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Automatic Fire Classification and Extinguish System Using Embedded Based Neural Network

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Abstract—

This paper proposed a monitoring and control system in Fire control process using microcontroller based embedded system. The monitoring process is implemented by sensing six types of gases along with temperature and determines the source of fire and activates the appropriate extinguishers. The classification of fire is based on the trained values of gas and temperature values using Artificial Neural Network (ANN). The Atmel based AT32UC3L064 microcontroller is used in this system and it also responsible to initiate the control process by selecting and activating appropriate Fire extinguisher. The system is able to classify six types of fire sources and activate the three type of extinguishers. The performance of developed system is examined in determination of fire types using measured and predicted values.

Keywords—Fire extinguishing system, Artificial Neural Network, Sensors, Monitoring and Control, Microcontroller

I. INTRODUCTION

Fire is a major hazards in households and in an industries. The incidence of accidental deaths an increasing trend during the period 2003 -2012 in India, with an increase of 51.8% in the year 2012 as compared to 2002, however 0.2% decrease was observed in 2003 over previous year 2002. The population growth during the period 2003-2012 was 13.6% whereas the increase in the rate of accidental deaths during the same period was 34.2% [1]. Fire protection is the study and practice of mitigating the unwanted effects of potentially destructive fires. The most common potential ignition sources are Alcohols, Kerosene, LNG /LPG, Chemicals, Jet Fuels, Paper/Wood, Diesel, Hydrogen, Textiles, Gasoline and Solvents [2]. The practice of using common extinguisher (water) is not appropriate in control of all type fires, the other extinguishers using like Foam, Dry Powder and chemicals are needed to control the fire from the sources of freely burning materials, flammable liquids and cooking oil respectively. Since the identification of fire types and its control system is necessary one. This work is focused about the classification fire sources and activates the respective extinguisher using microcontroller based system. The Neural Network is adopted in estimation of fire types. The proposed system is a monitoring and control system. The monitoring process is implemented using six types of gas sensors and one temperature sensor. The sensed values are store in a microcontroller, according to the sensed parameters the system will estimate the source of fire and initiate the control functions to sustain the fire using corresponding extinguisher. The knowledge in determination of fire type is acquired from the Artificial Neural Network. The neural system is trained using six types of Gas value and temperature, the accumulated weighted values will be stored in the microcontroller. In monitoring process, the embedded system will predict the fire and determine its types using values from Gas and Temperature Sensors, which are deployed in the field and also responsible to control the fire by activate the respective extinguisher, as an in situ device.

II. MATERIALS AND METHOD

When deciding on what fire protection is appropriate for any given situation, it is important to assess the types of fire hazard that may be faced. The Classification of fires and their appropriate Extinguishers are shown in Table I [3].

TABLE I CLASSIFICATION OF FIRES AND THEIR EXTINGUISHERS

CLASS	MATERIALS	EXAMPLE	EXTINGUISHERS
Class A	freely burning materials	Wood, paper, cloth, rubber, trash, plastics, textiles and other carbonaceous materials.	Water, Foam, ABC Dry Powder and Wet Chemical Extinguishers. Extinguishers with white, yellow or blue labels.
Class B	flammable liquids	Petrol, diesel, solvents, lubricants and spirits. Not alcohol or cooking oil.	Foam, ABC Dry Powder, Monnex Dry Powder and CO^2 Gas Extinguishers. Extinguishers with yellow, blue (not L2 or M28 Powder) or black labels.

Class C	flammable gases	butane and propane	ABC Powder and Monnex Dry Powder Extinguishers. Extinguishers with blue labels (not L2 or M28 Powder).
Class D	flammable metals	Sodium, lithium, magnesium and aluminum when in the form of surf or powder.	L2 Powder and M28 Powder Extinguishers (M28 Powder does not cover lithium). Extinguishers with blue labels (not ABC or Monnex Dry Powders).
Class F	cooking oil and fat	Olive oil, maize oil, sunflower oil, lard and butter.	Wet Chemical Extinguishers. Extinguishers with yellow labels.
Class E	electrical equipment	Photocopiers, fax machines and computers.	ABC Powder, Monnex Dry Powder and CO^2 Gas Extinguishers. Extinguishers with blue (not L2 or M28 Powder) or black labels.

A neural network consists of an interconnected group of artificial neurons, and it processes information using a connectionist approach to computation. In most cases an ANN is an adaptive system that changes its structure based on external or internal information that flows through the network during the learning phase. Modern neural networks are non-linear statistical data modeling tools [4] [5] [6]. In this work, an Artificial Neural Network (ANN) tool JustNN is used for fire-classification and extinguishers are activated based on the signals detected by the gas and temperature sensors.

III. EMBEDDED PLATFORM

The embedded platform is built around an AT32UC3L064 microcontroller. AT32UC3L064 is an Atmel family general purpose microcontroller 32KB Flash, 48pin, CAT Module, Flash Vault code protection and running at frequencies up to 50MHz.

The six gas sensors and a temperature sensor are shown in Table II, is used for recognition of the signals from the environment. All sensors are used tin oxide gas sensors and the different sensors are sensitive to different gases. The AT32UC3L064 microcontroller have a inbuilt Analog to Digital convertor and the analog signals are sensed from six gas and a temperature sensors are read by the microcontroller one at a time using the multiplexing characteristic of the ADC. An alphanumeric display is used to show the type of the fire from the sensors during the JustNN training phase and the microcontroller activates the appropriate extinguisher. In this work we used three types of extinguishers are water, foam and dry powder. Fig 1 shows the block diagram of the embedded system.

TABLE II VARIOUS SENSORS ARE USED TO TARGET GASES

S.N.	Sensor ID	Detectable Gases
1.	TGS 880	Volatile gases from food, Alcohol
2.	TGS 822	Xylene, Toluene, alcohol, volatile organic vapors
3.	TGS 2600	Air contaminants, CO_2, CO
4.	TGS 2611	Natural gas, methane
5.	TGS 2610	General combustible gas, LP gas, propane
6.	TGS 2602	Air contaminants, hydrogen sulfide, ammonia
7.	Thermistor	Temperature sensor

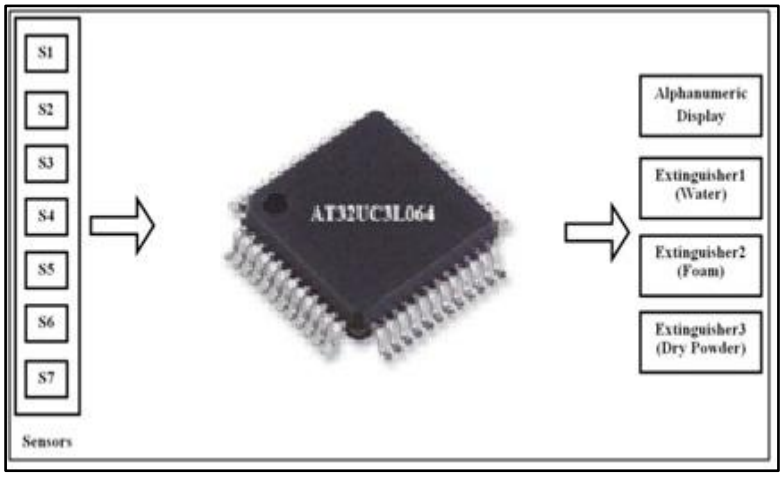
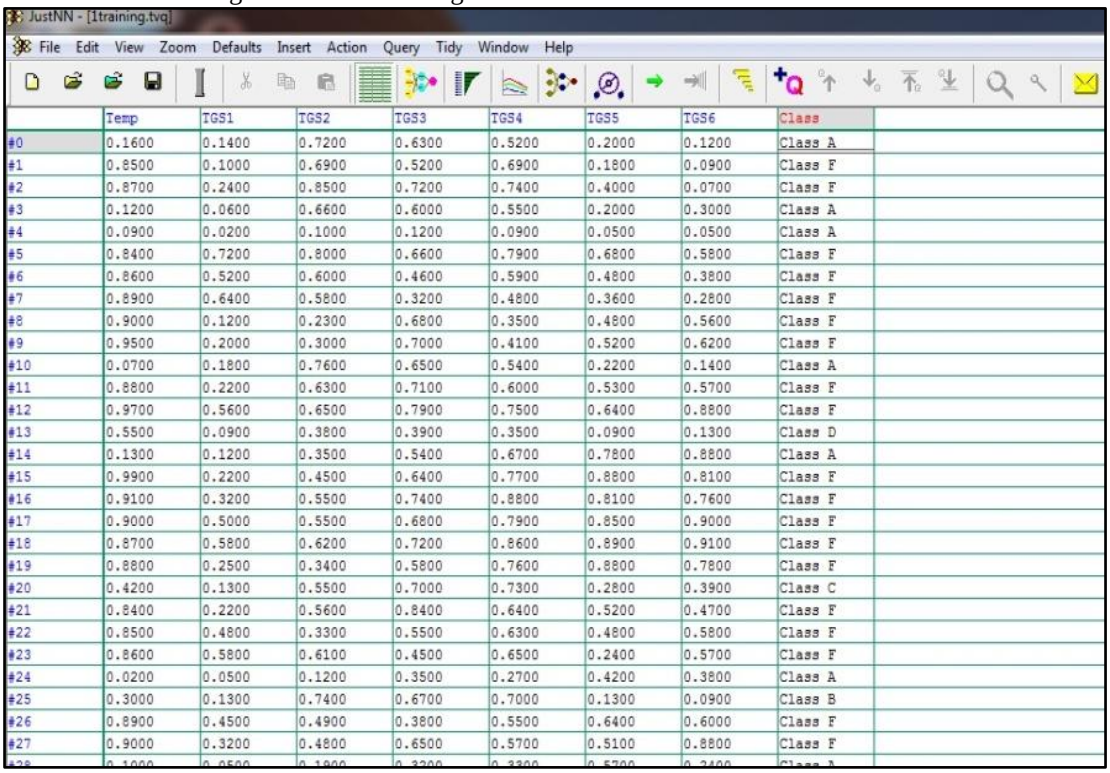


Fig 1: Block Diagram of the embedded system

IV. ANN IMPLEMENTATION

This work does not require the system to be able to continuously process data in real-time since once a fire is detected, system classifies the type of fire and activate appropriate extinguisher, and its work is finished. Even if the calculations required several seconds, this is acceptable for this application. This network is very large relative to the simplicity of the problem to be solved.

The JustNN was originally developed as a tool for training neural networks for use on a PC or comparable computing machine. Neural Network Training originally produced for the user an array of weights that corresponded to the weights in a neural network architecture designed by that user. The Grid window of JustNN Tool for training data set as shown in the Fig 2 [7]. It has one input layer with seven neurons, one hidden layer with five neurons and one output layer with one neuron as configuration shown in Fig 3.



	Temp	TGS1	TGS2	TGS3	TGS4	TGS5	TGS6	Class
#0	0.1600	0.1400	0.7200	0.6300	0.5200	0.2000	0.1200	Class A
#1	0.8500	0.1000	0.6900	0.5200	0.6900	0.1800	0.0900	Class F
#2	0.8700	0.2400	0.8500	0.7200	0.7400	0.4000	0.0700	Class F
#3	0.1200	0.0600	0.6600	0.6000	0.5500	0.2000	0.3000	Class A
#4	0.0900	0.0200	0.1000	0.1200	0.0900	0.0500	0.0500	Class A
#5	0.8400	0.7200	0.8000	0.6600	0.7900	0.6800	0.5800	Class F
#6	0.8600	0.5200	0.6000	0.4600	0.5900	0.4800	0.3800	Class F
#7	0.8900	0.6400	0.5800	0.3200	0.4800	0.3600	0.2800	Class F
#8	0.9000	0.1200	0.2300	0.6800	0.3500	0.4800	0.5600	Class F
#9	0.9500	0.2000	0.3000	0.7000	0.4100	0.5200	0.6200	Class F
#10	0.0700	0.1800	0.7600	0.6500	0.5400	0.2200	0.1400	Class A
#11	0.8800	0.2200	0.6300	0.7100	0.6000	0.5300	0.5700	Class F
#12	0.9700	0.5600	0.6500	0.7900	0.7500	0.6400	0.8800	Class F
#13	0.5500	0.0900	0.3800	0.3900	0.3500	0.0900	0.1300	Class D
#14	0.1300	0.1200	0.3500	0.5400	0.6700	0.7800	0.8800	Class A
#15	0.9900	0.2200	0.4500	0.6400	0.7700	0.8800	0.8100	Class F
#16	0.9100	0.3200	0.5500	0.7400	0.8800	0.8100	0.7600	Class F
#17	0.9000	0.5000	0.5500	0.6800	0.7900	0.8500	0.9000	Class F
#18	0.8700	0.5800	0.6200	0.7200	0.8600	0.8900	0.9100	Class F
#19	0.8800	0.2500	0.3400	0.5800	0.7600	0.8800	0.7800	Class F
#20	0.4200	0.1300	0.5500	0.7000	0.7300	0.2800	0.3900	Class C
#21	0.8400	0.2200	0.5600	0.8400	0.6400	0.5200	0.4700	Class F
#22	0.8500	0.4800	0.3300	0.5500	0.6300	0.4800	0.5800	Class F
#23	0.8600	0.5800	0.6100	0.4500	0.6500	0.2400	0.5700	Class F
#24	0.0200	0.0500	0.1200	0.3500	0.2700	0.4200	0.3800	Class A
#25	0.3000	0.1300	0.7400	0.6700	0.7000	0.1300	0.0900	Class B
#26	0.8900	0.4500	0.4900	0.3800	0.5500	0.6400	0.6000	Class F
#27	0.9000	0.3200	0.4800	0.6500	0.5700	0.5100	0.8800	Class F

Fig 2: Grid view of JustNN tool for training data set

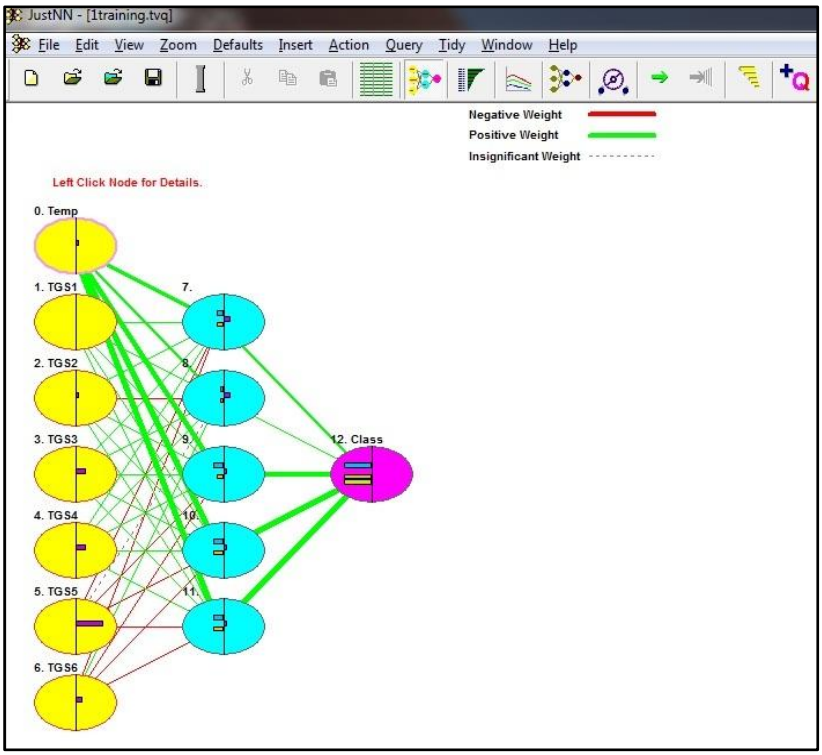


Fig 3: Network Window of JustNN Tool

V. RESULT AND DISCUSSION

The proposed system is used for the classification and extinguishes of various type of fire using the six gas sensors and a temperature sensor are scanned by the embedded system as discussed above. The values are trained in neural network tool JustNN. After the training is complete, the weights are saved to a text file and then ported to the embedded neural network application. The proposed system's efficiency is studied in number of test and compared to the trained values.

It is found that the regression equation (-124.34+1.008X) [8] arrived gives the unity slope and the intercept closes to the zero value. The value of slope is 1.0090483619, Correlation Coefficient is 0.9901268668 and intercept is -0.1684867395, shows that the predicted data is taken from the linear regression results. Fig 4 shows the linear regression between sensed value and trained value. Table III summarizes the result of the test cases.

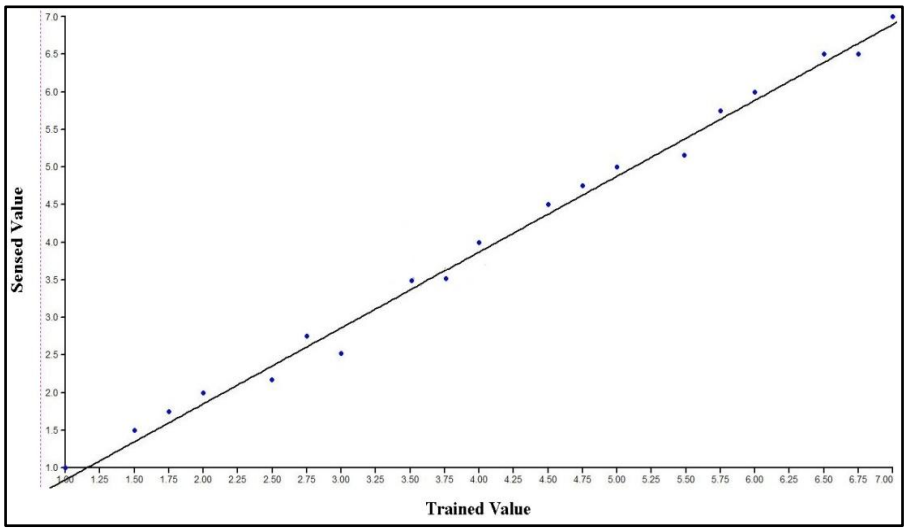


Fig 4: Linear regression between sensed value and trained value

TABLE III EFFICIENCY OF THE TRAINED NETWORK IN DIFFERENT TEST CASES

Test Case	No. of Tests	Correct Results	Incorrect Results	Remarks
Class A	2	2	0	100%
Class B	2	2	0	100%
Class C	2	2	0	100%
Class D	2	2	0	100%
Class E	2	2	0	100%
Class F	2	2	0	100%

This work used three types of extinguishers, which are water, foam and dry powder and one alphanumeric display shows the value from 0-255. The system compared the sensed value to the trained value after the comparison, the alphanumeric display shows the type of the fire. Then the system automatically activates the appropriate extinguisher.

VI. CONCLUSION

This work presents a solution for neural networks across many types of Fire production system. This work clearly shows that fire classification and extinguishes can be achieved by using embedded based artificial neural network tool along with the general purpose gas and temperature sensors. Moreover, the memory foot-print of the neural network can be minimized enough to fit in a limited memory space of a low cost microcontroller. The approach results a versatile intelligent fire classification and extinguishes system at a much lower price and thus can be used in real life situations to minimize fire hazards.

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