An Intelligent Fire Warning Application Using IOT And An ANFIS

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Abstract: Nowadays, fire accident is a very serious problem that can happen anytime and anywhere due to many people lose their lives. However, such fire alarm systems are sometimes false warning and the presence of fire classified as a false warning may act to the original actual indicate. Fire warning and alarm systems based on a combination of smoke sensors, flame sensors and alarm devices have been introduced to design a life safety system. An Adaptive neuro-fuzzy Inference System (ANFIS) is used to calculate the maximum likelihood of the true presence of fire and generate fire alert. The model includes sensors to collect important data from sensor nodes where fuzzy logic converts the raw data of a linguistic variable trained in ANFIS to obtain the probability of a fire occurrence. The proposed idea also generates alerts from a message sent directly to the user's Smartphone. The MATLAB-based simulation is used for experiments and the results show satisfactory output.

Index Terms – IOT, FDWS, Multi-Sensor, ANFIS, MATLAB Simulation.

I. INTRODUCTION

In past years, fire detection have become a very big issue, as it has caused heavy damage, including damage to human lives. These events become more destroying when the fire spreads to the surrounding area. False alarm can load of the fire brigade and can turn out to be a costly event so many studies conducted to reduce them[3]. Various methods such as autonomous were suggested in previous studies Fire alarm systems and wireless warning systems with fire fighting robots, notification devices. Fire alarm systems with notification devices can be expensive because they use visible and audible stimuli to notify residents[1].

The main objective is to reproduce and develop Economic solutions with minimum false alarms and warning system via GSM (Global System for Mobile Communications). The innovative idea is to use neuro-fuzzy logic to design a smart alarm system.

The system has introduced uses the micro-controller Arduino Uno based on the ATmega 328P. It is easily available and programmed using a set of cost-effective sensors using Arduino software (IDE). The proposed solution effectively uses a smoke sensor with a flame sensor with a specific increase in room temperature to further investigate the true presence of fire and to avoid false alarms, FDWS is trained with a neuro-fuzzy designer. The purpose of this intelligent fire alarm system is to understand the true occurrences of fire, to warn and notify the appropriate authorities.

The ANFIS idea was developed by Jang in 1993. Basically, an ANFIS is a combination of a neural network and a fuzzy inference system (FIS) and is effective in making decisions. ANFIS technology is used to design a fire detection control system and reduce false alarms. ANFIS technology has been used in mobile robot navigation, healthcare monitoring systems, air conditioning control, flood susceptibility modeling, and many other applications.
This system implemented on Arduino UNO micro-controller. Arduino Uno is used due to its high processing speed at low cost. Many sensors are used to collect data and these data were transferred to Arduino Uno. The GSM module alerts the fire monitoring station via SMS[1].

In the rest of the paper :- Section 2. Provides temperature Survey, Section 3. Discusses the used approach and architecture of the proposed ANFIS-based decision support system, Section 4. Provide the Conclusions.

II. LITERATURE SURVEY

Sarera Sarwar et al.(2019)have purpose a system [1] "An Intelligent Fire Warning Application Using IOT and ANFIS" An Adaptive neuro-fuzzy Inference System (ANFIS) is used in this paper to calculate the maximum likelihood of the true presence of fire and generate fire alert. The novel idea proposed in this paper is to use ANFIS for the identification of a true fire incident by using change rate of smoke, the change rate of temperature, and humidity in the presence of fire. The model consists of sensors to collect vital data from sensor nodes where Fuzzy logic converts the raw data in a linguistic variable which is trained in ANFIS to get the probability of fire occurrence. The proposed idea also generates alerts with a message sent directly to the user's smartphone. The primary objective of this system is to develop a reproducible and economical solution with minimum false alarms and a system that alerts via GSM (global system for mobile communication). The innovative idea is to use neuro-fuzzy logic to design a smart alarm system.In system is ANFIS-simulated in MATLAB environment; the obtained results show effectiveness and the robustness with good performances compared with the FIS method.

In 2020,et al. [2] author A.Vidya, P.Malini, S.Sathiya has implementation IOT Based Forest Fire Detection And Early Warning System Using Raspberrry Pi And GSM Camera is used to capture the fire image when a fire incident happens. The pixels in the Flame calculated using Hue Intensity Saturation color model.HSI rules were used for segmenting fire regions. Fire aliases can be avoided by seperating the pixels that have low intensity and low saturation in segmented fire regions. This method detects fire flames from test videos within a second.

In 2019,et al. [3] author Ngonidzashe A Mwedzi, Nwulu and Lekan Gbadamosi has created Machine Learning Applications for Fire Detection in a Residential Building. This application Suggestions of artificial intelligence algorithms for detecting fire using fire detection shaped characteristics from video footage A novel presents an intelligent fire detection system method.CNN network aims to achieve good image classification performance, minimal false alarms and high fire detection rates. VGGNET architecture has come from the CNN network. Through the application of CNN and VGINET technologies, better results were obtained by reducing system accuracy and false alarms by 85%.

In 2018,et al. [4] author S.R.Vijayalakshmi, S.Muruganand has implementation fire alarm based on spatial temporal analysis using fire video. spatial analysis is to reduce the error the introduction of a red object that has a pattern of movements such as fire in the temporal analysis. fire or smoke coloured remove using pixels colour based on HSV model. Spatial and temporal analysis is applied to smoke and fire frames to detect smoke and fire. It is tested with 10 different videos of smoking and non-smoking as well as videos of fire and non smoke and it detects 8 out of 10 frames correctly and the search rate is 80%.

Ke Chen et al. [5] (2019) have proposed Research On Image Fire Detection Based On Support Vector Machine(SVM).An image fire detection algorithm based on support vector machine is proposed by studying the features of fire in digital image. Firstly, the motion region is extracted by the inter-frame difference method and regarded as the suspected fire area. An image fire detection algorithm based on Support Vector Machine (SVM) is proposed based on the establishment of positive and negative fire samples data sets. In order to overcome the shortcomings of holes in the flame area, the algorithm uses scene classification method in remote sensing field to bring some background to the flame area then extracts the RGB feature, texture feature and color moment of the flame to get the feature vectors, and finally inputs the support vector machine model which trained before for fire judgment. The simulation results show that the algorithm can overcome the weaknesses of color model segmentation and improve the accuracy of detection. The basic idea of support vector machine classification algorithm is to find a hyper plane in space that can separate all data samples and maximize the distance between sample data points and hyper planes. The main steps of the support vector machine-based image fire detection algorithm adopted first of Read images and The motion region is extracted by frame difference method and used as fire suspected area, and then preprocessed. Then Resembling for the same size, extracting flame features including H component first moment feature, texture feature, color moment feature, etc. Then Normalize the extracted data to get the eigenvector. Then last Using the support vector machine model which trained before to judge. Python language is used to program and realize the small program of fire detection.

Yang Zhikai, et al. [6] (2018)introduced "Fire Alarm for Video Surveillance Based on Convolutional Neural Network and SRU". This system proposes a neural network model which combines CNN with SRU. A network structure of CNN + SRU was used to analyze the video clips and draw the conclusion of whether it is on fire. There are three models proposed in the paper, including Resnet18+SRU, Resnet34+SRU and resnet18(Maxpool)+SRU. The models were validated on a test set containing intensive indoor environmental interferences and compared with CNN-based single-frame and multi-frame fire identification methods. In the model which introduces motion identification, CNN extracts scene information and combines with SUR to extract the flame's motional characteristics. The layer number of SRU is 8 and each layer contains 256 Units. Finally, the feature vectors outputted by SRU go through a fully connection layer (FC), and the output is divided into two kinds: fire and no fire. 603 videos of dataset were recorded, in which there were 357 of fire and smoke videos under different lighting conditions, and 246 videos with blinking lights and moving objects under the same conditions. The average time of each paragraph was 11 seconds and its image size is 320*240 pixels. Compared with the flame detection only based on CNN with single-frame or multi frame video, CNN combining with SRU for fire detection of video sequences is more suitable for discovering the flames that exist under strong disturbances and complex backgrounds.

In 2019 et al. [7] author I. M. Reza Permana, M. Abdurohman and A. G. Putrada has presented Comparative Analysis of Mesh and Star Topologies in Improving Smart Fire Alarms. This system proposes a fire alarm system, using a WSN, with a mesh topology. The mesh topology is interesting because it is the nature of fault tolerance. To examine the effect of mesh topology, comparisons with star topology are provided. Based on the results of research on a fire alarm system using mesh topology, Star produces sensor data with less delay, packet loss and power consumption than topology. The test on the fire alarm system uses 4 rooms, each room will have a fire alarm detector node installed and each node will have ESP 32, each with gas, light and temperature sensors. Each topology will have a total of four nodes. Thing speak will be used as an IOT platform to collect fire alarm data. Research is limited to comparing only two WSN topologies, while there is also awareness of the existence of other WSN topologies, such as the tree topology.

III. APPROACH AND ARCHITECTURE OF ANFIS

The adaptive neuro-fuzzy inference system or adaptive network-based fuzzy inference system (ANFIS) is a type of artificial neural network based on the Takagi-Sugano fuzzy inference system. The technology was developed in the early 1990's.Its inference system corresponds to the assignment of obscure IF if it has rules that have the ability to learn in approximate nonlinear functions.

ANFIS technology is used to design a fire detection control system and reduce false alarms. An Adaptive neuro-fuzzy Inference System (ANFIS) is used to calculate the maximum likelihood of the true presence of fire and generate fire alert[1]. ANFIS is a combination of two main technology Fuzzy logic and ANN called the adaptive neuro fuzzy inference system.

ANFIS is a five-layer architecture that was developed in the early 1990s. The first layer is called the input layer. The second layer of ANFIS, called inputmf, is a fixed input membership function layer. The third layer depicts norms. The fourth layer, outputmf, is a fixed output membership function layer and the last is the output[1]. The basic block diagram of ANFIS with input and output is illustrated in Figure.
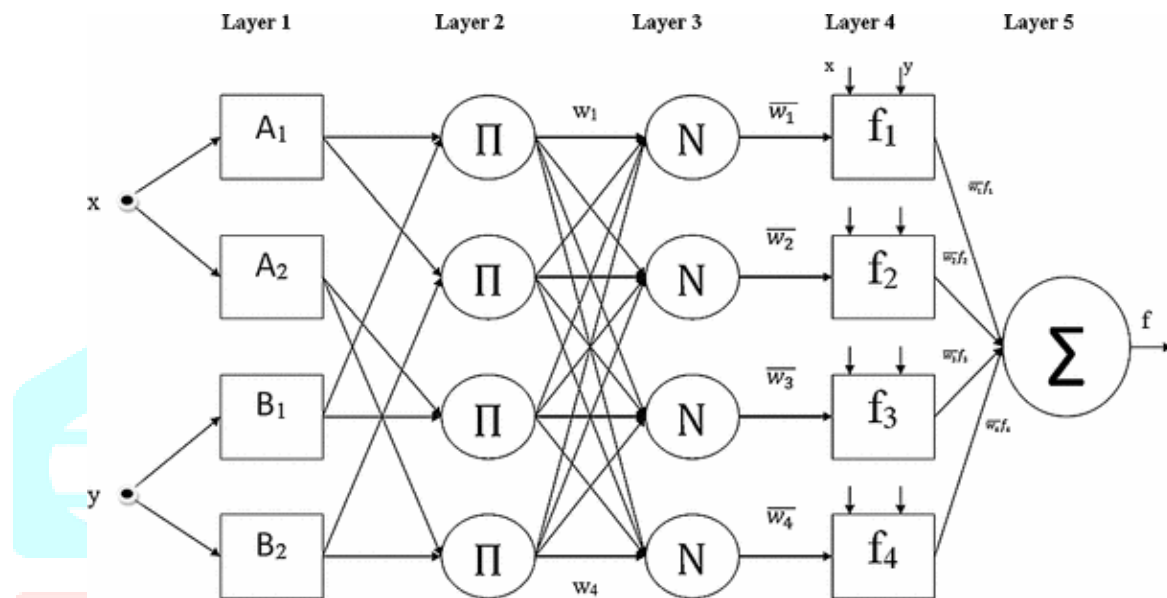
[Fig. ANFIS Structure]

In ANFIS system, Input collected from sensors is trained in various steps. In the first step of fuzzification, raw data is collected, and the fuzzy interface system creates different rules artificially. The created rules are then further trained using the Sugeno method in MATLAB with the help of the artificial neuro-network. In the last step of de-fuzzification, the fuzzified data are again converted into raw variables. The proposed Sugeno-based adaptive neuro-fuzzy interference system decides the presence of fire according to fuzzy rules and vital parameters collected from different sensors[1]. The designed real-time system collects data like temperature, smoke, humidity, and flame presence to provide the updated status to the owner using the GSM module.

3.1 Architecture of proposed FDWS

The combination of software and hardware together creates an automated fire detection system. The system has various sensors such as smoke sensor, temperature and humidity sensor, and flame sensor. These sensors collect data from sensor nodes and then transmit it to the GUI in the MATLAB. The data collected from the sensors are provided to the obscure logic as a linguistic variable as raw data that is trained by an adaptive neuro-fuzzy system to detect fire conditions[1]. If the parameters show that the probability of fire is serious, a message regarding the condition of the fire will be sent to the fire controllers by the GSM regarding the condition of the fire to the fire controllers and the home owner.

3.2 Hardware Development

The Arduino Uno is a microcontroller board based on the ATmega328. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz ceramic resonator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the micro-controllers simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started.

Some sensors are connected to each Arduino uno ATmega328p board module. Such as DHT11 is used which gives us two important measurements required for a smart fire monitoring system. It gives an output in degrees Celsius for temperature and percentage of humidity. The used flame sensor detects the flame at the range of 3 feet and at a 60 degree angle. The LED light shows the presence of fire. The MQ-2 Gas Sensor is used for the proposed system which is sensitive to carbon monoxide. Carbon monoxide results in a burning process. Its output boots with the concentration of CO level. It can detect CO anywhere from 200 to 10000 ppm.

3.3 MATLAB simulation

MATLAB Simulation is Used to analyze and simulate dynamic systems using block diagrams. Simulink is a graphical, drag-and-drop environment for simple and complex signal and system dynamic simulation - so easy to use. It allows users to compress on the format of the problem instead of worrying about the programming language. We need to simulate the model to study the behaviour of the system to verify that our model is correct.

IV. CONCLUSION

Working with different sensors that is based on fire warning system has become easier as this is cheaper and does not need high maintenance. As these papers consist of the survey of all different papers where the description of fire alarm system on different different method. In the future people will be very confident on the smoke and flame sensor based model which will help IOT and other real time based technologies to make decision and help people to predict fire.

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