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Application of Artificial Intelligence in Internet of Things

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***Abstract*—Artificial intelligence is the best solution to manage huge data flows and storage in the IoT network. IoT nowadays becoming more and more popular with the inventions of highspeed internet networks and many advanced sensors that can be integrated into a microcontroller. The data flows internets now will have sensors data and user data that send and receive from the workstations. With the increase in the number of workstation and more and more sensors, some data may be facing problems on the storage, delay, channels limitation and congestion in the networks. To avoid all these problems, there were many algorithms were proposed in the past of 10 years. Among all the algorithms, Artificial Intelligence still being the best solution to the data mining, manage and control of congestion in the network. The aim of this paper is to present the application of artificial intelligence system in the IoT. The importance of data mining and management will be highlighted in the paper. Also, the method used in the Artificial Intelligence like fuzzy logics and neural network also will be discussed in this paper in conjunction with IoT network. The self-optimizing network and software defined network are parts of the important parameters in the Artificial Intelligence IoT System**

Keywords-Neural network; self-optimizing network; software defined network; IoT; Artificial Intelligence

I. INTRODUCTION

IoT (Internet of Things) is a current technology to send a received the sensor data via internet networks. It is same like normal data communication except that in IoT, sensors and microcontrollers are usually used. The sending and receiving of data do not rely on the computer but relies on the microcontroller and portable communication devices such as cell phone, communication pad or even the smartwatch. With IoT, most of the sensors data can be directly routed into the server. This usually is done when the microcontroller is attached to WiFi and there is a connection between microcontroller and WiFi.

Unlike in traditional internet system, to send or receive data, the user must know the TCP/IP address and hence do the necessary setting in the network before transmission. Similarly, for WiFi connection, like in a portable computer, the user has to do connection with WiFi and ensure the service provider provide the channels, then the communication will be available.

In IoT, the WiFi setting usually is done through a programming. For example, Arduino program call for ESP command to have communication links will enable the ESP WiFi to make a necessary connection to the network. This can bypass a lot of steps in the internet setting. Configure the connection or setting through a program is much easier and convenient.

In some cases, the sensors belong to analogue. In order to send the analogue signals represents information signals, analogue to digital converter system must have. Luckily, in most of the modern microcontrollers like Arduino, there is a build in analogue to digital converter function. The only thing user should set in analogue to digital converter is the baud rate and resolution.

A very simple IoT system should comprise of selfoptimizing network and software defined networks. The selfoptimizing network helps to optimize the network for huge data transmission and reception. Normally in this optimizing network, time and the free channel will be computed and assigned to the user who wants to send and receive the data. The Self-optimizing network can be done automatically by a router and system update the router's table. The system will compute and determine the shortest path for the data to flows. In software defined networks, a specific software will be used to program the data to send and received. Arduino programming language and Python are two examples of software defined networks. Both of the compilers can instruct the data send, store and received from the receivers.

In order for the Artificial Intelligence system applied into the IoT networks, certain terms and principles must understand. For Artificial intelligence, there are two commonly used techniques - neural network and fuzzy logic [1].

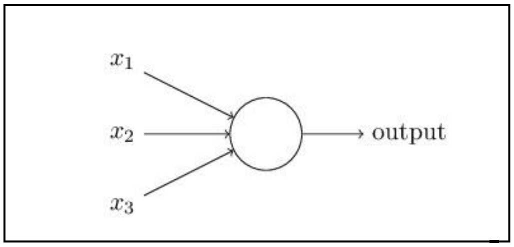

Figure 1. The principle of Artificial intelligence

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Figure 1 shows a neural network system, which comprises of input x_1 to x_3. All these inputs basically content weights by themselves, but they are not shown in the diagram. The middle circle component is the transfer function. It is a mathematical solution for the inputs. The solution will process the inputs then produce only one output. The decision making may be as below [2]:

$$\sum x_n > 1000 = 1 \qquad (1)$$

or

$$\sum x_n < 1000 = 0 \qquad (1)$$

The output either release 1 or 0 based on the transfer function and the decision making.

In more advanced Artificial Intelligence system, weight functions may be introduced to control the inputs. These weight functions produced weigh values that are parts of the parameters to control the input. The new output is reproduced from the input plus the control parameters in the transfer function. In some cases, the control parameters are adjusted so that the input signals can be trained. When input signals are trained, then the next inputs will be compared to the trained values. Finally the "yes" or "no" answer will appear at the output.

Take an example of Arduino voice recognition module. The module comprises a microphone and the processor. When the user wants to recognize the speech, he or she will record his or her voice into the module. The module uses an Artificial Intelligent technique to make user keep on recording the voice until the subsequence voice, one or two or three are matched with the first voice recorded. If this happens, we said that the voice is successfully trained. Once the voice is successfully trained, the user can use his or her voice to activate any devices.

In other words, all the signals coming from input must be trained before they can be used as references in the library. Another commonly used technique in the Artificial Intelligence is Fuzzy logic. Fuzzy logic uses a set of rule to determine a single output. Fuzzy different from traditional logic where digital 1 or 0 is produced. Fuzzy can analyze more detail on a certain condition and make the final decision on the output. Take an example below [3]:

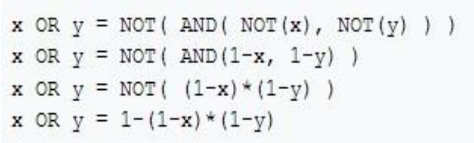
If the heat is hot = turn ON fan speed 40 rpm
If the heat is moderate hot = turn ON fan speed 100 rpm
If the heat is very hot = turn ON fan speed 120 rpm
If the heat is extremely hot = turn ON fan speed 200 rpm

As can see from the example above, the condition to adjust the speed of the fan depends on subsequence increment of heat continuous. The decision will not make just a hot and extremely hot.

Unlike traditional logic, there would be two speeds, which are 40 rpm and 200 rpm.

The best thing the fuzzy logic is, the programmer and the designer can fine tune the condition and make the decision making more precise.

We also can use traditional logic to represent a fuzzy logic. Here are the traditional logic applied to the fuzzy logic set [4]:



```
x OR y = NOT( AND( NOT(x), NOT(y) ) )
x OR y = NOT( AND(1-x, 1-y) )
x OR y = NOT( (1-x)*(1-y) )
x OR y = 1-(1-x)*(1-y)
```

In terms of programming, the fuzzy always implemented using "if-else" block. Some programs use "switch case" or even the "while" function to program the fuzzy logic. However, using "if-else" function is the most accurate and most practical.

II. REVIEW ON THE INTERNET OF THINGS USES ARTIFICIAL INTELLIGENCE

The research of Artificial Intelligence applied to the IoT is no more novel. In the past, there were many proposed ideas about Artificial Intelligence applied to the IoT. One of the ideas proposed is making all devices communicate to each other. This means that from the transport, a user can control home appliances. From the smart phone, the user not only making a call but also can control the home appliances.

Figure 2. IoT with Artificial Intelligence.

The commonly used IoT is the home appliances control (see Figure 2). As seen in Figure 2, an android phone or i-phone with suitable Apps is used to control the appliances ON and OFF via internet connection. Apart from that, some of the devices installed with sensors. The sensors then read the signals from natures and convert the signals into electrical varying voltages so that the signals can be processed and send to the receiver (Android phone). The signals are then displayed using an Apps. The information of signals also can be viewed from the internet page.

It is not surprising nowadays many people use voice recognition in IoT to control the appliances. By using voice to control appliances, a recorder with training system must be prepared so that the voice can be recognized [5].

A well known IoT device that uses WiFi to control the home appliances is Alexa. Figure 3 illustrates an example of Alexa.

Figure 3. Alexa voice control of electrical apparatus.

Another use of Artificial Intelligence in IoT is the data mining. Data mining is a technique used to manage the data and reduced the storage space. This means that when the data is getting more and more in the network, there will be a tendency to spend more time to dig out the desired data. In order to reduce such a time to look for the wanted data, data mining technique is employed. The steps involved in data mining are [6]:

1. Data integration
2. Data selection
3. Data cleaning
4. Data transformation
5. Data mining
6. Pattern evaluation

The data selection is a process to select a wanted data in a huge storage device. The selection of data may be a small portion or it may involve big portion. Once the data is selected, the system will perform.

In data cleaning process, those repeated data or there is a junk data in the system will be removed. If the repeated data is removed, then there will be a lot more storage space. In data transformation, some data is transformed into a package and send out to the network. Data must be transformed into another format due to two reasons: make the standard data to be able to read by differences workstations. Maximize storage space and cause the system run even faster [7].

III. DESIGN AND IMPLEMENTATION OF IOT WITH ARTIFICIAL INTELLIGENCE

A. Hardware and Circuit Design

A very simple hardware implementation of IoT using Artificial Intelligence is shown below:

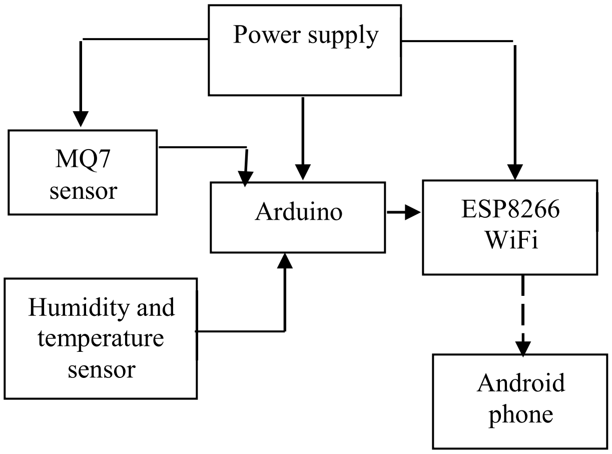


Figure 4. The proposed IoT hardware implementation using Artificial Intelligence Technology

The proposed idea comprises of two sensors: MQ7 gas sensor and humidity sensor. Both sensors output are connected to Arduino microcontroller. The Arduino is then connected to ESP8266 WiFi chip. The connection between the Arduino and Android phone is via an air interface. The dotted line of the arrow as shown in Figure 4 represents an air interface.

B. Programming Design for Artificial Intelligence used in IoT

By referring to block diagram as shown in Figure 4, the complete program written in Arduino C language is shown below:

```
#define BLYNK_PRINT Serial
#include "DHT.h"
#include <ESP8266_Lib.h>
#include <BlynkSimpleShieldEsp8266.h>
```

```
#include <SoftwareSerial.h>
SoftwareSerial EspSerial(2, 3); // RX, TX
#define DHTPIN 7
// Uncomment whatever type you're using!
#define DHTTYPE DHT11   // DHT 11
//#define DHTTYPE DHT22
#define DHTTYPE DHT21
// Startup the Artificial Intelligence
DHT dht(DHTPIN, DHTTYPE);

char auth[] = "24688ea5e1c44d5f874fdc5748e4aefe";

char ssid[] = "OPPO N5206";
char pass[] = "12345678";
#define ESP8266_BAUD 9600

ESP8266 wifi(&EspSerial);

BlynkTimer timer;

int mq7,mq135,hum,temp;

void setup() {
Serial.begin(9600);

delay(10);

// Set ESP8266 baud rate
EspSerial.begin(ESP8266_BAUD);
delay(10);

Blynk.begin(auth, wifi, ssid, pass);
timer.setInterval(15000L,SendWeb);
timer.setInterval(1000L,SendData);

  dht.begin();
}
// Artificial Intelligences
void SendData() {
float h = dht.readHumidity();
// Read temperature as Celsius (the default)
float t = dht.readTemperature();
// Read temperature as Fahrenheit (isFahrenheit = true)
  //float f = dht.readTemperature(true);

  hum = (int)h;   temp = (int)t;

   mq7=analogRead(A1);
   mq7=map(mq7,0,1023,0,255);
   Blynk.virtualWrite(V1,mq7);
   Blynk.virtualWrite(V2,temp);
   Blynk.virtualWrite(V3,hum);
}
```

```
void SendWeb()
{
  Blynk.virtualWrite(V0,mq7,temp,hum);
}

void loop() {
  // Wait a few seconds between measurements.
  Blynk.run();
  timer.run();
}
```

IV. PHYSICAL PROTOTYPE

The physical prototype build based on block diagram shown in Figure 4 is:

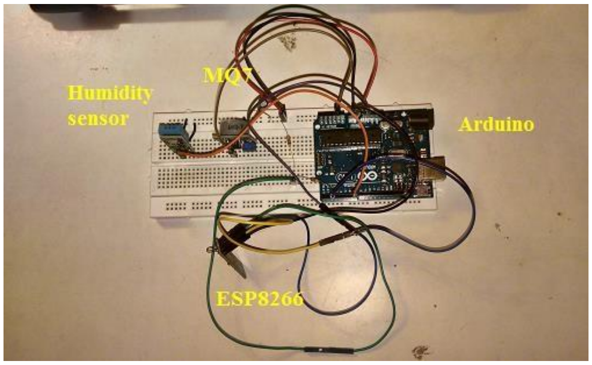


Figure 5. Simple IoT prototype with Artificial Intelligence

Notice that all the components are put on the breadboard to form a complete circuit and ready for testing. To test the system, the program in the previous section has to download into the Arduino and then follow the steps below to do the setup [8]:

1. Turn on the Arduino microcontroller
2. In the serial monitor of Arduino compiler, enter a correct WiFi username and password
3. Wait until the connection is read, then turn OFF the serial monitor

The serial monitor is a platform to check whether the Arduino has connected to WiFi or not. If the Arduino successfully connected to WiFi. The serial monitor will pop up a message and vice versa [9].

To view the data, one can access the page: https://thingspeak.com/channels/296352 or Download a

Blynk Apps and view the data. The data will be presented in the form of graphs [10].

The next section will an example of data plotted in the page of thingspeak.com. Note that, temperature and gas sensor data are plotted. The data is updated every 2 to 3 seconds.

V. RESULTS

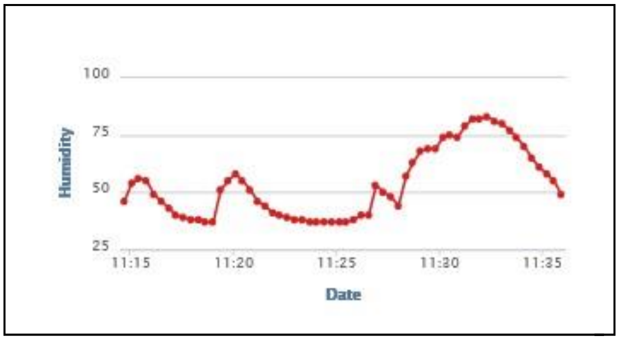


Figure 6. Humidity data plotted in Thingspeak.com.

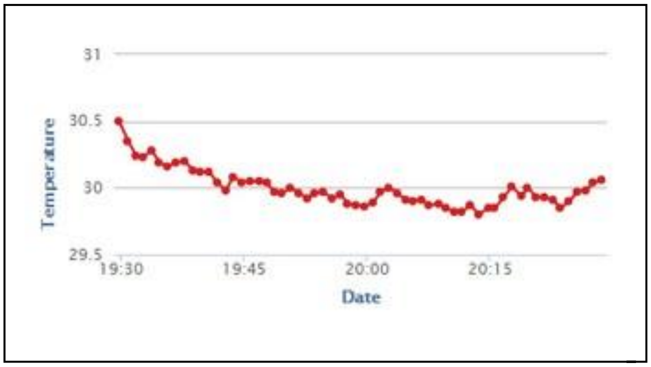


Figure 7. Temperature data plotted in Thingspeak.com.

From Figure 6 and 7, show the real time results of detecting natural temperature and humidity from the remote sensors. The sensors used were humidity sensor and LM 35 temperature. The signals of temperature were read by LM 35 whereas the humidity signals are read by the humidity sensor. The signals first process by Arduino, then the Arduino send the signals to the WiFi and upload the sensors' signals into the internet. Typical page used to display the sensors signals are thingspeak.com.

By refers to both graphs, it can see that the data of humidity sensor and temperature are plotted against the time. The data is first transmitted to ESP8266 WiFi and through the router, then terminated at the page www.thingspeak.com.

The Artificial Intelligence, in this case determine the optimum temperature and humidity. The Artificial Intelligence detects the maximum temperature and humidity, then make a report to the Arduino automatically so that Arduino can control cooling fan turn ON and reduce the temperature.

All the sensors' information is kept automatically into the server and it can be retrieved back. This is because the user has register one account on thingspeak.com. As can see that, to implement a real IoT, a simple Arduino and ESP8266 can do that. With the firmware downloaded into ESP8266 and properly program the Arduino board, the sending and receiving the sensor data through the internet is possible and effective.

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