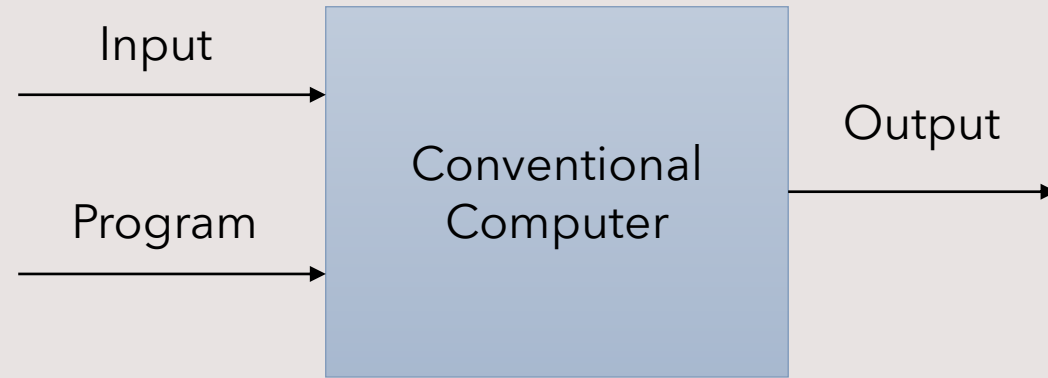
A Venn diagram illustrating the relationship between Artificial Intelligence, Machine Learning, and Deep Learning. It consists of three nested ellipses. The outermost ellipse is yellow and labeled 'Artificial Intelligence'. Inside it is a red ellipse labeled 'Machine Learning'. Inside the red ellipse is a blue ellipse labeled 'Deep Learning'. This visualizes that Deep Learning is a subset of Machine Learning, which is a subset of Artificial Intelligence.

**Artificial
Intelligence**

**Machine
Learning**

**Deep
Learning**

ML vs Programming



The background is a light gray color. It features decorative elements: a white circle in the top-left corner, a white circle in the bottom-right corner, and several wavy lines. Some lines are dashed and light blue, while others are solid and a darker teal color. These lines flow across the slide, adding a modern, abstract feel.

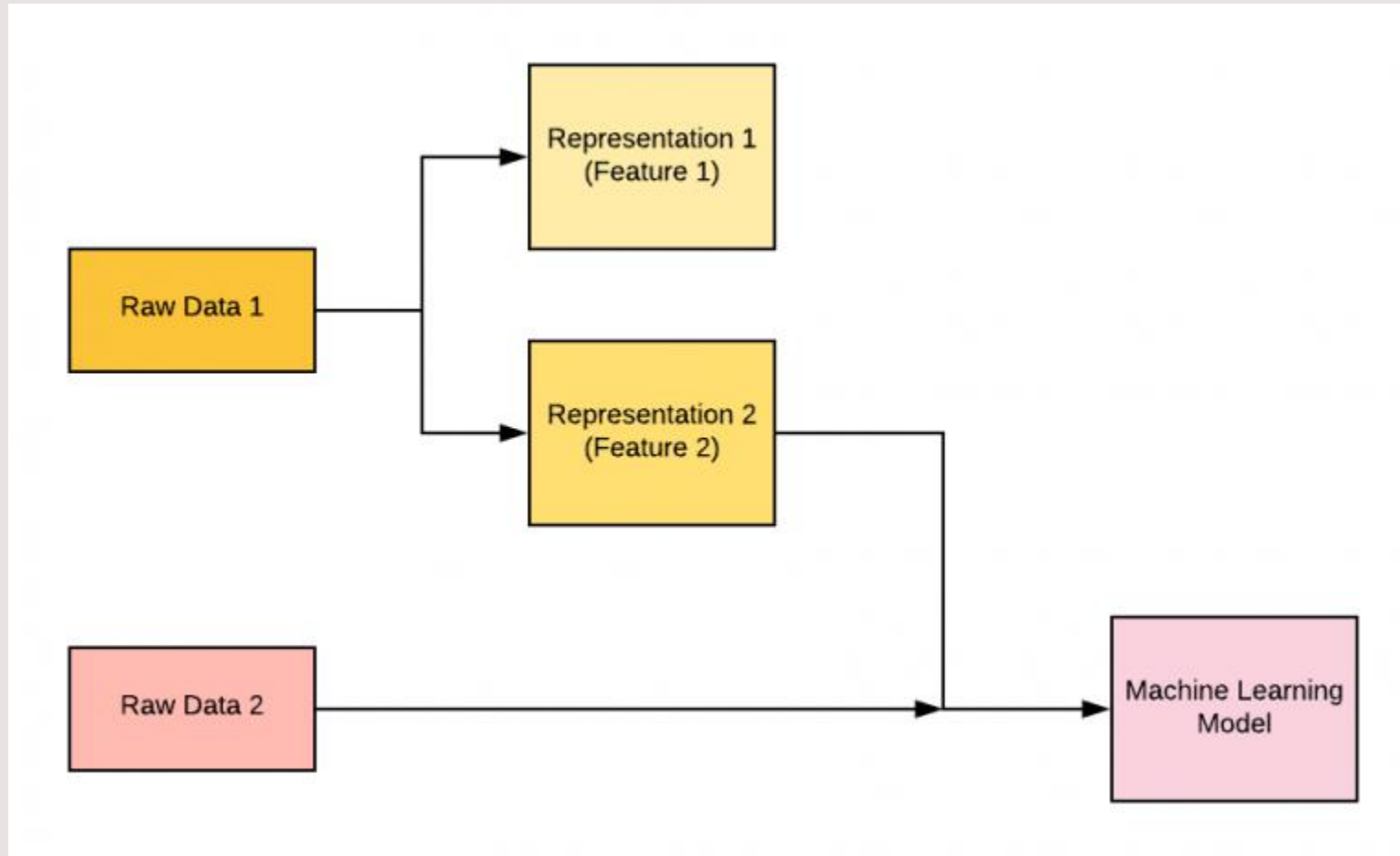
Features

- + Set of independent variables
- + Learned to predict the outcome

Example of Features

- + Predict the Grade ?
 - + No. of lectures attended
 - + No of Hours of Self Study
 - + Previous CGPA

Features



Feature Selection

All Features



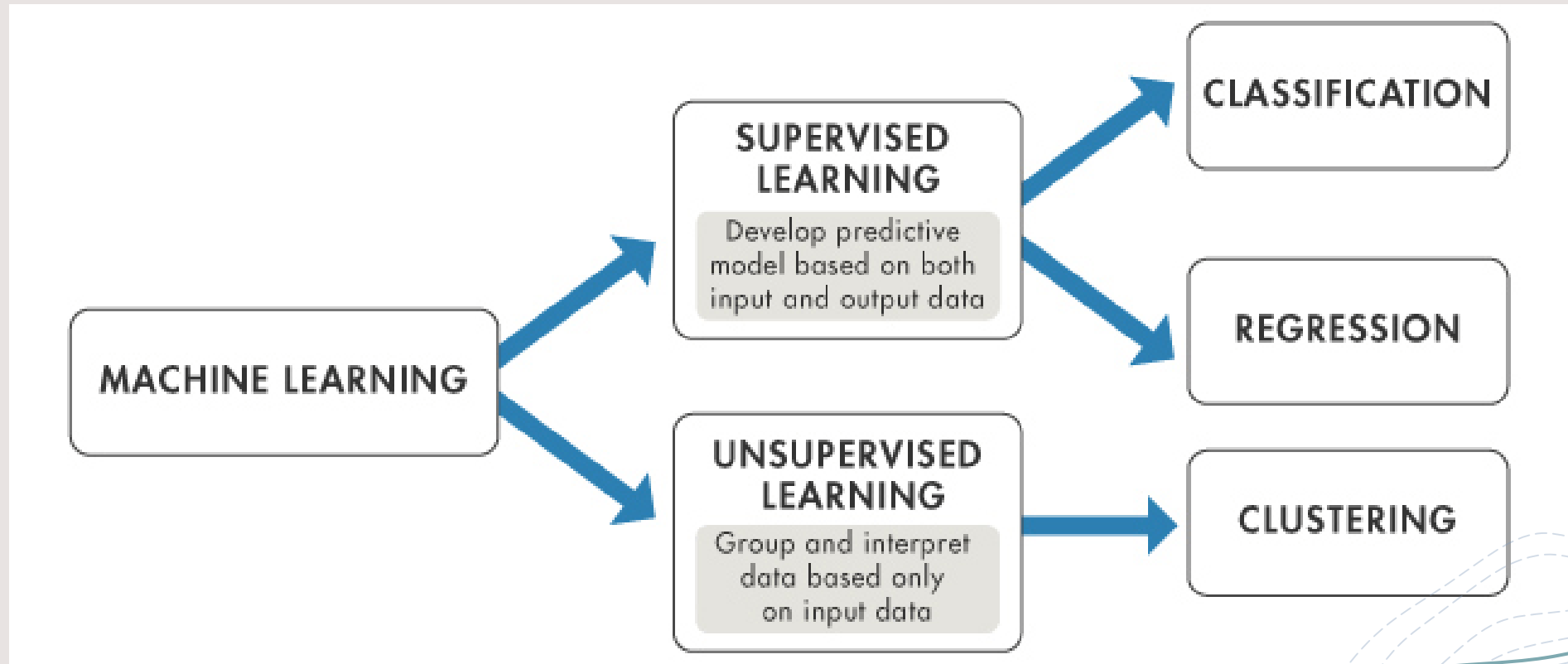
Feature Selection



Final Features

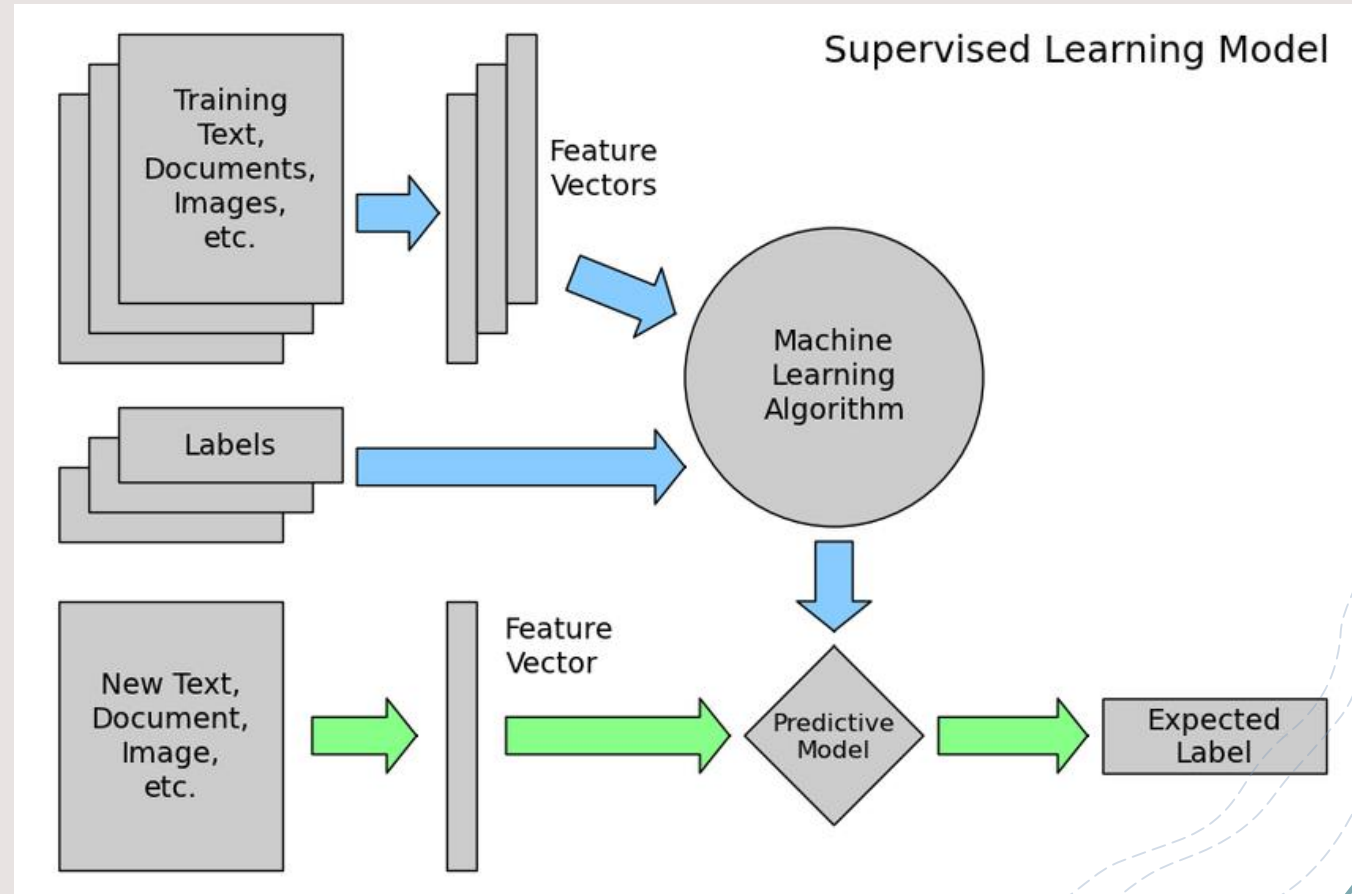


Overview of ML



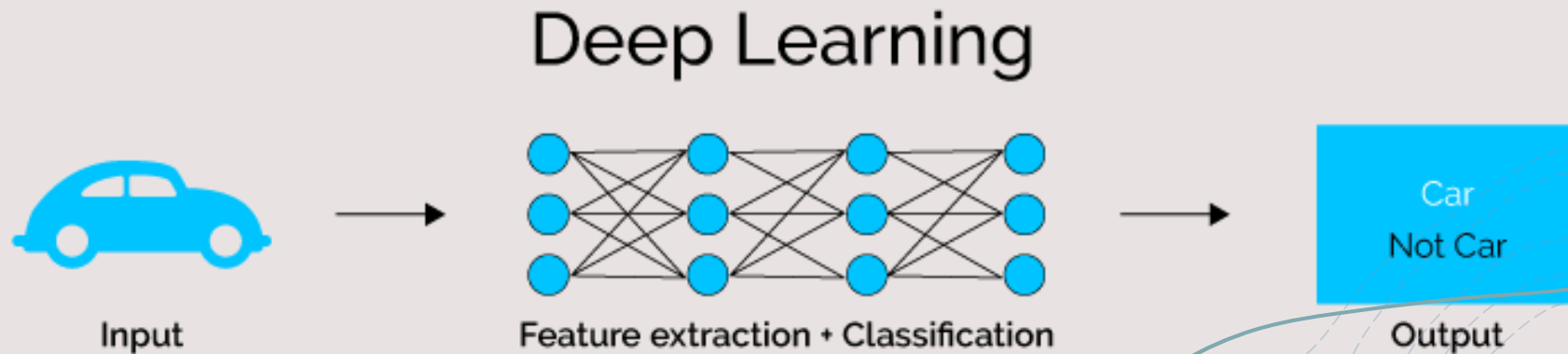
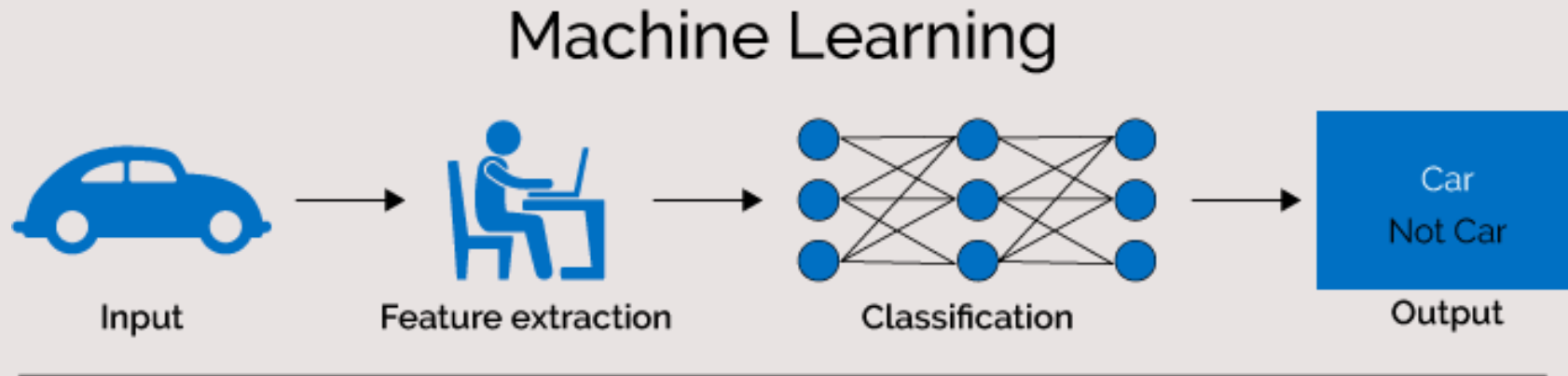
Classification ML Pipeline

- + Pre-process data
- + Extract Features (Attributes) on the basis of which a label can be predicted
- + Develop rules (Train)
- + Evaluate rules (Test)
- + Iterate between 3 and 4



Deep Learning Pipeline

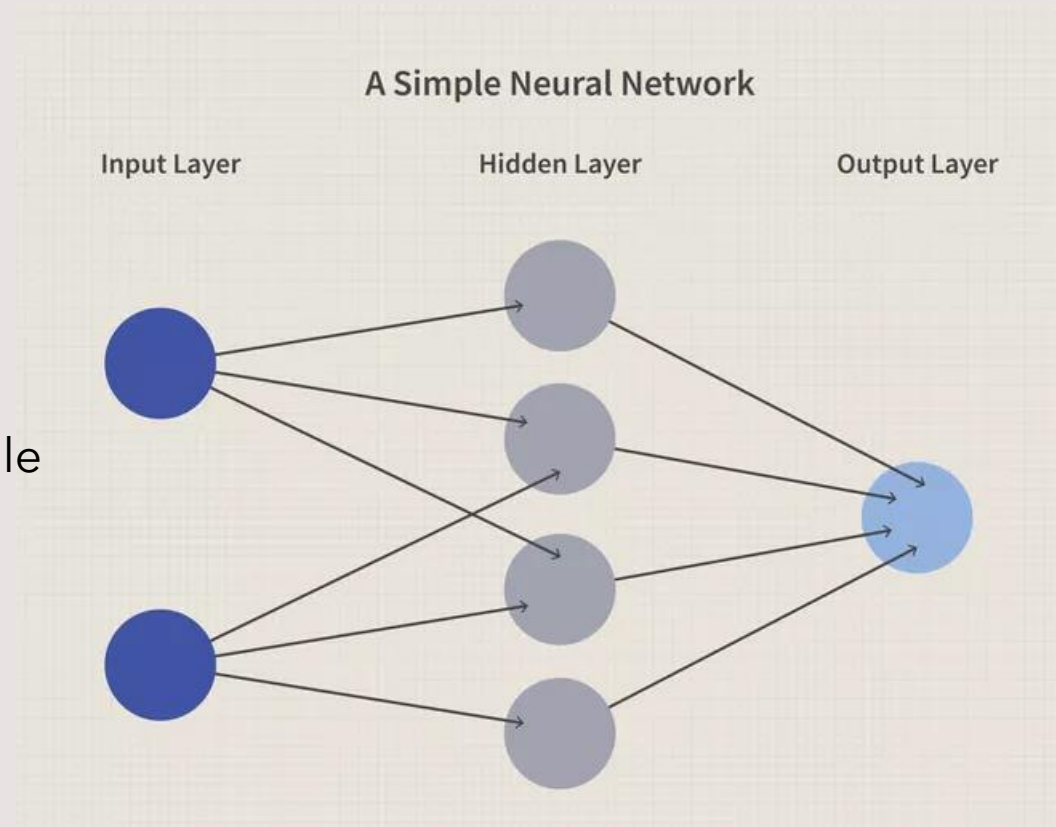
- + In DL, there is no dedicated process of feature extraction. It is bundled with classification



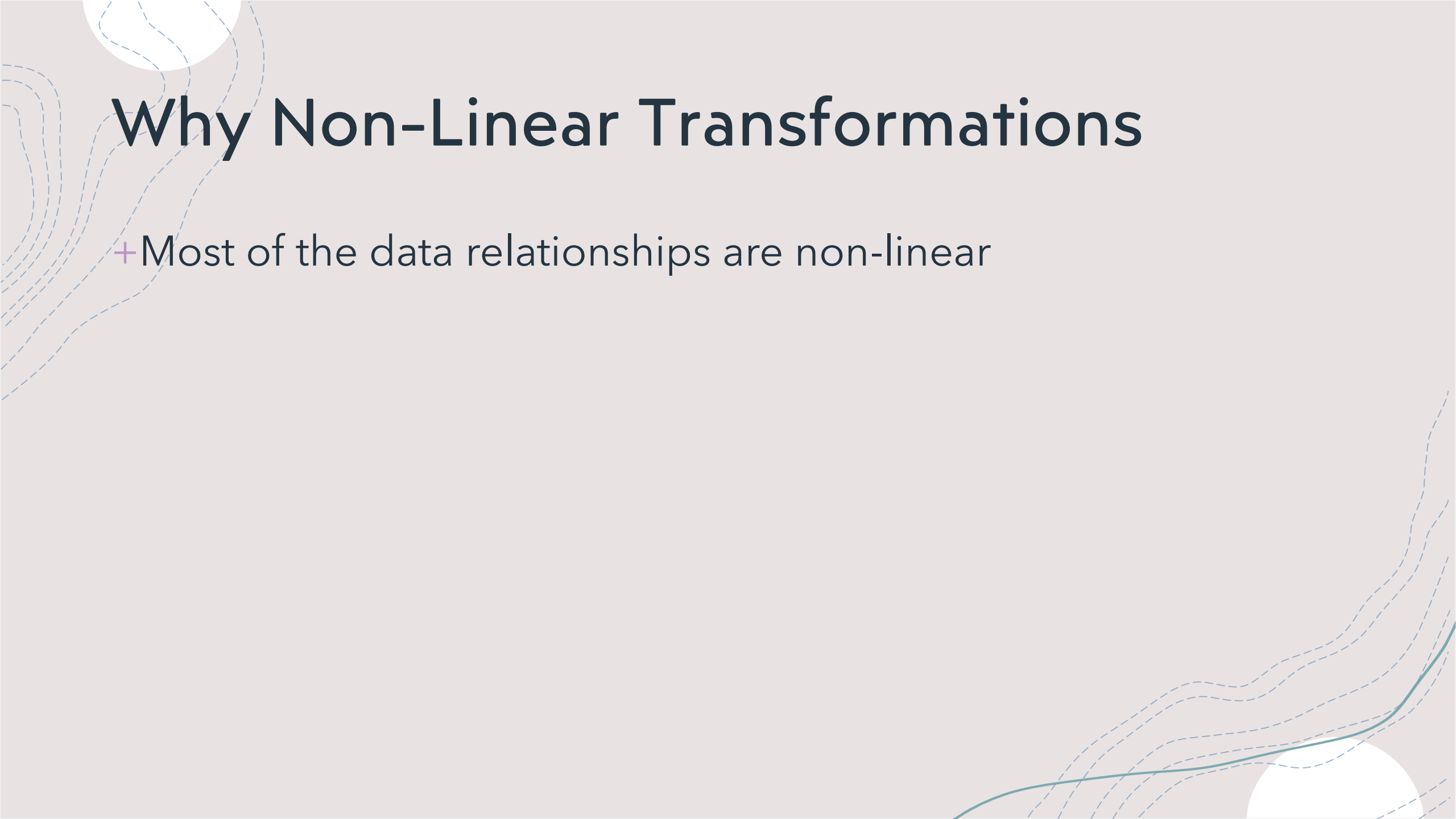
Neural Network

Input layer: Features

Output Layer: Predictor Variable



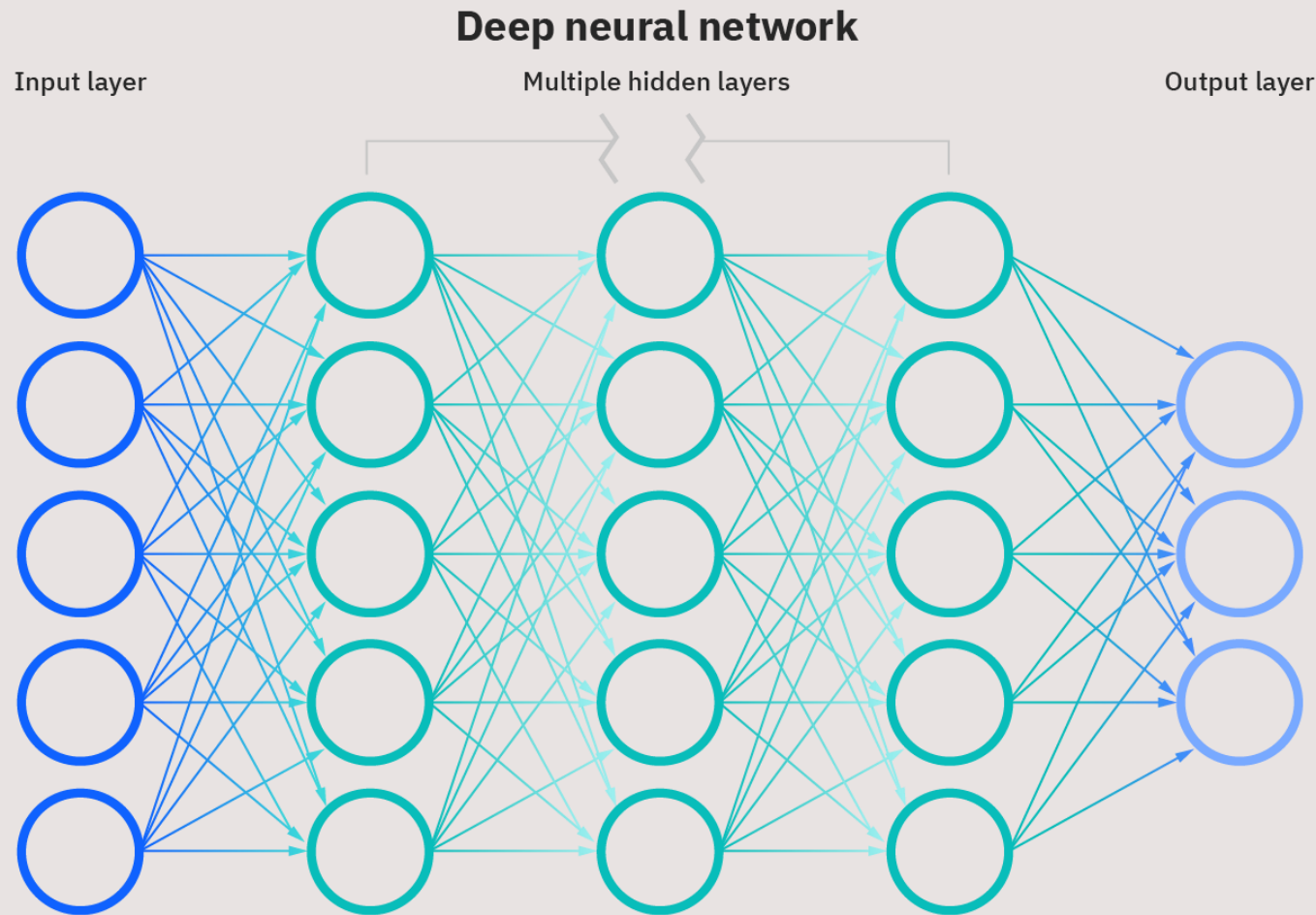
Hidden layer: Non-linear transformations



Why Non-Linear Transformations

- + Most of the data relationships are non-linear

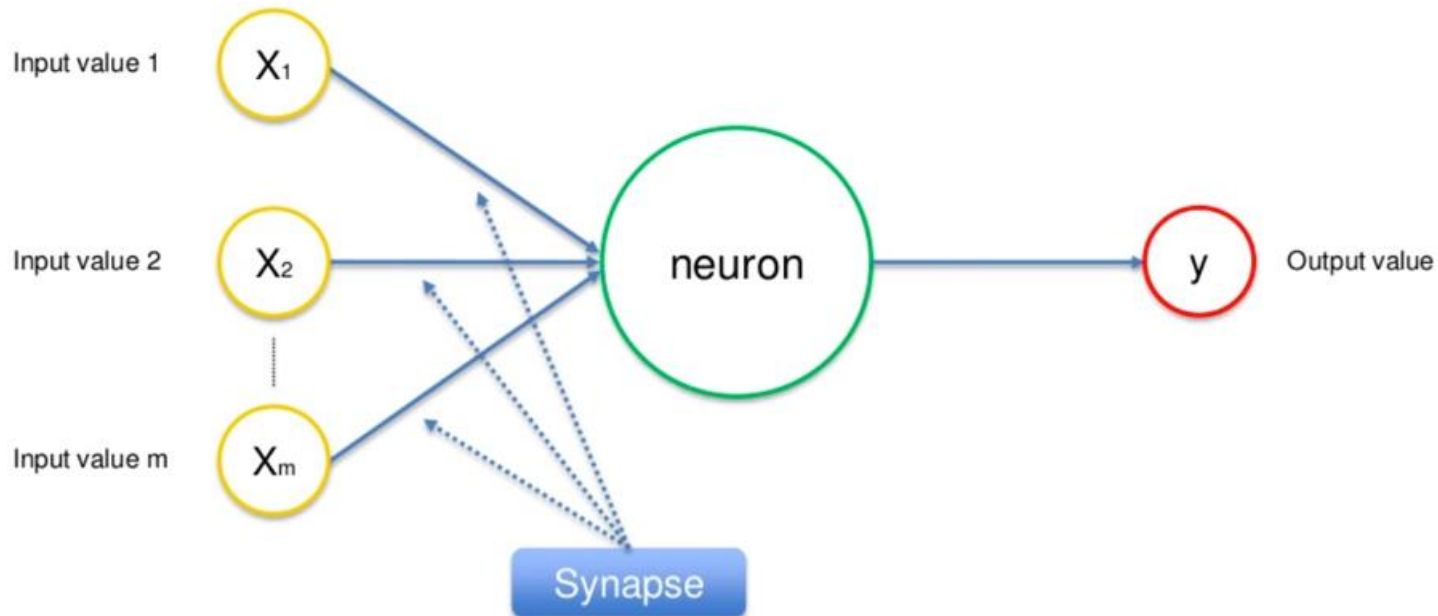
Deep Neural Network



Neuron

The Neuron

Clip slide



- Neuron is a smallest unit of Computation
- Takes weighted sum of inputs
- Applies activation function
- Computes output

Activation Function

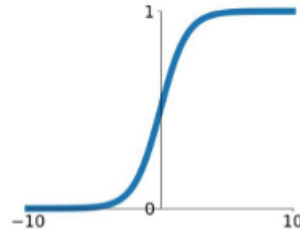
- + Mimics biological Neuron
- + Transforms an input to output

A few Activation Functions

Activation Functions

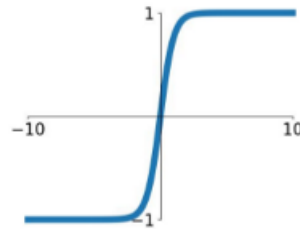
Sigmoid

$$\sigma(x) = \frac{1}{1+e^{-x}}$$



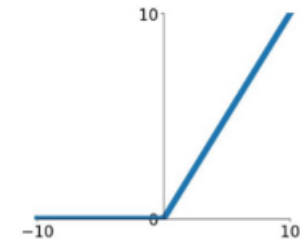
tanh

$$\tanh(x)$$

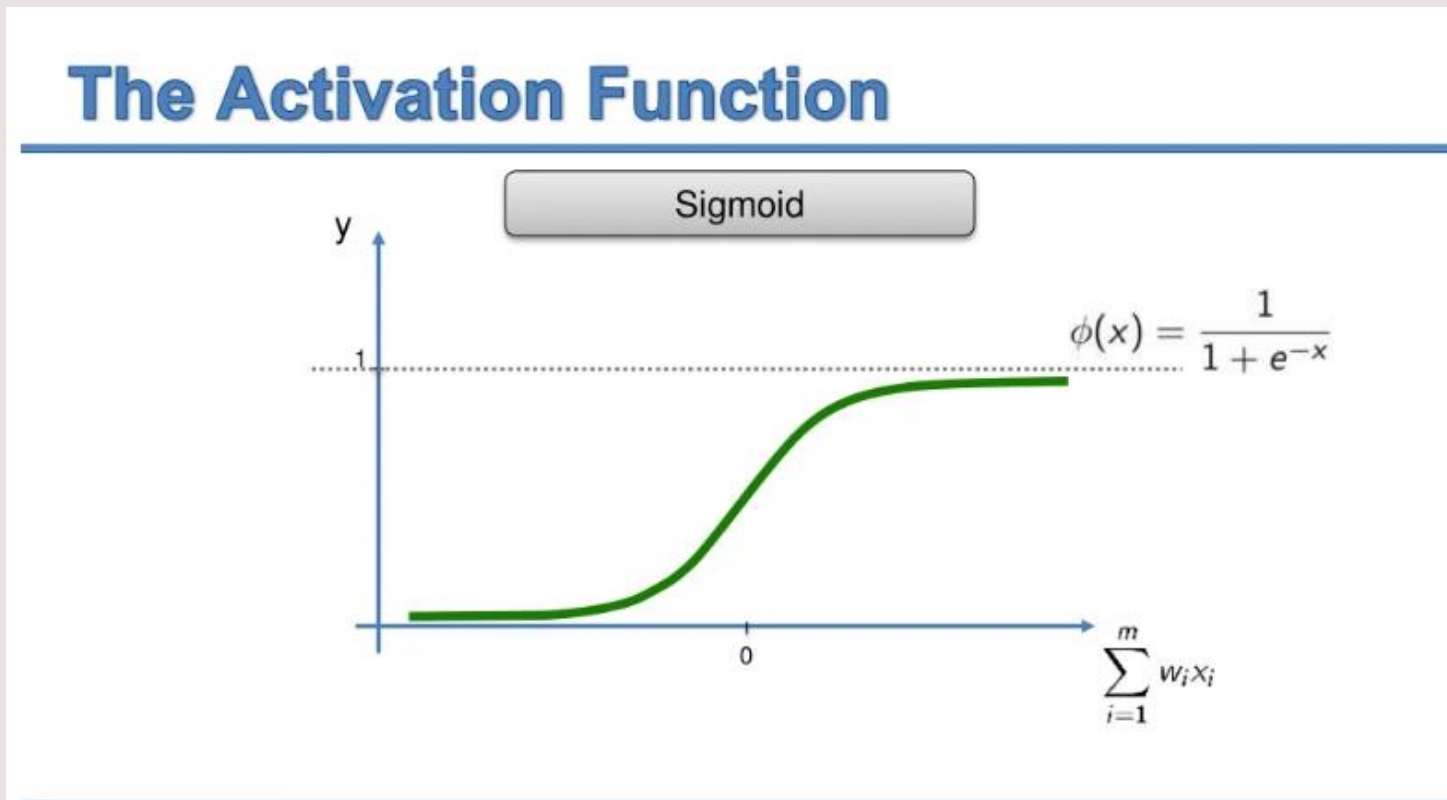


ReLU

$$\max(0, x)$$



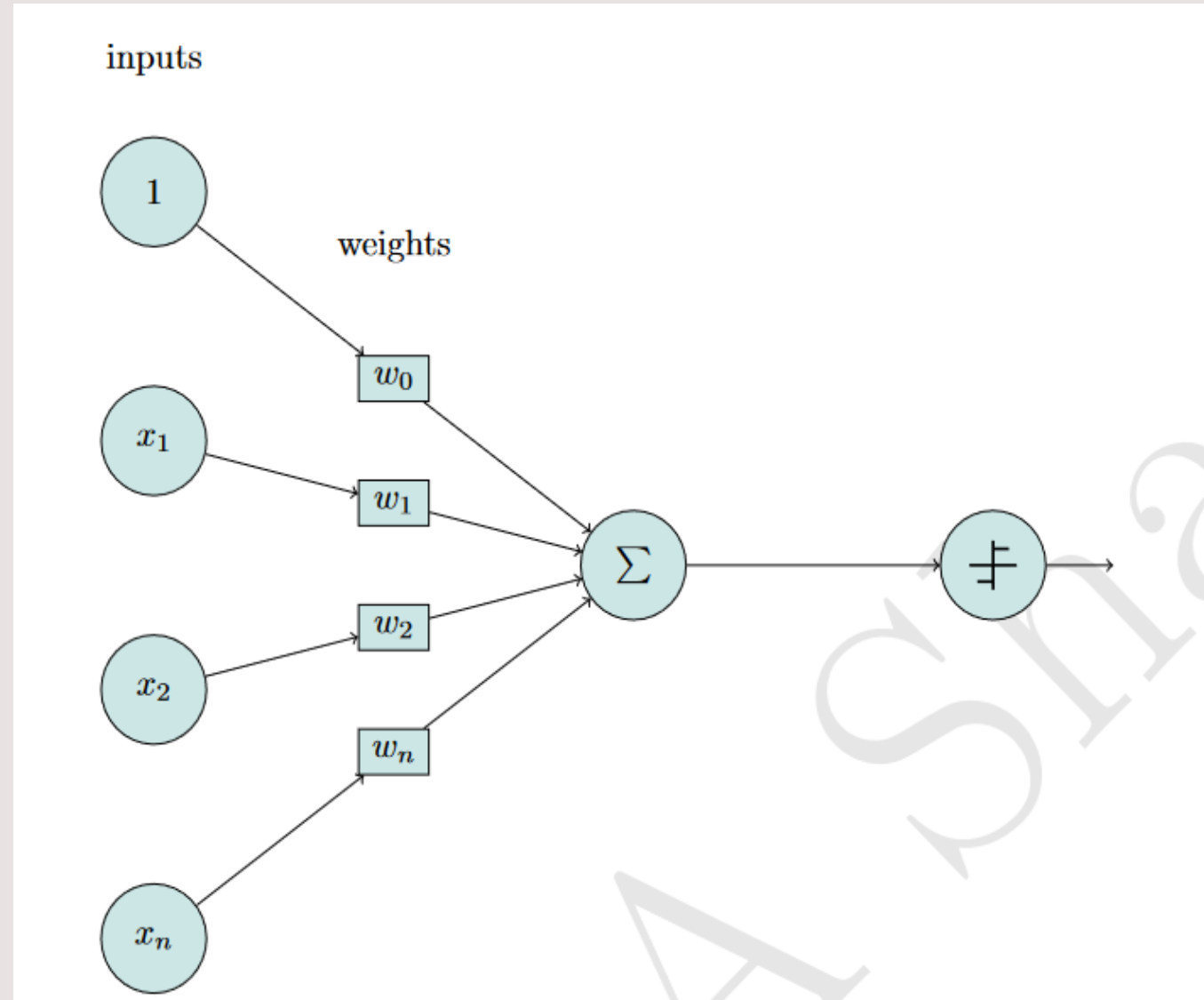
Sigmoid Activation Function



Neuron (Weighted Sum +Activation)

$$Z = \text{ActivationFunction}(w_1x_1 + w_2x_2 + w_3x_3 + b)$$

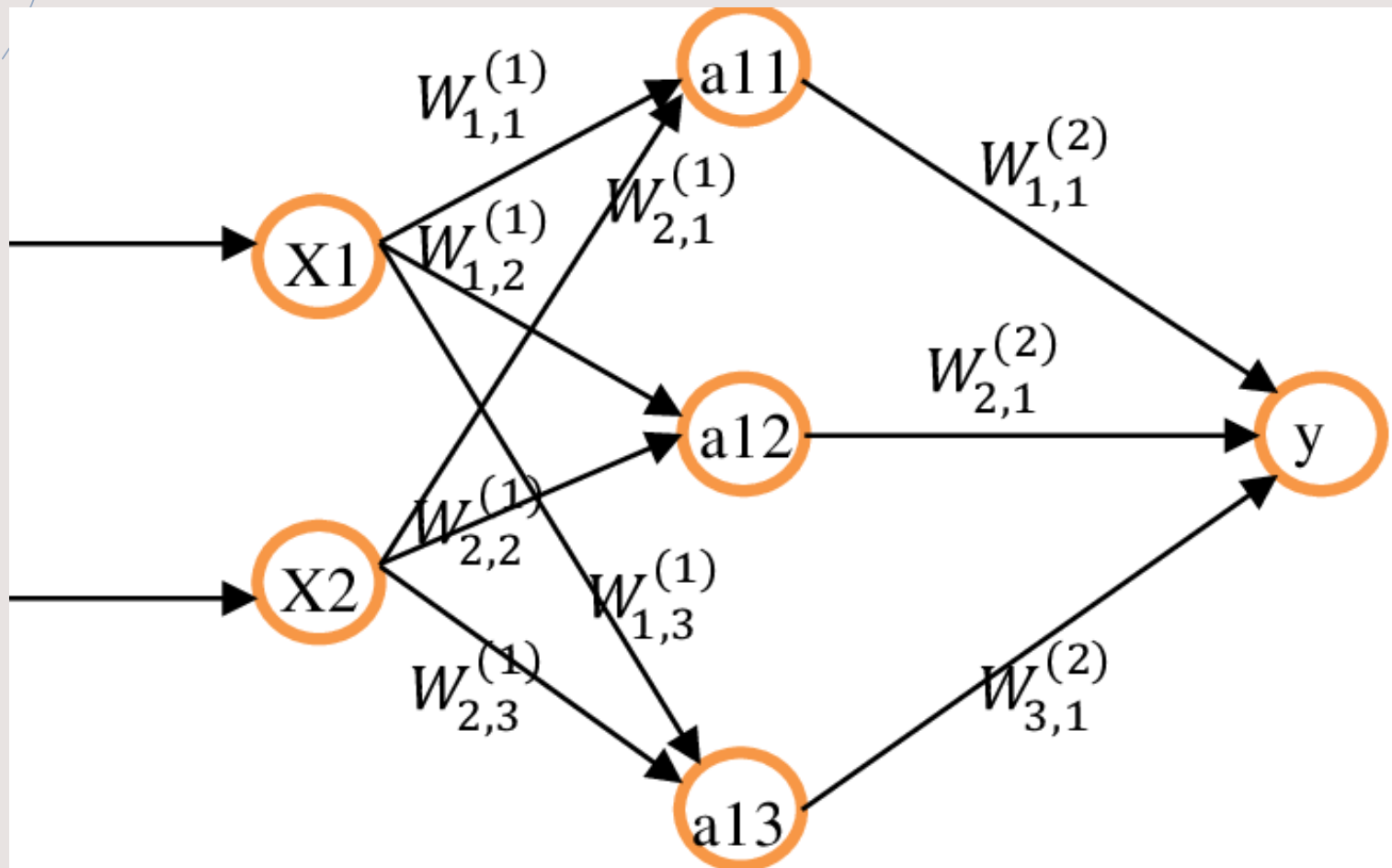
$$b = \text{bias} = (w_0 \cdot 1)$$



Neuron

1. Takes the input signals
2. Computes the weighted sum of the inputs
3. Applies a step function
4. Checks whether to trigger an output if the threshold exceeds a limit.

Output of DNN



Forward Propagation

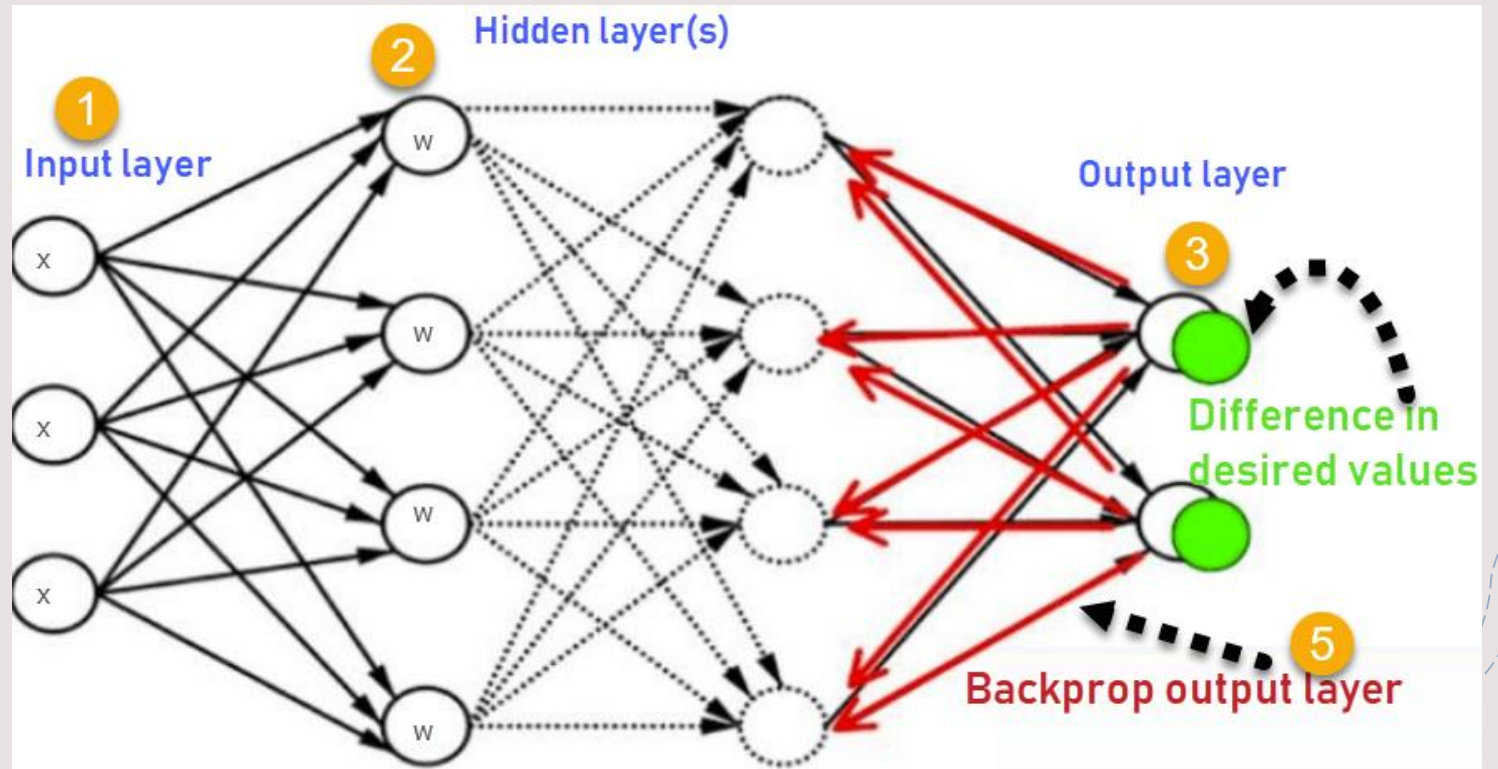


How to get it right

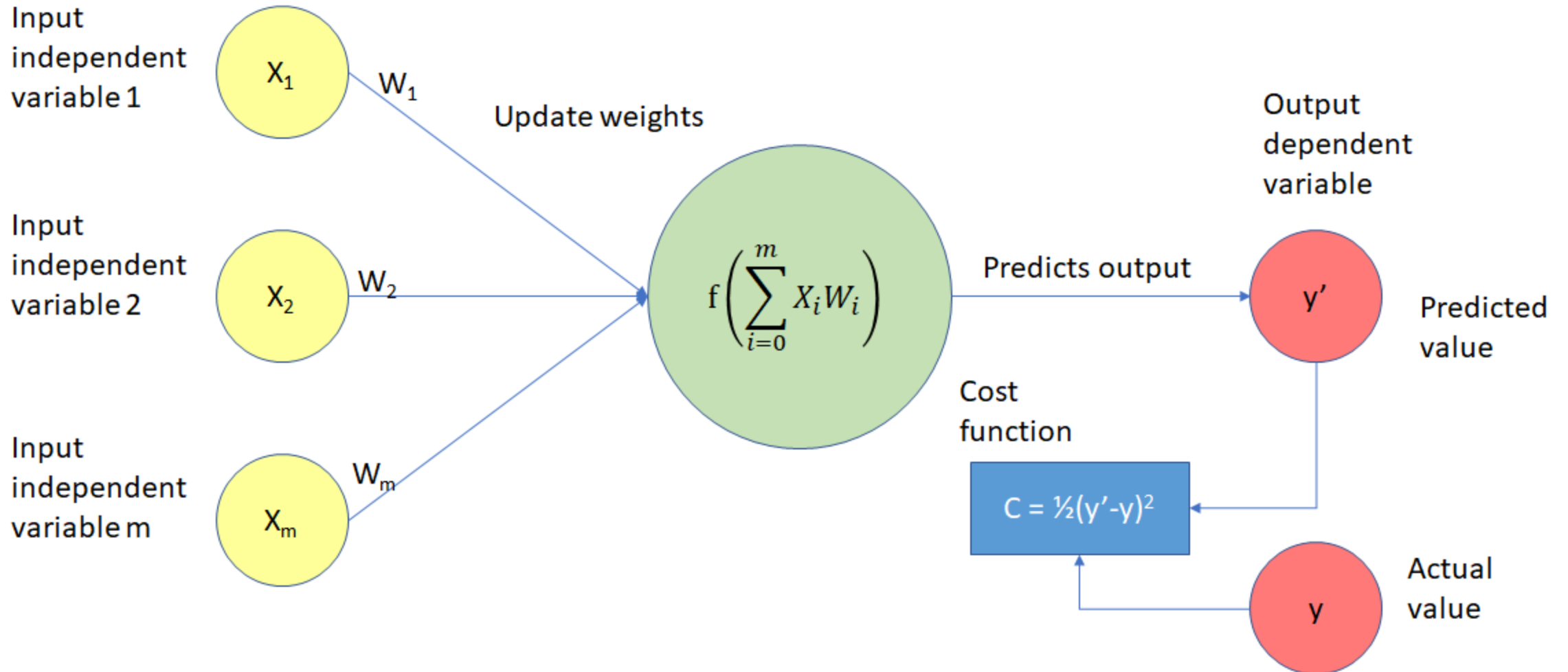
+ Prediction is accurate?

Back Propagation

- + Move backwards
- + Adjust weights



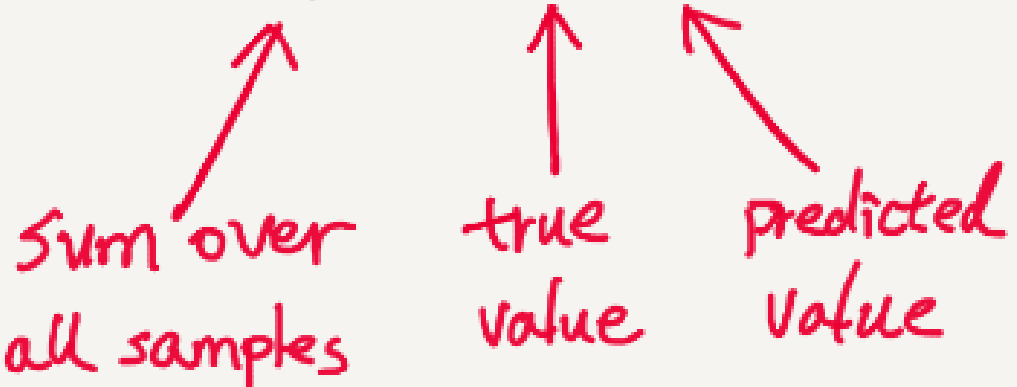
Cost Function



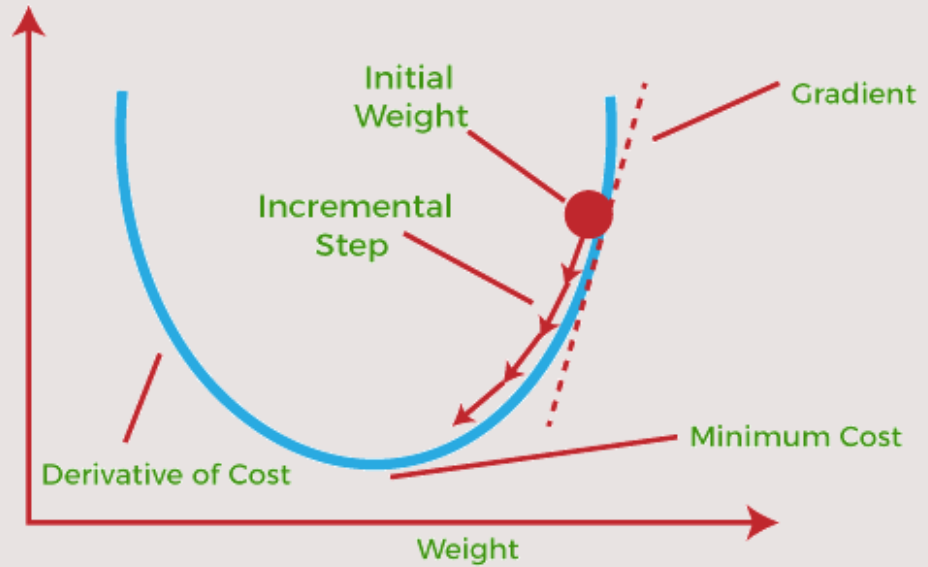
Cost Function

Cost function $J = \sum_1^m \frac{1}{2} (y - \hat{y})^2$

Sum over all samples true value predicted value

A diagram explaining the Cost Function formula. The formula is $J = \sum_1^m \frac{1}{2} (y - \hat{y})^2$. Three red arrows point from labels below to parts of the formula: one from 'Sum over all samples' to the summation symbol $\sum$, one from 'true value' to y , and one from 'predicted value' to $\hat{y}$.

How to minimize the error



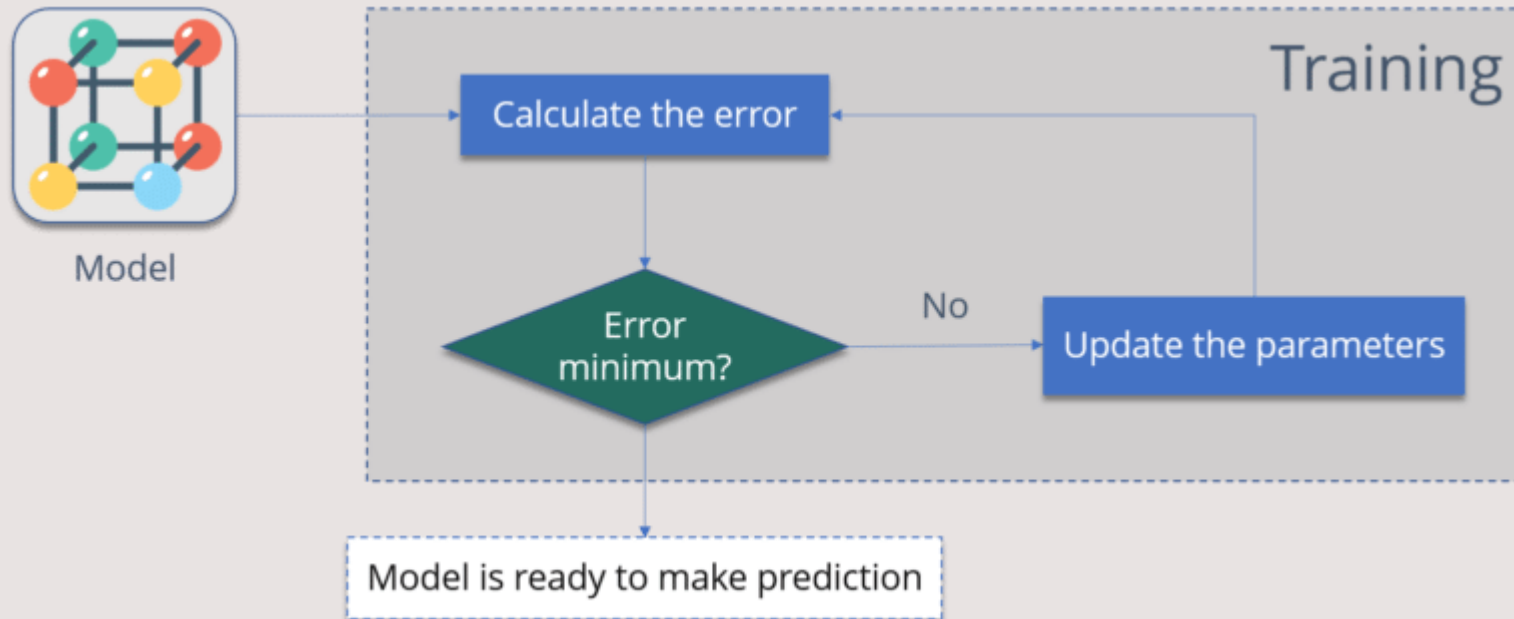
In summary, difference of weights (or weights adjustments) can be mentioned as follows:

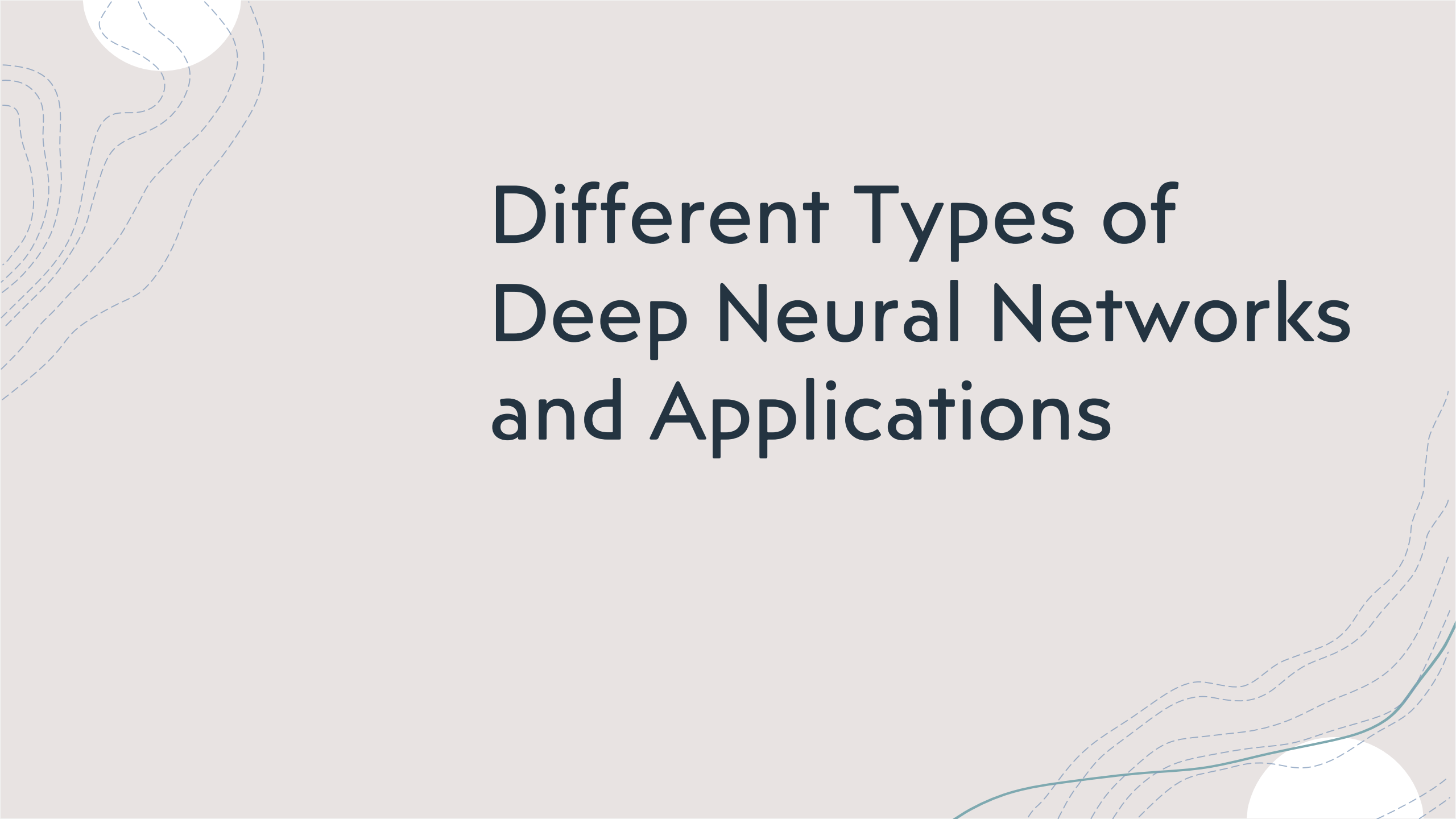
$$\Delta W_i = -\alpha \frac{\partial E}{\partial W_i}$$

In the above equation, α gives us the amount of step size; whereas,

$$\frac{\partial E}{\partial W_i}$$

Training



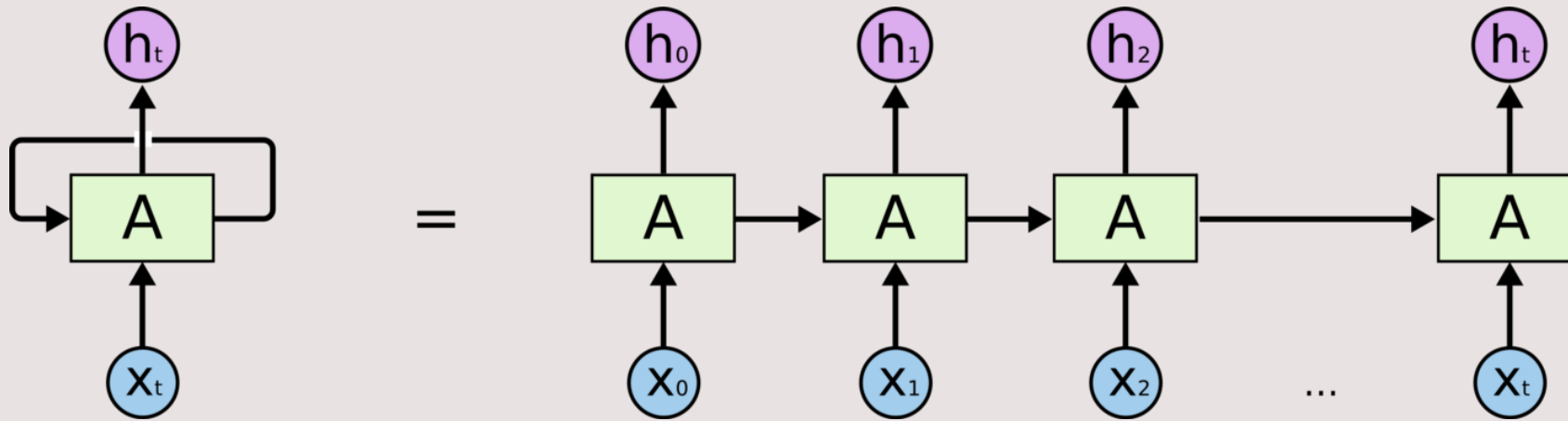
The background is a light gray color. On the left side, there are several concentric, wavy dashed lines in a light blue color, resembling topographical lines or ripples. In the top-left corner, there is a white circle. In the bottom-right corner, there is another white circle. A solid teal line also curves across the bottom right area.

Different Types of Deep Neural Networks and Applications

Application	Examples	Type of DNN
Sequence Learning	Machine Translation Sentiment Analysis Natural Language Processing	RNN LSTM GRU Transformers
Image Processing	Cancer Diagnosis Cat or Dog	Convolutional Neural Network
Object Detection	Search Engines	Modification of CNN (Yolo)
Autonomous Car	Driverless cars Robots	Reinforcement Learning
Deep Fake	Determination of outlier and anomaly. Creation of peer groups of machines and users.	Generative Adversarial Networks
Classification	Malware Other Classification Examples	Multi-Layer Perceptron

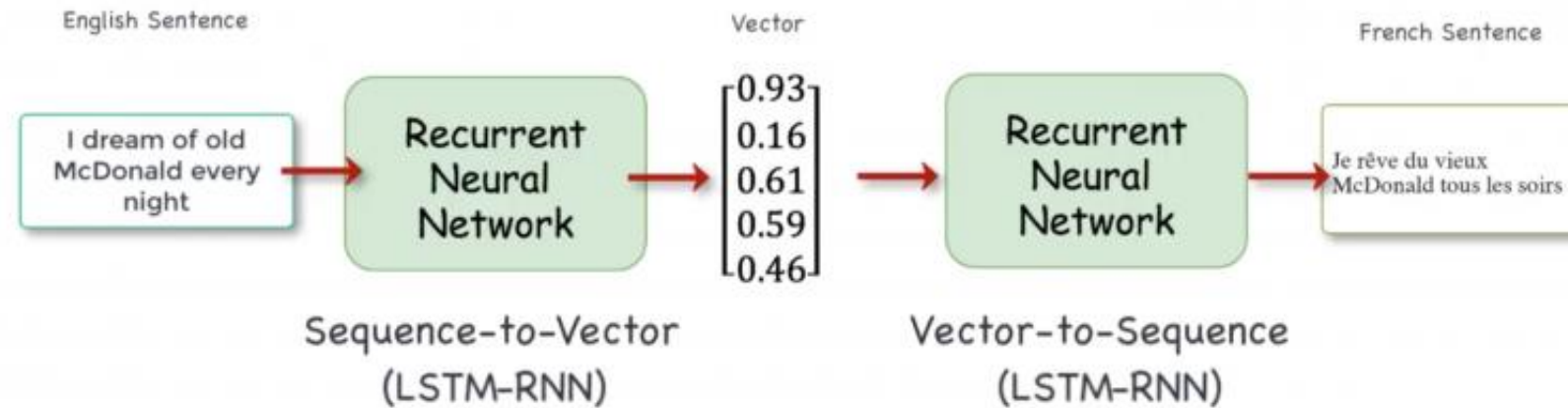
Sentiment Analysis using RNN

- + The food was good, not bad at all
- + The food was bad, not good at all



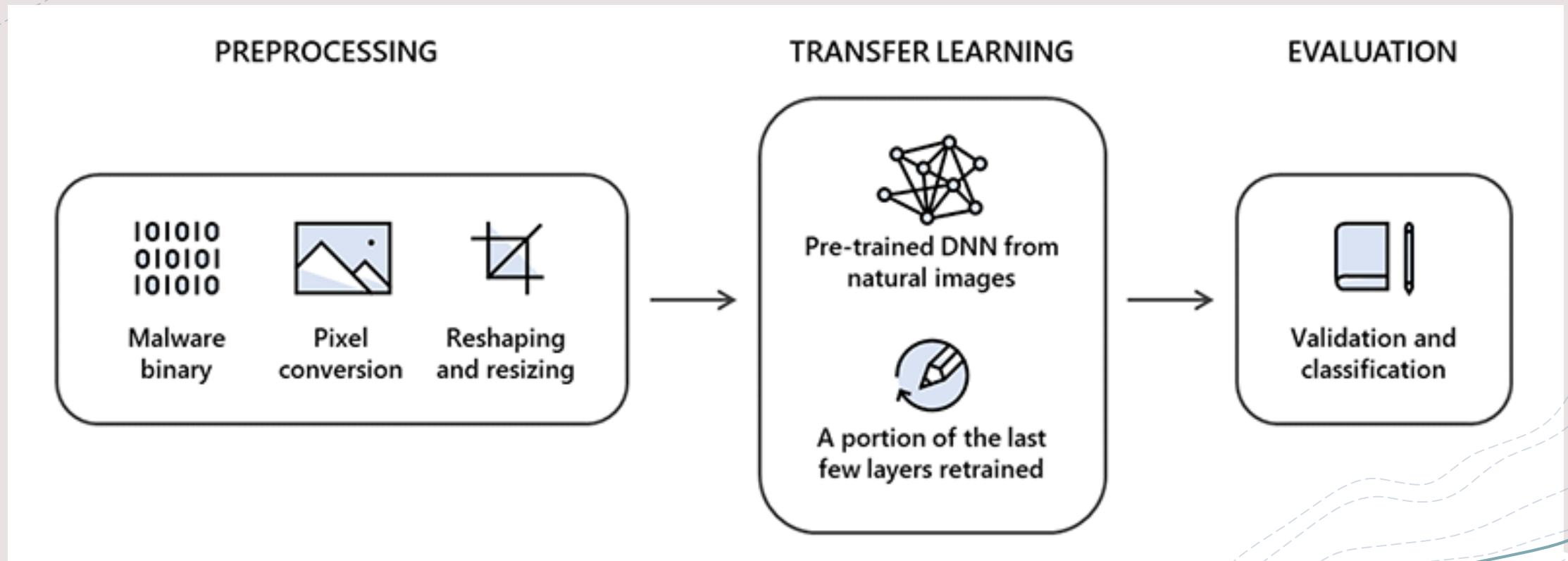
Machine Translation

Encoder-Decoder Architecture

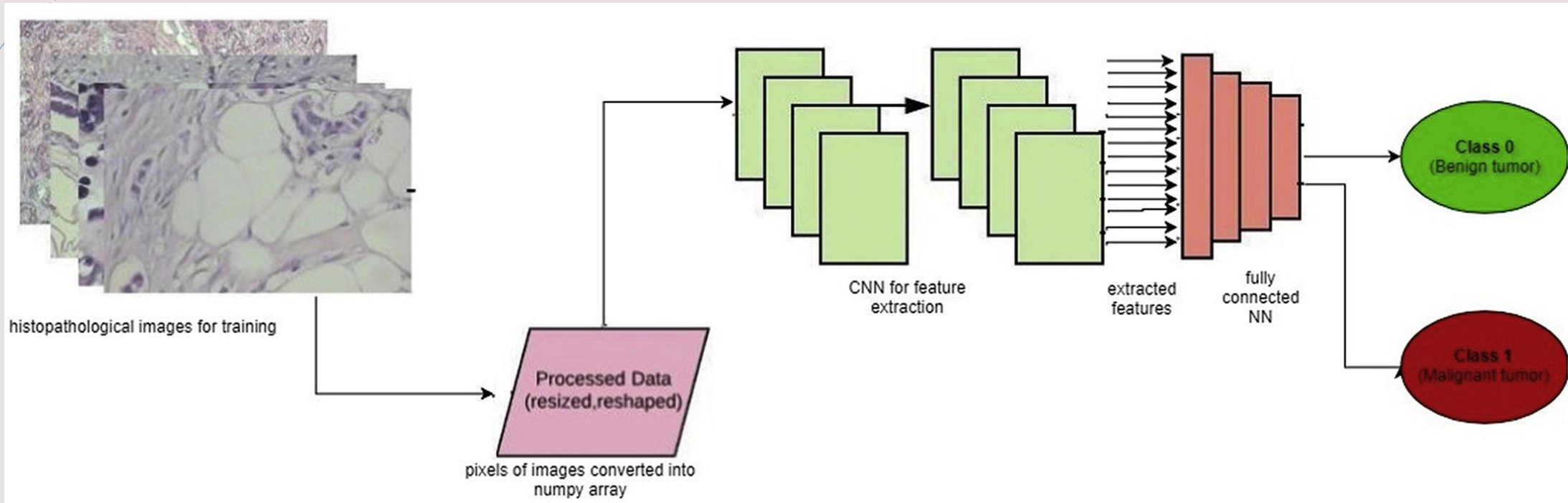


Malware Classification

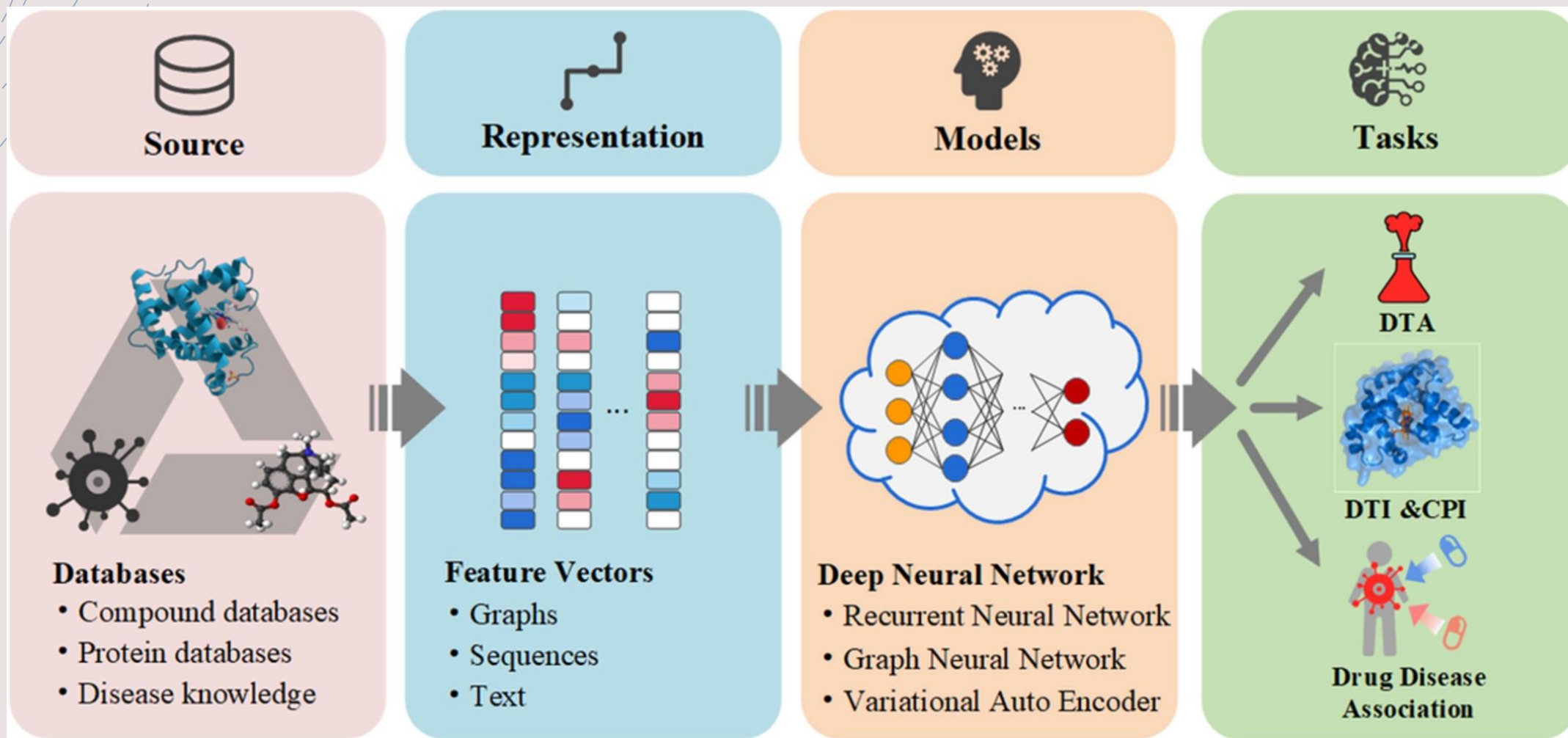
- + Malware files are converted to images
- + Features are extracted using CNN
- + Classify a software as benign or malware



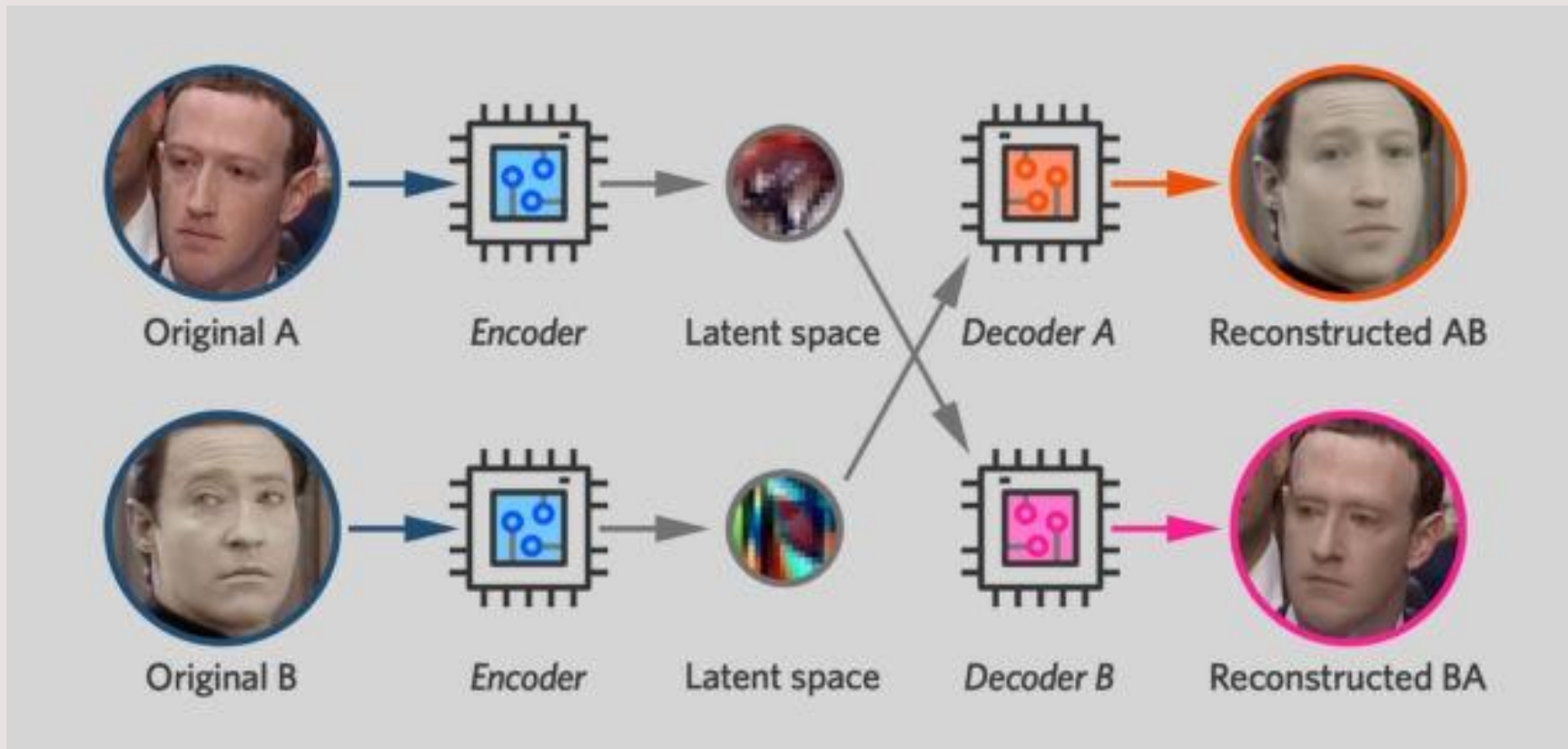
Cancer Diagnosis using CNN



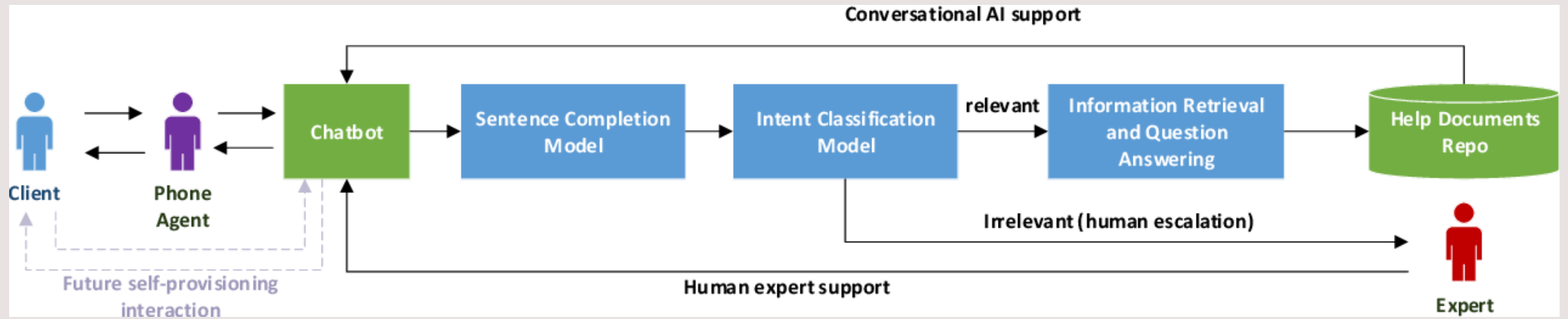
Drug Repurposing



Deepfake



Chatbot



Conclusion

```
graph LR; A[Emerging Area] --> B[Lots of Opportunities and Challenges]
```

Emerging
Area

Lots of
Opportunities
and
Challenges

The background features a light gray surface with a pattern of thin, wavy, dashed lines in a slightly darker shade of gray. Two large, solid white circles are positioned in the corners: one in the top-left and another in the bottom-right.

Hands-on Training

+

And Gate

<https://tinyurl.com/paews>

Modify it for OR gate or reduce hidden layers



Questions

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