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An IOT Based Fire Alarming and Authentication System For Work House

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Abstract— Ensuring minimum rights and safety of the garment workers has become a burning issue nowadays. The workers of garment factories are facing some labyrinths and broken out of fire is surely one of them. The investors are losing their interest and the prominence of this sector is getting toneless. In this paper, we have propounded a system which is capable to detect fire and can provide the location of the affected region. Raspberry Pi 3 has been used to control multiple Arduino which are integrated with a couple of sensors and camera. A 360ż relay motor is assembled with the camera so that it can snap the image in whatever angle the fire is detected. We have provided a confirmation of the fire suspecting system to avoid any false alarm. The system will immediately send a message along with the image of the affected spot and Arduino's location. An admin can confirm or deny the impeachment and if the admin confirms the situation as a breaking out of fire, then the system will immediately raise an alarm and an automatic message will be sent to the nearby fire brigade.

Keywords— Fire Detection; Raspberry Pi; WiFi module; Sensors; Arduino; Camera; Authentication; Notification.

I. INTRODUCTION

The Ready Made Garments (RMG) industry is the main driving force of the economy of Bangladesh. The RMG sector of Bangladesh is the main catalyst behind the averaged GDP growth rate. Over 4.2 million employment opportunities have been provided by this sector. More than a million laborers are working in these garments factories. But this outstanding growth is being challenged by the frequent accidents in factories and industries. Over the past decade the RMG sector of Bangladesh has been through a number of tragic accidents. The majority of those accidents were caused by fire. On 24 November 2012, fire took 117 lives in "Tazreen Fashion factory" in capital Dhaka [1]. 8 lives were lost when a fire broke out at a textile factory in the Mirpur industrial district on May 9, 2013. On 14 December 2010, 30 people died and 200

were seriously injured when fire broke out at the garment factory, "That's It Sportswear Ltd" in Ashulia, Dhaka. Twenty two lives were lost when a deadly fire broke out at the "Garib and Garib" factory in Gazipur, Dhaka on February 2010 [2]. This incident shows that many garment factories do not have proper fire prevention and rescue system. Hundreds of factories are vulnerable to fire broke out because the factories are

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very old and lack fire detection technology. Moreover, most of the factories do not have an automatic system to stop fuel and electricity supply when fire breaks out, and it takes a lot of time for the fire service to reach the disaster spot.In this perspective, a system to detect fire and alarm the employees before it breaks out is a crying need. In this paper, we designed an IOT based fire alarming system to help detect fire as soon as possible and save precious human lives. The system will use several sensors to detect any symptoms of fire. The sensors will be placed on proper places after doing surveys on the factory for its vulnerable places of fire. After choosing the best places for placing the sensors, the sensor will be activated. The data collected by sensors will be sent to Arduino microcontrollers placed on various places. The microcontroller will then process the data. All the microcontrollers will be controlled centrally by Raspberry Pi microcomputer. Intelligent algorithm is used to decide when to start alarm for fire. Besides, the system will stop gas and electricity supplies on sensing fire break out and will start firing suppression system, like opening fire extinguishing water valves. At the same time the system will send SMS using GSM module to the nearby fire service station informing them of the incident. The system will also inform the location of the fire to the administrator using GPS module. Several types of sensors will be used, for example, temperature sensor, gas sensor, smoke sensor, flame sensor, etc.

II. RELATED WORKS

Sowah et. al. [3] designed and implemented a fire detection system for vehicle using fuzzy logic. They used temperature, flame and smoke sensors for sensing fire. The system also can extinguish fire in 20 seconds and they used the air-conditioning system for extinguishing fire. The author in [4] proposed a paradigm for detecting forest fire with the help of wireless sensor network. The authors have focused on how to process the data collected by the sensors rather than how to detect or sense the fire. They used neural network for processing the collected data and make the network energy efficient. A fire alarming system based on video processing propounded in [5]. They used smoke color and spreading characteristics of smoke to detect possible fire outbreak. But processing the images is time consuming and needs sophisticated resources. In case of a garment factory, the fire should be detected as soon possible because the garments are very much susceptible to fire. In [6], a fire monitoring and control system was designed where they used various sensors like flame, smoke, gas sensors for detecting fire and staring fire extinguishing process

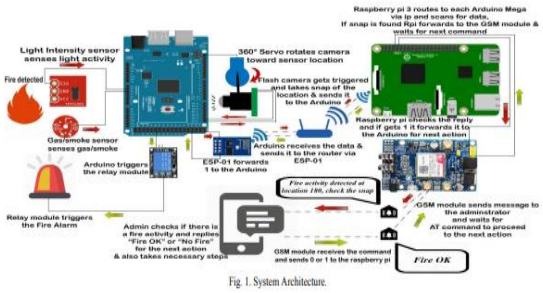

Fig. 1. System Architecture.

They also used the GSM/GPS system for locating the exact location of the fire. In our

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proposed system, we are using more sensors than the aforementioned system and we process them centrally using Raspberry Pi computer which can handle a lot of Arduino along with sensors very smoothly and efficiently. Fuzi et. al. [7] designed a fire alert detection system with ZigBee wireless module. The system consists of Arduino Uno Microcontroller, temperature sensor, buzzer alarm and operating software. The system used only temperature sensor for detecting fire and the receiver could receive signal from a distance of 10 meter. Our proposed system uses built-in Wi-Fi module on Arduino microcontroller and raspberry pi computer. Kwon et. al. [8] designed and implemented a system to detect fire outbreak using camera image processing. Although this is a novel approach, it is not as efficient and accurate in detecting fire as sensor based system. T. Islam et. al. [9] developed a fire detection system using the ZigBee wireless system. The authors used localization technique for finding the position and distance of fire. The system has a high relative cost and the authors used three sensors to localize a fire. A prototype for detecting forest fire using a wireless sensor network was presented in [10]. They used mobile agent as software apart from sensor nodes. The software mobile agents collect data from the sensor nodes and return them to the sink. They did not implement the system.

III. SYSTEM DESCRIPTION

A. System Architecture The propounded autonomous system uses Raspberry Pi 3 as main device, Arduino Mega as secondary device and consists ofcouple of sensors and module which are the Light intensity sensor, Gas sensor, ESP-01 WLAN Sensor Module, Servo motor, Camera module, GSM module and Relay module. The light intensity sensor has a photo-resistor \that can detect the intensity of light in the particular place or environment. The output signal of this sensor is analog value. The value of the sensor depends on the brightness of light. Gas sensor can detect the existence of gas in a particular area. The Camera module takes the shot of the limited place and the servo motor rotates the camera module. The ESP-01 WLAN sensor module helps to send data to the Raspberry Pi 3 by wireless communication system.The Relay module is used to activate the alarm and the GSM module helps to notify the master user or the admin. If the light intensity and gas sensor have desire value, then the camera module takes snap of the location and sends it to the Arduino.

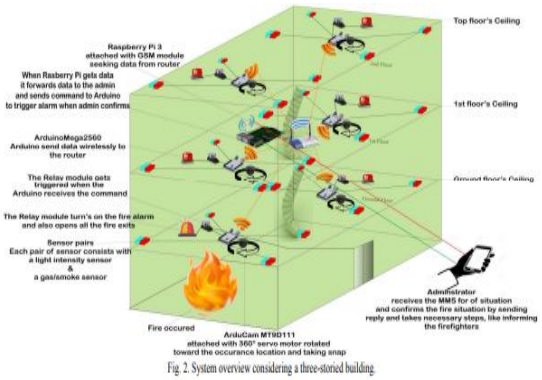

Fig. 2. System overview considering a three-storied building.

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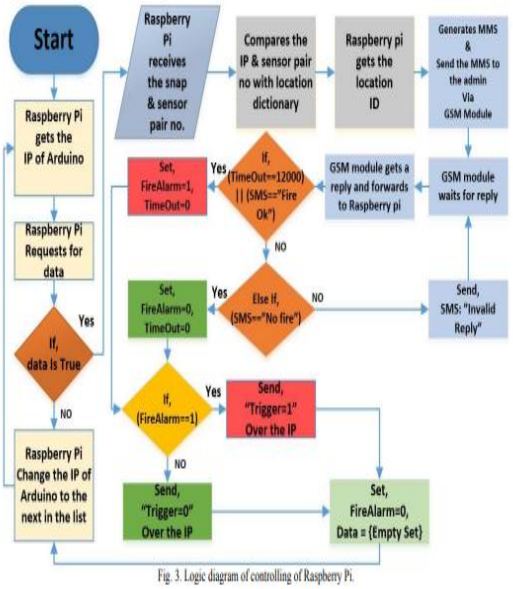

Fig. 3. Logic diagram of controlling of Raspberry Pi.

The camera Module can rotate 360° by using a servo motor. After this condition is true the fire alarm will trigger by the help of the Relay module. Arduino Mega can send this data to the Raspberry Pi by using ESP-01 module. When Raspberry Pi receives the data, then it will send the data to the admin by using GSM module and an admin will check the validity of the warning message of our system and confirm or deny any suspect. B. Logical Description In this autonomous system the process occur in two parts. One part is Arduino read the data from sensors and the other part is Raspberry pi receive the data what was taken by Ardunio. Here, the system is using few sensors. One of them is Light intensity sensor module is denoted as A and the other one is Gas sensor module is denoted as B.

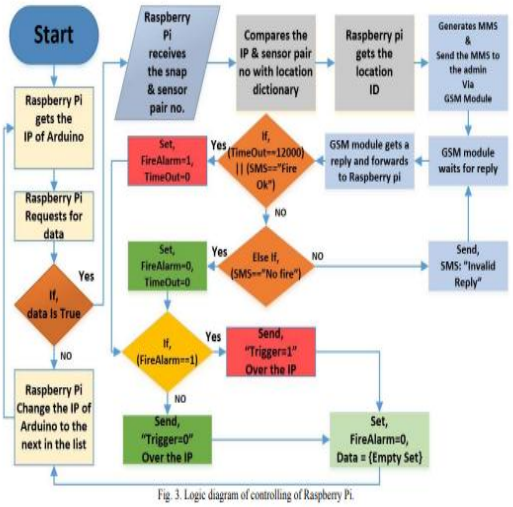

Fig. 3. Logic diagram of controlling of Raspberry Pi.

If both the sensor value is hit up to mark that means A>200 and B>500, then the condition is true and the camera module will rotate 60° by the help of servo motor. This condition will active when only a single pair of sensor value is true. But if the two pair are active at the same time, then the condition will be A>140 and B>350 for both pairs. After that camera module takes the snap, then it throws the pair no to the Raspberry Pi 3 by using ESP-01 used as Wifi module. When raspberry pi received the snap and sensor pair no then it will compare with IP and sensor pair no. If matched, then generate an MMS and send the MMS to the Admin via GSM module. The GSM module waits for reply. If the reply is "Fire OK" then it will trigger the alarm using relay. If the reply is "No fire" then it will stop the alarm. If the reply is unknown something, then it will return an invalid reply. After 5 minutes it will check the condition automatically. By using this single pair and multi pair sensor combination we can cover 360 degree and detect fire activity on a particular place.

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IV. SYSTEM IMPLEMENTATION

For implementation of the system, we will be using two different types of micro-controllers, the Raspberry Pi 3 and the Arduino Mega 2560 rev3. The code written Arduino would contain a specific IP address for each Arduino to identify the each of them. Each Arduino acting as Server takes the analog readings from the sensors, compares them to the threshold value. If the sensor values get to reach of threshold, the Arduino performs necessary actions, including throwing the data over IP via ESP-01, which contains snap of the situation, pair number of the sensor and also the IP the of Arduino, so that the admin can locate the actual place where the situation is hasty. During transmission of the data the Arduino converts the analog data to digital so that it could be understood by Raspberry Pi. The code written by python programming language in raspberry pi seeks data from Router via each IP as Client if there is any. Whenever the Raspberry Pi is able to get the data, it starts processing data for further actions. The motherboard named Raspberry Pi 3 acting as a Client is both a micro-controller and a CPU which has a processor of 1.2Ghz 64-bit quad-core ARMv8 Cortex A53 CPU alone with 1GB ram of 900Mhz, 4 USB ports, 1 HDMI port, 1 audio I/O port and 1 Ethernet port in it, including 40 GPIO pins which can be configured as digital input or output. The board Raspberry Pi 3 has built in wireless module in it that has both 802.11n wireless LAN and Bluetooth 4.1 including BLE feature by which we can both receive and transmit data wirelessly without any other partial device. In the proposed system, we will be using four pairs of sensors, where there will be TEMT6000 light intensity sensor and MQ-02 gas/smoke sensor in each pair. The TEMT6000 is an ambient light sensor which has three female pins in it, that are Vcc, GND and the Signal pin of the Arduino will be getting the analog readings. The sensor acts like the transistor, the greater the incoming light is the higher the analog value gets to. The MQ-02 gas/smoke sensor uses a small heater, including an electro-chemical sensor inside that is sensitive to Methane, Butane, LPG, smoke and also flammable and combustible gasses. It is used in indoors at room temperature. The sensor has to be calibrated to detect smoke with proper load resistor and burn-in, which can be done by gas sensor module. The module consists with four male pins which are Vcc, GND, AOUT (Analog out) and DOUT (Digital out). We will be using AOUT pens for taking a reading in the analog pin of Arduino as all the values will be converted to digital together later. The ArduCam MT9D111 will be used to capture the view of the situation which is 2 Megapixel optical lensed camera sensor module. The camera can capture in 4:3 format with RGB Bayer patterned color filter array. There are two frame rate, which are UXGA and SVGA. We will be using the SVGA frame rate as it consumes less data. The module has built in Xenon flash in it so that it can capture in both day and night time. The module has also auto focus system so that it can automatically set the range for the most perfect focusing. 360° Servo motor has been used to rotate the camera into every linear angle so that is can capture from all

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positions. The servo is able to deal with from 4.8-6.0 Volts. A three pins power and control cable is attached with it, where the Arduino rotates the servo in the specific angle, giving input in the signal pin from its digital I/O pins. A Single Channel Relay module will be attached to each Arduino, so that it can trigger the alarm whenever it gets reply 1 from the ESP-01 Wi-Fi module. ESP-01 has a ESP8266 chipset in it that allows microcontrollers to communicate wirelessly. The communication with the administration and the system will be maintained by the GSM cellular connection for which SIM808 GSM module will be used in the system. SIM808 GSM module is the latest GSM module that has GSM, GPS and Bluetooth connectivity system. It can send and receive data from GSM, GPS and Bluetooth and can also act over AT commands. The GSM module will be connected with the Raspberry Pi 3 and it will send the location and snap via MMS. The module will then wait for a specific reply that would trigger AT command that will be passed over to the Arduino for acting or not. A. Steps of Implementation: Step 1 (Configure the Programmable Devices): Write a program for each programmable device which are- Raspberry Pi 3, Arduino Mega 2560, GSM Module SIM808, ESP-01 Serial to Wi-Fi Module, ArduCam MT9D111 and the Wireless Router. Program in Raspberry Pi would be written in Python to traverse each Arduino with IP specified to each Arduino. All the IPs of from all the Arduino should be put in a list of Raspberry Pi's program. The Python program should also have the functionality to communicate with SIM808 GSM module where the cell number of the administrator should be mentioned. A Program should be written for all the Arduino, so that they can take read analogue data from sensors, can rotate servo in 360°, taking snap from ArduCam MT9D111, sending & receiving data over ESP-01 Wi-Fi module and also to trigger relay on. SIM808 GSM module should be set with a SIM card in it and should be configured as a GSM device via UART connection. The ESP-01 Wi-Fi modules should be configured as both STA and AP so that can both send and receive data and also setting them up with unique SSID and a common password so that each module could be identified and access easily. The SSID and password of the router should be mentioned in the ESP-01 so that they can automatically access the router and communicate. The ArduCam MT9D111 should be configured as 4:3 format, SVGA frame and the snap pixel
size into 2 MP so that it can capture and store the image efficiently. Step 2 (Burning the codes in the sketch of Arduino and Setting up code in Raspberry pi 3): The Arduino program should be burnt to each sketch of all the Arduino configuring the code with specific IP and MAC address. The program for the Raspberry Pi may be kept in any folder but the path of the file should be mentioned at /etc/rc.local file, so that the program runs automatically on the startup and Raspberry Pi could act as a micro-controller. Step 3 (Integrating the sensor modules): Each Arduino would be connected to 8 sensors where 4 of them will MQ-02 and 4 of them will be TEMT6000

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that means in total 4 pairs where each pair will contain a MQ-02 and a TEMT6000. The signal pin of the sensors will be connected to the Arduino from A0-A7 pin with one MQ-02 and one TEMT6000 repeatedly according the Fig. 6 VCC and GND pin of all the sensors will be connected to the 5v and GND pin of Arduino. Step 4 (Connecting the Servo and Relay module): The Relay module and the Servo motor both have a digital input pin, which will be connected to the D49 and D35 pin of the Arduino. VCC and GND pin of relay module will be connected to the 3.3v and GND pin of the Arduino. VCC and GND pin of servo motor will be connected to the 3.3v and GND pin of the Arduino. Step 5 (Plugging the ArduCam MT9D111): Plugging the ArduCam MT9D111 is more complex than other modules as it has both input and output along with triggering, capturing and storing functionality. The connection has to be established according to the Fig. 5, so that the camera can function properly. The digital and analogue pins can be changed to accommodate all the connection properly, but the needs to be mentioned in the program written for the functionality of the camera.After connecting the camera needs to be hooked up with servo motor for the rotational purpose.

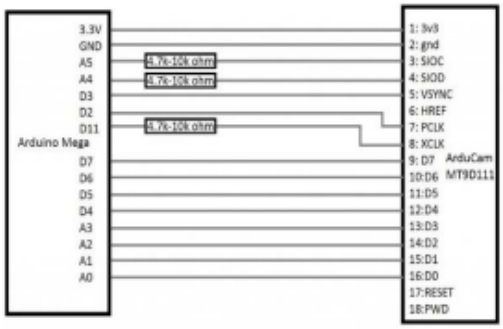

Fig. 5. Plugging the ArduCam MT9D111

Step 6 (Setting up the ESP-01 Wi-Fi module): ESP-01 module has total 8 pins, where 1st one is the transfer pin and the last one is receiver pin. The transfer pin need to be connected with one of the receiver pin of the Arduino and the receiver pin need to be connected with the transfer pin of that set of Arduino. Pin 5 and Pin 6 needs to be connected with the 3.3v port of Arduino and pin 4 need to be grounded. Step 7 (Connecting the SIM808 GSM module with Raspberry Pi 3): One of the transfer pin of SIM808 GSM module gets connected with GPIO 17 pin of Raspberry Pi and one of the receiver pin of SIM808 GSM module gets connected with GPIO 18 pin of Raspberry Pi. Step 8 (Powering up all the devices): In the proposed system, the main devices that will be directly connected to the power sources are the Raspberry Pi 3, Arduino, SIM808 GSM module and the Router. Raspberry Pi 3 and each of the Arduino needs to be connected with a 5v 2.5 power supply adapter. The SIM808 draws a good amount of power, so it needs a power supply adapter of 7v ~ 12v to be functional. The voltage of the router depends on its model, but generally it is 12v.

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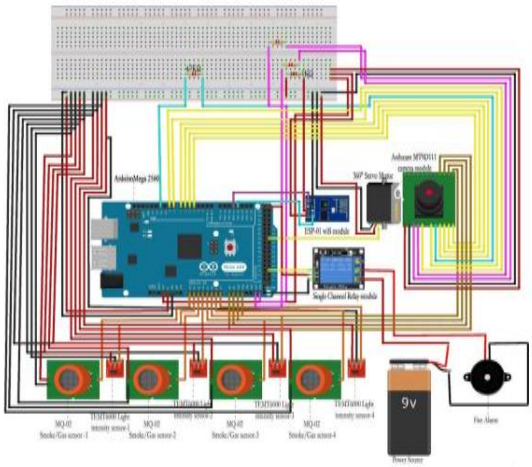

Fig. 6. Circuit diagram of fire alarming system.

V. EXPERIMENTED RESULT

After assembling our system, the reading of the sensors has been checked. We have tested the system response in different situations. The sensor reading, auto snapping and sending that snap, authentication and current status of the place are displayed in fig. 8.

Fig. 8. Sensor reading, taking and sending snap, authentication and fire status displaying in LED.

TABLE I. COMPARISON WITH OTHER RELATED WORKS

DWAFAS [11]	The system didn't explain any approach to detect fires. No authentication system to detect false alarm.	The propound system uses smoke sensor alone with light ambient sensor to detect fire. There is an authentication system to check if the situation is alarming.
FRASHB [12]	The paper only proposed some scenarios and actions according to those.	This system is applicable for almost all the scenarios and as it has an authentication system, there are less possibilities of system errors.
FAHB [13]	Costly and time consuming as multiple sensor nodes decide the possibilities of fire occurrence.	Cost effective and efficient as it is an upgraded of MSBN which uses sensor nodes but with less sensor decision.

Fig. 9 shows the triggering point of servo depending on smoke and light ambient data. After proper analysis, we found that the smoke Sensor gives a value 0~30ppm in normal state and raise from 500ppm upto 20000ppm on alarming situation. The light ambient also gives value within 60~80 on normal state and raise to 200~350 reacting on flaming light. According to experiment result, we found the threshold on 500ppm on smoke sensor and 200 for light ambient sensor.

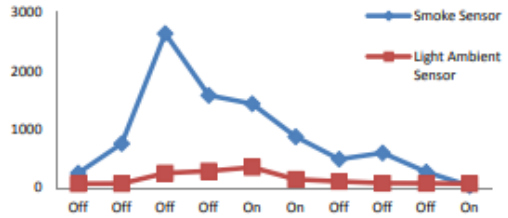

Fig. 9. Triggering servo motor after sensing the state of smoke sensor and light ambient sensor.

CONCLUSION

In this paper, we discussed the latest technology that can help to reduce catastrophic accidents caused by fire. We designed the whole system and evaluated its effectiveness as well as scalability. With the improvement of sensor technology, the system will become more efficient and useful. If this system can be successfully integrated in every factories, then it is hoped that the loss of life and property due to the fire accidents will reduce remarkably and the country's economy will not be stumbled by such tragic accidents.

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