200302211
Kecerdasan Buatan *(Artificial Intelligence)*
Program Studi Informatika

Session 5: Artificial Neural Network (Sesi 5 - Jaringan Saraf Tiruan)

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Pengertian Jaringan Saraf Tiruan
Artificial Neural Network: What is that?

our brain and when it's zoomed in...

- Sebuah jenis algoritma *machine learning* yang meniru otak manusia
- Dirancang untuk **mengenali pola** *(pattern recognizing)* dan membuat prediksi berdasarkan data

brain neurons

- *Neural network is a type of machine learning algorithm inspired by the human brain*
- *Designed to recognize patterns and make predictions based on data*

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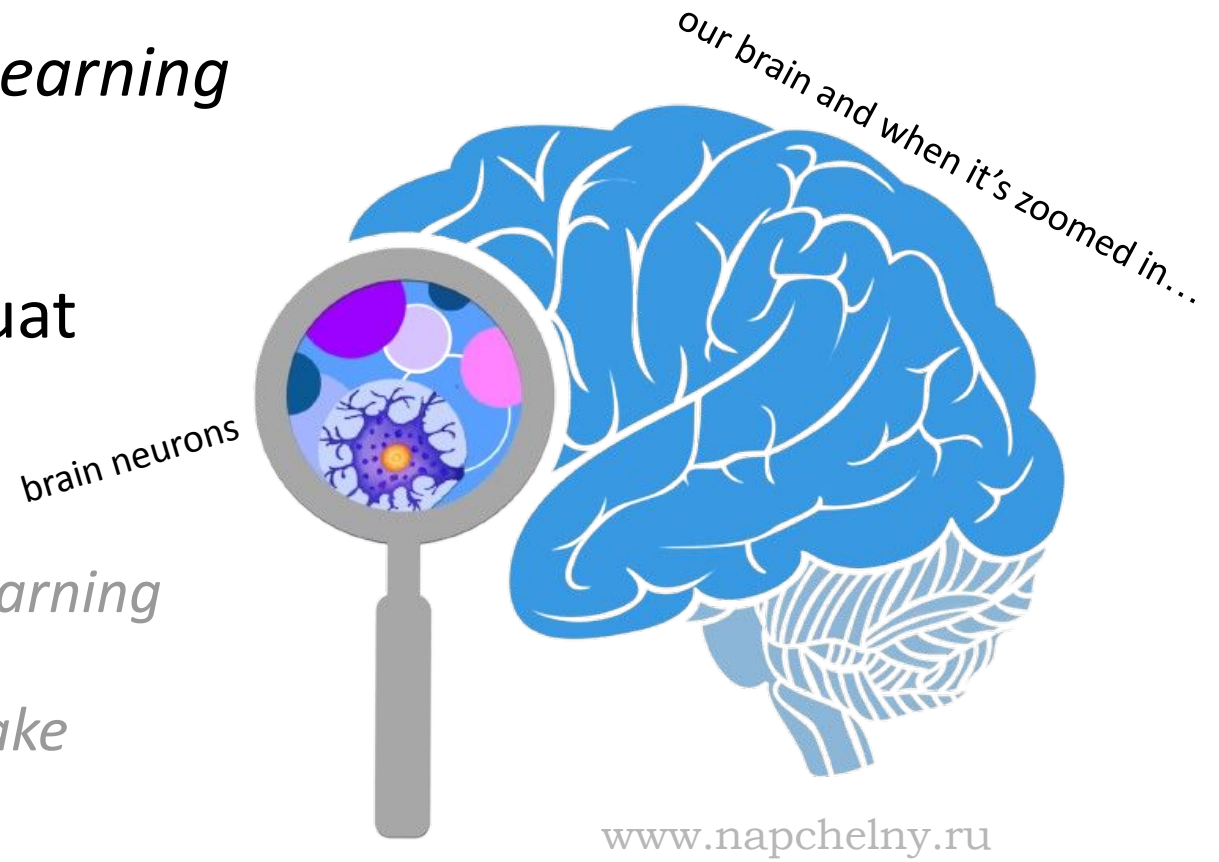
Contoh Jaringan Saraf Tiruan
Artificial Neural Network: What is it like?

familiar with this?

our brain can interpret the patterns of numbers, letters, or pictures even though it's imperfect!

that's how ANN work as well

THIS IS HOW NEURAL NETWORKS PROCESS VISUAL DATA THROUGH A LAYERED APPROACH

otak manusia dapat mengenali bentuk-bentuk yang kurang sempurna karena sudah terlatih dengan informasi serupa sebelumnya

begitu pulalah kita melatih JST
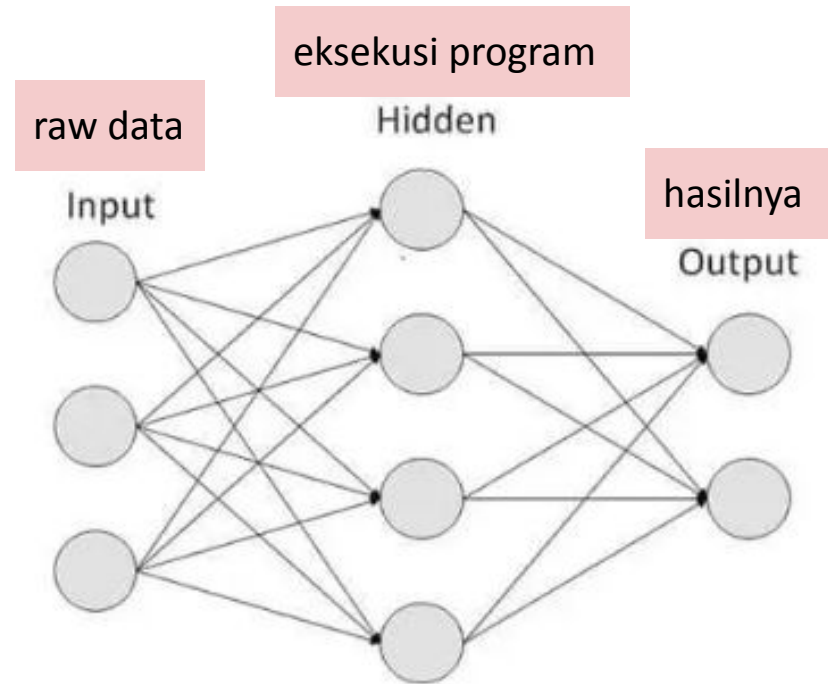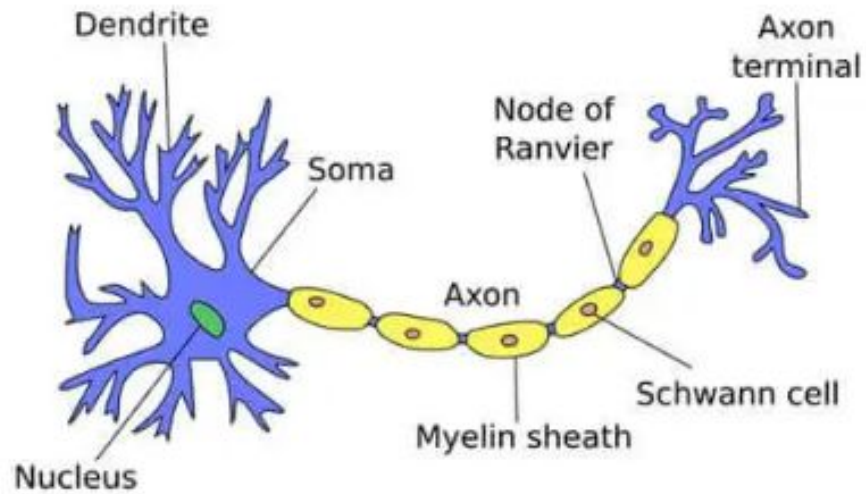
Session 5 - Artificial
Neural Network Part #1

Struktur JST
(ANN Structure)

Sel Saraf Asli vs Jaringan Saraf Tiruan (JST)
## *Real Neuron VS Artificial Neural Network (ANN)*

ON the left: The biological neuron graph & on the right: the artificial neural network

Kiri: Gambar jaringan saraf asli manusia; Kanan: JST pada AI system

Lapisan *(Layer)* di JST

- **Lapisan Input**: Menerima data mentah (contoh: nilai piksel, teks, atau data numerik). Setiap simpul berhubungan dengan satu fitur data input.

- **Lapisan Tersembunyi**: Memproses data input dengan melakukan komputasi dan tempat terjadinya *learning*. Lapisan ini <u>dapat memiliki beberapa simpul /lapisan</u>.

- **Lapisan Output**: Menghasilkan hasil akhir atau prediksi (misalnya, label klasifikasi atau nilai numerik)
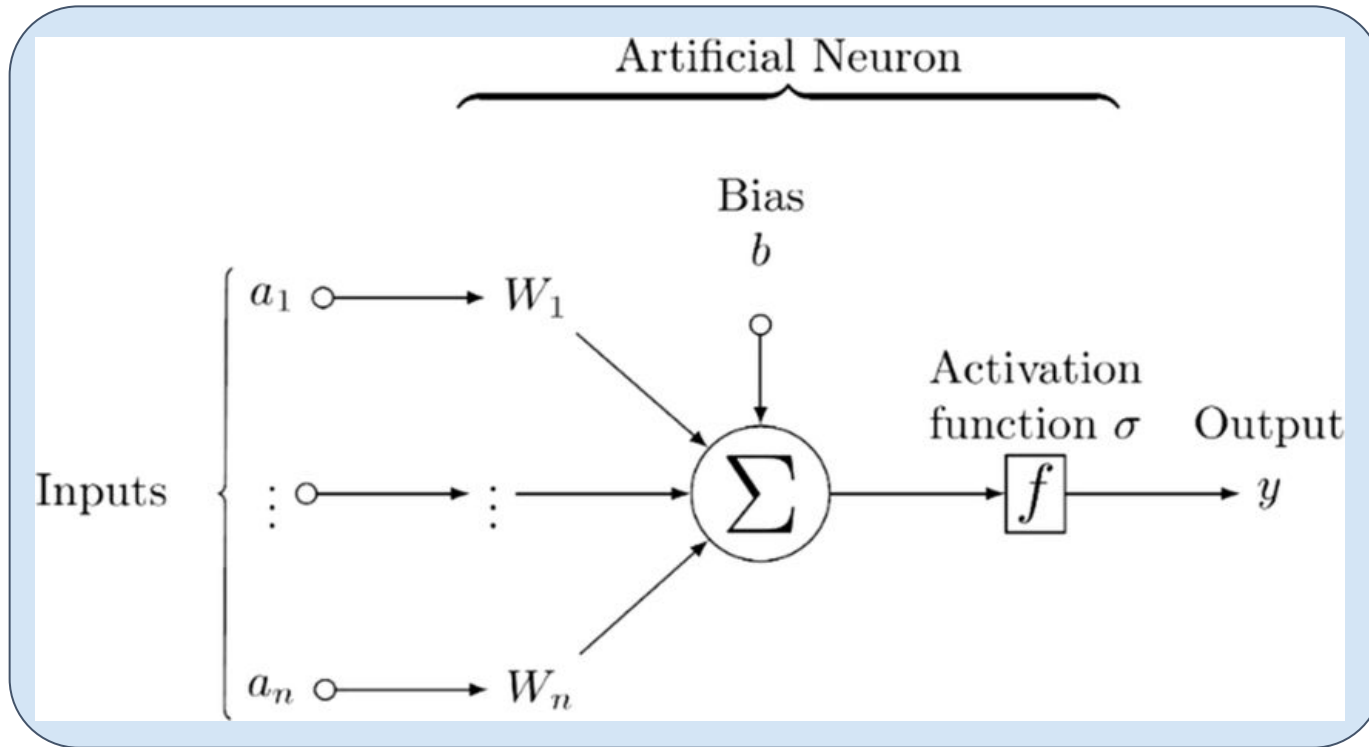

Input Layer in an ANN

Input Layer | Hidden Layer | Output Layer

X_1 X_2 X_3 X_4 | | Y_1 Y_2
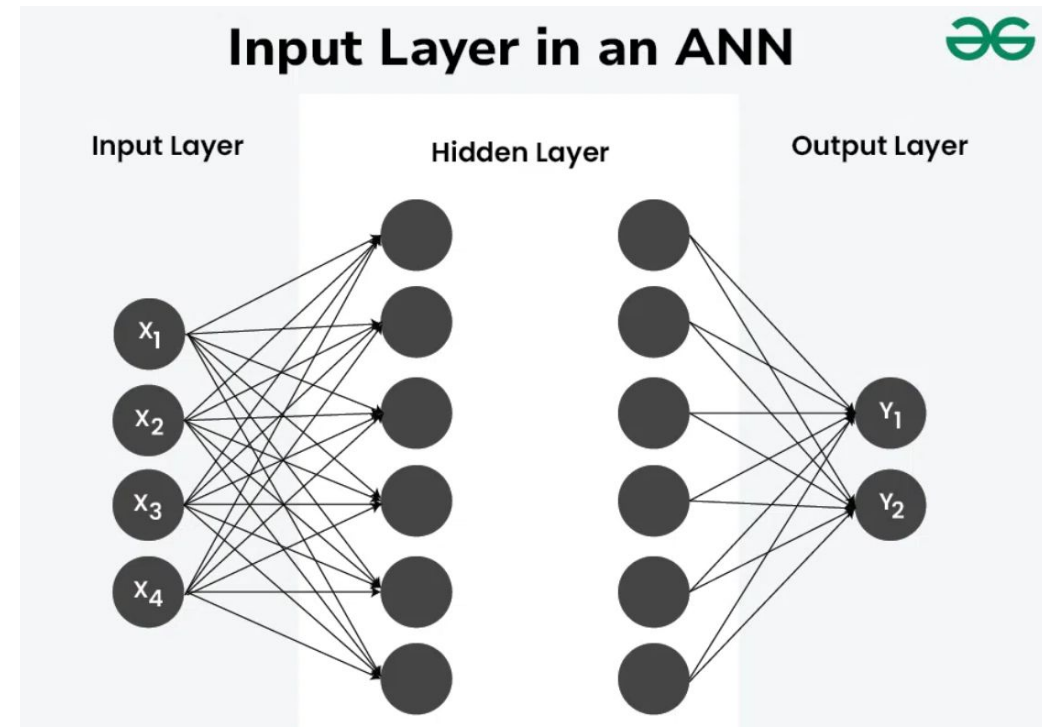
"Layer" in ANN

- **Input Layer**: Accepts the raw data (e.g., pixel values, text, or numerical data). Each node corresponds to one feature of the input data.

- **Hidden Layer(s)**: Process the input data by performing computations and where the learning happens —> can be multiple nodes/layers

- **Output Layer**: Produces the final result or prediction (e.g., a classification label or a numeric value)

Sel Saraf *(Neuron)* di JST

"Neuron" in ANN

Artificial Neuron

Bias b

Inputs $\begin{cases} a_1 & \rightarrow W_1 \\ \vdots & \rightarrow \vdots \\ a_n & \rightarrow W_n \end{cases}$

Activation function σ — Output y

Σ — f

- Setiap neuron dalam satu lapisan terhubung ke neuron di lapisan berikutnya

- Setiap koneksi memiliki bobot yang menentukan tingkat kepentingannya

- Dari satu *hidden layer* ke *hidden layer* lainnya, ada nilai bobot yang berbeda

- *Each neuron in a layer is connected to neurons in the next layer*
- *Each connection has a weight that determines its importance*
- *There is respective weight from one hidden layer to another hidden layer*

# Fungsi Aktivasi di JST
Activation Function in ANN

- Menentukan apakah neuron "diaktifkan" berdasarkan masukannya

  Determines whether a neuron is "activated" based on its input

- Menggambarkan hubungan antara tingkat aktivasi internal *(summation function)* yang mungkin berbentuk linear atau nonlinear

- Fungsi aktivasi umum

  Common activation functions

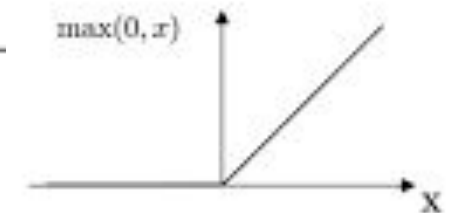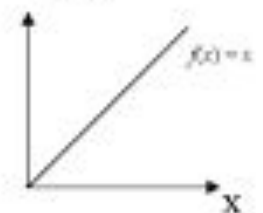 - **Sigmoid, ReLU (Rectified Linear Unit), Tanh, Softmax, Hard Limit, Purelin**
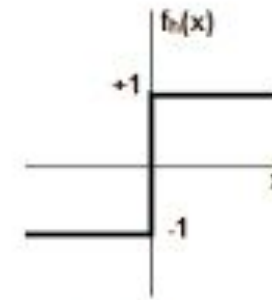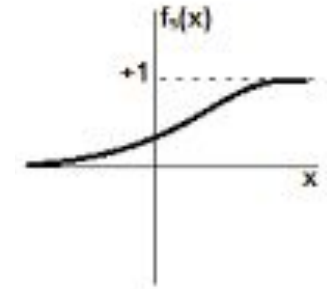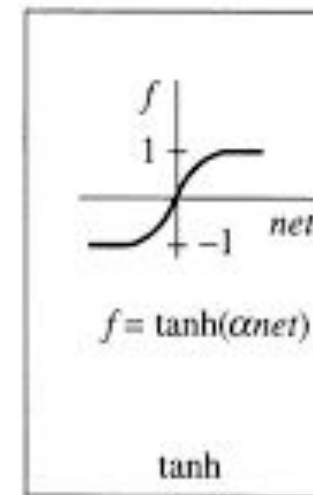
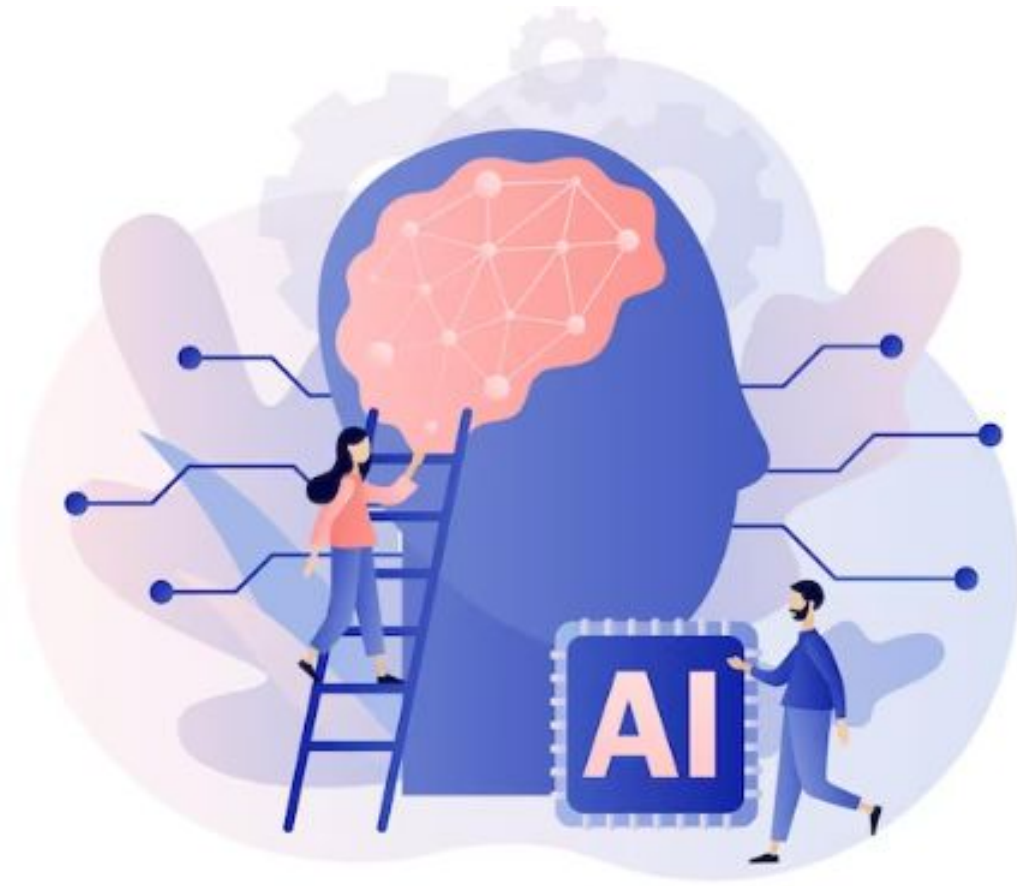**Session 5 - Artificial Neural Network**
<u>**Part #2**</u>

Cara Kerja JST
(How ANN works)

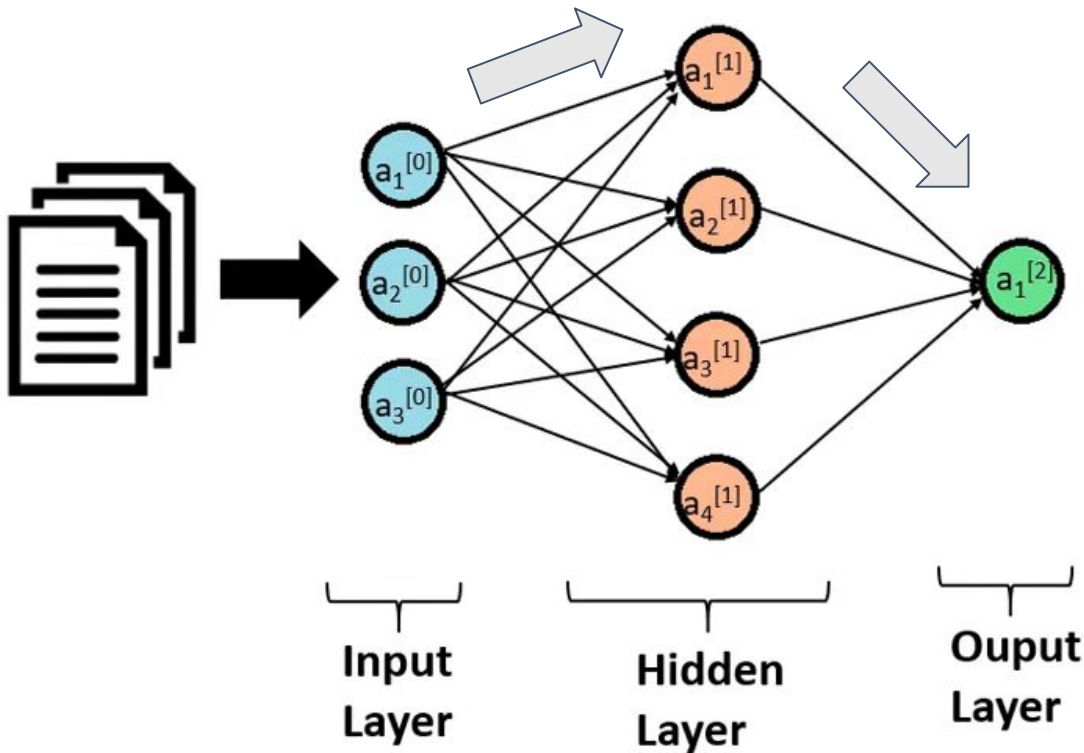# ANN Learning Process (1): Forward Propagation

❖ **Forward Propagation**

➢ Data masukan mengalir melalui jaringan dari depan ke belakang
   Input data flows through the network

➢ Setiap lapisan menghitung keluaran menggunakan formula berikut
   Each layer computes outputs using the formula

   $y = f(Wx + b)$

   W = weight matrix, x = input, b = bias, f = activation function, y = output
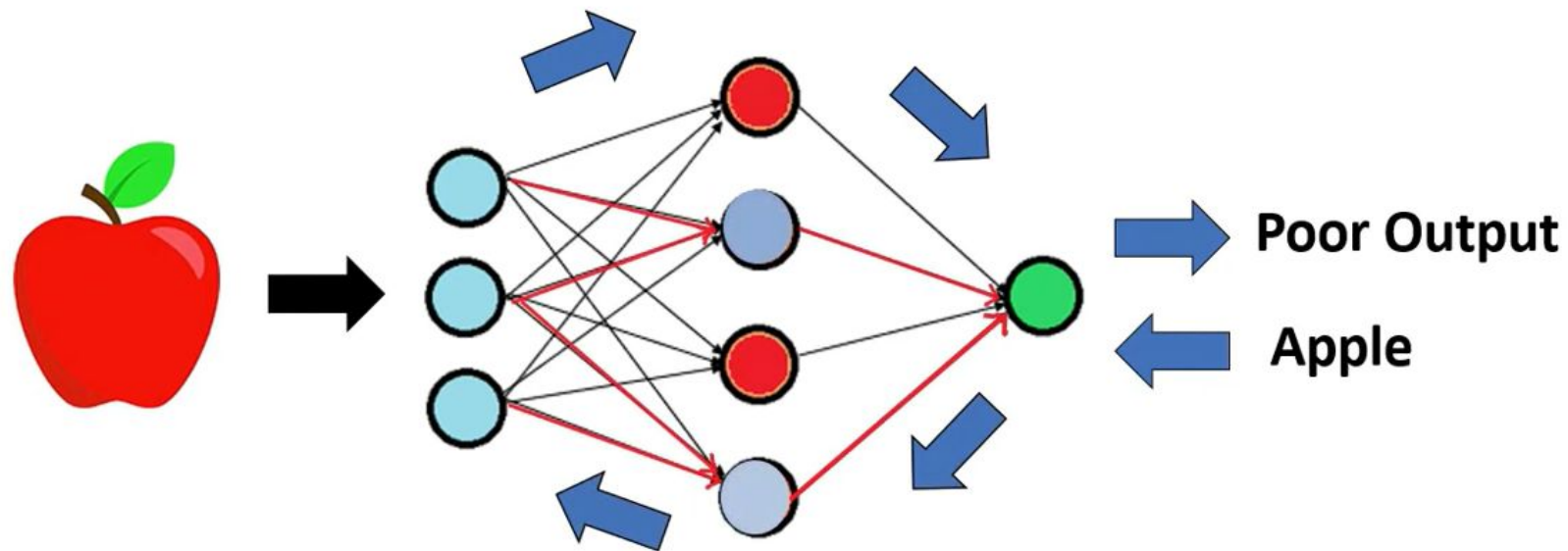
ANN Learning Process (1): Forward Propagation (cont'd)

$a_1^{[1]}$ = activation_function(
$W_{11}^{[1]} * a_1^{[0]} + W_{12}^{[1]} * a_2^{[0]} +$
$W_{13}^{[1]} * a_3^{[1]} + B1$)

$a_2^{[1]}$ = activation_function(
$W_{21}^{[1]} * a_1^{[1]} + W_{22}^{[1]} * a_2^{[1]} +$
$W_{23}^{[1]} * a_3^{[1]} + B1$)
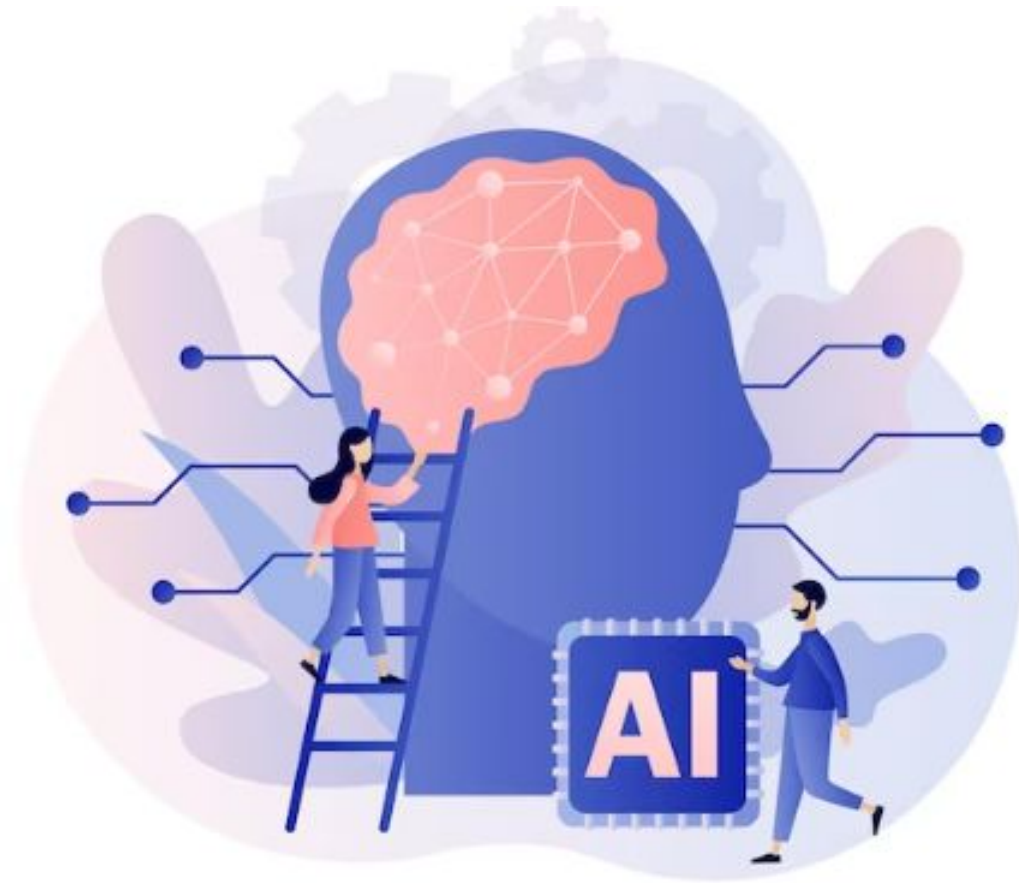
ANN Learning Process (2): Backward Propagation

❖ **Backward Propagation:** memperbaiki *forward propagation* dengan cara mengolah kembali nilai galat dari output sebagai parameter *training*

galat yang didapat dikembalikan lagi ke layers di depannya,
lalu neurons di layer tersebut memperbaiki nilai bobotnya

Session 5 - Artificial Neural Network
Part #3

Jenis-jenis JST
(Types of ANN)

(1) Feed-forward Neural Network (FNN)

- Data mengalir dalam satu arah, yakni maju dari input ke output
- Umumnya digunakan untuk tugas sederhana seperti klasifikasi atau regresi linear

- *Data flows in one direction (input → output)*
- *Commonly used for simple tasks like classification and regression*

Input layer

Hidden layer

Output layer
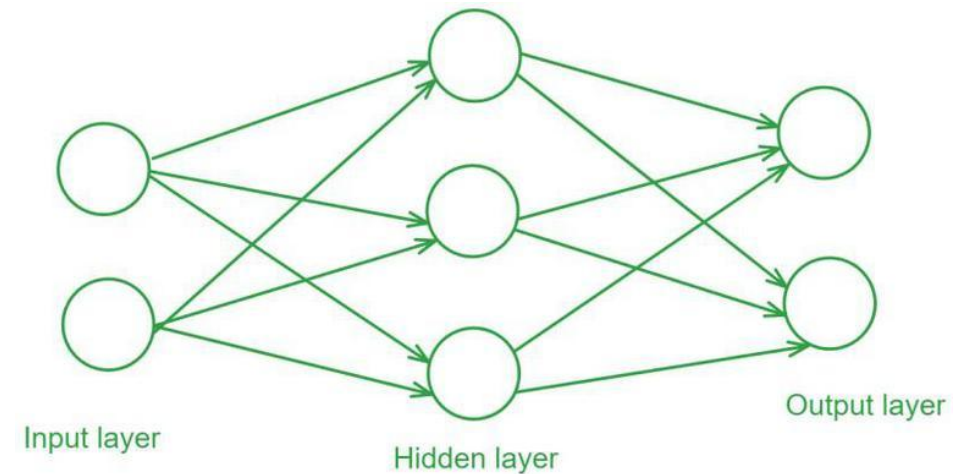
(2) Convolutional Neural Networks (CNNs)

- Menggunakan lapisan-lapisan *convolutional* (lilitan/tumpukan yang rumit, berkelok-kelok, dsb.) sebagai pendeteksi pola

- Umumnya digunakan untuk *image processing, speech recognition*

- *Data flows in one direction (input → output)*

- *Commonly used for image processing, speech recognition*

There are three level of layers which shows the learning process:
- convolutional layers
- pooling layers
- fully connected layers

(2) Convolutional Neural Networks (cont'd)
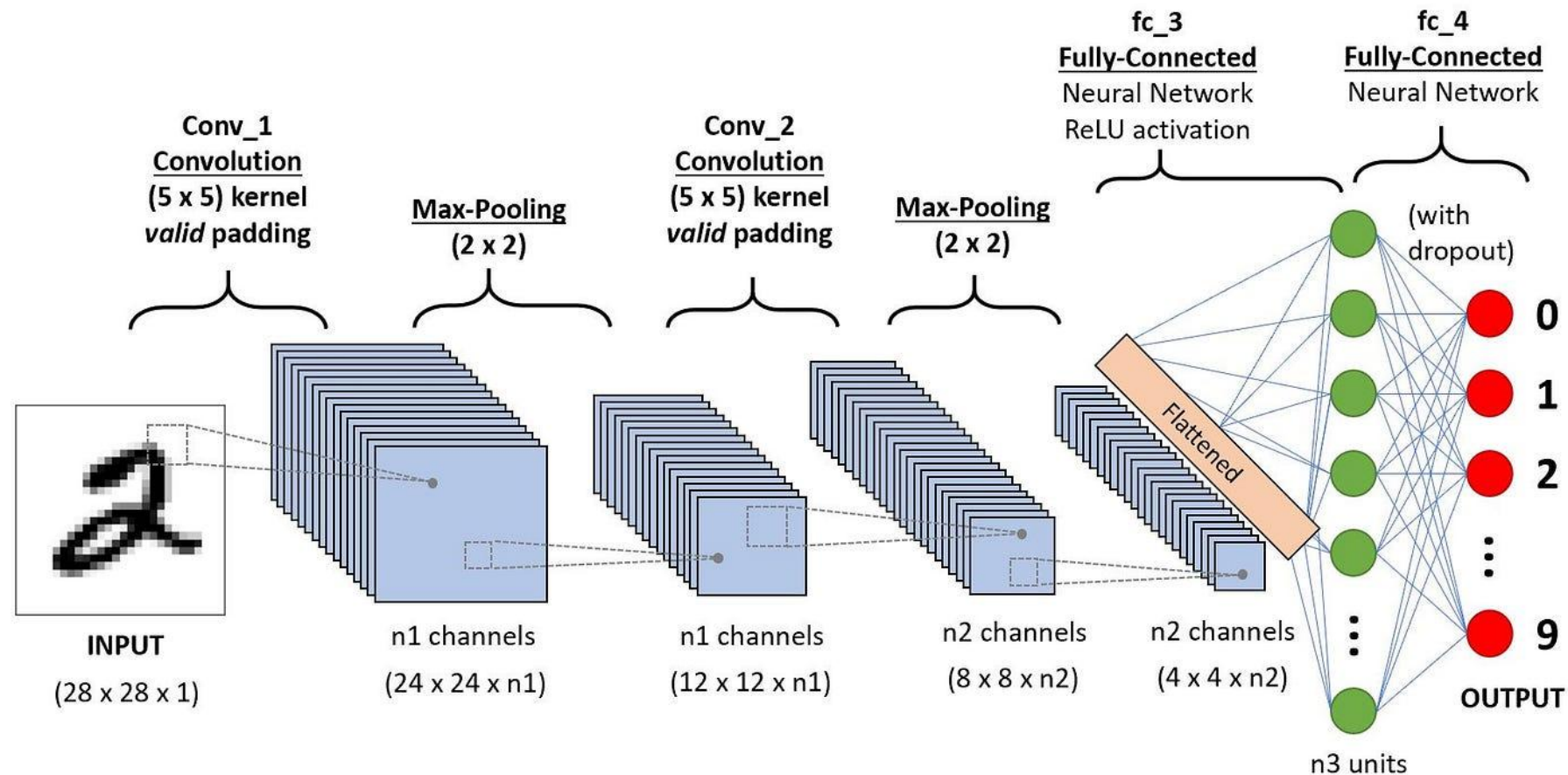
(3) Recurrent Neural Network (RNN)

- Menggunakan struktur *looping* untuk menyimpan informasi dari waktu ke waktu, yakni dengan cara output memberi umpan balik kepada input (penerapan *backward propagation)*
- Dirancang untuk data berurutan (contoh: deret waktu)
- *Use loops to retain information over time*
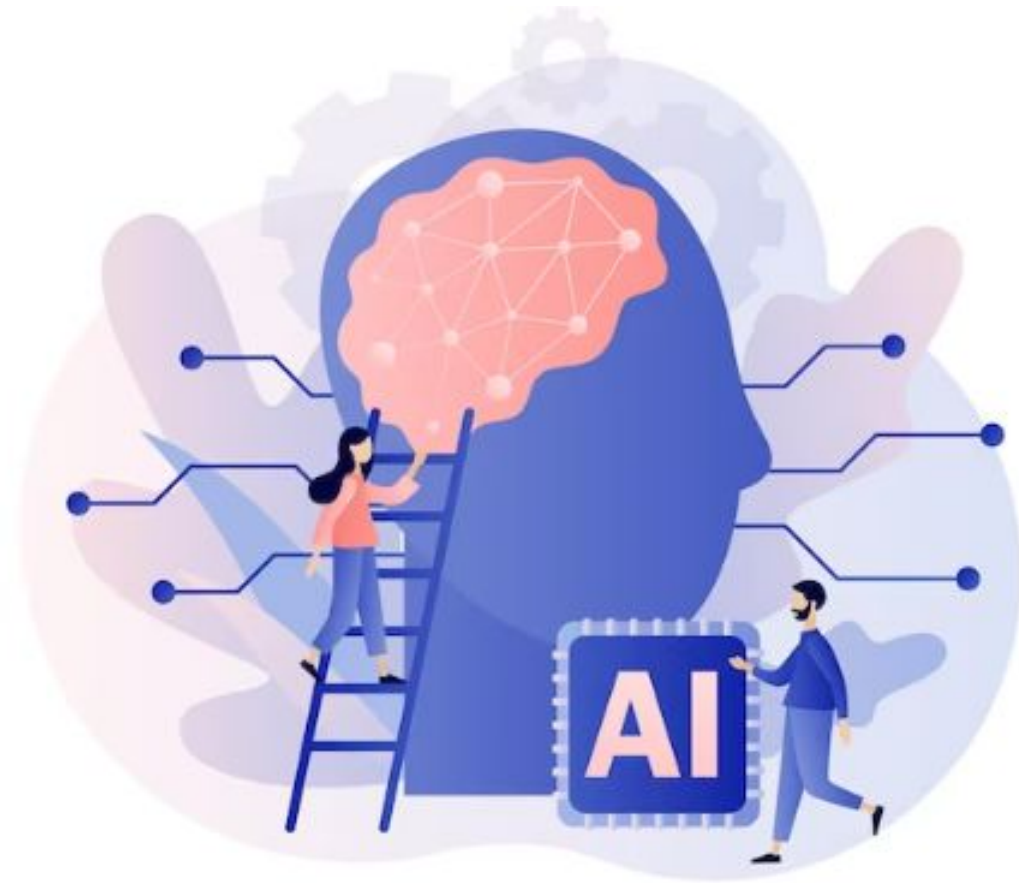- *Designed for sequential data (e.g. time series)*
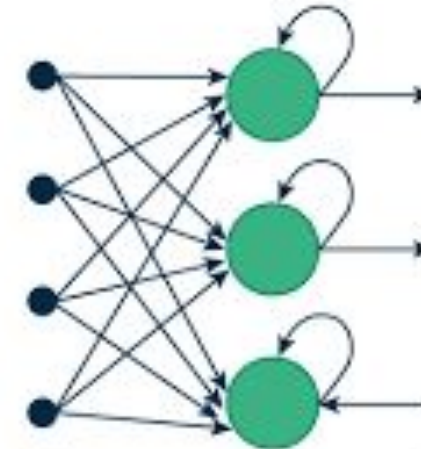
(a) Recurrent Neural Network
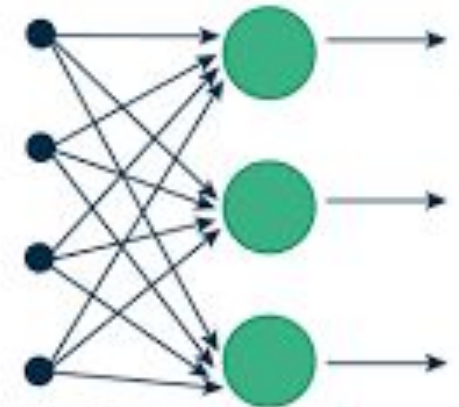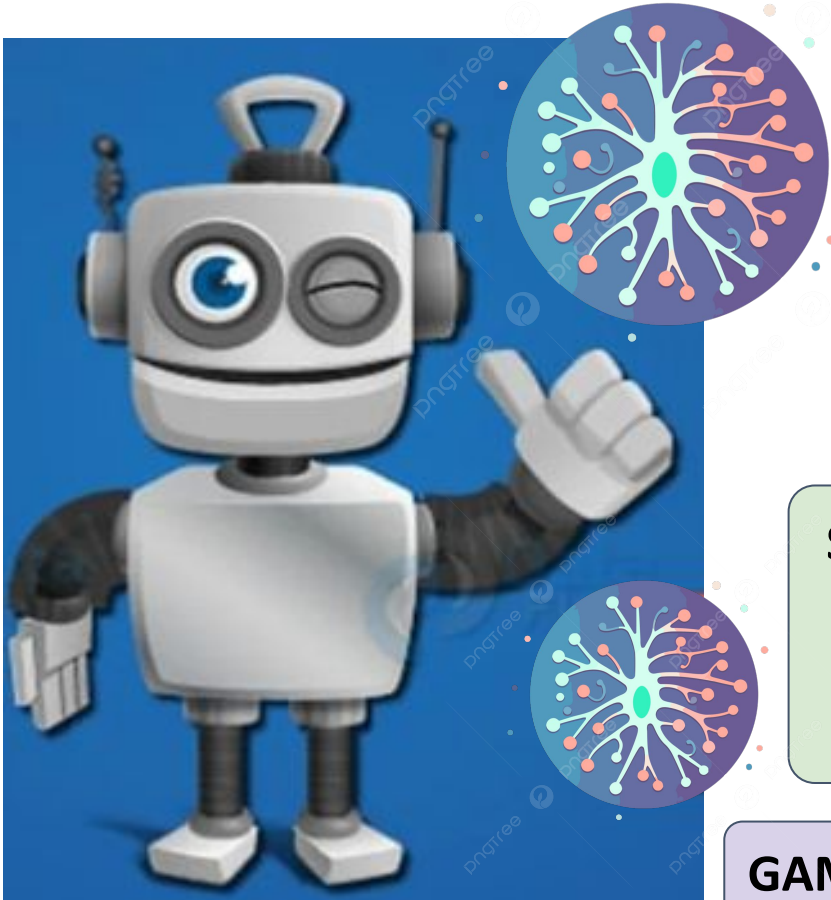
(b) Feed-Forward Neural Network

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Part #4

Aplikasi JST
(Application of ANN)

Some Applications of ANN

NATURAL LANGUAGE PROCESSING:

- **Language translation**
- **Text classification**
- **Sentiment analysis**

IMAGE PROCESSING:

- **Facial recognition**
- **Medical image analysis**
- **Object detection**

SPEECH PROCESSING:

- **Voice assistant**
- **Speech to text conversion**

AUTONOMOUS SYSTEM:

- **Self-driving cars**
- **Robotics**

GAMING (AI game agent), IMAGE and MUSIC GENERATION, etc.

References for More Study

- Activation function: https://medium.com/@byanalytixlabs/activation-functions-in-neural-networks-its-components-uses-types-23cfc9a7a6d7
- https://towardsdatascience.com/a-comprehensive-guide-to-convolutional-neural-networks-the-eli5-way-3bd2b1164a53 CNN
- RNN: https://encord.com/blog/time-series-predictions-with-recurrent-neural-networks/
- IBM Cloud Website

Thank You
See you at the next session!

Don't forget to check your LMS for further information or feedbacks! ☺