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Collage of Electronics Engineering
System & Control Engineering

Lec1: Computer Networks

Types & Components

Introduction to Computer Networks

- A computer network is a collection of interconnected devices.
- Devices share resources, data, and applications.
- Importance:
  - Internet access
  - Communication (email, messaging)
  - Business operations
  - Smart homes & IoT

Types of Computer Networks

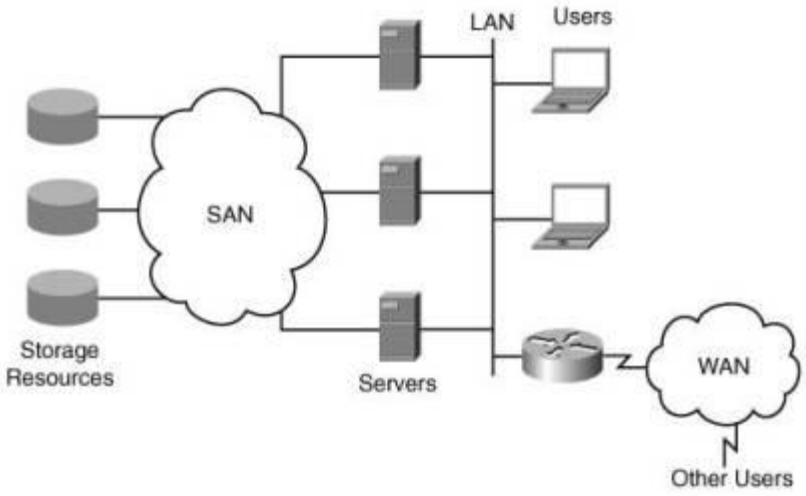
- Based on Geographical Coverage:
  - PAN, LAN, MAN, WAN

"How many of you use Wi-Fi daily? That's a simple LAN example."

PAN: Personal area, e.g., Bluetooth headset, phone tethering.
LAN: Local area, e.g., office Wi-Fi, school labs. Fast & secure.
MAN: Metropolitan, e.g., university campuses, city Wi-Fi.
WAN: Covers large areas; the Internet is the biggest WAN.

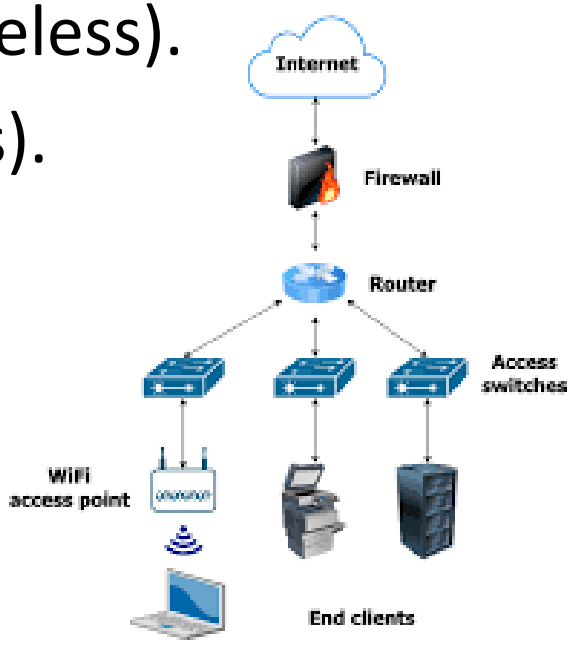
Types of Computer Networks

- Based on Ownership:
  - Private, Public
- Specialized Networks:
  - CAN: Campus Area Network.
  - SAN: Storage Area Net.
  - -VPN: Virtual Private Net.



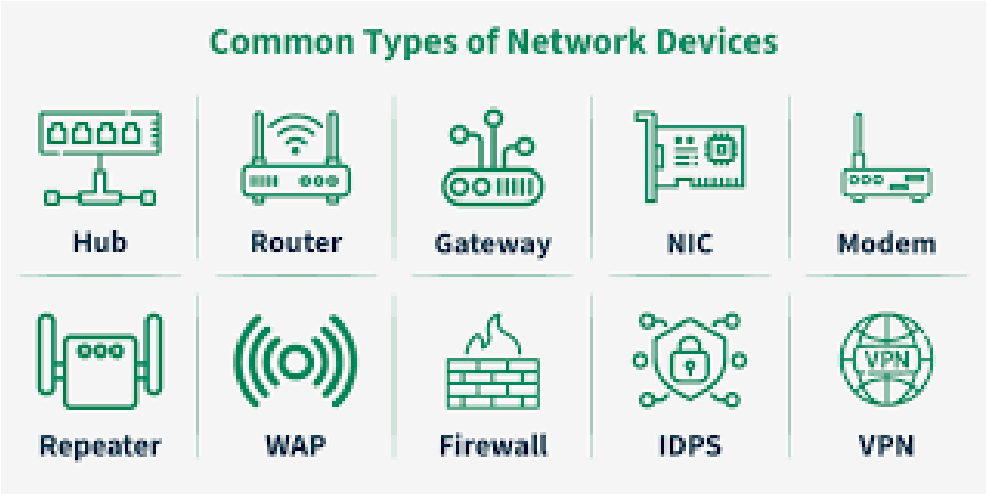
Basic Network Components

- Every network is made up of four main parts:
  - End devices (computers, phones).
  - Networking devices (routers, switches, etc.).
  - Transmission media (wired/wireless).
  - Software & protocols (the rules).



Networking Devices

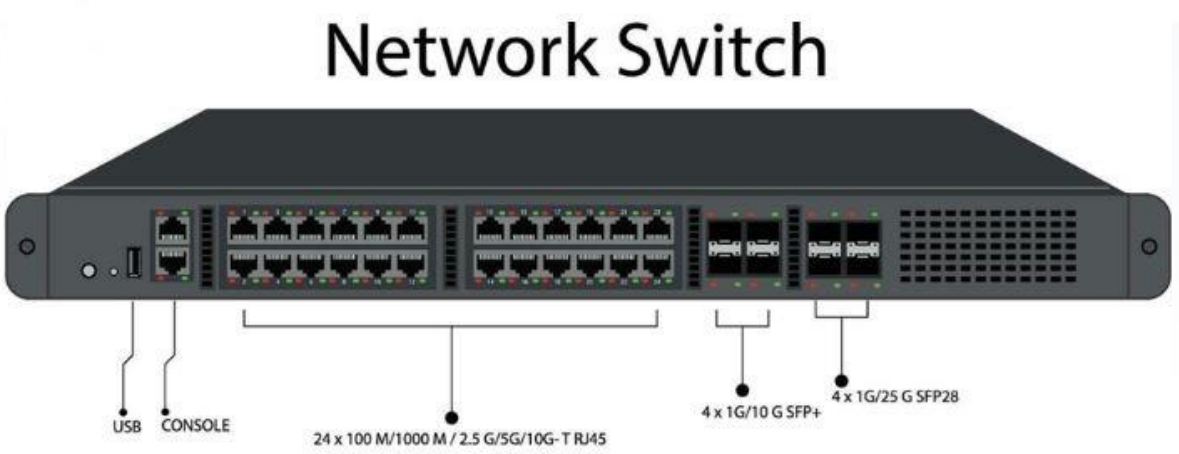
- Switch: smart connector, directs data only where needed.
- Router: gateway between networks (home router connects LAN to Internet).



Networking Devices

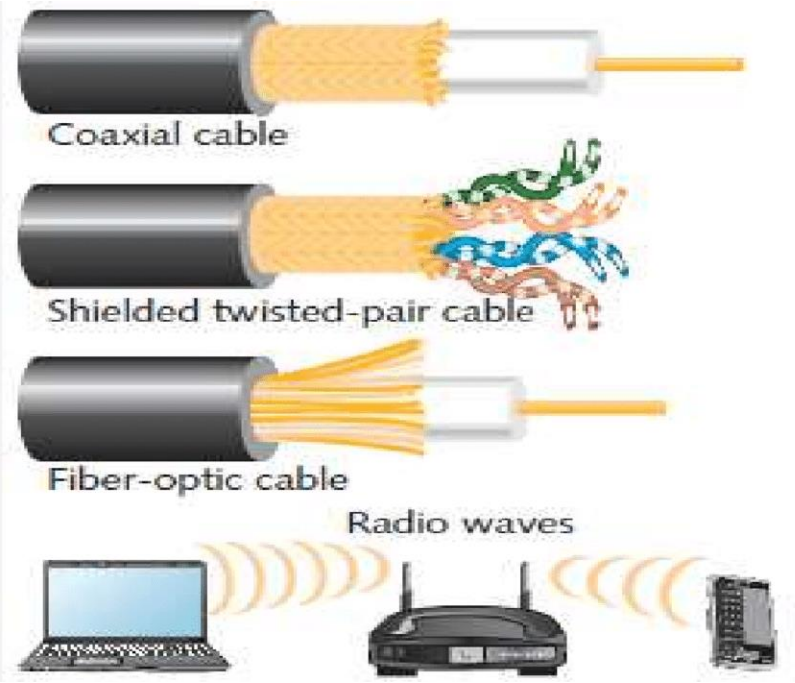
- Hub: old, less efficient; sends data to everyone.
- Access Point: gives wireless access, like Wi-Fi in cafes.
- Firewall: protects from hackers & malware.

Switch is like a receptionist directing calls, router is like a post office, firewall is like a security guard.



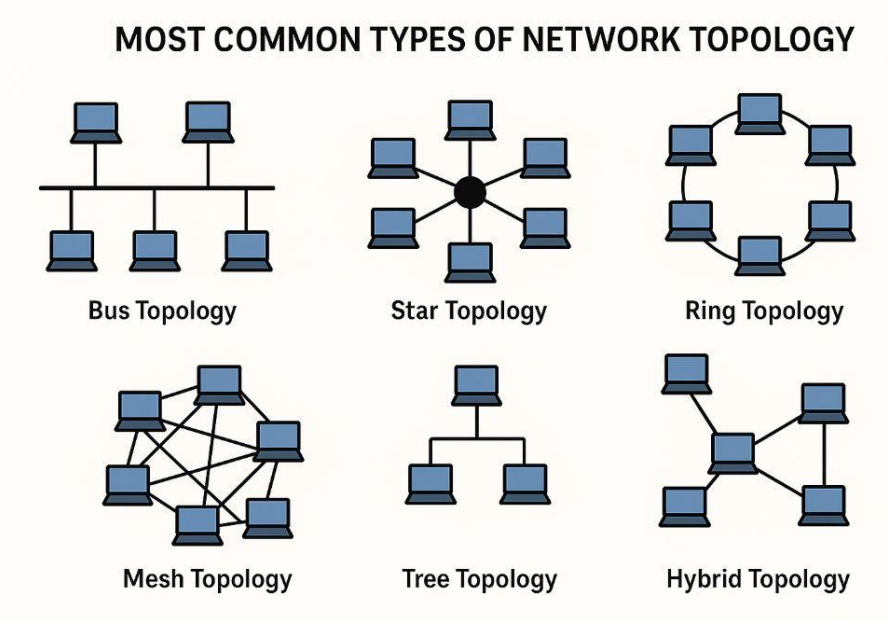
Transmission Media

- Wired:
  - Twisted pair cables (Ethernet)
  - Coaxial cable
  - Fiber optic cable
- Wireless:
  - Wi-Fi
  - Bluetooth
  - Cellular (4G/5G)



Network Topologies

- Bus – Simple backbone
- Star – Central hub/switch
- Ring – Circular connections
- Mesh – Redundant connections
- Hybrid – Combination



Bus: all connected in one line, cheap but fails if cable breaks.
Star: all devices connect to central switch, common today.
Ring: devices in a circle, less common now.
Mesh: every device connects to many others, very reliable but expensive.
Hybrid: mix of topologies (e.g., star + mesh).
Think of classrooms (star), a circle of students (ring), or a spider web (mesh).

Network Topologies

- Bus: all connected in one line, cheap but fails if cable breaks.
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- Think of classrooms (star), a circle of students (ring), or a spider web (mesh).

Applications of Networks

- Home – Smart devices, Wi-Fi
- Education – Online learning
- Business – Cloud computing, email servers
- Banking – Secure transactions (VPNs)

Home: Wi-Fi, smart devices, online gaming.
Education: e-learning platforms, library access.
Business: email servers, cloud storage, video conferencing.
Banking: secure online transactions, VPNs.

Summary & Q&A

- Definition of computer network
- Types: PAN, LAN, MAN, WAN, etc.
- Components: devices, media, protocols
- Applications in daily life

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Network Security Basics
Understanding Threats

Lec. Dr. Hussein M. Hussein

What is Network Security?

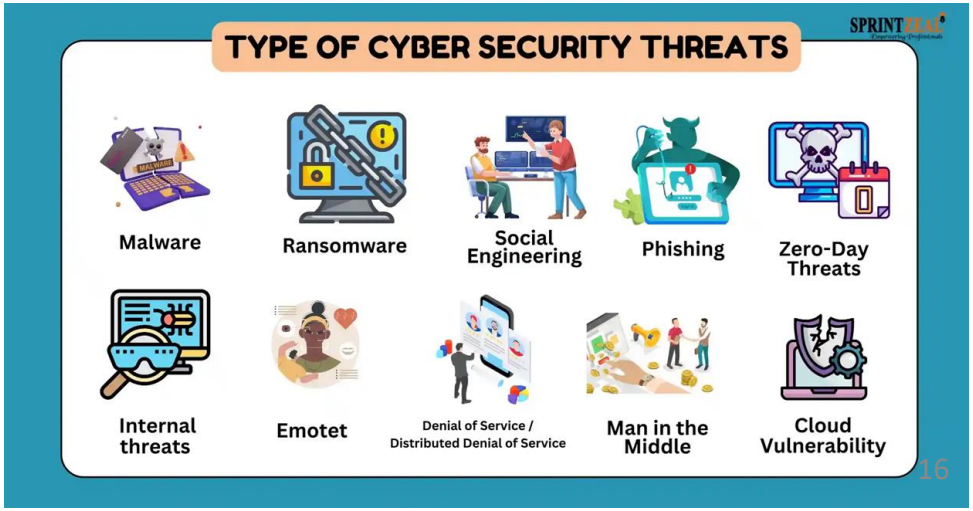
- Protection of data, devices, and resources in a network.
- Prevent unauthorized access, misuse, or damage.
- Goals: Confidentiality, Integrity, Availability (CIA Triad).

CIA Triad

- The goal of network security is to ensure three main principles:
  - Confidentiality: Keep data private.
  - Integrity: Keep data accurate and unchanged.
  - Availability: Keep systems and services accessible.

Types of Threats

- Threats to networks come in many forms:
  - Technical: Viruses, DDoS, password cracking, sniffing.
  - Human: Social engineering, insider threats.
  - Natural: Power outages, disasters (fire, flood, earthquake).

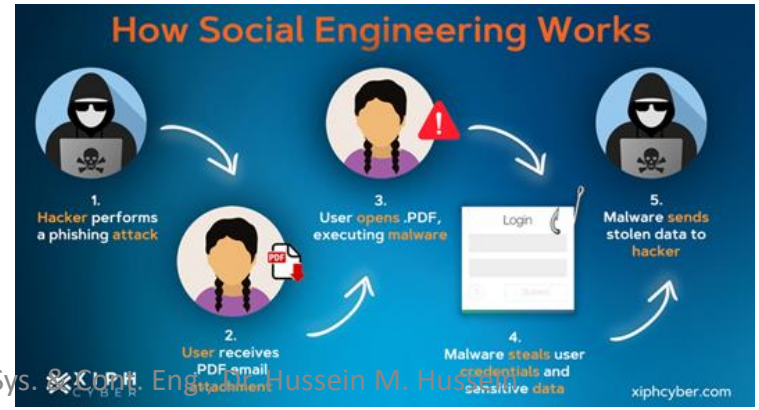


Technical Threats

- Attacks that exploit weaknesses in hardware, software, or networks.
- Examples:
  - Viruses & Worms – self-replicating malware
  - DDoS (Distributed Denial of Service) – overwhelming a server with traffic
  - Password Cracking – brute-force or dictionary attacks
  - Sniffing – intercepting network traffic

Human (Social Engineering) Threats

- Attacks that manipulate people into giving up sensitive information or access.
- **Examples:**
  - **Phishing** – fake emails or websites stealing passwords
  - **Pretexting** – attacker pretends to be authority (e.g., IT support)
  - **Baiting** – offering free items (USBs, downloads) with malware
  - **Tailgating** – following someone into secure areas

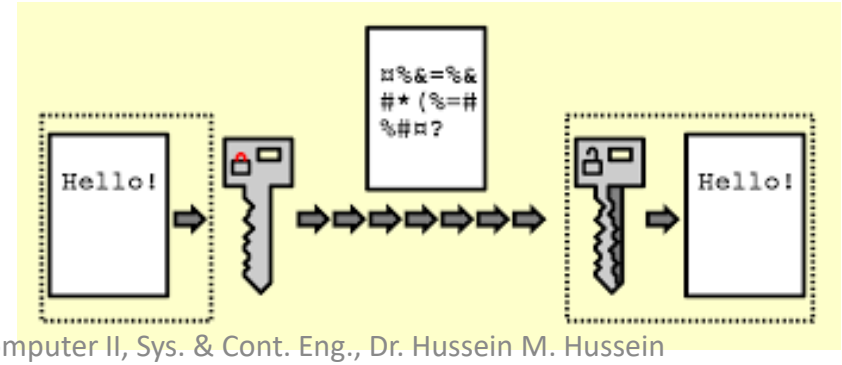


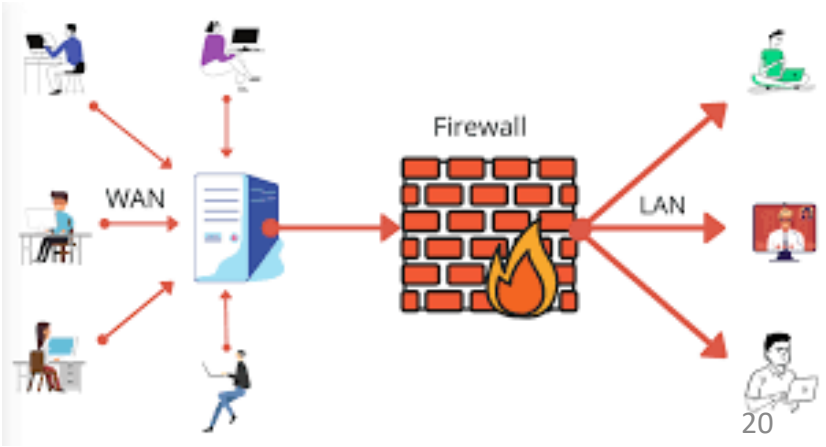
Natural Threats

- Events beyond human control that disrupt IT systems and networks.
- **Examples:**
  - **Power outages** – loss of electricity
  - **Fires** – destruction of equipment
  - **Floods/Earthquakes** – physical damage to data centers
  - **Storms** – cutting off internet or damaging infrastructure

Core Security Components

- To protect a network, we use different tools and techniques:
  - Firewalls (monitor & block traffic).
  - Encryption (protect data).
  - Authentication (verify identity).
  - Antivirus & anti-malware.





Firewalls

- A security system that monitors and controls incoming and outgoing network traffic based on predefined rules.
- **Types:**
  - **Packet-filtering firewall** (checks source/destination IP & ports)
  - **Stateful inspection firewall** (tracks ongoing connections)
  - **Proxy firewall** (acts as middleman between user & internet)
  - **Next-Gen Firewall (NGFW)** (includes intrusion prevention, app control)
- **Examples:**
  - Cisco ASA Firewall
  - Palo Alto NGFW
  - pfSense (open-source)

Encryption

- The process of converting readable data into an unreadable format to protect it from unauthorized access.
- **Types:**
  - **Symmetric encryption** (same key for encryption & decryption) → *AES, DES*
  - **Asymmetric encryption** (public & private key) → *RSA, ECC*
  - **Hashing** (one-way function for data integrity) → *SHA-256, MD5*
- **Examples:**
  - HTTPS uses RSA + AES
  - WhatsApp uses end-to-end encryption
  - VPNs use AES-256

Authentication

- The process of verifying the identity of a user, device, or system before granting access.
- **Types:**
  - **Password-based** (username + password)
  - **Multi-factor authentication (MFA)** (password + SMS/email/biometric)
  - **Biometric authentication** (fingerprint, face recognition)
  - **Token-based authentication** (smart cards, hardware tokens, OTP apps)
- **Examples:**
  - Gmail 2FA with SMS/Authenticator app
  - Windows Hello facial recognition
  - RSA SecurID token

Antivirus & Anti-Malware

- Software designed to detect, prevent, and remove malicious software from computers and networks.
- **Types:**
  - **Signature-based detection** (detects known malware)
  - **Heuristic-based detection** (detects suspicious behavior/code)
  - **Behavioral-based detection** (monitors real-time activity)
  - **Cloud-based protection** (uses online databases for faster detection)
- **Examples:**
  - Norton Antivirus
  - Kaspersky
  - Windows Defender
  - Malwarebytes

Protection Methods

- Keep systems updated.
- Strong & unique passwords.
- Multi-factor authentication.
- Regular backups.
- User awareness & training.

How to Create a Strong Password?

- Use at least 12 characters.
- Mix uppercase, lowercase, numbers, and symbols.
- Avoid dictionary words or personal info (name, birthday).
- Do not reuse passwords across accounts.
- Use a password manager if possible.

Conclusions

- Networks without security are vulnerable.
- Security = CIA triad + tools + awareness.
- Threats: technical, human, natural.
- Prevention requires both technology & safe practices.

Discussion Questions

- Have you experienced a virus or hacked account?
- How did you respond?

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E-Commerce and Electronic Banking

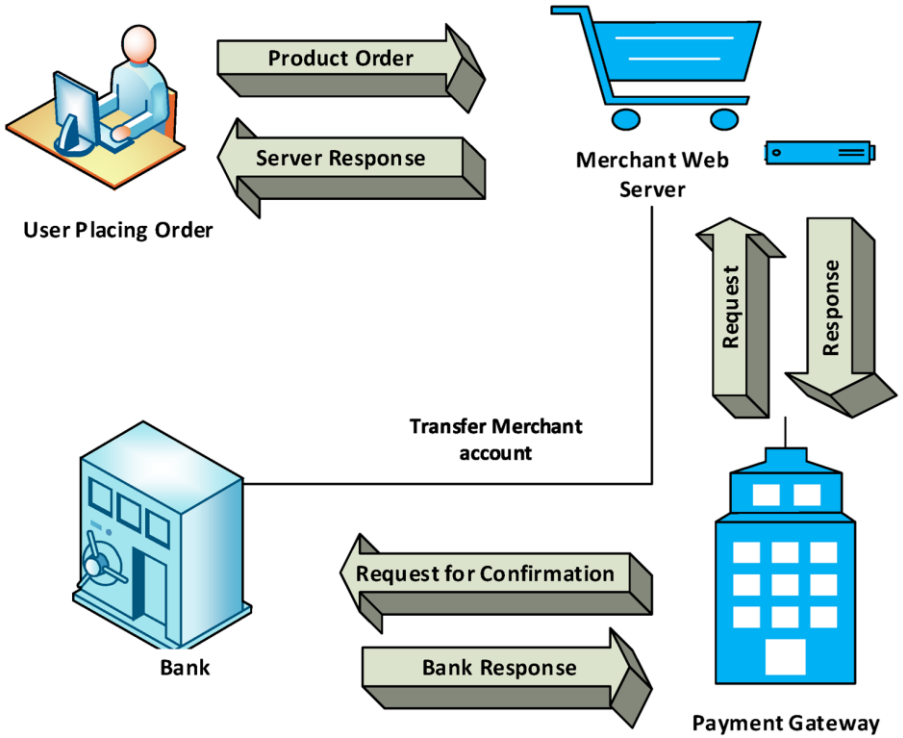
Digital World of Trade and Finance

Lec. Dr. Hussein M. Hussein

Introduction

- The world is moving rapidly toward digital transformation. **E-commerce** and **e-banking** are changing how we buy, sell, and manage money.

Both provide convenience, speed, and global access — but also require awareness of security and trust.

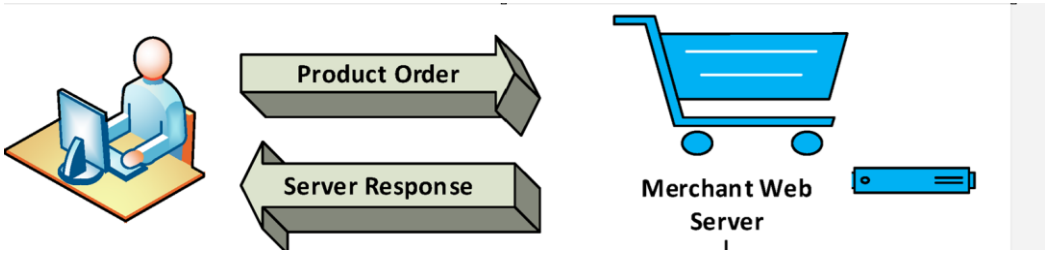


What is E-Commerce?

- E-Commerce (Electronic Commerce) is the process of buying and selling goods or services over the Internet.

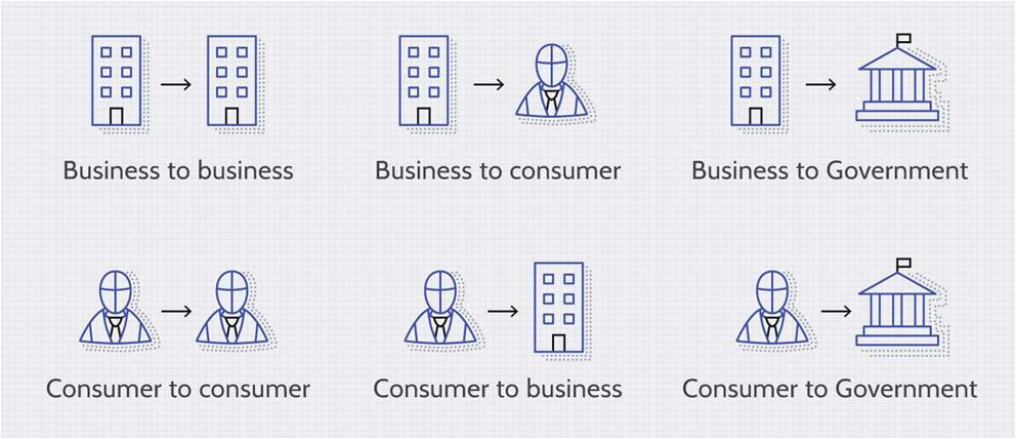
- Key Points:
  - Conducted via websites or mobile apps.
  - Uses digital payments (cards, wallets, etc.).
  - Accessible 24/7 from anywhere.

- Examples: Amazon, eBay, AliExpress.



Types of E-Commerce

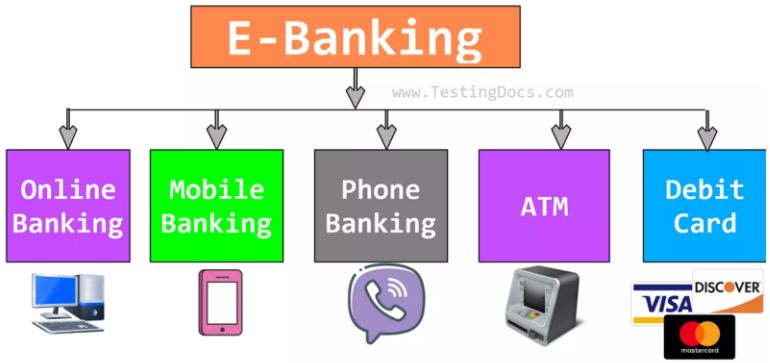
- 1. B2C: Businesses to customers (e.g., Amazon).
- 2. B2B: Businesses to businesses (e.g., Alibaba).
- 3. C2C: Consumers to consumers (e.g., eBay, Facebook Marketplace).
- 4. C2B: Consumers offer services to businesses (e.g., Fiverr, Upwork).



What is Electronic Banking?

- Electronic banking (E-banking) means performing financial transactions using digital platforms — via computers, phones, or ATMs.

- Benefits:
  - 24-hour access to accounts.
  - Fast and paperless.
  - No need to visit branches.



Online Banking Services

- Online banking lets customers access accounts via websites or apps.

- Examples:
  - Check balances, pay bills, transfer money.
  - Banks: Chase, HSBC, Al-Rafidain Bank.

- Security:
  - Use strong passwords and 2FA.

ATM and Debit Card Services

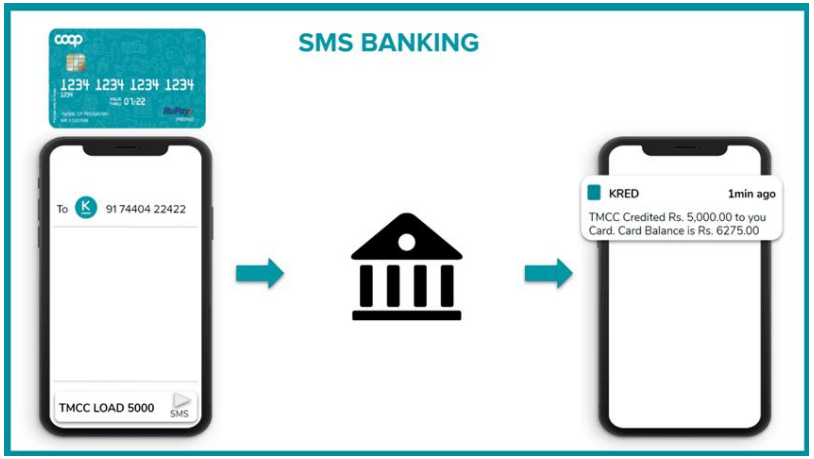
- ATMs and debit cards allow cash withdrawals, deposits, and balance checks without visiting a bank.
- Examples: Visa, MasterCard, local cards.
- Security Tips:
  - Cover PIN when typing.
  - Avoid unknown ATMs.

Phone and SMS Banking

- Banking via phone calls or SMS.

- Examples:
  - Balance inquiries by SMS.
  - Transfers via customer service.

- Advantages:
  - Works on any phone.
  - Useful without Internet.



Mobile Banking

- Banking through smartphone apps for real-time control.
- Examples: Zain Cash, Rafidain app, Apple Pay, Google Pay.
- Benefits:
  - Fast transfers and payments.
  - Integrated with online shopping.

E-Alerts and Notifications

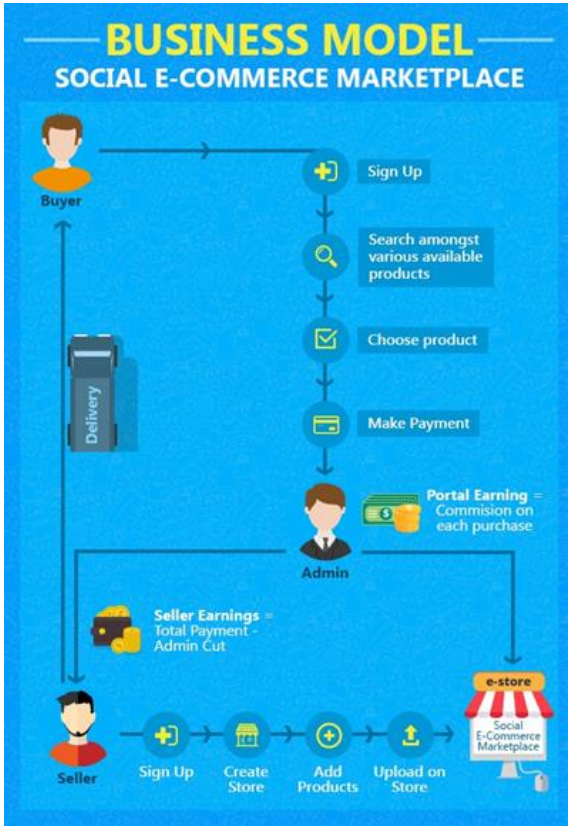
- Automated messages from banks about account activity.

- Examples:
  - SMS for withdrawals or deposits.
  - Email alerts for suspicious logins.

- Benefits:
  - Prevents fraud.
  - Keeps customers informed.

Online Shopping and Social Marketplaces

- **Online Shopping:**
  Online shopping refers to the process of purchasing goods or services over the Internet through websites or mobile applications.
- **Social Marketplaces:**
  Social marketplaces are online platforms integrated into social media networks that enable users to buy and sell directly within those apps.
- Examples:
  - Shopping: Amazon, Noon, eBay, AliExpress.
  - Social: Facebook Marketplace, Instagram Shops,
- Advantages:
  - Easy product comparison.
  - User reviews for trust.
- Risks:
  - Fake sellers — verify ratings.



Advantages of E-Banking and E-Commerce

- 24/7 access to services.
- Faster, paperless transactions.
- Global reach and scalability.
- Reduced costs for banks and customers.
- Personalized user experience.
- Real-time transaction monitoring.

Security and Safe Practices

- Tips:
  - Use strong, unique passwords.
  - Enable two-factor authentication.
  - Avoid public Wi-Fi.
  - Verify websites (https://).
  - Keep antivirus updated.
  - Beware of phishing messages.

Summary

- E-Commerce has revolutionized how we trade and bank.
- From ATMs and phone banking to mobile apps and social shopping, every transaction today can be digital.
- These technologies make our financial and commercial life faster, smarter, and more connected.

Discussion

- What electronic banking services do you use most often?
- Have you ever shopped from a social marketplace like Instagram or Facebook?
- What security steps do you follow when banking or shopping online?

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Computer Troubleshooting

Identifying and Solving Hardware and Software Problems

Introduction

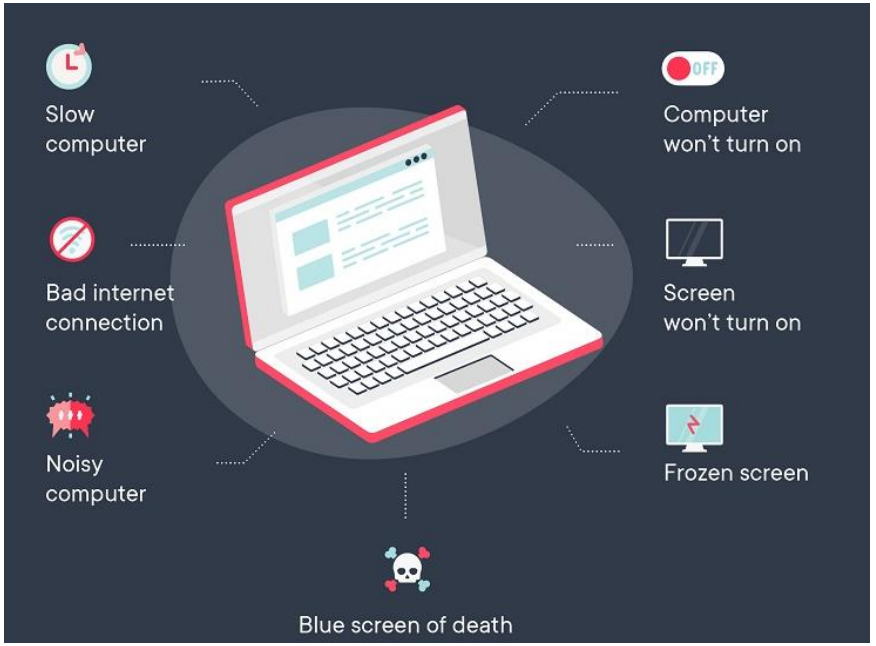
- Definition of troubleshooting.
- Why it’s important for users and IT professionals.
- The goal: to identify, analyze, and fix problems efficiently.

Why Troubleshooting Matters

- Prevents system downtime.
- Saves data and productivity.
- Reduces repair costs.
- Example: PC fails to boot before an exam → quick diagnosis saves hours.

Common Computer Problems

- Hardware issues (e.g., power, overheating).
- Software issues (e.g., crash, virus).
- Network issues (e.g., no internet, slow Wi-Fi).



Examples and Fixes

- Problem – Cause – Solution
- Computer not turning on → Power issue → Check cables.
- System slow → Too many startup apps → Disable extras.
- No internet → IP/driver issue → Renew IP, update driver.

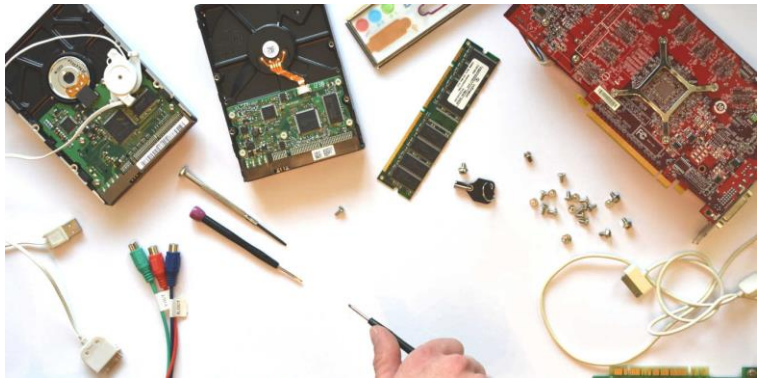
Troubleshooting Process

- 1- Identify the problem.
- 2- Gather information.
- 3- Test possible causes.
- 4- Apply a solution.
- 5- Verify and document.

Example: PC Won’t Boot

- Identify → No response
- Gather → Check lights/fans
- Test → Try different outlet/PSU
- Apply → Replace power cable
- Verify → System starts normally

Hardware Troubleshooting



- Power supply, cables, fans
- RAM, hard disk, peripherals
- Overheating or dust buildup
- **Common hardware components to check:**
  - Power supply, motherboard, RAM, hard disk, fans, and cables
- **Signs of hardware problems:**
  - Beeping sounds, no display, overheating, or random shutdowns
- **First rule: Check physical connections before replacing parts**

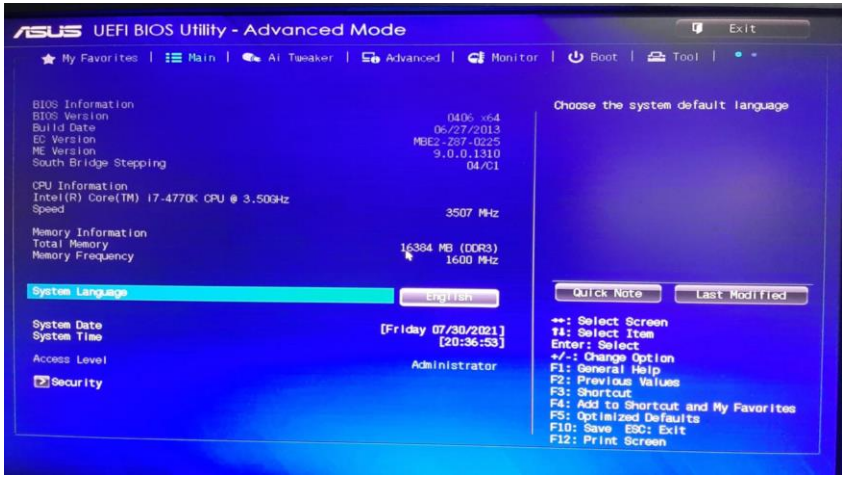
Hardware Problems Examples

Problem	Symptom	Likely Cause	Solution
Computer not turning on	No lights, no fan sound	Power cable unplugged or faulty PSU	Check connections, test power supply
Beeping on startup	Series of beeps	RAM not seated or defective	Reseat or replace RAM
Overheating and auto-shutdown	Fan loud, case hot	Dust or poor ventilation	Clean fan, reapply thermal paste
No display	Monitor on but blank	Loose cable or bad GPU	Reseat GPU, check display cable

Problem	Symptom	Likely Cause	Solution
Hard disk not detected	“No boot device” error	Loose SATA cable or failed HDD	Reconnect cable or replace HDD
Keyboard/mouse not working	No response	USB port damaged or driver issue	Try another port or reinstall drivers
Printer not responding	Offline or “not found”	Cable/Wi-Fi issue	Restart printer and reconnect
Laptop battery not charging	Plugged in, not charging	Faulty adapter or battery	Try different adapter or replace battery

Hardware Tools

- **BIOS/UEFI Access:**
  - Press *F2, F10, Del,* or *Esc* during startup
  - Check boot devices, memory, and hardware health
- **Memory Test:**
  - Use Windows Memory Diagnostic **mdsched.exe**
- **Disk Test:**
  - Use chkdsk or fdisk utility

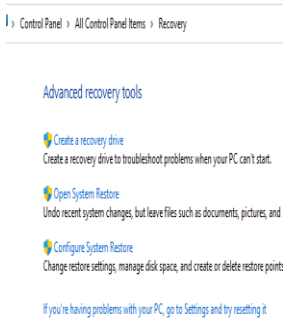


Software Troubleshooting

- Program errors, crashes, or freezing.
- Corrupted OS files.
- Compatibility issues.

Software Tools

- **Safe Mode:** Restart and hold *Shift + F8* or choose from Recovery options
- **System Restore:** Revert to a working configuration
- **Reinstallation:** Run Windows setup from USB/DVD
- **Command Prompt Tools:**
  - sfc /scannow – repairs system files This command checks the integrity of Windows system files and automatically repairs them if corruption is found
  - DISM /Online /Cleanup-Image /RestoreHealth – fixes image corruption
    - Repairs corrupt files in the Windows image by scanning the system and replacing missing or corrupted files with healthy ones from Windows Update

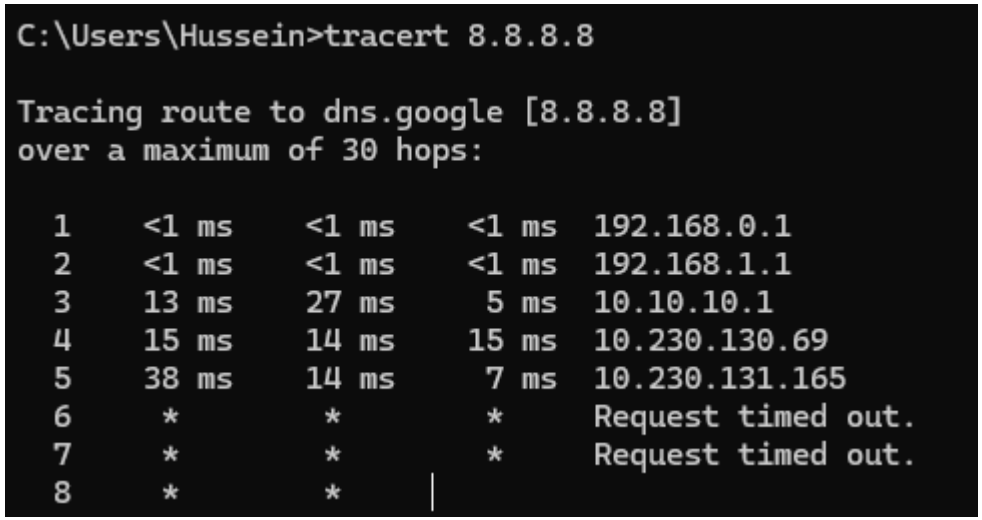


Network Troubleshooting

- Check cables, Wi-Fi connection
- Use ping to test connectivity
- Restart router and check IP settings

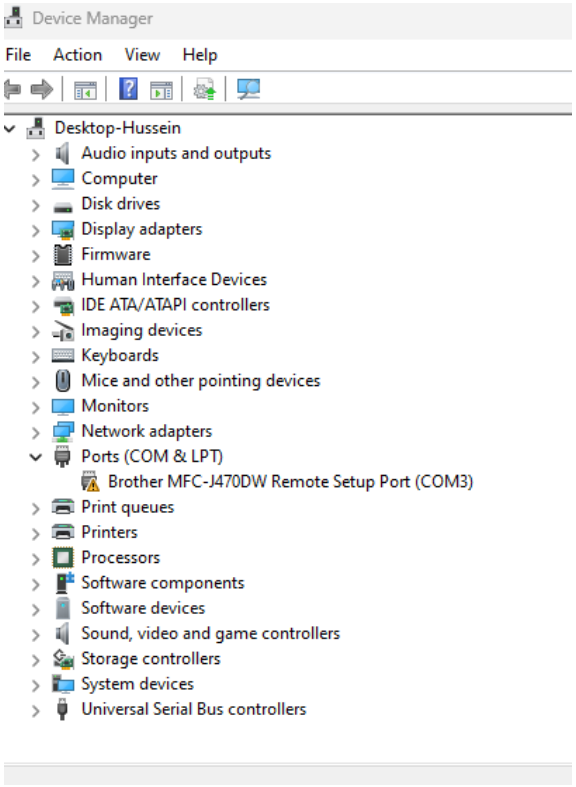
Network Tools

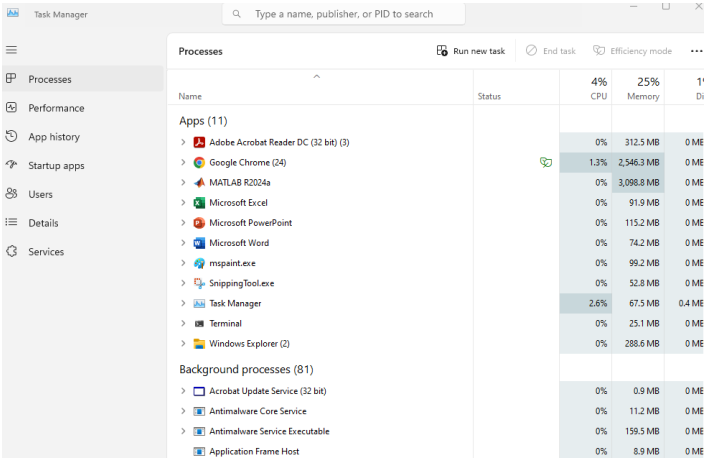
- **ipconfig /all** → Shows IP configuration
- **ping 8.8.8.8** → Tests connection
- **tracert** → Checks network path
- **Network Troubleshooter:** Built into Windows



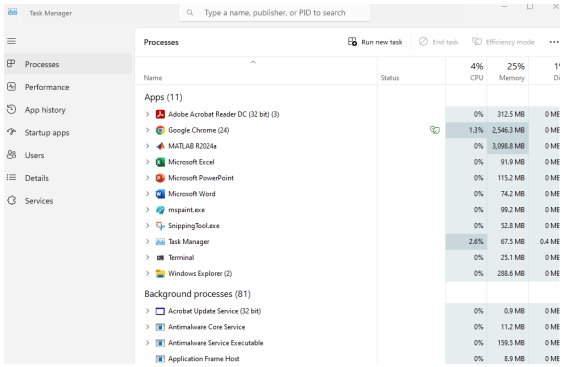
Basic Troubleshooting Tools

- **Task Manager:** End frozen processes
- **Device Manager:** Fix driver problems
- **Event Viewer:** Check error logs
- **System Restore:** Roll back to working state





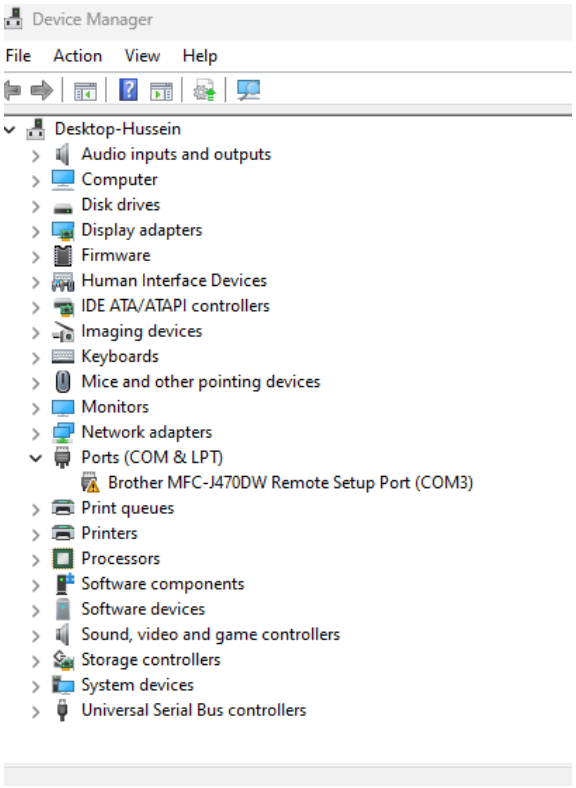
Task Manager



- Shortcut: *Ctrl + Alt+ Delete*
- Tabs:
  - **Processes:** End unresponsive apps
  - **Performance:** Check CPU/memory usage
  - **Startup:** Disable heavy programs

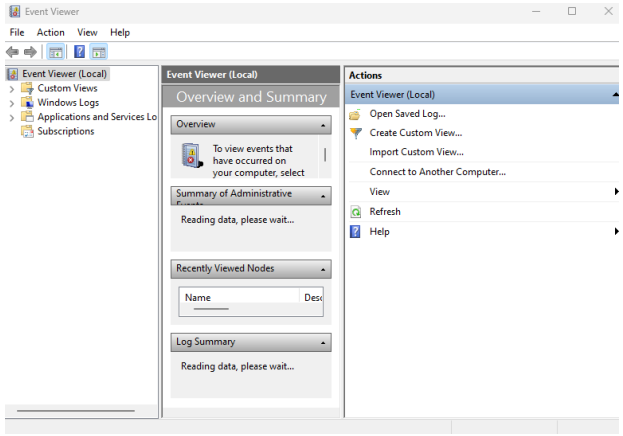
Device Manager

- Access via *Win + X → Device Manager*
- Check devices with ⚠️ yellow icon
- Right-click → “Update driver” or “Uninstall device”



Event Viewer

- Access: *Win + X → Event Viewer*
- Sections:
  - Application Logs
  - System Logs
- Look for critical errors to identify issues



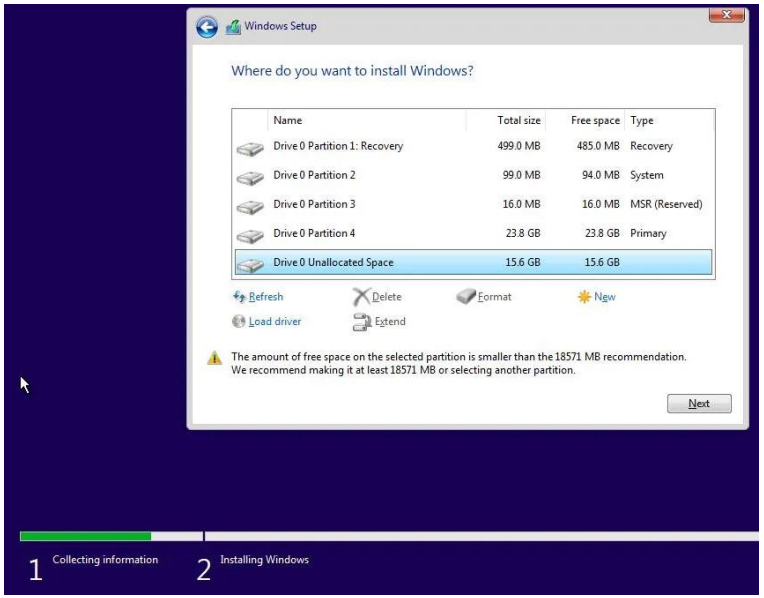
BIOS Setup

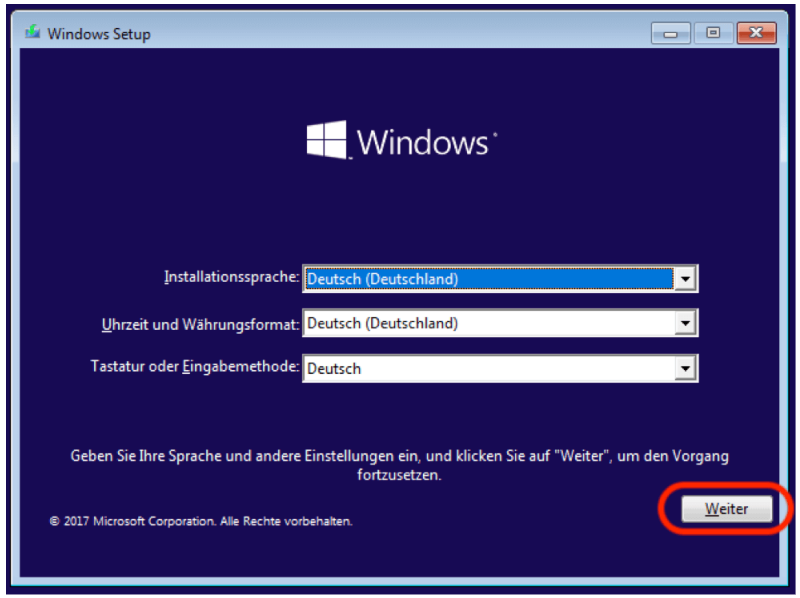
- Access BIOS during startup (Del, F2, Esc)
- Functions:
  - Change boot order
  - Enable/disable devices
  - Monitor CPU and temperature

- Example: Change boot device to USB for Windows installation

Windows Setup

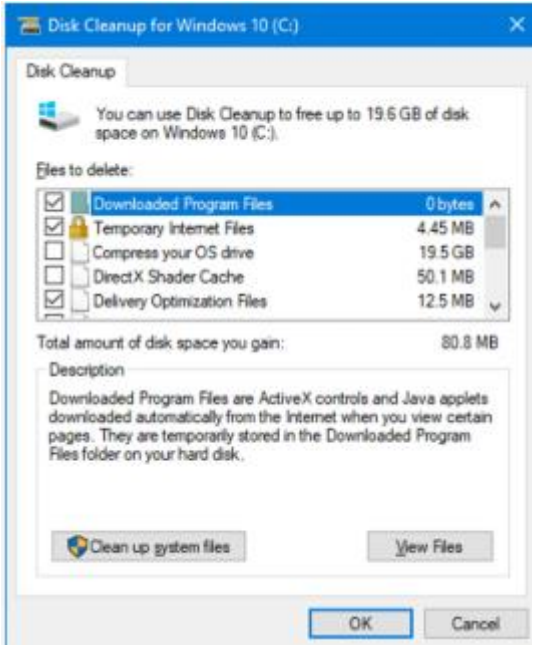
- Boot from installation media USB/DVD
- Choose language, partition and install
- Activate and update drivers





Preventive Maintenance

- Regular updates
- Antivirus scans
- Cleaning junk files
- Avoiding suspicious downloads



Cleaning junk files

1. **Use Disk Cleanup:**

   Search for "Disk Cleanup" in the Start menu, select your drive (usually C:), and choose the types of files to remove. For more options, click "Clean up system files".

2. **Use Storage recommendations**:

   Go to Settings > System > Storage and click "Cleanup recommendations." Review categories like "Temporary files," "Large or unused files," and "Unused apps" to clear them.

3. **Clear temporary files:**

   Go to Settings > System > Storage and click "Temporary Files" to select and remove them.

4. **Empty the Recycle Bin:**

   Right-click the Recycle Bin icon on your desktop and select "Empty Recycle Bin".

Real-World Examples

1. Slow PC → Clean temp files, upgrade RAM
2. Blue screen → Update drivers, run memory test
3. Printer not responding → Reinstall driver, check cable

Advanced Tools

- **Command-line diagnostics** (netstat, tasklist)
  - The netstat command displays active network connections, listening ports, routing tables, and network interface statistics. It is used for monitoring network activity and troubleshooting connection problems.
- **BIOS self-test (POST)**
  - The BIOS self-test, or Power-On Self-Test (POST), is a diagnostic process initiated when a computer starts up to check if essential hardware is working correctly before the operating system loads. It verifies the CPU, memory, and I/O devices, and signals any problems with beeps or on-screen messages.
- **SMART tools** for hard disk health

Troubleshooting Tips

- Keep notes of each step
- Change one variable at a time
- Use Google or forums for known error codes

Summary

- Troubleshooting = Identify + Test + Solve
- Tools simplify diagnosis
- Prevention reduces future issues

Questions

- Describe a computer issue you've faced and solution.

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Introduction to Artificial Intelligence (AI)

Definition, History, Techniques, and Approaches

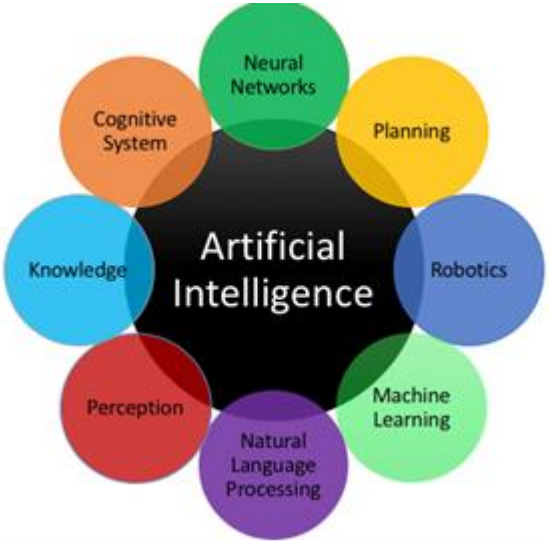
Lec. Dr. Hussein M. Hussein

What is Artificial Intelligence?

- “Artificial Intelligence allows computers to think and act like humans.
- AI means creating machines that can perform tasks that require human intelligence.
- Enables systems to think, learn, and adapt like humans.
- These tasks include learning, reasoning, problem-solving, perception, and language understanding.
- Example: voice assistants, self-driving cars, and recommendation systems.

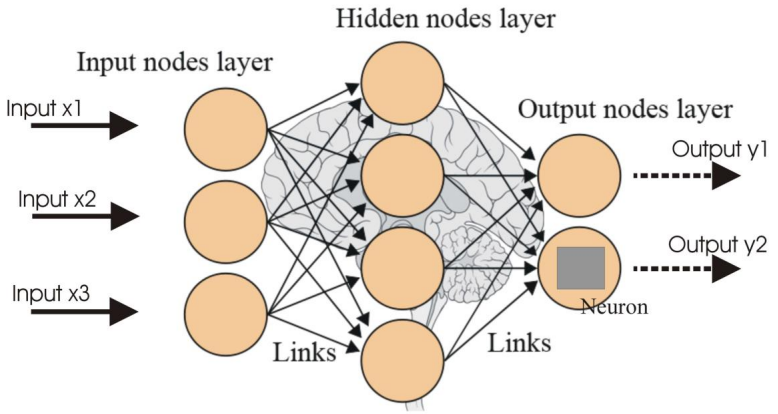
Goals of AI

- Create systems that can perform tasks requiring human intelligence.
- Improve efficiency and accuracy in decision-making.
- Enable automation and assist in complex problem-solving.

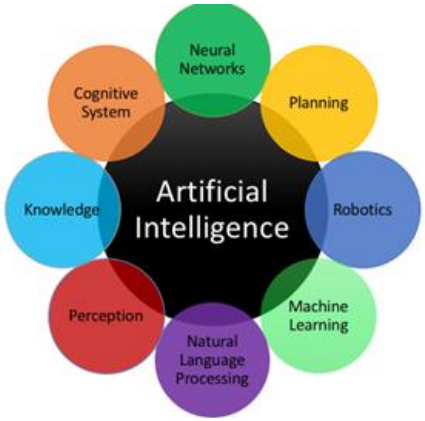


History of AI

- **1950s:** Alan Turing proposes the “Turing Test.”
- **1956:** John McCarthy coins the term ‘Artificial Intelligence’ first used at Dartmouth Conference.
- **1960s–1980s**: Rule-based systems and expert systems. Early AI programs like ELIZA and SHRDLU.
- **1990s–2000s**: Machine learning and data-driven approaches.
- **2010s–Now:** Deep learning and neural networks revolution.



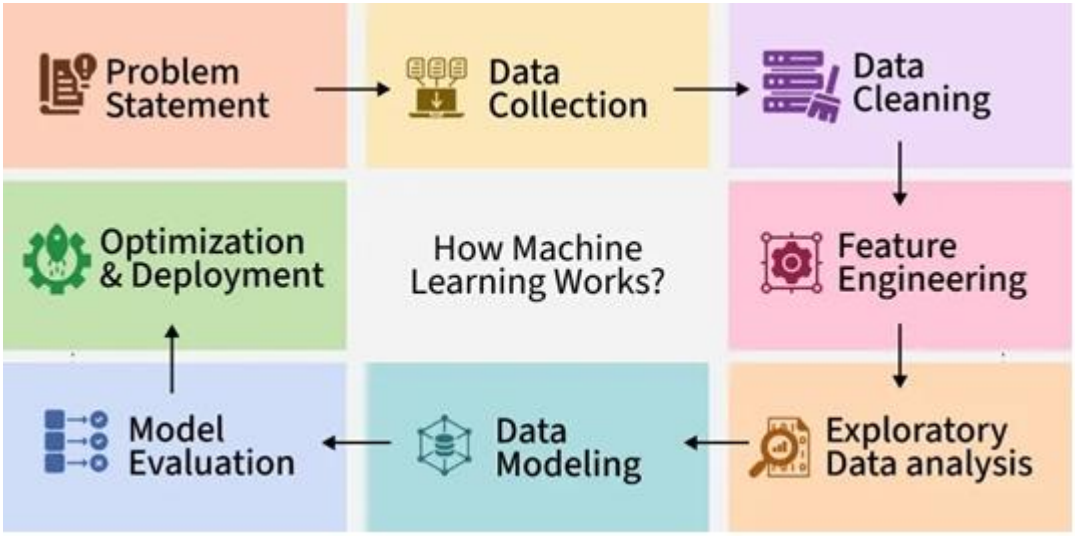
AI Techniques Overview



- 1. Machine Learning
- 2. Deep Learning
- 3. Expert Systems
- 4. Natural Language Processing (NLP)
- 5. Computer Vision
- 6. Robotics
- **These are the main tools that make AI systems function**
  - **Search Techniques:** used in games, pathfinding, and problem-solving.
  - **Knowledge Representation**: storing facts and rules for reasoning.
  - **Reasoning and Inference**: drawing conclusions from available data.
  - **Learning Techniques:** supervised, unsupervised, and reinforcement learning.

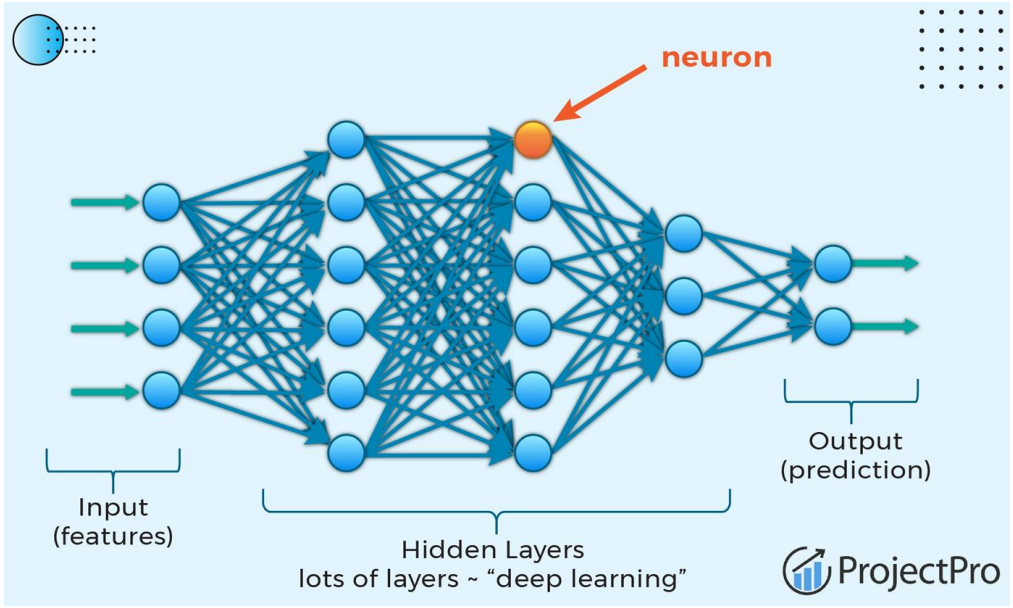
Machine Learning

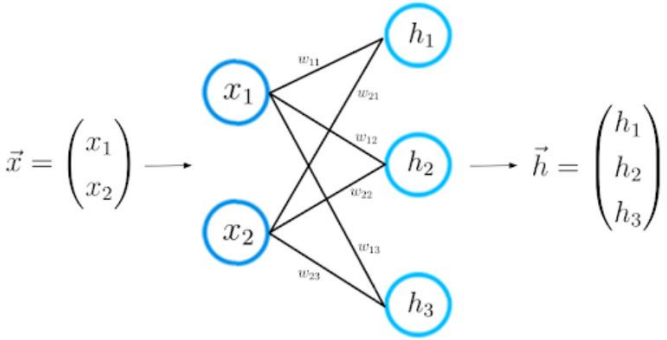
- Enables computers to learn from data without explicit programming.
- Types: Supervised, Unsupervised, Reinforcement Learning.
- Used in spam filtering, recommendations, and fraud detection.



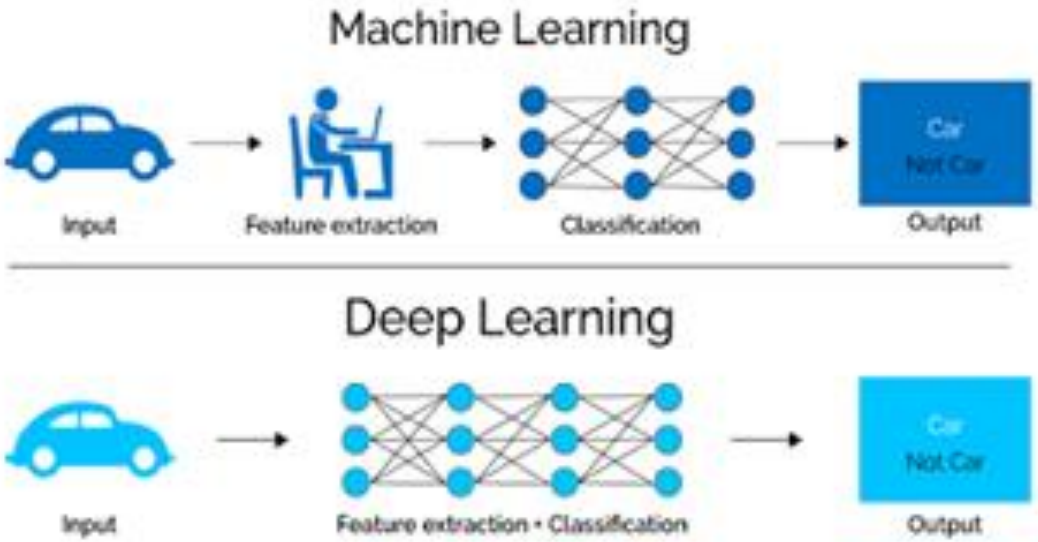
Deep Learning

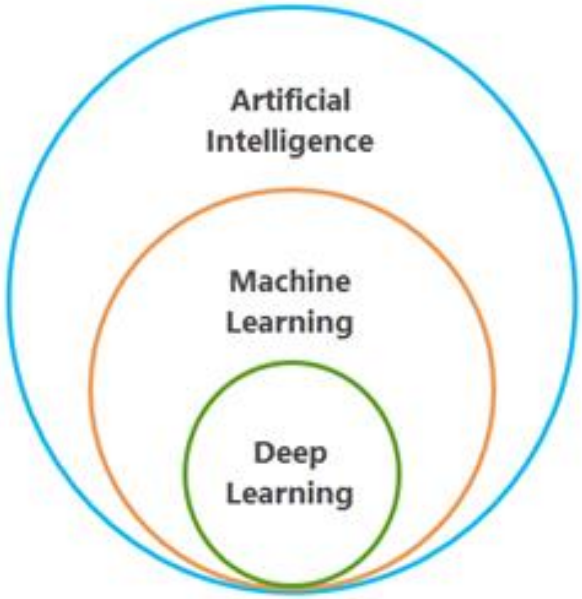
- Subset of Machine Learning using neural networks with many layers.
- Mimics human brain structure for pattern recognition.
- Used in image recognition, speech, and autonomous driving.





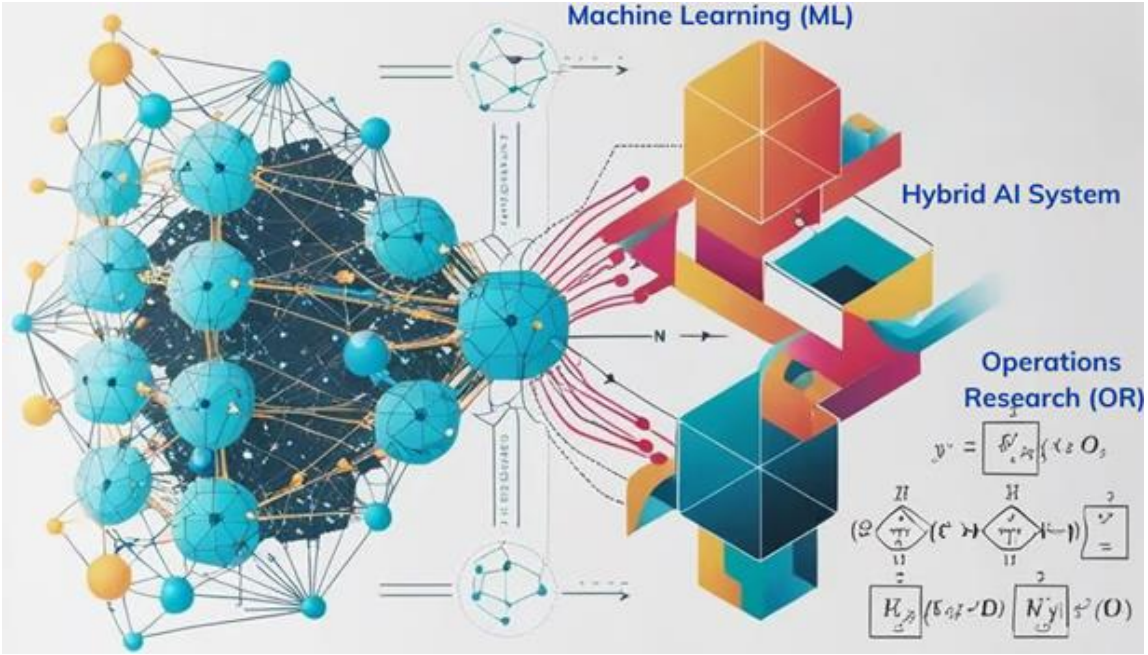
Machine Learning vs Deep Learning





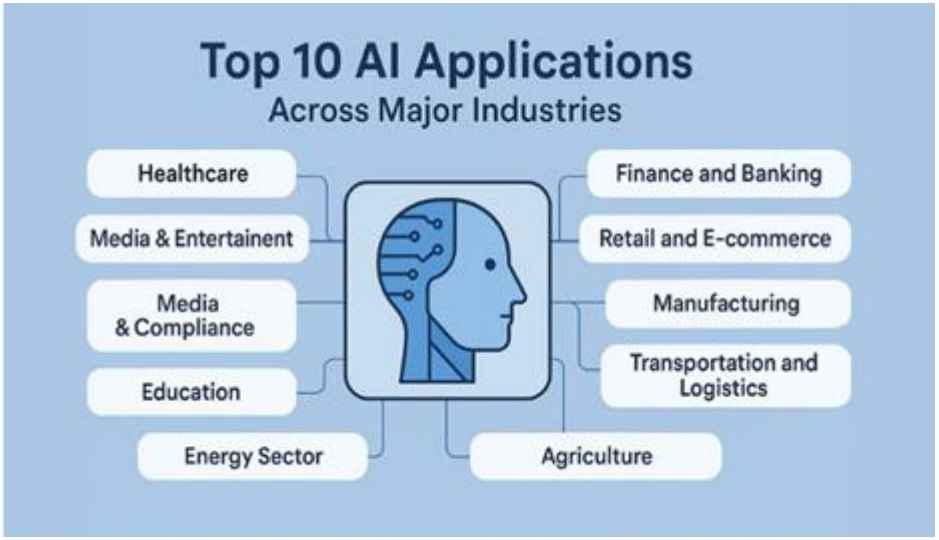
Approaches to AI

- Symbolic AI: Rule-based reasoning and logic.
- Connectionist AI: Neural networks learning from data.
- Evolutionary AI: Algorithms inspired by nature.
- Hybrid AI: Combines symbolic and neural methods.

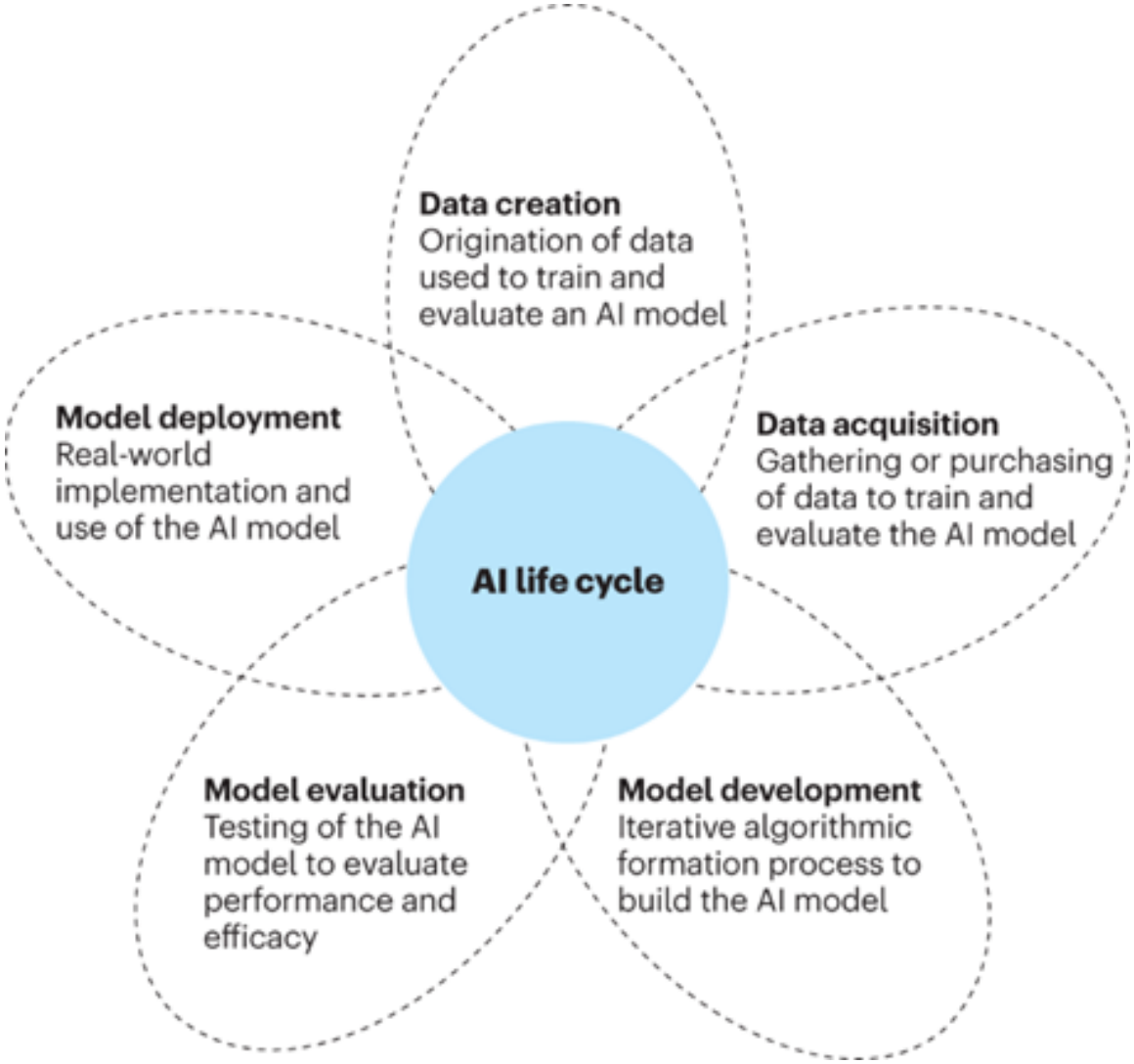


Applications of AI

- Healthcare: Diagnosis and treatment recommendation.
- Finance: Fraud detection and algorithmic trading.
- Transportation: Autonomous vehicles and route optimization.
- Customer Service: Chatbots and virtual assistants.
- Manufacturing: Predictive maintenance and automation.



AI Live Cycle

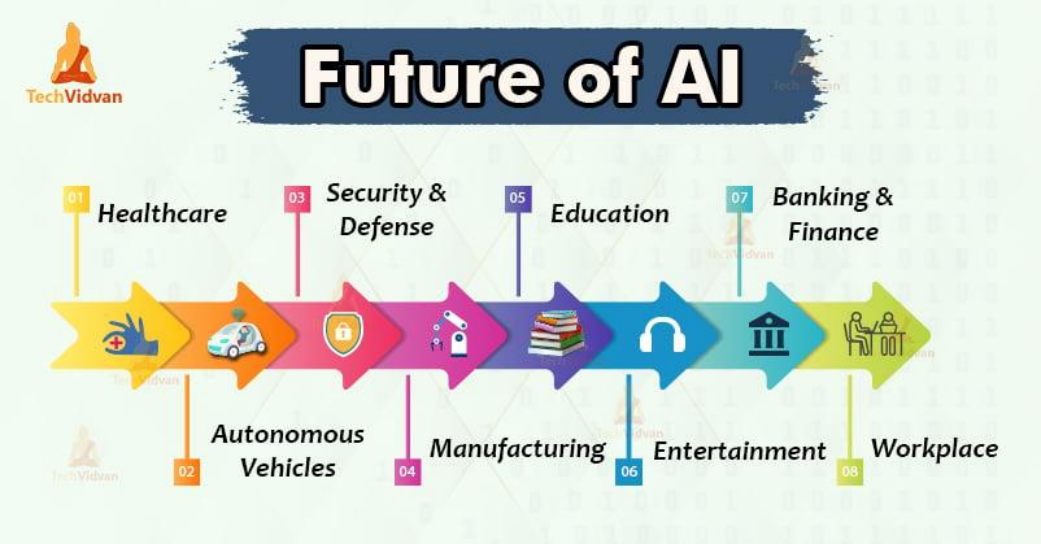


Advantages and Limitations

- **Advantages:** speed, accuracy, automation, 24/7 availability.
  Limitations: high cost, lack of creativity, data dependency, ethical issues.

Future of AI

- AI in daily life: smart homes, personalized assistants.
- AI ethics: privacy, fairness, job automation.
- Collaboration between humans and AI.



Summary

- AI enables machines to mimic human intelligence
- It evolved through decades—from logic-based to learning-based
- Techniques: search, reasoning, and machine learning
- Applications across all major industries

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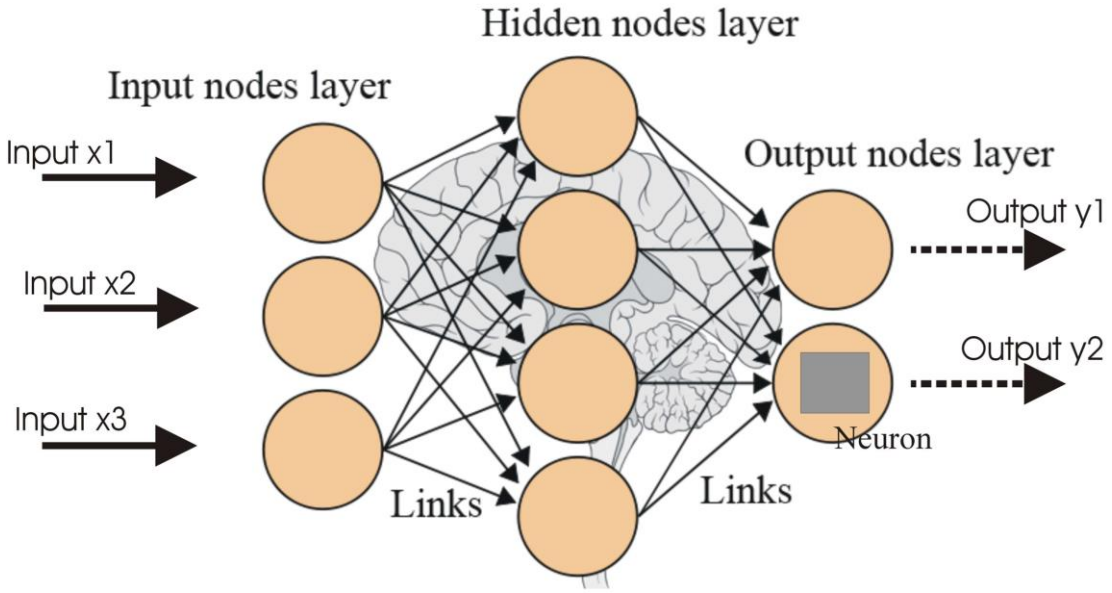
Neural Networks

Lec. Dr. Hussein M. Hussein

What is a Neural Network?

- A Neural Network is a computer model designed to work a little like the human brain. It is made up of many small processing units called neurons that are connected together. These neurons work together to recognize patterns, make decisions, or learn from data.
- **Simple Explanation**
- Imagine you show the network many pictures of cats.
  At first, it guesses randomly.
  But each time it gets a picture right or wrong, it adjusts its connections.
  Over time, it gets *better* at knowing what a cat looks like.
  This process is called **learning**.

Structure (How it looks)



A neural network usually has:

Layer Type	Role
Input Layer	Takes the data in (like image pixels or numbers)
Hidden Layers	Thinks and learns by adjusting neuron connections
Output Layer	Gives the final result (e.g., "Cat" or "Not Cat")

Training a Neural Network

- **Training a Neural Network** means teaching it how to make correct predictions by showing it many examples and letting it learn from its mistakes.
- How Training Works (Simple Steps)
- **1- Input Data:**
  - We give the neural network data (e.g., images, numbers, or text).
  - Example: Pictures of cats and dogs.
- **2- Forward Pass:**
  - The data moves through the network layer by layer.
  - The network makes a prediction (e.g., “This is a cat!”).

Training a Neural Network

- 3- **Compare Prediction** with the Correct Answer.
  - The network checks how far its prediction is from the true answer.
  - This difference is called Error or Loss.
- 4- **Backpropagation**:
  - The network adjusts the strength of the connections (weights) between neurons to reduce the error next time.
- 5- **Repeat Many Times (Epochs):**
  - We repeat this process with many examples until the network becomes accurate.

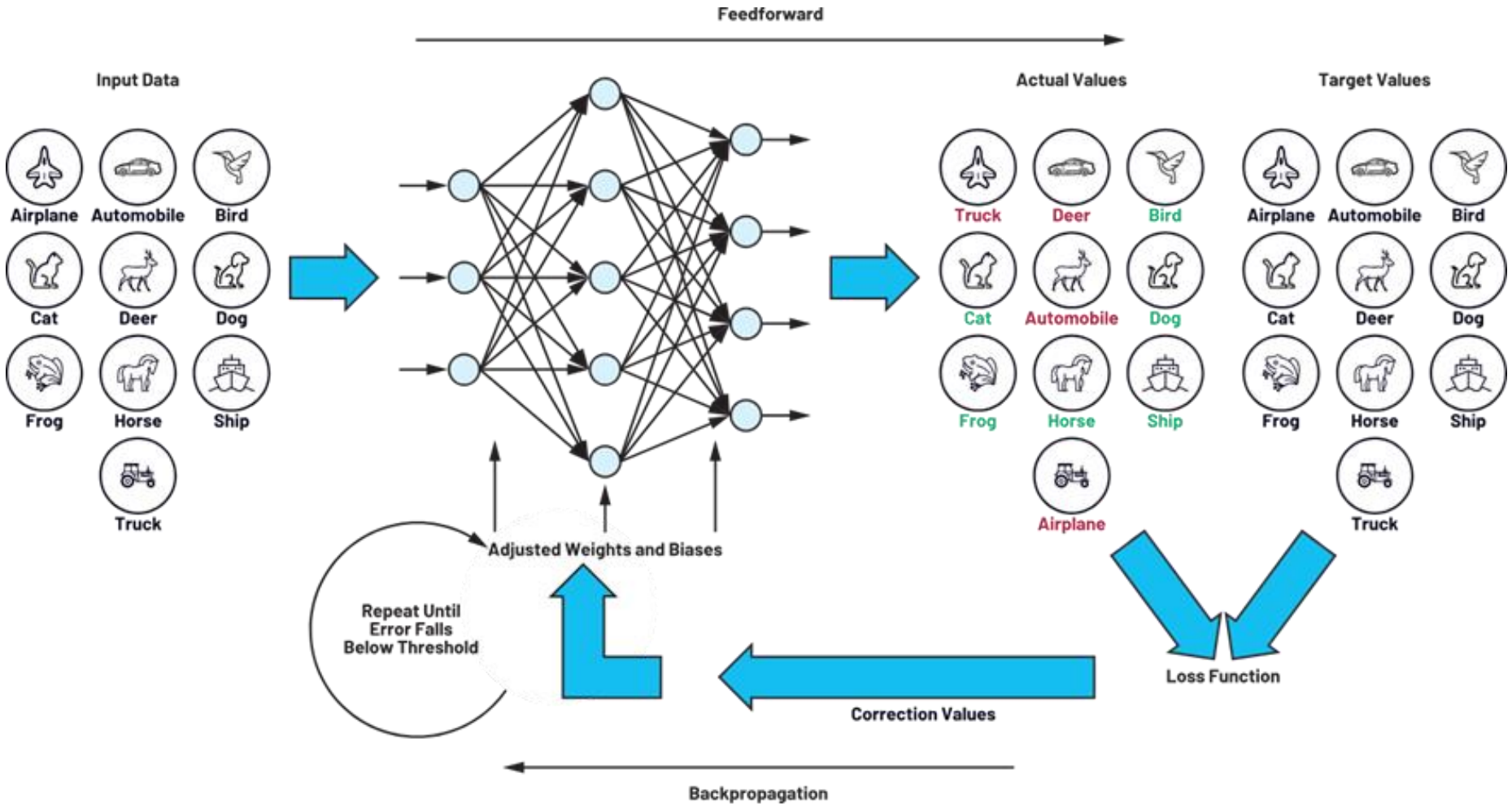
Training a Neural Network

- **Example**
- We want to train a network to recognize handwritten numbers.

Step	Action
1	Show a picture of a handwritten "5"
2	The network says "3" (wrong)
3	Calculate how wrong it is
4	Adjust weights to improve
5	Show another picture and repeat

After thousands of examples, the network learns what a “5” looks like.

Training a Neural Network



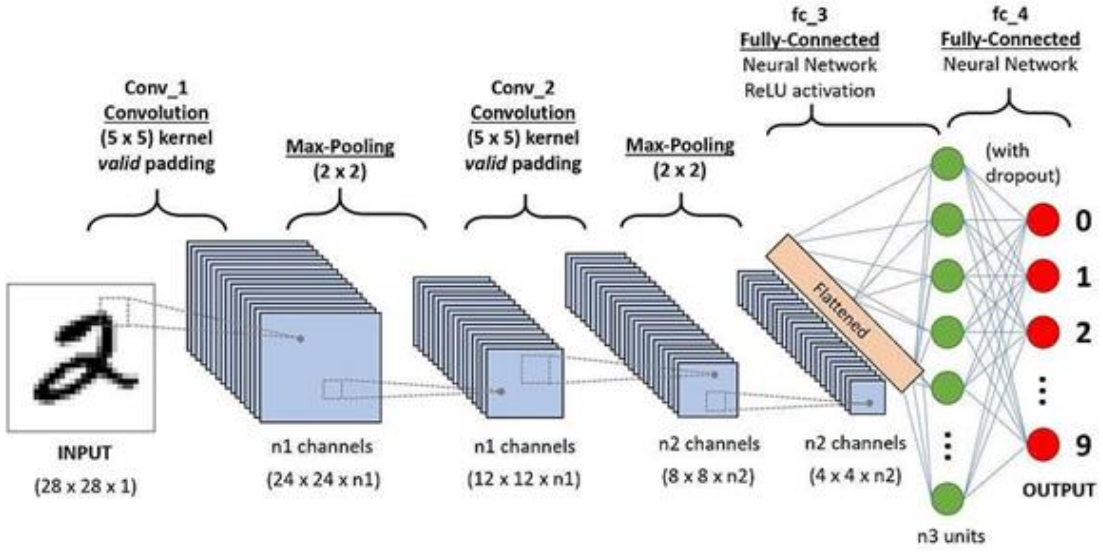
Training a Neural Network

- **Real-World Examples**
  - **Face recognition** in phones learns from many faces.
  - **Self-driving cars** learn from millions of road images.
  - **Spam filters** learn what spam emails look like.

- **In summary:**
  Training a neural network is a **learning process** where the network improves by comparing its predictions with correct answers and adjusting itself to reduce errors.

Types of Neural Networks

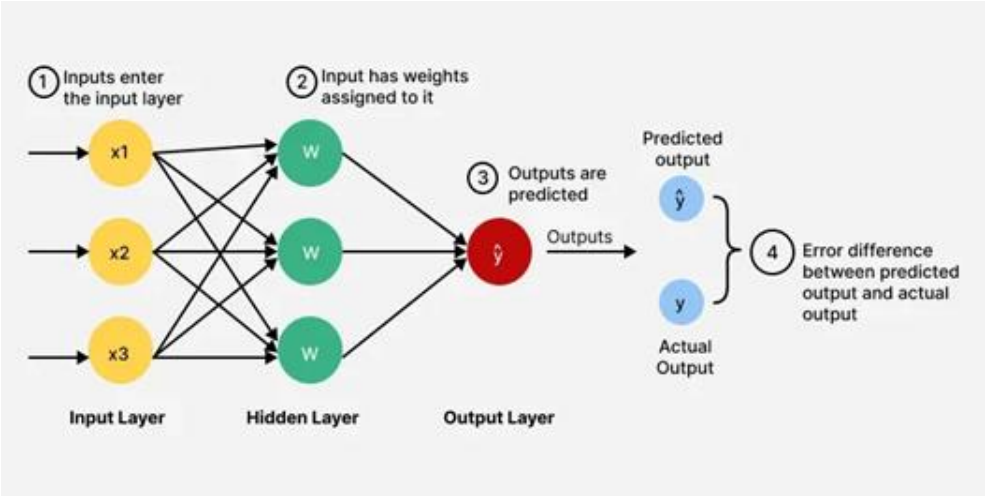
- **2. Convolutional Neural Network (CNN)**
  - Designed for **image and video** processing.
  - Uses **convolution filters** to detect patterns like edges, shapes, and objects.
- **Used in:**
  - Face recognition
  - Medical image analysis
  - Self-driving car vision



- **Example:**
  Identifying cats vs. dogs in images.

Types of Neural Networks

- **1. Feedforward Neural Network (FNN)**
  - The most basic type of neural network.
  - Information flows **in one direction**: input → hidden layer(s) → output.
  - No loops or feedback.
- **Used in:**
  Basic classification and prediction tasks.
- **Example:**
  Predicting house prices.



Types of Neural Networks

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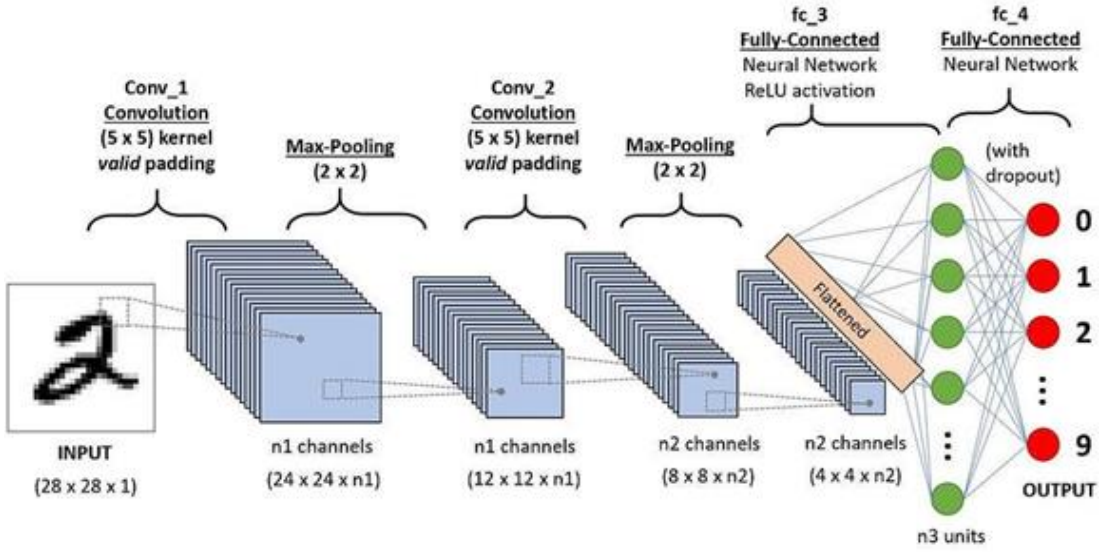
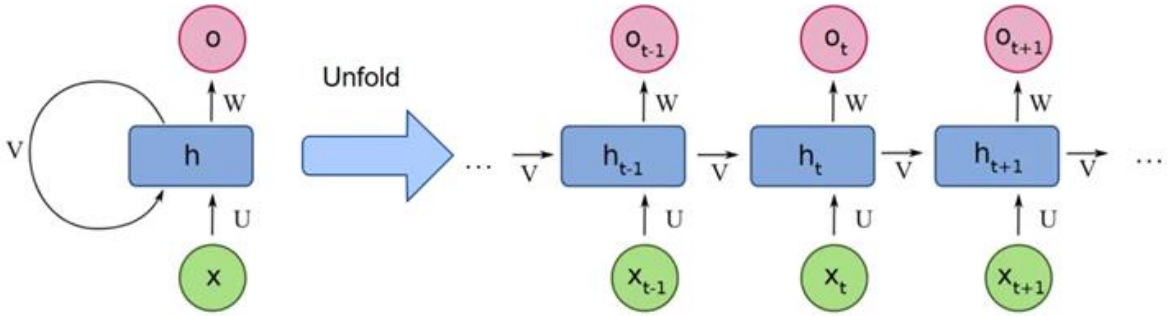


- **Example:**
  Identifying cats vs. dogs in images.

Types of Neural Networks

- **3. Recurrent Neural Network (RNN)**
  - Designed for **sequence data**; has loops that allow memory.
  - Remembers previous inputs in the sequence.
- **Used in:**
  - Speech recognition
  - Language translation
  - Text prediction

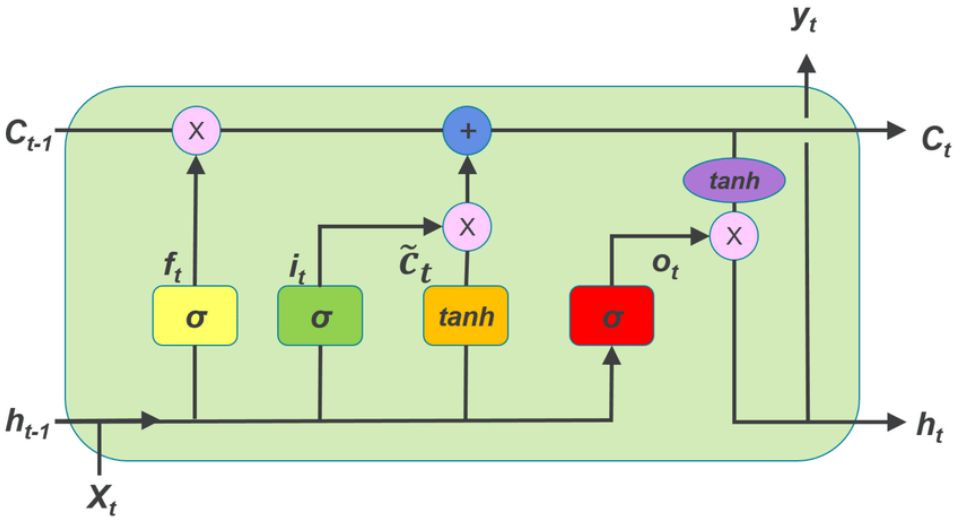


- **Example:**

  Predicting the next word in a sentence.

Types of Neural Networks

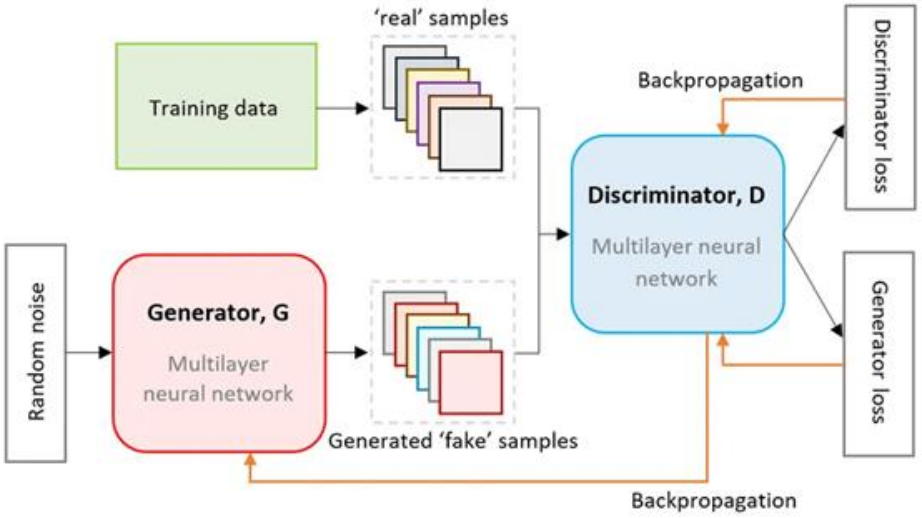
- **4. Long Short-Term Memory (LSTM)**
  - A special type of RNN that solves the **memory problem**.
  - Can remember information for a **long time**.
- **Used in:**
  - Chatbots
  - Assistants (like Siri, Google Assistant)
  - Time-series forecasting



- **Example:**
  Weather forecasting using historical data.

Types of Neural Networks

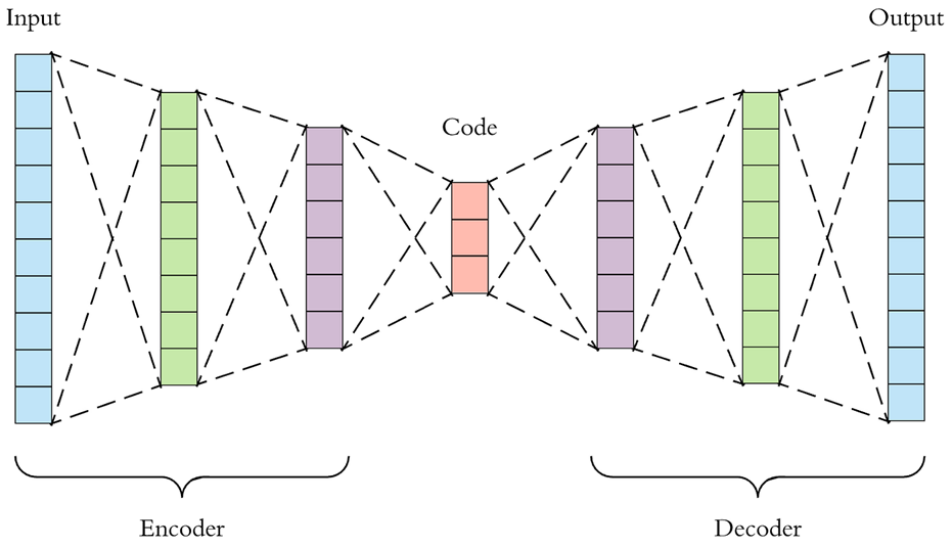
- **5. Generative Adversarial Networks (GANs)**
- Made of **two networks** competing:
  - Generator (creates fake data)
  - Discriminator (tries to detect fake data)
- **Used in:**
- Deepfake video creation
- Art and image generation



- **Example:**
  AI that creates realistic human faces.

Types of Neural Networks

- **6. Autoencoders**
  - Learn to **compress** data and then **reconstruct** it.
  - Useful for noise reduction and feature learning.
- **Used in:**
  - Image compression
  - Removing noise from audio/images
- **Example:**
  Enhancing blurry photos.



Types of Neural Networks Summary

Network Type	Best For	Real Example
FNN	Basic predictions	House price prediction
CNN	Images & video	Face ID on phones
RNN	Sequential data	Speech-to-text
LSTM	Long memory tasks	Chatbots & translation
GAN	Data generation	Creating deepfake images
Autoencoder	Compression/denoising	Fixing blurry photos

Time to questions

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Train NN Model

Lec. Dr. Hussein M. Hussein

Step 1 — Data Collection

- Prepare your dataset with two folders:

```
dataset/
    cats/
        cat1.jpg
        cat2.jpg
        ...
    dogs/
        dog1.jpg
        dog2.jpg
        ...
```

- Each folder name becomes the **label** automatically.

Step 2 — Load and Label the Dataset

```
%% Step 2: Load the Dataset
dataRoot = 'dataset';

imds = imageDatastore(dataRoot, ...
    'IncludeSubfolders', true, ...
    'LabelSource', 'foldernames');

countEachLabel(imds)
```

- Reads all images
- Uses folder names as labels (cats, dogs)
- Shows how many images in each class

Step 3 — Split into Training and Testing Sets

- 80% images → training
- 20% images → testing

```
%% Step 3: Split Data
[imdsTrain, imdsTest] = splitEachLabel(imds, 0.8, 'randomized');
```

Step 4 — Preprocess Images (Resize & Normalize)

- Resize all images
- Normalize pixel values
- Prepare for training

```
%% Step 4: Preprocessing
imageSize = [64 64 3];  % height, width, channels

augTrain = augmentedImageDatastore(imageSize, imdsTrain);
augTest  = augmentedImageDatastore(imageSize, imdsTest);
```

Step 5 — Build a Tiny Convolutional Neural Network (CNN)

- **Convolution**
- **Batch normalization**
- **ReLU**
- **Max pooling**
- **Fully connected layers**

```
%% Step 5: Tiny CNN Model

layers = [
    imageInputLayer([64 64 3])

    convolution2dLayer(3, 8, 'Padding','same')
    batchNormalizationLayer
    reluLayer
    maxPooling2dLayer(2,'Stride',2)

    convolution2dLayer(3, 16, 'Padding','same')
    batchNormalizationLayer
    reluLayer
    maxPooling2dLayer(2,'Stride',2)

    fullyConnectedLayer(32)
    reluLayer

    fullyConnectedLayer(2)   % cats, dogs
    softmaxLayer
    classificationLayer
];
```

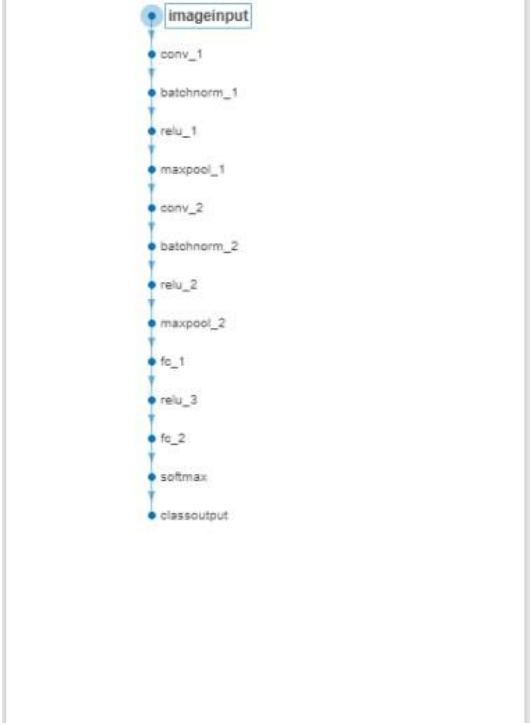
Step 5 — Build a Tiny Convolutional Neural Network (CNN)

Analysis for trainNetwork usage

Name: lgraph

Analysis date: 16-Nov-2025 20:20:30

132.6k	14	0	0
total learnables	layers	warnings	errors



LAYER INFORMATION

	Name	Type	Activations	Learnable Sizes	State Sizes
1	imageinput 64×64×3 images with 'zerocenter' norma...	Image Input	64(S) × 64(S) × 3(C) × 1(B)	-	-
2	conv_1 8 3×3 convolutions with stride [1 1] and ...	2-D Convolution	64(S) × 64(S) × 8(C) × 1(B)	Weig… 3 × 3 × 3 … Bias 1 × 1 × 8	-
3	batchnorm_1 Batch normalization	Batch Normalization	64(S) × 64(S) × 8(C) × 1(B)	Offset 1 × 1 × 8 Scale 1 × 1 × 8	TrainedMean 0 ×… TrainedVari… 0 ×…
4	relu_1 ReLU	ReLU	64(S) × 64(S) × 8(C) × 1(B)	-	-
5	maxpool_1 2×2 max pooling with stride [2 2] and pa...	2-D Max Pooling	32(S) × 32(S) × 8(C) × 1(B)	-	-
6	conv_2 16 3×3 convolutions with stride [1 1] and...	2-D Convolution	32(S) × 32(S) × 16(C) × 1(B)	Weig… 3 × 3 × 8 … Bias 1 × 1 × 16	-
7	batchnorm_2 Batch normalization	Batch Normalization	32(S) × 32(S) × 16(C) × 1(B)	Offset 1 × 1 × 16 Scale 1 × 1 × 16	TrainedMean 0 ×… TrainedVari… 0 ×…
8	relu_2 ReLU	ReLU	32(S) × 32(S) × 16(C) × 1(B)	-	-
9	maxpool_2 2×2 max pooling with stride [2 2] and pa...	2-D Max Pooling	16(S) × 16(S) × 16(C) × 1(B)	-	-
10	fc_1 32 fully connected layer	Fully Connected	1(S) × 1(S) × 32(C) × 1(B)	Weights 32 × 4096 Bias 32 × 1	-
11	relu_3 ReLU	ReLU	1(S) × 1(S) × 32(C) × 1(B)	-	-
12	fc_2 2 fully connected layer	Fully Connected	1(S) × 1(S) × 2(C) × 1(B)	Weights 2 × 32 Bias 2 × 1	-
13	softmax softmax	Softmax	1(S) × 1(S) × 2(C) × 1(B)	-	-
14	classoutput Cross-entropy loss	Pixel Classification L...	1(S) × 1(S) × 2(C) × 1(B)	-	-

Step 6 — Set Training Options

```
%% Step 6: Training Options
options = trainingOptions('sgdm', ...
    'MaxEpochs', 10, ...
    'InitialLearnRate', 0.001, ...
    'Plots', 'training-progress', ...
    'Verbose', false);
```

- Uses sgdm optimizer
- 10 training passes
- Shows training accuracy & loss

Step 7 — Train the Model

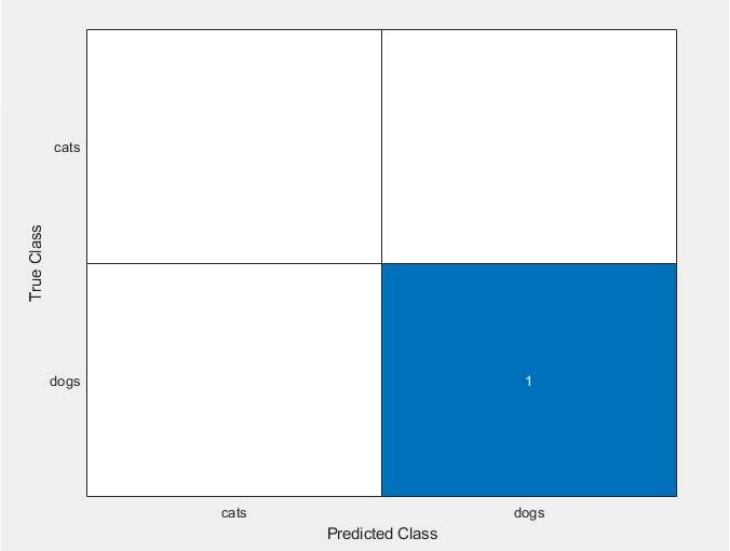
- Accuracy rising
- Loss decreasing

```
%% Step 7: Train the Network
net = trainNetwork(augTrain, layers, options);
```

Step 8 — Evaluate the Model

- How to calculate accuracy
- How to read a confusion matrix

```
%% Step 8: Evaluate on Test Data
YPred = classify(net, augTest);
YTest = imdsTest.Labels;

accuracy = mean(YPred == YTest)

confusionchart(YTest, YPred)
title('Cats vs Dogs Classification Results')
```



Step 9 — Test on a New Image

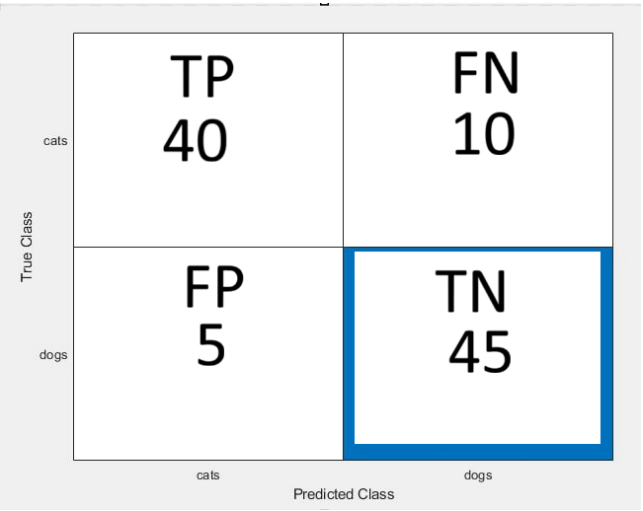
```
%% Step 9: Test on a new image
img = imread('mytest.jpg');
imgResized = imresize(img, [64 64]);

[label, score] = classify(net, imgResized);

imshow(img)
title(string(label) + " | Score: " + string(max(score)))
```

Confusion Matrix Basics

- For a binary classification problem (e.g., cat vs dog), the confusion matrix is:

	Predicted Cat	Predicted Dog
Actual Cat	**TP** (True Positive)	**FN** (False Negative)
Actual Dog	**FP** (False Positive)	**TN** (True Negative)

- Where:
- TP – correctly predicted positive (e.g., correctly predicted cat)
- TN – correctly predicted negative (correctly predicted dog)
- FP – predicted cat but it was dog
- FN – predicted dog but it was cat



Accuracy

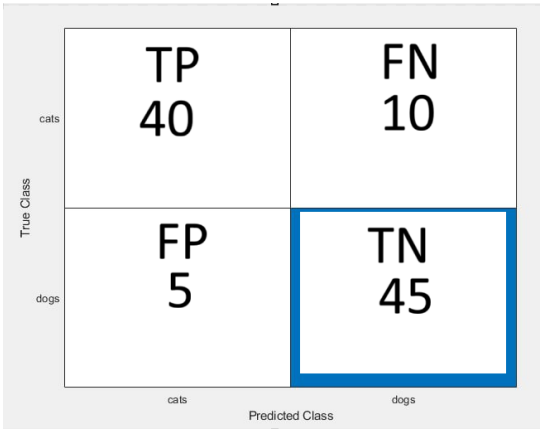
- Accuracy measures how many predictions were correct out of all predictions.

Formula

$$\text{Accuracy} = \frac{TP + TN}{TP + TN + FP + FN}$$

Example

$$\text{Accuracy} = \frac{40 + 45}{40 + 45 + 5 + 10} = \frac{85}{100} = 0.85 = 85\%$$



Precision

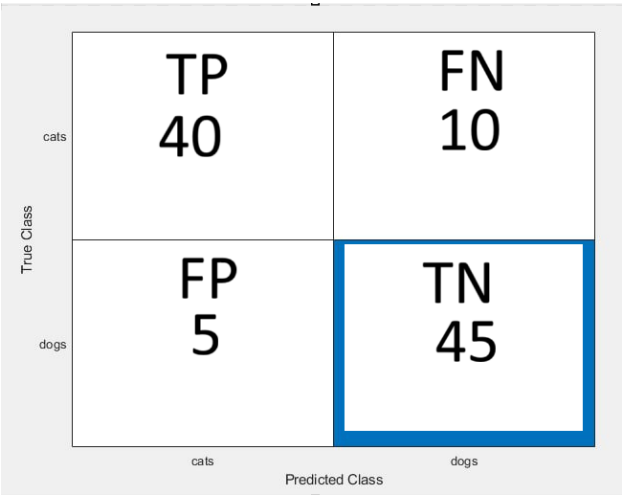
- Of all images predicted as “Cat”, how many were actually Cat?

Formula

$$\text{Precision} = \frac{TP}{TP + FP}$$

Example

$$\text{Precision} = \frac{40}{40 + 5} = \frac{40}{45} = 0.889 = 88.9\%$$



IoU (Intersection over Union)

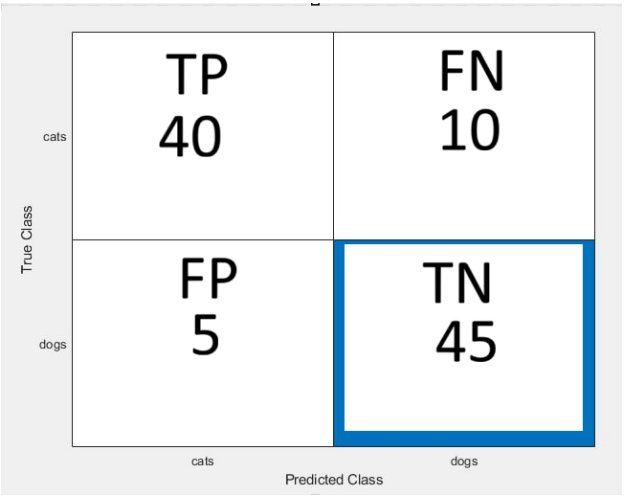
- IoU is usually used for **segmentation**, not classification.
  But for **binary classification**, we can use IoU for each class.

For the positive class (Cat):

$$\text{IoU}_{cat} = \frac{TP}{TP + FP + FN}$$

Example

$$\text{IoU}_{cat} = \frac{40}{40 + 5 + 10} = \frac{40}{55} = 0.727 = 72.7\%$$



Time to questions

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Introduction to AI in Smartphones

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Evolution of AI in Mobile Devices

- Timeline from basic automation to advanced AI chips
- 1- Early Automation Era (2000–2006)
  - Characteristics
    - No dedicated AI hardware.
    - Phones relied on simple algorithms running on CPUs.
    - Very limited automation.
      - **Examples**
    - T9 predictive text.
    - Basic voice commands (Nokia, early Motorola).
    - Simple rule-based automation (profiles, auto-brightness using sensors)

Evolution of AI in Mobile Devices

- 2. Smartphone CPU Era (2007–2012)
- 🔹 Characteristics
  - AI functions run on general-purpose CPUs.
  - Limited machine learning capabilities.
- 🔹 Key Milestones
  - 2007: iPhone released — no AI chip, but introduced multi-touch and smart UI (User Interface) automation.
  - 2011: Apple Siri introduced — processing done in the cloud.
  - 2012: Android Google Now — cloud-based predictive assistance.
- 🔹 AI Capabilities
  - Speech recognition (server-side)
  - Face detection (camera software)
  - Basic ML in apps

Evolution of AI in Mobile Devices

- 3- GPU Acceleration Era (2013–2016)
- 🔹 Characteristics
  - Mobile GPUs start accelerating simple neural networks.
  - AI inference begins shifting from cloud to on-device.
- 🔹 Key Milestones
  - 2014: Google introduces TensorFlow (mobile deployment later improves AI apps).
  - 2015: Qualcomm Snapdragon GPUs start supporting CNN acceleration (Hexagon DSP).
  - 2016: Mobile apps begin using CNNs for: Face unlock, Image enhancement, Object tracking.
- 🔹 Limitations
  - High battery consumption.
  - Low efficiency compared to future AI chips.

Evolution of AI in Mobile Devices

- 4. Dedicated NPU / Neural Engine Era Begins (2017–2020)
- The birth of true mobile AI hardware.
- 🔹 Key Milestones
  - 2017: Apple A11 Bionic introduces Neural Engine (first mainstream smartphone NPU). Huawei Kirin 970 introduces NPU (Neural Processing Unit) .
  - 2018: Qualcomm Snapdragon 855 includes DSP + AI Engine. Google Pixel introduces Pixel Visual Core for AI camera processing.
  - 2019–2020: AI becomes core function in mobile: On-device translation (Google, Apple), Biometric FaceID, Scene detection in cameras, Computational photography, Noise cancellation, AR processing
- 🔹 What NPUs enabled
  - 10× faster AI inference than CPUs
  - Low power consumption
  - Real-time image processing

Evolution of AI in Mobile Devices

- 5. Advanced AI Chip Era (2021–2023)
- AI becomes the center of the mobile experience.
- 🔹 Key Advancements
  - Multi-core NPUs with up to Tera-ops per second (TOPS).
  - Hybrid acceleration: CPU (control), GPU (parallel math), NPU (deep learning)
- 🔹 Milestones
  - 2021: Google Tensor chip integrates TPU-like NPU for Pixel phones.
  - 2022: Apple A16, Snapdragon 8 Gen 2 — >30 TOPS AI engines.
  - 2023: On-device LLMs and generative AI begin (Samsung, Google). Advanced camera AI: Night mode, Motion-blur removal, Real-time HDR fusion.

Evolution of AI in Mobile Devices

- 6. Generative AI Mobile Era (2024–2025)
- Mobile devices now run LLMs locally.
- 🔹 Characteristics
  - Phones can run: ChatGPT-style models, On-device image generation, Real-time speech synthesis, Offline translation.
- 🔹 Key Technologies
  - Qualcomm Snapdragon 8 Gen 3 — 45+ TOPS
  - Apple A17 Pro — improved Neural Engine for GenAI
  - Samsung Exynos 2400 — optimized for LLMs
  - Google Tensor G3 — Gemini Nano support
- 🔹 Use Cases
  - AI photo editing (erase objects, generated backgrounds)
  - AI-based phone assistants (Pixel's on-device Gemini)
  - Real-time transcription & summarization

Evolution of AI in Mobile Devices

Era	Years	Key Technology	AI Capability
Basic Automation	2000–2006	CPUs	Text prediction, simple sensors
Smartphone CPU Era	2007–2012	CPUs	Cloud AI (Siri, Google Now)
GPU Acceleration	2013–2016	GPUs/DSPs	Basic CNNs, face unlock
First Mobile NPUs	2017–2020	NPUs	Real-time AI, computational photography
Advanced NPUs	2021–2023	High-TOPS engines	On-device AI, AR, camera AI
Generative AI	2024–2025	LLM-capable NPUs	On-device LLMs, image generation

Evolution of AI in Mobile Devices

Feature	**CPU**	**GPU**	**NPU**	**TPU**
Full Name	Central Processing Unit	Graphics Processing Unit	Neural Processing Unit	Tensor Processing Unit
Designed For	General-purpose tasks	Parallel graphics/math tasks	AI & neural networks	Large-scale AI training/inference
Strengths	Flexible, good at logic & control	High parallelism	Fast AI inferencing, low power	Extremely fast tensor math
Weaknesses	Slow for large ML tasks	High power consumption	Limited to AI tasks	Not common in smartphones
Parallel Processing	Low	High	Very high	Extremely high
Power Efficiency	Moderate	Low	Very high	Moderate (usually server-side)
Usage in Smartphones	OS, apps, general tasks	Gaming, rendering, some AI	Face unlock, camera AI, speech, ML	Rare (mainly Google Cloud/edge devices)
Examples	Snapdragon Kryo, Apple CPU	Adreno, Mali, Apple GPU	Apple ANE, Qualcomm Hexagon, Samsung NPU	Google Edge TPU (not typical in phones)

Why AI Matters in Smartphones Today

- AI is now essential because it transforms phones from passive tools into **adaptive, intelligent companions**.
- **A) Personalization**

  AI makes phones understand *you*:

  – Keyboard learns your writing style
  – Camera adjusts settings based on your habits
  – Apps suggestions based on routines
  – Music/news recommendations
  – Adaptive brightness and volume
- **Result:** Phone feels customized for every user.

Why AI Matters in Smartphones Today

- **B) Efficiency**

  AI improves performance, saves power, and manages resources:

  – Predicts which apps you will open → faster loading
  – Closes unused apps intelligently
  – Optimizes battery usage with behavior learning
  – Adapts CPU/GPU activity to reduce heat
  – Enhances network connectivity (signal prediction)

- **Result:** Faster, cooler, and longer-lasting phones.

Why AI Matters in Smartphones Today

- **C) Security**
- AI-based security is far stronger than traditional methods:
  - Face recognition using deep neural networks
  - Fingerprint classification powered by ML
  - Fraud/spam message detection
  - Behavioral biometrics (gait, typing pattern)
  - AI-powered malware detection
- **Result:** Phones become harder to hack and more trusted for payments and authentication.

AI Technologies in Smartphones

- **Machine Learning & Deep Learning**
  - Algorithms that learn from data
  - ML powers predictive text, app suggestions, and more.
- **Natural Language Processing (NLP)**
  - Understanding and generating human language
  - NLP enables voice assistants and real-time translation.
- **Computer Vision & Image Recognition**
  - Object detection, facial recognition
  - AI sees and interprets the world through your camera.
- **Edge AI vs Cloud AI**
  - On-device vs server-based processing
  - Edge AI offers speed and privacy; cloud AI offers power.

AI-Powered Personal Assistants

- Overview of Siri, Google Assistant, Alexa
  - Capabilities and differences
  - These assistants are your voice-controlled helpers.
- Voice Recognition & Contextual Understanding
  - Wake words, ambient awareness
  - AI understands not just words, but intent.
- Task Automation & Smart Suggestions
  - Calendar, reminders, routines
  - AI anticipates your needs and acts proactively.

AI in Smartphone Cameras

- Scene Detection & Auto-Enhancement
  - AI adjusts settings for optimal shots
  - Your camera knows what it's seeing and adapts instantly.
- Portrait Mode, Night Mode, HDR
  - Depth sensing, low-light enhancement
  - AI creates studio-quality photos from your pocket.
- AI in Video Stabilization & Editing
  - Real-time corrections, auto-cuts
  - AI makes your videos smooth and cinematic.

AI in Security & Privacy

- Face Recognition & Biometrics
  - Secure unlock, payment authentication
  - AI protects your data with your face or fingerprint.
- AI for Fraud Detection & Threat Prevention
  - Malware detection, phishing alerts
  - AI guards your phone like a digital bodyguard.
- On-device AI for Data Privacy
  - Processing without sending data to cloud
  - AI keeps your secrets safe—locally.

AI for Performance Optimization

- Battery Management & App Prediction
  - Adaptive charging, usage forecasting
  - AI helps your battery last longer by learning your habits.
- Resource Allocation & Thermal Control
  - Smart CPU/GPU balancing
  - AI keeps your phone cool and fast.
- AI in Chipsets (Neural Engines)
  - Apple Neural Engine, Qualcomm AI Engine
  - AI hardware accelerates smart features.

AI in User Experience & Personalization

- Smart Notifications & App Recommendations
  - Context-aware alerts
  - AI filters noise and delivers what matters.
- Adaptive Interfaces & Accessibility Features
  - Dynamic UI, voice control
  - AI makes smartphones usable for everyone.
- AI in Predictive Text & Keyboard Input
  - Autocorrect, emoji suggestions
  - AI reads your mind—one word at a time.

Market Trends & Future Outlook

- Growth of AI-Enabled Smartphones
  - Market stats, adoption rates
  - AI is no longer optional—it's expected.
- Future Innovations in AI for Smartphones
  - Generative AI, multimodal interaction
  - The next leap is phones that think creatively.

Time to questions