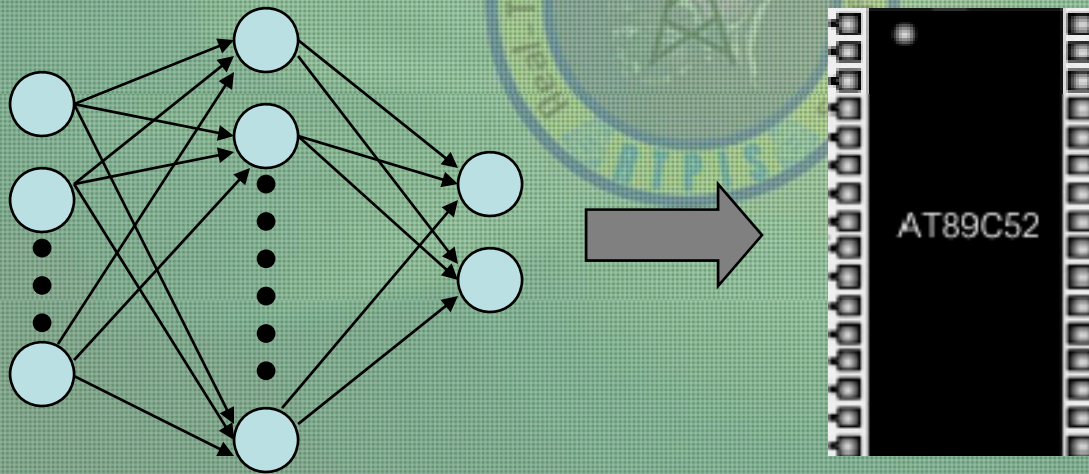


# Embedded Neural Network for Fire Classification Using an Array of Gas Sensors

Intelligent Algorithm Implemented in an  
Embedded System => Robustness + Reliability



# Embedded Neural Network for Fire Classification Using an Array of Gas Sensors

## 1. Introduction

- Fire is one of the most common hazards in households.
- In 2006 alone, 2705 people were killed in US due to fire in building structures.
- 74% of the deaths result from fires in homes with no smoke alarms or no working smoke alarms.
- This study discusses the development of a fire sensing system that is capable of detecting fire and classifying it based on the smell of the smoke in the environment.

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## 1. Introduction

- In this work, an Artificial Neural Network (ANN) is used for fire-classification based on the odor signals detected by an array of gas and temperature sensors.

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## 1. Introduction

This work differs from previous works in fire detection/classification in three major aspects:

- The ANN fire classifier is proposed to be used for selection of appropriate fire extinguishing materials in real time unlike other similar works that use ANN fire classifier for forensic investigation.
- The proposition in (i.) requires that the ANN be implemented in an Embedded System instead of previous PC based implementations.
- NFPA recommendation is used for classification.

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## 2. Embedded Platform

The embedded platform is built around an 89c55 microcontroller.

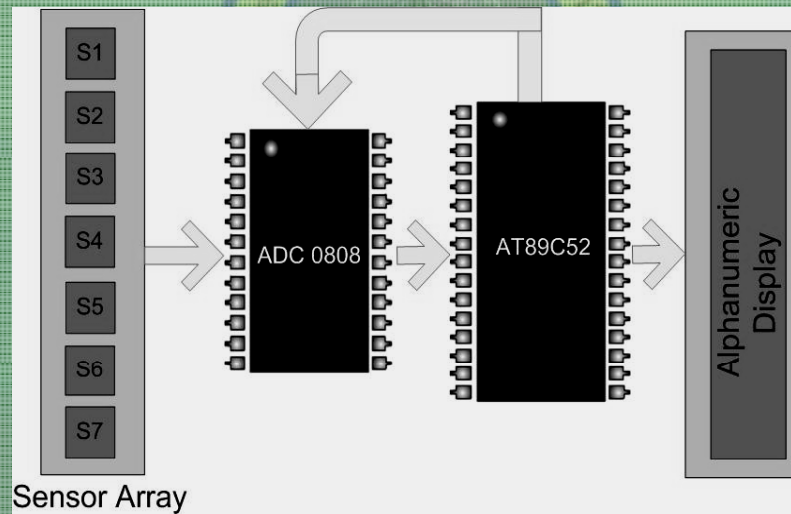


Figure: Embedded Platform Block-Diagram

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## 2. Embedded Platform

The gas-sensors used are tin oxide gas sensors from Figaro Engineering Inc and each sensor in the array is sensitive to different 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 <sub>2</sub> , 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

**Table: Details of the sensors used**

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## 3. Neural Network Implementation

- The ANN classifier is trained using the backpropagation algorithm to classify the input sensor patterns in to three different classes : NORMAL, CLASS A Fire and CLASS B Fire
- The sigmoid activation function is used in neurons.
- A multi-layered feed-forward neural network with a single hidden layer is used.
- The number of nodes in the input layer is equal to the number of sensors in the sensor array (i.e. 7). The hidden layer has 12 nodes and the output layer has 3 nodes.

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## 3. Neural Network Training

- The following data was obtained from the embedded system (normalized) to train the neural network in a PC:

Sample Case	Temp Sensor	TGS 880	TGS822	TGS 2600	TGS2611	TGS2610	TGS2602
Paper	0.72	0.14	0.72	0.63	0.52	0.20	0.12
Paper	0.67	0.06	0.66	0.60	0.55	0.20	0.30
Petrol	0.69	0.10	0.69	0.52	0.69	0.18	0.09
Petrol	0.56	0.24	0.85	0.72	0.74	0.40	0.07
Plastic	0.67	0.09	0.38	0.39	0.35	0.09	0.13
Plastic	0.67	0.01	0.43	0.56	0.50	0.13	0.16
Kerosene	0.60	0.13	0.74	0.67	0.70	0.13	0.09
Kerosene	0.63	0.19	0.78	0.66	0.63	0.14	0.08
Normal	0.58	0.02	0.10	0.12	0.09	0.05	0.08
Wood	0.73	0.13	0.60	0.60	0.66	0.23	0.29
Wood	0.69	0.13	0.55	0.70	0.73	0.28	0.39



# Embedded Neural Network for Fire Classification Using an Array of Gas Sensors

## 4. Results

- The Embedded Neural Network was successfully used to classify fire according NFPA recommendation with a high accuracy.

Test Case	No. of Tests	Correct Results	Incorrect Results	Remarks
Paper	2	2	0	100%
Wood	2	2	0	100%
Kerosene	2	1	1	50%
Petrol	2	2	0	100%
LPG	2	2	0	100%
Plastic	2	2	0	100%

## Embedded Neural Network for Fire Classification Using an Array of Gas Sensors

### 5. Conclusion

- **Neural Network can be used to extract valuable information by fusing signals from multiple sensors.**
- **Embedded implementations of Neural Networks for sensor signal processing have high potential as such systems are more robust and reliable.**
- **The Fire Classification system developed here can be used to develop smart fire-extinguishers that select appropriate extinguishing material for different fires.**

# Embedded Neural Network for Fire Classification Using an Array of Gas Sensors

A large, faded circular seal of the Missouri University of Science and Technology is centered in the background of the slide. The seal contains the university's name and a central emblem.

Questions?