The new architecture of the fire alarm system for smart homes on the Internet of Things

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***Abstract*— With the development of Internet technology, people are interested in using smart home technology and related security systems, such as firefighting systems. *Smart home security systems should* be able to automatically take measures to reduce financial and financial losses in critical situations. The proposed new architecture, using a combination of sensor and CCTV, examines the interior of the house and, in the event of a fire or its evidence, alerts the owners and, if the owners do not do the right thing at the right time and the alarm reaches the level of the critical, the system automatically takes action to reduce the damage.**

***Keywords*— Internet of Things, Smart Home security system, Fire Alarm System.**

I. INTRODUCTION

A smart home is one that incorporates advanced automation systems in order to provide its inhabitants, the sophisticated monitoring and control facilities over us various functions. For example, a smart home may have automated facilities for controlling lights, fans, air conditioners, temperature, multimedia systems such as home theater systems etc., security, window, door operations, curtains and many other functions [1]. These facilities, without additional cost, increase the level of welfare and health of residents and reduce the risks of fire, gas leakage, unauthorized entry and damage caused by them. Devices of the smart home can include door locks, temperature controllers, sensors and etc. The devices transmit data among each other through an wireless sensor networks [2]. when everyone is staying outside for either personal or professional reason. It becomes difficult for them to keep track of the happenings at home[3]. they are always worried about protecting their home and can't do their jobs quietly. Smart home security systems make it easy for the owner to view their home information instantly, with the smallest cost.

Users can control home appliances through laptops, iPhones, iPods and other smartphone devices[14]. As such, future home environments are set to accommodate a sundry of new internet connected devices which perpetually collect data on their surroundings and take action accordingly through the use of remote servers, where the information is processed, stored and interpreted [4]. WIFI is one of the key technologies that enable connectivity for smart home services [5] and Sensors are one of the most important parts of smart home technology[14]. Intelligent home appliances, often connected via WIFI, collect data and send it to the central server, and the central server connects via one or more Internet infrastructure to the Internet. In this way, it provides owners with remote access to the smart home and its equipment and can remotely control and monitor the interior of the home, control light and temperature, turn on or off Devices, interrupts power or gas, and any other smart home functionality. An intelligent home security system with proper and timely warning can protect the home against dangers such as fire, gas leakage, burglary, and so on, and provide a sense of relaxation and security for homeowners. Often, smart home appliances designed for this purpose have sensors that, according to planning, constantly monitor the smart home space and analyze and store information on a central system, in addition to proper warning, from stored data such as images Captured CCTV cameras when needed.

II. RELATED WORK

Semanur Karaca and colleagues [5] designed a control and monitoring system that consists of two sections of the interface and the home network connected to the local network and the Internet. Sensors collect information periodically and send it to the database, and the controller modules execute user-defined instructions based on the information they receive. In this system, the temperature of the permanent room temperature is controlled by the sensors, and if the alarm is activated, the system immediately sends an emergency message to the user. This alarm can be activated or deactivated via the smartphone application or the web interface.

M Akhil Raja and colleagues [6] designed and implemented by Arduino and GSM with the help of a central controller, it collects information from home monitoring sensors such as heat, humidity and toxic gases, and sends it via Wi-Fi or GSM. If, for example, the percentage of toxic gases goes up to normal, the system starts to alert the user, and if the gas level does not return to normal after 15 minutes, the alert will continue to the user. The system is used to ensure the two WIFI and GSM communication infrastructures, so if a route is not possible, another warning path will be made.

Mile Mrinal and colleagues [7] informs the user by using a series of sensors, keeping the door open, reducing the level of the tank water, and so on. The user can remotely control the equipment at home.

Xin Hong and colleagues [8] it has designed a three-layer network that allows a person to keep his home safe when he is not at home. The data collector acts as an important and central system and takes the system information and decides whether to inform the user or not. If the user, based on the information received, finds that the system is incorrect, can correct it incorrectly. For better performance, the system can share information and images with the police.

Shafiq ur Rehman and colleagues [12] proposed a secure architecture for smart home. In this architecture, using a firewall system, the internal network and the Internet are separated and security threats have been minimized using a hardware firewall and software between the network and the central hub.

G. K. Baddewithana and colleagues [13] designed system that is capable of detecting fire and sending the alarms via mobile messages to predetermined recipients. The system also distinguishes between an electrical fire and non-electrical fire. Upon detection of a fire, this system identifies the location of the fire, enables the fire extinguishing system of that particular location and sends mobile messages to fire departments. Moreover the system provides voice warnings and messages for the trapped people to evacuate to safer zones

Oxsy Giandi and colleagues [14] They have designed a system for fire detection and warning. Detecting fire signs at smart home is an important step to prevent fire. In the proposed system, by measuring the concentration of gases, it calculates the probability of fire and alerts the alarm.

Ferry Astika Saputra and colleagues [14] Using the sensors of temperature, humidity, smoke and carbon monoxide gas, they are sensing the space of the house and using an algorithm, they decide to send or not to send information to the central server. After sending, information is checked based on fuzzy logic and if a fire is detected, it attempts to open the door, signal an alarm and notify the owner. This system has up to 0.3% fire detection error.

S.R.Vijayalakshmi and colleagues [10] the fire warning system has been proposed to process video images as input data, which uses the digital image processing technique. This method uses integrated information such as color, space, time and motion to determine the position of the fire in video frames. When the system detects fire based on video analysis and image processing, it activates the alarm.

Md. Mahamudul Hasan and colleagues [11] proposed a system in which a video camera operates as a fire information gathering system. Recorded images are stored and analyzed on a computer. If the fire data is detected in a video image stream, a signal is immediately sent to the alert system and the system notifies the owner of the fire via SMS. If there is no feedback received from the SMS, the alarm section will sound the fire alarm. Finally, the alert is announced by SMS to the predefined fire station.

III. PROPOSED ALGORITHM

Our proposed architecture consists of a series of sensors, central server and warning systems that communicate with each other through a local area network. On the other hand, to send an alert, this network is connected to the Internet through a firewall. And the owner can also communicate remotely with the internal network. Sensors are constantly collecting information from the home. Our sensors include motion sensors for motion detection, a humidity sensor for measuring moisture content, a temperature sensor for measuring temperature, a smoke detector to measure the amount of smoke and a gas sensor to measure the amount of CO gas. It also has a CCTV camera for continuous shooting, capturing images, analyzing them and, if necessary, sending them to pre-defined users or authorized centers. The overall architecture of the system is presented in Figure 1, in which the S.F.D.S fire detection system by smoke, temperature, gas and humidity sensors, V.F.D.S is a fire detection suite via video images processing and M.D.S is a penetration detection through motion detection sensors.

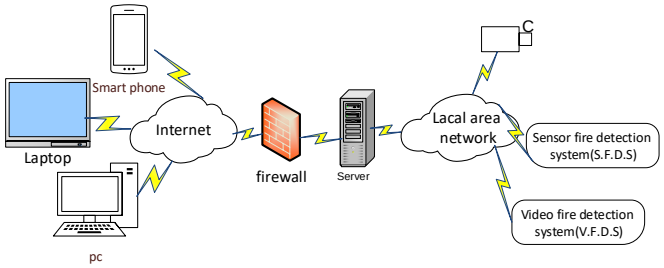

Fig. 1. Architecture of the system

Our security system consists of three parts. Motion sensors are used to protect against unauthorized input, temperature, humidity, gas and smoke sensors for fire protection and video surveillance cameras to help detect illegal logging and help detect fire. The alert level is divided into four levels: normal, alert, emergency, and critical. Levels of alert are defined by the owner, and different individuals can define these levels using their standard information and personal information. We define our actions according to the state and level of warning. These actions may include a change in the status of collecting information, alert the owner's, activating the alarm, or interrupting the gas and electricity supply of the building or contacting the Relief Center.

A. Fire Alarm

In our proposed architecture, we have used the system [9] to specify the fire alert levels. In this system, the data of temperature, humidity, co, and smoke sensors are collected and sent to the central server for analysis, and in the server, based on the fuzzy logic technique, a fire risk with three levels of normal, alert and fire is declared as output. The purpose of using fuzzy logic is to increase system reliability to reduce the proportion of fake alert sent to the user. In the proposed system [9], if the fuzzy logic output is Alert, a temporary alarm will be triggered, and if the Output is Fire, a permanent alarm will sound. But our response to the Fire and Alarm output will be different.

In this research, there are 4 input variables, each variable having three members and finally 3 * 3 * 3 * 3 = 81 rule. The example of this study is presented in Table I.

TABLE I. BASIC RULES OF FUZZY LOGIC

No	Temperature	Humidity	CO	Smoke	level
1	Normal	Wet	Low	Low	Normal
2	Normal	Wet	Low	Med	Normal
…	…	…	…	…	…
80	High	Dry	High	Med	Fire
81	High	Dry	High	High	Fire

Four sensors continuously monitor the environment and use their data to obtain a fire risk. To test the system [9], the maximum and minimum range is for three sensors for temperature and humidity and gas between 0 to 100 and for a smoke sensor between 0 and 300. The experiment was performed by taking 30 samples and based on the output obtained, only 2 were mistaken and 28 were correct. Therefore, the system error ratio is 6.67%.

Given that our proposed architecture has more reliability, along with the system above, we also used the proposed system [11]. The proposed system recognizes the occurrence of a fire by using video images and analyzing it. In this system, the nature and characteristics of flame and smoke are examined and the motion detection technique used in video images is also used. Using image processing techniques, it detects the occurrence of a fire and sends a signal to the alert section. Due to the fire detection rate in different operating conditions, the system has high reliability, especially in dark and shadow areas with 100% detection capability.

The high system capability is that has the ability to detect and distinguish smoke and fire. We considered three modes, normal, smoke, and fire to use this feature in fuzzy logic. Alert for smoke mode, and fire for fire mode.

In our proposed architecture, in the fire sector, the first system [9] and the second system [11] have been used in combination. That is, the possibility of fire through both sensors and image processing is investigated and the alert level is determined according to Table II and the appropriate action is taken.

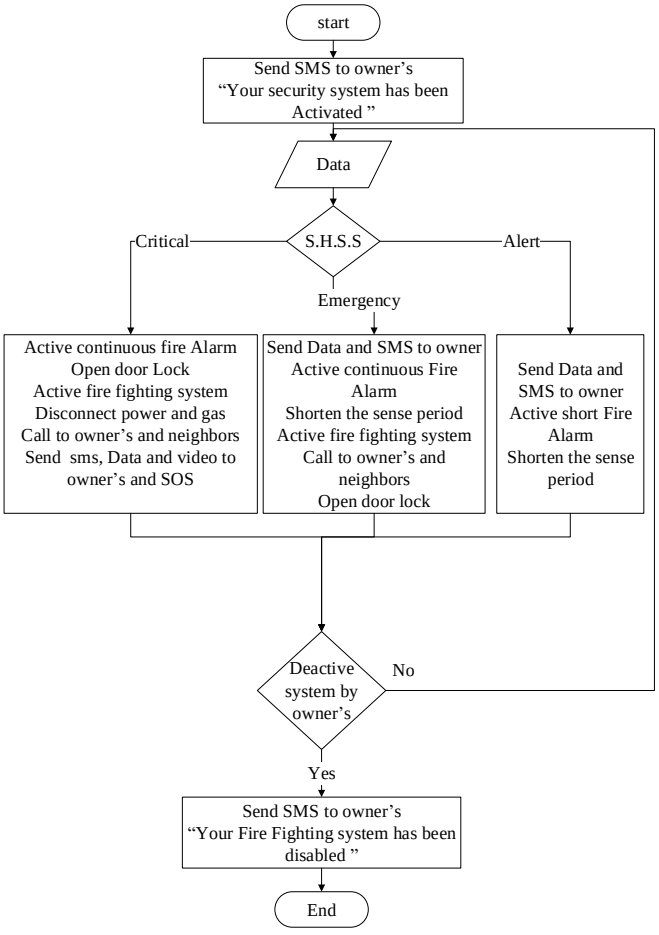

Fig. 2. Flowchart fire alarm system

B. *Advantages of proposed architecture*

- High reliability of the system than similar systems.
- Data collection and decision making based on information from multiple sensors and video images.
- Possibility of activating other systems, such as fire extinguishing or interrupting gas and electricity, etc. to reduce the threat of damage.
- Possibility to communicate and send video images to relief centers to make better decisions about the state of emergency and immediate action.

IV. SIMULATION

To simulate, the data of the two separate systems S.F.D.S and V.F.D.S were combined and using fuzzy logic, the probability of fire was detected in MATLAB software. The goal of using fuzzy logic is to increase the reliability and accuracy of the system to minimize the amount of fake alert to the homeowner.

In the fire detection algorithm, there are two S.F.D.S and V.F.D.S systems whose outputs are input to our fuzzy logic variables and the probability of fire is an output variable. Normal, Alarm, Fire membership function is set to any input variable and Normal, Alert, Emergency, Critical on the output variable. Figures 4 and 5 show diagram membership in the two variables S.F.D.S and V.F.D.S and Figure 6 shows the graphical membership in the output and the fire probability variable.

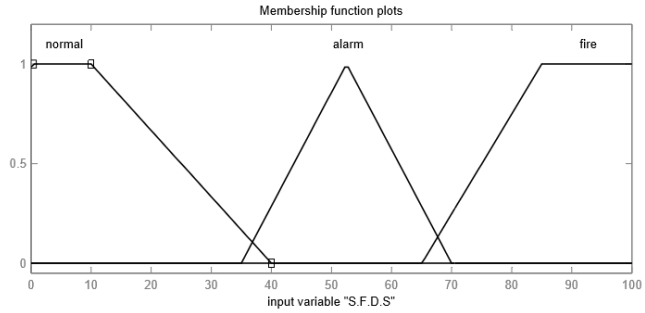

Fig. 3. Fire sensor membership function

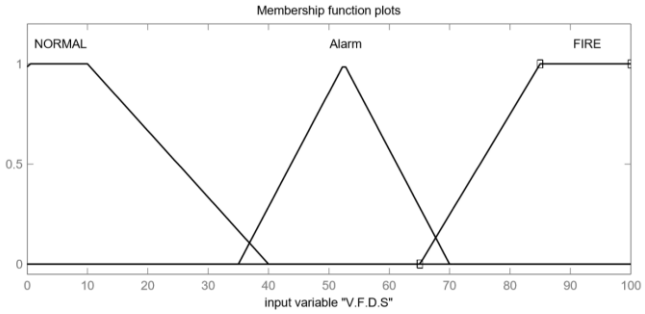

Fig. 4. Fire detection membership function by image processing

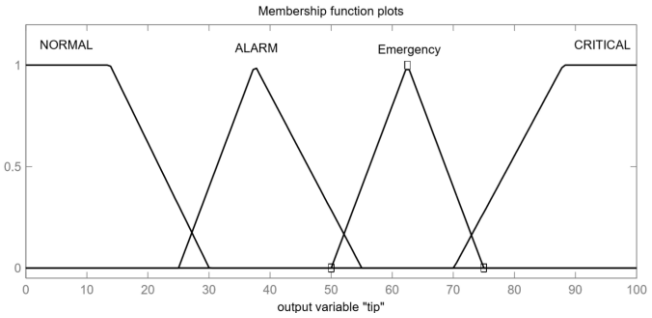

Fig. 5. Fire membership function

In this paper, we have two variables with three members that collectively record 9 (3 * 3 = 9) states in the output.

TABLE II. ALARM LEVELING IN THE FIRE DEPARTMENT

No	Sensor f.d.s	Video f.d.s	Alert level
1	normal	normal	normal
2	Alarm	normal	Alarm
3	fire	normal	emergency
4	normal	Alarm	Alarm
5	normal	fire	emergency
6	Alarm	Alarm	Alarm
7	fire	fire	critical
8	Alarm	Fire	Emergency
9	Fire	Alarm	Emergency

In this simulation, based on the input, from 1 to 33 normal, from 34 to 66 Alarm and from 67 to 100, Fire is considered, and in the output from 1 to 25, Normal and from 26 to 50, Alarm and from 51 to 75, Emergency and from 76 to 100, Critical. The experiment is implemented with 30 random data in the simulator. The simulation output is shown in Table IV.

TABLE III. THE RESULT OF THE SIMULATION OF FUZZY LOGIC

NO	s.f.d.s	v.f.d.s	category	fuzzy	Desired category
1	35	50	Alarm	39.8	Alarm
2	46	70	Emergency	62.5	Emergency
3	25	80	Emergency	62.5	Emergency
4	50	35	Alarm	39.8	Alarm
5	65	85	Emergency	62.5	Emergency
6	20	80	Emergency	62.5	Emergency
7	90	98	Critical	89.1	Critical
8	40	43	Alarm	39.7	Alarm
9	95	76	Critical	87.6	Critical
10	44	78	Emergency	62.5	Emergency
11	95	23	Emergency	62.5	Emergency
12	55	54	Alarm	39.2	Alarm
13	24	89	Emergency	62.5	Emergency
14	63	80	Emergency	62.5	Emergency
15	25	53	Alarm	39.4	Alarm
16	89	12	Emergency	62.5	Emergency
17	65	49	Alarm	39.7	Alarm
18	24	25	Normal	12.8	Normal
19	78	81	Critical	88	Critical
20	42	52	Alarm	39.5	Alarm
21	12	31	Normal	13.6	Normal
22	65	75	Emergency	62.5	Emergency
23	69	99	Critical	81.8	Critical
24	42	77	Emergency	62.5	Emergency
25	10	39	Alarm	36.3	Alarm
26	28	61	Alarm	39.5	Alarm
27	93	50	Emergency	62.5	Emergency
28	71	78	Critical	86.6	Critical
29	54	44	Alarm	39.4	Alarm
30	56	10	Alarm	39.2	Alarm

The architecture provided on the basis of the simulation does not make any mistake, and 100% of the states are correctly identified.

V. CONCLUSION

Our proposed architecture combines a variety of sensors and video surveillance cameras to protect the home and its people. Sensors and cameras monitor the environment and send it to the central system. The central system, by analyzing aggregate data, specifies the warning state and the system, in accordance with the alert level, takes appropriate steps to reduce the risk and damage. The problem with the proposed architecture is that the systems used (S.F.D.S, V.F.D.S) have some errors, which should be covered in the next steps.

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