Al-Mustaqbal University
College of Sciences
Intelligent Medical System Department

Embedded systems
Lecture 1 :
OVERVIEW

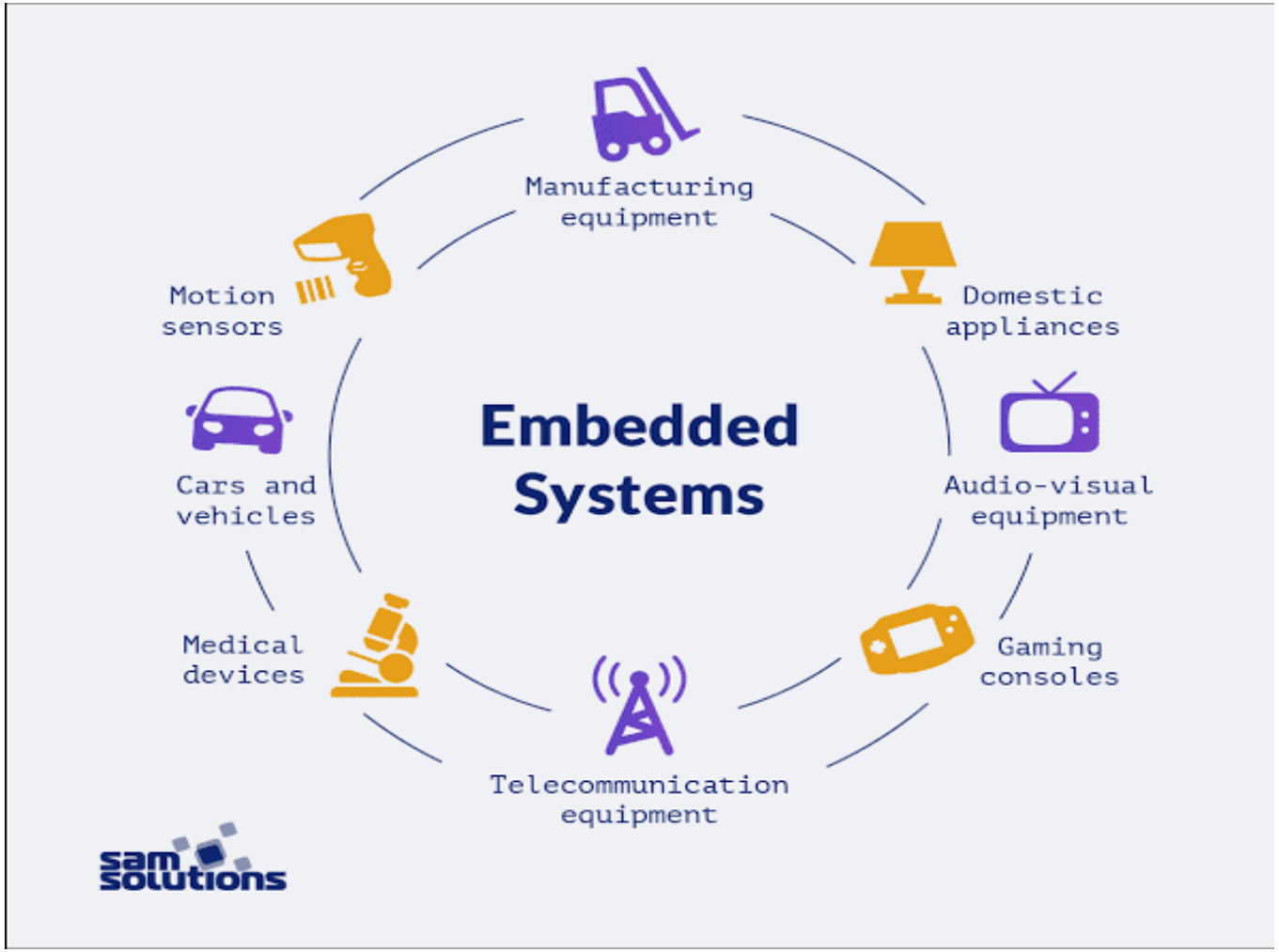
Prof.Dr. Mehdi Ebady Manaa

جامعة المستقبل
AL MUSTAQBAL UNIVERSITY

What is an Embedded System?

- **Embedded System:** An embedded system refers to a hardware system that has software integrated into it. It can operate independently or be part of a larger system. These systems, which are based on microcontrollers or microprocessors, are specifically designed to perform a dedicated function. For instance, a fire alarm is an embedded system as it is programmed to detect only smoke.

Embedded System



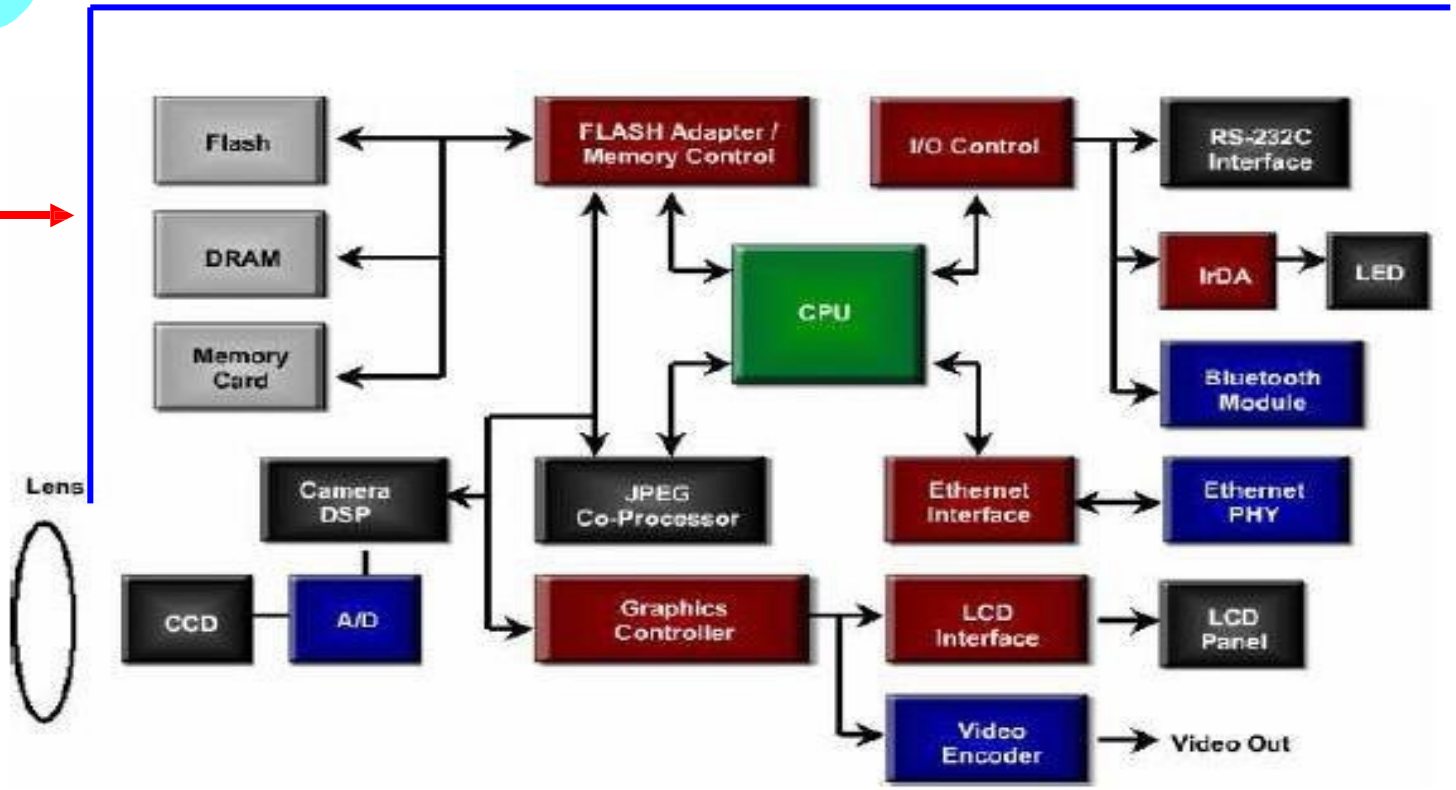
Embedded Systems

An embedded system has three components :

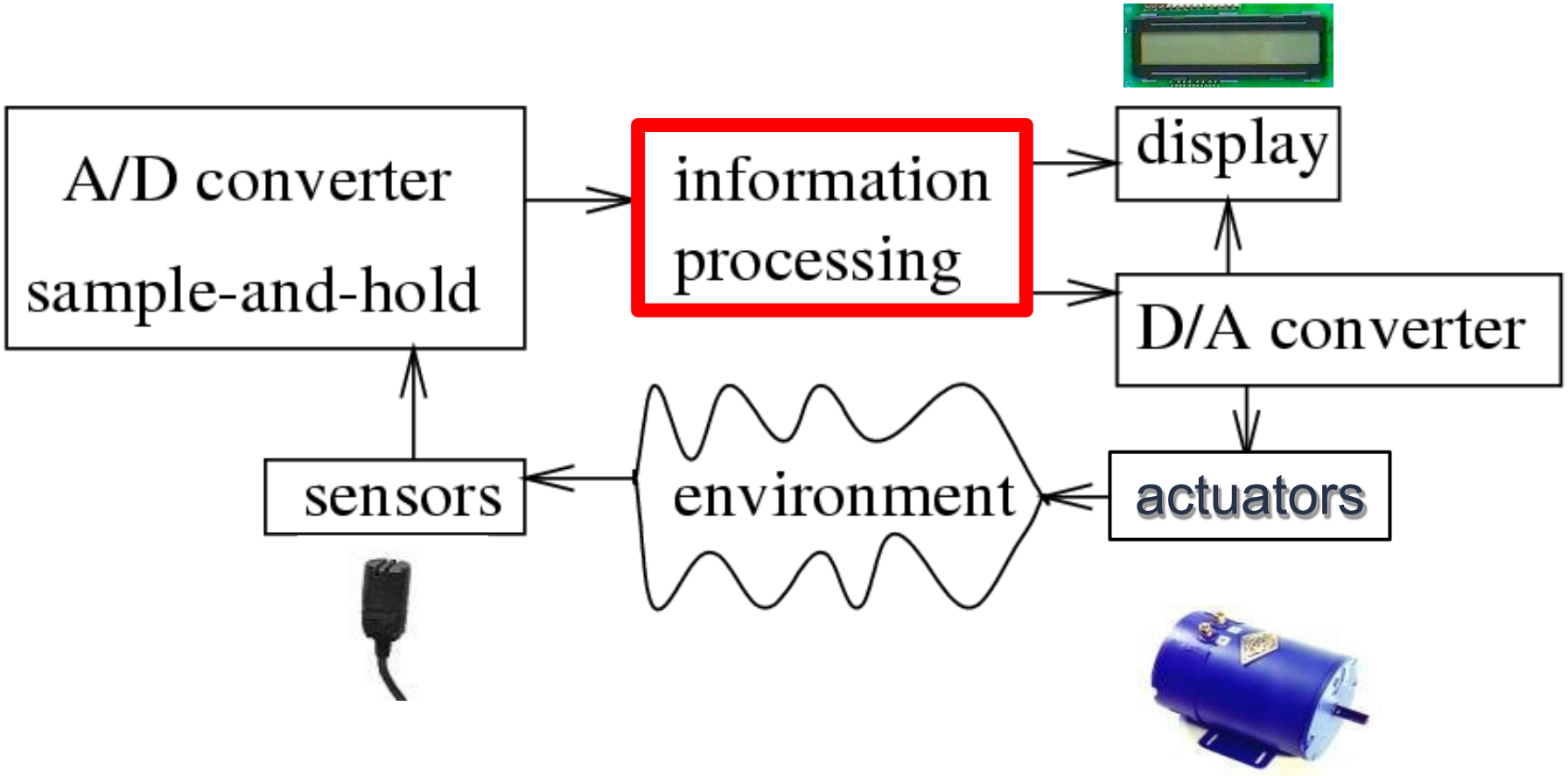
- **It has hardware.**
- **It has application software.**
- **It has Real Time Operating system (RTOS) that supervises the application software and provide mechanism to let the processor run a process as per scheduling by following a plan to control the latencies. RTOS defines the way the system works. It sets the rules during the execution of application program. A small-scale embedded system may not have RTOS.**
- **So we can define an embedded system as a Microcontroller based, software driven, reliable, real-time control system.**

An Example Embedded System

Digital Camera Block Diagram



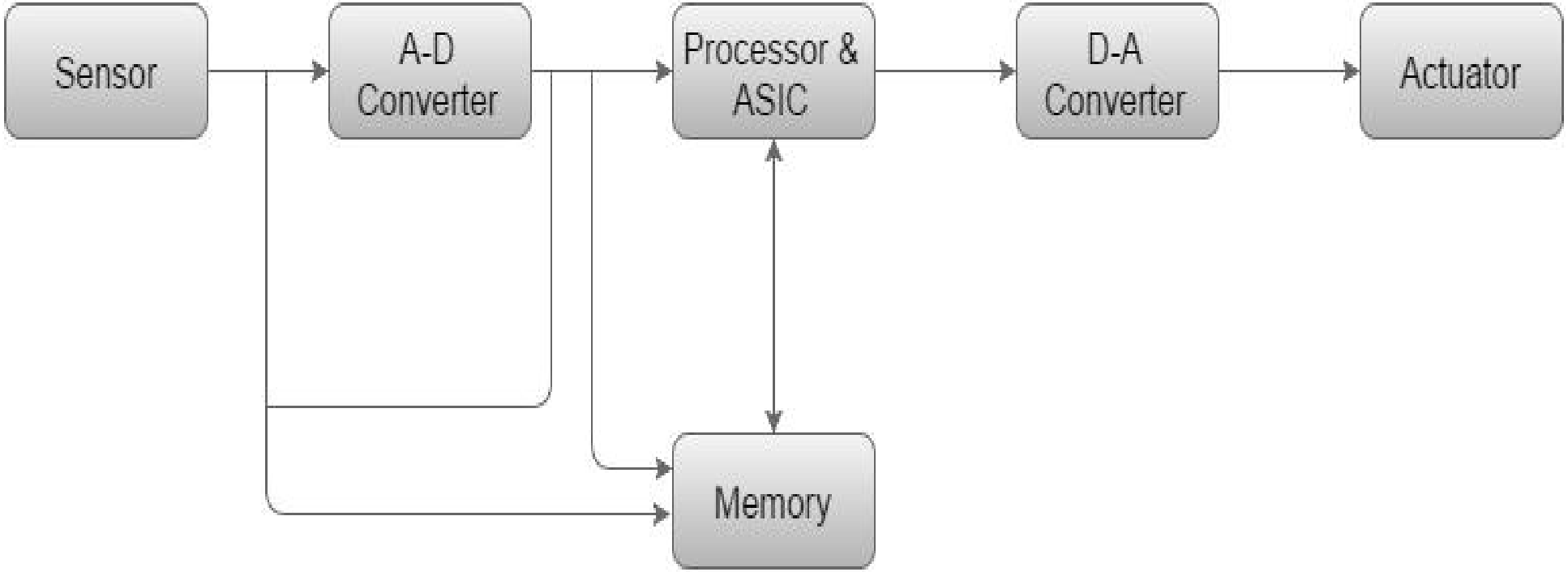
Simplified Block Diagram



A Short List of Embedded Systems

- Anti-lock brakes
- Auto-focus cameras
- Automatic teller machines
- Automatic toll systems
- Automatic transmission
- Avionic systems
- Battery chargers
- Camcorders
- Cell phones
- Cell-phone base stations
- Cordless phones
- Cruise control
- Curbside check-in systems
- On-board navigation
- Pagers
- Digital cameras
- Disk drives
- Electronic card readers
- Electronic instruments
- Electronic toys/games
- Factory control
- Fax machines
- Fingerprint identifiers
- Home security systems
- Life-support systems
- Medical testing systems
- Modems
- MPEG decoders
- Network cards
- Network switches/routers
- Photocopiers
- Point-of-sale systems
- Portable video games
- Printers
- Satellite phones
- Scanners
- Smart ovens/dishwashers
- Speech recognizers
- Stereo systems
- Teleconferencing systems
- Televisions
- Temperature controllers
- Theft tracking systems
- TV set-top boxes
- VCR’s, DVD players
- Video game consoles
- Video phones
- Washers and dryers
- IUG- Embedded System

Basic Structure of an Embedded System



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 sensor stores the measured quantity to the memory.
- **A-D Converter** − An analog-to-digital converter converts the analog signal sent by the sensor into a digital signal.
- **Processor & ASICs** − Processors process the data to measure the output and store it to the memory.
- **D-A Converter** − A digital-to-analog 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.

Embedded System Vs. Computer System

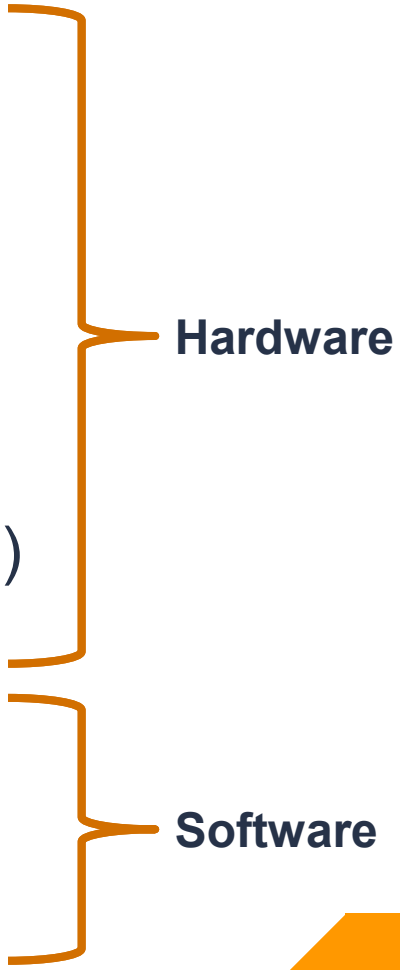
- The design of an embedded system to perform a dedicated function is in contrast to that of the personal computer. It toois comprised of computer hardware and software and mechanical components (disk drives, for example). However, a personal computer is not designed to perform a specific function. Rather, it is able to do many different things. Many people use the term general-purpose computer to make this distinction clear. Introduction to Embedded Systems

Embedded System Vs. Computer System

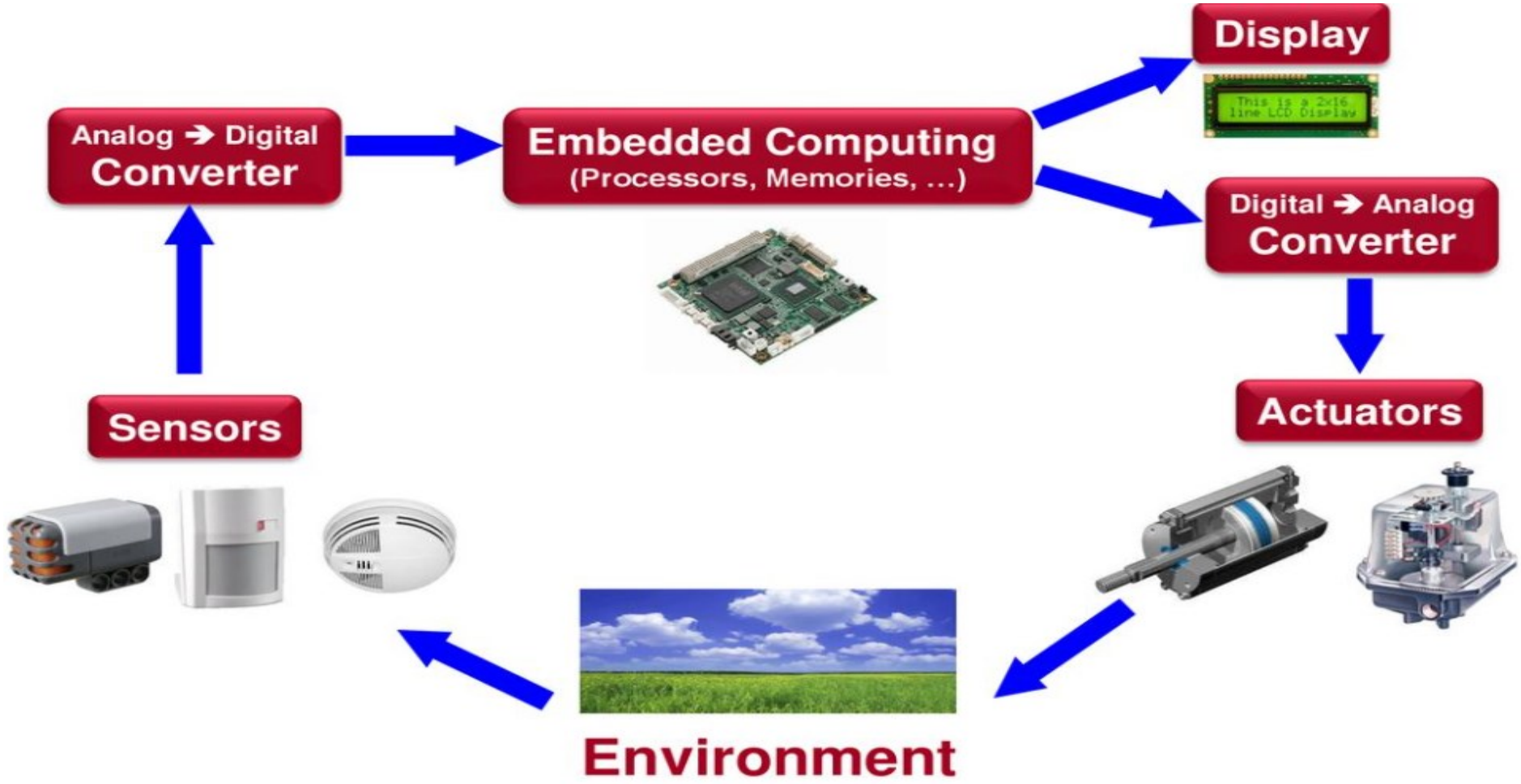
Criteria	General Purpose Computing System	Embedded System
Contents	A system which is a combination of a generic hardware and a General Purpose Operating System for executing a variety of applications.	A system which is a combination of special purpose hardware and embedded OS for executing a specific set of applications.
OS	It contains a general purpose operating system (GPOS).	It may or not contain an operating system for functioning.
Alterations	Applications are alterable (programmable) by the user. (It is possible for the end user to re-install the OS and also add or remove user applications.)	The firmware of the embedded system is pre-programmed and it is non-alterable by the end-user.
Key factor	Performance is the key deciding factor in the selection of the system. Faster is better.	Application specific requirements (like performance, power requirements, memory usage, etc.) are key deciding factors.
Power Consumption	More	Less
Response Time	Not critical	Critical for some applications
Execution	Need not be deterministic	Deterministic for certain types of ES like 'Hard Real Time' systems.

Components of Embedded Systems

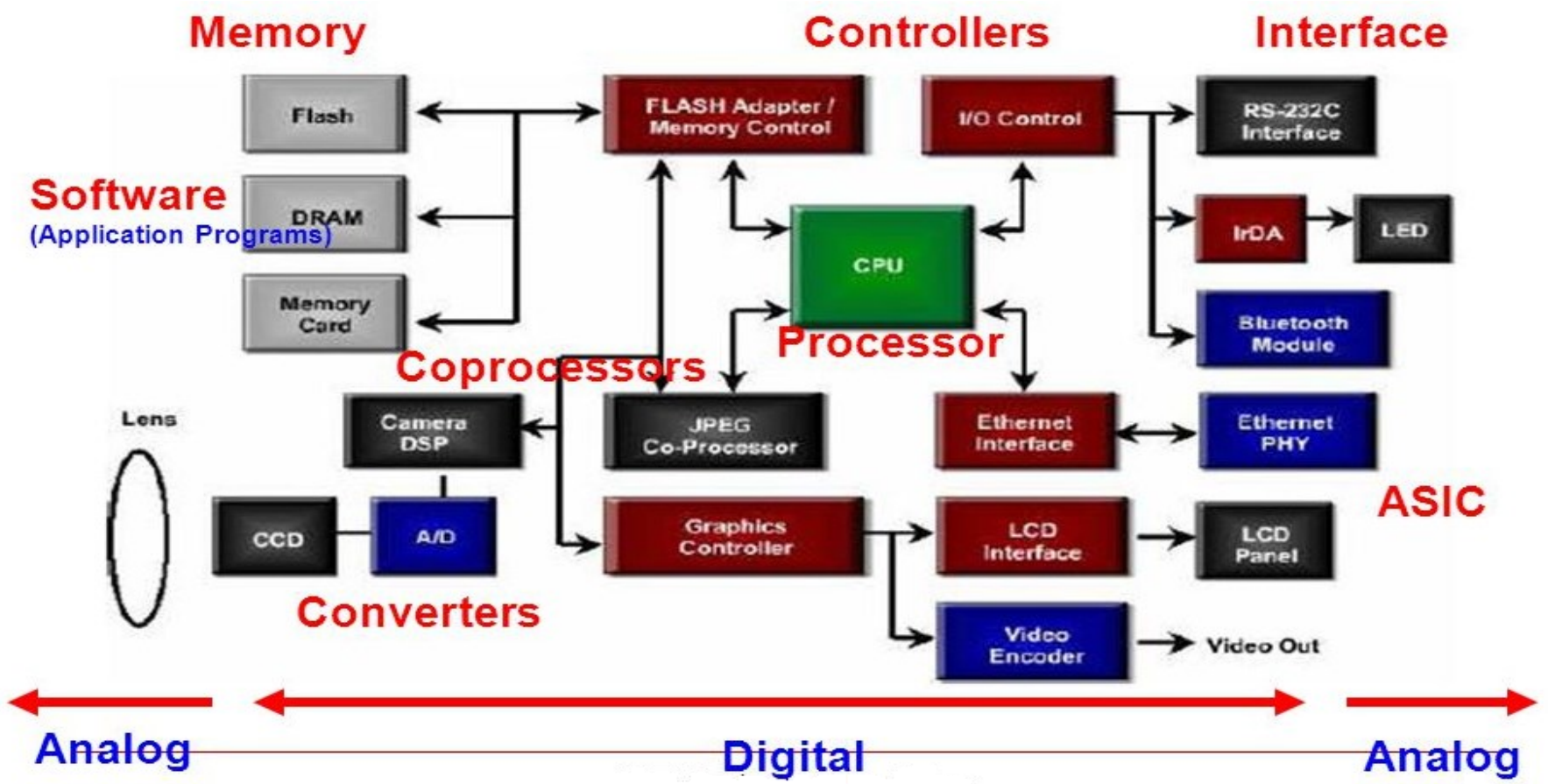
- Analog Components
  - Sensors, Actuators, Controllers, …
- Digital Components
  - Processor, Coprocessors
  - Memories
  - Controllers, Buses
  - Application Specific Integrated Circuits (ASIC)
- Converters – A2D, D2A, …
- Software
  - Application Programs
  - Exception Handlers



Components of Embedded Systems



Hardware Components of Embedded



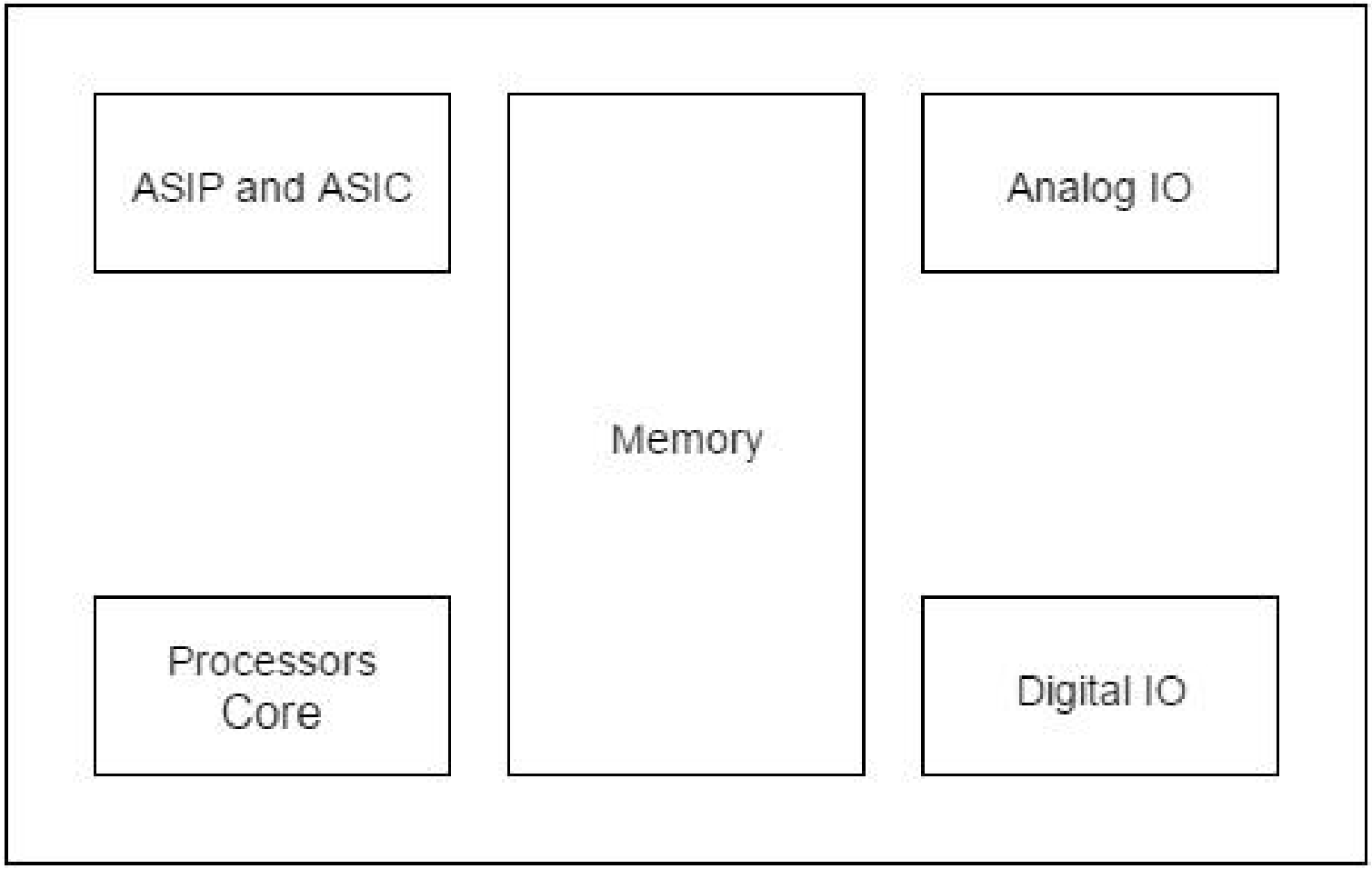
Characteristics of an Embedded System

- **Single-functioned** − An embedded system usually performs a specialized operation and does the same repeatedly. For example: A pager always functions as a pager.
- **Tightly constrained** − All computing systems have constraints on design metrics, but those on an embedded system can be especially tight. Design metrics is a measure of an implementation's features such as its cost, size, power, and performance. It must be of a size to fit on a single chip, must perform fast enough to process data in real time and consume minimum power to extend battery life.
- **Reactive and Real time** − Many embedded systems must continually react to changes in the system's environment and must compute certain results in real time without any delay. Consider an example of a car cruise controller; it continually monitors and reacts to speed and brake sensors. It must compute acceleration or de-accelerations repeatedly within a limited time; a delayed computation can result in failure to control of the car.

Characteristics of an Embedded System

- **Microprocessors based** − It must be microprocessor or microcontroller based.
- **Memory** − It must have a memory, as its software usually embeds in ROM. It does not need any secondary memories in the computer.
- **Connected** − It must have connected peripherals to connect input and output devices.
- **HW-SW systems** − Software is used for more features and flexibility. Hardware is used for performance and security.

General Block Diagram of an Embedded System



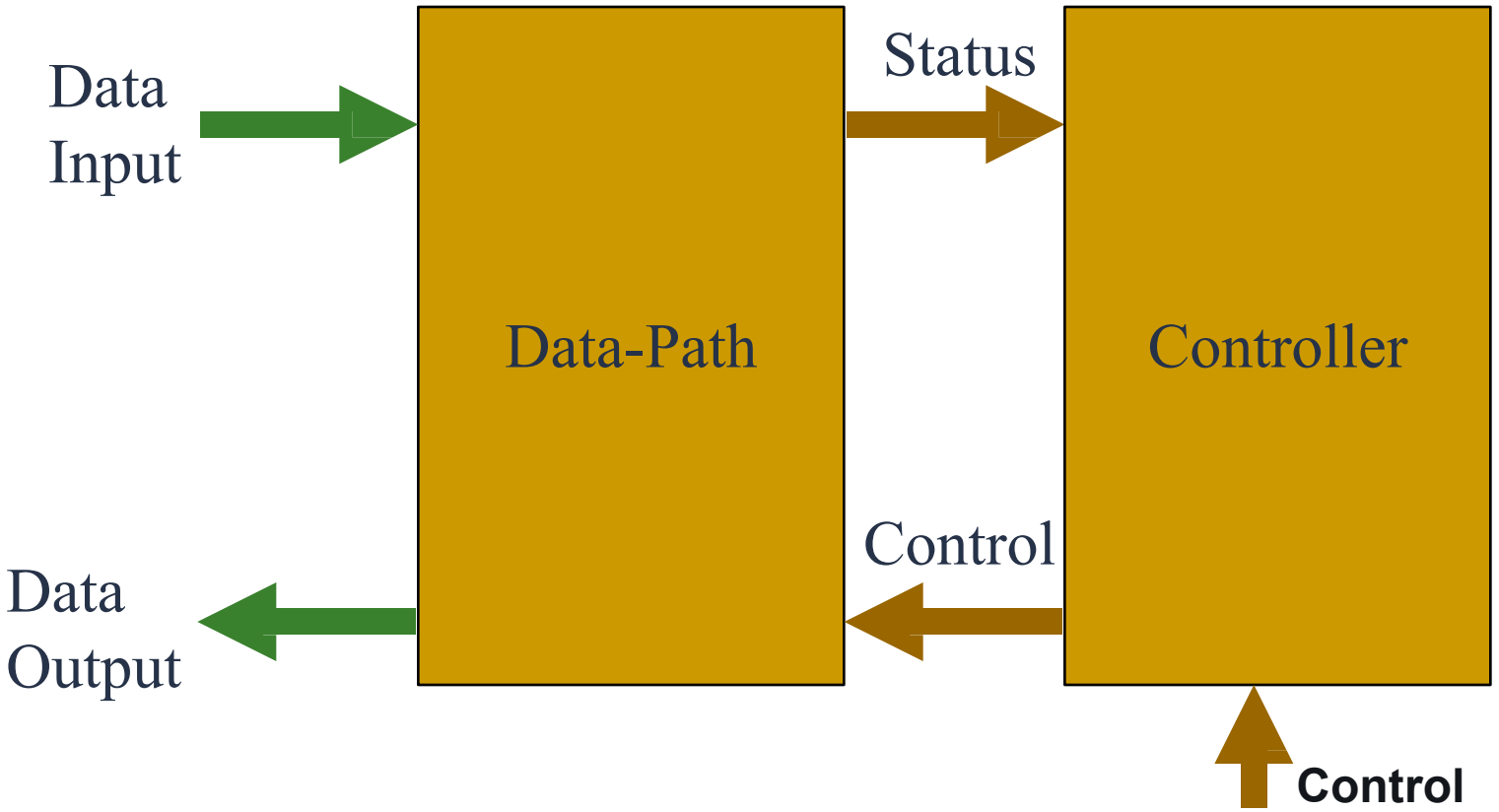
Processors in a System

- It is the heart of an embedded system. It is the basic unit that takes inputs and produces an output after processing the data. For an embedded system designer, it is necessary to have the knowledge of both microprocessors and microcontrollers.
- A processor has two essential units –
  - Program Flow Control Unit (CU)
  - Execution Unit (EU)
- The CU includes a fetch unit for fetching instructions from the memory. The EU has circuits that implement the instructions pertaining to data transfer operation and data conversion from one form to another.
- The EU includes the Arithmetic and Logical Unit (ALU) and also the circuits that execute instructions for a program control task such as interrupt, or jump to another set of instructions.
- A processor runs the cycles of fetch and executes the instructions in the same sequence as they are fetched from memory

Processors comprise of the following categories –

- General Purpose Processor (e.g., microprocessor, microcontroller, embedded processor, etc.)
- Application Specific System Processor (ASSP)
- Application Specific Instruction Processors (ASIPs)
- GPP core(s) or ASIP core(s) on either an Application Specific Integrated Circuit (ASIC) or a Very Large Scale Integration (VLSI) circuit

GP/SP Processor Architecture



Thank You