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Code RED: Environment Recognition and Safety Protocol for Fire Fighters

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ABSTRACT

In this paper, an improved firefighting equipment is designed to progress security and more efficient execution of firefighting missions. New firefighting equipment is provided with temperature sensors, sensors for detecting chemical waste and toxic fumes and sensors for monitoring user's health. When a fire attack occurs in urban areas many emergency response teams, in most cases lack sufficient equipment necessary for rescue work. In many cases due to intense smoke the visibility is almost zero and there is also a general lack of thermal cameras in India .Even when these tools exist they are standalone and the firefighter is encumbered with heavy and unyielding tools which consume precious time and energy during emergency. Poor understanding of the site temperature conditions an fire progression in the current scenario. Significant number of fighters dies by breathing in toxic gases. Finding an injured fire fighter amidst a fire is very difficult with the current radio communication system.

KEYWORDS *— Augmented Reality Display, Internet of Things (IoT), Assistive technology for first responders, environment monitoring, collision detection, thermal vision, cloud computing, emergency rescue robots, autonomous robotic navigation*

I. INTRODUCTION

Firefighters save lives and millions a year in property damage. The existing methods of determining the rapidly changing interior conditions, as the fighter approaches the site, are time consuming and hazardous. Tools available to the fighters demand a lot of physical work and take time to access. The fighters on the site, report by radio continuously among themselves and to the department. Finding an injured fire fighter amidst a fire is very difficult. We propose a novel solution that could possibly enhance the current firefighter safety protocols. A smart connected helmet with a plethora of sensors that detect the interior conditions of temperature, gas concentration and the user's own vitals. The data is intuitively displayed to the user using an

Augmented Reality projection system which comprises of an OLED that comes with the helmet the data from the sensors are overlayed on the vision of the user without obstructing the user's vision. Accelerometers to detect potential attacks, injuries and trauma when debris collides with the user's head. The raw data is sent to local cloud and transmitted to the nearest fighter when the other one is in danger.

We plan to expand the system by monitoring more parameters and by using a FLIR Thermal Imaging sensor integrated on a Mini Rover with gas and temperature sensors that accompanies the fighter enabling him safely assess the room before entering. As the current sensor is not hermitically sealed, it might pose a fire hazard thus to prevent it we have chosen to use a metal-oxide semiconductor sensor to detect gases. Also we plan

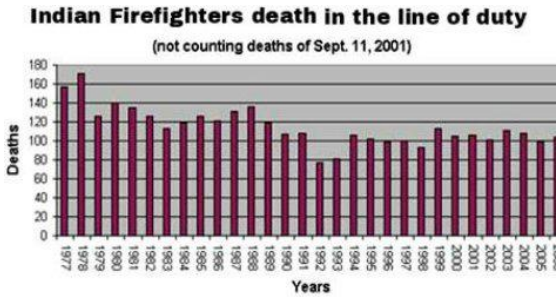
to integrate our system to the emergency wireless network which is used currently by first responders. The location of the downed fire fighters can be found using Trilateration to aid rescue. The usual trend in the previous implementation is the use of smoke detectors and physical sensors for fire detection as well as depth manipulation. Generally most sensors have low range and are sensitive to environmental changes. In [1], they propose a computer vision based algorithm for fire detection and for directing the robot towards the detected fire, thereby overcoming the above limitations. Color segmentation is used in initial detection.

Correlation is used to extract the non-static property of fire. Temperature sensor and UV-TRON sensor are used to confirm the presence of fire along with depth mapping. Finally, a water sprinkler is used to extinguish the detected fire. In firefighter environments navigational support could help to reduce casualties. The Yarnell Hill Fire was a wildfire near Yarnell, Arizona, ignited by lightning on June 28, 2013. On June 30, it overran and killed 19 City of Prescott firefighters, members of the Granite Mountain Hotshots. This event resulted in the highest wildland firefighter death toll in the United States since the 1933 Griffith Park Fire killed 29 firefighters, and the highest death toll from any U.S. wildfire since the 1991 East Bay Hills fire killed 25 people. It is the sixthdeadliest American firefighter disaster overall and the deadliest wildfire ever in Arizona [2].

II. CHENNAI CITY FIRE STATISTICS

India has a large number of firefighters and yet our firefighters lack proper equipment. There is a need for a low cost sensory system to aid the firefighters. We have an addressable market of 155,000 firefighters worldwide and India has 49,769 firefighters. Death due to firefighters accounts for 7.8% deaths in India. There is deficiency of 72.75% in fire stations across India making it more vital for these unsung heroes to get better equipment to do their jobs.

The Chennai Metropolitan Area is one of the largest city economies of India. Chennai is nicknamed "The Detroit of India", with more than one-third of India's automobile industry being based in the city. In January 2015, it was ranked third in terms of per capita GDP.



In the year 2013
Total fire accidents : 25,109
Small fire accidents : 24,337
Medium fire accidents : 550
Serious fire accidents : 222
Σ Total rescue calls (non-fire) : 13,705
Σ Property lost : Rs.42.55 Crores (approximately)
Σ Property saved : Rs. 338.33 Crores (approximately)
Σ No. of lives lost in fire calls : 75
Σ No. of lives saved : 85
Σ No. of lives lost in Rescue calls : 1586
Σ No. of lives saved : 3649

In the year 2012
Total fire accidents : 32273
Small fire accidents : 31,414
Medium fire accidents : 629
Serious fire accidents : 228
Σ Total rescue calls (non-fire) : 12,935
Σ Property lost : Rs.27.02 Crores (approximately)
Σ Property saved : Rs. 337.99 Crores (approximately)
Σ No. of lives lost in fire calls : 87
Σ No. of lives saved : 137
Σ No. of lives lost in Rescue calls : 1722
Σ No. of lives saved : 3659

In the year 2011
Total fire accidents : 22,219
Small fire accidents : 21,494
Medium fire accidents : 555
Serious fire accidents : 170
Σ Total rescue calls (non-fire) : 12,655
Property lost : Rs.27.59 Crores (approximately)
Σ Property saved : Rs.374.68 Crores (approximately)
Σ No. of lives lost in fire calls : 84
Σ No. of lives saved : 166
Σ No. of lives lost in Rescue calls : 1878
Σ No. of lives saved : 3768

CHENNAI CITY FIRE STATISTICS FOR THE YEAR 2010

	Fire Call				Property		Human Lives		Rescue	Human Lives	
Month	Serious	Medium	Small	Total	Loss	Saved	Loss	Saved	Calls	Loss	Saved
January	3	14	128	145	6504750	21776650	0	0	59	5	11
February	2	17	141	160	1710600	92649300	0	0	47	3	18
March	3	12	196	211	944950	11512600	1	2	76	8	50
April	3	6	251	260	1457400	14951600	0	0	89	6	35
May	3	13	244	260	1921150	12345450	0	0	109	8	22
June	2	4	149	155	11381900	34005600	0	0	118	6	21
July	3	9	120	132	1246000	22429790	0	0	106	6	29
August	2	7	140	149	917650	16428950	0	0	94	5	26
September	3	6	121	130	949300	49656900	3	0	77	6	15
October	2	3	122	127	613180	16974060	2	0	88	10	23
November	1	2	134	137	5473250	58764300	0	0	85	22	25
December	1	4	90	95	664600	56091000	0	0	72	13	21
TOTAL	28	97	1836	1961	33784730	50495 9300	6	2	1020	98	296

III. ARCHITECTURE

MEMS based accurate yet low cost gas sensors which we can use to monitor various dangerous compounds. A small FLIR Lepton camera module making it suitable for an AR helmet. Fully integrated MEMS thermopile sensors that measure the temperature of an object without having to be in direct contact. The Pulse Sensor – A photoplethysmography based heart-rate sensor. CodeRED would integrate tools like thermal sensing, gas analysis while also monitoring vitals comfortably. The data would be streamed to a custom AR display freeing the firefighter's hands. The process of networking among firefighters enables them to communicate better to each other and manage tasks properly. Each year many firefighters lose their lives while saving others. It is our belief that providing access to better equipment would be a gift they would be glad for. Further such a system would enable them to increase their productivity and help them save more lives in the process.

A sensor infused remote companion rover would also accompany the firefighter enabling him safely assess a given room/area before entering. Adding a FLIR Thermal Imaging sensor to the rover to capture a thermal image of the surroundings and sharing it with the fighter. Integrating our system to the current emergency wireless network (4G + LTE). The location of the downed fire fighters can be found using Trilateration to aid rescue. Situations arise for a station officer, when the water tender alone, is unable to combat fires, or to contain it, in his area. Areas such as Ports, air ports, chemicals and oil processing industries, will require other extinguishing agents, depending on the risks involved. If such risks exists in his station ground, the officer in charge ensures that the appliances he is holding will be able to successfully combat such risks or he gets the required appliances with out delay from a near by station or through a standing

Mutual aid scheme , with other Stations, for special situations. Special appliances, or Emergency tenders, - Are designed to tackle special situations, rescue operations the fire and escue services has to respond, such as;

1) Large urban fires and rescue operations, requiring
the use of Breathing apparatus, special tools, and equipments to enhance illumination.
2) Major fires involving power stations, or transformers.
3) Ship fires at ports.
4) Accidents in lifts, roads, or railways where special equipments are not available locally.
5) Major leakages, spills of toxic or other dangerous substances.

A few special appliances with the facilities available in them is listed below

1) Emergency Tender Type A is fitted with a generator and compressor. Power is provided by an independent hydraulic motor which are driven by a pump through a Power take off from the road engine. Other equipments
includei)

Five B.A. sets with spare cylinders.
ii) Air lines.
iii) Control equipments.
iv) Chemical protection suits.
v) Documentation gear.
vi) Jacks.
vii) Lifting tackle.
viii) Cutting gear.

Emergency tender Type B :- This functions also as a B.A. Tender and control unit. Carries all equipments and tools as Type A, except, do not have a generator.

They are capable of covering extensive dock areas, and carries special equipment, to deal with ships.
Water carriers, Carries large quantity of water Minimum 4500ltrs , 4 lengths of 4 lengths of 25mm,45mm delivery hoses , light portable pump which can pump straight from the tank, lift water and fill the tank via a goose neck , supply hose reel, also water can be discharged quickly into portable dams.
Foam Tender: - Different capacities suitable to the risk area are available .Delivers foam concentrate in bulk to the fire ground as a back up unit. Some have fixed monitors, carries a high capacity pump and water to operate for long duration. 2 dams of 225 ltrs and 450 ltrs to hold open volume of foam concentrate to feed monitors is also carried. control units :-During major incidents, control units are established at the Fire ground to coordinate all the units taking part in the operation, and for calling reinforcements . An officer coordinates with other teams with this mobile unit, which is fitted with communication equipments. For easier identification these units are marked with red and white checks a round its sides, and have a telescopic mast to flash a beacon. Large scale maps with details of water supplies available and access to them is carried. Dry powder tender: - Carries large quantities of Dry chemical powder, with other accessories, mounted is a monitor which can throw large quantities of powder, with longer reach. Powder is expelled by Nitrogen gas carried in several cylinders.

Hose laying vans;-Assists for laying hoses for long relays when water supplies are limited at the Fire ground. It Carries 90mm size hose, kept coupled and flaked in continuous lines. Can be laid in single or double lines as the situation requires at a speed of 50kph. Besides these , there are FOAM nursers, and lighting vans when illumination, require to be improved.

An officer keeps studying his station areas of the existing risks, and additional risks coming up that add to his fleet, the required appliances, to combat the anticipated fires.