# EMBEDDED SYSTEMS FOR MULTIMEDIA AND IMAGE PROCESSING

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**Abstract:**
**Embedded Multimedia and Image Processing Systems are widely used in a variety of applications, including Internet of Things (with IP, Smart, and Cognitive cameras), Automotive, Medical Imaging, Security, Consumer, and so on. The ever-increasing user demands/expectations have resulted in a significant increase in the availability of advanced multimedia services in embedded multimedia systems. Furthermore, video resolutions are expected to rise from High Definition to Ultra High Definition to Super-Vision, necessitating a 100x increase in processing power over current generation standards. On the one hand, due to the massive data rates, these systems have extremely high computational and power requirements. Due to embedded applications, these systems, on the other hand, are subject to stringent design constraints in terms of power and area. As a result, developing such embedded multimedia and image processing systems has proven to be a significant challenge.**
**Keywords:Embedded System, Multimedia, Image Processing, embedded multimedia, Embedded Systems with Applications, FPGA-based image processing**.

## Introduction:

Digital multimedia systems have advanced far beyond traditional analogue devices. Embedded systems with multimedia features are becoming more common as technology advances. As technology becomes an indispensible part of our lives and content becomes more widely available, consumers are demanding seamless audio-video experiences at home and on the go. This trend is being driven by feature-rich multimedia solutions, which are being adopted by device manufacturers in the smartphone, infotainment, broadcast, video surveillance, and video conferencing industries. Multimedia systems necessitate real-time and efficient processing. However, quality, power efficiency, performance, and latency are critical issues that must be addressed intelligently. [1]

Technology has become an indispensible part of our daily lives, and consumers have begun to demand seamless audio-video experiences in both indoor and outdoor settings. This trend is driven by feature-rich real-time multimedia systems and solutions. While smartphone manufacturers adapt, others continue to face challenges regarding performance, quality, power efficiency, and other factors that must be addressed with care. With its deep expertise in audio, video, and image processing, Embien provides dependable solutions to complex multimedia-related challenges. [2]

An embedded system is a type of computer system that is primarily designed to access, process, store, and control data in various electronics-based systems. Embedded systems are made up of hardware and software, with the software being known as firmware that is embedded in the hardware. One of the most important features of these systems is that it provides the o/p within the time constraints. Embedded systems assist in making work more precise and convenient. As a result, embedded systems are frequently used in both simple and complex devices. Embedded systems are used in a variety of devices in our daily lives, including microwaves, calculators, TV remote controls, home security systems, and neighbourhood traffic control systems, among others. [3]

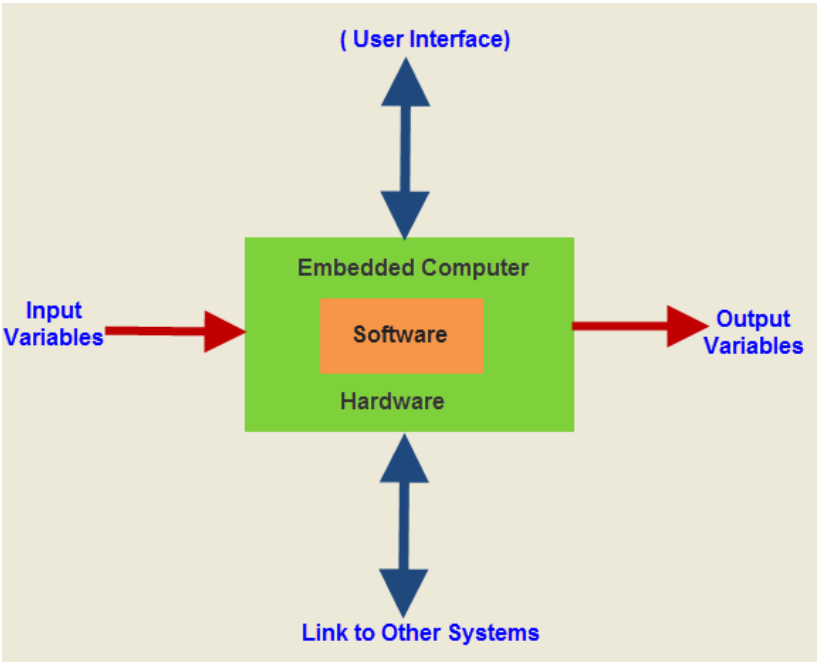


Figure 1: Classification of Embedded Systems with Applications

An embedded system is a set of computer hardware and software that is specifically designed to perform a specific task, either as a standalone system or as a component of a larger system. At the heart of the system is an integrated circuit designed to perform computation for real-time operations. Among the numerous possible hosts of an embedded system are industrial machines, automobiles, medical equipment, cameras, household appliances, aeroplanes, vending machines, and toys (in addition to the more obvious cellular phone and PDA). [4-5]


**Figure 2: Application of Image Processing**

The use of a digital computer to process images using an algorithm is known as image processing. In other words, it is the use of computer algorithms to convert data from a still or video camera into a decision or a new representation, resulting in an improved image or the extraction of useful information. For example, the input data could be a live video feed, the decision could be that a face was detected, or a new representation could be the conversion of a colour image to a greyscale image.

## Result and Discussion

### Image Processing Applications in Embedded Systems

Embedded systems for advanced image processing applications, particularly those involving machine learning or AI models, necessitate a significant amount of processing power and memory in addition to high resolution video. These capabilities should ideally be combined into a single package with a small form factor and plenty of onboard memory for data storage. Add network or wireless connectivity, and you have all the ingredients for a powerful machine-learning-based image processing system. [6]

Many designers looking to develop new products in this area can design a custom board for their product, but there are other options. Most development boards (for example, Arduino) limit the form factor and functionality to modules that can be connected via standard headers or USB. You will also be restricted to running relatively simple machine learning models with low latency. This is fine for still image processing, but these simpler systems are unsuitable for video processing.

- **Image identification.** This task is intended to segment an image into distinct features. Pose identification is an excellent example, in which specific body parts in an image must be identified, and the arrangement of those body parts is then used to determine the pose of a human body.
- **Image segmentation.** This task is meant to segment an image into specific features. An excellent example is pose identification, where specific body parts in an image must be identified, and then the arrangement of those body parts is used to determine the pose of a human body.
- **Image classification.**Images are classified here based on the features they contain. Sentiment analysis based on facial features and quality control on a production line are two examples of applications. I recently read a research paper on the use of image classification with a neural network for tumour detection; this type of application could be easily deployed on one of NVIDIA's modules.

These applications' models can be built on top of neural networks or with other machine learning techniques. There are numerous open-source libraries available for use with your embedded system. [7-8]

**Board Design for Embedded Systems for Image Processing**

The Jetson Snapshot board from Gumstix is a great system if you're interested in quickly deploying scalable image processing embedded systems for a variety of applications. With 4 GB of RAM and a quad-core ARM A57 processor, this board has more than enough memory to run image processing models. Additionally, this board has 4 Jetson Nano COM slots, each of which can accommodate 4 vertical camera connectors that work with the Raspberry Pi Camera Module V2. Then, either gigabit Ethernet or WiFi can be used to link this system to a local network.

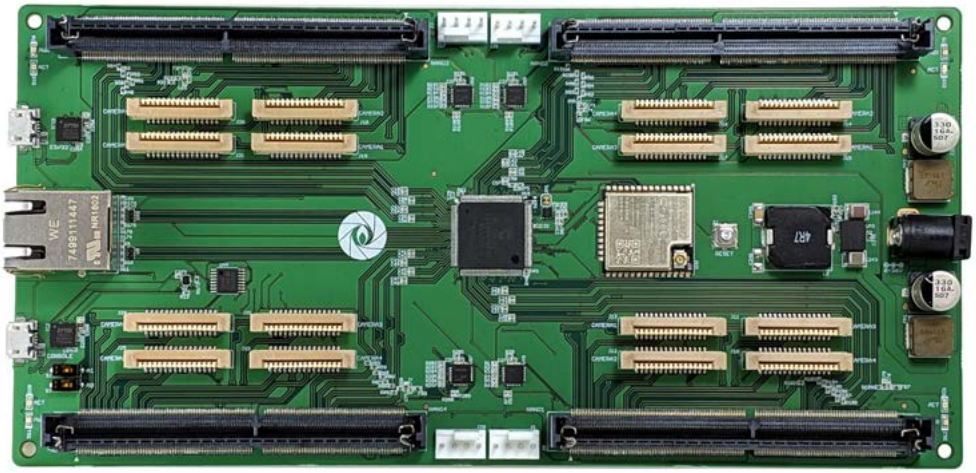

Figure 3: 16 1080p 30fps video streams in a single board

modular design approach allows you to take advantage of standardized electrical connections between modules when designing your board. [9-10]

Increased road network capacity, reduced congestion and pollution, shorter and more predictable journey times, improved traffic safety for all road users, more efficient logistics, improved management and control of the road network (both urban and inter-urban), increased efficiency of public transport systems, and better and more efficient response to hazards, incidents and accidents are all potential benefits of embedded systems applied to urban environments and road networks.

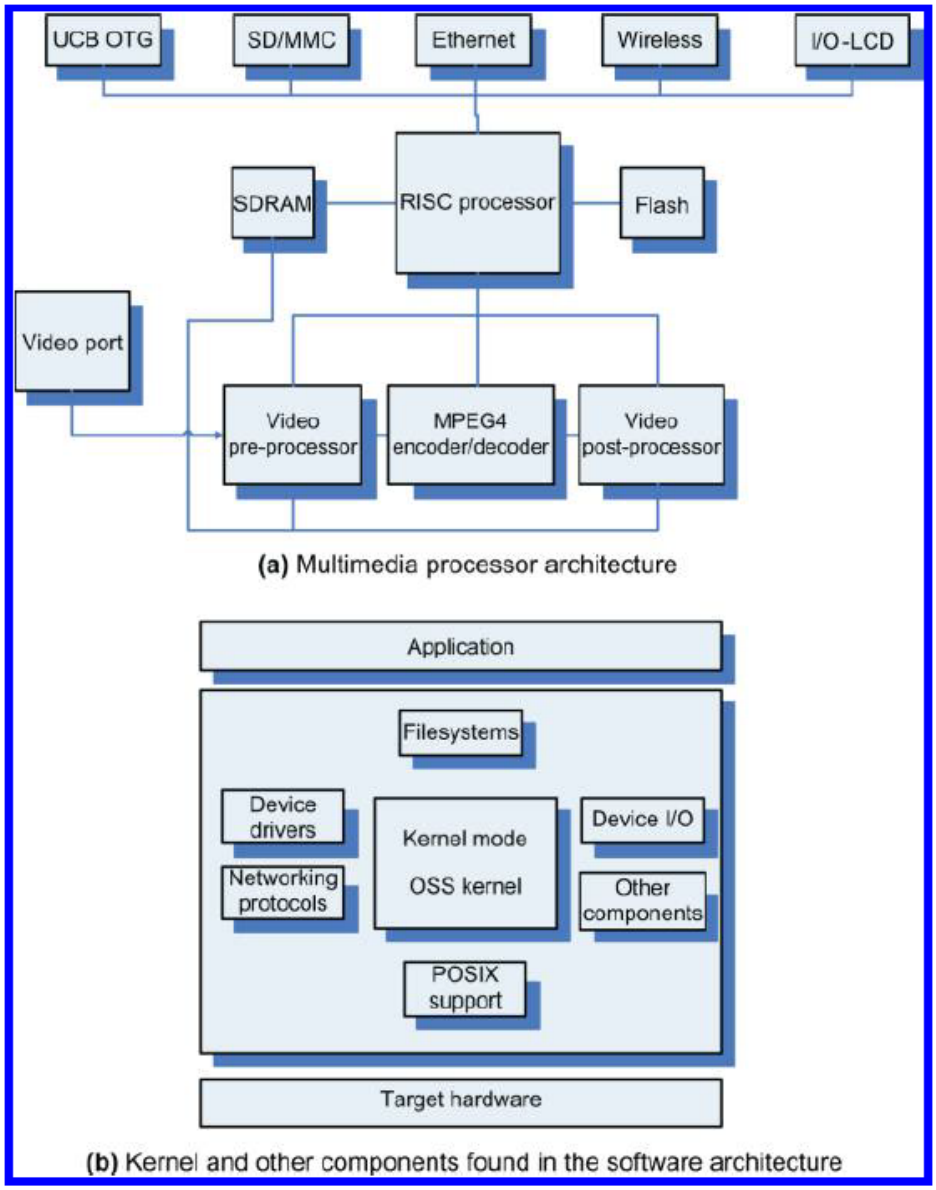


Figure 4: A generic embedded system suitable for the ITS domain: (a) multimedia processor architecture and (b) kernel and other software architecture components.

Accidents (Fuchs and Bankosegger, 2009; Tuominen and Ahlqvist, in press). The majority of related works in the field of urban environments are usually related to vehicle to vehicle (V2V) and vehicle to infrastructure (V2I) communications (Hinsberger et al., 2007). [11-12]

**FPGA-Based Image Processing: Develop Embedded Systems Faster**

These applications necessitate the use of small, lightweight, energy-efficient, real-time image processing components. Traditional computer architectures with general-purpose processors are insufficient as a hardware platform for these requirements. As a result, embedded systems based on FPGAs are frequently used. These logic components' circuit structure can be freely configured using a special type of programming.

The low-level, hardware-related VHDL language is commonly used for this purpose. The issue here is that most image processing applications are available in higher programming languages such as C/C++, and converting them to embedded systems is time-consuming. VHDL is not only distinct from other programming languages, but it must also be tailored to the specific hardware. Existing VHDL programmes cannot be transferred to other hardware. With each new system, software developers must virtually start from scratch. [13]

Figure 5: FPGA-based image processing

As part of the Tulipp project, a consortium of eight partners from six countries, including Fraunhofer IOSB in Karlsruhe, has significantly simplified this procedure. As a result, a development platform with design guidelines, a configurable hardware platform, a real-time operating system that supports multi-core processors, and a programming tool chain has been created. "A starter kit, which was also developed as part of Tulipp, also helps." "With it, such applications can be developed much faster and more easily." "The Tulipp Starter Kit can be used to port C++ programmes to FPGA, on which a developer has frequently worked for months, in a matter of weeks," says Igor Tchouchenkov, group leader at Fraunhofer IOSB. [14]

**Conclusion:**

This research will focus on real-time image and video analysis across various aspects of embedded systems. The topics covered in this course include image/video sampling, image/video transform, image/video filtering, face detection, blob detection, multi-object tracking, stereo vision, augmented reality, and gesture recognition. Embedded systems are becoming increasingly prevalent in our daily lives, deploying a wide range of rich capabilities.

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