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Intelligent fire emergency response system

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***Abstract*- Present-time infrastructures around the world have become intricate and enlarged. Provided the structural attributes of present-time infrastructures, quick evacuations using emergency exits or evacuee guidance markers during blackouts due to fire, building collapse, earthquakes, or aging of buildings have become complex and leads to problematic situation. This paper advocates an Internet of Things (IoT) based intelligent fire emergency response system including WMSN, and information fusion technology based on Dempster-Shafer evidence theory. This system can detect the exact location and status of fire and people trapped in the building using CMOS image sensors. All the information gathered by CMOS image sensors will be automatically fast processed using DSP chips. The information fusion technology will fuse the information arriving from different sensors and provide best evacuation plan .It provides directional guidance smartly with the safest path and helps in quick evacuation using intelligent slide system plus automatic safe haven .Earthquake cum fire proof bed is used when the structure properties of the building gets damaged or the building is going to collapse. Thus the emergency response plan to fire disaster can save many lives with less energy consumption.**

Index terms- WMSNs, fire detection, image processing, D-S evidence theory

I. INTRODUCTION

In present-times traditional fire emergency response system , emergency exit guides do not consider the location of the fire and merely direct people to the nearest exit. Takes more than half an hour to evacuate from a fire, one of the most frequent disasters, diminishes survivability greatly. Monotonous evacuation guidance such as exit lights are scanty for guiding evacuees during a fire. The fumes generated contains solid, liquid particles and poisonous gases, very menacing for human body. Fume inhalation is the root for most death polls. Elevators often fail during a fire, confining the occupants. IoT technology combined with WMSN(Wireless multimedia sensor network), information fusion technology footed by D-S evidence theory, fire proof beds, and the automatic safe haven proposal will barricade all the above defined muddles. Image signals possess big volume of multimedia data , consumes more energy than that of traditional methods of fire emergency response so it is difficult to implement due to energy problems. This paper proposes a system that on the occurrence of fire in any part of infrastructure, traditional sensors like smoke sensors and temperature sensors will detect fire in

a high frequency while image sensor like CMOS camera to acquire digital images periodically. Those datas are processed on the processing module immediately using the DSP chips. And once the results show suspicious fire areas then the traditional sensors will trigger alarms and the processing module will signal to monitoring computer to turn on sprinklers on that particular fire area, the image sensor will work continuously and the processing module will make further analysis to judge locations under fire and locations that are not. At the same time, those images can be transferred to the monitoring computer through the low power wireless network, for further manual recognition. In this way evacuation pattern will be more advanced and can save numerous lives with less energy consumption.

II. DATA OR INFORMATION FUSION TECHNOLOGY BASED ON D-S EVIDENCE THEORY

In information or data fusion system with multi-sensor, fire alarm is the integration of data detected from different sensors. The system collects information from sensors, thus constitutes the evidence of the theory. Then system needs to make judgement by examining some combination of the evidence by D-S evidence theory. The essence of D-S theory is merging different basic probability assignments to a general basic probability assignment with Dempster-Shafer integration rules in a suitable framework. The general basic probability assignment is a new body of evidence. That means it information fusion program will receive the signals from various

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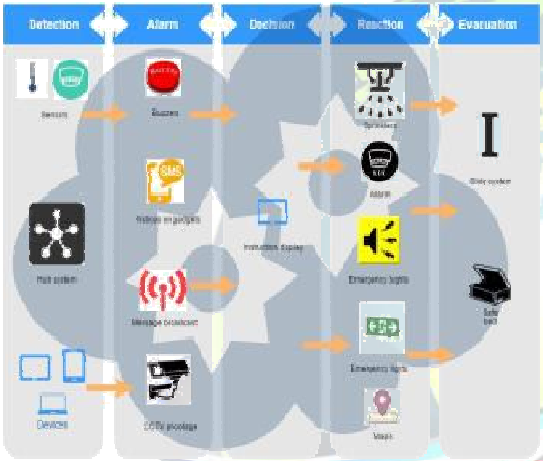
sensors and generates probable solutions or evacuation plans and chooses the best solution by making final decision

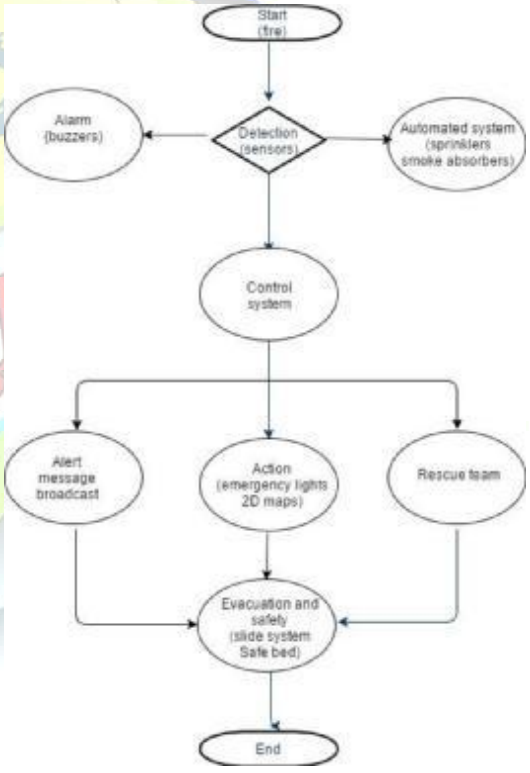
III. ARCHITECTURE OF THE SYSTEM

The architecture of the system comprises data acquisition and processing module consisting of numerous sensors like smoke sensors, temperature sensors, vibration sensors, heat sensors etc and microprocessor (DSP chip). ,and, information fusing program, data transmission network which consists of numerous wireless nodes and the monitoring computer.



As shown in Fig. 1, the data acquisition and processing module is responsible for acquiring field data and reducing it to suitable size, such as the smoke concentration, temperature and images, and processing those images, in less time to save energy, to recognize fire and send signals to the monitoring computers in central hub in control room. Sensors also send direct signals to the smart devices in the detection phase. Then in the alarm phase signal is received by the buzzers from the sensors and message broadcasting is done to send notices on the gadgets. Then based on the CCTV photos, messages broadcasted to devices and information fusion technology on the basis of DS evidence theory the decision is taken for the best evacuation plan and instructions are displayed on the LED TV's . Then in the reaction phase sprinklers are activated automatically, for the area under fire only, after receiving the signals from sensors and according to the instruction displayed. Then in that phase only fire alarms, smoke absorbers, emergency lights, for clear vision, are also activated and 2d maps are activated on the smart phones and the earthquake proof beds are also activated by the sensors installed in it to protect the person, who is sleeping, from fire and structural damage of building due to fire. Then in the evacuation phase the slide systems are activated for people to slide on the fire pole and come out of the building as soon as possible and it will be controlled by the motion sensors to prevent the collision between the the people and 2d maps on the smart phones will show the route to the nearest exit. The information fusion program based on DS evidence theory, in the decision phase, will provide the best solution plan for evacuation of evacuees stuck in the building

IV. FLOWCHART



V. HARDWARES ACQUIRED

A. Data acquisition and processing module

The data acquisition and processing module mainly comprises of various sensors, including the smoke sensor, the temperature sensor and the image sensor,

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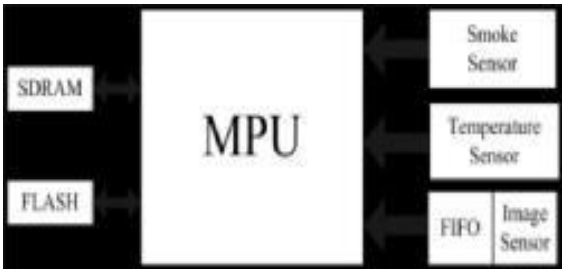
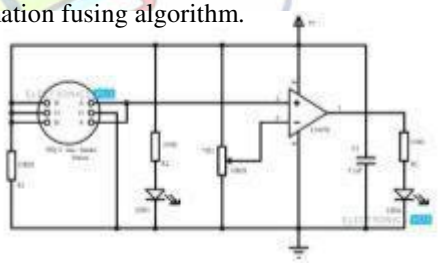
and low power microprocessors. Given below is the hardware architecture.



1) Microprocessor: Because the module needs to process images for fire image detection, thus it requires a microprocessor with powerful calculating ability. We adopt the DSP chip,as the microprocessor. With performance of up to 1600 million instructions per second at a clock rate of 200 MHz, the chip offers cost-effective solutions to high-performance DSP programming challenges. The DSP possesses the operational flexibility of high-speed controllers and the numerical capability of array processors. This processor has 32 general-purpose registers of 32-bit word length and eight highly independent functional units. The eight functional units provide six arithmetic logic units for a high degree of parallelism and two 16-bit multipliers for a 32-bit result. The C6205 DSP also has application-specific hardware logic, on chip memory, and additional on-chip peripherals. Program memory consists of a 64K-byte block that is user-configurable as cache or memory-mapped program space. Data memory consists of two 32K-byte blocks of RAM. The peripheral set includes two multichannel buffered serial ports (McBSPs), two general-purpose timers, a peripheral component interconnect (PCI) module that supports 33-MHz master/slave interface and 4-wire serial EEPROM interface, and an external memory interface (EMIF) capable of interfacing to SDRAM or SBSRAM and asynchronous peripherals. In this design we need EMIF to interface to SDRAM, FLASH and FIFO.

2) Smoke sensor: A smoke sensor is a device that senses smoke, typically as an indicator of fire. Smoke detectors are housed in plastic enclosures, typically shaped like a disk about 150 millimetres (6 in) in diameter and 25 millimeters (1 in) thick, but shape and size vary. Smoke can be detected either optically (photoelectric) or by physical process (ionization), detectors may use either, or both, methods. An ionization smoke sensor uses a radioisotope, americium-241, to ionize air; a difference due to smoke is detected and an alarm is generated. Ionization detectors are more sensitive to the flaming stage of fires. The smoke detector has two ionization chambers, one open to the air, and a reference chamber which does not allow the entry of particles. The radioactive source emits alpha particles into both chambers, which ionizes some air molecules. There is a potential difference (voltage) between pairs of electrodes in the chambers; the electrical charge on the ions allows an electric current to flow. The currents in both chambers should be the same as they are equally affected by air pressure, temperature, and the ageing of the source. If any smoke particles enter the open chamber, some of the ions will attach to the particles and not be available to carry the current in that chamber. An electronic circuit detects that a current difference has developed between the open and sealed chambers, and signals to data acquisition and processing module and information fusing algorithm.



3) Temperature sensor: In the design, the DS18B20 digital thermometer is used to acquire field temperature. The temprature sensor provides 9-bit to 12-bit Celsius temperature measurements and has an alarm function with non-volatile user-programmable upper and lower trigger points. The temprature sensor communicates over only 1 bus that requires only one data line (and ground) for communication with a central microprocessor. It has an operating temperature range of -55°C to +125°C and is accurate to ±0.5°C over the range of -10°C to +85°C. In addition, the temprature sensor can derive power directly from the data line, eliminating the need for an external power supply. Each temprature sensor has a unique 64-bit serial code, which allows multiple DS18B20s to function on the same 1-Wire bus. Fig 4 is the diagram of the DS18B20. The temperature sensed by it is send to data acquisition and processing module and to information fusion algorithm.

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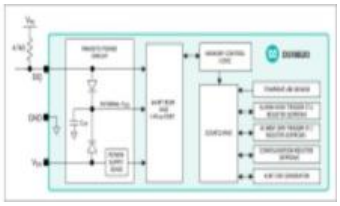
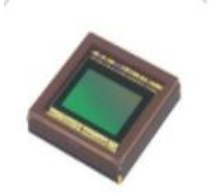
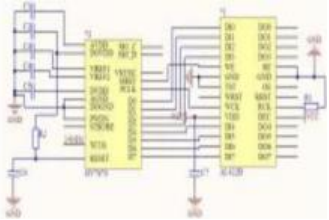


4) Image sensor: An image sensor or imaging sensor is a sensor that detects and conveys the information that constitutes an image. It does so by converting the variable attenuation of light waves ,as they pass through or reflect off objects, into signals, small bursts of current that convey the information. The waves can be light or other electromagnetic radiation. There are two types of image sensors CCD (semiconductor charge-coupled devices) and CMOS (complementary metal–oxide– semiconductor) image sensors. Each cell of a CCD image sensor is an analog device. When light strikes the chip it is held as a small electrical charge in each photo sensor. The charges in the line of pixels nearest to the (one or more) output amplifiers are amplified and output, then each line of pixels shifts its charges one line closer to the amplifier(s), filling the empty line closest to the amplifiers(s). This process is then repeated until all the lines of pixels have had their charge amplified and output. A CMOS image sensor has an amplifier for each pixel compared to the few amplifiers of a CCD. This results in less area for the capture of photons than a CCD, but this problem has been overcome by using micro lenses in front of each photodiode, which focus light into the photodiode that would have otherwise hit the amplifier and not be detected. Some CMOS imaging sensors also use Back-side illumination to increase the number of photons that hit the photodiode. CMOS sensors can potentially be implemented with fewer components, use less power, and/or provide faster readout than CCD sensors. They are also less vulnerable to static electricity discharges. The image captured by it is transferred to data acquisition and processing module and to information fusion algorithm.





B. Wireless node

Wireless node is the basic component of the WMSN, and the basic platform of fire detection system. The main task of the wireless node is to build a wireless network and transfer the data collected by the data acquisition module, which are the key factors of the system's reliability. As the wireless node is also battery-powered, hence the node hardware must be low-energy. In the system, JN5148 wireless microcontroller, a kind of SoC chip, is selected as the nucleus of the wireless node and the JenNet protocol is chosen as the communication protocol between the nodes. The JN5148 is an ultra-low power, high performance MCU combined with an IEEE802.15.4 compliant transceiver. It is targeted at low-power wireless networking applications, and features an enhanced 32-bit RISC processor offering high coding efficiency through variable width instructions, a multi-stage instruction pipeline and low power operation with programmable clock speeds and various sleep modes. The device comprises 128 kB of ROM, 128 kB of RAM, and a rich mix of analogue and digital peripherals. The operating current is below 18 mA, allowing operation direct from a coin cell. The Router in addition to running applications, its main tasks include relaying message from one node to another and allowing other nodes to connect to it. It can often be battery powered and, when not transmitting or receiving, can sleep in order to conserve power. Each sensors are connected with a data acquisition and processing module and information fusion program in the decision phase through routers using RS232 bus

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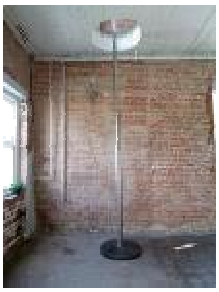
VI. EVACUATION PLANS USING MOBILE TECHNOLOGY AND SLIDING SYSTEM



A. Smartphone Application Development: There should be a Smartphone app developed to alert evacuees of the building to a fire and allow evacuees who could not escape by following the emergency lights and whose visibility is obstructed by smoke to check their location and the evacuation path. The app provides the building blueprints and evacuation map necessary for evacuation (a) to 2G phones as text information and (b) to 3G phones as text information and in the form of an App. The information allows the approximate location of an evacuee to be assessed for a quick rescue based on the information on the time and location of the ignition, progression of the fire, direction of the evacuation route, and connection with the integrated control centre through the App.

B. Sliding system: Use of sliding system for evacuation might prove to be fastest evacuation technique. Motion sensors will be installed for preventing collisions between people.

C. Earthquake-proof bed: Earthquake-proof bed 'swallows' you when it senses the ground shaking: Mechanism drops you and your mattress into a sealed box full of supplies such as water,oxygen mask,first aid kit,fire extinguisher,food. Resembling a cross between a strong box and a Venus flytrap, the mattress drops into a chamber covered with a protective lid when sensors feel the ground shaking.The occupant inside would then wait out the quake in the strong box until help arrived, or the quake subsided. The box can be opened from the inside, as well as the outside. There are also no details about where the exit would be, in the event of a large piece of debris landing on the lid and locking it shut.

VII. CONCLUSION

This paper suggests an I-o-t based Fire Emergency Response System that can diminish causalities during the fire hazard by detecting the current and exact location of fire to prevent the directional havocs of emergency lights and unbefitting evacuation guidance and provides clear path towards the automatic safe heaven. The intelligent emergency evacuation system can also aid fire fighting because it allows for a quick analysis of the exact location of the fire by integrating the intelligent and automated evacuation system with the central national emergency management agency and WMSNs ,information fusion technology based on DS evidence theory. This will diminish casualties and the time required for evacuation ,by guiding evacuees to safe locations which are not under fire, and save numerous lives and energy consumption.

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