

Introduction to Emerging Technologies (EmTe1012)

Chapter 7

Other Emerging Technologies

Objectives

- Explain nanotechnology and its application.
- Explain biotechnology and its application.
- Explain block-chain technology and its application.
- Gain insights about the cloud, quantum and autonomic computing, their differences, and applications.
- Explain how computer vision works and its application.
- Identify and explain embedded systems and their pros and cons.
- Describe cybersecurity, types of threat and its benefits.

7.1 Nanotechnology

- ▶ **Nanotechnology**:- is **science, engineering, and technology** conducted at the **nanoscale**, which is about 1 to 100 nanometers.
- ▶ **Nanoscience** and **nanotechnology** are the study and application of extremely small things can be used across all the other science fields, such as **chemistry, biology, physics, materials science, and engineering**.
- ▶ It's hard to imagine just how small nanotechnology is.
 - ▶ One nanometer is a billionth of a meter or **10^{-9}** of meters. Here are a few examples
 - ▶ There are 25,400,000 nanometers in an inch
 - ▶ A sheet of newspaper is about 100,000 nanometers thick
 - ▶ On a comparative scale, if a marble were a nanometer, then one meter would be the size of the Earth

7.1 Nanotechnology ...

- ▶ **Nanoscience** and **Nanotechnology** involve the ability to see and to control individual atoms and molecules.
 - ▶ Everything on Earth is made up of atoms—the food we eat, the clothes we wear, the buildings and houses we live in, and our own bodies.

7.1 Nanotechnology

- ▶ The microscopes needed to see things at the **nanoscale** were invented relatively recently about 30 years ago
- ▶ As small as a nanometer is, it's still large compared to the atomic scale.
- ▶ An atom has a diameter of about 0.1 nm.
- ▶ An atom's nucleus is much smaller about 0.00001 nm.
- ▶ You and everything around you are made of atoms.
- ▶ Nature has perfected the science of manufacturing matter molecularly.
 - ▶ For instance, our bodies are assembled in a specific manner from millions of living cells. Cells are nature's nanomachines.
- ▶ At the atomic scale, elements are at their most basic level.
- ▶ On the **nanoscale**, we can potentially put these atoms together to make almost anything.

7.1 Nanotechnology ...

- ▶ **Nanoscience** - the study of phenomena and manipulation of materials at atomic, molecular and macromolecular scales, where properties differ significantly from those at a larger scale.
- ▶ **Nanotechnologies** - the design, characterization, production, and application of structures, devices, and systems by controlling shape and size at the nanometer scale.

7.1 Nanotechnology ...

- ▶ properties of materials can be different at the nanoscale for reasons
 - ▶ nanomaterials have a relatively larger surface area when compared to the same mass of material produced in a larger form
 - ▶ quantum effects can begin to dominate the behavior of matter at the nanoscale particularly at the lower end - affecting the optical, electrical and magnetic behavior of materials.
- ▶ Today's scientists and engineers are finding a wide variety of ways to deliberately make materials at the nanoscale to take advantage of their enhanced properties such as **higher strength, lighter weight**, increased control of light spectrum, and **greater chemical reactivity**.

7.1 Nanotechnology

Applications of nanotechnology:

- ▶ **Medicine:** customized nanoparticles the size of molecules that can deliver drugs directly to diseased cells in your body.
- ▶ **Electronics:** it answers for how we might increase the capabilities of electronics devices while we reduce their weight and power consumption.
- ▶ **Food:** it has an impact on several aspects of food science, from how food is grown to how it is packaged. Nanomaterials will make a difference not only in the taste of food but also in food safety and the health benefits that food delivery.

7.1 Nanotechnology

- ▶ **Agriculture:** it can possibly change the whole agriculture part and nourishment industry anchor from generation to preservation, handling, bundling, transportation, and even waste treatment.
- ▶ **Vehicle manufacturers:** Much like aviation, lighter and stronger materials will be valuable for making vehicles that are both quicker and more secure.

7.2 Biotechnology

- ▶ biotechnology is technology based on biology.
- ▶ biotechnology harnesses cellular and biomolecular processes to develop technologies and products that help improve our lives and the health of our planet.
- ▶ We have used the biological processes of microorganisms to make useful food products, such as bread and cheese, and to preserve dairy products
 - ▶ Brewing and baking bread are examples of biotechnology (use of **yeast** (= living organism) to produce the desired product).

7.2 Biotechnology ...

- ▶ Modern form of biotechnology will generally involve a more advanced modification of the biological system or organism.
 - ▶ **For example,**
 - ▶ **Genetic engineering** is the process of transferring individual genes between organisms or modifying the genes in an organism to remove or add a desired trait or characteristic.
- ▶ Today, biotechnology covers many different disciplines (e.g. **genetics, biochemistry, molecular biology**, etc.)

7.2 Biotechnology ...

- ▶ New technologies and products are developed every year within the areas
 - ▶ Medicine (development of new medicines and therapies),
 - ▶ agriculture (development of genetically modified plants, biofuels, biological treatment) or
 - ▶ industrial biotechnology (production of chemicals, paper, textiles, and food).
- ▶ In modern biotechnology, researchers **modify DNA** and **proteins** to shape the capabilities of living cells, plants, and animals into something useful for humans.
- ▶ **Biotechnologists** do this by sequencing or reading, the DNA found in nature, and then manipulating it in a test tube – or, more recently, inside of living cells.

7.2 Biotechnology ...

Applications of biotechnology

► **Agriculture** (Green Biotechnology):

- Biotechnology had contributed a lot to modify the genes of the organism known as Genetically Modified Organisms such as Crops, Animals, Plants, Fungi, Bacteria, etc.
- Genetically modified crops are formed by the manipulation of DNA to introduce a new trait into the crops.
 - are done to introduce traits such as pest resistance, insect resistance, weed resistance

► **Medicine** (Medicinal Biotechnology):

- This helps in the formation of genetically modified insulin known as humulin.
 - in the treatment of a large number of diabetes patients. It has also given rise to a technique known as gene therapy.

7.2 Biotechnology ...

▶ **Aquaculture Fisheries:**

- ▶ It helps in improving the quality and quantity of fishes. Through biotechnology, fishes are induced to breed via gonadotropin-releasing hormone.

▶ **Environment** (Environmental biotechnology):

- ▶ is used in waste treatment and pollution prevention.
- ▶ Environmental biotechnology can more efficiently clean up many wastes than conventional methods and greatly reduce our dependence on methods for land-based disposal.
- ▶ bacteria digest the waste at the site and turn it into harmless byproducts

7.3 Blockchain technology

- ▶ **Blockchain** is a growing list of records, called blocks, that are linked using cryptography.
- ▶ Each **block** contains a cryptography hash of the previous block, a timestamp, and transaction data (generally represented as a Merkle tree).
- ▶ **Blockchain** is a system comprised of
 - ▶ **Transactions** : is a historical archive of decisions and actions taken
 - ▶ **Immutable ledgers**: it is extremely difficult to change the blocks, technology accounts for the issues of security and trust
 - ▶ **Encryption processes**: security by hash functions in block
 - ▶ **Decentralized Peers**: decentralized peer to peer connections
 - ▶ **Smart contracts**: Business logics

7.3 Blockchain technology ...

- ▶ **Blocks** on the blockchain are made up of digital pieces of information having:
 - ▶ Blocks **store information about transactions** like the date, time, and dollar amount of your most recent purchase from Amazon.
 - ▶ Blocks store information about **who is participating in transactions**. A block for your splurge purchase from Amazon would record your name along with Amazon.com, Inc.
 - ▶ Blocks store **information that distinguishes them from other blocks**.
 - ▶ Much like you and I have names to distinguish us from one another, each block stores a unique code called a “hash”
- ▶ When a block stores new data it is added to the blockchain..

7.3 Blockchain technology ...

- ▶ **In order for a block to be added to the blockchain:**
 - ▶ A transaction must occur
 - ▶ After clicking through multiple checkout prompt, you go against your better judgment and make a purchase.
 - ▶ That transaction must be verified.
 - ▶ When you make your purchase, that network of computers rushes to check that your transaction happened **in the way you said** it did
 - ▶ That transaction must be stored in a block. After your transaction has been verified as accurate,
 - ▶ The transaction's dollar amount, your digital signature, and Amazon's digital signature are all stored in a block
 - ▶ That block must be given a hash. it must be given a unique, identifying code called a hash.
 - ▶ The block is also given the hash of the most recent block added to the blockchain. Once hashed, the block can be added to the blockchain.

7.3 Blockchain technology ...

- ▶ By design, a blockchain is **resistant to modification of the data**.
- ▶ The blockchain network has **no central authority**
 - ▶ very nature transparent and everyone involved is accountable for their actions.
- ▶ The first work on a cryptographically secured chain of blocks was described in 1991 by **Stuart Haber** and **W. Scott Stornetta**.
- ▶ The first blockchain was conceptualized by a person (or group of people) known as **Satoshi Nakamoto** in 2008.
- ▶ The design was implemented the following year by Nakamoto as a core component of the cryptocurrency bitcoin
 - ▶ it serves as the public ledger for all transactions on the network
 - ▶ from January 2016 to January 2017, the bitcoin blockchain grew from 50 GB to **100** GB in size.

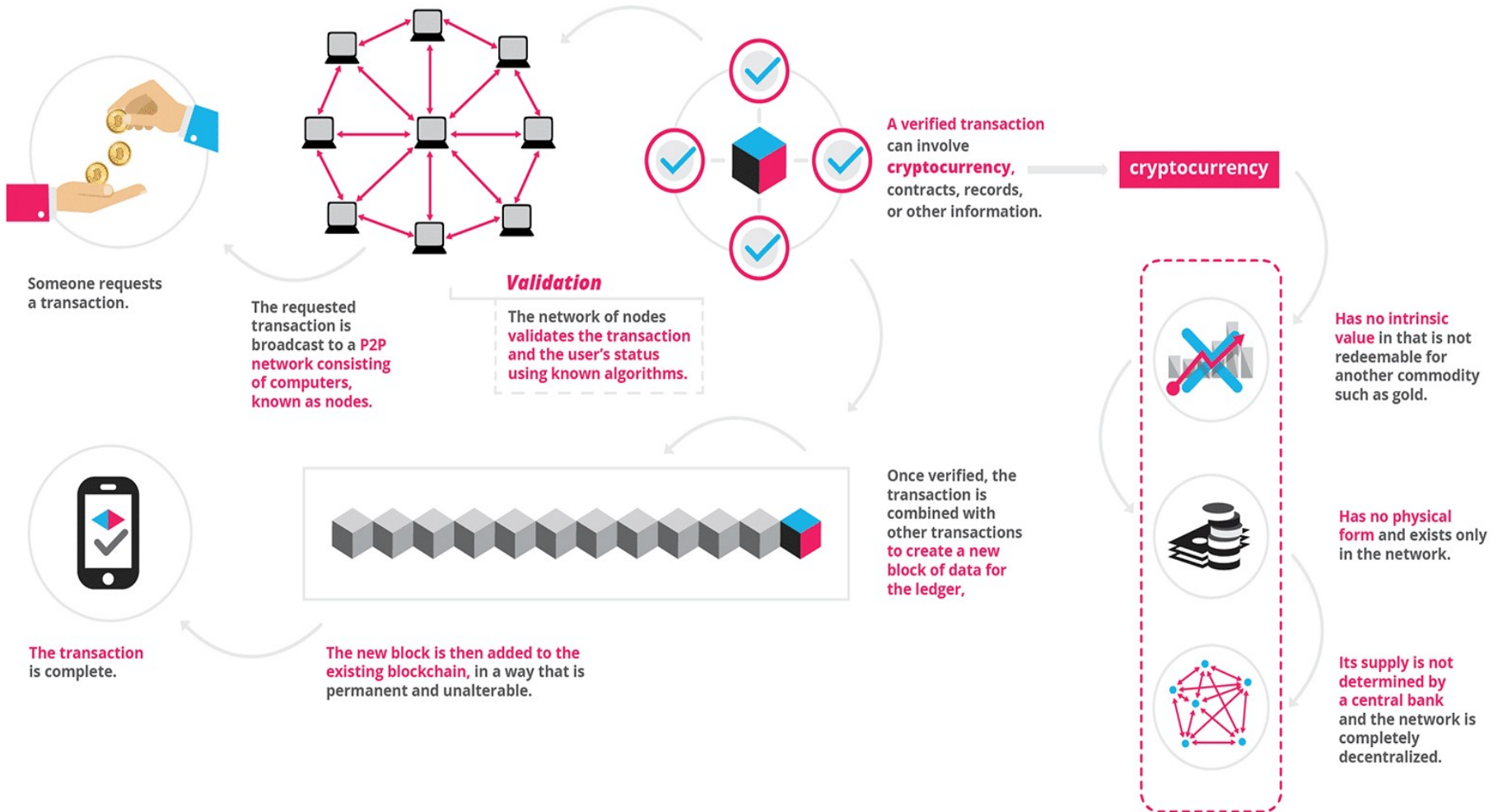
7.3 Blockchain technology ...

Basic processes

- ▶ One party to a transaction initiates the process by creating a block.
- ▶ This block is verified by thousands, perhaps millions of computers distributed around the net.
- ▶ The verified block is added to a chain, which is stored across the net, creating not just a unique record, but a unique record with a unique history.
- ▶ Falsifying a single record would mean falsifying the entire chain in millions of instances.

7.3 Blockchain technology ...

Example of Basic processes in cryptocurrency



7.3 Blockchain technology ...

The three main properties

► Decentralization

- Information is not stored by one single entity. In fact, everyone in the network owns the information.

► Transparency

- A person's identity is hidden via complex cryptography and represented only by their public address.
- In a person's transaction history, you will not see "Bob sent 1 BTC" instead you will see
"1MF1bhsFLkBzzz9vpFYEmvwT2TbyCt7NZJ sent 1 BTC".
- So, while the person's real identity is secure, you will still see all the transactions that were done by their public address.

7.3 Blockchain technology ...

► Immutability

- once something has been entered into the blockchain, it cannot be tampered with.
- Using cryptographic hash function , hashing means taking an input string of any length and giving out an output of a fixed length.

► Example

INPUT	HASH
This is a test	C7BE1ED902FB8DD4D48997C6452F5D7E509FBCDBE2808B16BCF4EDCE4C07D14E
this is a test	2E99758548972A8E8822AD47FA1017FF72F06F3FF6A016851F45C398732BC50C

- no matter how big or small the input is, the output will always have a fixed length

7.3 Blockchain technology ...

why the blockchain has gained so much admiration is that:

- ▶ **It is not owned by a single entity**, hence it is decentralized
 - ▶ meaning the records it keeps are truly public and easily verifiable.
 - ▶ No centralized version of this information exists for a hacker to corrupt.
 - ▶ Hosted by millions of computers simultaneously
- ▶ The data is cryptographically stored inside
- ▶ The blockchain is immutable, so no one can tamper with the data that is inside the blockchain.
- ▶ The blockchain is transparent so one can track the data if they want.

7.3 Blockchain technology ...

Applications of blockchain technology

► The sharing economy

- enabling peer-to-peer payments, the blockchain opens the door to direct interaction between parties a truly decentralized.

► Crowdfunding

- initiatives like Kickstarter and GoFundMe are doing the advance work for the emerging peer-to-peer economy
- potentially creating crowd-sourced venture capital funds
- In 2016, experiment, the Ethereum-based DAO (Decentralized Autonomous Organization), raised an astonishing \$200 million USD in just over two months

► Governance

- distributed database technology could bring full transparency to elections.
- The app, **Boardroom**, enables organizational decision-making to happen on the blockchain.
 - this means company governance becomes fully transparent and verifiable when managing digital assets, equity or information.

7.3 blockchain technology ...

Applications ...

► Supply chain auditing

- Distributed ledgers provide an easy way to certify that the backstories of the things we buy are genuine.
- UK-based Provenance offers supply chain auditing for a range of consumer goods
- a Provenance pilot project ensures that fish sold in Sushi restaurants in Japan have been sustainably harvested by its suppliers in Indonesia

► File storage

- Distributing data throughout the network protects files from getting hacked or lost.
- An internet made up of completely decentralized websites has the potential to speed up file transfer and streaming times
- It's a necessary upgrade to the web's currently overloaded content-delivery systems

7.4 Cloud and quantum computing

Cloud computing is a means of networking remote servers that are hosted on the Internet.

► Rather than storing and processing data on a local server, or a PC's hard drive, one of the following three **types of cloud infrastructure is used**.

i. public cloud: Here a third-party provider manages the servers, applications, and storage much like a public utility. Anyone can subscribe to the provider's cloud service.

7.4.1 Cloud computing ...

Cloud computing ...

ii. Private cloud: a business or organization would typically use the computing infrastructure exists as a private network accessible over the Internet

iii. Hybrid cloud: Here private clouds are connected to public clouds, allowing data and applications to be shared between them.

- ▶ a hybrid offers a business more flexibility. Often a hybrid cloud includes multiple service providers.
- ▶ Hybrids also enable applications to keep sensitive client data in a private cloud but connect to end-user software in a public cloud.

7.4.1 Cloud computing ...

Cloud computing: Focus on infrastructure, web development or a cloud-based app.

- ▶ **Infrastructure as a Service (IaaS):** gives you management of the whole deal: servers, web development tools, applications.
- ▶ **Platform as a Service (PaaS):** offers a complete web development environment, without the worry of the hardware that runs it.
- ▶ **Software as a Service (SaaS):** allows access to cloud-based apps, usually through a web browser interface.

7.4.1 Cloud computing ...

Cloud computing has been around since 2000. Yet it's only in the last 10 years that major players like **IBM**, **Amazon**, and **Google** have offered commercially viable, high-capacity networks.

Advantages of cloud computing

- ▶ A cloud provider's hardware and software are shared, **there's no need for the initial costly capital investment**.
- ▶ Allows you and multiple users to access your data from any location.
- ▶ Business processes its data more efficiently, increasing productivity. **Maintenance is much cheaper, often free**, so reliability is rarely a worry.

7.4.2 Quantum computing

Quantum computers truly do represent the next generation of computing.

- ▶ Unlike classic computers, drives their computing power by harnessing the power of quantum physics.
- ▶ a classic computer, data is stored in tiny transistors that hold a single bit of information, either the binary value of 1 or 0.
- ▶ a quantum computer, the data is stored in qubits (a sequence of quantum bits).
- ▶ based on mechanics of quantum physics, subatomic particles obey their own laws, a qubit can exist in two states at the same time called superposition.
 - ▶ So, a qubit can have a value of 1, 0, or some value between

7.4.2 Quantum computing ...

- ▶ Quantum computers are big machines, reminiscent of the old mainframe computers of the 1960s.
- ▶ Currently, the only organization which provides a quantum computer in the cloud is **IBM**. They allow free access to anyone who wishes to use their 5-qubit machine
- ▶ Not to be outdone, Google provided the fastest quantum computer with 53 qubits and speed of 200 seconds computation while the supercomputer took 10000 years.

7.4.2 Quantum computing ...

Advantages of quantum computing

- ▶ Allow scientists to crunch very long numbers.
- ▶ could help in the **discovery of new drugs**, by unlocking the complex structure of chemical molecules
- ▶ financial trading, risk management and supply chain optimization.
- ▶ With its ability to handle more complex numbers, data could be transferred over the internet with much safer encryption

7.5 Autonomic computing (AC)

- ▶ **AC** : is an approach to address the complexity and evolution problems in software systems.
- ▶ self-managing computing model named after, and patterned on, the human body's autonomic nervous system.
- ▶ system would control the functioning of computer applications and systems without input from the user like nervous system
- ▶ The goal is to create **systems that run themselves**, capable of **high-level functioning** while keeping the system's complexity invisible to the user.

7.5 Autonomic computing (AC) ...

- ▶ **AC:** refers to the self-managing characteristics of distributed resources, adapting to unpredictable changes while hiding intrinsic complexity to operators and users
- ▶ Initiated by IBM in 2001, this initiative ultimately
 - ▶ aimed to develop computer systems capable of self-management, to overcome the rapidly growing complexity of computing system management,
 - ▶ to reduce the barrier that complexity poses to further growth.

7.5 Autonomic computing (AC) ...

Characteristics of Autonomic Systems

Autonomic systems/applications exhibit eight defining characteristics

- ▶ **Self-Awareness:** “knows itself” and is aware of its state and its behaviors.
- ▶ **Self-Configuring:** should be able to configure and reconfigure itself under varying and unpredictable conditions.
- ▶ **Self-Optimizing:** should be able to detect suboptimal behaviors and optimize itself to improve its execution.
- ▶ **Self-Healing:** should be able to detect and recover from potential problems and continue to function smoothly.

7.5 Autonomic computing (AC) ...

Characteristics of Autonomic Systems ...

- ▶ **Self-Protecting:** should be capable of detecting and protecting its resources from both internal and external attacks and maintaining overall system security and integrity.
- ▶ **Context-Aware:** should be aware of its execution environment and be able to react to changes in the environment.
- ▶ **Open:** must function in a heterogeneous world and should be portable across multiple hardware and software architectures. Consequently, it must be built on standard and open protocols and interfaces.
- ▶ **Anticipatory:** should be able to anticipate to the extent possible, its needs and behaviors and those of its context, and be able to manage itself proactively

7.6 Computer vision ...

- ▶ Deals with how computers can be made to gain a high-level understanding of **digital images or videos**.
- ▶ From the perspective of engineering, it seeks to automate tasks that the **human visual system can do**.
- ▶ tasks include **methods for acquiring, processing, analyzing** and **understanding digital images**, and extraction of high-dimensional data from the real world.
- ▶ transformation of visual images (the input of the retina) into descriptions of the world that can interface with other thought processes and elicit appropriate action
 - ▶ using models constructed with the aid of geometry, physics, statistics, and learning theory

7.6 Computer vision ...

- ▶ Can be also defined as is building algorithms that can understand the content of images and use it for other applications.

How computer vision works

- ▶ **Acquiring an image:** Images, even large sets, can be acquired in real-time through video, photos or 3D technology for analysis.
- ▶ **Processing the image:** Deep learning models automate much of this process.
- ▶ **Understanding the image:** an object is identified or classified.

7.6 Computer vision ...

Types of computer vision that are used in different ways

- **Image segmentation** partitions an image into multiple regions to be examined separately.
- **Object detection** identifies a specific object in an image. Advanced object detection recognizes many objects in a single image: a football field, an offensive player, a defensive player, a ball and so on.
- **Facial recognition** not only recognizes a human face in an image but identifies a specific individual.
- **Edge detection** is a technique used to identify the outside edge of an object or landscape to better identify what is in the image.
- **Pattern detection** is a process of recognizing repeated shapes, colors and other visual indicators in images.
- **Image classification** groups images into different categories.
- **Feature matching** matches similarities in images to help classify them.

Simple applications of computer vision may only use one of these techniques, but more advanced users, like for self-driving cars, rely on multiple techniques to accomplish their goal.

7.6 Computer vision ...

Applications of computer vision

- **Optical character recognition (OCR)**
- **Machine inspection:** rapid parts inspection for quality assurance
- **Retail:** object recognition for automated checkout lanes
- **Medical imaging**
- **Automotive safety**
- **Surveillance:** monitoring for intrude
analyzing highway traffic
- **Fingerprint** recognition and biometri



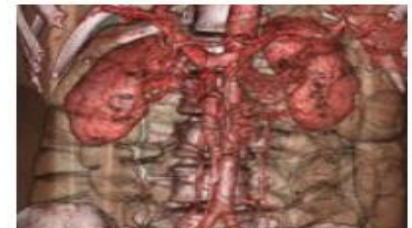
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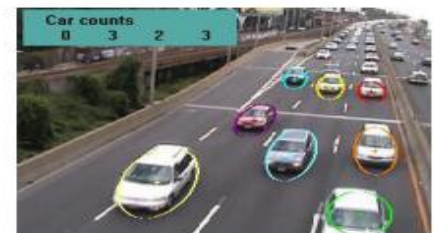
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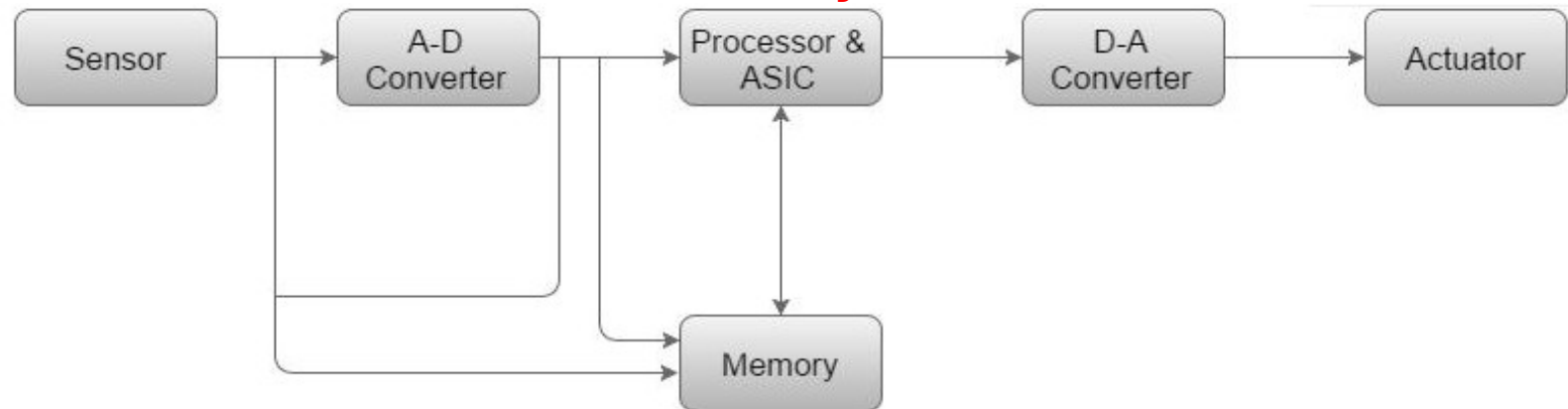
7.7 Embedded systems

- ▶ **Embedded systems** is a controller with a dedicated function within a larger mechanical or electrical system, often with real-time computing constraints
- ▶ It is embedded as part of a complete device often including hardware and mechanical parts.
- ▶ Ninety-eight percent of all microprocessors manufactured are used in embedded systems.
- ▶ Modern embedded systems are often based on microcontrollers (i.e. microprocessors with integrated memory and peripheral interfaces)

7.7 Embedded systems

- ▶ The processor(s) used may be types ranging from general-purpose to those specialized in a certain class of computations, or even custom designed for the application at hand
- ▶ common standard class of dedicated processors is the digital signal processor (DSP).

Basic Structure of an Embedded System



7.7 Embedded systems ...

Basic Structure of an Embedded System

- ▶ **Sensor** – It measures the physical quantity and converts it to an electrical signal which can be read by an observer or by any electronic instrument like an A2D converter.
- ▶ **A-D Converter** – converts the analog signal sent by the sensor into a digital signal.
- ▶ **Processor & ASICs** – process data to measure the output and store it to the memory.
- ▶ **D-A Converter** – converter converts the digital data fed by the processor to analog data.
- ▶ **Actuator** – An actuator compares the output given by the D-A Converter to the actual (expected) output stored in it and stores the approved output.

7.7 Embedded systems ...

Advantages of Embedded

- ▶ Easily Customizable
- ▶ Low power consumption
- ▶ Low cost
- ▶ Enhanced performance

Disadvantages of Embedded systems

- ▶ High development effort
- ▶ Larger time to market

7.8 Cybersecurity

- ▶ **Cybersecurity** is the protection of computer systems from
 - ▶ theft of or damage to their hardware, software, or electronic data, as well as from the disruption or misdirection of the services they provide.
- ▶ Cybersecurity is becoming more important due to increased reliance on computer systems, the Internet and wireless network standards and due to the growth of smart devices, that constitute the Internet of Things.
- ▶ Due to its complexity, both in terms of politics and technology, cybersecurity is also one of the **major challenges in the contemporary world**.
- ▶ It focuses on **protecting computer systems from unauthorized** access or being otherwise damaged or made inaccessible.
- ▶ **cybercrime** is used to describe an unlawful activity in which computer or computing devices which are stand-alone or a part of a network are used as a tool or/and target of criminal activity

7.8 Cybersecurity ...

Types of cybersecurity threats

- ▶ **Ransomware:** It is a type of malicious software. It is designed to extort money by blocking access to files or the computer system until the ransom is paid. Paying the **ransom does not guarantee** that the files will be **recovered** or the system **restored**.
- ▶ **Malware:** is a type of software designed to gain unauthorized access or to cause damage to a computer.
- ▶ **Social engineering:** it is a tactic that adversaries use to trick you into revealing sensitive information.
- ▶ **Phishing:** - it is the practice of sending fraudulent emails that resemble emails from reputable sources.
 - ▶ It's the most common type of cyber-attack

Cybersecurity measures

some security measures to be taken to prevent cybercrimes

- ▶ **Staff awareness training**
- ▶ **Application security**
- ▶ **Network security:**
- ▶ **Leadership commitment:** -
- ▶ **Password management**

7.8 Cybersecurity ...

Benefits of cybersecurity

- ▶ Business protection against malware, ransomware, phishing, and social engineering.
- ▶ Protection for data and networks.
- ▶ Prevention of unauthorized users.
- ▶ Improves recovery time after a breach.
- ▶ Protection for end-users.
- ▶ Improved confidence in the product for both developers and customers

Cybersecurity vendors

- ▶ will typically use endpoint, network and advanced threat protection security as well as data loss prevention.
- ▶ commonly known cybersecurity vendors include **Cisco**, **McAfee**, and **Trend Micro**.

7.9 Additive manufacturing (3D Printing)

Additive manufacturing, also known as 3D printing, uses computer-aided design to build objects layer by layer.” ASTM,(The American Society for Testing and Materials)

Today, the precision, repeatability, and material range has increased to the point that 3D printing is considered as industrial production technology, with the name of additive manufacturing”. Wikipedia

► “the industrial version of 3D printing”. Deve Turbide

7.9 Additive manufacturing (3D Printing) ...

- ▶ **Additive Manufacturing:** A Bytes-to-Parts Supply Chain “Additive manufacturing” (AM) is a big-picture term more at home in the boardroom than the factory floor or garage.
 - ▶ more about the **manufacturing process** transformed by 3D printing
- ▶ It enables customized parts, in volume, and involves stocking raw materials like filament and printing spare parts on demand.
- ▶ Describes types of advanced manufacturing that are used to create three-dimensional structures out of plastics, metals, polymers and other materials that can be sprayed through a nozzle or aggregated in a vat.

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I'm Happy to Have you All!

