Fire detection using fiber optics and neural network

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Abstract

A monitoring system is proposed to detect fire in an important building.

In this paper, fibber optics is used as a connection cables and temperature sensing. Star topology has been proposed to connect all rooms in the specified building.

The temperature values have been taken from the important rooms by optical sensors and fed in back-propagation neural network in order to diagnose fire occurrence or not.

Keywords: Fiber optic , neural network , fire detection.

الخلاصة

تم اقتراح طريقة لأكتشاف الحرائق في بناية مهمة.

تستند هذه الطريقة على استخدام الالياف الضوئية كمتحسسات للحـــرارة وأيضـــا استخدامها كقنوات نقل للمعلومات. تم وضع المتحسسات في غرف البناية ورُبطت عـــن طريق الالياف الضوئية الى مستقبل واحد بطريقة النجمة، قيم درجات الحرارة المـــأخوذة من هذه المتحسسات يتم تغذيتها الى شبكة عصبية صممت من أجل التعرف على درجـــة الحرارة المؤدية الى حريق واعطاء انذار.

1. Introduction:

The choice of particular sensors types for a given sensing application depends upon the parameter being measured and the physical properties of the sensor.

The parameter being measured can be strain, temperature, pressure...etc. Fiber optic sensors have gained an importance in recent years and have been used in a variety of structural applications[1]. However some sensors exhibit non-linear output, which poses a requirement on processing capabilities and a processor must

accomplish these tasks quickly and efficiently to make the smart structure an on-line system. Artificial neural networks (ANN) have attracted increasing attention in recent years due to their capabilities in pattern recognition. For large monitoring system having numerous built- in sensors, real time operation requires high computing speeds. ANN have parallel computing architectures, and when implemented in hardware, can quickly process multiple inputs. In this paper, an approach is proposed for the detection of real time fires occurring in an important building.

Optical fiber is chosen to be used as a backbone to the building. Room temperature is very important control variable, and the temperature in various regions of the room can be obtained from the continuous optical measurements. This approach involves the collection of rooms temperature from fiber-optic detectors in different regions. After some preliminary data treatment, Back-propagation neural network will be used for recognition of temperature patterns, and gives an alarm for the existence of fire or not.

2. Optical fiber :

Fiber- optic technology can be considered as a savior for meeting human need because of its potentially limitless capabilities: huge bandwidth [nearly 50 tera bits per second (Tbps), low signal attenuation (as low 0.2 dB/km), low signal distortion, low power requirement, low material usage, small space requirement, and low cost [2].

2.1 Advantages of optical fiber communications:

1. **Large transmission capacity**: When signals are carried by higher frequency carriers, more information can be transmitted.
2. **Low loss**: Because optical fibers can transmit signals 5 times greater than waveguides and 50 times greater than twisted –pair wires.
3. **Immunity to interference**: Because of the waveguide nature and easy isolation, optical signals can be easily confined in a fiber without any external interference.
4. **High – speed interconnections** : Optical communication is also well suited for high- speed interconnections. optical signals can be transmitted and received through free space.
5. **Parallel transmission**: Because optical signals can be transmitted in free space, parallel transmission in three dimensions is possible. This provides powerful ways to interconnect large numbers of processors for parallel processing.

6. **Immunity against chemicals**: As the basic fiber is made of glass, it will not corrode and is unaffected by most chemicals. It can be buried directly in most kinds of soil.
7. **Safe to use**: Since the only carrier in the fiber is light, there is no possibility of a spark from a broken fiber.
8. **Security:** Fiber optic cable is ideal for secure communications systems because it is very difficult to tap compare to other media [3].

3. Neural Network:

Many successful applications of Neural Network (NN) have raised the interest of researches from different scientific disciplines in the neural network area. Various and complex problems have been treated successfully using NN.

The NN is a collection of processing elements or nodes the output of each node has two basic parts:

1. Summation function that receives the various input activation through input connections (synapses) and sums them into a single activation.
2. Threshold function which transfers the summation of input activation into output activation through output connection as shown in fig.(1)

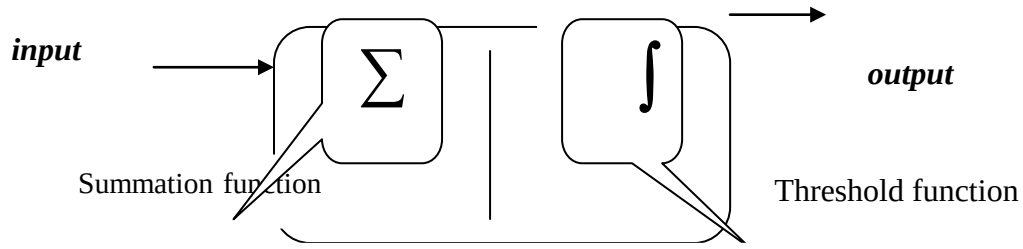

Fig. (1) Artificial neuron

Instead of programming a NN, we teach it to give a correct output. Entering the input and desired output patterns, assigning the initial weight values to the connections within the network, then it will adjust those weights over and over until it gives a correct output.

Back-propagation (BP) is the most widely used learning algorithm in the NN and can be applied to handle any problem that requires pattern mapping from input pattern to output pattern.

BP network is considered to consist of three layers or more of processing elements, the input layer, hidden layers and the output layer. Each neuron is connected to every unit in the layer above and

the layer below, so the network is fully connected. The activation function in BP algorithm is typically a sigmoid function.
The sigmoid compresses the range of the neuron output so that it lies between (0,1) or (-1,1).
The operation of the BP algorithm involves two phases, the forward phase and the backward phase. During the forward phase the input is presented and propagated toward the output, while during the backward phase, the errors are formed at the output and back propagated toward the input.[4]

4- The proposed approach:

4.1 first stage :

4.1.1 Optical system: All optical system consists of three main sections:
1- Transmitter unit.
2- Optical fiber channel.
3- receiver Unit.
The function of transmitter is to convert the electrical signal into optical form and to launch the resulting optical signal into the optical fiber[3]. But in this research, optical thermometer is used as sensor and media so there is no need for this unit.
The optical fiber channel is used as a backbone to the whole system. Several types of fiber are available in the word markets, the one that has been chosen for this research is the signal mode fiber because it is suitable for carrying high bandwidth information.
An optical receiver converts the optical signal received at the output end of the optical fiber back into the original electrical signal as shown in fig.(2):

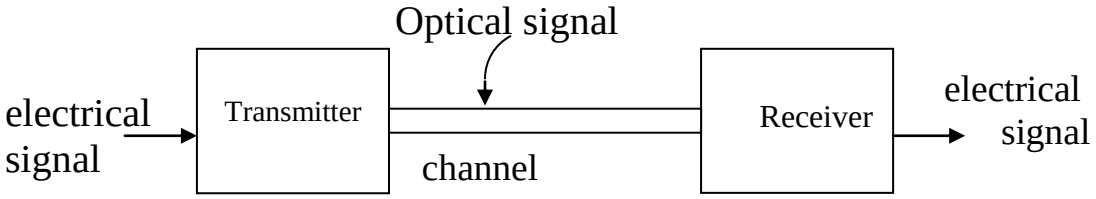

Fig. (2) optical system

4.1.2 Optical thermometer:

Temperature value are collected by fiber optic thermometers that are located in building room. These unit comprise high accuracy, measure wide temperature ranges without physically contacting the target material.

The result is a highly reliable system offering outstanding accuracy and repeatability with high response speed.

Fiber optic glasses can be doped to serve directly as radiation emitters at hot spots so that fiber optics serve as both the sensor and the media. The can be used for distributed temperature monitory as in many corners of room.

An activated temperature measuring system involves sensing head containing luminescent phosphor attached at the tip pf an optical fiber as in fig.(3). A pulsed light source from the instrument package excites the phosphor to luminescence and the decay rate of the luminescence is dependent on the temperature.

These methods work well for non-glowing, but hot surfaces below about (400c) [5].

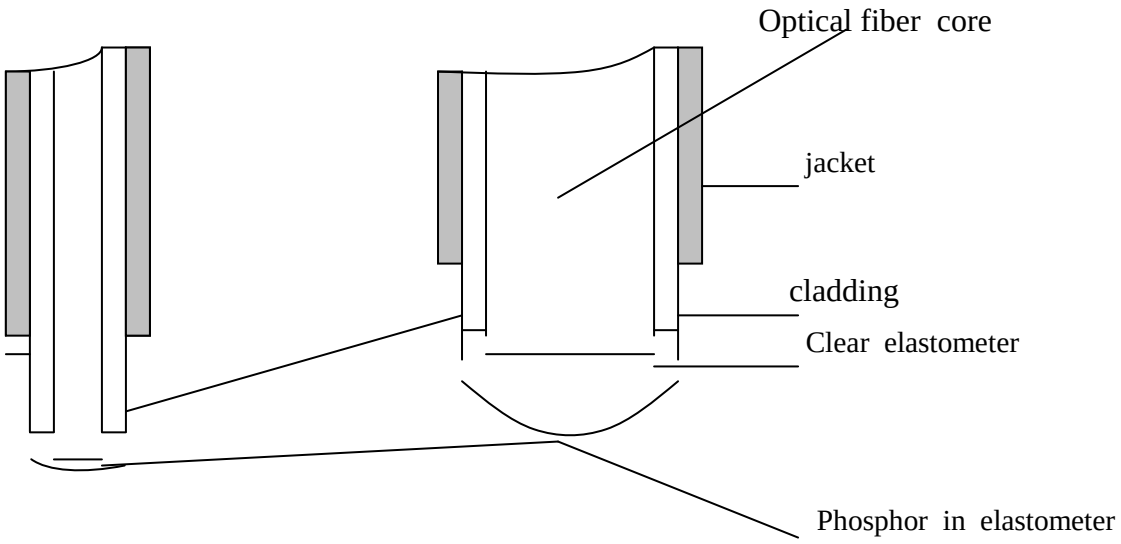

Fig. 3 fiber optic probe construction

4.2: Second stage: Bp neural network is designed to recognize temperature pattern from the sensor output to diagnose the existence of fire or not. This network consists of (9) nodes in the input layer and (12) nodes in the hidden layer and one output node as shown in fig. (4):

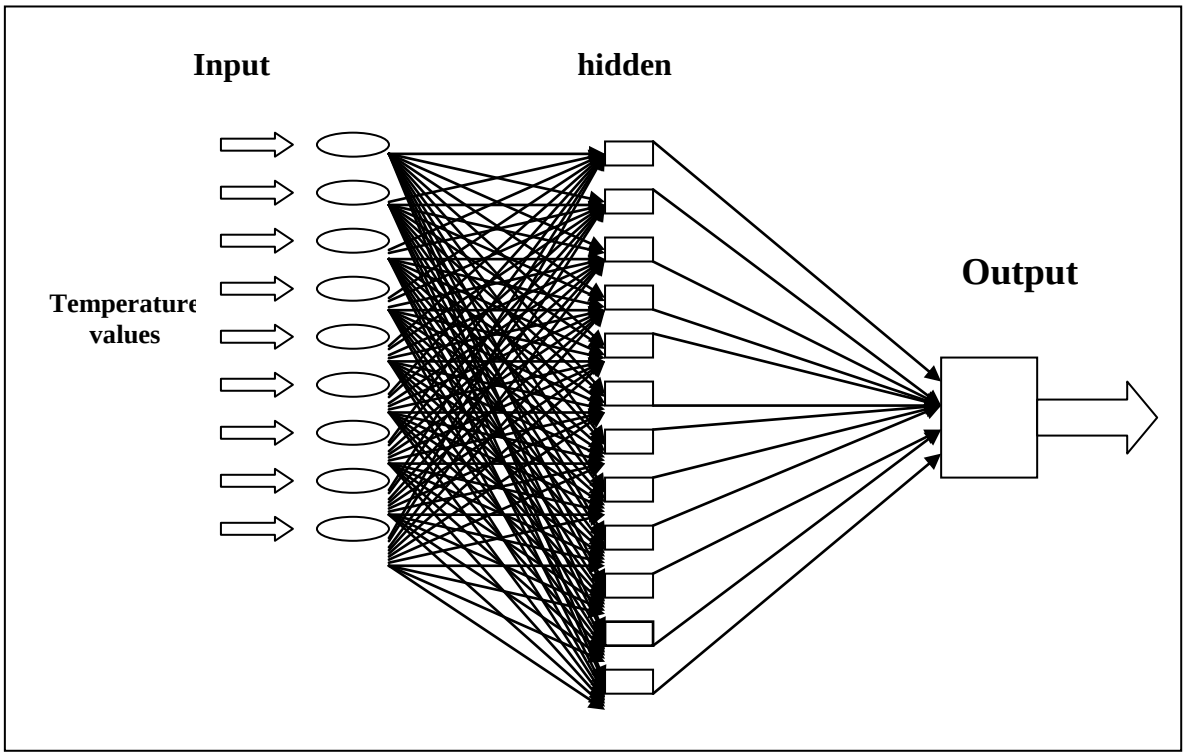

Fig. (4) NN model of second stage

The NN is trained according to pattern of (512) raw for (1500) epochs to reach the desired mean square error . The optimum set of weight are saved to give the final network. When sensors present the temperature values to the NN, it should be recognized. If they were similar to the learned pattern, they NN produces similar output. If the output node gives (1), then it is an indication of the fire existence, and the whole system will give an alarm.

The block diagram of the proposed method is illustrated in fig.(5):

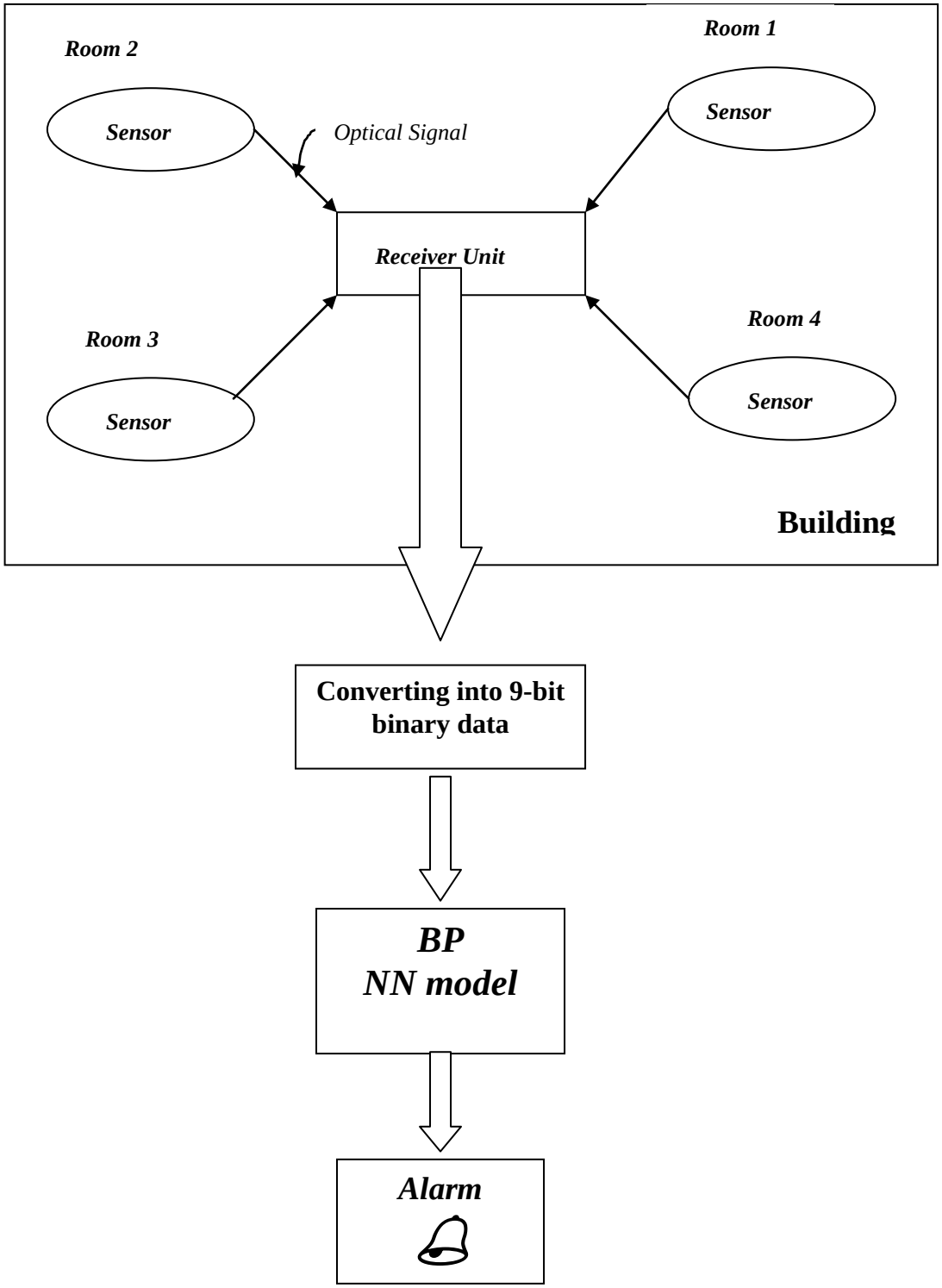

Fig.(5) Block diagram of the proposed method

5.Conclusion:

We have proposed an approach to detected fire in an important building. This approach consist of two stages, where the first stage use the fiber optic as a sensor and channel. In the second stage Back Propagation neural network is designed to recognize the data output from the first stage and give an alarm if there is any fire. The network is trained with (512) value of temperature that yields to automatic diagnoses. This method is designed to aid the measurement and detection of hot regions in the building.

Future work will include experimentally obtaining sensors data to be tested with different neural network.

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