Tishk International University
IT Department
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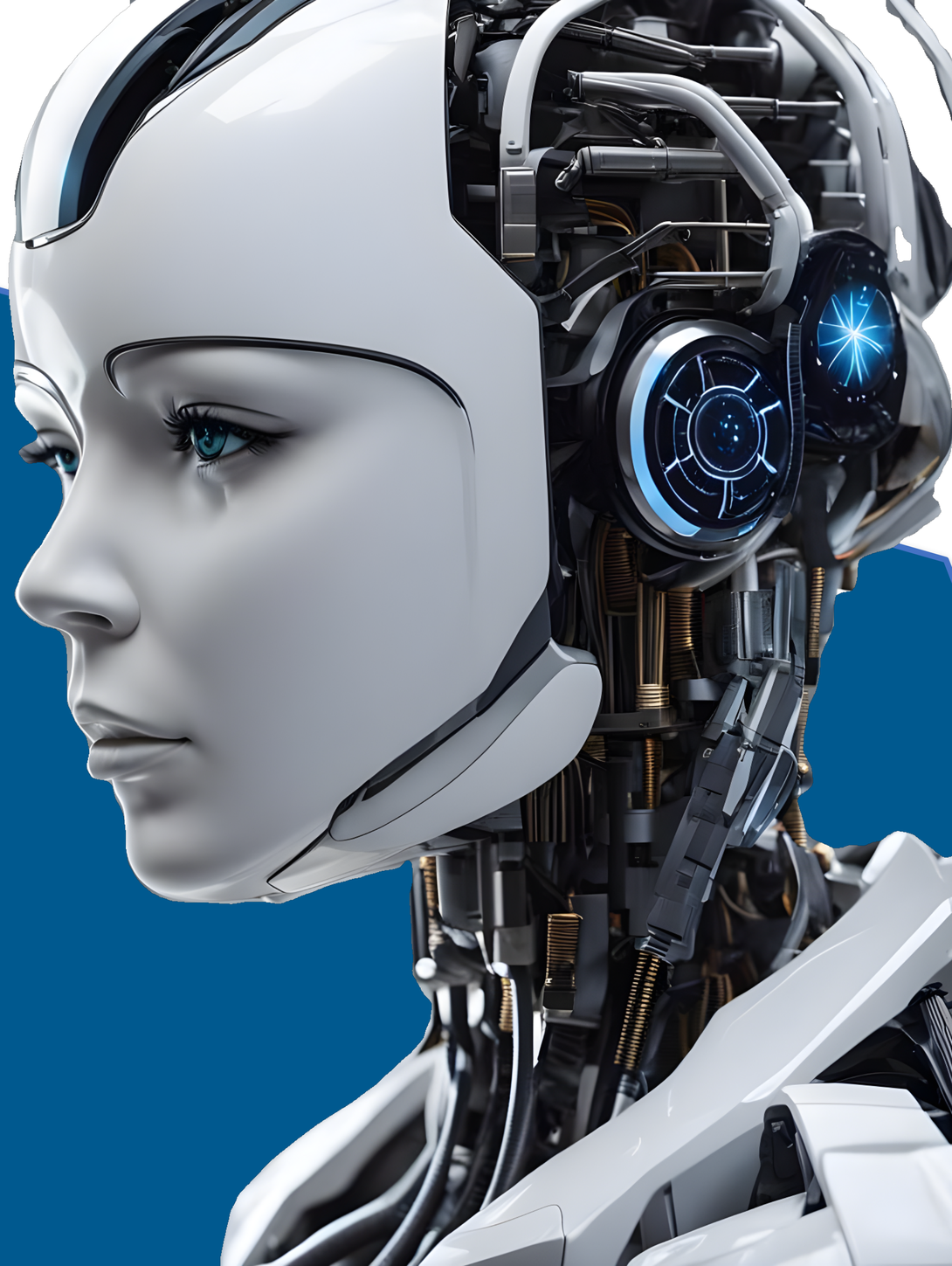

Introduction to Machine Learning

Neural Networks

Lecture 10

Spring 2024
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Outline

- Introduction to Neural Networks
- Example of NN applications
- Biological Neurons
- Neural Networks
- Neurons as Functions
- Types of NN
- Ethical Considerations

Introduction to Neural Networks

- Neural networks have become one of the major thrust areas recently in various pattern recognition, prediction, and analysis problems
- In many problems they have established the state of the art.
- A **neural network** is a computational model inspired by the way biological neural networks in the human brain process information. It consists of interconnected groups of artificial neurons, which are the basic units that perform computations.

Introduction to Neural Networks

Neural Network

What is a **neuron**?

fundamental unit
(of the brain)

What is a **network**?

connected elements

neural networks are connected elementary (computing) units

Neural Networks and the Job Market

This guy didn't know about neural networks (a.k.a deep learning)

This guy learned about neural networks (a.k.a deep learning)

Examples of Neural Network Applications

ThisPersonDoesNotExist.com uses AI to generate endless fake faces

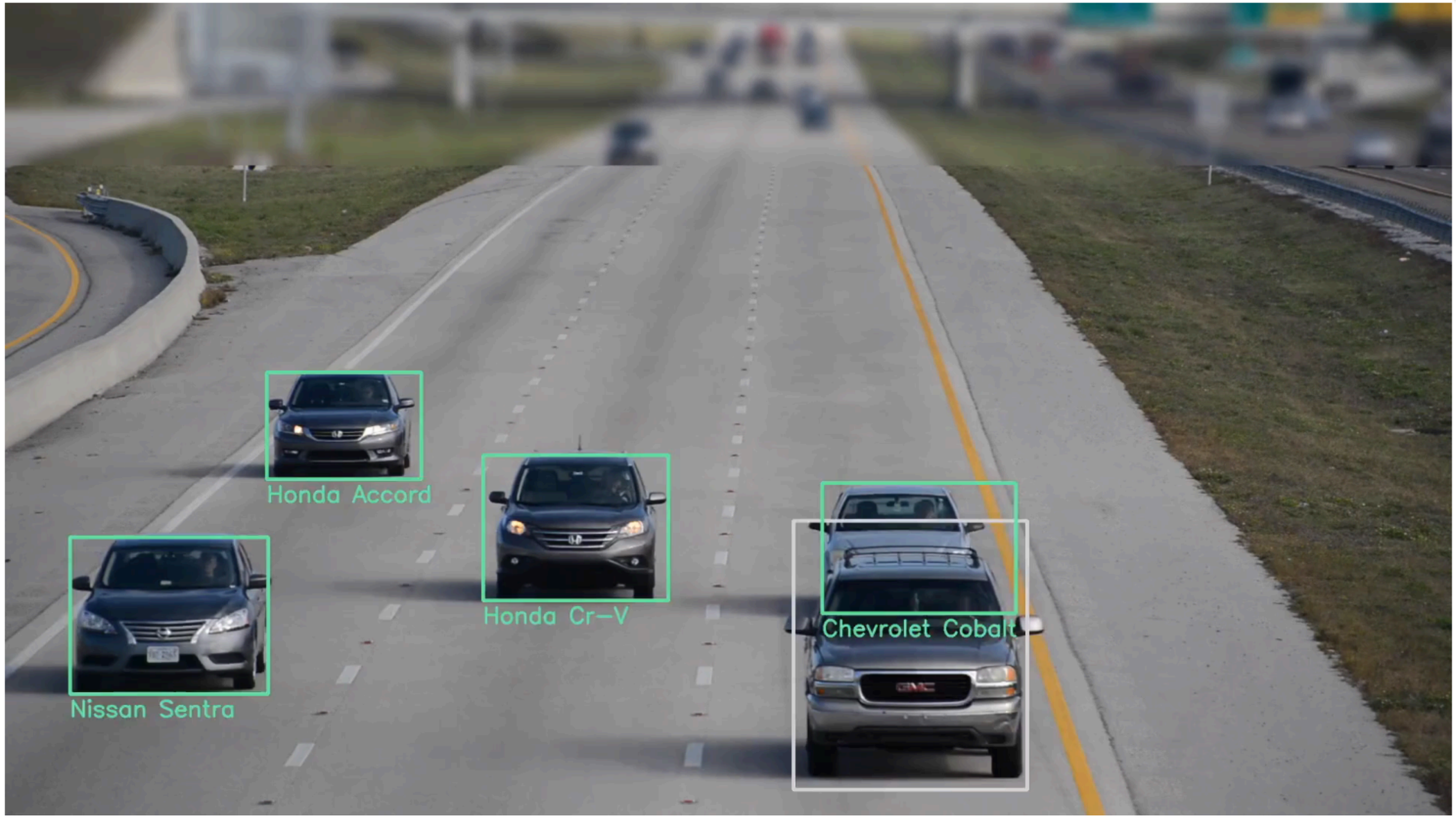
Hit refresh to lock eyes with another imaginary stranger

By James Vincent | Feb 15, 2019, 7:38am EST

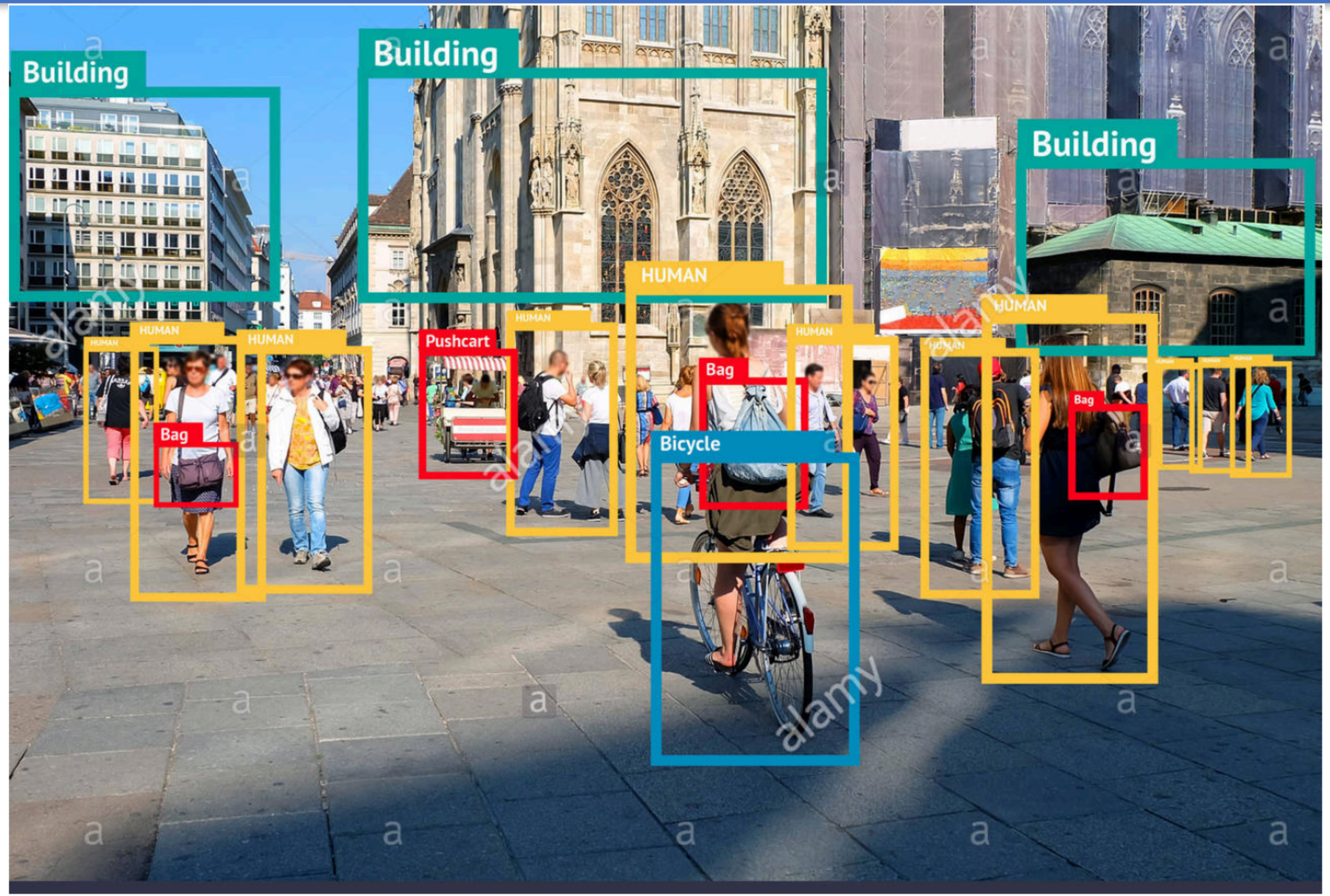
SHARE

A few sample faces — all completely fake — created by ThisPersonDoesNotExist.com

Examples of Neural Network Applications



Examples of Neural Network Applications



Examples of Neural Network Applications

Examples of Neural Network Applications

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Microsoft AI Beats Humans at Speech Recognition

By Richard Adhikari
Oct 20, 2016 11:40 AM PT

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Image: Adobe Stock

Microsoft's Artificial Intelligence and Research Unit earlier this week reported that its speech recognition technology had surpassed the performance of human transcriptionists.

Most Popular Newsletters News Alerts

How do you feel about Black Friday and Cyber Monday?

- They're great -- I get a lot of bargains!
- The deals are too spread out -- I'd prefer just one day.
- They're a fun way to kick off the holiday season.
- I don't like the commercialization of Thanksgiving Day.
- They're crucial for the retail industry and the economy.
- The deals typically aren't that good.

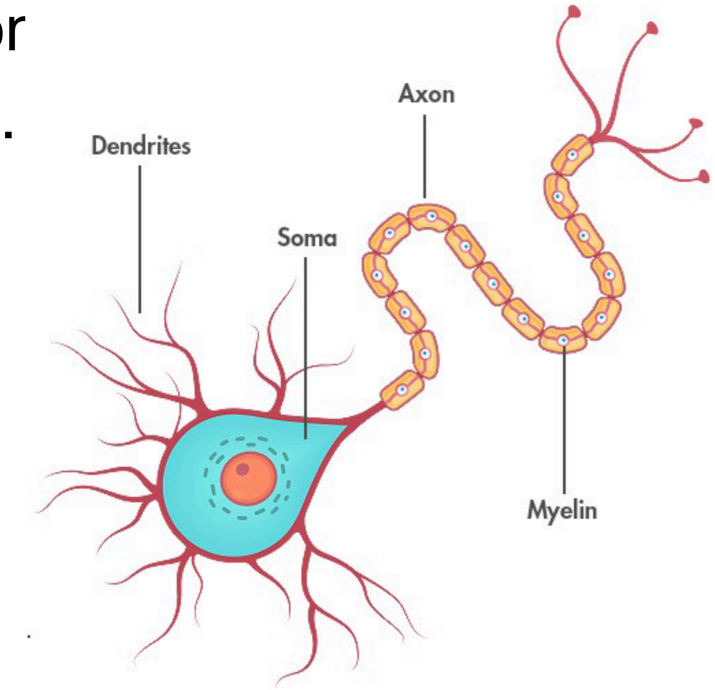
Vote to See Results

E-Commerce Times

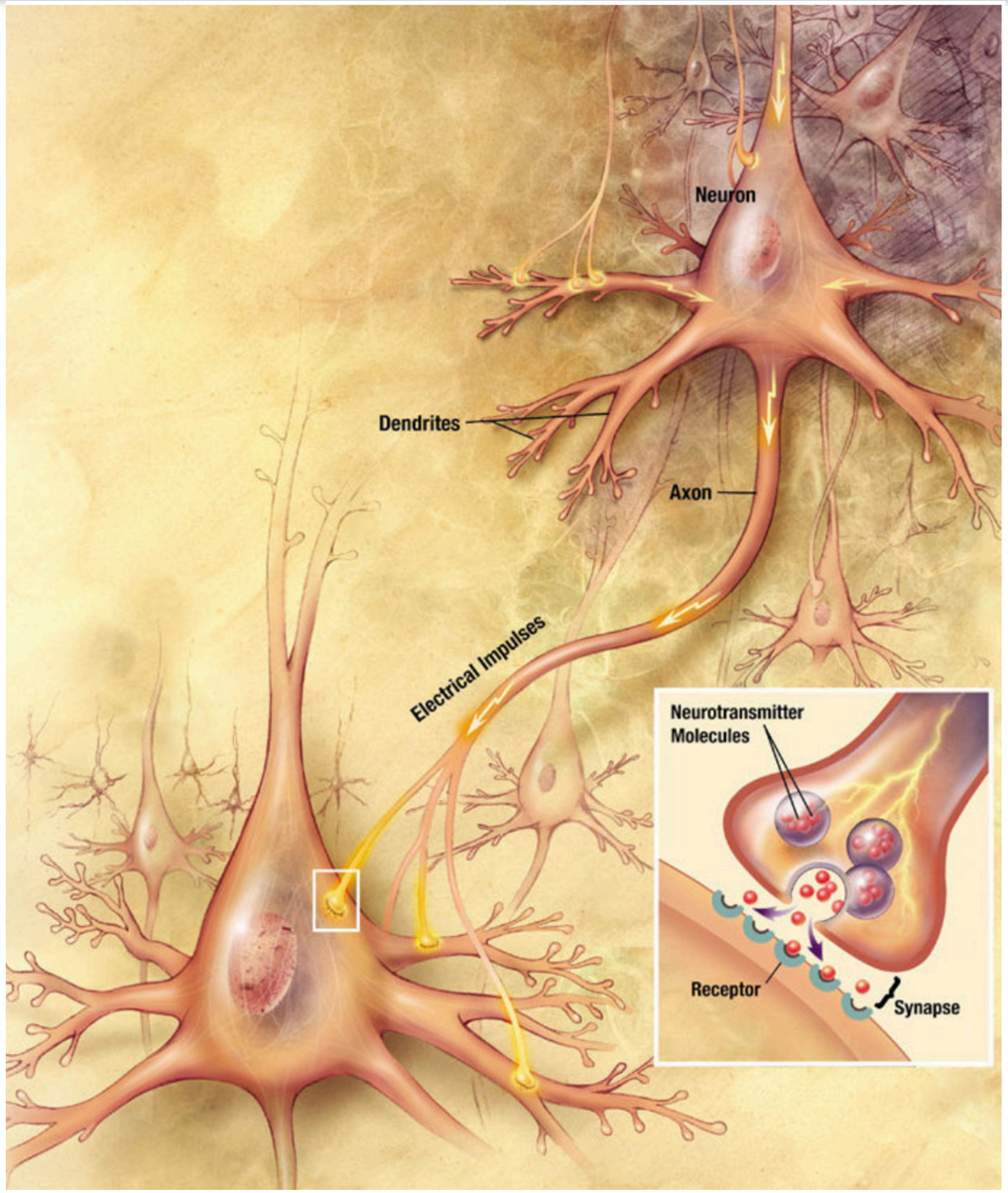
- Black Friday Shoppers Hungry for New Experiences, New Tech
- Pay TV's Newest Innovation: Giving Users Control
- Apple Celebrates Itself in $300 Coffee Table Tome
- AWS Enjoys Top Perch in IaaS, PaaS Markets
- US Comptroller Gears Up for Blockchain and

Biological Neurons

- Biological neurons are the fundamental units of the brain that:
  - **Receive sensory input:** They gather information from the external environment or from other neurons.
  - **Process and transmit signals**: They transform incoming signals and relay them to other neurons.
  - **Send output signals**: They convey signals to other neuror commands to muscles, enabling movement and response.



Biological Neurons



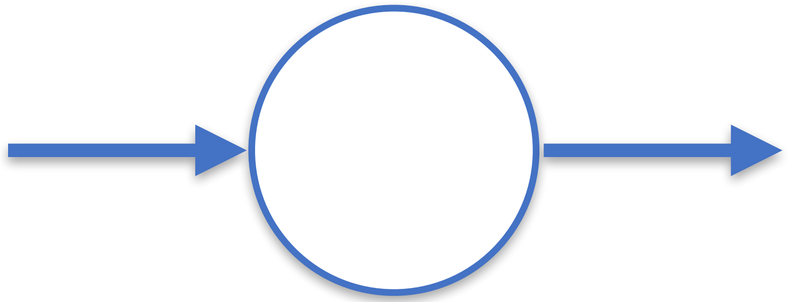
Neural networks

- Network of neurons
- When discussing neural nets, we are specifically referring to Artificial Neural Networks (ANNs).
- Designed to mimic the structure and functioning of biological neural networks found in the human brain
- Learning from Data: ANNs are capable of learning from data through a process called training, where the network adjusts its **weights** and **biases** based on the input data and desired output.

Artificial Neurons

Artificial neurons are the fundamental units of artificial neural networks that:

- **Receive Inputs:** They take in data from various sources, such as the output of other neurons or raw input features from datasets.
- **Transform Information:** They process the incoming data by applying a weighted sum of the inputs and a bias, followed by an activation function.
- **Generate Outputs:** They produce an output signal that can be used as input to other neurons in subsequent layers or as the final output of the network..



Neurons as Functions

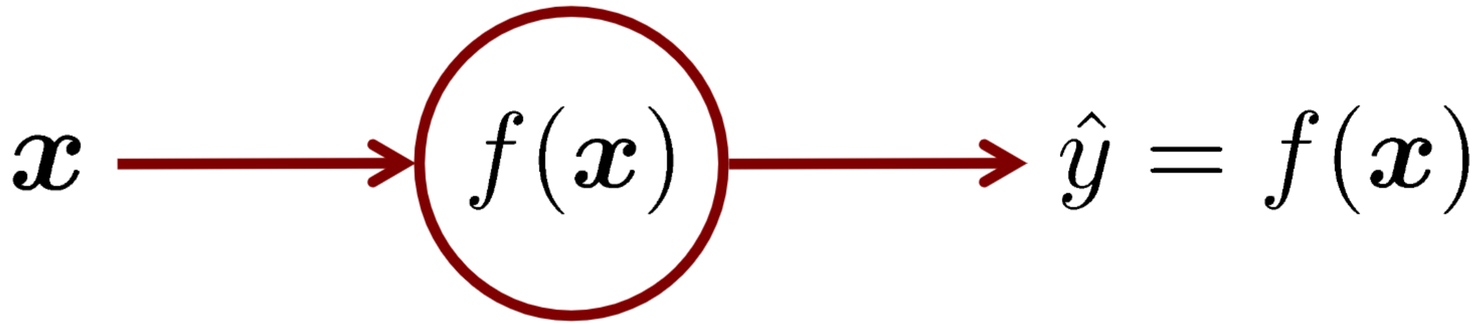
Neural networks consist of nodes, also known as units, connected by links.

- Links with Weights and Activation Levels: Each connection between **nodes** has an associated **weight** and activation level, determining the strength and impact of the signal passed.
- **Node Functions:** Each **node** has an **input function**, typically summing the weighted inputs it receives, an activation function that applies a transformation to this sum, and an output that it transmits to other nodes or serves as the network's final output.

Neurons as Functions

We can see a neuron as a function

- Input given by $\boldsymbol{x} \in \mathbb{R}^N$
- Transformation of the input data can be described by a function f
- Output $f(\boldsymbol{x}) = \hat{y} \in \mathbb{R}$

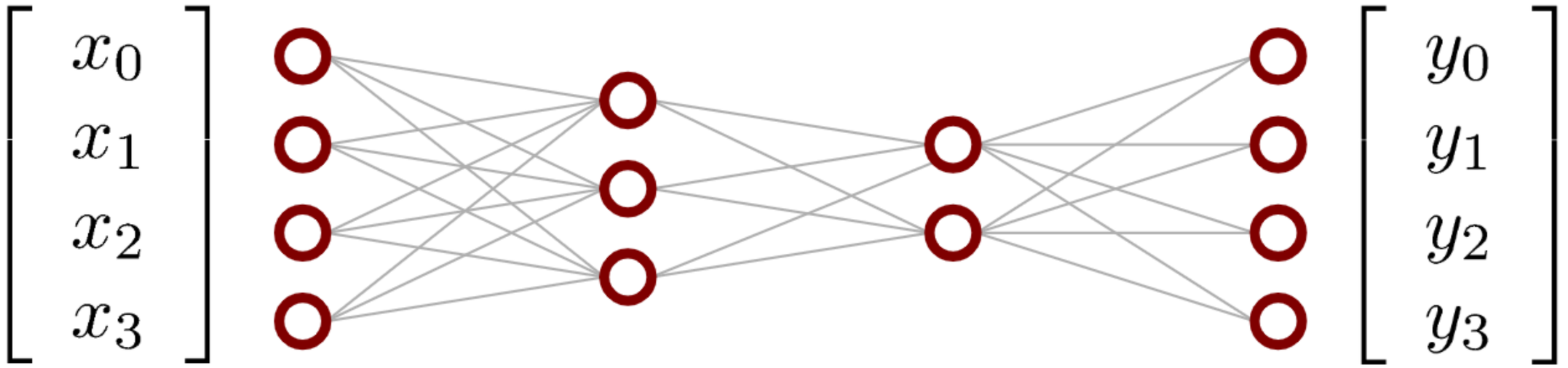


Neural Network as a Function

input layer

hidden layers

output layer

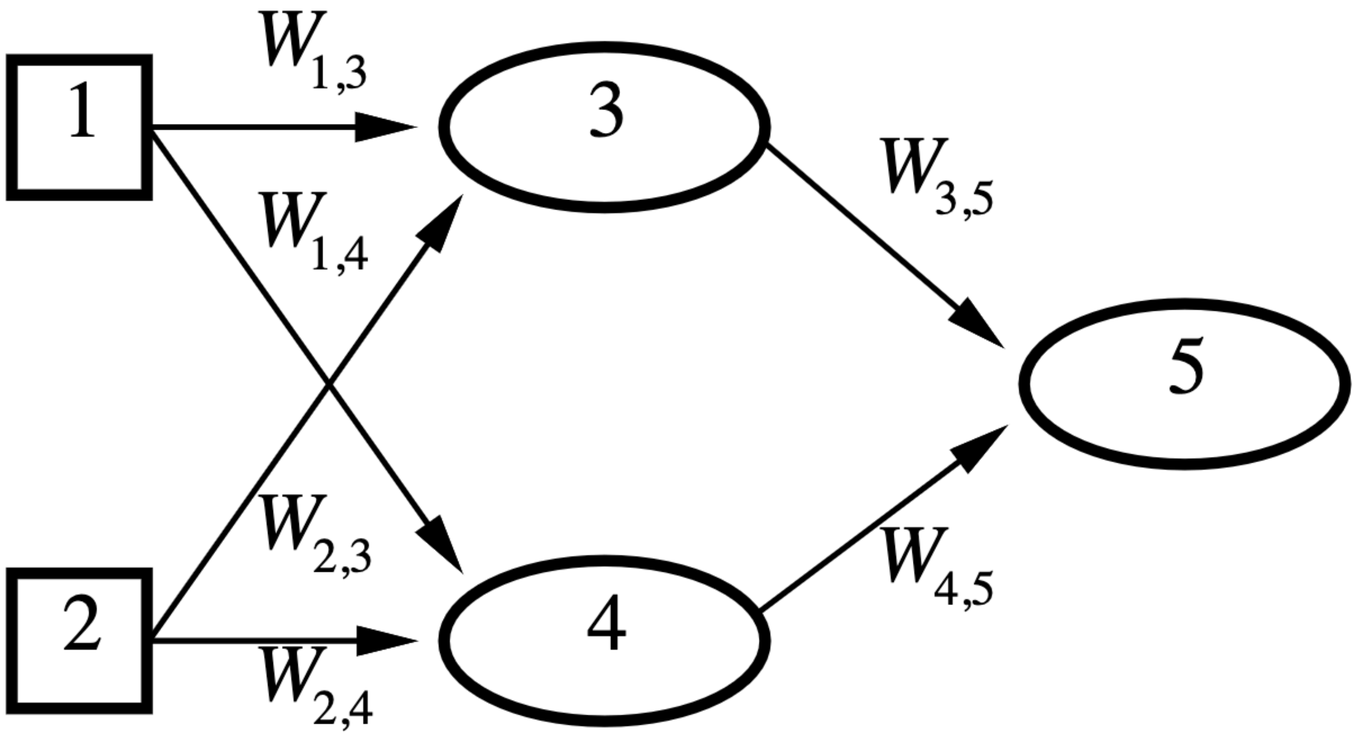


$\boldsymbol{x} \in \mathbb{R}^4$

$\hat{\boldsymbol{y}} = f_{NN}(\boldsymbol{x})$

$\hat{\boldsymbol{y}} \in \mathbb{R}^4$

How it works?



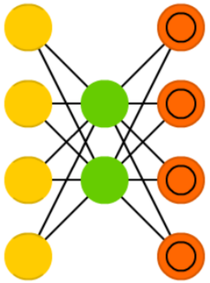
$$
\begin{aligned}
a_5 &= g(W_{3,5} \cdot a_3 + W_{4,5} \cdot a_4) \\
&= g(W_{3,5} \cdot g(W_{1,3} \cdot a_1 + W_{2,3} \cdot a_2) + W_{4,5} \cdot g(W_{1,4} \cdot a_1 + W_{2,4} \cdot a_2))
\end{aligned}
$$

Different Types of NNs

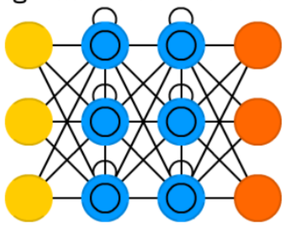
- Perceptron
- Convolutional Neural Networks (CNN)
- Recurrent Neural Networks (RNN)
- Long Short-Term Memory Networks (LSTM)
- Gated Recurrent Unit Networks (GRU)
- Autoencoders
- Self-Organizing Maps (SOM)
- Transformer Networks
- …

Perceptron (P)

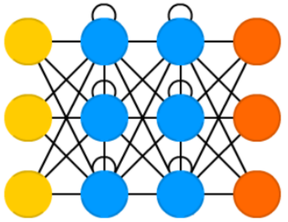
Auto Encoder (AE)



Long / Short Term Memory (LSTM)



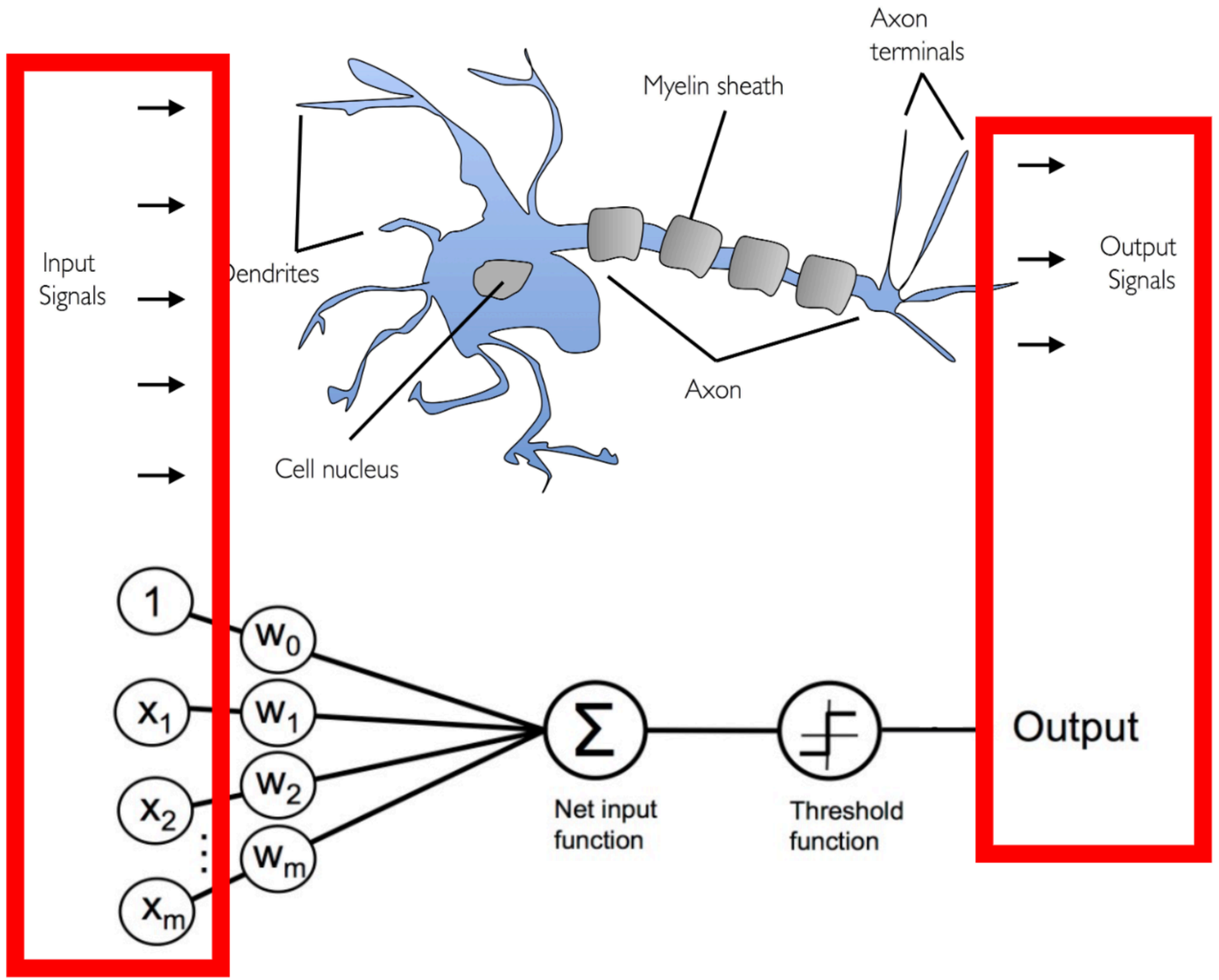
Recurrent Neural Network (RNN)



Perceptron

Biological Neuron:

Artificial Neurons (e.g., Perceptron):



Last point

Ethical Considerations in Machine Learning

- **Bias and Fairness in Machine Learning Models:** Machine learning models can perpetuate biases present in the data used to train them, leading to unfair outcomes for certain groups.
  - Example: Hiring algorithms, robot police, ..
- **Privacy and Data Protection:** Machine learning models often require large amounts of data, raising concerns about privacy and the protection of sensitive information.
  - Example: Healthcare AI applications that use patient data must comply with strict regulations (like GDPR or HIPAA) to protect patient privacy
- **Transparency and Interpretability:** Users should understand how machine learning models make decisions and be able to interpret their outputs.
  - Example: financial services

Thank You