Detection and Classification of Pesticide Residue in Human Food Based on an Artificial Neural Networks

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بِسْمِ اللَّهِ الرَّحْمَٰنِ الرَّحِيمِ

ٱلْحَمْدُ لِلَّهِ رَبِّ ٱلْعَٰلَمِينَ ﴿٢﴾ ٱلرَّحْمَٰنِ

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نَعْبُدُ وَإِيَّاكَ نَسْتَعِينُ ﴿٥﴾ ٱهْدِنَا ٱلصِّرَٰطَ

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(صَدَقَ اللَّهُ الْعَلِيّ الْعَظِيمِ)

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ABSTRACT

The industrial revolution and rapid technological development, in addition to the excessive use of natural resources available in the environment, was reflected on nature and thus on human life because it is linking to his health.

The ecosystem is unable to identify the pollution producing from human activities and identify its causes besides that, the inability to treat it and remove damage to the ecosystem promptly. The pollution extends for days, months, or even thousands of years, all of this constitutes accumulations of polluting materials that are reflecting on the environment.

The means of detecting and identifying environmental waste to be treated had been developed, thus removing the danger to human life. Recently, it has witnessed a remarkable development of the detecting methods of environmental pollutants, including pollution, as a result of chemical pesticides and their toxic effect on the human nervous system over the years.

Detection and classifying system had been proposed to detect and distinguish various types, and different quantities of chemical pollutant materials in human food. With low cost and portable device, which makes the analysis process implement on-site without needing to the laboratory. The availability of the module sensor, where it can be obtained very easily by each person even if the person's financial income is low.

The detection system had been designed by using multifunction sensor TDS, PH, DS18B20, depending on Nernst' law and Kohlrausch's law and the Debye-Hückel-Onsager theory.

The artificial neural network had been training, which represents the contribution in this study, where the entered data is used, which had taken from sensors in the first stage. Two type of network had been used the first network is the perceptron network, and the second network is the feed-forward network. The detection system results was that the sensor can detect very low concentration of pesticide less than (0.005 or 0.002 ml) and that excellent because the purpose to detect the residue of pesticide, where decrease with the increase the number of ions per unit volume. The concentration of pesticide at (0.4 ml) and less than the sensor can detect, where the reading increase with the decrease the number of ions per unit volume. The concentration of pesticide large then (0.4 ml) the reading will be saturated or constant. The comparison with research which had been done previously the percentage of the relative standard deviation at (5 %). The proposed system had been proved that is perfect in detect the residue of pesticide at low concentration with percentage more than (50 %) in water and more than 10% in other liquid like orange juice. The best performance to perceptron network at 0.5, which had been getting at epoch equal 1 iteration or 3 iteration, with mean absolute error (mae), and as a hard limit. The best performance to feed-forward neural network at R=1, with 3 hidden layers have 10 neurons, and the last layer is the output layer with 4 neurons.

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Chapter one

Introduction

1.1 Background

Since the last years of this century witnessed a remarkable increase in the etiology of the pollutant materials. several materials are containing in water, despite the effectiveness some time to eliminate or treat some cases but it poses a danger if it streams in water, subsequently human and animal health are being posed to harm. Pollutant by chemical materials considered one of the environmental pollutions. It is one of the most important and most dangerous issues because it is directly related to human health [1].

The danger of chemical pollutant materials is related to the severe environmental pollution that arises mainly from the accumulation of non-degradable chemicals in the ecosystem. The synthetic chemical pollutants are considered one of the most significant, and it is severe issues which are exposed with the humans and the environment together. The acceleration in the pace of the evolution process at the international level and the keenness of all countries to distribute and increase their food production to meet human's needs, led to the employment of all means of production available to them in this direction [2].

Pollutant materials detection is necessary to the provision of production requirements, including a chemical materials, as one of the most important of a pollutant generation factors. Chemical material can be used as an effective means of protecting crops and eliminating some of the damage to environmental components or reduce pollutants with elements closely related to humans especially water, if they are used correctly [3].

Despite the many advantages of evolution process, but most of the chemical materials which are considered one of the causes of pollution must be considered as a last resort in using to improve the performance of productions. Most of the chemical materials are toxic substances and lead to harm to humans and the environment with a high rate of misuse to environmental resources. It has become necessary to be careful to reduce its damages and develop methods of detection [4]. Some methods of detection have been discussed, which are easy to use, cheap, and the possibility of providing them to anyone, where any person can carry out the examination process without effort at home [5].

1.2 Detection methods of polluting materials

Sensors feature two functional component recognition elements to supply a binding, which being as selective specified with the analysis of the target. The components of the transducer for referring to the event, which is using for binding. significantly two fundamental parameters, which are being depended to deal with The efficiency of the sensor, to recognize the effectiveness of the process in terms of the time of responding, the selectivity, and the ratio between the signal to the noise$(\frac{s}{N})$, and the limit of detection to each sample (LOT), which means the least value of substance, which can be detected, or distinguished if it compare with other sample (free sample) [6].

For improving the processes like the transduction in addition to the recognition, it must develop new components to get sensors with as high efficiency as possible. To get suitable methods for determining the content of polluting materials in water and fruit juice. It is necessary more sides than just a food safety perspective and enabling an ecosystem to be an effective, pure, and healthy food products to sell that could be obtained by controlling and monitoring of the polluting materials harmful levels and

preserve them at a minimum value. It is essential for showing which method could be valid, accurate analysis to polluting materials detection, and determination [7].

The concentration has been done continuously to design and development of multifunctional detectors, where it is an opportunity to obtain several features to the analysis by connecting two or more different detectors. In the proposed system the concentration of three types of sensors, two of them used for detecting polluting materials, which are the TDS, PH sensor, and the third one is used to adjust aqueous solution temperature[8]. There are some matters for the production of multifunction detectors that have been taking care one of them is the space needed to get less space as possible for three sensors and low cost where the PCB designing board for three sensors can replace in one PCB board [9].

The proposed system has a substantial role in Analyzing and estimating or assessment of polluting materials in food, water, and air. For this reason, there are many methods of [10] nanoparticles, chemical, bio, fiber-optic, and optical, etc. to the analysis methods to detect polluting materials and determine their concentration but the method, in this study it has differed from other methods. In ease to use and accuracy of its result. Choosing the appropriate method depends on the levels of polluting materials to be assessed [11], the degree of sensitivity required and the type of targeted information. So more than one sensor will collect to explain some of the methods used to detect polluting materials and to get a multifunction detector. All sensors which had been used in this study are sensor transducer type [12].

1.3 Relative standard deviation

It is referred to as RSD or the coefficient of variation. It is a common formula used in probability theory and statistics to calculate a

standardized measure of the ratio of the standard deviation to the mean value of a set samples contain a different concentrations of pollutant materials. The data which has been analyzed is the control sample in addition to pollutant material with different concentrations. Ii is used in comparing with the other related data like the data of control sample without adding any pollutant materials, and the data of raw pollutant material without any additives [13].

1.4 The Conductivity of the electrolyte

The conductivity indicates the water has the feature of portability to electricity conducting. The values can measure by sensors, where it represents the opposite value to resistivity with Siemens to each meter as the unit which is used in readings value ($\frac{S}{n}$) [14], which supplies amounts measuring of salts which are being dissolved in water. The chemicals dissolved values is proportional to the conductivity values, where increase the dissolving values leads to higher conductivity value. The conductivity of distilled water to electricity is as poor as compared with the conductivity for the ionized water as shown in table (1-1). The ions are formed from breaking the dissolved salts in a liquid to teeny particles, which are charged electrically is called ions, which make the liquid has the portability of electricity conducting increasingly with increasing of common ions of dissolved salts in electrolyte. For example chloride, magnesium, and organic components, and alcohols, etc. the result is an electrical current is generating. The aqueous should have no ability for conducting electricity in sugar because the ions aren't forming when sugar is dissolving [15].

Table (1-1) Indicates some standard EC values to water.

Type of water	the quality	EC value in (μS/cm)	Temperature
Deionized	high	0.05	25℃
Seawater	/	50,000	25℃
Drinking	perfect	200-800	25℃

According to the additive contribution of ions, the concentration of a dilute liquid is dependent, and the kohlrausch's laws are applied [16].

1.5 Literature Survey

There is a high demand for the development of cost-effective, sensitive is high, miniature sensors, which requires progressing technology coupled with essential knowledge in biology, chemistry, and material sciences.

The recent methodologies which is approaching of this study had reviewed to detect the pollutant materials in water and orange juice. It includes quantification and monitoring of pollutant materials. Several of methodologies had reviewed briefly as indicates in the literature, several of studies for sensing pollutant materials are different in detecting manner. It is different between each other in the attitude of pollutant materials detection or recognition for example. Some of them depending on conductivity, and the other depending on the enzymes, aptamers, and antibodies etc. Free sample are used to examine the existence of the pollutant materials. Consequently develop the detection system most of the studies confirm it's validated in detection and control the pollutant materials quantity especially in water. The principle work to the proposed system had chosen depending on several studies which represents the combination of ideas which presented in those studies to achieve system. To developed and improve the performance and to cover more sample with low concentration, so this represents an expanding to an aspect of those

studies. Detection ways and the main features of the test in those studies which took into account. It is recommending to use in this study with some of the differences between them, as is illustrating below:

*Wang Changlong Zhang Shengwei Yuan Ting Shen Maosong, (2009) [17], presented a rapid detection of pesticide residues in vegetables with a mini-colorimeter, which is rapid, accurate, cheap, widely used, shortest time. It is a new measurement method to detect the pesticide residuals in samples [18]. The Chlorsalicylamide and Organophosphates (Omethoate) pesticides toxicity based on a mini-colorimeter.

The suggestion method takes a measuring time to detect pesticide residue as short as possible. It is common and widely used in each market because the price is low cost and convenient. The value of turbidity, which is measuring, and the residual concentration of pesticides are the most reasons to detect any change in the output of the detection system. The relationship between them does not simple. [19]

The first difference between this study and our study is that the absorbency method to the four photodiodes is the way to detect the pesticide residues in water and agricultural products samples, besides that the sensitivity of water to light especially, the light green and purple. The other hand, the sensitivity of Chlorsalicylamide to light is being just on purple without a green light. The proposed system is using to detect any type of pollutant materials including pesticide residue, and distinguish between them and not rely solely on pollution by pesticide. The method of detection, which used in detecting is the electrical conductivity in water and orange juice samples by using TDS instead of reliance on the light absorbance in water and agricultural products samples by using the four photodiodes.

The second difference is the neural network in this research uses the artificial neural network of back propagation to determine the residual concentration of the pesticide, and its relationship with the turbidity of samples. In the proposed system, the neural network especially, the perceptron network and a feed-forward network had trained to identify the different types of pollutant materials and distinguish between them either by giving the name of the pollutant materials or identify its class by classifying the data to (0) or (1). The data is classifying, or identifying to differentiate the different types of pollutant materials.

The study uses the relationship of the concentration with turbidity. In the proposed system the relationship was between the concentration values and the total dissolved solids.

The concept of turbidity depended on collide the light with the molecules of the substances, but the total dissolved solids depend on the pollutant materials dissolved in electrolyte or solution and convert to ions. The movement to those ions in solution behaves like an electrical conductivity generation in the electrolyte.

*Xia SUN, Xiaoxu SUN, Xiangyou WANG, (2013) [20], presented a (design of portable pesticide residue detection system based on the enzyme electrode). It is a method for realizing the miniaturization and portable of the detecting instrument by design the shorter time, lower cost, rapidly, portable, and direct detection of an excessive amount of pesticide residues which based on Acetylcholinesterase enzyme.

The block diagram in the research paper of hardware of the detection system which is consist of constant voltage + three-electrode system + input voltage converter + prime amplifier + differential amplification + low pass filter + microchip system + displayer.

From above: the difference between research paper above and our proposed system can notice that the three-electrode had replaced with DS18B20, PH, and TDS sensors. This part represents the probes, amplifier, and the filter all that is prefabricated, ready-made, and called meters like TDS and PH. The microchip processor had been used Arduino with a microchip (ATmega328p). The I/V converter convert from analog to digital signal is already found in Arduino. The displayer part had used (LCD 2×16) liquid crystal. The experiment had done with those sensors. The result obtained after complete all the experiments, that all components can combine by manufacturing the (PCB) designing board. The two research have the same block diagram in designing the system but are different in the electronics component, which the proposed detection system had been using.

The principle work depends on the electromotive force between the working electrode and the reference electrode. The precision in the voltage source value has a substantial role in the system precision. The proposed system, the working electrode with the reference electrode found in the probe part, the principle work depends on the ions moving in the electrolyte between the working and reference electrode.

*Mejula, Janat J., et al., (2018) [21], presented electrochemical oxygen sensors and biosensors used with IoT and base on an amperometric enzyme. It can divide into three parts: the first part is sensors act on sensing any change in a specific sample behavior and detect it according to its detection ability and the type of materials that need to test.

The second part is: Arduino acts as a microcontroller are connecting to laptops. Arduino software with programmable code will control the sensor. The third part is: LCD screen acts on display all results of programming code and then display the value of pesticide residue, which

detected. The following some advantages to use the system in pesticide residue detection. Does not depend on Temperature, it can able to use by anyone, simple to use, Very effective usage, Reducement of causing diseases.

The first difference between this study and our study is that the type of sensor, which used is the gas sensor depending on the electrochemical oxygen sensors, and also the enzyme sensor, which depends on chemical biosensors and depends on the element of biological. The sensor transducer converts the physical or, chemical or biological reaction to an electrical signal. The proposed system the TDS and PH, and DS18B20 sensors had used, which depend on the electrical conductivity and the electrical potential, and the temperature value.

The second difference is that this study does not depend on Temperature as in our work, the temperature value is substantial in the behavior of the movement of the molecules of the aqueous solution.

The third difference is: that this study is using to detect the pesticide residue in vegetables and fruits, while in the proposed system, the sensor had used to detect pollutant materials of any type, including pesticide residue. The identification process by using a neural network to distinguish the type of different pollutant materials which is contained in electrolyte and classified it according to its kind to several classes. It represents the contribution, which had been added to the proposed system.

*Deepali Gupta, Balwinder Singh, Harpreet Singh, (2016) [22], proposed design and development of pesticide residue detection system using EC, PH, and LDR sensor. It is a new system for monitoring the values of the free and containing pesticide residue in market samples to various parameters like EC, pH, and the absorbance of light.

The block diagram to this research paper consists of sensor unit + control unit ADC0808+AT89S52 + power supply + LCD, where in the proposed system, the control unit ADC0808+AT89S52 is replaced with Arduino only with a microchip ATmega328p because the Arduino provides development environment which allows us adding more parameter and more sensor at the same microchip depending on the number of the bin to Arduino. It supply improve the performance without remove or damage to other parts. For those reasons Arduino is using, so there is a need to the codes to operate the sensor.

The performance of the detection system in the proposed system is developing, which makes the detection system covers more types of samples especially, water and orange juice, which has different behavior.

The procedure work of the detection system is developing not only to detect pesticide residue but also to detect any type of pollutant materials, including pesticide that may contain in water and fruit juice samples. In addition, an artificial neural network is added to the design to make identification by classifying and predicting the type of pollutant materials by training the collected data from the sensor unit.

TDS sensor in water sample the percentage of standard deviation is more than 50%, while at orange juice more than 10%. PH sensor the percentage of relative standard deviation in water less than 10%, and in orange juice less than 5%. The comparison with research which had been done previously the percentage of the relative standard deviation at (5 %). The TDS sensor had been proved that is perfect in detect the residue of pesticide at low concentration with percentage more than (50 %) in water and more than 10% in other liquid like orange juice.

1.6 Aims of the study:

1. A multifunctional sensors system had been proposed to detect the pollutant materials in water, fruits juice. The proposed sensor system consists of developing laboratory sensor techniques to check and recognize different parameters like electrical conductivity by TDS, temperature by DS18B20, and electrical potential by PH. The proposed system is most reliable alternative to develop a portable device, easy to design, low cost, smaller size, and analysis time is undemanding which makes it a candidate of developed more than the previous detection techniques.

2. Simulation to implement an algorithm depending on identification by training an artificial neural network to classify or distinguish the data which is collected to identify the type of the pollutant materials. To get the best performance the error must be less as possible by comparing the output of the neural network and the target if the difference between them is zero then the error is equal to zero.

Consequently, a classification process is correct, so it can do by dealing with the data in the form of (0 and 1) and depending on tools in MatLab that makes it is easy to design.

Chapter two

Methodology

2.1 Introduction

In this chapter, each component of the detection system has been describing minutely. In addition to that the principal work has been explaining for each part and the theory that is using in proving it. The working principle has discussed. The most important conductivity, and concentration laws depend on Nernst's law or Kohlrausch's law and the Debye-Hückel-Onsager theory, in addition to their relationship with using the TDS sensor and related parameters like PH, Temperature. Classification and identification had been done by training artificial neural network ANN by using the perceptron code and feed forward network.

2.2 Components of the proposed system

The whole system consists of two parts: the first part is how to detect pollutant materials depending on the principle like electrical conductivity, electrical potential, and temperature.

Materials of the first stage:

Arduino UNO R3.

TDS Meter (V1.0) Dfrobot.

DS18B20.

PH sensor at the type of (DIY MORE).

LCD 2×16 liquid crystal display.

(330) ohm resistor.

(100KΩ) linear-rotary potentiometer.

Big prototyping breadboard 4 bus 1660 tie-points.

Jumper wires female-female, male-female, and male-male DuPont line20 lines.

The second part includes training data which had been detecting by using an artificial neural network ANN to make predictions and identification for the type of data. By classifying the data into two or one class and separate each other by bias line and adjust the weight to get the best performance to the network. After training, the network results will be able to distinguish between two types of pollutant materials or more by entering its data and the required target.

The codes which had used for training is as follows:

Perceptron code and (hardlim) transfer function.

Feed forward network.

All above will be explained subsequently in detail in this section.

2.3 TDS sensor

Sensors for detecting the polluting materials which is a device, machine, module, or subsystem that can measure a signal which is transforming to the sensor, where sensors is detecting any change in the stimulation of physical. The purpose of using the sensor is for sensing the elements that had been changing. For instance, if the stimulation process is to change the resistance by changing the temperature, so it can be responded by the thermistor sensor. The detection events, or detects any change in its environment is called sensor as showing in figure (2-1) [23].

Figure (2-1) Sensor mechanism

If the sensors transmit the information to other electronics, then it is called sensor transducer as shown in figure (2-2) below:

If the transformation of power from a specific system to another one is different or similar, then it is called a transducer, which contains sensing elements to pulse-associated circuitry had been combined. For example, if the thermistor is connecting to an electronic circuit like bridge cct. Where it acts to convert any change in resistance that causes by a temperature change into a voltage change. So it is called a transducer as showing in figure (2-2) below:
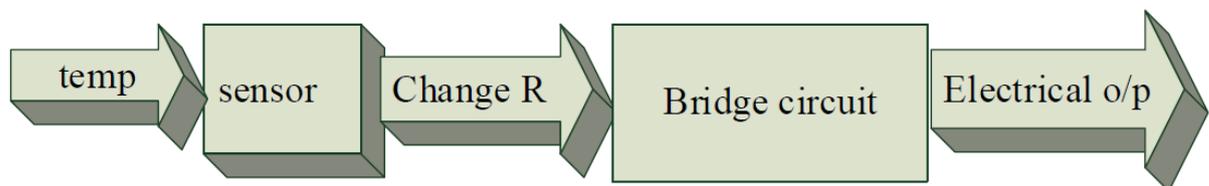
Figure (2-2) Transducer mechanism

The energy is transduced from thermal form to electrical form by the whole circuit, which it had mentioned in figure (2-2) previously above all process is called the transduction process.

Where R: represents the resistance.

TDS is a shortened form of the word Total Dissolved Solids is expressed directly by the abbreviation TDS whether inorganic and organic components existed in the electrolyte.

The conductivity of a liquid can measure by using a TDS sensor. TDS meter with Arduino the value of TDS can consist in the water, then it can show on the LCD screen. The value of EC illustrates the quality of water and the range of cleanliness of the water in the field of monitoring in addition testing. It can be considered as a reference point by measuring the soluble solids in milligrams or parts per millions (ppm), which are dissolving in a liquid like water per liter, so the unit of measuring is (mg/L) [24].

Constituent materials to soluble solids in liquid, especially salts, in addition, to other substances like cationic and further anionic, or an organic substance, which it leaked to the sources of the supply water system, whether domestic or hydroponic and other pollutants such as heavy metals [25].

Population growth in addition to the expansion in the activities like industrial and agricultural influences climate, and consequently, threaten the environmental cycle.

The TDS sensor which had been used in the proposed system can be made a perfect water quality monitoring system, a water quality monitoring system can be made, by using the TDS Gravity V1.0 meter had been connected with the temperature sensor is digital and waterproof called (DS18B20) one-wire, and (16×2 LCD) with Arduino for measuring the TDS value [26].

The DS18B20 had used for the temperature compensations probe has no sensor for temperature measuring to get an accurate value with high calibration.

Either an algorithm in the programmed code had been confining and saving. The temperature value compensation is as constant as the default value is 25 degrees centigrade, or it is considering as a variable value depending on the value of the analog pin, which connects the Arduino with the TDS sensor by writing a temperature compensation formula in the code [27]. Sugar has non-ionic particles, so TDS doesn't detect it, and the zero value to TDS represents the ideal value.

The Gravity TDS has two parts: the first part is the probe which has two electrodes are spacing evenly apart, and electrodes can measure the charge when it immersed in an aqueous solution. Dissolved solids break down to positive and negative charges cause to generate free ions act on conduct the electricity. The concentration of ions in solution represent a measure to the level of purity where the conductivity is lower that's mean the liquid is pure and then the detecting signal transform to the second part of sensor which represents the meter part. A meter part contains a combination of electronics elements are assembling to receive the analog signal, and it had converted to the voltage value and then to ppm value or TDS value. The TDS meter is connecting to the microcontroller by Arduino which provides processor can upload code to control in TDS sensor working, where distilled water is almost an insulator, but salt water is a very efficient electrical conductor [28].

Pure liquid has no soluble salts at zero ppm value. Conversely, it conducts charges at completely dissolved materials.

The electrical charges in electrolyte do not be generated by themselves in an electrolyte, and any dissolved solids have the electric charges and ions, which have movement-free permissibility between the two electrodes, so it can create by it, where the number of dissolved solids is proportional with the ppm Value. 1 EC is equal to 900 PPM, where EC represents the electrical conductivity or electrical charge.

If the value of the TDS sensor is less than the value of 300 mg/liter so the water could consider excellent to use.

If the value of the TDS sensor is between the values of (300 and 600) mg/liter so the water could consider good to use.

If the value of the TDS sensor is between the values of (900 and 1200) mg/liter so the water could consider fair to use.

If the value of the TDS sensor is greater than the values of 1200mg/liter so the water could consider unacceptable to use.

The maximum range of pollutants level for TDS in ppm unit is:

- In (U.S. EPA) is equal to (500).

- In (World Health Organization WHO) equals to the value of (1000).

A (16x2 LCD) Display used to display the measured values to The TDS Sensor, which has interfaced with the Microcontroller of an Arduino, [29]

2.4 Relative standard deviation

It used to compare data with other, where it can be represented as percentage or number the calculation steps as follows:

First step is calculating the mean value (x).

Second step is subtracting the mean value from each input data (x_i), and the result is squared.

$$(x_i - x)^2 \tag{2-1}$$

Third step is summation the result of step two:

$$\sum_{i=1}^{N}(x_i - x)^2 \tag{2-2}$$

Forth step N had been calculated:

$$N = \sum x_i \tag{2-3}$$

Fifth step is the results from third step had been multiplied by$\frac{1}{N}$ as follows:

$$\frac{1}{N} \sum_{i=1}^{N}(x_i - x)^2 \tag{2-4}$$

Sixth step is taking a square root to the result in step five and this called a standard deviation (S) as follows:

$$S = \sqrt{\frac{1}{N}\sum_{i=1}^{N}(x_i - x)^2} \tag{2-5}$$

Seventh step is relative standard deviation had been calculated by multiplying (s) from step six by (100) and the result is dividing by (x) [30] as follows:

$$relative\ standard\ deviation = \frac{(S \times 100)}{x} \tag{2-6}$$

2.5 Nernst' law and Kohlrausch's law and the Debye-Hückel-Onsager theory

Molar conductance is dependent on the concentration of the electrolyte. At dilution, the number of ions available per unit volume reduces. The result is the reduction of the conductivity, so the conductance of ions that occurs in a unit volume of the solution is called conductivity of a solution. The conductance is proportional directly to ions per unit

volume because the current is carried forward by the ions. It changes with the concentration of the electrolyte. In the case of dilution, the concentration of the liquid will decrease with its volume increases, so the number of ions per unit volume (ions/volume = conductivity) decreases, then the conductivity decreases. As a result with dilation, the conductivity will decrease.

An equivalent conductance of electrolyte is a conductance of a volume of the solution including 1 equivalent of the weight of dissolved substance when placed between two parallel electrodes (1 cm) apart, which is large enough to contain all the charges of the solution between them. [31]

An equivalent conductivity of the (anions and cations) which are containing in the electrolyte. In case of infinite dilution of the solution, is equal to the (sum of the equivalent conductance).

Molar conductivity is conducting power for the whole of ions, which is creating by dissolving the substances in a liquid. It is causing charges are creating consequently is generating ions, which it is creating per one mole of the liquid. At a given concentration of the molar conductivity of a solution is the conductance of volume (V) of a solution including, one mole of electrolyte kept between two electrodes with a distance of unit length and an area of cross-section (A) [32].

$$\Lambda_m = K/c \tag{2-7}$$

Where:

Λ_m represents the molar conductivity.

C Represents the *concentration in* $\frac{moles}{volume}$.

K Represents conductivity.

As shown in the equation below:

$$\Lambda_m = K\ V \qquad\qquad (2\text{-}8)$$

Molar conductivity of both weak and strong electrolytes increases with a decrease in concentration on dilution, because the degree of dissociation and the total number of ions increases. On the other hand, at dilution the total volume (V) of an electrolyte increases per one mole, the concentration decreases. At zero concentration value of the electrolyte, at this value, the molar conductivity is calling limiting molar conductivity (Λ_{m0}). The relationship between the molar conductivity with concentration to each of strong and weak electrolytes is not the same. Specific conductivity (K) decreases at decrease in concentration. The molar conductivity of the solution increases because on dilution, ions get more apart and mobility of ions increases, while the number of ions per unit volume = conductivity, which carry the current in a solution is decreasing, on dilution.[33]

The law of Kohlrausch's states on the limiting of molar conductivity (Λ_{m0}) of an electrolyte at weak or strong, where can be calculated as the sum of the individual contributions of the anion and cation of the electrolyte. In electrochemistry, for full cell or half-cell reaction the potential of an electrochemical reaction reducing to the standard electrode potential is related to the Nernst equation limiting molar conductivity (Λ_{m0}) for the ionic diffusion coefficients. The temperature and activities of the chemical species undergoing oxidation and reduction

most of the time are approximating by concentrations. It is using to calculate the ionic diffusion coefficients from the experimental limitation of conductivity. The Nernst-Einstein equation is: [34]

$$\Lambda_{m\,0} = (F^2/RT)\,(v_+\,z_+{}^2\,D_+ + v_-\,z_-{}^2\,D_-) \tag{2-9}$$

Where:

(F) Represents the Faraday constant.

(R) Represents the gas constant.

(T) Represents the thermodynamic temperature.

(z+, z–) represents the valences of the ions.

(V+, v–) (Represents the number of cations and anions per formula unit of electrolyte).

(D+, D–) represents the diffusion coefficients of the ions.

Einstein equation has been using as a basis for determining the molecular structure of proteins and other colloidal substances by using this formula:

$$\eta = \eta_0\,(1 + 2.5\ V) \tag{2-10}$$

η Represents the viscosity of a suspension of solid spheres.

η_0 represents the viscosity of the dispersion medium.

V represents the volume in parts of a cubic centimeter occupied by the dispersed solid.

The Nernst distribution law is one of the laws applying for ideal dilute solutions. It determines the relative distribution of the component that is soluble in two liquids, whether immiscible or miscible to a limited extent.

The Einstein general relation is:

$$D = \mu \, kBT \tag{2-11}$$

Where:

D Represents the diffusion coefficient.

μ Represents the mobility, is the ratio of the particle's terminal drift velocity to an applied force. [35]

$$\mu = \frac{v_d}{F} \tag{2-12}$$

k_B Represents the Boltzmann's constant.

T Represents the absolute temperature.

The two important and specific formulas of the equations that are frequently using are as follows:

$$1\text{-} \left(D = \frac{\mu_q \, K_B T}{q}\right) \tag{2-13}$$

Represents the electrical mobility equation, to diffusion particles charges:

$$2\text{-}\ (D = \frac{k_\text{B}T}{6\pi\eta r}) \qquad\qquad (2\text{-}14)$$

Represents the Stokes-Einstein equation, for the diffusion of spherical particles through the liquid with low Reynolds number:

Where:

q Represents the practical's electrical charge.

μ_q Represents the electrical mobility to particle's charges.

η Represents the dynamic viscosity.

r Represents the radius to the spherical particle.

Stokes' law

The force of viscosity on a small sphere moving through a viscous fluid is given by [36]

$$F_d = 6\pi\eta RV \qquad\qquad (2\text{-}15)$$

Where:

F_d Represents the frictional force – known as Stokes' drag – acting on the interface between the fluid and the particle.

η Represents the dynamic viscosity.

R   represents the radius of the spherical object.

V   represents the flow velocity relative to the object.

F_d is given in newton = $kg\ m\ s^{-2}$, η (= $kg\ m^{-1}\ s^{-1}$), R in meters, and v in   (m/s).

Electrical mobility equation:

The electrical mobility (μ_q) for a particle with an electrical charge (q) is referred to the equation below:

$$\mu = (\frac{\mu_q}{q})$$ (2-16)

$$D = \frac{\mu_q\ K_B T}{q}$$ (2-17)

Where:

μ_q represents the ratio between the particles velocities of the terminal drift to an applied electric field.

M   represents generalized mobility.

D   represents the diffusion coefficient ($m^2\ S^{-1}$).

μ_q Represents the electrical mobility ($m^2\ V^{-1}S^{-1}$).

q   Represents the particles electric charge in (coulombs C unit).

T   Represents electrons or ions temperature in plasma (K).

$$D = \frac{\mu_q\ T}{Z}$$ (2-18)

Where:

Z   represents the particle charge number without unit.

T   represents electrons or ions temperature in plasma (V).

From eq (2-9), (2-14), and (2-16) can obtain on molar conductivity [37]

$$\Lambda_{m0} = \frac{Fez^2}{6\pi\eta r} \tag{2-19}$$

Where:

F = Faraday's constant.

e = the elementary charge.

z = the valence.

At weak electrolytes, the relationship between molar conductivity (Λ_m) and $c^{1/2}$, where (c) is the concentration is not a straight line at higher concentrations electrolyte there is a significant increase in the number of ions. Consequently, dissociation ratio is low, and the molar conductivity is also low value while at low concentration electrolyte. The molar conductivity of the weak electrolyte rises steeply, while at dilution, the number of ions is spacing apart, that make the attraction of the internal ions is weak consequently, increasing the conductance. The limiting molar conductivity the graph between those parameters cannot get it. The limit molar conductivity can be calculated to weak electrolytes by (Kohlrausch's law) or by using a graph between those parameters.

The (strong electrolytes) there is no increase in the number of ions with dilution because the strong electrolytes are completely ionized in solution at all concentrations, While at dilution, the ions become far apart

from one another, and interionic forces decrease. So that the molar conductivity will increase slowly with the dilution, the relationship formula between molar conductivity (Λ_m) and ($c^{1/2}$), where c is the concentration is representing by a straight line. [38]

From that:

- Strong electrolytes the molar conductivity of a strong electrolyte decreases slightly with the increase in concentration.

- The molar conductivity of a weak electrolyte rises steeply at low concentrations.

Weak electrolytes are weak conductors of electricity, and strong electrolytes are good conductors of electricity.

  * An estimation of the water ability for conducting electricity. Is called specific electrical conductance, or electrical conductivity.

  * The conductance of ions present in a unit volume of the solution. On dilution is called the conductivity of a solution, where the number of ions per unit volume decreases and the conductivity decreases.

2.5.1 Kohlrausch's law

It is a principle in physical chemistry that states that the independent migration of anions in the limit of infinite dilution. Anionic species contribute to the total molar conductivity of an electrolyte solution irrespective of the nature of other ions, which is associated with it. It depends only on the nature of that specific ion solvent, and the potential gradient but it is independent of the other ions present. Kohlrausch's law is utilized the same in both kinds of weak and strong electrolytes. [39]

$$\Lambda_m = \Lambda_m{}^0 - K' \times C^{1/2} \qquad\qquad (2\text{-}20)$$

Where K' Is an empirical constant = line slope and V is the volume of the medium. $K = K' \times C^{1/2}$ or $K = K' \times V^{1.5}$.   (2-21)

Infinite dilution is a solution that contains so much solvent that, if more solvent has been adding, so there will be no change in a concentration of a solution.

Ions migrating is the movement of a charged particle during an electrolyte toward an electrode of opposite charge sign. The losses in a neutral salt around two electrodes through the passage of an electric current depend on the velocities of ions migrating from these electrodes.

The law is to calculate the molar conductivity to any electrolyte at zero or infinite dilution concentration that cannot be experimentally measured. So the limiting molar conductivity of an electrolyte can be represented as the summation of the individual contributions of the anion and cation of the electrolyte Λ_0 to a weak electrolyte can be obtained from Λ_0 values of strong electrolytes [40].

2.5.2 Debye-Hückel theory

The chemists peter Debye and Erich Hückel theorized that:

The extra parameter is altered proportionally with the concentration called gamma (Υ). It has significant total contribution energy, where it affects the calculation of the activity coefficients, which is caused by an interaction between the objects is considering. The interaction energy of ions in solution usually depends on the relative position of the particles. [41]

As the concentration of the solutes is fundamental to the calculation of the dynamics of a solution, they developed the Debye-Hückel limiting law and Debye-Hückel equation.

It states: on the electrolyte even at low concentrations does not behave ideally because of the dynamics of anionic solvent, which is containing in the electrolyte. So Debye-Hückel limiting law is using to calculate the coefficient of a known ionic strength activity at dilute.

It represents a theoretical explanation of the non-ideality of electrolyte solutions and plasmas and departure from ideality ideal electrolyte solutions mean a solution whose colligative properties are proportional to the concentration of the solute at the very lowest concentrations, real electrolyte liquid illustrates leaving the ideality. The linearized model called Poisson-Boltzmann which nevertheless, a quite modified assumes simplifying the model of electrolyte extremely notwithstanding at dilute, the mean activity coefficients to the prediction ions.

To calculate ion activity(a_c), so the concentration C and the activity coefficient ϒ must be known:

$$a_c = \gamma \frac{[c]}{[c^-]} \qquad (2\text{-}22)$$

Where:

ϒ = activity coefficient of C.

C^- = Represents the concentration of the chosen standard state, 1 mol/kg if molality is used.

C = Represents the measure of the concentration of C.

Dividing C with C^- gives a dimensionless quantity.

At very dilute solutions, an ideal electrolyte solution can achieve.

One is an integer number to represent the activity coefficients of all ions fundamentally electrostatic forces act on the attraction of opposite charges to each other and repulsion between the ions at similar ions charges from each other. It causes non-ideality which means a non-concentrated solution, experimentally Activity coefficients of single ions cannot measure because an electrolyte solution must include both, negatively and positively ions charges. The result they do not distribute randomly through the electrolyte, except in an ideal solution. Instead, a mean activity coefficient $(\gamma_\pm)$ is used in single ions. [42]

$$\gamma_\pm = (\gamma_+ + \gamma_-)^{\frac{1}{2}} \qquad (2\text{-}23)$$

From These concepts a quantitative theory was developing including ions and charges (z_1e^+), and (z_2e^-).

Where:

(z) Is an integer number.

Coulomb's law is a fundamental supposition which state that every two electric charges or ions have force, spaced apart a distance, (r) medium with relative permittivity (ε_r) is as follow: [43]

$$force = \frac{Z_1 Z_2 e^2}{4\pi\epsilon_0\epsilon_r r^2} \qquad (2\text{-}24)$$

Suppose that:

1- A strong electrolyte a and the solute are completely dissociating.

2- Ions are spherical, and they aren't polarized by the surrounding electric field.

3-dissolving of Ions neglected except its influential sizes.

4- There is no role to solvent except supplying a medium where:

Dielectric = constant.

Relative permittivity = constant.

5- Electrostriction doesn't exist.

6- Cation and anion is surrounded by a spherically symmetric respectively negative and positive cloud of other ions and charges. Statistically, the cloud represents a central ion surrounding Individual ions to form continuous charge density and a minimum distance to get approach as close as possible. [44]

Debye and Hückel: treatment was giving at any system that doesn't expose to the external field like the electric motivation force. If there is a dealing with the conductivity so, the external field will oscillate. The reason is when the electrodes are immersing in the aqueous solution, so there will be an AC voltage or analog signal will create so Debye and Hückel equation modified by Lars Onsager.

The difference between the two assumptions is that the original one is the same and save, but the new thing which modified is that the charges could be distorted space away from the spherical symmetry to the electric field with the specific movement to the ions like viscosity and

electrophoretic effects. Onsager proves an equation theoretically by kohlrausch's law which express on the empirical relation for the molar conductivity, (Λ_m). [45]

$$\Lambda_m = \Lambda_m{}^0 - K' \times \sqrt{C} \qquad (2\text{-}25)$$

Debye–Hückel–Onsager equation at infinite dilution is limiting as:

$$\Lambda_m = \Lambda_m{}^0 - (A + B\Lambda_m{}^0)\sqrt{C} \qquad (2\text{-}26)$$

Where:

$$K' = A + B\Lambda_{m0} \qquad (2\text{-}27)$$

A and B: represents the values of a constant, and it must supply with known quantities like charges which break to generate the ions and other parameters like temperature. The viscosity of the solvent, and the dielectric constant the following two-equation used only at a dilute electrolyte, while the other cases can replace by an equation which explained previously. [46]

$$A = \frac{z^2 e F^2}{3\pi\eta} \left(\frac{2}{\varepsilon RT}\right)^{1/2} \qquad (2\text{-}28)$$

$$B = \frac{q z^3 e F}{24\pi\varepsilon RT} \left(\frac{2}{\varepsilon RT}\right)^{1/2} \qquad (2\text{-}29)$$

Where (ε) represents the electric permittivity.

2.6 The electrical admittance model

The model indicates representation to the two electrodes immersed in an electrolyte, by figure combination of resistors and capacitors in series and parallel. It can be used to model the electrical admittance between two electrodes immersed in an electrolyte as shown in figure (2-3) below:

The model of electrical admittance between two
electrodes immersed in an electrolyte
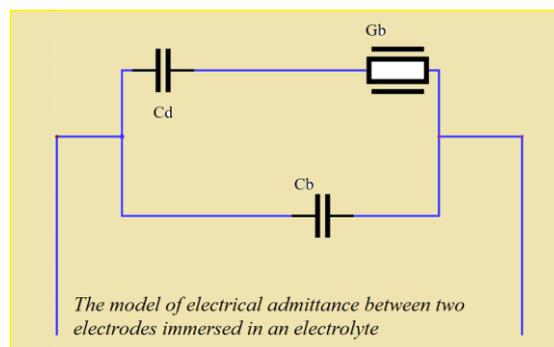
Figure (2-3) The model of electrical admittance.

Where:

C_d = represents the double-layer capacitance of the electrode/electrolyte interface.

G_b = represents the bulk electrolyte conductance.

C_b = represents the geometrical capacitance of the two electrodes separated by the measured electrolyte.

G_b, C_d, and C_b related to (G_m and B_m).

The electrode/electrolyte interface: the two phases have a difference in potential, which sets up across its interface that happens. If the metal has immersed partially in an electrolyte. The phases could be liquids,

solids, or gases. At the interface, a double layer is setting up, which represents the most common terminology in electrochemistry. Two electrodes mean two phases are setting up a potential difference between them across its interface for any reason. The reason, which is the most common, is across the interface will occur a charge movement between the two electrodes and the two phases. Through this process, an electron movement across the interface will cause a charge separation. The second reason: the appearance of potential differences between a set of activation surfaces at the ionizable media (solid, liquid, or gas). It induced dipoles, or orientation of permanent electrical, structural, and compositional properties exist at the interface in the double-layer between two phases. At every phase if dealt with the density of charge increasing, so it named with The compositional and electrical properties, on the other hand, if the dealing with distribution to each of the following parameter ions, electrons, dipoles, and neutral molecules, so it named with the structural properties, this part covers (the interfacial region).

(G_b) Represents the bulk electrolyte conductance, where: it does not only depend on the properties of the materials but also the physical parameters including, the frequency where at high-frequency point affects the ionic conductivity more than other variables

The admittance measurement was being in form of:

- A capacitance C_m at series

- Conductance G_m at parallel

2.6.1 Relationship conductance (G_m) with frequency

- Below (100 kHz)   the conductance varies with a frequency but remains constant above this value.

- Above (100 kHz) conductance incrementing effectiveness depends on concentration, not on the frequency.

When the concentration value increase, so the volume will increase, and the number of ions per unit volume decrease, consequently the conductivity decrease because the conductivity of a solution is the conductance of ions present in a unit volume of the solution. On dilution, conductance = conductivity, so conductance (G_m) will decrease [47].

2.6.2 Relationship the admittance and frequency

Admittance in form of a capacitance C_m.

- At a lower: (C_m) decrease with increases the frequency.

- At high frequencies: is saturates because (C_d) is effectively a short circuit at high frequencies and $(G_m = G_b)$

$$Y = G + jB \tag{2-30}$$

Y= admittance in Siemens.

G= conductance in Siemens $\qquad \frac{R}{R^2 + X^2}.$ $\tag{2-31}$

B=susceptancein Siemen $\qquad B = -\frac{X}{R^2 + X^2}.$ $\tag{2-32}$

$X_{C=} \frac{1}{2\pi f c}$ $\tag{2-33}$

The calculation can be done by $(C_m\ G_m)$ below 100 kHz if above 100 kHz so, it can calculate (G_m) only so a (100 kHz) can be taken as a standard to the measurement.

The conductance (conductivity) of the natural solution is higher than the solution that is concentrating. So at a dilute solution the conductance will decrease with the increase in the percentage of concentration.

2.6.3 Temperature Relationship

With concentration and conductance:

The Percentage rate of change of conductance with the temperature at a dilute solution is decrease with the increase of concentration.

2.7 Neural network

Neural network imitates the mechanism of the brain and the information processing paradigms inspired by biological nervous systems, which have consisted of the elements operating in parallel simply.

The brain is composed of connections for neurons, the neuron of the neural network had represented by nodes. It is assembling to connect the input with the output, the stored information is saving in the form of weights of the signal (w) and the bias (b). Before weight enters the neuron, each input signal is doubling by weight, and the output of the neuron is multiplying the weight with the input vectors, that make a summation for the neurons plus the bias value. The results represent the output of the neurons, the activation function determines the behavior of a node.

There are several types of neural networks depending on the methods of connection between the neurons. The layer connection is the most type of connection prevalent, not accessible layers between I/O neurons are known as hidden layers. The architecture of the neural network is gradually developing from simple to complex, initially (single-layer neural networks) which has I/O neurons, later the additive hidden layers to the first type is called (shallow neural network). The neural network is called deep if it has more than two layers, the signal progressing is passing sequentially from (input, hidden then output) neurons, that means it had received then it is processing by neurons to transmit to the next new layer. [48]

In general, the connections between elements (weights) can determine by the network function. By adjusting the values of the connections (weights) between elements. A neural network can train to perform a particular function

Usually, neural networks are trained or adjusted by comparing between the output and the target vector until the network output matches the target, which illustrates in figure (2-4) below. A specific target output can obtain from a particular input. Typically, many such input/target pairs are needed to train a network. A Neural network has trained to solve problems that are difficult for human beings or conventional computers also perform complex functions in various fields, including identification pattern recognition, speech, classification, control systems, and vision paradigms that build up to. It can use in financial, engineering, and other practical applications that cause to emphasize the use of the neural network. [49]
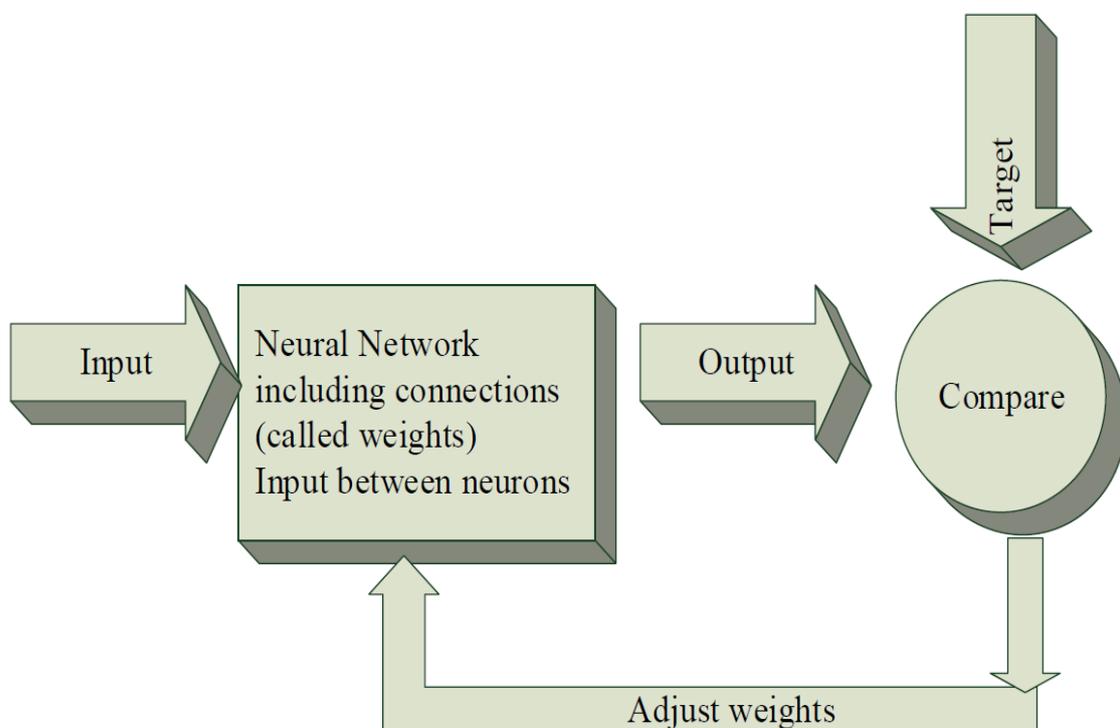

Figure (2-4) Mechanism of neural network

System identification is a fundamental aspect that needs to be considered to comprehending the process before taking the procedure to handle it and before the controller design, the ability of the system to know the model is to be the main target of system identification.

Neural networks have been using to solve problems that the human brain is perfect at, such as recognizing text, sound, and pictures, where it can be used to features extraction from algorithms for classifying and clustering. [50]

Neural networks contain the arrangement of neurons in interrelated layers. The information transforms from the input to the hidden layers by multiplying the inputs by the weights, and then a bias adds to the input feeding the current, and an activation function has been applying to the result which decides if the neuron must be activated or not and move the output in the next layer and keep repeating the process until it arrives in the last layer [50]. The training process continue to adjust the input weighting by updating the weights and biases of the neurons until the error becomes as minimal as possible as is illustrated in figure (2-5) and (2-6) below:
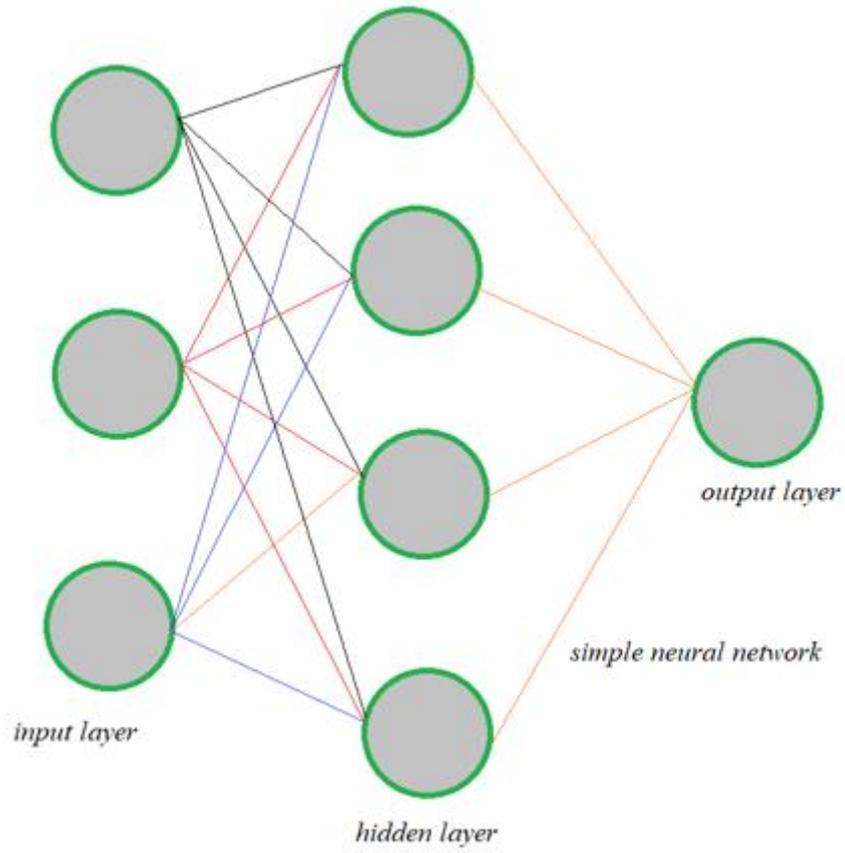
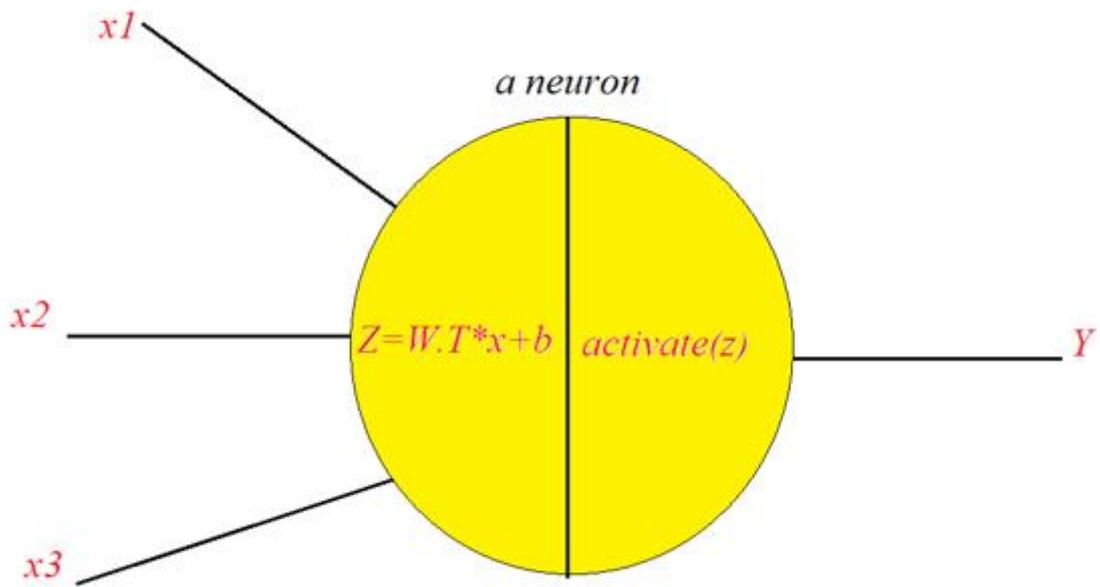Figure (2-5) Structure of neural network

Figure (2-6) Structure of neuron

The activation function is dividing into two types:

(Linear or identity activation function) must be differentiated.

$$f(x) = x .$$

$$f'(x) = 1 .$$

- (Non-linear activation function).

If there is no activation function so the weights and bias would act as a linear transformation. A linear equation is easy to solve, but the capacity to solve complex problems is limited, besides complex functional mappings from data that needs less power to learn. The complex data can learn the network to give accurate predictions and a function representing a question. At each neuron of the Linear or identity the activation function of a neural network, the inputs are multiplying by weights the result will be great. The output signal is proportional to the input signal, which is only a linear function of the input signal, where there is no need to know how many layers which the neural network has, The reason returns to its behavior like a single layer. The last layer represents a linear function of the first layer by summing the layers. The result is a linear function else. It is not strong enough to model data, In addition, there is no relation to the input because the derivative of the linear function is a constant number that is equal to (1), thus is impossible to use back-propagation for understanding a better prediction which weights in the input neurons can be provided [50].

The non-linear activation functions that have high dimensionality, and they allow the model for creating a complex mapping between (I/O) of the network because they have a derivative of the function. It is related to the inputs so by using back-propagation is possible, that is fundamental to learn and model complex data like video, image, audio. The most

commonly used transfer function for multilayer networks is illustrating in the figure below:

a

+1

0

n

-1
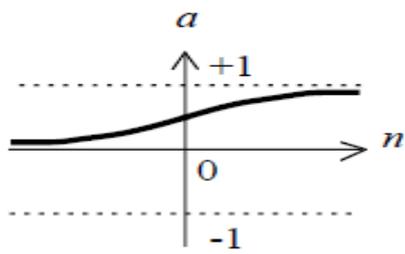
$a = logsig(n)$ $\frac{1}{1+e^{-n}}$ (log_sigmoid transfer function)

The output range between 0 and 1, as the neuron's net input goes from negative to posative infinity.

a

+1

0

n

-1
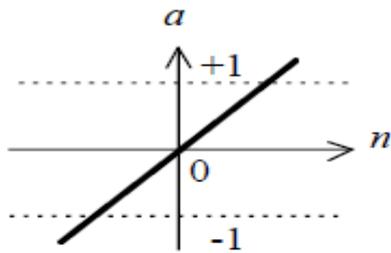
$a = purelin(n)$ $a = n$ (Linear Transfer Function).

a

+1

0

n

-1
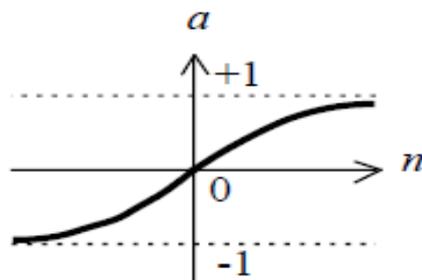
$a = tansig(n)$ (Tan-Sigmoid Transfer Function).

a

+1

0

n

-1
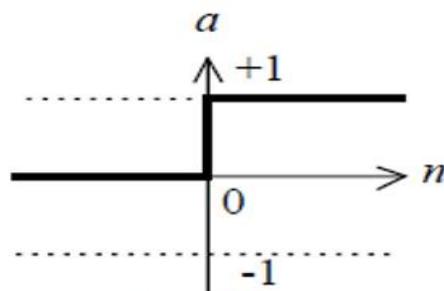
$a = hardlim(n)$ $a = 0 \; n < 0 , a = 1 \; n \geq 0.$

(Hard Limit Transfer Function).

Figure (2-7) Types of transfer function

(40)

2.8 Identification by using neural network

2.8.1 Perceptron network

The neural networks were developing to the perceptron network. It represents a network with single-layer, which is the simplest one thus the first training algorithm. The biases and weights with the corresponding input vector is being frequently trained for producing the required vector of the target, and that happens if the target vector is equal to the output of the neural network then the difference between them will be zero which is the error. The training technique is called the perceptron learning rule [50].

The perceptron has been interested because of its ability for generalizing from its training vectors. The randomly distributed connections that could learn from its initial perceptron is suitable essentially to a simple problem in pattern classification in addition, it is a reliable and fast network to a problem which can solve and understand more complex networks. The operations of the perceptron give a good, a hard-limit function (hardlim) is the transfer function which is using in the neuron of perceptron a suitable weight w1j can adjust with each external input for the network weight w1j. After summing the weighted inputs, the hard-limit transfer function will receive it. The output of transfer function is either 0, or 1, and the input 1 value is transmitting through the bias. If an input to the transfer function is equal to or greater than (0), the perceptron neuron gives a (1), or else it will be a value equal to (0) [50].

As is illustrating in the figure below:
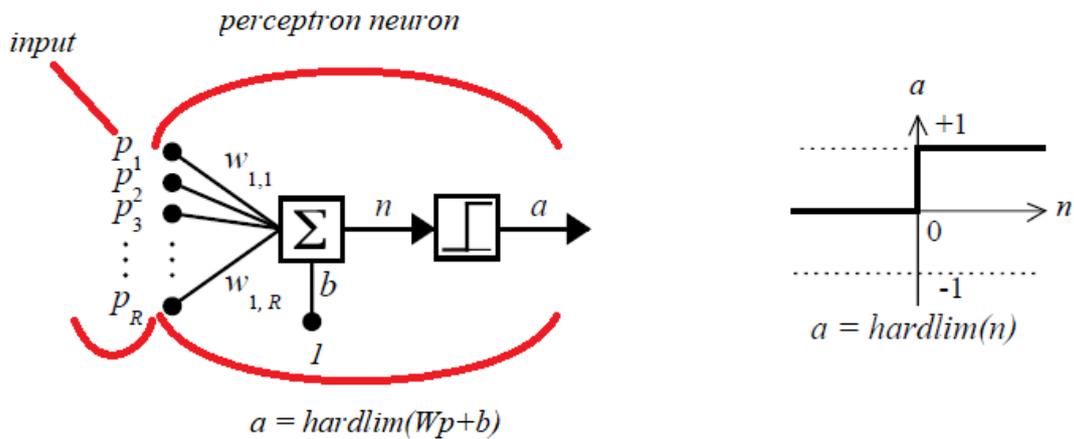
Figure (2-8) Hardlim transfer function

A hard-limit transfer function provides the ability of a perceptron for classifying the vectors of inputs where the input data is being divided into 2 regions by a separating line is called the bias. Precisely, the first region is output (zero) when the input of the network (n) $n < 0$ or outputs (1), when the input of the network (n) $n \geq 0$.

There is a decision boundary line (L) this line is perpendicular to a weight matrix (W) by this line. The output regions can classifying. It shifted by the amount of the bias (b) to the input vectors above, and the left of the line (L) so network input is > 0 then, the output result of a hard-limit neuron is (1), or else the vectors of input is below and toward the right of the line (L). The result of the output of hard limit neuron (0). The values of weight and also the bias could choose for directing the dividing line (L) and moving it so that. If the space of the input vector had been classifying to the required location, the neurons of a hard limit could consider without bias, so the classification line going through the origin. In addition to the bias permits to shift of the decision boundary far from the origin. The bias permits to solve problems by the neuron where if two sets of input vectors do not existing, on different sides of the origin. The decision boundary would be shifted far from the origin by using the bias.

The linear networks are identical to the perceptron, expect their transfer function is linear but a hard-limit in perceptron, which permits to pick each value by the outputs, while the output vector of the perceptron is bounded to be either (zero) or (one), where the networks which are being linear have similarity to the perceptron. It can just fix problems that have separable is linear for any input vector, there is an output vector that can be calculated. As the error value is the subtraction of the target from the output vector [50].

Fortunately, linear systems have a single error minimum and can be calculated directly. The network weights and biases values can be found to get minimized or below a particular value to the sum of the squares of the error. In most cases, the network can be always training for having a minimum error to the given input vectors and the target vectors by using the least mean squares [50].

The direct determination of the linear network is being happened when the minimum value of error had been gotten with respect to a given vector of input and target. While the calculations with a numerical value prevent the direct determination. A linear layer is created and designed for a particular target by using the function (newlin) [50].
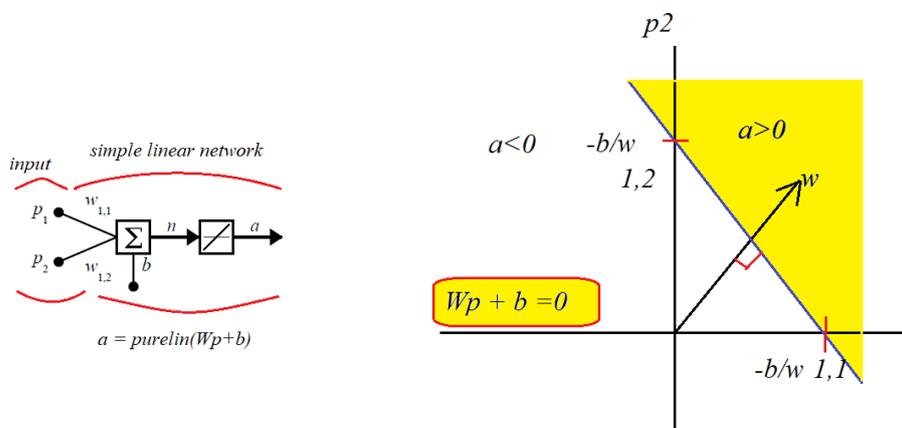
Figure (2-9) purelin transfer function

The existence of a decision boundary in the linear network like in perceptron network, which is determined by the vectors of network input (n) when is being with a zero value as is illustrating in figure (2-9). For n is equal to zero, so the equation is to be as follows: (Wp + b = 0) for a decision boundary designating. The vectors of Input at the right yellow upper part leads to the output is > (zero). The vector of inputs at the left white lower part leads to the output is < (zero). So, the classification of objects into two categories can do by using the linear network, where in the method of the objects can be linearly separated anyway[50].

The limitation in a linear network is like in the perceptron, and to training the network in figure (2-10). It must be doing the following steps:
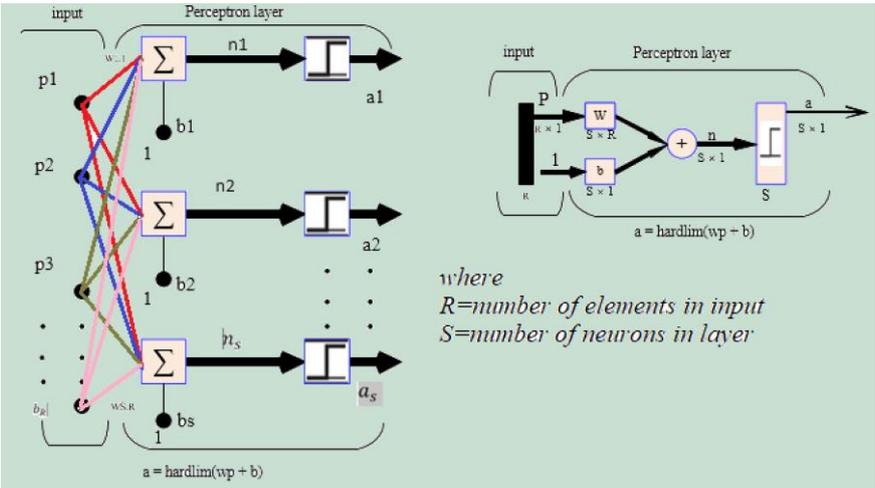
Figure (2-10) Neural network structure

S = neurons of a single layer perceptron.

R = inputs, Wi, j = weights set connect (jth) inputs to the (ith) neurons

(newp) is the function that creates a perceptron network, and we can call it as follow [54]:

P   = input vector to each R element

t = correct target vector to each S element must be equal either (0 or 1) if we use the hardlim transfer function, which outputs only 0 or 1.

a= the output of the network, which represents the neuron responding.

(hardlim, logsig, tansig, and purelin) is the most common function is using in perceptron. The objective to minimize the error (e) where:

$$(e = t - a).$$ (2-34)

(learnp) = is The perceptron learning rule determines the required changes for perceptron weight and biases (learnp) is implemented many times each time there is a change to get the correct outputs at every change the output value will be better. The perceptron rule approaches a solution to a finite number of repetitions, and the function (learnp) are using to get a result with minimum error through altering the weight vector (w)only or the weight(w), and bias (b)vector. If the solution converges toward input vectors then the output will be classified as (1) else the output vector will be classified as (0), and it is away from the input [54].

Three cases appear for a single neuron:

CASE 1- a = t, e = t − a = 0, so the weight vector w is not changed.

CASE 2 - a = 0, t = 1, e = t − a = 1, input vectors (p) are added to weight vectors (w). That means the weight vector point approaches the input vector and led to an increasing in the chance of input vector. Classing as 1

CASE 3-a = 1, t = 0, e = t − a = −1, where p = input vectors are subtracting from w = weight vectors, that means the weight vector heading away from an input vector and led to increasing the chance of input vector. Classing as (0) [50].

There are no errors, then-new weights and biases can stop repeating the process with all the linearly separable classification problems. The objects can be classified by separated by a single line repeatedly usage to (sim and learnp) led to change the weights and biases values to present inputs. For a perceptron according to the error, which finally solves the problem as long as it can solve by using perceptron. The transitions between inputs and targets vector through the training process is called a pass [50].

Now the process of training the network.

$$net = train \ (net, p, t) \tag{2-35}$$

$$net.trainParam.epochs = 500 \tag{2-36}$$

First of all, analyze the required problem must be sure if it is suitable for the perceptron network. The function train performs like a loop of calculation ,and it doesn't warranty a resulting of the network is doing as required, and the new values to the weight and bias must retrain by calculating the output of the network in addition to error at every trajectory. The function train progresses at specific successive inputs in addition for each input vector is being adjusted with the sequence of inputs are presenting in the network for seeing. If all targets are correctly calculating, for more training passes the train function can be called and repeated continuously until the performance of the network is succeeding.

The training steps can write, briefly as follows [50]:

The input and target vectors had been entered, then great a perceptron network by function newp as follows:

$$net = newp \ (P, T) \tag{2-37}$$

Initiation to weights and bias

$$net.b \{1\} = [0] \tag{2-38}$$

$$net.IW \{1, 1\} = w \tag{2-39}$$

Data division to training, validation, and test by function divideParam to change the data dividing ratio to get the best performance.

$$net.divideParam.trainRatio = 1 \tag{2-40}$$

$$net.divideParam.valRatio = 0 \tag{2-41}$$

$$net.divideParam.testRatio = 0 \tag{2-42}$$

Train the input vectors at specific epochs suppose one epoch.

$$net.trainParam.epochs = 1 \tag{2-43}$$

$$net = train (net, p, t) \tag{2-44}$$

The output simulation.

$$a = sim (net, p) \tag{2-45}$$

The output of the network calculation

$$hardlim (W (1) p2 + b (1)) \tag{2-46}$$

The result of comparison to the output of the network with the target vectors that are entering at the beginning of the network to get the error.

$$e = t - a \tag{2-47}$$

According to the result of an error, adjust the weight and bias to get a new weight and bias by using function learnp for repeating the training process until getting error zero or minimum error as much as possible.

$$W^{new} = W^{old} + ep^{T} \tag{2-48}$$

$$b^{new} = b^{old} + e \qquad \text{(2-49)}$$

$$w = net.iw \{1, 1\} \qquad \text{(2-50)}$$

$$b = net.b \{1\} \qquad \text{(2-51)}$$

$$dw = learnp \qquad \text{(2-52)}$$

$$W = W + dw \qquad \text{(2-53)}$$

Repetition to the training of the network

$$net = train (net, p, t) \qquad \text{(2-54)}$$

Repetition to the simulation.

$$a = sim (net, p) \qquad \text{(2-55)}$$

Repetition to the calculation steps of the output of the network [50].

$$a = hardlim (W (1) p2 + b (1)) \qquad \text{(2-56)}$$

$$e = t - a \qquad \text{(2-57)}$$

If the error reaches zero or minimum value, then stop training and take the result, so by all above, there are two or more objects that can identify and make a classification to its type according to its input data which is entering into the network in the beginning. To get the best performance to the network the two data vectors must separate by a constant number like K. Separate the two input vector to avoid interference between data and make the network doing the classification process correctly without error which caused by interference of the two data input vectors.

Chapter three

Proposed system

3.1 Introduction

The chapter aims to detect or sensing various types, and different quantities of pollutant materials in water and orange juice, and other solutions' extraction from fruits. The second stage is a discussion of how to train a neural network to distinguish the type of pollutant materials depending on the data detected, which is getting from the detection system in the first part by using perceptron code and feed forward network.

3.2 Steps of designing

The system consists of three parts that are connecting with Arduino, each part of the system contains a group of elements, each of the three types depends on a different principle, and the results have been explaining as illustrates below:

First stage:

TDS sensor had been connected with Arduino, and the readings depend on electrical conductivity and the PH sensor had been connected with Arduino and the readings depend on measuring the voltage, or difference in electrical potential between the measurement electrode and reference electrode to PH sensor. A DS18B20 waterproof one-wire sensor had been connected with Arduino, which is used to measure a digital temperature.

The following procedures have been tracing to design a detection system, and a summary had been giving by four steps:

The circuit diagram had been drawn by using tinker cad (www.tinkercad.com), and (fritzing software). The code had been written by Arduino IDE software version 1.6.13.

The system had been operating and making calibration to the (TDS, PH, DS18B20) sensor. The results had been showed on screen (LCD 2×16), or by serial monitor, this step will discuss in chapter four.

Second stage:

Identification by using perceptron code, feed-forward network was doing. Four type of data had been used which represent data to the type of pollutant materials. By measuring wavelength and absorbance to the four types of data and made classification. At first as two-class by using perceptron network. The second classification to classify the parameter of the proposed system by using the feed-forward network. After doing that, the type of pollutant materials can identify to which class belongs. It can be represented by 0 or 1 to each class. The workflow for any problems to train the network has seven primary steps:

The first step is collecting data. This step is outside the MatLab setting, where it took from the first stage. The second step neural network is created. Third step is neural network is configured. Fourth step is the weights and biases values are initialized. Fifth step neural network is trained. Sixth step is neural network is validated. Seven steps neural network ready to use.

The representation of the whole system can be represented by chart in figure (3-1).

3.2.1 Circuit diagram drawing

The Connection of TDS, PH, and DS18B20 sensors with Arduino UNO and LCD screen (2×16) can be shown in figure (3-2) below:
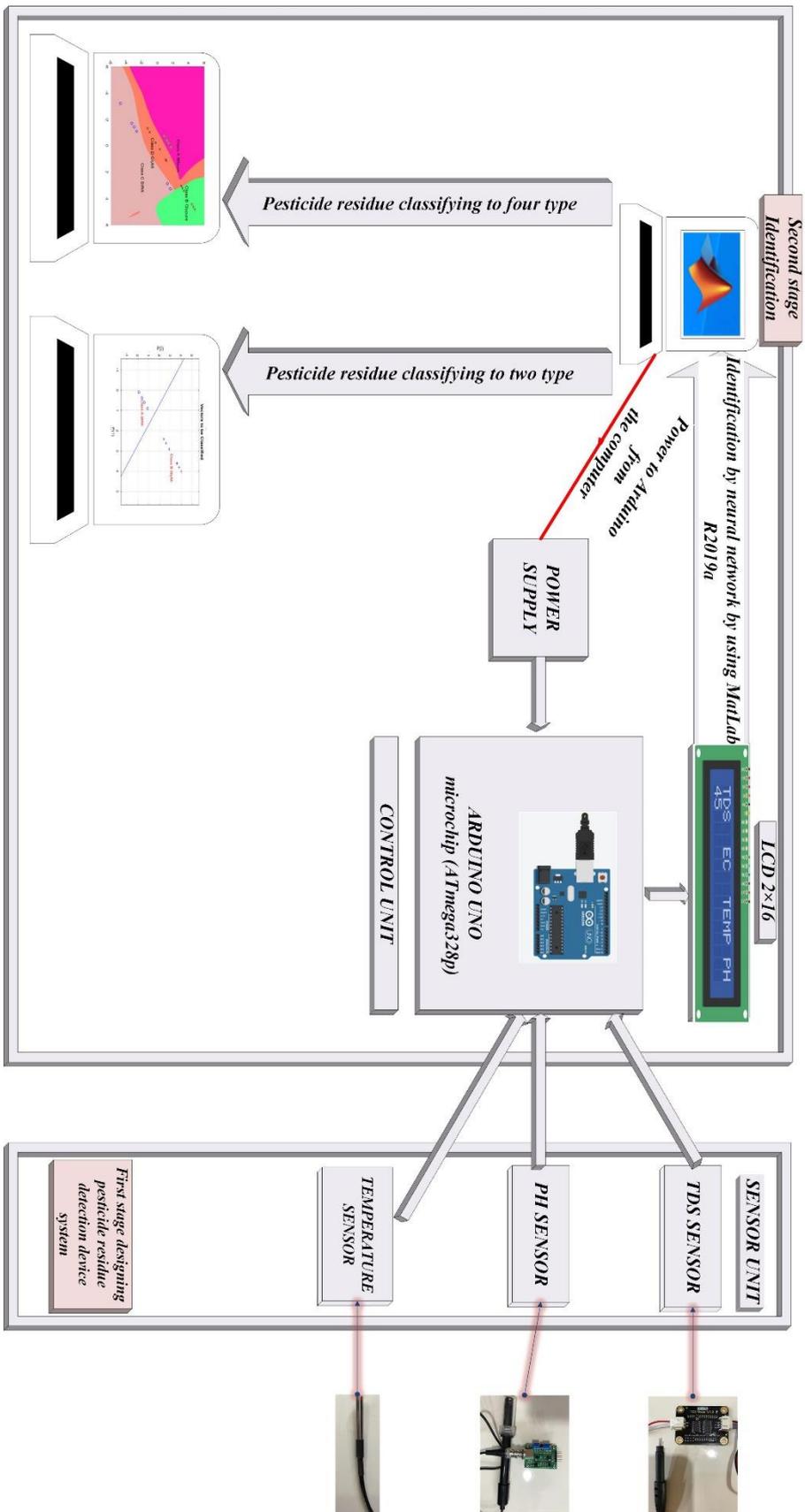
Figure (3-1) Block diagram to the proposed system.
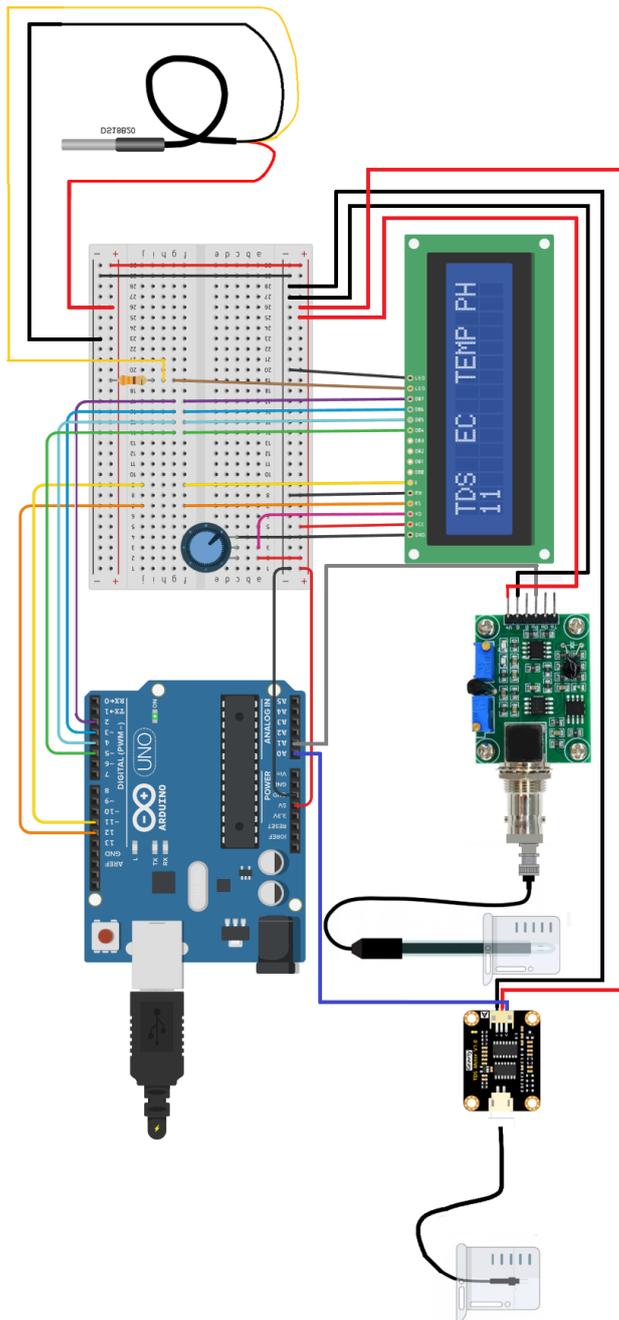
Figure (3-2) TDS, PH, and DS18B20 circuit diagram

3.2.2 The code writing

The steps to write code to TDS and DS18B20 sensor by Arduino IDE as follows:

All libraries that must include in Arduino IDE software had been uploaded to operate the sensor and execute the code properly. All that can be done by sketch Icons then choose (include library), and then choose (Manage Libraries) to download from internet or if the folder had been downloaded previously. It can be added to Arduino IDE by Add. ZIP Library as shown in figure (3-3), and (3-4) below:

The libraries which had been downloaded as follows: (EEPROM, Gravity TDS library, one wire library, Dallas temperature library, Liquid crystal library)

The libraries above had been called by order include in Arduino IDE.
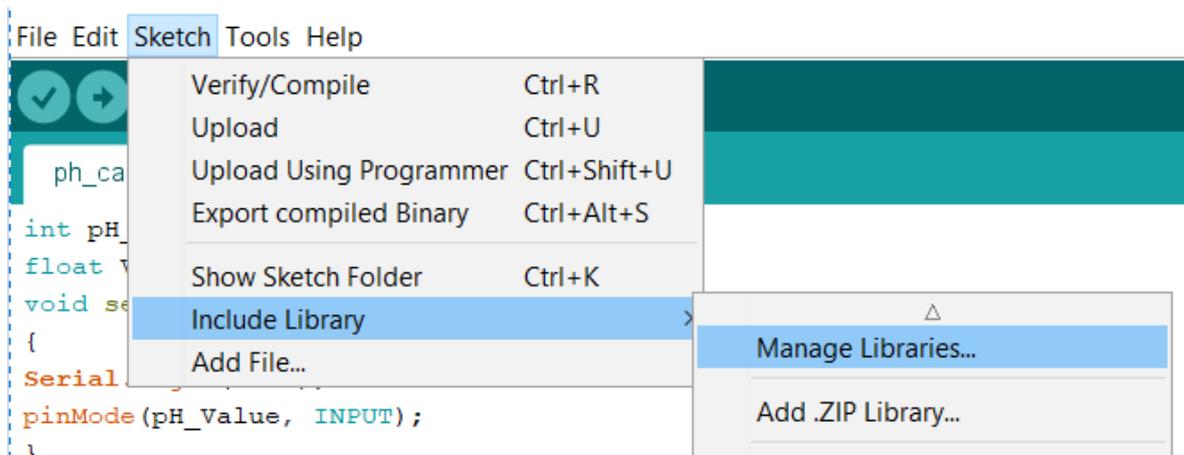
Figure (3-3) Library download interface.
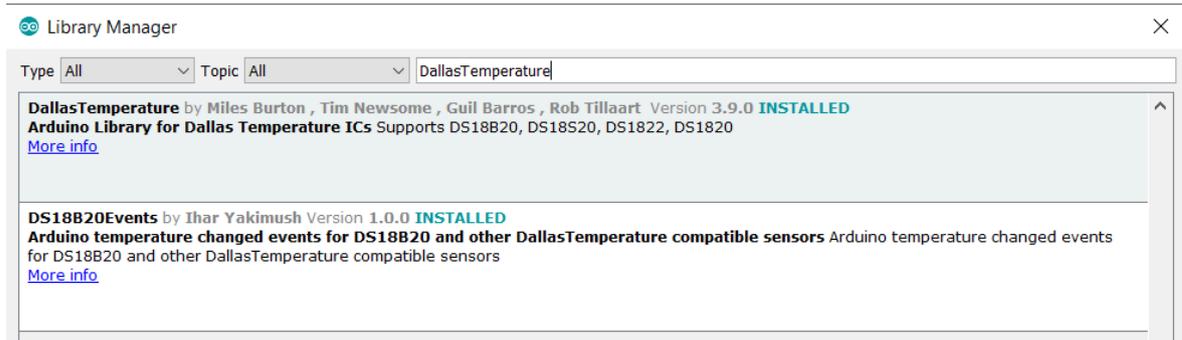
Figure (3-4) Library Manager Interface.

All the libraries and LCD 2×16 had been defined and initialized with the numbers of the interface pins in Arduino Uno. For each sensor had been taken a reference and its calibration by integer or float number. Void setup loop had been begun. Debugging on hardware serial from A0 to A5 according to sensor pin which is connected with Arduino. Serial begin at (115200). The LCD and all sensors had been begun.

The reference voltage had been put on ADC, default (5 v) on Arduino Uno. Put 1024 for 10bit ADC, 4096 for 12bit ADC. Gravity tads had been begun to make initialization. Begin void loop. Temperature sensor had been added and read the value where:

$$\text{Temperature} = \text{read temperature}();$$

The temperature setting and executing temperature compensation. Sample and calculate. The values had been gotten. The analog value had been read more stable by the medium filtering algorithm and the analog value had been converted. Temperature compensation formula as follows:

$$\text{fFinalResult}\left(25^{\wedge}\,C = \frac{\text{fFinalResult(current)}}{1.0 + 0.02 * (\text{fTP} - 25.0)} \right);$$

EC value had been gotten by temperature and calibration compensation with formula as follows:

$$ec = \left(\frac{\text{analog reading}}{\text{temperature coefficient}} * ec\ \text{calibration} \right);$$

All the results tds, EC, temp values had been showed and printed in a serial monitor. LCD clear. All the results tds, EC, temp values had been showed and printed in LCD 2×16 screen. Delay in mille second which represent time rate between each reading with the next. End by closing void loop.

3.2.3 The code implementation and calibration

To TDS and DS18B20 sensor:

Codes are substantial to write because each part had connected with Arduino, so it must be programmed to operate it, where it can do that by uploading the programming code which had been programming to the microcontroller ATmega328p of Arduino.

All codes had been written by Arduino IDE software version 1.6.13. Everything which the sensor had been implementing is being controlled by using the code, consequently, the results can view or show on the serial monitor interface or a liquid crystal LCD. All orders that wish to implement the required results. It can call up by code for that reason, that part can consider as scalable and changes its results by controlling the order in codes

Adjust the Arduino interface at the port at (COM5) and choose the Arduino board at Arduino Uno and uploading the code, then open the serial monitor of the (Arduino IDE) as showing in figure (3-5).
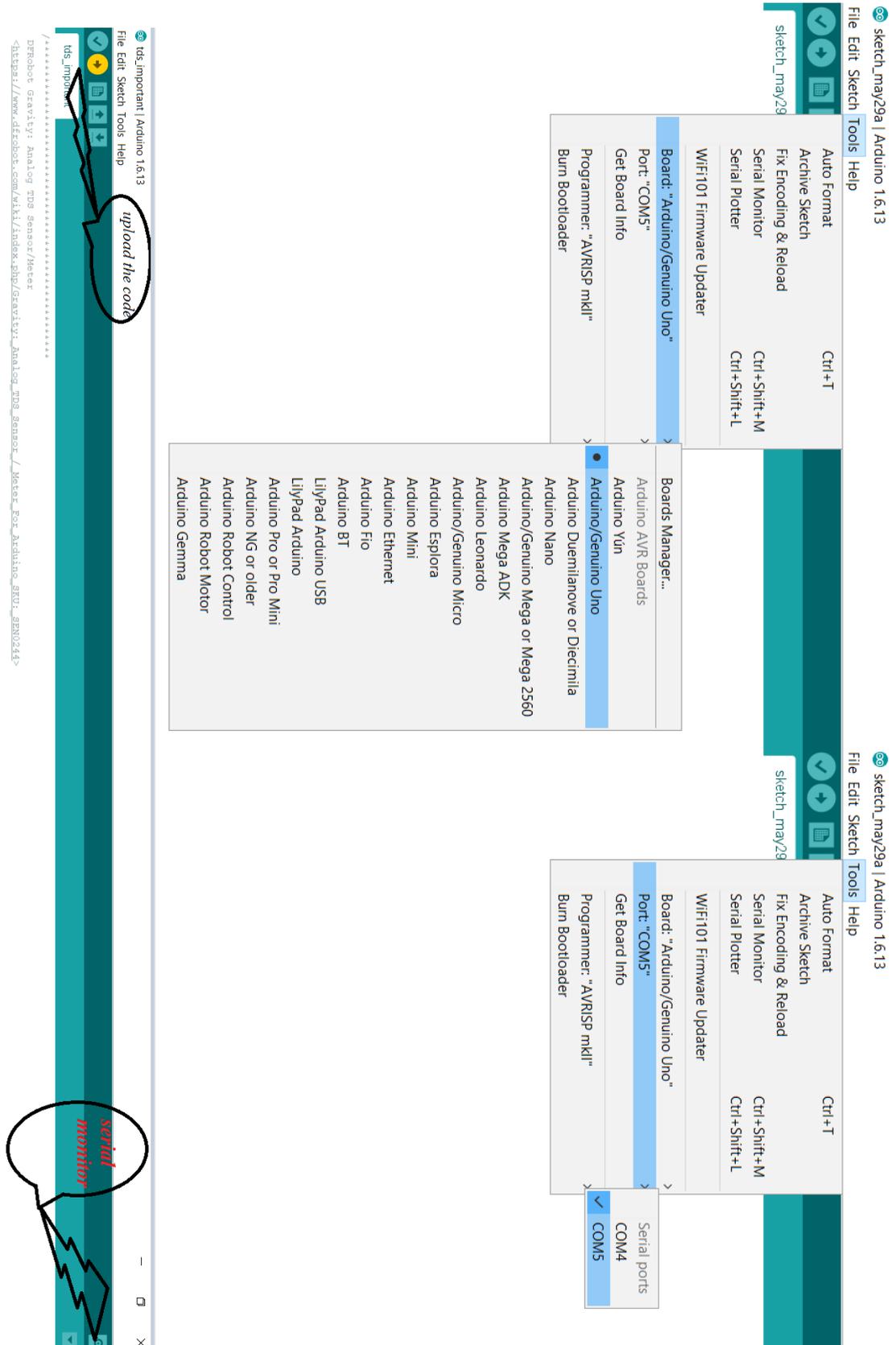
Figure (3-5) Arduino IDE setting interface.

The calibration mode had been done before measurement. Besides, for more accuracy, it is advised to connect a temperature sensor for temperature compensation to improve accuracy because the temperature effect is very substantial, and the effect measurement so takes the measurement value at (25℃).

- Before the calibration be sure that the serial (dubbugging) number in the (serial monitor) is the same as the code in the (void set up) loop because: if that doesn't execute, then the measurement value will not occur, as the temperature sensor is connecting with the sensor, so it prefers to put a value number equal to (115200).

- Make calibration mode after uploading code by controller board, and then open the (serial monitor) of the Arduino IDE and write Input command (enter) as showing in figure (3-6).

Enter the command (cal: TDS value) for calibrating the sensor, ionic water has been using with a TDS value for water are known, calibrate at (110ppm) at 25℃, so input command (cal: 110).

Put a TDS probe into the water and slowly stir it, then get the TDS value of the water when the reading is to be stable as showing in figure (3-7).

Figure (3-6) Serial monitor interface

COM5 (Arduino/Genuino Uno)

cal:110|

>>>Confrim Successful,K:1.95, Send EXIT to Save and Exit<<<
106ppm
EC:0.21
Temperature:25.87
110ppm
EC:0.22
Temperature:25.87
110ppm
EC:0.22
Temperature:25.87

Figure (3-7) Tds calibration.

Enter (exit): to (save) and then (exit) as shoeing in figure (3-8).

COM5 (Arduino/Genuino Uno)

exit|

```
Temperature:25.06
117ppm
EC:0.23
Temperature:25.06
117ppm
EC:0.23
Temperature:25.12
117ppm
EC:0.23
Temperature:25.12
117ppm
EC:0.23
Temperature:25.12
>>>Calibration successful,K value Saved,Exit Calibration Mode<<<
117ppm
EC:0.22
Temperature:25.12
```

Figure (3-8) Serial monitor interface indicates the step of calibration TDS sensor value.

After the calibration, use the TDS sensor to take results.

The electrical conductivity value can calibrate in the code at a value equal to electrical (conductivity = (TDS/conversion factor), (conversion factor = 0.67).

SO   EC = TDS / 0.67.

3.2.4 PH code writing

The steps to write code to PH sensor by Arduino IDE as follows:

All libraries that must include in Arduino IDE software had been uploaded to operate the sensor and execute the code properly, libraries can be uploaded as shown in figure (3-3), and (3-4), then call order include to include all the libraries as follows (Wire library, Liquid crystal library).

All libraries and LCD 2×16 library had been defended and initialized with the numbers of the interface pins in Arduino Uno the PH meter analog output is connected with the Arduino's analog pin. For each sensor had been taken a reference by integer or float number and reference to sample = 10. The average value of the sensor feedback had been stored as unsigned longint, then begin void setup, and put the output pin at digital pin mode in Arduino with serial begin at (9600). Begin the LCD and all sensors, then begin void loop, and loop 1 had been begun to get 10 sample from the sensor for smooth the value.

If the reading equals to 10 then take the analog reading, or else repeat for loop 1. The analog reading had been taken, then delay in mille second. For loop 2 had been begun to the value of (i) to sort the analog sensor reading from small to large. For loop 3 had been begun to the value of counter j. Sensor reading analog reading = i, then take counter

$j = i + 1\ where\ j < 10$ If the sensor reading is greater than counter j, then

$$Sensor\ reading\ i = counter\ reading\ j$$

Or else repeat loop 2. The value of new i had been taken, then the average value of the six center sample had been taken. The voltage had been read and then the analog signal had been converted into millivolt, then the millivolt value had been converted to PH value. All loops had been closed.

All the results of PH values in the serial monitor had been shown and printed. LCD had been cleared. All the results of PH values in LCD (2×16) screen had been showed and printed. The output had been shown on digital pin of Arduino as high and low. Delay in mille second which represent time rate between each reading with the next. End by close void loop.

3.2.5 PH implementation and calibration

To PH sensor:

Interface circuit has (6 male headers), which are being labeling as follow: (Do) represents (3.3V) DC output pin,(To) which is the temperature output, two ground pin and (V+)pin, Out of these six pins just three pins had been used (V+, G, and Po).

Connections:

The interface circuit	connection with	the Arduino
Two ground PIN G	one of them connected to ground	
		PIN G
PIN (V+)		PIN (V+) 5v
Analog output PIN (Po)		analog PIN A1

DC output PIN D0 (3.3v)   without connection

To temperature output   without connection

Laptop   Arduino

All those connections can illustrate in figure (3-2)

Settings:

Arduino board Arduino Uno had been selected.

 Communication port (COM5) had been selected.

The code had been uploaded, and wait for a while.

The serial monitor had been opened.

The analog signal at (P0) had been read, and the voltage had been displayed on the serial monitor. All those settings can illustrate in figure (3-9).

The PH value had been calibrated at the standard for each sample analysis.

- PH for distilled water = 7.

- PH for ionized water which had been used in this research = 7.8.
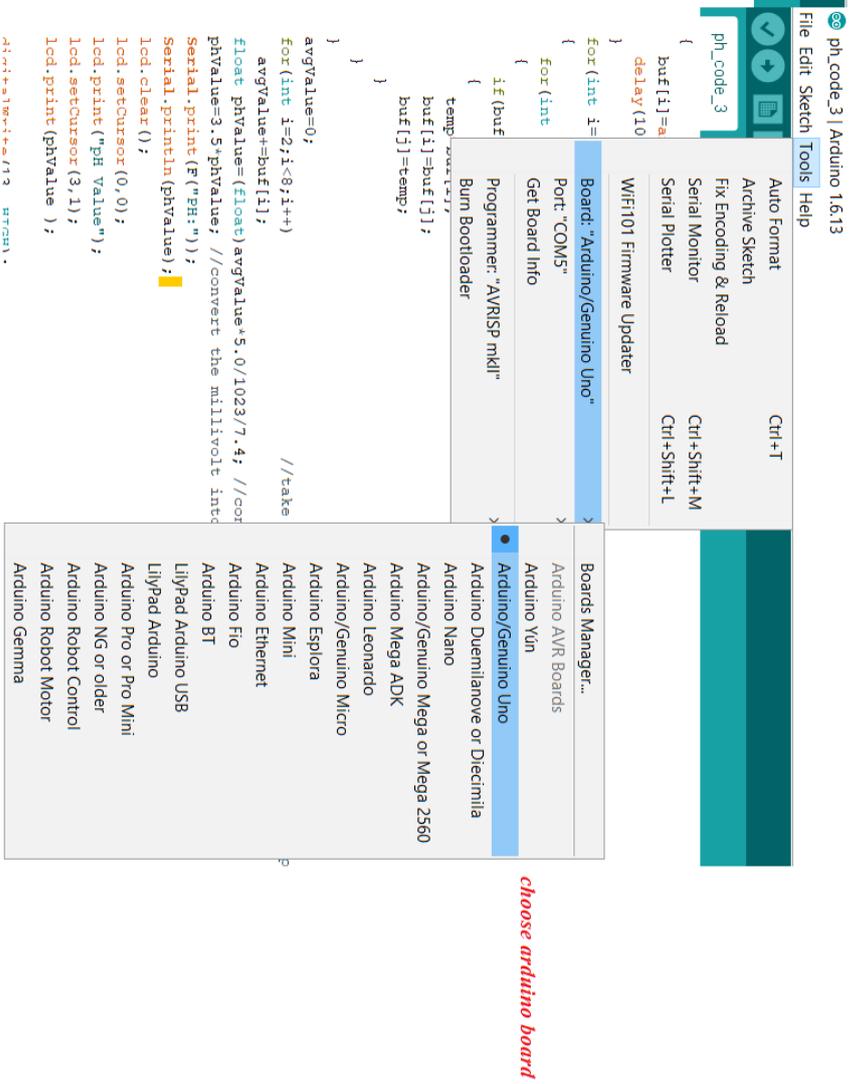
- PH for orange juice = 3.6-3.2.

ph_code_3

```
Tools
Auto Format                    Ctrl+T
Archive Sketch
Fix Encoding & Reload
Serial Monitor                 Ctrl+Shift+M
Serial Plotter                 Ctrl+Shift+L
WiFi101 Firmware Updater
Board: "Arduino/Genuino Uno"
Port: "COM5"
Get Board Info
Programmer: "AVRISP mkII"
Burn Bootloader
```

n small to large

Serial ports
COM4
✓ COM5

choose communication port

```
avgValue=0;
for(int i=2;i<8;i++)
    avgValue+=buf[i];                //take the average value of 6 center sample
float phValue=(float)avgValue*5.0/1023/7.4; //convert the analog into millivolt
phValue=3.5*phValue;  //convert the millivolt into pH value
Serial.print(F("PH:"));
Serial.println(phValue);
lcd.clear();
lcd.setCursor(0,0);
lcd.print("pH Value");
lcd.setCursor(3,1);
lcd.print(phValue );
digitalWrite(13, HIGH);
delay(800);
digitalWrite(13, LOW);
```

ph_code_3

```
Tools
Auto Format                    Ctrl+T
Archive Sketch
Fix Encoding & Reload
Serial Monitor                 Ctrl+Shift+M
Serial Plotter                 Ctrl+Shift+L
WiFi101 Firmware Updater
Board: "Arduino/Genuino Uno"
Port: "COM5"
Get Board Info
Programmer: "AVRISP mkII"
Burn Bootloader
```

```
Boards Manager...

Arduino AVR Boards
● Arduino/Genuino Uno
Arduino Yún
Arduino Duemilanove or Diecimila
Arduino Nano
Arduino/Genuino Mega or Mega 2560
Arduino Mega ADK
Arduino Leonardo
Arduino/Genuino Micro
Arduino Esplora
Arduino Mini
Arduino Ethernet
Arduino Fio
Arduino BT
LilyPad Arduino USB
LilyPad Arduino
Arduino Pro or Pro Mini
Arduino NG or older
Arduino Robot Control
Arduino Robot Motor
Arduino Gemma
```

choose arduino board

```
avgValue=0;
for(int i=2;i<8;i++)
    avgValue+=buf[i];                //take
float phValue=(float)avgValue*5.0/1023/7.4; //cor
phValue=3.5*phValue;  //convert the millivolt into
Serial.print(F("PH:"));
Serial.println(phValue);
lcd.clear();
lcd.setCursor(0,0);
lcd.print("pH Value");
lcd.setCursor(3,1);
lcd.print(phValue );
digitalWrite(13, HIGH);
```

Figure (3-9) Arduino IDE software interface.

V+:3.3v to 5.5v
G:Ground
G:Ground
P0:Analog voltage O/P

D0:3.3v output
T0:Temperature O/P

PH sensor probe — DIY MORE PH sensor kit

trimmer used to calibrate the sensor — leds

connector

BNC connector

PH sensor interface circuit pinout
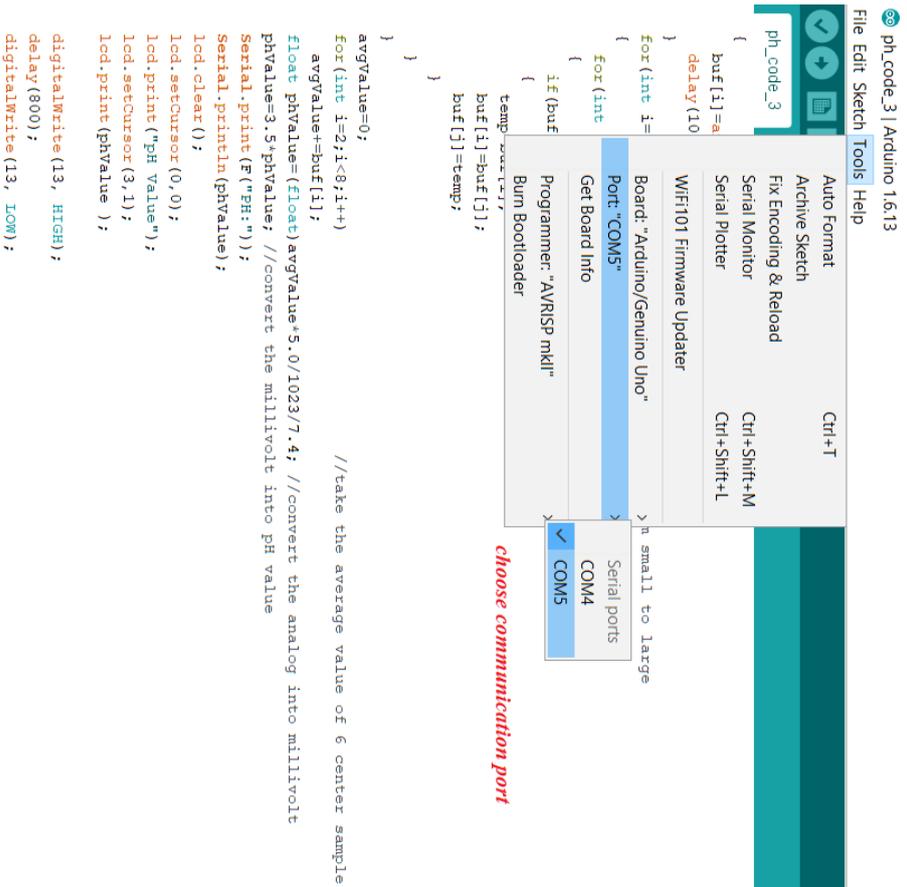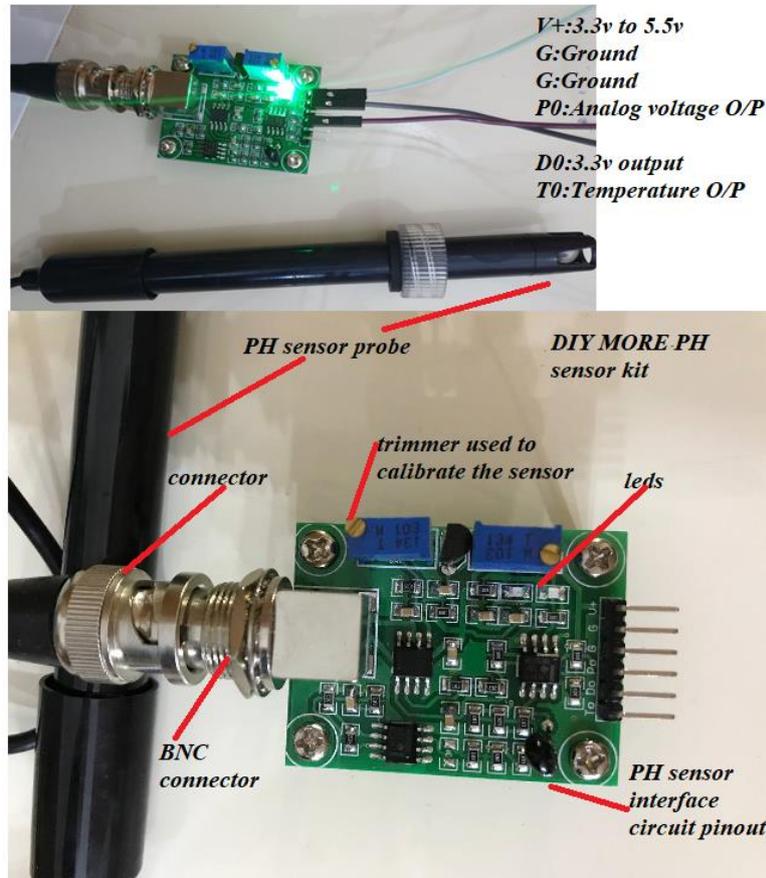
Figure (3-10) PH sensor

After uploading the code, (open the Serial monitor): to check the PH value for any samples, where the value is knowing in this code, and ionic water with PH = 7.8 had used. The voltage will be higher than (2.5), because the PH of 7 means 2 Volts. If the value of PH is higher or lower this value, so it must be adjusting by using a trimmer, which illustrates in the picture above figure (3-10). The PH sensor is now calibrated and display the PH value on the (LCD 2×16) liquid crystal or by serial monitor.

Serial monitor had been setting at debugging on hardware is equal to (9600) because this serial had registered in the code. The value will not occur in the (serial monitor) if the serial debugging don't be the same as the code in void setup loop. This value is not constant, sometime is being at (115200) if temperature sensor connected with them.

The calibration to the PH sensor can be done by two steps as follows:

The value of PH sensor had been adjusted by rotate the trimmer which is containing in the electronic parts to PH sensor as showing in figure (3-10) by compared the PH value with a known value liquid. By write code to do calibration to PH sensor by the following steps:

PH and the voltage value had been defended by integer and float values. Void setup loop had been begun. Serial at (9600) had been begun. All sensor and the LCD screen had been begun. Void loop had been begun. Analog reading at Arduino pin = PH value. The voltage had been read and the analog signal had been converted into millivolt.

All the results voltage values had been showed and printed in the serial monitor. Delay in mille second which represent time rate between each reading with the next. End by close void loop. The PH value had been compared with a known value liquid.

All the previous three-part can be showing in the figure (3-11) below which represent the proposed system:
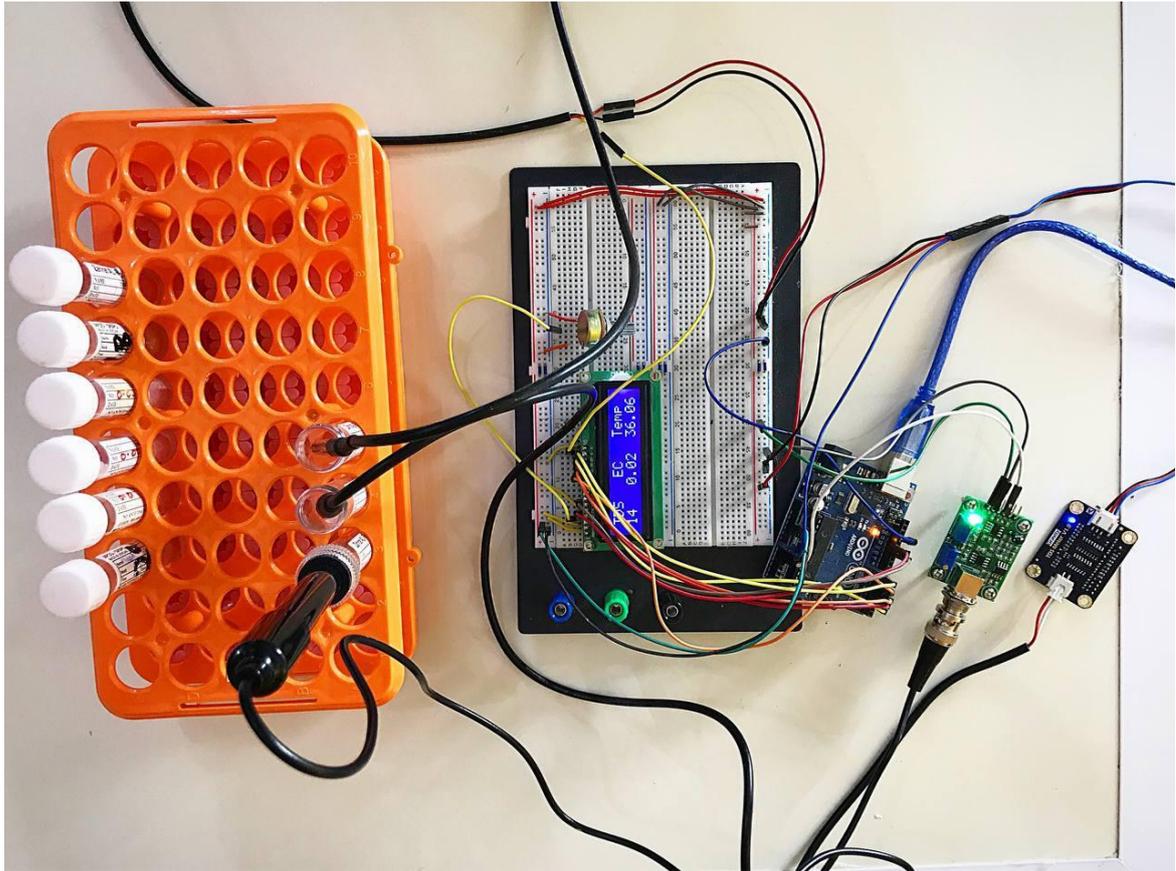
Figure (3-11) Detection pesticide residue experimental apparatus.

3.3 Classification by using perceptron code

The four data had been taking, which are as follows:

Type 1 data consist of two class with:

Class A: Bifenthrin 25EC: (181 test samples), which represents a pyrethroid insecticide.

Class B: Glyphosate 48%SL: (181 test samples), which represents an organophosphate herbicide.

Type 2 data consist of two classes with:

Class A: Bifenthrin (9 test samples).

Class B: Glyphosate (7 test samples).

Each type had been taking and classified into two classes by training a neural network using perceptron code the code which had been writing to distinguish the data type can be represented as steps as follows:

3.3.1 The code implementation

Training a neural network to data type 1, and the results is classifying into two classes. Class A (181 test sample): Bifenthrin, and class B (181 test sample): Glyphosate, which is representing by the following steps:

All the opened window had been closed and clear, then a constant number had been put to separate the two class of data and had been named as k. The number of data to each class had been put, and it had been named as N with the data of class A had been inserted, and it had been named as k1. The data of class B had been inserted, and it had been named as K2 plus the constant k. The data of k1 had been put in the form of matrix and it had been named as C1. The data of K2 had been put in the form of matrix and it had been named as C2. The input vectors had been inserted in terms of C1 C2. The target vector had been interred in terms of zeroes for all N to class A, and ones for all N to class B.

Perceptron network had been called to begin training and the number of epochs for training had been put. The perceptron network had been trained in terms of net, input, and target and the output of the network in terms of C1, and C2 had been simulating. Input and target vectors had been plotted and the weight and biased values had been plotted. The text Class A: Bifenthrin had been showed, with the text color for example red color. The text Class B: Glyphosate had been showed, with the text color for example red color. The grid had been operated then end the network training with a hard limit transfer function had been used at the output layer of the network as showing in figure (3-12) below:
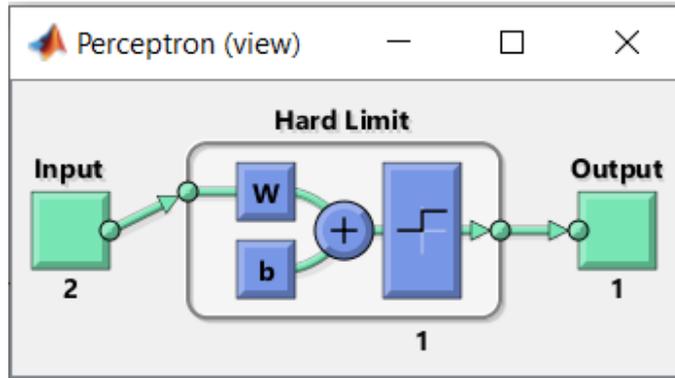
Figure (3-12) Perceptron network.

The best performance at epoch equal 3 iterations, mean absolute error and a hard limit transfer function had been using, so the classification will be as 0 or 1 because the output to hard limit is (0,1) all the training information shown in figure (3-13) below:

Figure (3-13) Training network interface.

To test the net if it operates correct or not, the following command can be used in the command window, where class A equal 0 and class B equal 1

- Network information can display by writing (view net) in the command window.

3.3.2 The code implementation

Training a neural network to data type 2, and the results is classifying into two classes class A: Bifenthrin (9 test sample), and class B: Glyphosate (7 test samples), which is representing by the same steps in type 1 with different number of data test only and the output of the network as shown in figure (3-14) below:
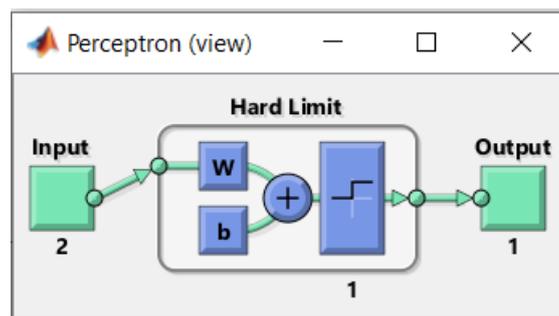
Figure (3-14) Perceptron network.

All the information of training and the results indicates in figure (3-15): the best performance at epoch equal 1 iteration, mean absolute error and a hard limit transfer function had been using, so the classification will be as 0 or 1 because the output to hard limit is (0,1).
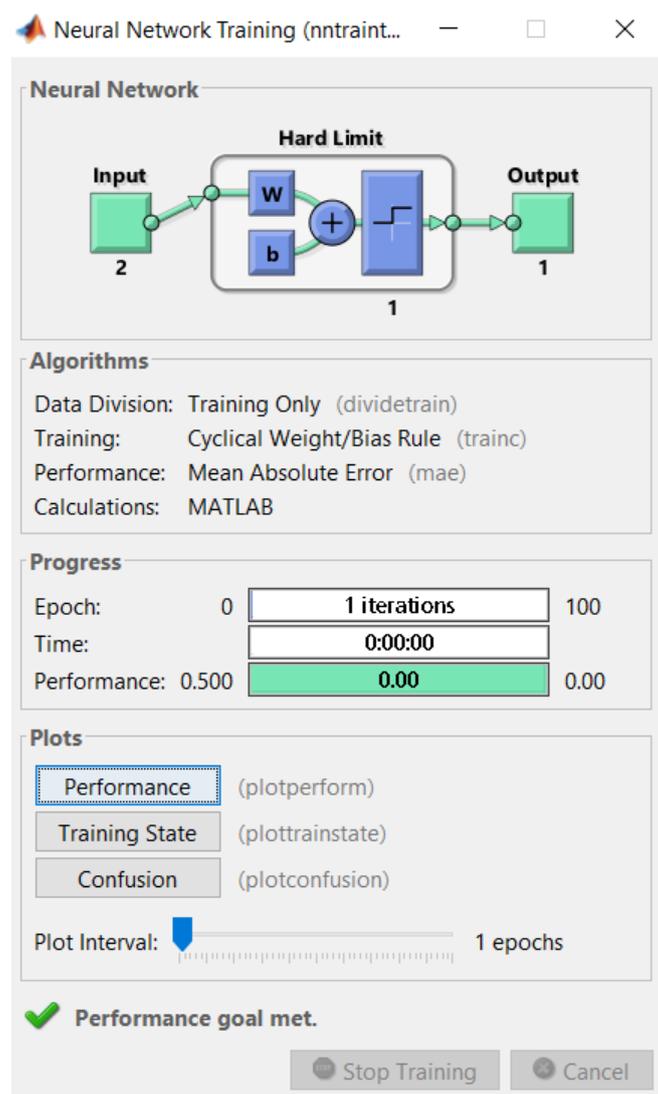
Figure (3-15) Training network interface.

To test the net, if it operates correctly or not, by the following command, which had been using in the command window, where class A is equal to 0, and class B is equal to 1.

- Network information can display by writing (view net) in the command window.

3.3.3 The Code implementation

For training a neural network to classifying the data parameter for the proposed system (TDS, EC, PH, temp) by using feed forward artificial neural network by doing the following steps:

All the opened window had been closed and clear, then a constant number had been put, and it had been named as (N), which is used to separate each two data about each other. The data to parameter 1 had been inserted, and it is called as k1. The data to parameter 2 had been inserted, and it is called as K2 plus the constant number N. The data to parameter 3 had been inserted, and it is called as k3. The data to parameter 4 had been inserted, and it is called as k4 plus the constant number N. The four clusters of the data parameter had been defined. The offset number of classes had been put as a constant number, and it had been named as q.

Class A is equal the data parameter 1(TDS) – offset number, data parameter 1 (TDS) + offset number. Class B is equal the data parameter 2(EC) – offset number; data parameter 2(EC) + offset number. Class C is equal the data parameter 3(PH) – offset number, data parameter 3(PH) + offset number. Class D is equal the data parameter 4(temp) – offset number data parameter 4(temp) + offset number.

The four clusters had been plotted. Text labels for each clusters had been put. Coding (+1/-1) to separate the four classes. The input data had been put as a vectors, where the samples from all the four classes had been combined, and it had been named as P vector. The target vector had been defined, and it had been named as T. Neural network had been created by using a feed forward network with three hidden layers each layer has 10 neurons and the four hidden layer with 4 neurons. The network training process had been begun.

The data had been divided as a ratio into three ratio (Training ratio, Validation ratio, Test ratio). The number of epochs, which need for training had been put. The network training had been begun in term of net, input, and target. The output of the network had been simulating in term of A, B, C, D.

The network had been viewed. The performance evaluation decoding a network response. The target class evaluation. Prediction class evaluation. The number of all samples had been evaluated, and it had been named as N. The number of misclassified samples had been evaluated, and it had been named as a constant k, and the k value is equal to 0. The subtraction of predict class from target class had been evaluated.

If there exist a misclassified samples, so the number of misclassified samples must be gotten, or else end the loop. The correct classified samples is the sentences, which printed to show the correct samples. The network output had been plotted. The grid had been operated. A neural network had been simulated on a grid. Classification regions had been plotted, and based on MAX activation. End the network training process.
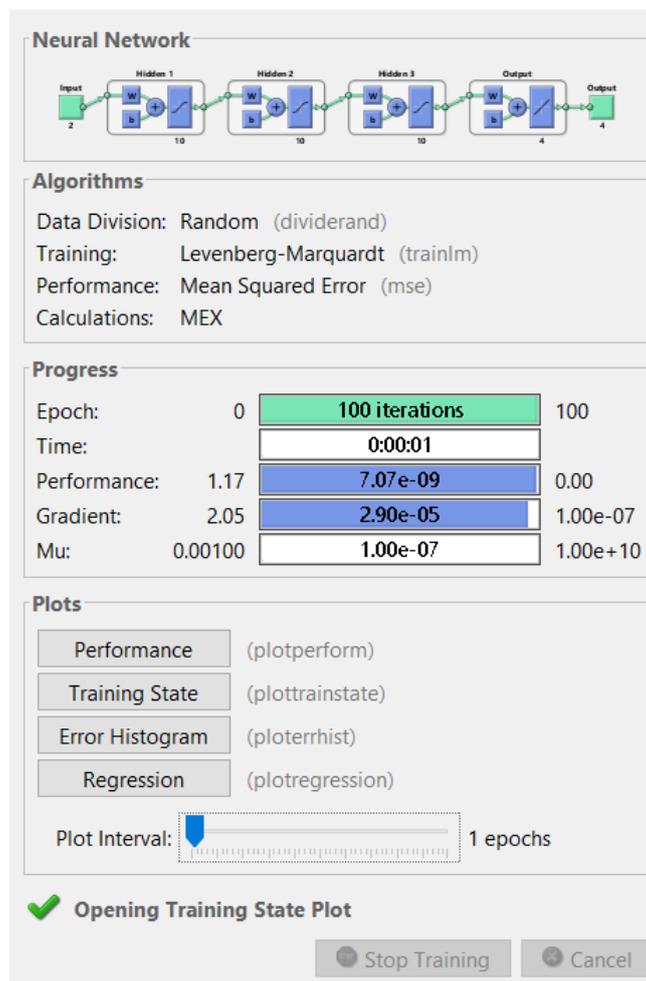
Figure (3-16) Training network interface.
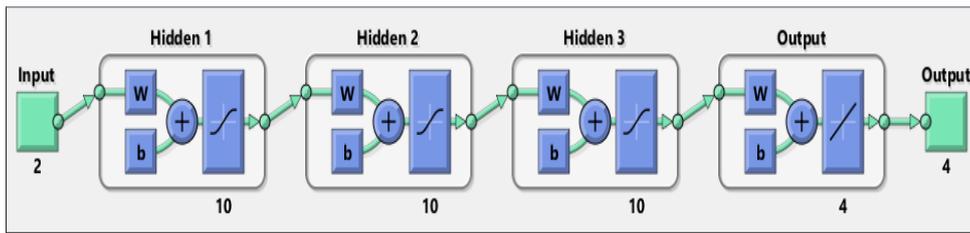
Figure (3-17) Result of training network interface.

As shown in figure (3-16) and (3-17) indicates the results for four parameter of the proposed system TDS class A, EC class B, PH class C, and temp class D. The sample had been taking to wavelength and absorbance is 7 samples only. The feed-forward neural network is used with 4 layers where the first three layers are hidden layer with 10 neurons, and the last layer is the output with 4 neurons. The conclusion is that the training must continue until gives the best performance in classifying data at R=1, where at this point, the output data fit on the training data. It had been getting at algorithms with random data division in this training all data distributed to training without validation and test data. The reason of the data which, had been chosen, that it is seven samples only, so it is a little. It just sufficient for training without validation and test, training had been doing with Levenberg-Marquardt, mean square error with 100 epochs.

The whole process to the detection system can indicate in flow chart (3-18) below:

Figure (3-18) Process of the proposed system or methodology

Chapter four

Results and discussion

4.1 Introduction

In this chapter, the discussion about the results which had obtained from implementing the first part. The proposed system is a detection device system of polluta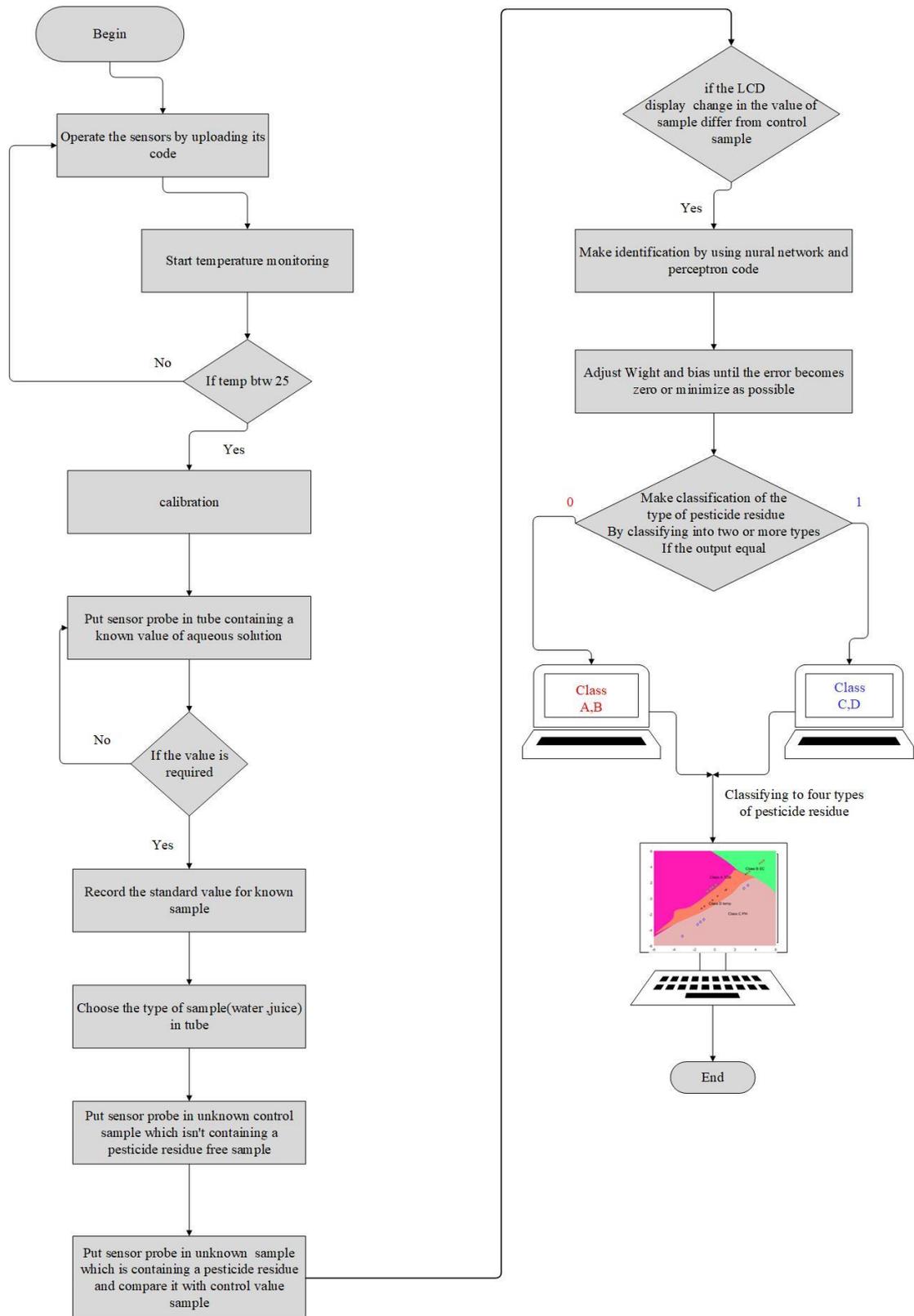nt materials. The calculations had been done by excel to calculate the mean value for a set of samples. The standard devotion and relative standard deviation to show the difference between the performances to each part of the system and then draw the chart to calculations. The second part which is concern identification by using neural network and write the most substantial remarks, which had concluded, when implementing the two-parts.

4.2 Results of a system device

4.2.1 TDS results

The value of TDS and EC had been indicates in table (4-1), (4-2), and (4-3), which had been taking from analysis samples. After that, the calculations to each reading are doing like mean value. The standard deviation and relative standard deviation value by using excel as shown in figure (4-1) and then graph a chart to indicate the difference between readings. All calculation is doing to distinguish any change between samples, which contain pollutant materials and free samples. The type of pollutant materials that had been using in the samples test is a type of pesticide, which is a (Glyphosate 48%SL). The aim is to detect the pesticide and to distinguish the pesticide from the other materials which are containing in water by a control sample.

the Relative Standard Deviation calculations

$$STDEV.S(\ )=standard\ deviation$$

Standard Deviation (S)	10.55935604

Sample Mean is calculated as:

mean value = SUM( )/COUNT( )=the sum of the values over their count

Sample Mean (x¯)	606

Relative Standard Deviation is calculated using the formula given below
Relative Standard Deviation (RSD) = (S * 100) / x¯

Relative Standard Deviation	1.742467994

Figure (4-1) indicates the calculation in excel

Table (4-1) Indicate the values measurements of the TDS and EC at different concentrations of ionized water market samples.

Type of sample	Concentration	EC	TDS	TEMP
Ionized water with Glyphosate	0.01	0.15	115	25.37
Ionized water with Glyphosate	0.002	0.23	174	25.37
Ionized water with Glyphosate	0.005	0.17	121	25.37
Ionized water with Glyphosate	18	3.89	3642	25.37
Ionized water with Glyphosate	20	3.93	3656	25.37
Free sample	control	0.3	139	22.94
Ionized water with Glyphosate	0.1	3.8	2069	22.94
Ionized water with Glyphosate	0.2	4.03	2300	22.94
Ionized water with Glyphosate	0.4	4.07	2354	22.94
Ionized water with Glyphosate	0.6	4.08	2354	22.94
Ionized water with Glyphosate	0.8	4.07	2354	22.94
Ionized water with Glyphosate	1	4.08	2354	22.94

Table (4-2) Indicate the values measurements of the TDS and EC sensor at different concentrations of orange juice market samples.

Type of sample	Concentration	EC	TDS	TEMP
Orange juice	free	1.62	1285	20.75
Orange juice	0.2	3.68	3596	20.75
Orange juice	0.4	4.21	4572	20.75
Orange juice	0.6	4.22	4590	20.75
Orange juice	0.8	4.22	4590	20.75
Orange juice	1	4.22	4590	20.75

The results in table (4-1) and (4-2) depends on Kohlrausch's law and the Debye-Hückel-Onsager theory, which had been explained in detail in chapter two. An equivalent conductance of electrolyte is a conductance of a volume of the solution including 1 equivalent of the weight of dissolved substance when placed between two parallel electrodes (1 cm) apart. It is large enough to contain all the charges of the solution between them.

The ion's movement behavior between the two electrodes of the sensor probe and the electrolyte when is immersing in liquid can be detected or sensed by sensors consequently, an electrical conductivity had been generated. It can be sensed by the TDS sensor, in addition to the electrical potential which can detect by PH sensor.

Molar conductance is dependent on the concentration of the electrolyte. At dilution, the number of ions available per unit volume reduces. The result is the reduction of the conductivity. The conductance of ions that occurs in a unit volume of the solution is called conductivity of a solution. The conductance is proportional directly to ions per unit volume because the current is carried forward by the ions, it changes with

the concentration of the electrolyte. In the case of dilution, the concentration of the liquid will decrease with its volume increases. The number of ions per unit volume (ions/volume = conductivity) decreases, then the conductivity decreases. As a result with dilation, the conductivity will decrease.

The conclusions are as follows:

The sensor can detect very low concentration of pesticide less than (0.005 or 0.002 ml) and that excellent because the purpose is detecting the residue of pesticide, where decrease with the increase the number of ions per unit volume.

If the concentration of pesticide residue at (0.4 ml) and less concentration of pesticide the sensor can detect, where increase with the decrease the number of ions per unit volume. The concentration of pesticide residue large then (0.4 ml) the reading will be saturated or constant.

Table (4-3) Indicate the values measurements of the TDS and EC at different concentrations of Distilled water market samples.

Type of sample	Concentration	EC	TDS	TEMP
Distilled water	free	0.05	24	22.94
Distilled water	0.2	4.09	2363	22.94
Distilled water	0.4	4.09	2363	22.94
Distilled water	0.6	4.09	2363	22.94
Distilled water	0.8	4.09	2363	22.94
Distilled water	1	4.09	2363	22.94

The conclusions from the results of table (4-3) as follows:

At the beginning the control sample (free sample) without pesticide residue, when the pesticide residue had been added to sample with

different concentration at the beginning the reading of the EC will increase from (0.05 to 4.09) and after that will be constant. Despite of more concentration of pesticide residue had been added, that because the distilled water is a non-ionized water so the increment in the reading at the beginning had been caused by the ions from dissolved solid from pesticide. After that the reading remains constant because the electrolyte is a non-ionized water (distilled water). There will be no exchange in ions between the electrolyte and the two electrodes, so the sample mustn't prepare from the distilled water. The sample must prepare from the ionized water to get change in reading with different concentration of pesticide residue. The sample must dilution with ionized water with avoid a distilled water.

The results of orange juice has the same explanation above to ionized and distilled water.

Table (4-4): The results of the statistical calculations to TDS values.

The analyzed type	The number		Arithmetic mean to the TDS values		Standard deviation	Relative% deviation
	Free Market Samples	Containing Market Samples	Pollutant materials Free market Samples	Pollutant materials Containing market Samples	Pollutant materials Containing samples	Pollutant materials Containing samples
Ionized water	1	11	139	1953.91	1281.768	65.6
Distilled water	1	5	24	2363	0	0
Orange juice	1	5	1285	4387.6	442.586	10.087

Figure (4-2) Chart indicates the TDS value of the different concentrations of ionized water market samples.

Table (4-5): The results of the statistical calculations to conductivity EC values.

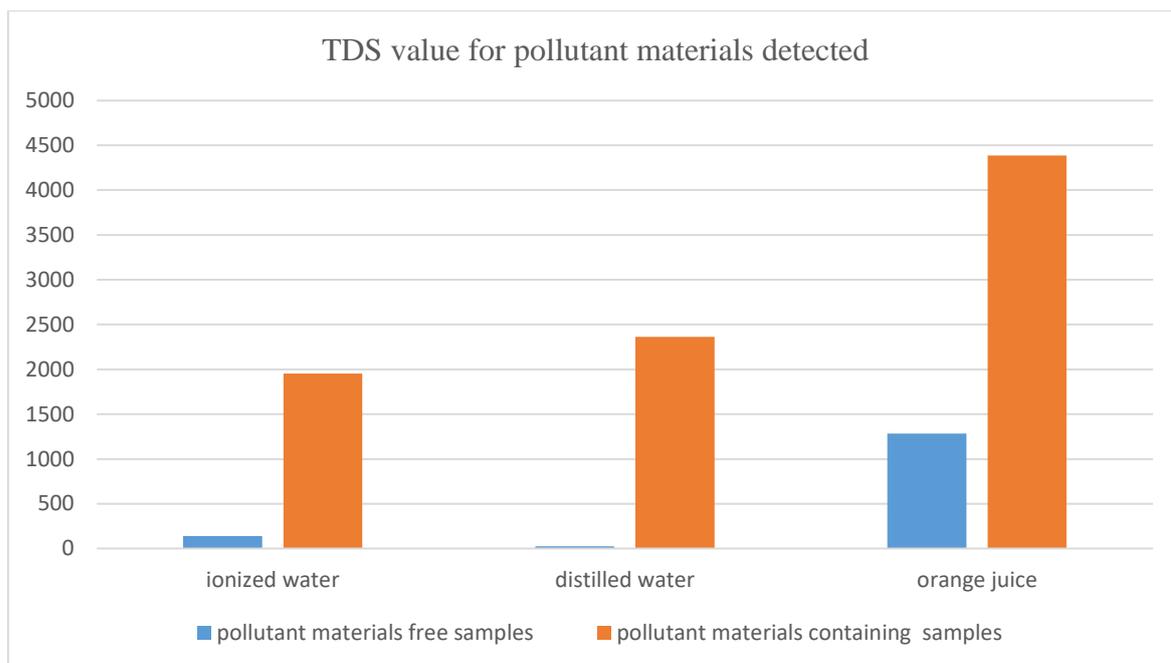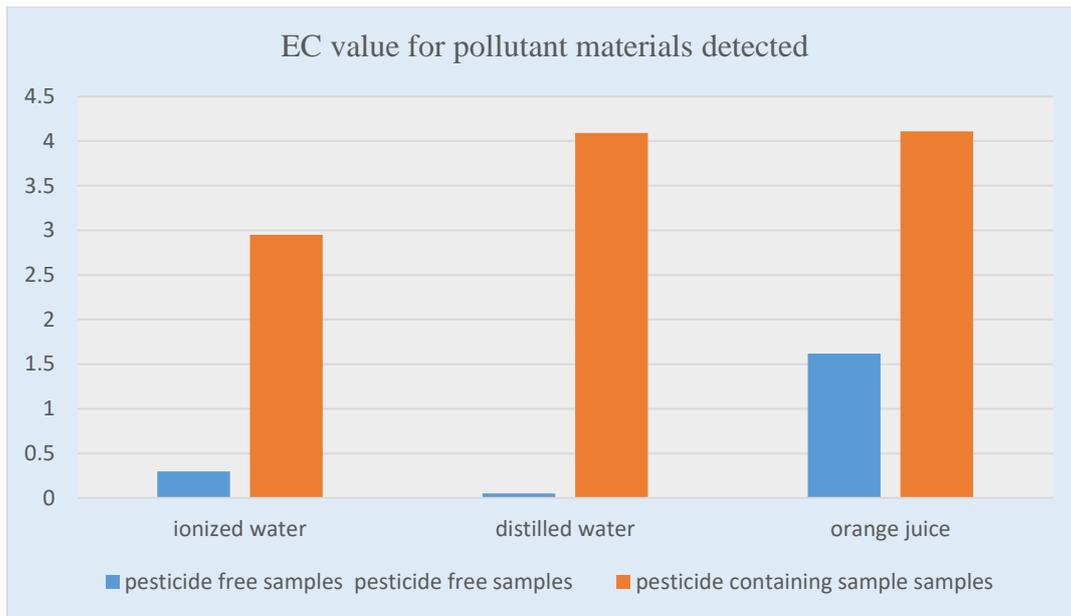| The analyzed type	The number		Arithmetic mean to the EC values		Standard deviation	Relative% deviation
	Free Market Samples	Containing Market Samples	Pollutant materials Free market Samples	Pollutant materials Containing Market samples	Pollutant materials Containing samples	Pollutant materials Containing samples
Ionized water	1	11	0.3	2.95	1.782	60.320
Distilled water	1	5	0.05	4.09	0	0
Orange juice	1	5	1.62	4.11	0.24	5.8495

Figure (4-3) Chart indicates the EC value of the different concentrations of ionized water market samples.

4.2.2 PH results

The results in table (4-6) below depends on Nernst' law, which had been explained in detail in chapter two. Where the increase in the value of PH is proportional to the increase in concentration to the pesticide which had been added to the electrolyte.

Table (4-6) Indicate the values measurements of PH sensor at different concentrations of market samples.

Type of sample	Concentration	PH value
Ionized water with Glyphosate	0.01	8.82
Ionized water with Glyphosate	0.002	9.1
Ionized water with Glyphosate	0.005	8.97
Ionized water with Glyphosate	18	10.86
Ionized water with Glyphosate	20	9.59
Free sample	control	7.93
Orange juice	free	3.65
Orange juice	0.2	3.64
Orange juice	0.4	3.61
Orange juice	0.6	3.6
Orange juice	0.8	3.59

Table (4-7): The results of the statistical calculations to PH values.

| The analyzed type	The Number		Arithmetic mean to the PH values		Standard deviation	Relative% deviation
	Free Market Samples	Containing Market Samples	Pollutant materials Free market Samples	Pollutant materials Containing market Samples	Pollutant materials Containing samples	Pollutant materials Containing samples
Ionized water	1	5	7.93	9.47	0.83	8.767
Orange juice	1	4	3.65	3.61	0.0216	0.5984
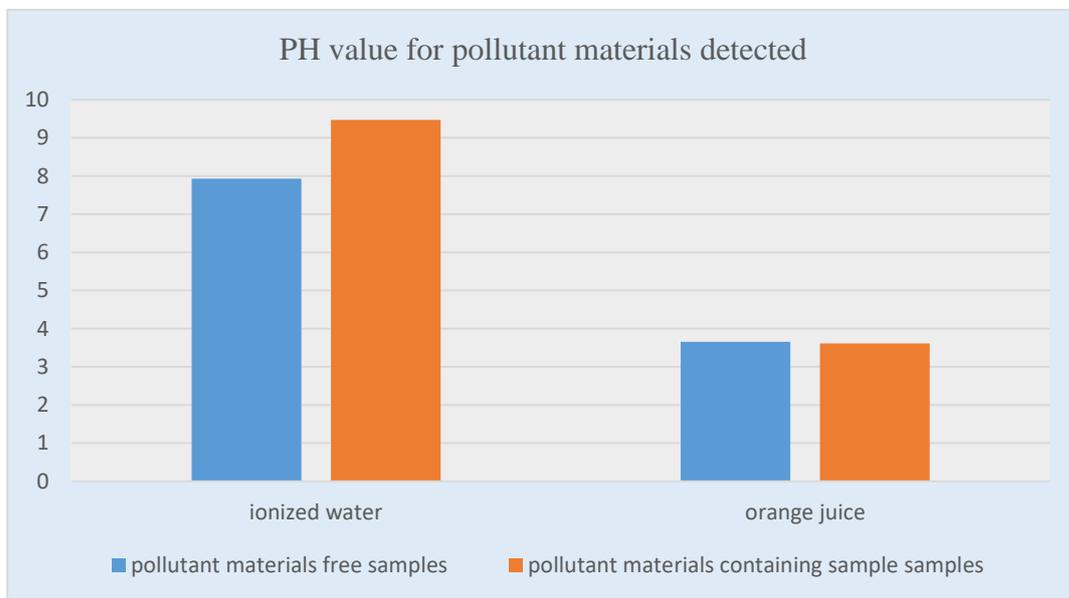
Figure (4-4) Chart indicates the PH value of the different concentrations of market samples.

The relative standard deviation in table (4-4), (4-5), (4-7), indicates the tds sensing to pesticide residue in TDS and PH sensor where:

TDS sensor in water sample the percentage of standard deviation is more than 50%, while at orange juice more than 10%. PH sensor the percentage of relative standard deviation in water less than 10%, and in orange juice less than 5%. The comparison with research which had been done previously the percentage of the relative standard deviation at (5 %). The TDS sensor had been proved that is perfect in detect the residue of pesticide at low concentration with percentage more than (50 %) in water and more than 10% in other liquid like orange juice.

4.3 Results of perceptron code

4-3-1 Results of training a neural network

To classify type 2 data to (9 samples) Bifenthrin, and (7 samples) Glyphosate:
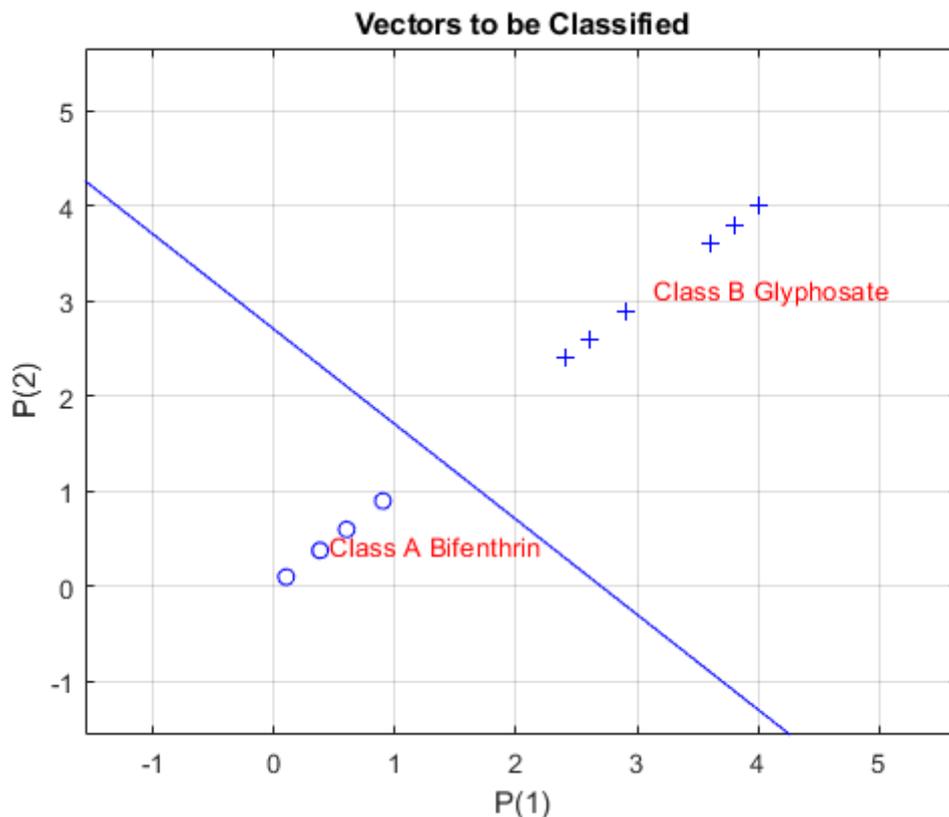

Figure (4-5) Results of training.
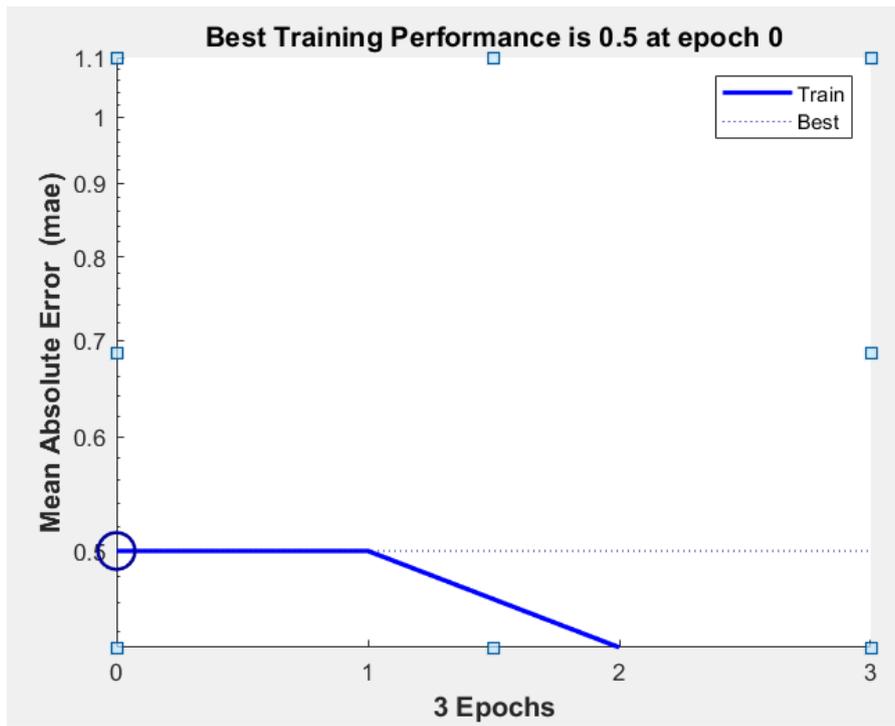
Figure (4-6) The performance of training.

Figure (4-7) The confusion interface.

The best performance shown in figure (4-7) above: at epoch equal 3 iterations, mean absolute error (mae). A hard limit transfer function is using so the classification will be as 0 or 1 because the output to hard limit is (0, 1), with the output results of the confusion matrix for the training, validation, and test matrix. All the output of confusion matrix show that all sample is training and the data divide just in training data and the other validation and test there is no data because the data is little so is sufficient, for training only. The number of training data is equal to (7) samples for each type.

4.3.2 Results of training a neural network

To classify data type 1 (181 samples) Bifenthrin, and (181 samples) Glyphosate:
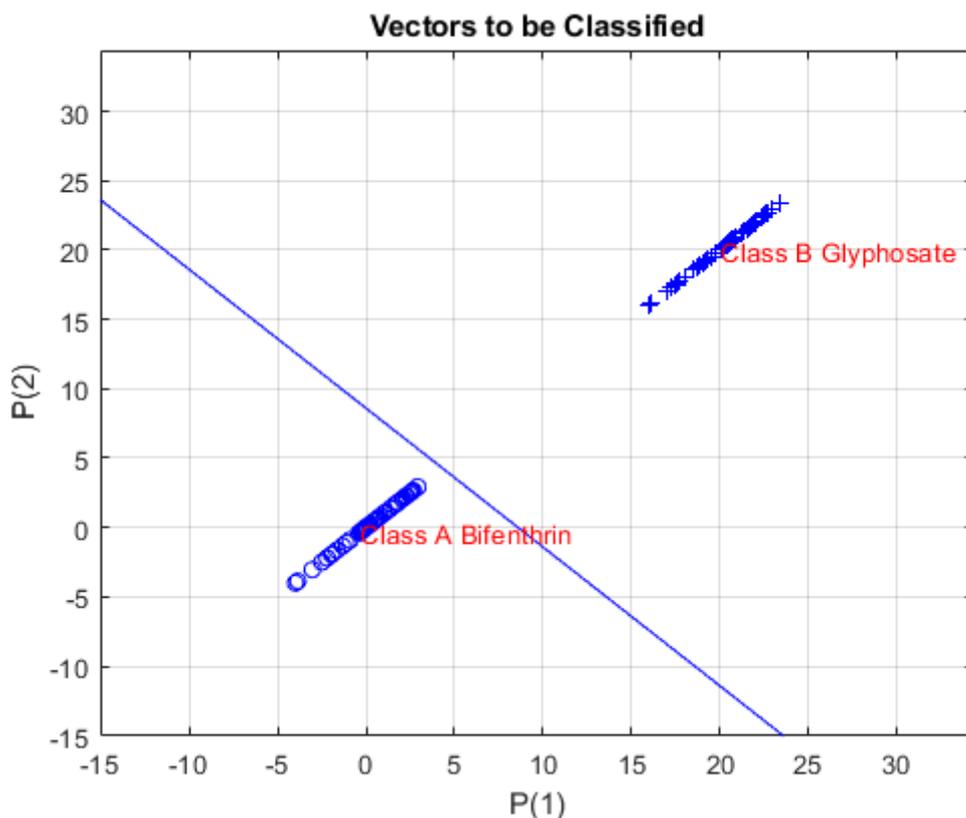

Figure (4-8) Results of training
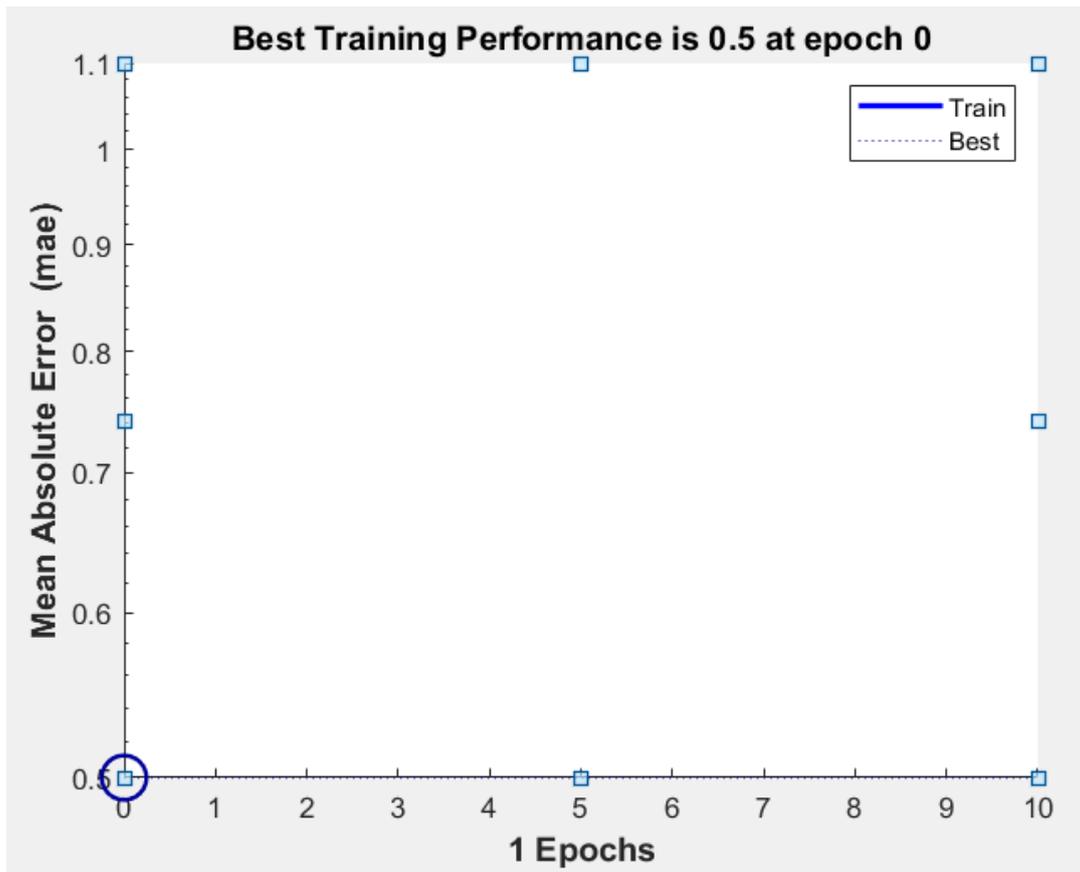
Figure (4-9) The performance of training interface.

All the information of training and the results indicates in figure (4-9): the best performance is (0.5) at epoch equal 0 iteration to one epoch, and mean absolute error and a hard limit transfer function had been using, so the classification will be as 0 or 1 because the output to hard limit is (0,1).
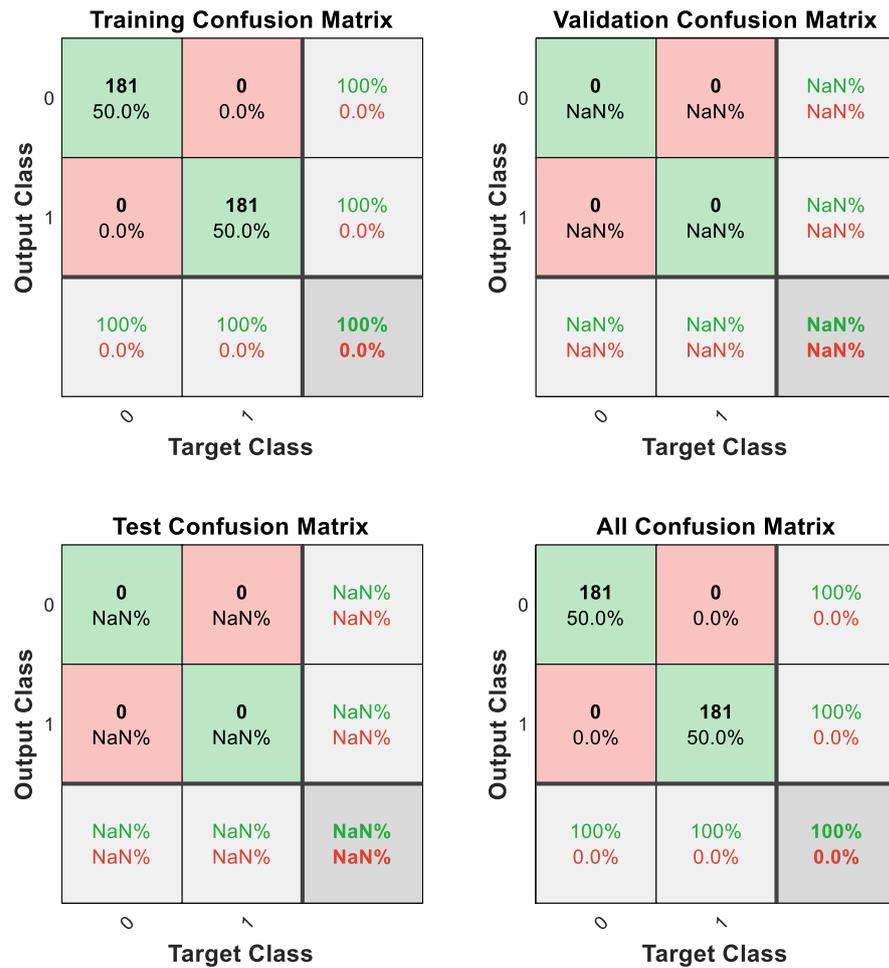
Figure (4-10) The confusion interface.

The best performance: had been getting at epoch equal 1 iteration, mean absolute error (mae), and as a hard limit. Transfer function had used so the classification will be like 0 or 1 because the output to hard limit is (0, 1) as illustrates in figure (4-9). Also figure (4-10) illustrates the output of the confusion matrix for the training, validation, test matrix and all confusion matrix number of training data is equal to (181) sample for each type.

4.3.3 Results of training a neural network

To classify the parameter of the proposed system to TDS, EC, PH, temp. The figure (4-11) ,(4-12), (4,13)below: shows that each color

represents the type of class besides, the label to each class and the shape with its color to make representation to each class on the figure shown below. Each time the code is implementing. The color of classes will change because the continuous implementation to weight and bias will change the output of the network, the weight, and the bias values. So that, it will cause changes in the region of the color classes. The implementation continues until it gives the best performance, with the best zone to each color or class.
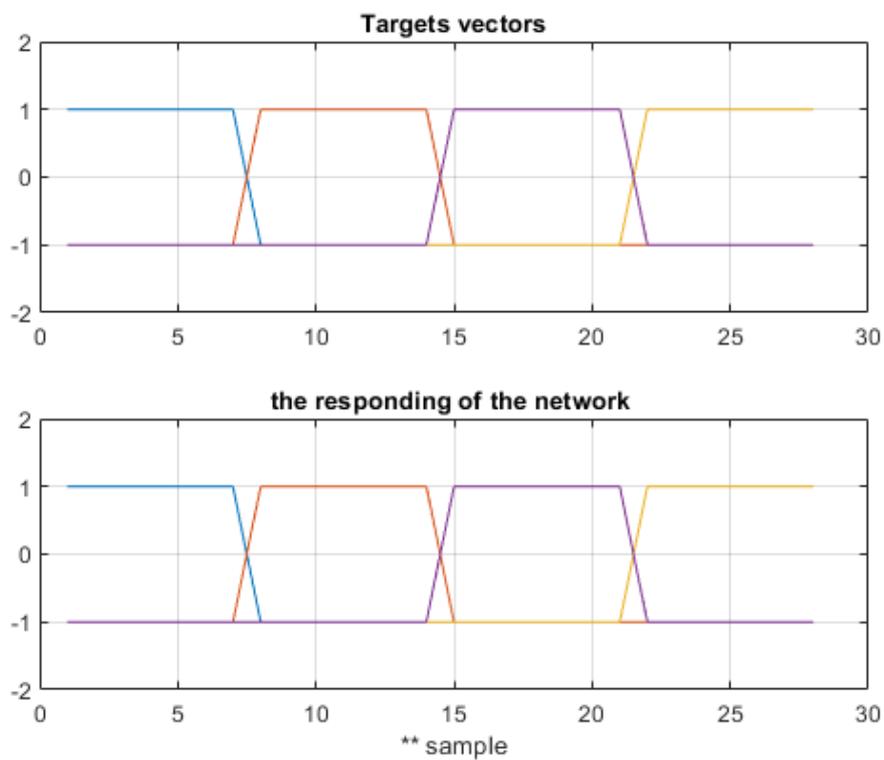
Figure (4-11): The network output with the output of the target.

B:
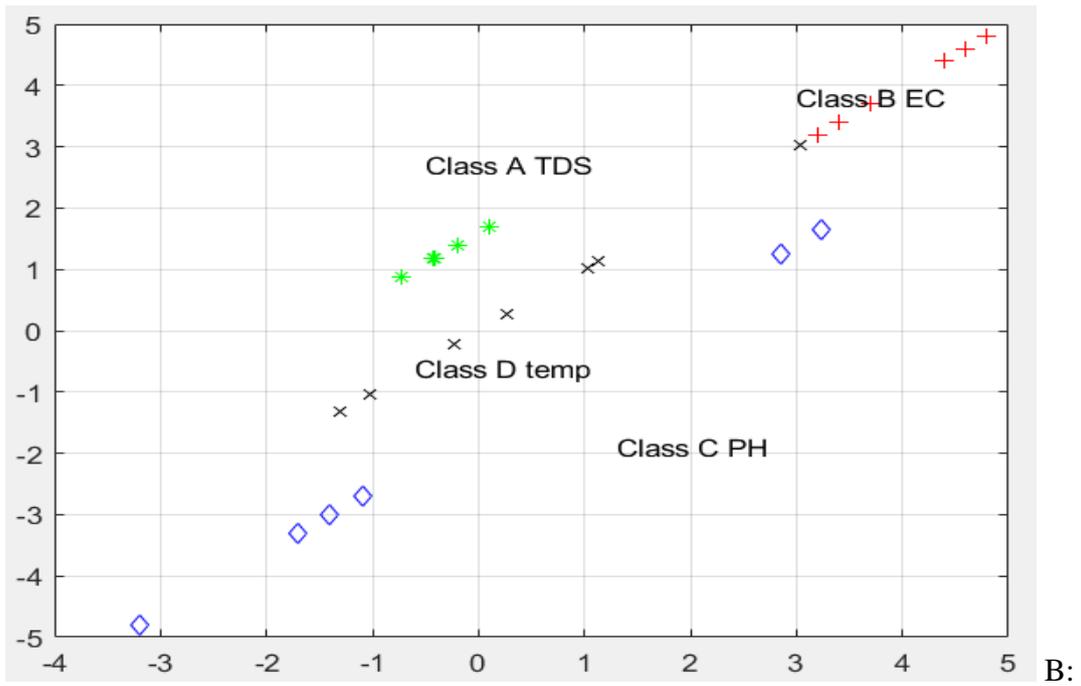
Figure (4-12): The classification regions based on MAX activation.
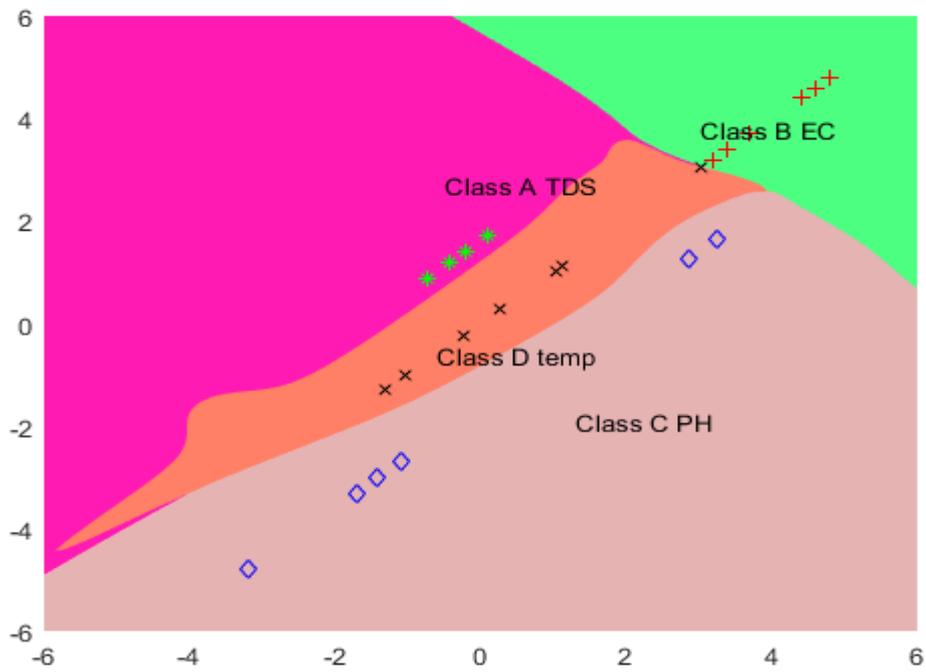
Figure (4-13): The four clusters of input data.
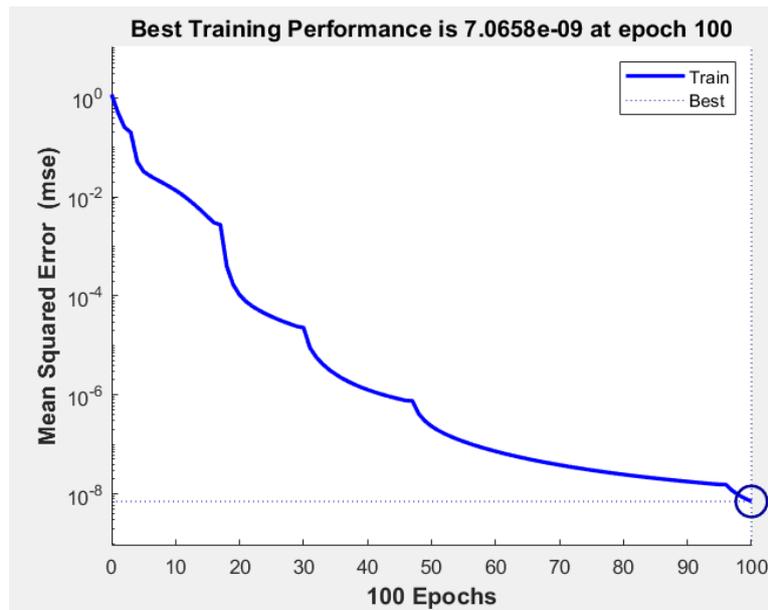
Figure (4-14) (TR) plotperform.

The values of error versus the number of epochs for training, test, and validation network performance of the syntax (TR) which means a training record that can return by the (train) function as shown in figure (4-14).

Generally, more epochs of training, that's mean the error value will decrease, to match the training data. The network begins to increase the data set of validation: by default. After six successive increases in a validation error, the training process will stop, and then get the best performance is taking from the epoch at the point where the lowest validation error as possible.

From the result, some points can be noticing: There is training data but without validation and test data because the data is few and is sufficient only for training. The best performance at (7.0658e-09) at epoch = 100, with mean squared error (mse), the best performance could get when the curve of training data in the blue color match with the curve line in the dashed line.
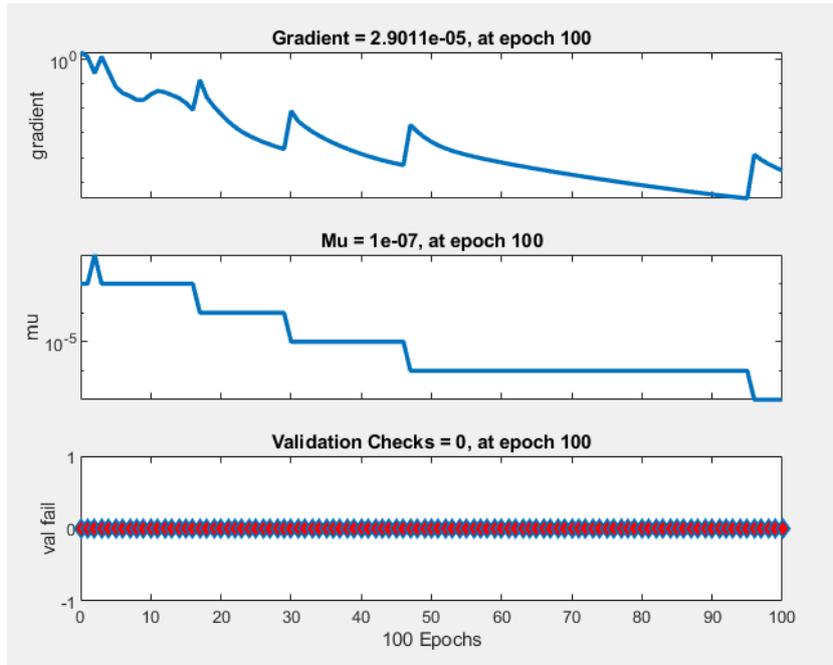
Figure (4-15) (tr) plottrainstate.

The state values of the training process from the Syntax (tr) the training record, which is returning by the train function. As shown in figure (4-15) the following points can be noticing:

All the states had taken at epoch = 100 and the gradient at: (2.9011 e-05),

The validation at epoch 100 is equal to zero.
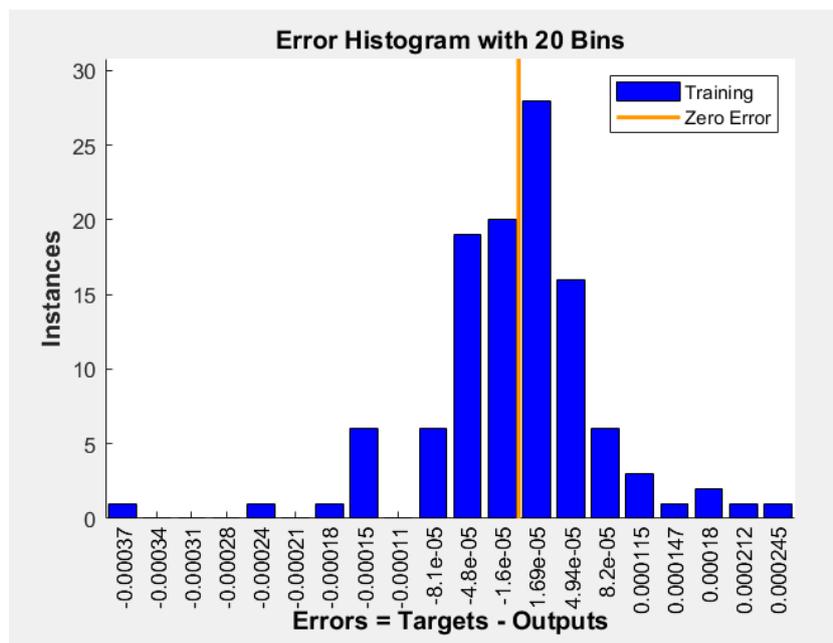
Figure (4-16) ploterrhist (e).

A syntax that is using to plot the values of error (e), and it can be represented by a histogram as shown in figure (4-16). The error zero value is in the orange color line, and the training data is in blue, and the value of Error = Target – Output, so the error at each training data can view.
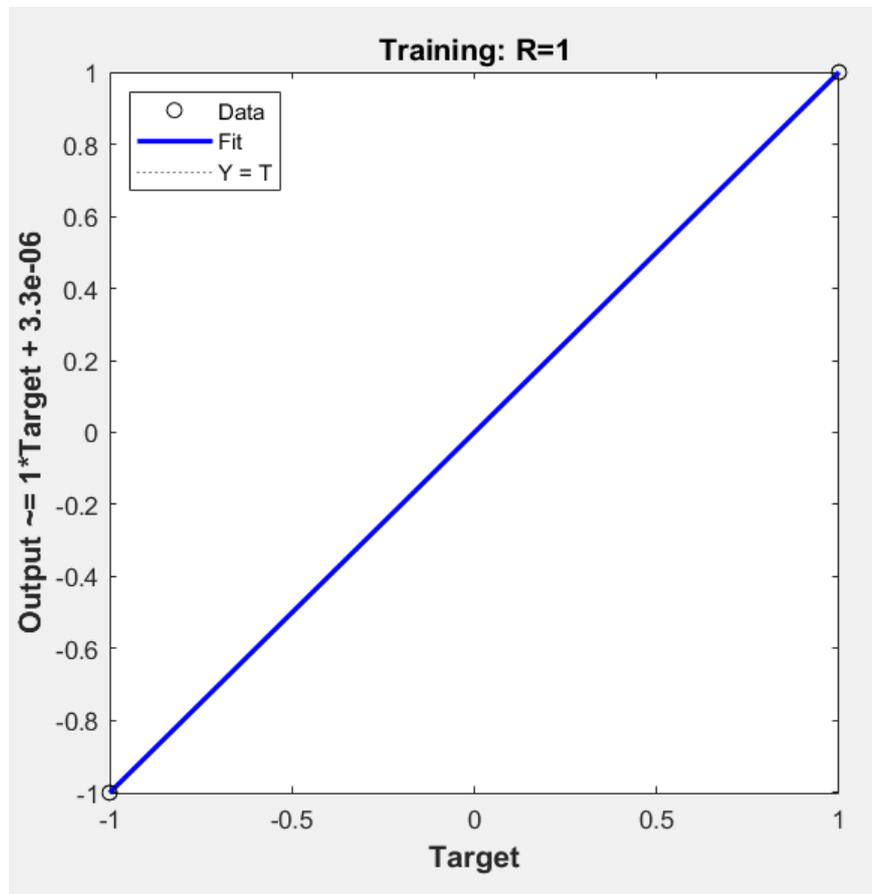
Figure (4-17) Syntax: plotregression (targets, outputs).

A syntax that is using to plot the linear regression of the targets relative to the outputs. The best performance can get at R = 1 when. R=1, which means that the data in the form of the circle will match with the blue line, which represents the fit data, and the dashed line represents the zero error then Y = T as shown in figure (4-17). The output of the network is (Y), and T is the target. If the output value equal the target value that means the error zero and then the blue line will match with the dashed line and the R will equal to 1. As shown in the figure above the output result after training is Output ≅ 1*Target + 3.3e-06.

4.4 Discussion

In this thesis, three type of sensors had been used to detect pesticide residue in human food (TDS, PH, and DS18B20). Good results were obtained with TDS. The percentage of standard deviation is more than 50%, while at orange juice more than 10%. PH sensor the percentage of relative standard deviation in water less than 10%, and in orange juice less than 5%. The comparison with research which had been done previously the percentage of the relative standard deviation at (5 %). The TDS sensor had been proved that is perfect in detect the residue of pesticide at low concentration with percentage more than (50 %) in water and more than 10% in other liquid like orange juice.

The results of classification to two type of neural network the first is perceptron network to classify type 1 data consist of (9 samples) Bifenthrin, and (7 samples) Glyphosate: with best performance at epoch equal 3 iterations, mean absolute error (mae). A hard limit transfer function. Second to classify type 2 data (181 samples) Bifenthrin, and (181 samples) with the best performance is (0.5) at epoch equal 0 iteration to one epoch, and mean absolute error and a hard limit transfer function. The results of the second network is feed forward network to classify the parameters of the detection system with the best performance at R = 1.

Chapter five

Conclusions and suggestion for future work

5.1 Conclusions

The following points represent the most important results which had been concluding from this research.

The proposed system proved experimentally in the detection of pollutant materials in water, and orange juice, especially in water. Three-part of sensors had used to provide a multi-function system. The characteristics and benefits of each sensor were being collected and used in detecting the pollutant materials. The conclusion is:

The sensor can detect very low concentration of pesticide less than (0.005 or 0.002 ml) and that excellent because the purpose is detecting the residue of pesticide, where decrease with the increase the number of ions per unit volume. If the concentration of pesticide at (0.4 ml) and less the sensor can detect, where the reading increase with the decrease the number of ions per unit volume. The concentration of pesticide large then (0.4 ml) the reading will be saturated or constant. The sensor behavior at distilled water is different about the ionized water.

TDS sensor in water sample the percentage of standard deviation is more than 50%, while at orange juice more than 10%. At PH sensor the percentage of relative standard deviation in water less than 10%, and in orange juice less than 5%. The comparison with research which had been done previously the percentage of the relative standard deviation at (5 %).

The TDS sensor had been proved that is perfect in detect the residue of pesticide at low concentration with percentage more than (50 %) in water and more than 10% in other liquid like orange juice.

The values of pollutant materials that can't detect by a specific sensor module can be compensated the detecting process by using the other part PH and DS18B20. The two conditions can get, first the detection of low concentration by TDS sensor and the detection of more types of pollutant materials samples by using the other part of the detection system like PH and DS18B20 sensor. Every part is different from the rest by its sensitivity, and the speed of response according to the type of sample and the number of pollutant materials which excites in the test sample.

In addition to the previous, this system is low cost. The availability of the module sensor where it can be obtained very easily by each person even if the person's financial income is low. The reason which distinguishes this detection system is in-field detection and portable that makes the analysis process implement on-site without needing to the laboratory. The contribution in the proposed system was an identification or classification to the type of pollutant material which had been included in a liquid by using artificial neural network.

The proposed system is characterized by a high ability to develop by connecting the system with a wide type range of a module which, is made, especially to improve the system performance, and be easy and fast using. The artificial neural network has a wide application, so utilizing the ANNs, which act like the human brain. After training it to do the required work that, let's to develop the performance to the system to do several aspects in identifying the type of pollutant materials and classify to which kind of pollutant materials are dealing. All that can do by training the neural network on data which taken from the first part of the proposed system (sensor system). By training those data by neural network and identification had been done to more than one type of pollutant materials.

The whole system work summarizes with detecting the pollutant materials in the sample, and then identify the kind of pollutant materials.

5.2 Suggestion for future work

1- Improving the performance of the detection system and make it detect the low concentration and to cover detecting a wide range in water and fruit juice samples. A lot of things can do to improve the performance of the system and develop its operation processes in the monitoring of pollutant materials some points can propose to indicate that:

2- The Arduino allows to connect the sensor with a (IOT). By using the modules that act with various operations for example, it permits to use of the sensor with (IoT). By using a lot of modules like (ESP8266) of type (ESP-32S We MOs wireless/Bluetooth development board). Modules permit to connect the sensor with computer and phone and remote control devices to connect those parts by phone with use (Wi-Fi or Bluetooth). The data can be transmitted to the mobile by message or text on a mobile, and that permit to use the sensor in pollutant materials monitoring. Those modules allow to increase the aspects of use to the detection system and use it in many application and connect it with (IoT).

3- The second part is using an artificial neural network in identification and classification also can be allowed to use as a control system if the range of data must control. The identification process for pollutant materials had done by using (MatLab software), which is characterizing with a new tool and apps icon in MatLab. MatLab provide a ready-made tools in MatLab and other downloaded online add-ons (add-on explorer). All those tools provides of using the detection system in a wide range of equipment and application.

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Appendix

Appendix A1- information about perceptron network type 2:

9 sample and 7 sample:

```
>> net
net =
    Neural Network
               name: 'Perceptron'
           userdata: (your custom info)
    dimensions:
          numInputs: 1
          numLayers: 1
         numOutputs: 1
     numInputDelays: 0
     numLayerDelays: 0
  numFeedbackDelays: 0
  numWeightElements: 3
         sampleTime: 1
    connections:
        biasConnect: true
       inputConnect: true
       layerConnect: false
      outputConnect: true
    subobjects:
              input: Equivalent to inputs{1}
             output: Equivalent to outputs{1}
             inputs: {1x1 cell array of 1 input}
             layers: {1x1 cell array of 1 layer}
            outputs: {1x1 cell array of 1 output}
             biases: {1x1 cell array of 1 bias}
       inputWeights: {1x1 cell array of 1 weight}
       layerWeights: {1x1 cell array of 0 weights}
    functions:
           adaptFcn: 'adaptwb'
```

```
       adaptParam: (none)
         derivFcn: 'defaultderiv'
        divideFcn: 'dividetrain'
      divideParam: (none)
       divideMode: 'sample'
          initFcn: 'initlay'
       performFcn: 'mae'
     performParam: .regularization, .normalization
         plotFcns: {'plotperform', plottrainstate,
                   plotconfusion}
       plotParams: {1x3 cell array of 3 params}
         trainFcn: 'trainc'
       trainParam: .showWindow, .showCommandLine, .show, .epochs,
                   .time, .goal, .max_fail
weight and bias values:
               IW: {1x1 cell} containing 1 input weight matrix
               LW: {1x1 cell} containing 0 layer weight matrices
                b: {1x1 cell} containing 1 bias vector
methods:
            adapt: Learn while in continuous use
        configure: Configure inputs & outputs
           gensim: Generate Simulink model
             init: Initialize weights & biases
          perform: Calculate performance
              sim: Evaluate network outputs given inputs
            train: Train network with examples
             view: View diagram
      unconfigure: Unconfigure inputs & outputs
        evaluate:        outputs = net(inputs)
```

Appendix A2: information about perceptron network type 1: 181 samples

```
>> net
net =

    Neural Network

                name: 'Perceptron'
            userdata: (your custom info)
    dimensions:

           numInputs: 1
           numLayers: 1
          numOutputs: 1
      numInputDelays: 0
      numLayerDelays: 0
   numFeedbackDelays: 0
   numWeightElements: 3
          sampleTime: 1
    connections:

         biasConnect: true
        inputConnect: true
        layerConnect: false
       outputConnect: true
    subobjects:

               input: Equivalent to inputs{1}
              output: Equivalent to outputs{1}
              inputs: {1x1 cell array of 1 input}
              layers: {1x1 cell array of 1 layer}
             outputs: {1x1 cell array of 1 output}
              biases: {1x1 cell array of 1 bias}
        inputWeights: {1x1 cell array of 1 weight}
        layerWeights: {1x1 cell array of 0 weights}
    functions:

             adaptFcn: 'adaptwb'
```

```
      adaptParam: (none)
        derivFcn: 'defaultderiv'
       divideFcn: 'dividetrain'
     divideParam: (none)
      divideMode: 'sample'
         initFcn: 'initlay'
      performFcn: 'mae'
    performParam: .regularization, .normalization
        plotFcns: {'plotperform', plottrainstate,
                  plotconfusion}
      plotParams: {1x3 cell array of 3 params}
        trainFcn: 'trainc'
      trainParam: .showWindow, .showCommandLine, .show, .epochs,
                  .time, .goal, .max_fail
  weight and bias values:
              IW: {1x1 cell} containing 1 input weight matrix
              LW: {1x1 cell} containing 0 layer weight matrices
               b: {1x1 cell} containing 1 bias vector
  methods:
           adapt: Learn while in continuous use
       configure: Configure inputs & outputs
          gensim: Generate Simulink model
            init: Initialize weights & biases
         perform: Calculate performance
             sim: Evaluate network outputs given inputs
           train: Train network with examples
            view: View diagram
     unconfigure: Unconfigure inputs & outputs
    evaluate:        outputs = net(inputs)
```

Appendix B: Specifications

B1: Arduino UNO R3: Specification

1-Microcontroller based on a microchip (ATmega328p), and the chip can be replacing.

2-(AREF) represents the voltage of reference to analog pins.

3- Six pins: for analog input.

4-The speed of the clock to the quartz crystal is equal to (16 MHZ).

5- Fourteen pins to Digital input/output, (six of which provide eight-bit PWM used as an output or input [3, 5, 6, 9, 10, 11]). By the control of software.

6-Programmable with the Arduino (IDE) integrated development environment.

7-it has been supplied with power by a laptop by (USB cable) or by (9-volt) an external battery by adapter (AC-to-DC)

8- The current of DC to (3.3v) to each pin is equal to (50 mA).

9- (7 to 20 volts) represents the range voltage of input which be acceptable.

10- The current of DC to each pin of input/output is equal to (20 mA).

11- (5 volts) represents the operating voltage.

12- It contains pins for (Serial/UART) pin with zero value with the ground to represent the receive (RX) and pin with value one with (Vcc) source to represent the transmit (TX).

13-(SPI) represents the interface of serial peripheral, (10 ss), (12 MISO), (13 SCK) represents the pins that used the (SPI) library to support the communication of the (SPI).

14-the dimension of size is (L= 68.6 mm, W = 53.4mm).

15 – The Weight is equal to (25 g).

16- (SRAM) is equal to (2 KB), (EEPROM) is equaling to (1 KB).

B2: TDS: Specification

1. (3.3 ~ 5.5V) represents the range voltage of the input.

2. (3 ~ 6mA), represents operating current.

3. (± 10%F.S. (25 °C)) the accuracy of measurement to TDS.

4. (0 ~ 2.3V) represents the voltage of the output.

5. (0 ~ 1000ppm) the range of measurement to TDS.

6. (XH2.54-2p) represents the interface of the electrode to the probe of TDS with number two of needles.

B3: DS18B20: Specification

1- (100cm) represents the length of the cable, the size of stainless steel sheath = (6×50mm).

2- (3.0v to 5.5v) represents the range of power supply.

3- (-55°C to +125°C(-67°F)) represents the range of operating temperature.

4-the best thermal conductivity.

5- Heat-shrink tubing separates the chip on each pin.

6- (-55°C to+125°C(-67°F to +257°F)) represents the range of storage temperature.

7- Over (-10°C to +85°C = ±0.5°C) represents the range of accuracy.

8-waterproof.

9- Resistance of flexibility.

10-output leads = yellow (data), red (vcc), black (GND).

11-there is no unique single bus interface, and external components (30pcs) are using for each lead.

B4: PH sensor: Specification

1- (5 ± 0.2v) AC.DC represents the heating voltage.

2- (5-10mA) represents the working current.

3- (0-14 PH) represents the range of the detectable concentration.

4- Detection temperature range = (0-80℃) represents the range of the detection temperature.

5- The time of response (≤ (5S)), the time of settling (≤ (the 60S)).

6- (42mm×32mm×20mm) represents the size of the module.

7- (Analog voltage) represents the signal of output.

8- Gravity connector and BNC connector.

9- The calibration process is Easy.

10- ≤ 0.5 W represents the power of the component.

11- (-10~50℃) represents the operating temperature range, (65% RH) represents the Nominal ratio of humidity.

B5: (330) ohm resistor:

The First terminal between yellow wire pin data of DS18B20 and pin 15 (NC) in LCD, and the second terminal to (VCC).

B6: (100KΩ) linear-rotary potentiometer:

It is a top adjustment single linear potentiometer with three terminals and knurled shaft, where it is using in daily operate-time easily and to control electrical components like volume controls on audio equipment in this study is used to adjust LCD 2×16 display.

Features:

1- (3-pin) the potentiometer with washer and nut.

2- (15 mm) represents the length of the slip shaft, which is knurling.

3- Resistor (100KΩ).

4- Adjustment by the top knob.

5- (½ W) it representing the maximum power.

6-the number of the pin is equal (3).

7- (5mm) represents the approximate value of the shaft diameter.

8- (15mm) represents the approximate value of the base diameter.

B7: big prototyping breadboard:

Specification

1- (4 bus), (1660) represents the tie-points.

2- The power lines are equal to (4), and the tie-point is equaling to (40).

3- The double-strips are equal to two, and the tie-point is equaling to (126).

4- The binding posts are equal to three.

5- (16.5 × 11.1× 0.85cm) represents the size.

6- It is perfect to use for the Arduino shield prototyping and testing.

7- (ABS) housing, the contact clip made from brass, in addition to (ABS) housing.

8- Accept wires with diameter (20-28AW) represent the diameter for the accepted wires.

9- The voltage is equaling to (300 v), and the current is equal to (3-5 A).

10- Virtually all the components like (LEDs, capacitors, resistors, diodes, and transistors) are accepted.

11- There is a twin of the adhesive back, which could be facilely fixed or removed for any position.

12-the Protection from the short circuit, the overload, and the overvoltage

13- The plated spring clips are making from phosphor bronze nickel.

14-the free air convection is the method of cooling.

15-All the material is "RoHS" compliance.

16-it distinguishes with its low coast, and the reliability is high.

17-it is fully reusable

B8- Breadboard jumper wires:

It is a ribbon cable (female-female, male-female, and male-male) (DuPont line20 lines 20 pcs 1*20cm).

Specification

1- To make it safe and durable for use, so it makes from a High-grade copper wire material.

2-   (20cm/8-inch)   represents   the   cable   length.
3- The breadboard jumper wires length equals (20cm), and the pin equals (20 pins).

4- The male ends are meant for insertion into standard (0.1, 2.54) mm female sockets, and the female ends are meant for insertion onto standard (0.1, 2.54) mm male headers.

5- A non-standard odd-spaced headers are being connected and supported by jumper wires.

6- The properties are easy and safe for use and have a portable design.

B9- LCD 2×16 (liquid crystal display):

It is screen module blue backlight (16×2) means it displays 16 characters per line, and 2 means it has 2 lines, each line has 16 characters, where each character is displayed in a (5×7) pixel matrix as showing in figure (2-4), where this screen has two registers called data and command, where The command instruction which is giving to the LCD for doing a redefining task is storing by the command register. For example, command instructions are initializing set the cursor position, controlling the display, clearing the screen, etc.

The data displayed on the LCD can store on a data register, this data is the (ASCII) value of a character to be displayed on a screen. This screen is a very substantial electronic module and is commonly used to display the data in several circuits, where it is used in a wide range of applications because it is economically, easily programmable, animations, has no limitation of display custom and a special unlike characters in (7 segments), etc.

List of symbol

symbol	meaning
a_c	Ion activity.
Λ_m	The molar conductivity.
Λ_{m0}	limiting molar conductivity
B	Susceptancein Siemen.
C	The *concentration in* $\frac{moles}{volume}$.
C^-	The concentration of the chosen standard state, 1 mol/kg.
C_d	The double-layer capacitance of the electrode/electrolyte interface.
G_b	The bulk electrolyte conductance.
C_b	The geometrical capacitance of the two electrodes separated by the measured electrolyte.
D	The diffusion coefficient ($m^2\ S^{-1}$).
D^+, D^-	Diffusion coefficients of the ions.
e	The elementary charge.
ε	The electric permittivity.
F	Faraday's constant.
F_d	The frictional force – known as Stokes' drag – acting on the interface between the fluid and the particle in newton = kg m s^{-2}.
G	Conductance in Siemens.
K	Conductivity.
k_B	Boltzmann's constant.
$K^{'}$	An empirical constant
M	Generalized mobility.

μ	The mobility, is the ratio of the particle's terminal drift velocity to an applied force.
μ_q	The electrical mobility to particle's charges $(m^2\ V^{-1}S^{-1})..$
μ_q	The ratio between the particles velocities of the terminal drift to an applied electric field.
η	The dynamic viscosity in kg $m^{-1}\ s^{-1}$.
η_0	The viscosity of the dispersion medium.
q	The particles electric charge in (coulombs C unit).
R	The radius of the spherical object in meter.
R	Gas constant.
r	The radius to the spherical particle.
T	Thermodynamic temperature.
T	Absolute temperature.
T	The electrons or ions temperature in plasma (K).
T	The electrons or ions temperature in plasma (V).
V	The volume in parts of a cubic centimeter occupied by the dispersed solid.
V	the flow velocity relative to the object in m/s.
V+, v−	the number of cations and anions per formula unit of electrolyte
Y	Admittance in Siemens.
ϒ	Activity coefficient of C.
Z	The particle charge number without unit.
z	The valence.
$z_1e^+,\ z_2e^-$	Charges.

List of Abbreviation

Abbreviation	Meaning
ANNs	Artificial neural networks.
Arduino IDE	Arduino integrated development environment
Arduino UNO	The number of version to Arduino which mean one.
BNC	Bayonet Neill Concelman.
DIY MORE	The type of PH sensor.
DS18B20	Digital chip for temperature sensor.
EC	Electrical conductivity.
GND	ground
hardlim	The Output transfer function of ANNs.
LOT	Limit of detection
LCD	2×16 liquid crystal display.
logsig	The Output transfer function of ANNs.
pvc	Polyvinyl chloride, which used in cable as an insulation cover.
PCB	Printed Circuit Board.
purelin	The Output transfer function of ANNs
RSD	Relative standard deviation
$\frac{S}{N}$	Signal to noise ratio.
TDS	Total dissolved solid.
tansig	The Output transfer function of ANNs.

الخلاصة

الثورة الصناعية والتطور التكنلوجي السريع بالاضافة الى الاستخدام الخاطىء والمفرط للموارد الطبيعية المتوفرة في البيئة أنعكس وبشكل واضح على الطبيعة وبالتالي على حياة الانسان لارتباطها بصحته.

في الوقت الذي تكون فيه البيئة غير قادرة على تحديد التلوث الناتج من النشاطات البشرية ومسبباته وبالتالي عدم المقدرة على معالجته وأزالة الضرر عن النظام البيئي في الوقت المناسب حيث ان التلوث يمتد أيام او أشهر أو حتى الاف السنين كل هذا يشكل تراكمات من المواد الملوثة التي تنعكس على البيئة.

وسائل الكشف عن المخلفات البيئية وتحديدها قد تم تطويرها ليتم معالجة الملوثات وبالتالي أزالة الخطر عن حياة الأنسان في الآونة الاخيرة شهدت تطور ملحوظ في وسائل الكشف عن الملوثات البيئة ومن ضمنها التلوث نتيجة المبيدات الكيميائية وتاثيرها السام على الجهاز العصبي للأنسان على مر السنين.

في هذه الدراسة تم اقتراح نظام للكشف وتصنيف بقايا الملوثات من المواد الكيميائية الموجودة في غذاء الانسان بحيث يسهل حمله للافراد بدون الحاجة الى مختبرات الى جانب التكلفة القليلة بحيث يمكن توفره لكل شخص حتى لو كان دخله قليل.

بالنسبة للجزء الذي يقوم بالكشف تم تصميه بأستخدام مستشعرات متعددة الوظائف (TDS,PH,DS18B20) وتم تطبيق النظريات التالية Nernst' law and Kohlrausch's law and the Debye-Hückel-Onsager theory.

أما جزء الشبكات العصبية فقد تم بأستخدام نوعين من الشبكات الشبكة الاولى هي

Perceptron network, والشبكة الثانية هي feed forward network

النتائج التي تم الحصول عليها بالنسبة للجزء الذي يقوم بالكشف انه يقوم بالكشف عن التراكيز القليلة جدا من المبيدات اقل من (0.005-0.002) ملي وهذا هو المطلوب لان الهدف الكشف عن بقايا للمبيدات ومن الملاحظ ان في التراكيز القليلة كلما تزداد نسبة المبيد المضافة كلما تقل النسبة بين الايونات الذائبة وحجم المحلول والتي تمثل التوصيلية الكهربائية. بينما التراكيز الاقل من (0.4) ملي كلما تزداد نسبة المبيد المضافة كلما تزداد النسبة بين الايونات الذائبة وحجم المحلول والتي تمثل التوصيلية الكهربائية. بينما تبقى ثابتة اذا كانت تراكيز المبيدات المضافة اكثر من

(0.4). بينما معدل الانحراف أظهر نسبة أعلى من 50% بالنسبة للماء بينما بقية المحاليل مثل عصير البرتقال أظهر 10%, بالرغم النتائج للدراسات السابقة أظهرت نسبة تتراوح بين ال 5% و ال 10%.

نتائج الشبكات العصبية بالنسبة لشبكة (Perceptron network)

أفضل اداء تم الحصول عليه هو (0.5) عند الفترة صفر أو ثلاثة وبأستخدام الدالة hardlim (Feed forward network) عندما تنطبق البيانات المدخلة مع الهدف المراد تحقيقه عندئذ الخطأ سيكون صفر وذلك عندما R=1 وتم تحقيق ذلك عند تدريب الشبكة العصبية تتكون من ثلاث طبقات مخفية تحتوي كل منها على 10 عقد وطبقة الاخراج التي تحتوي على أربع عقد.

جمهورية العراق

وزارة التعليم العالي والبحث العلمي

جامعة بابـل

كلية الهندسة / قسم الهندسة الكهربائية

كشف بقايا المبيدات وتصنيفها في غذاء الانسان بالأعتماد على الشبكات العصبية الاصطناعية

رســــالـــة

مقدمة الى كلية الهندسة في جامعة بابل

كجزء من متطلبات نيل درجة الماجستير

في الهندسة / الهندسة الكهربائية / الكترونيك

من قبل

نورا كامل فليح حسن

أشـــراف

الاستاذ الدكتور / أبراهيم عبد الله مرداس

١٤٤٣هـ ٢٠٢٢م