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Intelligent Management of using Natural Resources in Agriculture

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Abstract— Agriculture is a major source of life that plays a predominant role in the development of the economy in most countries but with the phenomenon of droughts and the decrease of water, we are facing problem in decreasing agricultural production that's why in this work we propose to make an intelligent system of diagnosis and control to improve agricultural production and to optimize the use of naturel resources like water. Our study focuses on the production of vegetables or fruits that live in greenhouses because they have specific factors to give a good performance of the crop yield. Those factors such as temperature, air humidity, soil humidity and brightness. In our work we use the artificial neural networks (ANN) in this system and in particular the paradigm of the counter propagation network (CPN) thanks to its classification capacity and if we talk about the diagnosis of course we talk about the classifications of data for analysis and decision making.

Keywords— Control and Diagnostic System; Artificial Neural Networks; Self- Organizing Map; Grossberg; Counter Propagation Network; Classification; Agriculture field.

1 Introduction

Agriculture has been a big part in researches for the past few years because it can be a very important part of economic growth in most countries, especially developing countries that's why researchers started to make new systems that helps farmers make adequate decisions to increase crop yield or agricultural production. Morocco confronted a water deficit that had the Kingdom's GDP in 2015 and despite the many anti-drought provisions made by the Ministry of Agriculture Morocco still until now has water issues. The experts in the field are formal Morocco incurs the permanent risk of being in water stress, that is to say in a situation where water needs exceed the available quantities, and taking into account future climate changes, the situation will only get worse in the years to come. Therefore it is of great urgency to take the necessary measurement to guard against them, so all these problems lead to the decrease of agricultural productivity, here comes the importance of the use of agricultural information systems. Agricultural information interacts with and influences agricultural productivity in a variety of ways. It can help inform decisions regarding land, labour, livestock, capital and management. Agricultural productivity can arguably be improved by relevant, reliable and useful information and knowledge. Hence, the creation of agricultural information (by extension services, research, education programmes and others) is now often managed by agricultural organisations that create information systems to disseminate information to farmers so that farmers can make better decisions in order to take advantage of market opportunities and manage continuous changes in their production systems. Therefore, there is a need to understand the functions and use of particular agricultural information systems in order to manage and improve them [1].

Some countries use agricultural information systems to assist different users such as planters, researchers, prospective investors, importers and exporters [2]. In this work we propose to make an intelligent system of diagnosis and control in the field of agriculture. This system has become a highly recommended tool for the growth of the complexity of systems in various fields, medical, agricultural, industrial. Among the traditional methods that can be found in the diagnosis are (residues, causal graphs, etc.) [3], but these methods take a lot of time at the levels of modeling and classification for this reason we base on artificial neural networks. It becomes a new technology that provides a solution tailored to complex problems in the diagnosis. The objective of our research is to create a system capable of diagnosis and control in greenhouses because vegetables or fruits that live in greenhouses have specific factors to give a good yield of crops among these factors we find: temperature, air humidity, soil humidity and brightness at the same time we will give an intelligent management of using naturel resources such as water. For that, in this work we made association between embedded system and our intelligent system. In the first one we will use sensors to get the values of temperature, air humidity, soil humidity and brightness and also we'll use the arduino map to transmit the physical quantity of these sensors in digital information, for the second one we develop an advanced algorithm of neural networks to diagnose this information and to control it at the same time. There are several models of neural networks such as multilayer perceptrons (MLP), self-organizing map (SOM), conventional neural network (CNN) etc. Diagnosis systems are known for their data classification and analysis. In our work we propose the model counter propagation network (CPN) thanks to its great classification capacity.

2 Literature Review

There are several works treated neural networks in agriculture field such as:

[4] Developed agricultural management need simple and accurate estimation techniques to predict rice yields in the planning process. The necessity of the present study were to: (1) identify whether artificial neural network (ANN) models could effectively predict rice yield for typical climatic conditions of the mountainous region, (2) evaluate ANN model performance relative to variations of developmental parameters and (3) compare the effectiveness of multiple linear regression models with ANN models. In this paper describes the development of artificial neural network models as an alternate and more accurate technique for yield prediction.

[5] Used artificial neural networks to combat the meteorological conditions because they have a direct effect on the performance of the crop yield. In this paper they are based on various parameter of soil and also parameter related to

atmosphere such as that pH, nitrogen, phosphate, potassium, depth, temperature in order to make an intelligent prediction system to predict the effective crop yields associated with these parameters.

[6] Employed an advanced technology named Weighted-Self Organizing Map (W-SOM) in accurate crop and weather prediction, which is the combination of both Self Organizing Map (SOM) and Learning Vector Quantization (LVQ). In this paper, the prediction accuracy is enhanced by minimizing the Within Class Error (WCE) among the clusters. Therefore, this new approach outcome shows a clear idea about suitable crop cultivation in Mysore. Experimental outcome shows that the proposed approach improved accuracy in crop and weather prediction up to 0.5-2% compared to the existing methods: SOM, Kernel-Nearest Neighbors (KNN) and Ensemble Neural Network (ENN).

3 The artificiel neural network in diagnosis system

The application of ANN in diagnosis is a kind of the form recognition because each fault can be associated with the most likely cause from an input vector containing the parameters of systems to be diagnosed. The purpose of form recognition is to decide which classes a, b and c should be associated with a new form; that's mean we can look in which area of the space is the new observation (Fig.1.). We can apply this approach for diagnosis that ease knowledge of which operating mode corresponds a new observation.

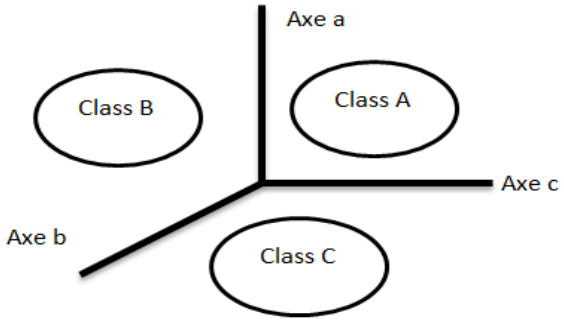

Fig. 1. The classification of data in neural network

4 The artificiel neural network

The artificial neural networks concerning a class of systems inspired by the functioning of the biological nervous systems. They imitate their abilities to learn from observations and generalize about new situations, which are not presented before. This inspiration allows the neural networks to obtain the complex operation of a system, and only based on the measurements taken. The ability to learn from the measurements make them very powerful tools that fight against nonlinear problems and allow to approximate all input-output relationships from simple operations, performed by elementary elements (neurons), and consequently they allow to treat problems of different nature that classic tools have trouble solving.

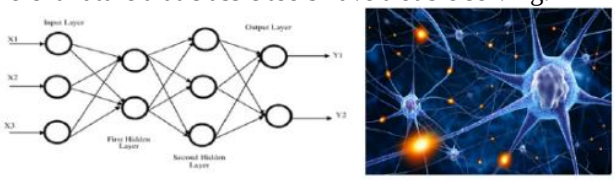

Fig. 2. Artificial Neural Network and Biological Neural Network.

4.1 learning and architecture of neural networks

The connections between the neurons that make up the network describes the topology of the model, it may be arbitrary, but most often it's possible to distinguish two major types of neural network architectures:

- The static neural networks (FeedForward);
- The dynamic neural networks (FeedBaak).

A network of FeedForward neurons performs one (or more) algebraic function of its inputs by composition of the functions performed by each of its neurons. In such a network (Fig.3), the flow of information flows from the inputs to the outputs without going back.

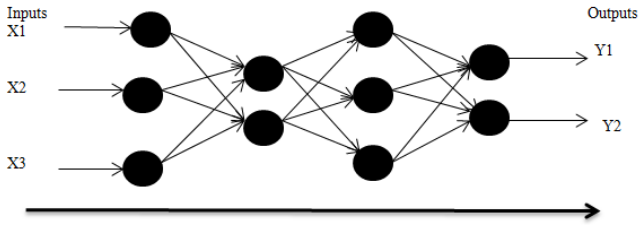

Fig.3. The a static neural network or FeedForward network

The most general architecture for a neural network is the "FeedBaak", whose connection graph is cyclic: when one moves in the network following the direction of the connections, it is possible to find at least one path which returns to its point of departure (such a path is referred to as the "cycle"). The output of a neuron network can therefore be a function of itself, this is obviously conceivable only if the notion of time is explicitly taken into consideration.

Thus at each connection of a FeedForward neural network (or at each edge of its graph) is attached a weight as for FeedBaak networks, a delay, multiple integer (eventually null) of the chosen unit of time. At a given moment a quantity can't be a function of its own value at the same instant, any cycle of the network graph must have a non-zero delay.

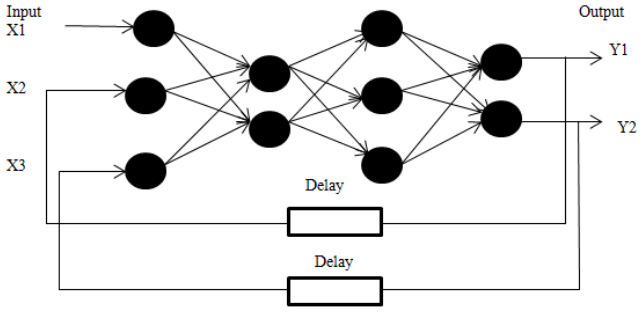

Fig.4. The dynamic neural network or FeedBaak neural network

The crucial point in the development of a neural network is its learning. It is an adaptive procedure by which neuron connections are adjusted to an information source. In the case of artificial neural networks, the learning algorithm is often added to the description of the model, the model without learning is of little interest. In the majority of the current algorithms, the variables modified during the learning are the weights of connections. Learning is the modification of network weights in order to give the network response to examples and experiences.

There are many types of learning rules that can be grouped into two categories: supervised and unsupervised learning rules but the fundamental purpose of learning remains the same.

a learning is said to be supervised when the network is forced to converge towards a definite final state, at the same time as it is presented with a motive, this kind of learning is carried out using a learning base, consisting several types of input-output examples. The usual procedure for forecasting is supervised learning which involves associating a desired specific response with each input signal.

Unsupervised learning is the process of adjusting weights from a single learning set of data only. No desired results are provided to the network. But what exactly does the network learn in this case Learning consists in detecting the similarities and differences in the learning set. The weights and outputs of the network converge, in theory, to the representations that capture the statistical regularities of the data. This type of learning is also said to be competitive and / or cooperative. The advantage of this type of learning lies in its great adaptability, which is recognized as a self-organization, (Kohonen, 1987). Unsupervised learning is mostly used for signal processing and factor analysis [7].

5 Proposed work

Neural networks have several models such as; multilayer perceptrons (MLP), self-organizing map (SOM), counter propagation network (CPN). Choosing the model depends on the application itself, so in this paper we propose the model counter propagation network (CPN) because it remains a good choice for the diagnosis system at the level of its great classification capacity.

5.1 The Counter Propagation Network

Another ANN model using competitive learning is the counter-propagation network (CPN). This network is developed by R.Hecht Nielsen and can be used in diagnostic and control system. CPN consists of two layers connected successively (Fig.5.). The first layer (Kohonen layer or SOM layer) uses the "unsupervised" learning method and can work in two regimes (accreditation regime and interpolation regime), the second layer (Grossberg layer) uses the method of the "supervised" learning. Thanks to this architecture of which two deferent types of the neuron structure are connected between them, CPN possesses properties absent in the isolated structures, and predominates the other models of RNAs in the tasks of diagnosis and control because it learns quickly enough, simple for the realization and their learning ability in classification. However in the regime of interpolation the accuracy of this network is low.

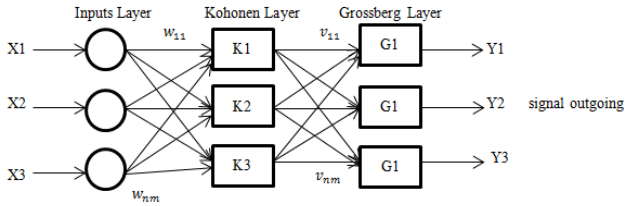

Fig.5. The counter-propagation network structure

5.2 The learning algorithm of Counter-Propagation Network

CPN contains the Kohonen layer, but in general uses supervised learning, during learning the input vectors and the desired vectors of the output are presented at the input and the output of the network successively. Kohonen layer realizes the classification, and a single neuron will be named winner for similar vectors, the output value of this neuron is one and zero for the other neurons (accreditation regime). The winning neuron is determined according to scalar product method or the Euclidean distance. The synaptic weights between the winning neuron and the neighboring neurons of one by and the components of the input vector (the initial network layer) are modified in such a way to bring their values closer.

A. The Self-organization map (SOM) or Kohonen Layer

Neurons are modeled in the simplest possible way (neuron model near to reality). The neural networks are inspired by biological observations of the nervous systems. Indeed, there are areas of the brain that have the same topology as sensory sensors. That is to say, two close areas in the visual cortex correspond to two near areas in the retina. It is interesting to note that these provisions within the brain are not genetic, but are due to learning.

As a result of these observations, Kohonen proposed a self-adaptive topological map model. Only entries change the process, so learning is unsupervised. It's about reproducing the neuronal principle of the vertebrate brain: stimuli of the same nature excite a very particular region of the brain. Neurons are organized in the cortex so as to interpret all types of stimuli imaginable. In the same way, the adaptive map deploys to represent a set of data, and each neuron specializes to represent a particular group of data according to the common points who bring them together. It allows multiple dimension visualization of cross-data.

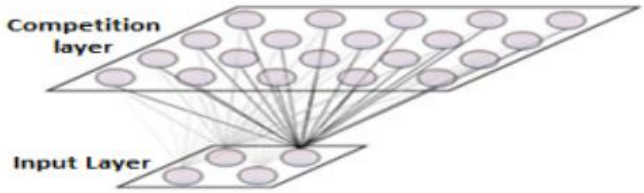

Fig.6. The self-organization map or Kohonen layer

As it known in learning process, the Kohonen layer do an analysis of the data (the inputs vectors) to determine the winner neurons (these are network outputs) that associated for such a situation or such an observation and group theme into a cluster for simplify the data classification because this network solve the issues of classification in various problem domains.

The learning procedure begins with a preliminary data processing which provides scaling of the vectors lengths according to the following formula [8].

$$x_i = x_{i\,/} \sqrt{\sum_{j=0}^{n-1} x_j^2} \qquad (1)$$

At the beginning of learning we will randomly initialize the weights of neurons and then we will present to the network a vector x of the learning set to determine the neuron whose weight vector is the closest to input vector x.

For determine the winning neuron we will use Euclidean distance:

$$\| x_j - x \| = min_n \| w_n - x \| \quad (2)$$

Where n is the number of node, w is the weight vector, and the x is the input from node j.

After we will update the weight of node j and its neighbors for other neurons take a chance to be winner, the vector weight of the neuron j_0 is modified by the rule:

$$wj0\ (t+1) = wj0\ (t) + \alpha\ (t)\ hjj0\ (h)\ (x - wj0\ (t)) \quad (3)$$

In order to complete the counter propagation model we will use the values obtained at the output of the Kohonen layer at the entrance of the second layer is called the Grossberg, for to calculate the values of the network output.

B. The Grossberg Layer

The simple model has n entries represented by a vector $x=(x_1, x_2, x_3 \ldots X_n)$ and for each x_i we associate a synaptic weight v_{ij} linked to the neuron j this last calculates the weighted sum of these entries then this value passes through the activation to produce the output.

In our case the inputs of this layer are the outputs of Kohonen:

$$yj = \sum_i ki\ .vij \quad (4)$$

Where *yj* the output of Grossberg layer, *ki* the output for Kohonen layer, and *vij* Synaptic weights between the i nd neuron of the Kohonen layer and the j nd neurons of the Grossberg layer.

In the next step the synaptic weights of the Grossberg layer are modified to approximate the values of the input vector components and the component values for the desirable vector of the network output.

$$wij\ (t+1) = vij\ (t) + \beta\ (dj - vij\ (t))\ ki \quad (5)$$

Where β Speed of learning, *dj* desirable value of the neuron output of the Grossberg layer and *ki* value of the neuron output of the Kohonen layer.

6 The adaptive approach of use ANN in Management Natural Resources for Agriculture

The population is increasing at a very high rate which is directly related to the increase in the demand for food for that in this paper intelligent system of diagnosis and control in greenhouses is used to improve the crop yields by various factors of temperature, air humidity, soil humidity and brightness and the same time to optimize the use of natural resources like water etc. For that purpose we are used artificiel neural network (ANN). This project shows the ability of artificiel neural network technology to be used for the diagnosis and control system of improve crop yields and an intelligent management of using the naturel resources in agriculture.

6-1 design of an intelligent system by ANN to improve the corps yields and to optimize the naturel resources in agriculture

In this system we will base on two systems. The first one is embedded system we use the arduino programmable integrated circuit for obtained the digital information about the sensors of temperature, air humidity, soil humidity and brightness and the second one we developed the advanced algorithm of neural network for to process this digital information and give an adequate answer for such a situation or observation.

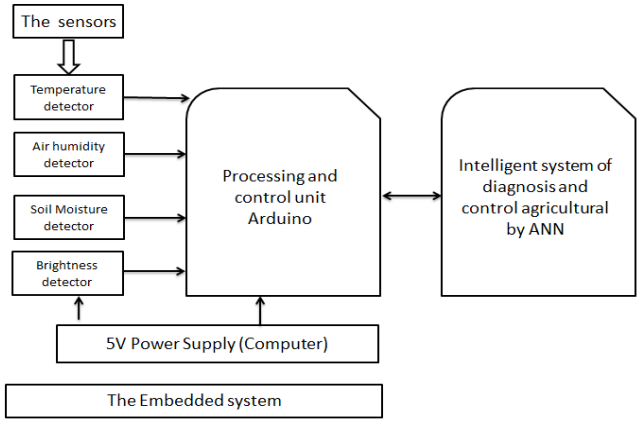

Fig.8. diagram for the approach of ANN in an intelligent system of diagnosis and control agricultural

The objective of our system is to determine the defect from the sensors we have and control them at the same time to secure and increase agricultural production because each fruit or each vegetable has precise thresholds we can't exceed them in order to give a good production for examples:

If we have a defect from temperature sensor or the air humidity sensor that is to say these sensors exceed the threshold we have, so in this case we must launch a fan system for cooling the air.

If we have a defect from brightness sensor (this sensor exceed the threshold we have) we must launch a lighting system to make an automatic lighting because there are the fruits or the vegetables that can live in the light 24/24, for lighting system we used a simple lamp.

If we have a defect from soil humidity sensor (this sensor exceed the threshold we have), in this case we must run a watering system to make an automatic irrigation because the soil is dry, for irrigation system we used the servo motor the arduino sets the angles between which the servo motor should rotate to open and close the irrigation system;

In this moment we make an intelligent management of how using natural resources in agriculture hence the intelligent system that we have lead us to an automatic irrigation that optimize the water used better than traditional agriculture methods for irrigation (e.g, the drip irrigation).

Drip irrigation is the traditional agriculture method uses a system of tubes looped around each of your plants at the soil level so that water can seep into the ground for instant moisture.

Fig.9. The drip irrigation

In this traditional agriculture method we find many problems like:

- The drip irrigation controlled manually or with a timer so the farmer has to control it every day.
- Sunlight bombards exposed tubing with ultraviolet rays, reducing its lifespan to around five years.
- Drip irrigation emitters are vulnerable to clogging and dysfunction (water filters required, regular flushing of pipe system) because the plants suffer when a drip system is not working effectively or needs to be cleaned.
- High skill requirements for irrigation water management in order to achieve optimal water distribution.

this traditional methods used for irrigation is not very efficient so some additional technologies like intelligence is in much need for that we can apply artificiel intelligence to make an irrigation efficient and to optimize the use of water.

7 Build the diagnosis and control Model

Using Artificiel Neural Network (ANN) to build the diagnosis and control model, in this system we used the model counter propagation network (CPN), it separated into 2 steps.
The first step is the creation of Kohonen layer and the second step is to create the Grossberg layer.
After that we used the arduino map to get the learning data from temperature sensor, air humidity sensor, soil humidity sensor and brightness sensor.

Table 1. The concept of our system

Sensor of temperature	Sensor of air humidity	Sensor of moisture humidity	Sensor of brightness
If the value >=27	If the value >=30	If the value <700	If the value <60
Action : we have to launch the fan system	Action : we have launch the fan system	Action : we have launch the irrigation system	Action : we have launch the lighting system

For create the model counter propagation network we must to create the first layer (Kohonen) after the outputs of this layer are the inputs for the second layer (Grossberg).
a window is triggered requesting the insertion of the map dimension, Maximum Iteration, the first stopping condition, Minimal Error, the second stopping condition and the Learning Rate for the Kohonen layer as well as Minimal Error, Maximum Iteration, Learning Rate for the Grossberg layer (Fig. 10).

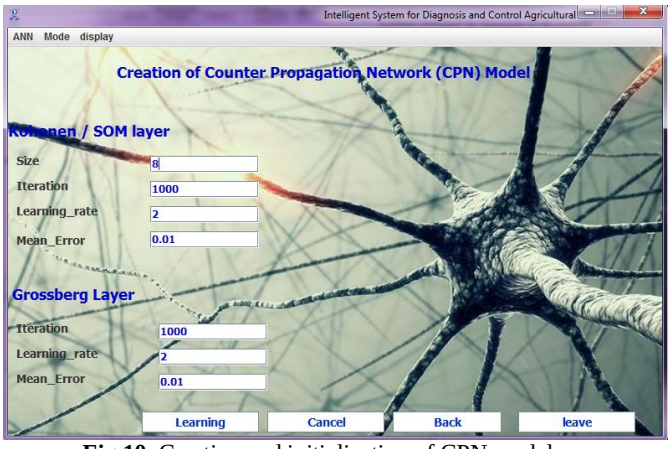

Fig.10. Creation and initialization of CPN model

After the initialization of the CPN model, we will do the learning so that we can use it. So, we click on the button Learning and we wait a few seconds. The learning is completed when one of the two conditions (Mean Error or maximum iteration) is achieved, the results of the outputs and the weights of CPN model is represented in (Fig.11).

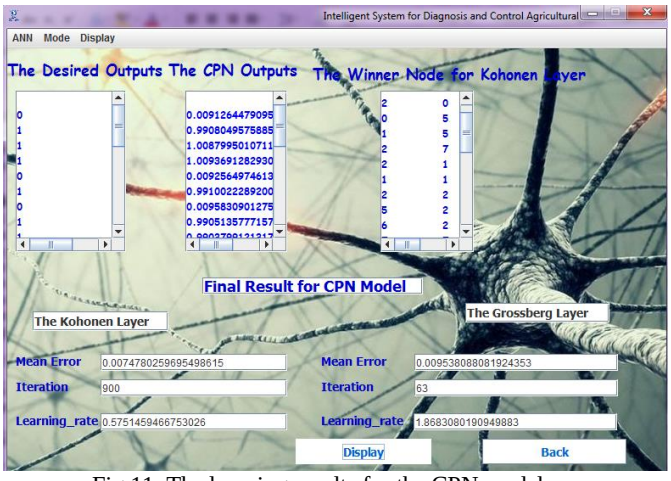

Fig.11. The learning results for the CPN model

For the desired outputs the binary values (1 and 0) have been chosen to control.
1: for an abnormal state the system must do the control.
0: for a normal state "no fault has not been detected".

The outputs of the model CPN will be used for the diagnosis and the control in real time, the window is triggered asking the insertion of the data these last come automatic and in real time from the sensors that one has for the entries to our algorithm advanced neural networks for the latter gives a characteristic answer on the state of system in order to make a good diagnosis and a good control at the same time, (Fig.12)

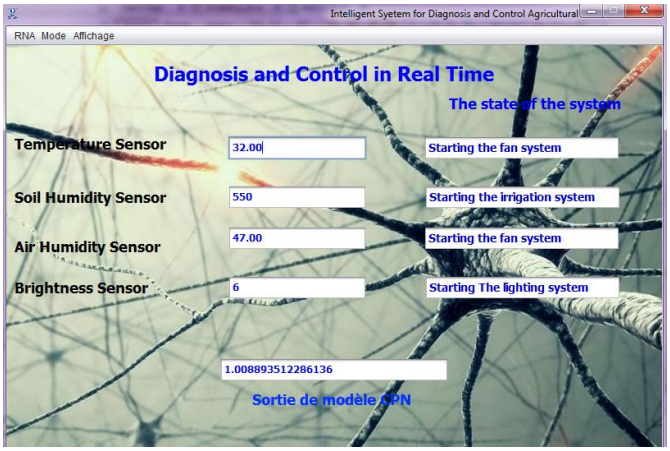

Fig.12. Diagnosis and control agricultural in real time

In this case we have 4 default from a temperature sensor, soil moisture sensor, air humidity sensor and brightness sensor also the output of our CPN networks is approaching 1 so the system must react in real time to diagnose and control them at the same time.

Fig.13. The real demonstration for our intelligent system

The white led is lit to indicate that the servo motor is open for the purpose of doing an irrigation because the soil is dry, this technique has allowed us to optimize the water in an efficient way, also we have a green led is On indicates that the lighting system is running and in the end a fan system is started to decrease the temperature value.

7 CONCLUSION

The paper proposed the use of artificiel neural network for make an intelligent system of diagnosis and control to improve the crop yields in greenhouses agricultural and to optimize the use of naturel resources like water. From the above result we can conclude that the system gives the best result by ANN, thanks to:

- The capacity of classification
- The capacity of learn
- The generalization on new situations

For improve the production agricultural we find many factors, in this work we worked on abiotic factors such as: (temperature, air humidity, soil humidity and brightness). Our perspective is to develop this system for treat the several factors like biotic factors and the optimize the several naturel resources.

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