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Microcontrollers for Artificial Intelligence and Machine Learning

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Abstract - *As the technology, innovation and manufacturing is progressing, electronic devices are becoming smaller and smaller day by day. Computers have shrunk both in size and cost tremendously over the past decade, to the point where they are now affordable for personal use. Today devices are even manufactured at micro and nano scale. The main reason for this change is to reduce power consumption, cost of the device, and most importantly to maintain and/or to improve the efficiency of the devices. Microcontrollers are one such devices which are compact which has almost all the features of a normal sized computer, designed to do a specific task. These microcontrollers are generally designed to automate devices and to remotely control the devices. Microcontrollers are typically programmed using different programming software platforms. These devices can automate things but do not have the ability to think intellectually or make any spontaneous decisions. Both Machine Learning (ML) as well as Artificial Intelligence (AI) have the ability to understand human communication. To perform these arduous tasks, we require powerful super computers for complex calculations, but now-a-days, microcontrollers are also designed which are compatible with AI or ML, which can be achieved with the help of TinyML and AI at the Edge. The central object to design these devices is because of its flexibility, efficiency, privacy, low power consumption, compactness, and low cost. These microcontrollers architecture is evolving rapidly which are capable for performing vigorous tasks.*

Key Words: **Artificial Intelligence, Machine Learning, Microcontrollers, TinyML, AI at the Edge.**

1. INTRODUCTION

Artificial intelligence is a set of hardware and software technologies that can provide computing units with capabilities that appear to a human observer to be similar to human intellectual abilities. The basic definition of artificial intelligence is defined as the ability of robot to accomplish the tasks that are usually done by human beings. AI uses a collection of naturally influenced computer methods to solve complicated real-time issues when mathematical or conventional modelling has been inefficacious. AI is evolved from a pattern-detection algorithm. On a traditional multi-core computer, the Artificial Neural Network (ANN) is commonly operated in simulation. Ultimately, the goal is to implement the ANN in hardware using a network of artificial neurons that communicate with one another by timed electrical pulses, as the brain does. Artificial Neural Networks (ANNs) is highly talented in decoding numerous problems that arise in daily lives of people in an effective way. A common concept is that raw sensor data is delivered to a powerful central remote intelligence, necessitating a large amount of data bandwidth and processing power. The three principal tasks that are involved in the creation of a neural network are designing a network model, training the network, and inferring the results from the network model. However, MCU's can run the Deep Neural Networks (DNNs) themselves, provided they are optimized for MCU's. The code written on the MCU can be optimized to adapt to its memory, processing and power capabilities and the generated code is significantly smaller than the original code with minimal loss of accuracy. This paper mainly focuses on explaining about the Microcontrollers for Artificial Intelligence and Machine Learning

1.1 AI Processors

AI processors are particularly designed for simplifying complex computing tasks and with the help of AI these tasks can be done in an effective way. Machine learning can as well be achieved through artificial intelligence. A system containing many processors, each with specific capabilities, is referred to as an AI chip. Normal CPUs are designed to accommodate mobile applications and are placed in a smaller chip size, giving full system characteristics required to run mobile device applications.

A Neural Processing Unit (NPU) is built into AI circuits, allowing for substantially quicker AI performance and longer battery life. For AI applications, AI processors deliver great performance and power efficiency. Image identification and processing become much faster, allowing your smartphone to handle numerous tasks at once. They can also handle specialized programming jobs far more quickly and effectively than standard CPUs.

Large-scale computing activities can be handled significantly faster by AI processors than by ordinary processors. AI chips are processors with heterogeneous computing capabilities that are designed for AI-focused computer activities. AI chips are simply designed to perform complicated computer jobs faster and more effectively than traditional processors.

2. Microcontrollers for Machine Learning and AI

AI and ML have always been linked with powerful computers with fast CPUs and GPUs, large amounts of RAM, and cloud-based algorithms.

To execute Machine Learning we can efficiently use a microcontroller that is powered by a single coin cell battery. You might think it's impossible, but with today's technology, anything is feasible with Microcontrollers.

2.1 Advantages of Microcontrollers for ML and AI

Despite little memory spaces, they have numerous advantages that outweigh this con. They are:

Low energy consumption:

- Microcontrollers use relatively little energy and are efficient due to their compact size, which comes at the sacrifice of processing power, memory, and storage.
- To power GPUs and computers for machine learning, a lot of power is usually required, which results in restrictions and constraints.
- Contrastingly, microcontrollers are considered a different matter. Microcontrollers are typically not connected to the mains and rely on batteries or energy harvesting to operate. A microcontroller, for example, can run for weeks or even months on a single coin battery.
- Because microcontrollers do not need to be hooked into the mains, they are simple to install and use.

Cost

- Normally, to develop a high-performance machine learning workstation, you must pay a few thousands of dollars.
- Microcontrollers, on the other hand, may be had for as little as $200 and are extremely reliable.

Flexibility

- Microcontrollers are widely used. They are practically everywhere around us, such as in our household appliances, toys, automobiles, and so on. When we apply machine learning to microcontrollers, the possibilities are unlimited.
- You may use microcontrollers to bring AI to a variety of devices without having to rely on network access, which is typically limited by bandwidth, power, and latency.

Privacy

- Normally, you'll have to upload all your raw data to the cloud for machine learning, which may contain confidential or private information.

2.2 Recommended Microcontrollers for ML and AI

Coral Dev Board:

On a disposable system-on-module, the Coral Dev Board contains an eMMC, SOC, wireless radios, and Google's Edge TPU (SOM). It's great for IoT devices and other embedded systems that need fast machine learning inference on the go.

NVIDIA Jetson Nano Developer kit:

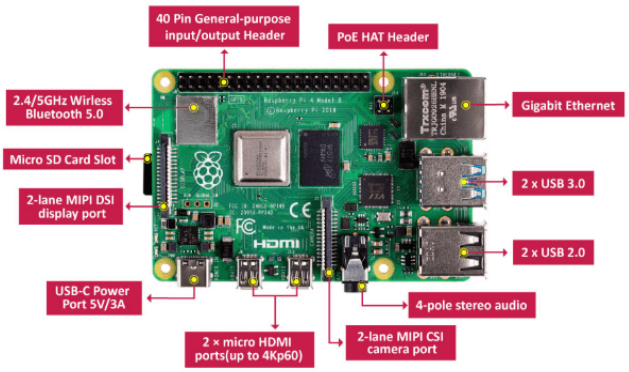
Developer Kit provides exceptional processing capabilities for modern AI tasks in terms of size, power, and cost. AI frameworks and models are now available to developers, creators and learners. These frameworks and models are for image classification, object identification, segmentation, and speech processing are now available to developers, learners, and creators.

Sipeed MAIX GO Suit:

MAIX is a Sipeed module that is designed to operate AI at the edge. It has a small physical and power footprint, allowing for the deployment of high-accuracy AI at the edge, and its low cost makes it simple to integrate into any IoT device.

Raspberry Pi 4 Computer Model B:

A recent inclusion to the popular Raspberry Pi computer line is the Raspberry Pi 4 Model B. It boasts revolutionary improvements in processing speed, multimedia capability, memory, and connection while maintaining backwards compatibility and similar power consumption to the previous generation Raspberry Pi 3 Model B+.



3. Optimizing Microcontrollers using TinyML and Edge AI

TinyML:

TinyML optimizes machine learning (ML) workloads required for processing on microcontrollers as small as a grain of rice and utilizing only a few mill watts of electricity.

TinyML provides intelligence to little devices. We mean minuscule in every sense of the word: as small as a grain of rice and requiring very little energy. TinyML transforms the Internet of Things (IoT). TinyML has the support of Google, Arm, Qualcomm, and many more.

TinyML takes edge AI a step further by allowing deep learning models to be run on microcontrollers (MCU), which have far fewer resources than the small computers we carry in our pockets.

To diminish deep neural networks into a size that fits on small-memory computing devices, several efforts are made.

To lower the number of parameters in the deep learning model, the majority of the efforts have been made.

TinyML on microcontrollers provides new methods for evaluating and comprehending the huge amounts of data created by the Internet of Things. Deep learning algorithms, in instance, can be used to process data from sensors that detect sounds, take photos, and track motion.

Although TinyML is a relatively new paradigm, it is already producing surprising results for interfacing with relatively modest microcontrollers and training with minimal accuracy loss.

Edge AI:

Edge AI is a model for creating AI workflows that span centralized data centers (the cloud) and devices closer to humans and physical objects outside the edge.

Edge AI is used for inferencing, while new algorithms are trained with the help of cloud AI. Inferencing algorithms use a fraction of the computing power and energy that training methods do. Well-designed inferencing algorithms are at times implemented in edge devices using current CPUs or even less powerful microcontrollers. In other circumstances, highly efficient AI processors boost inferencing performance while lowering power consumption or doing both.

Benefits of Edge AI:

- Increased data security
- Improved autonomous systems
- Reduced higher speeds and cost
- Reduced bandwidth requirement and power

4. CONCLUSIONS

Our paper mainly focuses on microcontrollers that can be used for AI and ML or which are compatible and which can be optimized using AI and ML. Because of their inexpensive cost, they're great for adding interactive features to traditional products like toys and household appliances. Microcontrollers have allowed gadgets to have color screens and multimedia features in recent years. Microcontrollers with low power consumption can be utilized in wearable's, cameras, and other devices that run for a long period on a little battery. TinyML and Edge AI takes these microcontrollers to the next level as it brings intelligence to these devices rather than transmitting data to a sever over the cloud, saving a lot of memory and power. These microcontrollers might be the next biggest thing on the market because of their compatibility, compactness and flexibility.

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