Embedded Systems
(Lec_01 Overview)

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Embedded Systems - Overview

- System

  A system is an arrangement in which all its unit assemble work together according to a set of rules. It can also be defined as a way of working, organizing or doing one or many tasks according to a fixed plan.

  For example, a watch is a time displaying system. Its components follow a set of rules to show time. If one of its parts fails, the watch will stop working. So we can say, in a system, all its subcomponents depend on each other.

Embedded System

- As its name suggests, Embedded means something that is attached to another thing. An embedded system can be thought of as a **computer hardware system having software embedded in it**.

- An embedded system can be an **independent system** or it can **be a part of a large system**.

- An embedded system is a **microcontroller** or **microprocessor based system** which is designed to perform a specific task. For example, a fire alarm is an embedded system; it will sense only smoke.

Embedded system major 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

Embedded System: Detail

- A device that controls mainly physical things
  - control strategy is preinstalled
  - limited data manipulation
  - limited interconnection
  - limited ability to remember previous events
- Has “intelligence”
  - Can be configured, personalised, “programmed”

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.

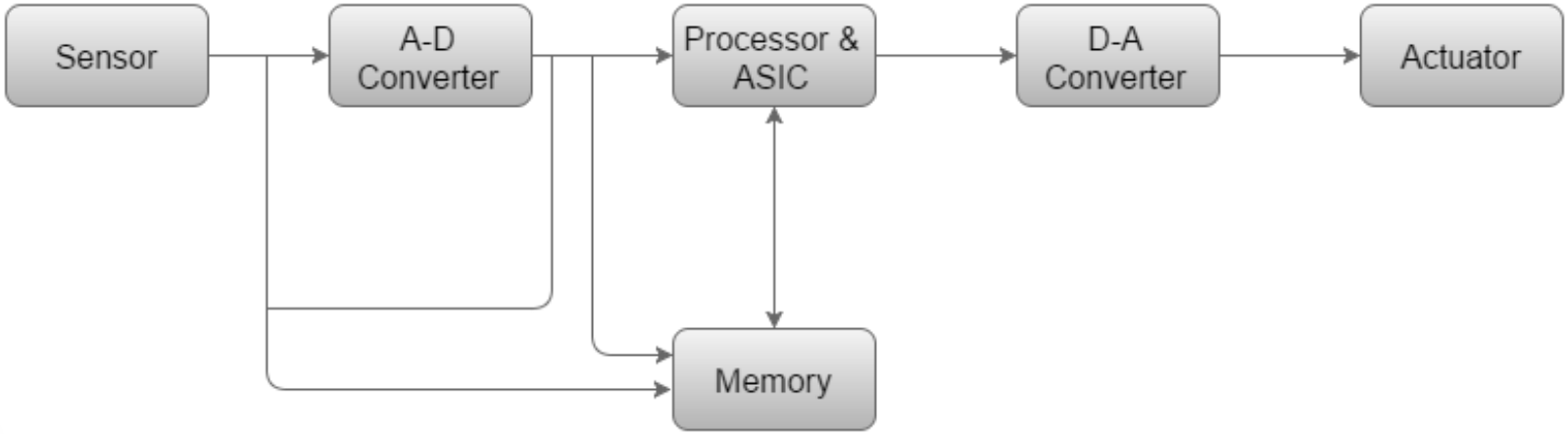
Consider an example of a car cruise controller; it continually monitors and reacts to speed and brake sensors. It must compute acceleration or de-accelerations repeatedly within a limited time; a delayed computation can result in failure to control of the car.

- **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.

- Advantages
  - Easily Customizable
  - Low power consumption
  - Low cost
  - Enhanced performance
- Disadvantages
  - High development effort
  - Larger time to market

Basic Structure of an Embedded System

The following illustration shows the 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.

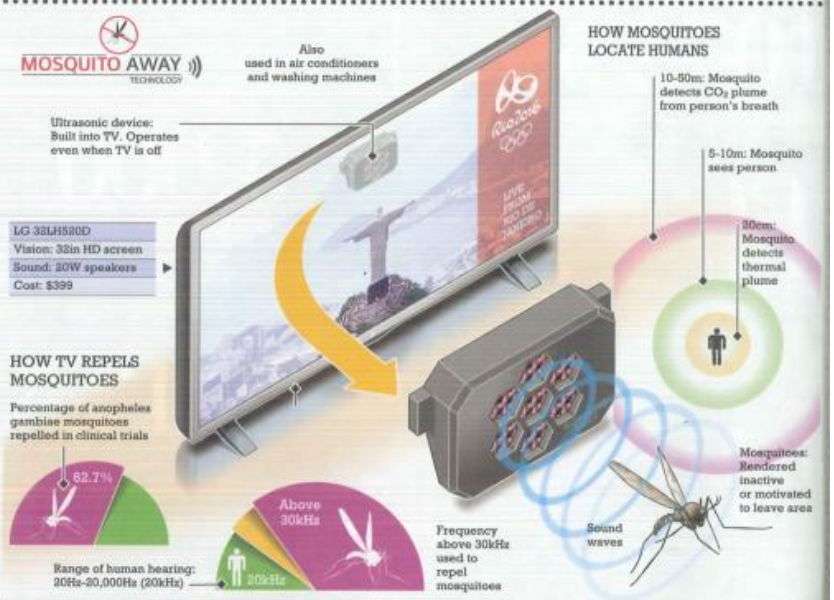
- **D-A Converter** – A digital-to-analog converter converts the digital data fed by the processor to analog data.

- **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

The Indian division of LG Electronics has developed a TV set with an ultrasound emitter that it claims can repel mosquitoes, which spread diseases such as malaria, Zika and dengue.

The Graphic

Mosquito-repelling TV



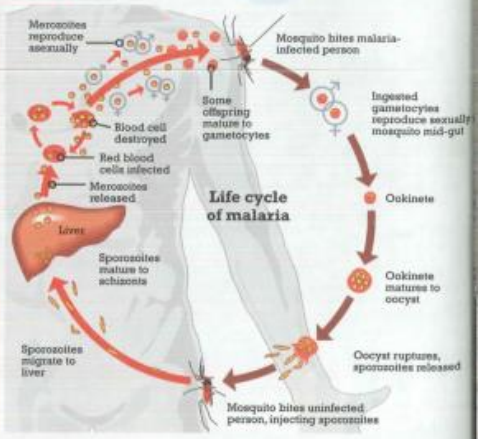


IMAGE SOURCE: GETTY IMAGES; LG; CALTECH; WIRE AGENCIES; AP; GRAPHIC NEWS

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CHINA

ALIEN-SEARCHING TELESCOPE COMPLETED

Construction of the world's largest radio telescope, the size of 30 football fields and designed to search for signs of extra-terrestrial life, has been completed in China's Guizhou province. bit.ly/telescope1607

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BELGIUM

ROBOT LANDS FIRST JOB IN HOSPITAL

The emotion-reading humanoid robot Pepper has started work in the hospital environment as a receptionist and helping patients find their way around. bit.ly/pepper1607

PACIFIC

SUBSEA HIGH-SPEED INTERNET CABLE LIVE

A 9,000km subsea cable connecting the US with two cities in Japan has been launched transmitting up to 100Gbit of data per second. bit.ly/subseacable1607

THE NETHERLANDS

OCEAN CLEAN-UP PLATFORM TESTED

A prototype system designed to remove plastic waste from oceans using only the energy of currents is being tested in the North Sea. bit.ly/oceancleanup1607

SWITZERLAND

STUDENTS' EV BREAKS ACCELERATION RECORD

A Formula Student car dubbed Grimsel has broken the world record for acceleration by an electric vehicle, getting from 0 to 100 km/h in 1.513 seconds. bit.ly/evrecord1607

USA

FIRST SELF-DRIVING CAR FATALITY

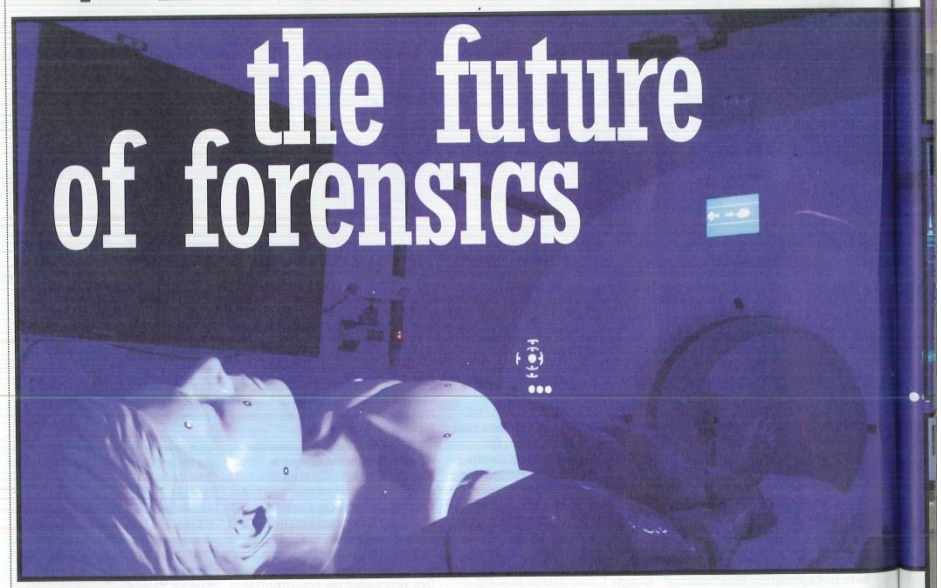
A man had died in a crash of a Tesla Model S car steered by the Autopilot functionality, authorities have revealed. bit.ly/autopilotcrash1607

Transforming the work of forensic pathologists, the Virtopsy project is a suite of non-invasive imaging techniques that is revolutionising police investigations in both the living and the dead. By **Louise Murray**

Could crime scene reconstruction and virtopsies change the forensic world?

VIRTOPSY

the future of forensics

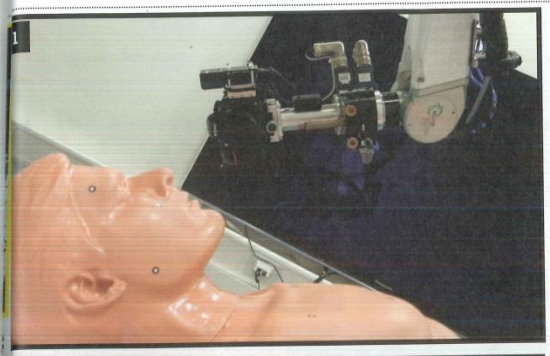


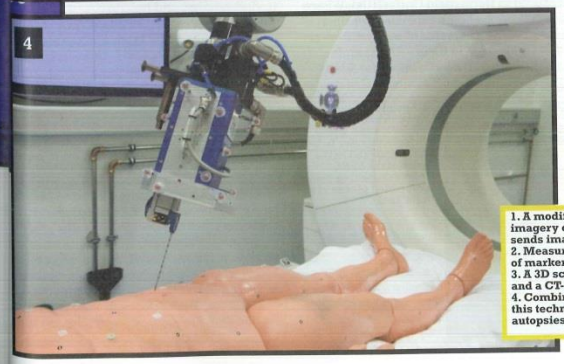
LOUISE MURRAY

THE SLEEPING BEAUTY of forensic science is forensic pathology – post-mortem examination to determine the cause of a death. While there have been groundbreaking innovations in the fields of DNA analysis and toxicology in recent years, most forensic pathologists continue to rely on techniques developed in the 19th century or even earlier. Their day-to-day work differs little from that of their medieval predecessors – dissecting corpses in a basement morgue and writing reports of the findings. That may be about to change.

A quiet revolution is happening in Switzerland, where visionary forensic scientists have joined forces with engineers, radiologists, computer scientists and roboticists to integrate the latest developments in 3D imagery and radiological medical scanning – CT and MRI – and apply them to the understanding of death and its causes. This is the Virtopsy project.

Virtual autopsy or digital autopsy is a non-invasive attempt to answer the questions that would normally require a conventional autopsy. The digital autopsy can also help in cases where religious faith may make a





conventional dissection difficult.

The co-founder of the project, Professor Michael Thali of the Zurich-based Institute for Forensic Medicine and Imaging, explains: "We bridge forensic science and radiology, which has brought about the new field of forensic imaging. Virtopsy can act as a triage system for full scalpel autopsies, making many unnecessary. It can also up-skill the pathologists by allowing them to spend more time on analysis and interpretation rather than dissection and recording.

"We are also proud that Virtopsy results are now accepted within the Swiss court system," Thali adds. Ten per cent of all conventional autopsies in Zurich are now cancelled as the cause of death is evident from Virtopsy scanning alone. The system has also detected three additional murder cases from strangulation that had not been flagged by an autopsy.

Virtual autopsy tools

The first step in a virtual autopsy procedure is to photograph and scan the outer surface of the body. Markers placed at specific points on the skin will later be used to integrate and align the results from surface and interior CT or MRI scans.

The Virtobot is a modified automotive robotic arm that has three tools: a Nikon D800 camera with a wireless transmitter, which shoots surface images of the body – front and back from pre-programmed positions – and will pick up any injuries present on the skin surface.

Next, a 3D scanner, which uses blue light to record the surface topography, creating a digital and permanent version of the body that can later be animated or placed in a 3D crime scene reconstruction when combined with CT scan data. This will also map surface wounds, which will be photographed manually at 1:1 or greater magnification. The 3D scanner was originally developed in the automotive industry for accurate quality-control measurements.

The final tool is a biopsy needle for taking precise tissue samples, but this is only deployed if required after a CT scan and if the pathologist deems it necessary. All this can be done without exposing pathologists to harmful radiation or bodily contaminants. "Virtopsy removes the element of subjectivity," adds Thali. "You no longer have to rely on the judgment of a single pathologist as the data set can be reviewed by anyone, anywhere in the world."

The CT scan is the most common form of forensic imaging used worldwide and takes place at the Zurich Institute after surface photography and scanning. It forms a permanent record of the corpse by >

1. A modified industrial robot makes comprehensive digital imagery of a body using a mounted Nikon D800 camera, which sends images wirelessly to the operator.
2. Measurements and positioning are aided by the placement of markers on the 'corpse'.
3. A 3D scanner using blue light completes the surface imaging and a CT-guided biposy needle takes invasive samples.
4. Combined with a full CT scan and postmortem angiography, this technology can act as a triage system for conventional autopsies, rendering many of them unnecessary.

Summary

- Embedded systems are dedicated to ONE specific purpose usually

- Three elements are needed
  - Electronics
  - Microcontroller
  - Programming Skills

- Need to understand
  - Number systems
  - Microcontroller architecture and operation
  - Programming languages applied to microcontrollers
- Look at all areas in more detail as we progress