International Journal of Advanced Research in Engineering Technology & Science
ISSN: 2349-2819
Email: editor@ijarets.org Volume-8, Issue-6 June- 2021 www.ijarets.org

USE OF EMBEDDED SYSTEMS IN ARTIFICIAL INTELLIGENCE AND THE APPLICATION IS ON DIGITAL COMMUNICATION

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ABSTRACT

Advancements in artificial intelligence algorithms and models, together with embedded device support, have resulted in the issue of excessive energy consumption and poor compatibility when deploying artificial intelligence models and networks on embedded devices becoming solved. In response to these issues, this paper presents three aspects of methods and applications for deploying artificial intelligence technologies on embedded devices. These aspects include acceleration methods for embedded devices, neural network compression, and current application models of embedded AI. Additionally, the paper discusses artificial intelligence algorithms and models on resource-constrained hardware. In this paper, a comparison is made between the relevant research, the strengths and shortcomings are highlighted, and the conclusion includes a summary of the study as well as future directions for embedded artificial intelligence..

Keywords: *Artificial intelligence, embedded systems, Internet of Things, machine learning*

INTRODUCTION

The complexity of many machine learning models has been significantly lowered over the course of the years as a result of the development of artificial intelligence and its applications. This has made it much simpler to implement these models on electronic devices that have limited resources. As an additional point of interest, matching support for models and algorithms on these devices has emerged. These breakthroughs have made it possible to move in a new direction with research, which is embedded artificial intelligence. The concept of embedded artificial intelligence was initially presented in reference, which suggested that the Internet of Things (IoT) could develop into the Wisdom Web of Things (W2T). The article also highlighted the fact that embedded intelligence about individuals, the environment, and society could increase the number of users of existing Internet of Things (IoT) systems, promote environmental sustainability, and enhance social awareness. Both of these references combine embedded artificial intelligence with internet of things technology. Recent breakthroughs in embedded AI are detailed in these references. The integration of embedded artificial intelligence with the Internet of Things (IoT) is the current dominant research area for embedded AI. This includes edge computing with convolutional accelerators and load distribution. It is said in the reference that the combination of embedded intelligence and the internet of things is the path that progress will go in the future. Additionally, artificial intelligence can be integrated with edge computing to produce what is known as edge intelligence. This is a combination of the two technologies.

The dissemination of information is becoming increasingly dependent on high-tech means as a result of the rapid growth of science and technology as well as the rapid expansion of commercial and cultural interactions. The term "digital multimedia" refers to a relatively new media idea that integrates the functions of online advertising and the publication of information in real time. With the primary purpose of disseminating advertising material to certain individuals, it is primarily utilized in particular physical locations and during particular time intervals. Because of its strong commercial application prospects and research value, it has recently emerged as a magnet for the research and development efforts of high-tech businesses both in the United States and in other countries.

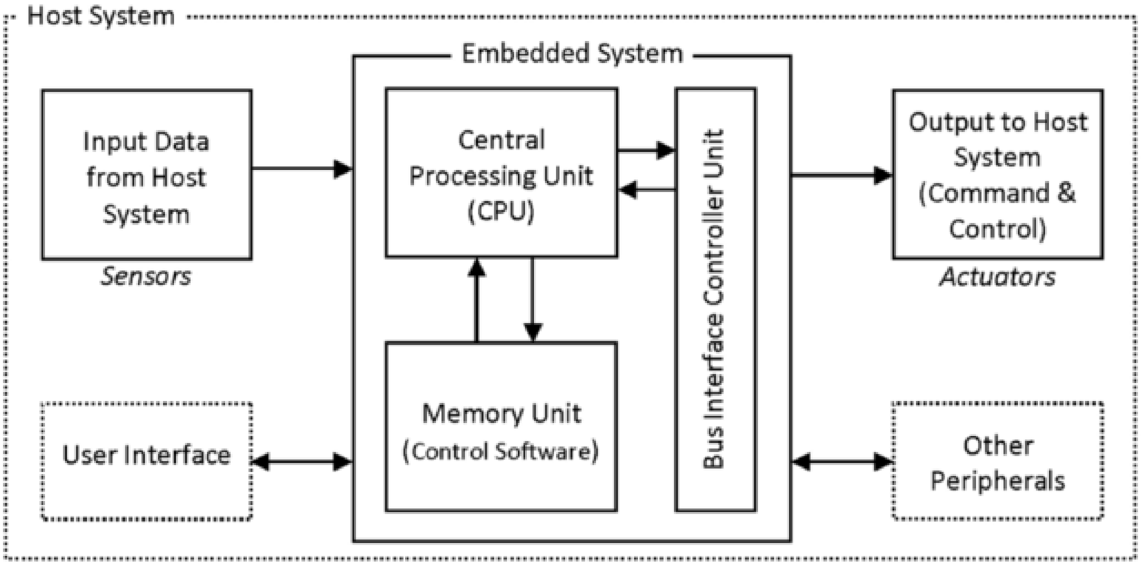
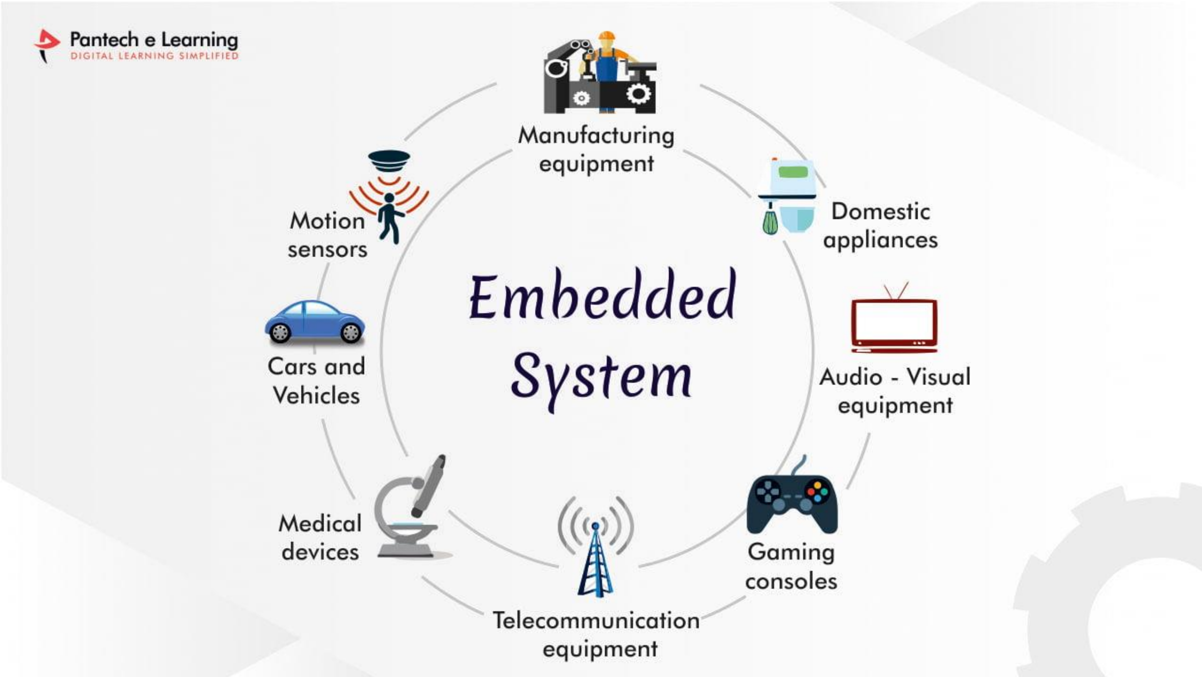
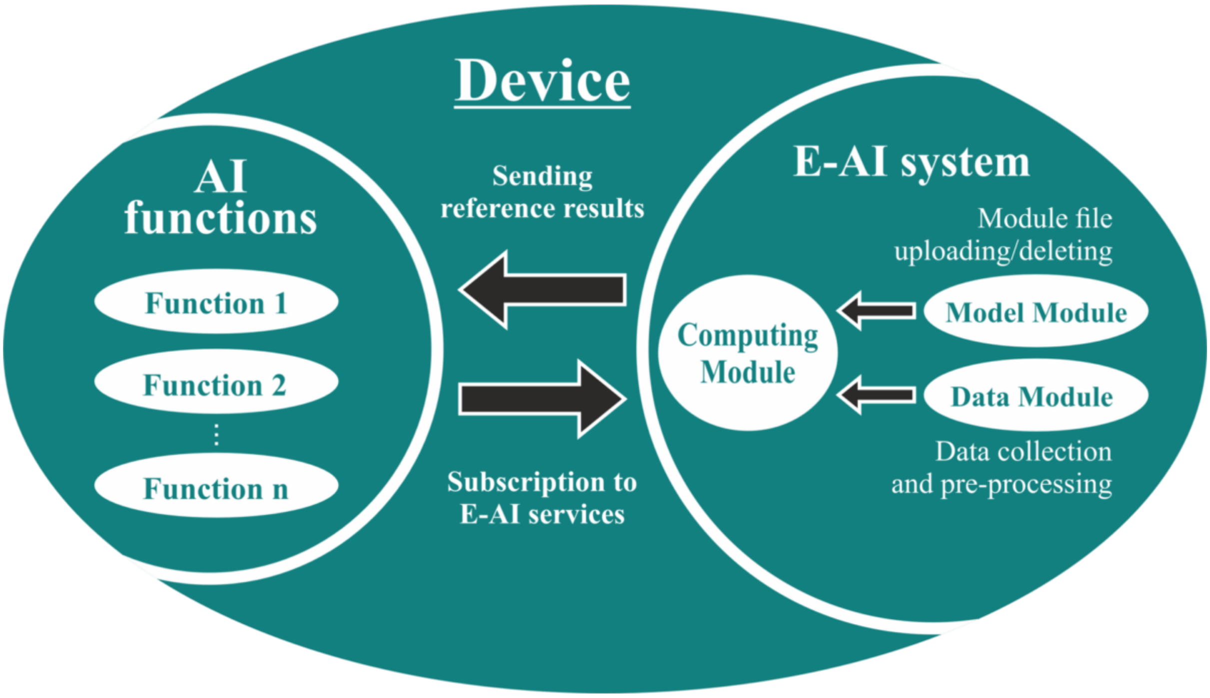


Figure 1 Block diagram of an embedded system showing basic functional components

Wearable systems for health monitoring, wireless systems for military surveillance, networked systems like those found in the internet of things (IoT), smart appliances for home automation, and antilock braking systems in automobiles are just some of the areas that are finding useful applications for embedded computing systems. Embedded computing systems are rapidly proliferating in every aspect of human endeavor today. In recent years, there has been a convergence of machine learning techniques with embedded computing practices for a variety of applications in the field of computer technology research. By way of illustration, in order to combat the hostile and dynamic nature of mobile ad hoc networks (MANETs), it is possible to improve the self-configuration of a MANET by employing techniques from machine learning. In addition, the recent advancements in deep learning models in application fields such as computer vision, speech recognition, language translation and processing, robotics, and healthcare have highlighted the importance of this overlap as a crucial research direction for the development of next-generation embedded devices. As a result, this has resulted in the establishment of a study focus between embedded devices and machine learning models, which is referred to as "Embedded Machine Learning." In this framework, machine learning models are implemented within environments that are limited in resources. This research investigates some of the most important concerns that arise from the convergence of machine learning and embedded systems.



For efficient training and inferencing, machine learning techniques such as support vector machines (SVMs) for feature categorization, convolutional neural networks (CNNs) for intrusion detection, and other deep learning approaches demand a significant amount of CPU and memory resources. It is impossible for general-purpose central processing units (CPUs) to satisfy the enormous computational demand of deep learning models, despite the fact that their architecture has been modified over the years to include pipelining, deep cache memory hierarchies, multi-core upgrades, and other similar features. On the other hand, graphic processing units (GPUs), which are characterized by their high floating-point performance and thread-level parallelism, are better suited for the training of deep learning models. A significant amount of research is currently being conducted in order to construct appropriate hardware acceleration units by utilizing FPGAs, GPUs, ASICs, and TPUs. The goal of this research is to produce heterogeneous and often distributed systems that are capable of meeting the high computational demand of deep learning models. In order to enable the efficient execution of machine learning models in mobile devices and other embedded systems, optimization techniques for classical machine learning and deep learning algorithms are being investigated at both the algorithm and hardware levels. Some examples of these techniques include pruning, quantization, reduced precision, hardware acceleration, and others.



A variety of options for study in computing technology have become available as a result of the convergence of machine learning methods and embedded systems. These systems target the resource-constrained embedded environment with computationally expensive machine learning models. Despite the fact that EML is still in its infancy, a significant amount of work has been done to:

(1) Different machine learning models should be optimized so that they can be used in situations with restricted resources.

(2) For the purpose of accelerating the implementation of these algorithms, it is necessary to develop efficient hardware architectures (acceleration units) that make use of bespoke chipsets. and

(3) In order to fulfill the high-performance requirements of these models, you will need to develop specific hardware designs that are both original and innovative..

Therefore, it is necessary to combine various points of view together in order to supply the researcher who is interested with the core principles of EML and to further assist the computer architect with insights and possibilities inside this domain.

OBJECTIVES

1. To study use of embedded systems in artificial intelligence
2. To study its application on digital communication

Embedded system based on artificial intelligence algorithm

- **The hardware configuration of an embedded system that is in accordance with an algorithm for artificial intelligence**

As embedded technology continues to advance at a rapid pace, embedded systems are likewise continuously increasing in sophistication. There are an increasing number of situations in which embedded technology has been used, and it serves a role that cannot be replaced. Embedded systems have transitioned from the prior hardware design to software implementation in order to achieve more efficient software and hardware co-design. This movement came about as a result of the growth of technology and the ongoing improvement of system performance needs. More and more embedded systems are adopting dedicated hardware optimization and acceleration algorithms as a result of the advancement of technology and the increasing demand for system performance. In this research, the unique hardware environment and embedded platform are combined in order to optimize the embedded environment and increase the recognition performance of the artificial intelligence algorithm. The majority of embedded devices consist of embedded computer systems and hardware that is associated to them. The embedded computer is the most important component of the system. It is primarily made up of four layers: the software layer, the hardware layer, the system software layer, and the intermediate layer. In the context of embedded system development, the term "software layer" mostly refers to the software layer that is utilized. Memory is the primary component of the hardware layer, along with an embedded processor, universal device interface, and it will soon contain. This is the fundamental component of the embedded system. File systems, network protocols, graphics, and real-time operating systems are major components of the software layer. The middle layer, which is also referred to as the driver layer software, is responsible for separating the system software from the underlying hardware. This allows the system device driver to be independent of the hardware during operation. Optimizing the hardware configuration of the embedded system is done on the basis of this information. Figure 2 depicts the framework of the embedded system in its most fundamental form.

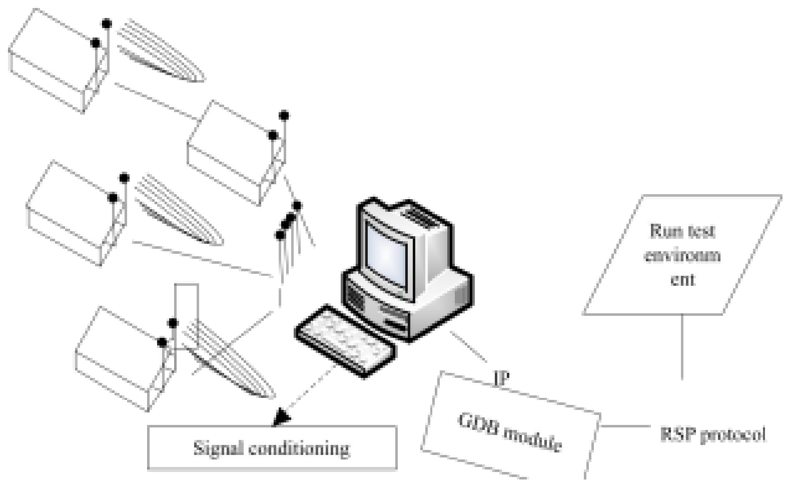


Fig.2 Basic structure of embedded system

When it comes to embedded hardware systems, we take into consideration not only the primary control components, but also the storage, communication, debugging, display, and other auxiliary functions that are associated with the embedded system. The embedded peripherals that are currently in widespread use can be classified into three distinct groups based on the functions that they perform: memory, communication device, and display. The multi-channel batch operating system, the time-sharing operating system, and the real-time operating system are the three operating systems that are currently in widespread use. Linux is a collection of operating systems that are based on UNIX and are used in these systems. The system's task switching mechanism allows for the creation of a genuine environment that supports several users and multiple tasks at the same time. It is one of the many significant benefits of using an embedded operating system. Small in size, low in power consumption, low in cost, high performance, online control, support of thumb (16 bit) / arm (32 bit) dual instruction set, large capacity of flash memory, low cost, storage of a large number of intelligent programs, fast execution speed, flexible addressing, high execution efficiency, fixed instruction length, and mature hardware conditions of embedded intelligent sensors are some of the characteristics that are present in the embedded microprocessors that are currently available. At the moment, technologies such as artificial intelligence, neural networks, fuzzy, and others have been successfully implemented in a variety of disciplines, and the theories that are generally utilized are relatively excellent. The knowledgebase, the inference engine, the knowledge acquisition program, and the comprehensive database are the primary components that make up the intelligent control module. These components are stored in the embedded microcontroller unit (MCU). It is entirely possible to implement embedded intelligent sensors in hardware, intelligent theory, software, and other parts of integrated intelligence. It is on the basis of this that the master control structure of the embedded system is optimized. Figure 3 illustrates the structure that has been optimized.

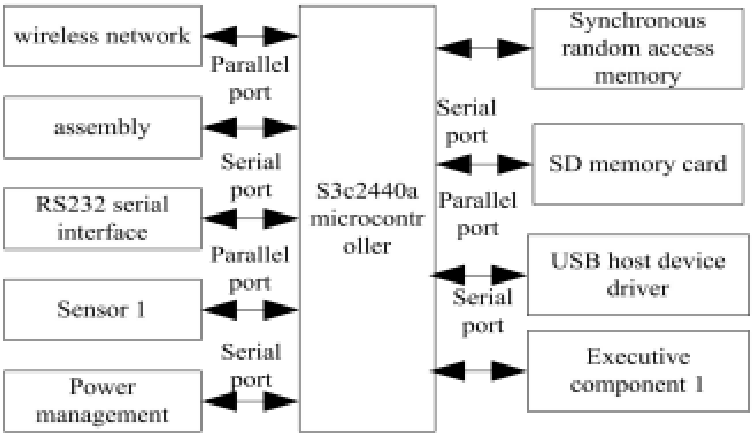


Fig. 3 Main control structure of embedded system

With regard to the field of computer communication, the embedded DSP processor that is based on the low-end embedded microprocessor and the highly integrated embedded chip system that is based on the high-end embedded DSP processor are both examples of the available options. The intelligent control module is equivalent to the embedded microprocessor plus the intelligent control module (which may be based on artificial intelligence technology, neural network technology, or fuzzy technology) plus the sensor system. An intelligent control module that is also equipped with intelligent sensors is what it represents. It is capable of simulating the method by which human specialists solve problems and possesses extensive expert knowledge in disciplines that are connected to it. It has the capacity to engage in effective thinking and possesses a certain capacity to gain knowledge; yet, its overall capability is far higher than that of experts. It is also adaptable, transparent, and interactive, and it possesses a certain degree of complexity and difficulty.

- **The development of an operations algorithm for embedded system software that is based on an artificial intelligence algorithm**

The constant development of embedded systems has resulted in the widespread application of embedded technology in a variety of disciplines. Embedded technology plays a significant part in all aspects of production and life. When it comes to computer technology and applications, the definition of embedded system is typically based on an application. It is possible to personalize both the software and the hardware, making it suited for specialized computer systems that have stringent requirements regarding function, dependability, level of cost, volume, and power consumption. An embedded system is one that is strongly relevant to particular applications and is intimately tied to those applications. It is possible to modify and adapt it in accordance with the actual requirements, and it is also possible to concentrate the primary resources on particular applications, which can play a more effective role in fostering the development of embedded systems. Combining the embedded microcontroller (MCU) with the embedded software results in a function that is flawless. Despite the fact that there is no general embedded system software, this does not have any impact on the intelligence of embedded devices. Additionally, it is possible to construct it using a generic language such as VC + +. The application software is the most important component of an embedded system. This feature is distinguished by high requirements for the storage capacity of software as well as high requirements for the quality and dependability of software code. Real-time implementation that takes into account multiple tasks at once raises the bar for what is considered desirable. The multitask real-time processing platform of the embedded system is developed on the basis of this, as can be seen in Figure 4.

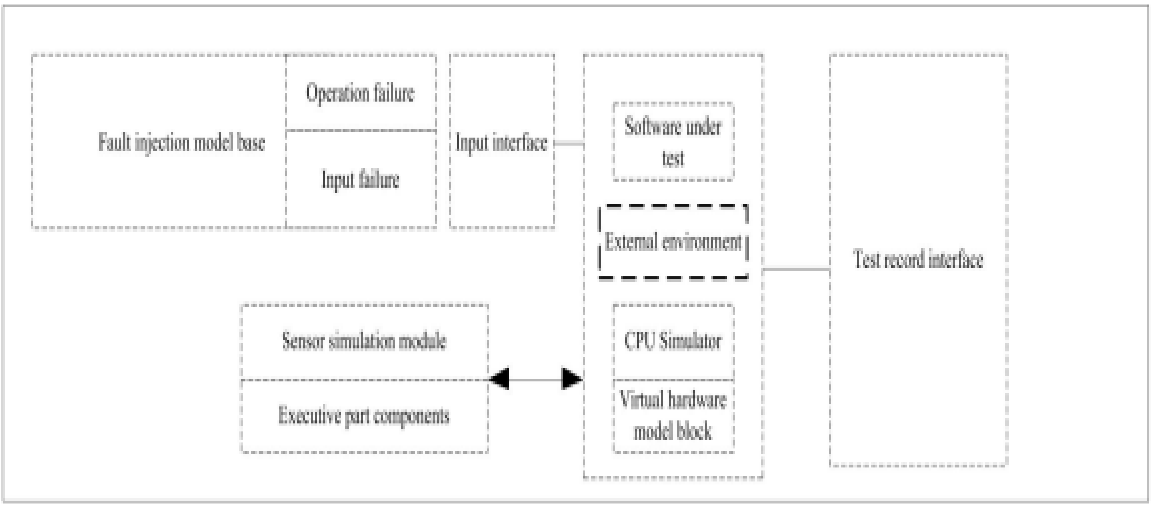


Fig. 4 Multitask real-time processing platform of embedded system

An application of the embedded system can be found in the field of artificial intelligence. In the case of the core module of the entire system, the embedded system is responsible for transmitting the information regarding artificial intelligence to the embedded system for the purposes of analysis and processing. The results are then processed in accordance with the instructions that were previously defined. The optical module in this system is responsible for completing the collection of artificial intelligence information, then utilizing the digital module to convert the information about artificial intelligence into a signal format that can be processed by the embedded system, and finally sending these digital signals to the core module so that they can be processed. The required artificial intelligence features are obtained through the utilization of an artificial intelligence processing algorithm, in accordance with the components of artificial intelligence. These features are then extracted from the system positioning module for the purposes of processing and analysis. Following this, control is output and executed in accordance with the predetermined target value. The information collection can be accurately described by the outcomes of linear equations when the acquisition time is set to A. This describes the information collecting.

$$B=\frac{(B_2-B_1)}{(A_2-A_1)X}+\frac{(B_1A_2-B_2A_1)}{(A_2-A_1)} \quad ......(1)$$

The values of the start time of information gathering are denoted by the letters B1 and B2 in the formula, whereas the letters A1 and A2 represent the start time of the information collection process. In order to represent the current status of information acquisition, the software design of a mobile network information intelligent acquisition system that is based on embedded MCU is realized. This realization is accomplished by using the data that is computed by linear equation. The model's prediction output, denoted by ym(k), is composed of two distinct components. The free reaction to Yi (k), also known as the input response, is only one component of the whole. The control of the previous instant is the only thing that matters in this situation; the control of the present moment and the control of the future moment are completely irrelevant. After the control function has been played, the other response is the forced response, which is denoted by the expression yf(k). This response, which is equivalent to the zero state response, is the model response that is added. From the perspective of predictive functional control, the newly added control function can be written as a linear combination of numerous known functions, denoted by the letter fn. The algorithm for predictive functional control is optimized in the following manner based on this information:

$$u(k+i)=Bt_s\sum_{n=1}^{N_f}\overline{\mu}_n\overline{f}_n(i), i=0,1\ldots N-1 \quad ....(2)$$

In this equation, n represents a basis function, fn(i) represents the value of the basis function, ts represents a sampling period, Nf represents the optimal prediction length in the time domain, and Un represents a linear combination coefficient. The selection of the basis function is contingent upon the characteristics of the control plant as well as the values that have been established, including the predicted step size, slope, and exponential function if applicable. As a result, the forced response output can be computed offline for the basis function that has been chosen.

$$y_f(k+i)=u(k+i)\sum_{n=1}^{N_f}\overline{\mu}_n\overline{g}_n(i), i=0,1\ldots N-1 \quad ....(3)$$

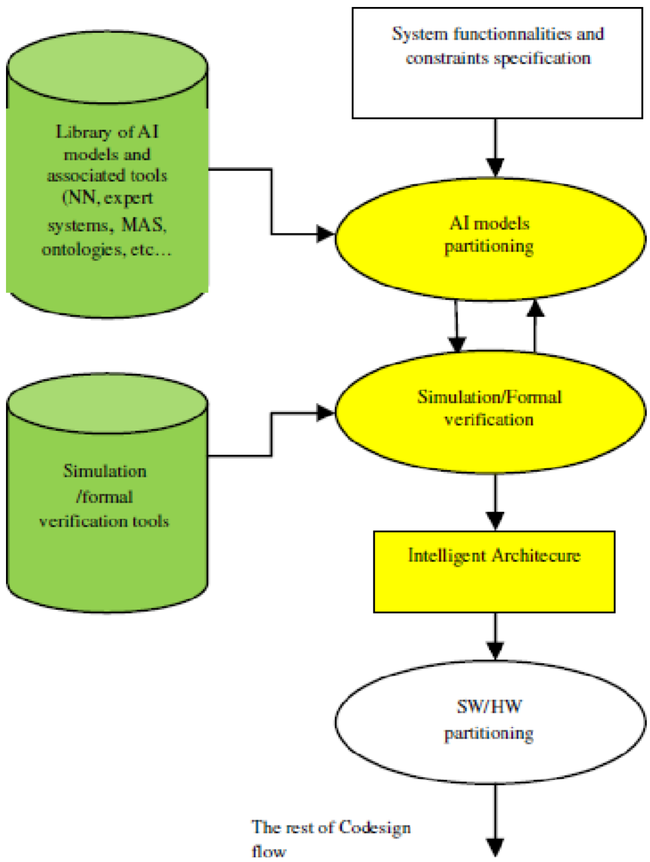
The model output of fn(i) is denoted by the variable gn(i). Because of this, the output function of the model that predicts the future is standardized.

$$y^m(k)=y_i(k)+y_f(k)/y_f(k+i) \quad ......(4)$$

It is important to note that embedded application software is not the same as regular application software. The specific hardware platform is chosen in accordance with the unique application scenarios, and the specific hardware resources are assigned in accordance with the anticipated quantity of demand from the user. When it comes to the development of embedded application software, we typically make use of a dependable embedded operating system. This system not only guarantees the real-time performance of all types of work, but it also guarantees the stability of running time, which helps to reduce the amount of resources that are consumed by a variety of systems.

- **Optimization of the operation process of embedded systems based on an algorithm based on artificial intelligence**

The implementation of embedded technology is inextricably linked to the development of intelligent sensor technology from begin to finish. The sensor is able to perform functions such as calculation, communication, and intelligent judgment as a result of the integration of classical sensors and embedded technology. Not only is the embedded program capable of connecting to the Internet, but it also possesses the capability to carry out communication actions. There will be intelligent sensors of the Internet of Things due to the presence of intelligent algorithms, and there will also be intelligent algorithms made available through embedded systems. Consequently, embedded technology is an essential component of the Internet of Things (IoT). Software and hardware collaborative synthesis is a process that involves optimizing the target by inputting function application and constraint conditions described by a particular model, determining the system calculation, communication resources and task allocation, map drawing, processing, voltage adjustment, and so on, and ultimately obtaining the optimized system software and hardware structure. It is essential to conduct research on the algorithm in order to understand the various designs, which include single processor, dual processor, multi-core, and multi-core systems. At the moment, the use of embedded systems is advancing at a rapid pace, and the development of embedded systems is also becoming an increasingly urgent matter. At this time, the majority of embedded products are unable to fulfill the requirements of actual use. Generally speaking, the embedded artificial intelligence system is based on the embedded platform, which includes graphic collection equipment, artificial intelligence processing equipment, artificial intelligence display equipment and artificial intelligence processing equipment. It is necessary to improve the information collecting process of embedded systems in accordance with the principle of artificial intelligence in order to guarantee that the system will function effectively.



This paper refers to it as hardware / software co synthesis or system integration. The meaning of both terms is identical. This is due to the fact that the system level synthesis of embedded systems requires the co design of both software and hardware. In the beginning, the function, performance, and limitations of the embedded system are presented. Following this, the system is described using plain language, formal language, and a task diagram. In order to ascertain the computational and communication resources that are available to the system, the architecture selection or allocation process is utilized. These resources can be chosen from the fixed platforms that are already in existence, or the system architecture can be made up of a variety of components, including a processor, memory, communication unit, and a specialized hardware accelerator.

In order to make the autonomous design of embedded systems a reality, it is necessary to devise an effective optimization algorithm that takes into account the particular processes of system synthesis as well as the constraints of design parameters. When it comes to tackling space, sub-problems like assignment and mapping are considered to be more difficult than NP. Tasks that are independent constants will interfere with one another during their life cycle and interval if they are independent. The calculation of the task priority algorithm is performed. It is required to create an effective optimization algorithm in order to implement the automatic design of embedded systems. Additionally, it is necessary to take into consideration the specific synthesis phases and the limitations of design parameters within the design process. In a general sense, the sub-problems that include assignment, mapping, and processing are examples of combinatorial optimization problems that have a huge space for solving and various problems. Numerous optimization algorithms have been investigated and put into use. The priority of the job is r when the cycle value is a, and the number of tasks that need to be processed is n when the total number of tasks is n. This is the basis for the task being processed, which is accomplished through the combination of processing management technology and artificial intelligence. If jobs are independent constants, then they will not interfere with each other within the time periods and lifecycles that are specific to each of them. It is possible to solve the task priority algorithm using this information.

$$A \leqslant y^{m}(k)+a(\sqrt[n]{2r}-1) \quad \ldots\ldots(5)$$

The idle time di(t) of the task margin is further standardized because it is based on the algorithm described before. Assuming that Ei (t) is the amount of time that the task takes to be executed on the central processing unit (CPU) of the real-time operating system and that I is the deadline for the task within the system, we are able to obtain the time point sorting algorithm of tasks on each path in the following manner:

$$L_i(t) = A\sum\sum\lim_{x\to\infty}\frac{d_i(t)-E_i(t)-i}{A\sqrt[n]{2r}-1} \quad \ldots\ldots.(6)$$

Standardization of the operation parameters of embedded systems is done in accordance with the theory of artificial intelligence. This is done in order to determine whether or not the tasks that have been allocated to the system can be handled centrally. According to the artificial intelligence dynamic task priority change algorithm, in order to guarantee that the scheduling limit of tasks is proportionate to the resource consumption rate, and in order to realize the monotonous processing of the system operation ratio, it is necessary to ensure that the scheduling limit of tasks is appropriate. According to the analysis presented above, it has been discovered that the advantage of the algorithm for artificial intelligence is in the high utilization rate of system operation. This is done in order to actualize the monotonous processing of task processing ratio. The effect of the step system running.

ANALYSIS OF EXPERIMENTAL RESULTS

The following configurations are used for the test environment: Initially, the real-time operating system terminal PC should have a virtual machine ar ware and kuntu2.0 operating platform installed. After that, thirty processing tasks should be randomly assigned, and the processing delay performance should be adjusted. The processing algorithm is responsible for calculating the delay allocation function, which is the result of applying the embedded principle. After that, install a processor with a core 2/6 CPU operating at 1.6GHz and 21 gigabytes of system memory. Windows 8 will be selected as the development platform, and Windows Server 2007 will be available. The structure of the sensor hardware is straightforward, as it makes use of a single-chip microcontroller with six bits and 256 bits of programmable memory. The speed at which information is transmitted over a mobile network can be increased by utilizing a digital signal converter with 12 bits and 10 KB of random access memory. Through the utilization of the mcs1210 as the primary chip of the embedded MCU, it is possible to establish a multi node sensing network with only a limited number of external receiving components. Regression test results are displayed in the figure for the purpose of ensuring that the embedded system is accurate in comparison to both the traditional system and the system when it comes to accuracy.

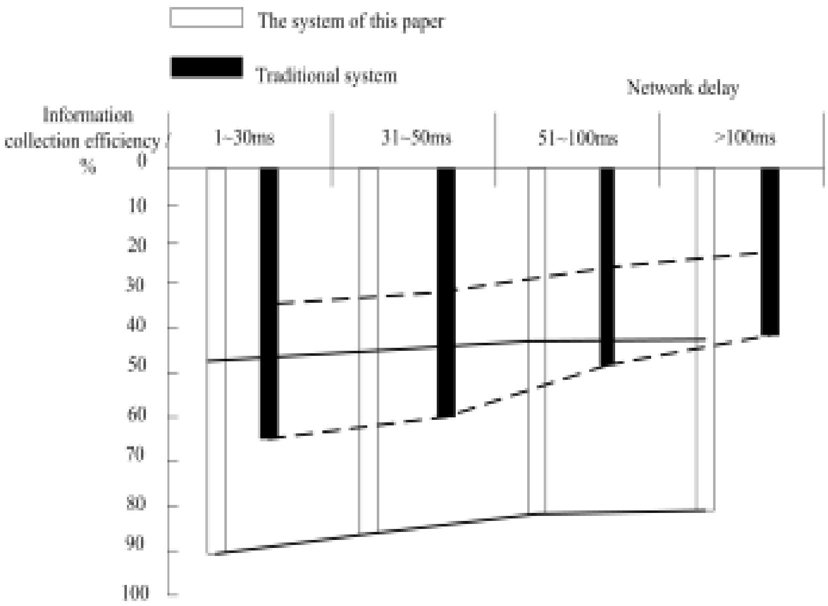


Fig. 4 comparison test results

The figure demonstrates that the system is capable of simulating the environment in which embedded application software is executing and achieving dynamic identification of both software and hardware through the utilization of fault injection technology. In comparison to the conventional test behavior and function, it possesses superior performance and a greater number of advantages. With this architecture, it is possible to imitate the environment in which an embedded system is operating and to facilitate the operation of embedded application software. With this design, the software test performance is higher, and the running effect of the system is better guaranteed. This is in comparison to the traditional test behavior and function.

CONCLUSION

An unlimited number of commercial embedded operating systems are being developed as a result of the development of computer software technology and the ongoing enhancement of the performance of embedded processors. Microprocessors are responsible for a significant share of these embedded operating systems. Embedded operating systems have seen widespread adoption in recent years. Over the course of the past few years, the expansion of the Internet has resulted in the creation of a vast application space for embedded systems. More and more stringent constraints are being imposed on embedded systems as a result of the fast growth of these systems. Smart embedded system technology is the technology in question. The development of embedded systems is headed in the direction of improving people's work efficiency and quality of life, which is the way that embedded systems will be heading in the future.

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