Identification of Fruits and Vegetables using Embedded Sensor

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Abstract. In precision agriculture, computational techniques play a critical role. It is a vital job to detect and classify fruits and vegetables from crops and gardens. In fruit detection and yield estimation, an intelligent detection system is used as a key technology where embedded sensor techniques are being implemented. Many researchers developed a different classification system for classifying the fruits or vegetables using image processing techniques and machine learning algorithm. Big computers with fast CPUs and GPUs, massive RAM sizes or cloud algorithms have often been associated with them even simple applications. In this article Tensorflow and Arduino BLE sense are used to identify the fruits and vegetable with less resource.

Keywords: Embedded sensor; Tensorflow; Arduino Nano 33 BLE

1. INTRODUCTION

The manual identification of fruits from plant is a boring, annoying, and requires more effort. Detection of fruits based on machine-based systems can be making the assignment simple and less time consuming. Machine learning methods are widely used in many conventional applications of artificial intelligence [1]. The breakthrough in cognitive performance has enabled the system to evolve sophisticated ML algorithms in a relatively short time, providing real-time human-machine interaction [2, 3]. Accuracy of the detection rate involves specialized optimization of ML between all those applications and reduces the importance of high dimensional data. This leads to a strong demand for the computing platform. Most applications, mainly graphics processing units (GPUs), are currently being implemented on general-purpose computing engines. Nevertheless, studies recently performed through both industry and academy demonstrates an integrated circuit design pattern for machine learning algorithm. This article offers a summary of the architecture of the hardware accelerator, the different forms of machine learning and deep learning acceleration, and the techniques used to increase the performance of algorithm computing hardware computation.

There is no doubt that many of the technical and personal facets of our lives have been influenced by the modern deep learning techniques. Deep learning gives better precision and flexibility than other machine learning, which allows machines to act more smartly. So there is typically no availability of cheaper or lower power consumption solutions on the market when it comes to the implementation of these deep learning techniques. Nowadays, there is a new trend to customize anything from automobiles to choosing and putting devices. Electrical robots are becoming more and more "intelligent" with the
addition of predictive maintenance and process monitoring features. The following are reasons machine
learning runs on embedded device,

- Safety and confidentiality: When designing private algorithms and applications, data can be
  stored locally, preventing apprehension.
- No access or internet problems: There is no sending and receiving data as models are run on
  the system, reducing latency and network utilization that can be a key problem in neighboring
countries.
- Lower delay and power usage: The new embedded device significantly reduces the power
  consumption and eliminates the delay due to anything that happens on the device.

Deep learning is the technique often used addresses many key challenges in the IT sector [4, 5].
The colorimeter and proximity sensor can be operated or interconnected through Arduino Nano BLE in
this situation. In this research work real world scenario will utilize Deep Learning concepts. This article
concentrates on the sensor fused with embedded device for identifying the fruits and vegetables. In this
article Tensorflow plus Nano repository and Arduino Nano BLE Sense's spectrophotometer and motion
detector are used to identify the fruits and vegetable with less resource.

1.1. Organization of the paper

This research work is reported in some studies. Section 2 presents the hardware specification of the
system. Section 3 describes the software specification of the system. Section 4 reports the conceptual
structure and implementation. Finally Inferences and possible works are discussed in Section 5.

2. HARDWARE SPECIFICATION OF THE SYSTEM

The Nano BLE Sense is the least expensive product line for the Arduino 3.3V AI powered board. The
Arduino Nano BLE Sense, a brand new board through a well sleek design. An episode of embedded
sensors emerges with it:

- Inertial sensor with 9 axes: it allows this device suitable for handheld sensors
- Temperature and humidity sensor: to obtain extremely exact calculations of climate factors
- Barometric sensor: a basic temperature sensor could be made for you
- Microphone: for real time sound recording and review
- Motion, movement, light source and sensor of light intensity: measure the brightness of the room,
  and moreover moves close to the board

The nRF52840 microcontroller is based on the Nano BLE Meaning is shown in Table 1.

| Parameters      | Specification       |
|-----------------|---------------------|
| Controller      | nRF52840            |
| Working power   | 3.3V                |
| Power (input)   | 21V                 |
| Current (DC)    | 15 mA               |
| Clock           | 64MHz               |
| Code memory     | 1MB (nRF52840)      |
| I/O pins        | 14                  |
The Nano BLE Sense is just advancement of the standard device, but with a much faster computer, the Nordic Semiconductors’ nRF52840, a 64 MHz 32-bit ARM® Cortex®M4 CPU and pin out details are shown in Fig.1. This will enable us to make larger programs (it has 1 MB of memory address, 32 times more powerful), and with a lot more parameters than with the Arduino Uno.

Figure 1. Pin out details of Arduino Nano BLE

3. SOFTWARE SPECIFICATION OF THE SYSTEM

3.1 Tensorflow lite

TensorFlow Lite is a fully accessible, business model, cross-platform computational intelligence platform that transforms a particular format that can be optimized for acceleration or capacity to a pre-trained framework in Tensorflow as shown in fig.2. On sensor nodes such as smart phones that use smart sensors focused on IPhone or android or Linux along with Raspberry Pi or Microcontrollers, the special format model can be deployed to allow the inference at the Edge.

Figure 2. Black diagram of Tensorflow Lite

3.2 Arduino IDE

To develop software code and upload this code to the Arduino hardware, the Arduino IDE (Integrated Development Environment) is used [6]. The Arduino IDE is quite plain, and this elegance is undoubtedly one of Arduino’s key reasons for being so famous. We may definitely claim that it is now one of the key criteria for a new microcontroller board to be compatible with the Arduino IDE.
3.3 Colab

In AI analysis, Google is pretty efficient. Google launched an AI system called Tensorflow over several years, and a runtime environment called Colaboratory. Tensorflow is open-sourced today and since 2017, Google announced Platform that includes open for public use. The lab is now known as Google Colab, or just Colab. The use of the GPU is another interesting feature provided to programmers by Google. GPU support is provided by Colab and it is totally free. The motivation for pursuing it publicly accessible may be to allow its tools a baseline in machine learning and data science teaching academics. It may also have a deep vision of developing a client base for Google Cloud APIs that are offered on a per-use plan.

4. CONCEPTUAL STRUCTURE AND ITS IMPLEMENTATION

The conceptual system structure consists of various modules. These modules are explained as follows:

4.1 Convolutional Neural Network

The most popular structural design of machine learning/deep learning is CNN. There is a rise in involvement in deep learning because of its tremendous success and efficacy in congregations. There has been considerable change in just three years. The block diagram of Tensorflow lite is as shown in figure.3.

![Block diagram of Tensorflow Lite](image)

**Figure 3. Block diagram of Tensorflow Lite**

4.1.1 Convolutional layer

This layer has been used to collect the attributes from the image. It preserves the correlation among pixel values when collection via training feature vectors with tiny squares of raw data.

4.1.2 Pooling layer

When the images are too large, pooling layers relate to the number of parameters. Limits the availability each map's size, but still preserves the essential details. Pooling can be of different kinds:

- Max Pooling
- Average Pooling
- Sum Pooling
4.1.3 Flattening

The easiest step where every other column with in function map is organized into a separate cell is flattening. The importance of this column is provided as an input to the hidden layers.

4.1.4 Activation function

The Activation function is applied to the end of every neural network production. It is also known as the role of transition. This is used to evaluate the neural network performance. Based on the function, it tends to assign the value to anything from 0 to 1 or -1 to 1. Linear and Non-Linear activation are two types of activation function. In this model, the ReLU function is used.

4.2 Implementation

The goal of Arduino is to enable machine learning simple so that everyone could use. The availability of the Arduino Library Manager Tensorflow Lite Micro is released after the couple of week. Inbuilt libraries like speech recognition, basic machine vision, and gesture recognition are available with this software. In this paper, Tensorflow plus Nano repository and Arduino Nano BLE Sense's spectrophotometer and motion detector are used to identify the fruits and vegetable. This system will run a small neural network on the board itself to do this.

Finally, using Arduino Build, the model trained, compile and upload it to Arduino board. The Arduino Build IDE will be opened by system or laptop: Click the Access and Load model.h key in the menu bar that you have copied from Colab. This will take a minute to start the identification process in the serial monitor when it is done. Place the RGB sensor of Arduino Nano near the fruits or vegetable, the performance of the classifier will see in the monitor. The hardware implementation of fruits and vegetable identification system is shown in the fig.4.

![Figure 4. Fruits identification prototype setup](image-url)
In order to get the emoji’s in serial terminal, enable the unicode in the Arduino code. Now the classifier output is displayed with emoji’s as shown in fig.5.

5. CONCLUSION AND FUTURE WORK

The fruit identification system is proposed by embedding the neural network model with Arduino Nano BLE33 board. The model has trained using apple, banana and orange images. The model provides 93.11% of accuracy. The complete and independent system may solve the real world problems including industrial projects. For the future work, sensor fusion approach will analyse the image attributes for the effective identification fruit and vegetables and also expand the dataset by adding the more fruits and vegetables with different classes.

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