REAL TIME APPLICATIONS OF EMBEDDED SYSTEMS IN HEALTH CARE

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ABSTRACT

This paper focuses on the use of embedded systems in the medical field before introducing the reader to various types of embedded systems, their various applications, and embedded processor types. Our primary focus is on new age embedded medical devices, but we have included some existing embedded medical devices as well. Our primary focus is on Foetal Monitor, Oximeter, Defibrillator, and other medical devices, and we are attempting to demonstrate how these devices have made the lives of people in the medical field much easier and their profession more efficient.

Keywords: *Embedded Systems; Health Care; Embedded Operating System; clinical care; Medical field.*

INTRODUCTION

An embedded system is a subsystem of a larger operating system designed to perform one or two specific tasks. Embedded systems are frequently used for data storage in the healthcare industry. Because healthcare applications may be used in harsh operating conditions with temperature fluctuations and exposure to shock and vibrations, OEMs must typically select industrial grade embedded systems. Industrial grade products are designed for use in such harsh environments and can withstand them without losing functionality. [1]

Historically, medical instruments were large, heavy machines that had to be transported with the patient. As needed, a few machines could be wheeled around the hospital. The emphasis these days is on portable instrumentation. There are obviously still some large static machines...a hand-held MRI scanner is unlikely to appear in the near future. What is the significance of this shift? Because *we can, of course - modern electronics make portable equipment more feasible than ever before. However, "the great motivator" - money - is also driving the move.*

To understand the finances of modern healthcare, which are a key driver of medical instrument design, the following contexts must be considered:

1. Proactive health consists primarily of preventive measures and health monitoring.

2. Home care - an extension of (1) in which there may be intervention, drug delivery, and/or data networking.
3. Residential care, such as in a nursing home.
4. Hospitalised acute care

In general, the cost of healthcare delivery rises from (1) to (4) in each of these contexts. As a result, there is a high demand for devices that facilitate (1) and (2) in particular (though improvements in (3) and (4) are also welcome). Portable devices are obviously popular. [2]

TYPE OF EMBEDDED SYSTEM

The following are the different types of embedded systems:

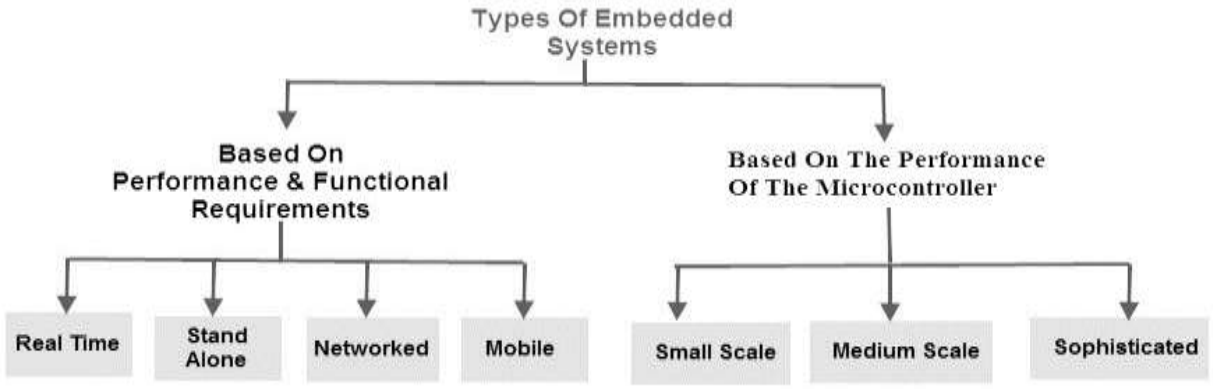

Figure 1: Types of Embedded Systems

Based on their performance and functional requirements, embedded systems are classified into four categories: [3]

1. Real time embedded systems
   A real time embedded system is one that provides a required o/p at a specific time. These embedded systems adhere to time constraints for task completion. Soft and hard real time embedded systems are the two types of real time embedded systems.
2. Standalone embedded systems
   Standalone embedded systems do not require a host system, such as a computer, and can function independently. It takes input from analogue or digital input ports and processes, calculates, and converts the data before passing it on to the connected device, which controls, drives, and displays the connected devices. MP3 players, digital cameras, video game consoles, microwave ovens, and temperature measurement systems are examples of stand-alone embedded systems.

3. Networked embedded systems
   To access resources, these embedded systems are linked to a network. The network to which you are connected can be LAN, WAN, or the internet. Any wired or wireless connection can be used. This type of embedded system is the fastest growing application area in embedded systems. The embedded web server is a system in which all embedded devices are linked to a web server and can be accessed and controlled via a web browser. A home security system with all sensors connected and running on the TCP/IP protocol is an example of a LAN networked embedded system.
4. Mobile embedded systems
   Mobile embedded systems are found in portable embedded devices such as cell phones, mobile phones, digital cameras, MP3 players, and personal digital assistants, among others. The primary limitation of these devices is the lack of other resources and memory.

Based on the performance of the microcontroller, embedded systems are classified into three types [4].

1. Small Scale embedded systems
   These embedded systems are built around a single 8 or 16-bit microcontroller that can even be powered by a battery. The main programming tools for developing embedded software for small scale embedded systems are an editor, assembler, cross assembler, and integrated development environment (IDE).
2. Medium Scale embedded systems
   These embedded systems are built with a single or multiple 16 or 32 bit microcontrollers, RISCs, or DSPs. These embedded systems are complex in terms of both hardware and software. The main programming tools for developing embedded software for medium scale embedded systems are C, C++, JAVA, Visual C++, RTOS, debugger, source code engineering tool, simulator, and IDE.
3. Sophisticated embedded systems
   These embedded systems have enormous hardware and software complexities that may necessitate the use of ASIPs, IPs, PLAs, scalable or configurable processors, and so on. They are used for cutting-edge applications that require hardware and software collaboration, as well as components that must be assembled into the final system.

Embedded systems rarely interact with the end user directly. They work reactively and in real time with limited resources for a single purpose, and they are capable of performing highly critical tasks in their usage areas on occasion.

The use of embedded systems in the medical sector has grown in popularity because it offers numerous benefits. Because the design of both the software and the hardware is usually tailored to

each application, these systems are considered highly customizable and controllable. Furthermore, the developer has complete control over the system at all times due to the complete design of the hardware, firmware, and software. In, the author discusses various design techniques for lightweight, reconfigurable medical systems based on embedded systems. In terms of price, these are low-cost systems with a dedicated design that makes these systems cost-effective; this feature has paved the way for disposable or widely adopted electronic devices, such as wearable electronics. The author emphasises the use of embedded systems in low-income countries. Finally, because these systems are highly optimised, response times can be kept to a minimum, ensuring real-time execution. This feature is critical in the medical industry because it reduces the time required for sanitary reaction or even to dose the treatment. The significance of real-time systems in insulin pump devices is demonstrated.

Is a programmable device that consists of development hardware and software and is used as a component of an electrical device. Because embedded systems are real-time and extremely fast, they are preferred for medical applications. Embedded systems are computer systems, and we must understand and control all of their details and features. An embedded system is a hardware and software combination that includes a microprocessor, memory for storing data and programmes, converters such as microcontrollers or digital signal processors (DSP), sensors, actuators, and other interfaces. [5]

In healthcare, embedded systems have numerous applications. They are used in virtually every imaging system, including PET scans, CT scans, and MRIs, to monitor vital signs and amplify sounds from electronic stethoscopes and vital signs.

Many medical devices, such as pacemakers, CPAP machines, glucose metres, and other biomedical sensors, require embedded systems.

With biomedical applications, embedded systems enable medical professionals to diagnose and treat patients while remotely monitoring their health using telemedicine and other distant technologies. [6]

EMBEDDED OPERATING SYSTEM (OS)

The operating system is a collection of programmes that allows the management of hardware resources on an embedded system. Because embedded operating systems frequently rely on platforms with limited processing capacity, they are highly optimised. Unlike desktop operating systems such as Windows 10 or Debian, they do not typically provide a plethora of software resources and tools. Most of the time, the developer must create such customised libraries.

The main characteristics of embedded operating systems are multitasking capability, real-time operation, and suitability for safety-critical applications such as medical devices or automotive solutions. Some operating systems are pre-certified for critical applications, making the embedded device certification process easier. Furthermore, the operating system to be used is determined by the platform on which it will be run.

Wind River, Integrity, [QNX, Nucleus, or SafeRTOS] are some of the operating systems that are currently pre-certified for medical devices. They all provide software and documentation that is ready to be integrated into medical devices.

In the case of non-medical operating systems, it is necessary to use operating systems that allow the separation of different parts of the software. To mitigate or simplify risks during the design and development phase of the medical device, it will be critical to separate safety-critical and non-critical software. A critical piece of software is one whose failure could endanger the patient or the operator.

Furthermore, for medical systems that require real-time response, such as those that generate alarms or can administer medication, the operating system must provide extremely fast response times. [7]

EMBEDDED SYSTEM HARDWARE:

They are electronic systems designed to perform a specific function; microprocessors are used for the central processing unit in systems with low processing load (fire alarm, etc.), whereas microprocessors are used for the central processing unit in systems we call hard-real time (systems that result in the transition from life to death with the smallest delay). Embedded systems are also used to read sensors such as temperature, humidity, gas, flow, ultrasonic, and so on. This world can be entered by hobbyists using inexpensive and simple-to-use embedded systems (Arduino).

Embedded systems are systems that contain low-power processors within high-frequency processors, have an operating system or direct, real-time management infrastructure, and control sensors and trainers. Although the volume of transactions remains lower than that of computer systems, the development of today's technology and industry 4.0 studies has begun to close this gap. When it comes to operations-based activities like rationalising robotic systems, artificial intelligence, and machine learning, embedded system design takes up a lot of space. [8]

OBJECTIVES:

1. Study on Embedded System
2. Study on Real time Applications of Embedded systems in Health care
3. Define Applications of Embedded systems in Health care

RESEARCH METHODOLOGY:

In this Research, we look at the various steps that a researcher takes when studying a research problem, as well as the logic behind them. The researcher must understand not only the research methods/techniques but also the methodology. A close reading and detailed analysis of secondary sources is required in order to apply the analytical and descriptive methods to the research. It is critical to obtain additional perspectives in order to expand on the textual analysis, which would necessitate close reading analysis of a few secondary materials.

RESULT AND DISCUSSION:

Applications of Embedded systems in Health care

There are numerous applications for embedded systems in healthcare. They are used for vital sign monitoring, sound amplification in electronic stethoscopes, and nearly every type of imaging system, including PET scans, CT scans, and MRIs. Embedded systems are also used in glucose monitors, pacemakers, CPAP machines, and a variety of biomedical sensors. Embedded systems with biomedical applications enable doctors to remotely monitor patients' health and make diagnoses and treatment decisions via telemedicine and other remote systems.

Medical embedded systems, like embedded systems in other industries, enable patients to monitor their health from home and improve communication between patients and healthcare professionals. Devices are becoming smaller and smarter, making them easier to use and comprehend. Medical equipment can be intimidating and difficult to use. Making them more efficient and streamlined for patients improves their overall healthcare experience. The Internet of Things (IoT) has grown rapidly in recent years, owing in part to the fact that smart technology simply makes life easier. So, how are healthcare professionals making use of it? They make doctors more aware of their patients' health, and they make patients more aware of their own.

One of its applications is embedded technology in medical devices. There are numerous advantages to using "Embedded technology" as well as graphical user interfaces in medical devices.

Heart problems are one of the most common problems in today's world, affecting one out of every two people. So, in order to continue monitoring the patient, we need something that can monitor the patient for 24 hours. Yes, cardiology is the only medical specialty that fully utilises embedded technology.

Track your own health

Monitoring your own health provides you with the tools you need to better understand what is going on in your body and how you can help it. Medical equipment such as glucose monitors can help diabetics keep track of their blood sugar levels, which is critical for diabetic health. Instead of constantly pricking your finger to test your blood sugar, a small sensor can be inserted beneath the skin to provide a consistent read on glucose levels. The sensor's data will be sent to your smartphone or another connected device for you to review at any time. Fitness trackers function similarly, though they are not worn beneath the skin. Apple Watches and Fitbits have embedded technologies that can track your heart rate, activity levels, and body composition to keep you informed about whether or not you are meeting your fitness goals. If your doctor tells you that you need to lose weight, this technology can hold you accountable and track your progress towards your goals. You can also receive nutrition tips and different ways to modify your workouts to maximise your abilities by using connected apps.

Doctors can now Remotely Monitor their Patients' Health

The ability to analyse patient data enables doctors to detect new issues or imbalances more accurately. Medical embedded systems, such as pacemakers, have altered the outlook on cardiac health in recent years. Essentially, the embedded technology in pacemakers allows them to function as a mobile EKG machine; the sensors alert doctors to irregular heartbeats and provide a comprehensive report on the patient's heart health. Modern CPAP machines are similar to the health app on iPhones or the sensors in watches with embedded technologies, but they are more advanced. Outside of the hospital, healthcare professionals can monitor the sleep schedules of patients with sleep apnea. The machine is returned to the patient, but the sensors in it alert the doctor to poor sleeping habits, allowing the doctor to reach out to his or her patient to find a solution. In the hospital, a bed is no longer just a bed; it is now a smart bed. Self-monitoring patients all night can be time-consuming and exhausting. Smart beds can detect when a patient needs to be readjusted and make the necessary adjustments automatically, allowing nurses to spend more time with patients. If a patient moves a lot or tries to get out of bed, the nurse's connected device will send a notification to come to the right room at the right time to check on the patient. Some medical embedded systems remain in the hospital, while others are taken home. Their portability is extremely beneficial to the patient, and while doctors are notified of changes in health, the patient also bears responsibility for properly tracking and maintaining their health. The goal of advanced

technology and wearable devices is to give patients the freedom to go about their daily lives without having to stop to get checked up as frequently.

Prosthetics and embedded sensors

Intuitively connected devices are now assisting researchers and healthcare professionals in the field of prosthetics. A patient's life is made more difficult by the loss of a limb. They must learn to function without it, suffer from phantom limb, and must adjust to the new appendage if they choose to wear a prosthetic. Medical embedded technologies are altering how patients adjust to a fabricated limb. Typically, the frustration stems from the fact that it is difficult to instruct a limb that is not connected to your brain on how to move Healthcare professionals and researchers can study neurotransmissions from an implanted neuromusculoskeletal interface to track sensory feedback using embedded systems. Prosthetic developers can use this data to track a patient's prosthetic control and motor intent. The bioelectric signals can then be used to fine-tune prosthetic functionality and make them more reliable for everyday tasks. It also makes the patient more comfortable and places their well-being at the centre of the process.

Smart technology and clinical care

The most important takeaway from all of this is that healthcare is adapting to the shift of connected devices and the Internet of Things, but it is far from eliminating the need for healthcare professionals.

Medical equipment must keep up with technological advances in order to detect patient symptoms and allow doctors to analyse those symptoms based on reports. Smart technology allows for more accurate health readings and can make adjustments for patients with minimal human intervention, but this does not mean that humans are not required in the applications. Medical embedded systems are being used by doctors and nurses to supplement their work and provide better, more comprehensive patient care. They are more in tune with what their patients require at specific times. They can detect abnormalities and potential trauma more quickly.

Proactive care is preventative care. Smart technology can detect changes in the body much faster than a patient can feel the symptoms. Embedded systems give patients a better understanding of their personal health, allowing them to focus more on what they need to do to care for their bodies. Embedded, connected devices can track medical conditions from anywhere and allow patients to live a more balanced life free of constant doctor visits and medication trial and error.

CONCLUSION

Every day, technicians, medical professionals, and engineers strive to improve patient health. Monitoring devices are becoming smaller and easier to use. Sensors and pacemakers are becoming more intelligent. The healthcare industry is working to improve the accessibility and responsiveness of medical equipment. When doctors, nurses, and patients use embedded systems to monitor their health, there is less room for error and more room for growth.

The use of embedded systems in healthcare has given doctors and patients alike more power. Doctors can use embedded systems to diagnose health problems without having to perform exploratory surgery, and they can also use those same imaging tools to track treatment progress. The use of embedded systems in healthcare also allows for near-instant tracking of vital signs. For patients, embedded systems have made it easier to manage their conditions at home. People with diabetes, for example, can use a glucose monitor to reduce the number of finger sticks they must perform while remaining constantly aware of their blood sugar levels.

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