JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue
JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)
An International Scholarly Open Access, Peer-reviewed, Refereed Journal

DESIGN OF A MOBILE ROBOT TO DETECT AND FIGHTING SYSTEM FOR INDUSTRY AND UPDATE TO IOT

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Abstract

Oil and gas refineries can be a dangerous environment for numerous reasons, including heat, toxic gasses, and unexpected catastrophic failures. In order to augment how human operators interact with this environment, a mobile robotic platform is developed. This paper focuses on the use of Wi-Fi for communicating with and localizing the robot. More specifically, algorithms are developed and tested to minimize the total number of Wi-Fi access points (APs) and their locations in any given environment whiletaking into consideration the throughput requirements and the need to ensure every location in the regioncan reach at least k APs. When multiple WiFi APs are close together, there is a potential for interference. A graph-coloring heuristic is used to determine AP channel allocation. In addition, Wi-Fi fingerprinting based localization is developed. All the algorithms implemented are tested in real world scenarios with the robot developed and results are promising.

KEYWORDS: *Fire-fighting Robot, Embedded System, Robotics, Camera.*

I. Introduction

As advancements in technology continue, new possibilities that increase people's safety are being developed. These advancements range from robotic surgeons to automated factories and can be distributed in environments that are typically hostile to humans. Oil and gas facilities are often located inhostile environments. Whether it is the frigid cold of the frozen north, the extreme heat of the Middle East,or the isolation of an ocean, each location provides its own unique risks. The oil and gas infrastructure consists of four major components: extraction, re nement, distribution, and transportation in between each component. Each stage presents its own unique risks, from drilling practices during extraction, volatile explosions at refineries, to contamination during transportation and distribution. This work aims at reducing risk of human operators at the oil and gas tenement level. More specifically, this work considers oil and gas re neries in Abu Dhabi, United Arab Emirates (UAE), which is among one of the biggest oil and gas industries in the world. Hazards are numerous when it comes to oil and gas refineriesin Middle East. Temperatures exceed 50o C for the majority of the summer, which combines with the highhumidity of the region. Workers who are exposed often fall victim to heat stroke and related injuries. Sandstorms also ravage the area, reducing visibility to meters, and result in the erosion of equipment. Gasand steam leaks that are invisible to human senses can be fatal if humans are exposed. These leaks canalso result in re or even in an explosion of high-pressure vessels, leading to catastrophic failure. The workpresented in this is part of a multi-disciplinary project, contracted by the Petroleum Institute in Abu Dhabi,UAE, which aims to automate oil and gas processes. Oil and gas re nery environments can be seen in mobile robotic system capable of autonomous path planning, path tracking, obstacle avoidance, and inspection has been created. The system is capable of tele-operation, various forms of shared control, and full autonomous control for various inspection tasks. The system consists of a Segway Robotic Mobile Platform (RMP), a 5 degree of freedom (DOF) arm, and a sensor package mounted at the end of the arm that is capable of a height of 2 m when fully extended.

II. Related work

Fire-fighting robot may be used in industrial environment and even in household areas wherethere is moreprobability of occurring accidental fire [8-10]. Different sensors are used and fusion of their performancesis ensured by an intelligent algorithm in Arduino computing platform or by soft computing techniques [11-

12]. Su et al. [13] made an automatic fire detection system using Adaptive Fusion Algorithm (AFA). Multisensor Fire Detection System (MSFDS) along with Visual Basic to receive information was used anda general interface for supervised computer was designed in his study. Viguria et al. [14] built an aerial/ground robot team applied to fire detection. They used a disturbed market based algorithm, calledS+T and coordinated in between aerial and ground vehicles. Their simulations showed that if the numberof services increased, communication and energy requirement would also increase. Nam Khoonet.al [15]developed an Autonomous Fire Fighting Mobile Platform (AFFMP) that is equipped with the basic fightingequipment that can patrol through the hazardous site via a guiding track with the aim of early detection for fire. The tasks for the AFFMP once it navigates out of the patrolling route include the obstacle avoidance, locating for more precise location of fire source using front flame sensor and extinguish the fire flame. Their work was focused on outdoor fire fighting robot. For early warning, a vision sensor basedfire detection method is proposed by Ko et al. [16]. They developed an AVM classifier for fire pixel verification. Kim et al. [17] made a portable fire evacuation guide robot system and demonstrated that robot system can be thrown into a fire to gather information, locate displaced people and evacuate them.They designed the robot with aluminum compound metal for thermal resistance with waterproofing and an impact distribution frame for impact resistance. White et al. [18] developed a vehicle mounted fire fighting system and included a series of flame and heat retardant coverings placed on all exposed parts of the system to prevent damage from exposure to extreme heat. Our effort is to develop an autonomousfire fighter robot which is constructed by locally available fire resistant and water-proof materials and performs on an arduino based fire detection and extinguishment algorithm. The robot is also fabricated so that it can save itself from fire by keeping safe distance from the source. At different distances from the fire and at different day time, the performance of the robot is evaluated by performing sensitivity testson the sensors taking serial monitor readings in Arduino. The vast majority of the work on fire fighting robots is focused on fire detection algorithms and less on the mobility of the robot inside the building such as climbing stairs and obstacles. Fighting fire within the building requires good thermal protection of the electronic components of the robots. This kind of protection has been considered in the proposed firefighting robot. Taiser T [19], presented the design and assembly details of a robot developed to take part in an educational robotic competition. A control law based on Lyapunov theory was developed and implemented on a Programmable Logic Controller to control the robot. Daniel J. et al. [20] conducted a design project to create an autonomous mobile robot that navigates through a maze searching for a fire (simulated by a burning candle), detects the candle's flame, extinguishes the flame, and returns to a designated starting location in the maze. The firefighting contest promotes interdisciplinary design and teamwork. Kuo et al. [21] designed fire detection system using three flame sensors in the fire fighting robot. The adaptive fusion method was proposed for fire detection of fire fighting robot. He usedcomputer simulation to improve the method to be adequate for fire detection. He incorporated the fire detection system in the fire fighting robot, and program the fire detection and fighting procedure using sensor based method. Chee et al. [22] have conducted a good review paper about variety of technologiesand state-of-the-art technology of fire fighting mobile robot. The paper also describes the first Malaysiandesigned and built fire fighting mobile robot, namely, MyBOT2000.

III. Problem Statement

Detecting fire and extinguishing it is a dangerous job that puts the life of a firefighter at risk. There are many fire accidents which firefighter had to lose their lives in the line of duty each year throughout the world. The research and development in the field of Artificial Intelligence have given rise to Robotics. Theaim here is to design a Fire Fighting robot based on IOT. The robot will not only extinguish the fire but caneven act as a path guider. The Robot should be able to find a fire before it rages out of control and must also reduce the risk of injury to victims. The Robot is based on Android application, used for controlling the robot and receiving live feedback from the Wireless IP Camera installed on the robot

IV. Proposed Work

We are interested in the effects of transmission power on the received signal strength (RSSI), bandwidth,

and link quality. In order to characterize our device at its max and min transmission powers a number of experiments were performed in di erent locations. This test was performed in two locations. The placement of the access point (AP) for each environment can be seen in Figure. Outdoor testing is performed on CSM's South IM Field as seen in Figure while indoor testing is performed in CSM's Brown Building on the secondory as seen in In both environments, we start at 1.524 m (5 ft.) from the AP. We then transfer a le through an FTP client to determine the average bandwidth while taking 10 RSS readingsusing the icons command. We also test link quality through the use of the Ping command. We then retreat 4.572 m (15 ft) and continue testing until we reach a distance of 100.584 m (330 ft) in the outdoorenvironment and 73.152 m (240 ft.) in the indoor environment. Each experiment is conducted twice, oncewith a transmission power of 11 dbs., and again at 29 dbs. in both environments These environments were used to determine the effects of transmission power on received signal strength (RSSI), bandwidth,and signal quality. The following paragraphs explain in detail our results for both the indoor and outdoor environments, both at a transmission power of 11 dbs. and 29 dbs.

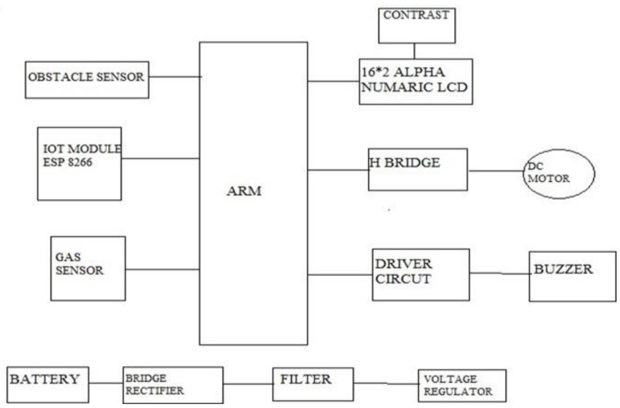

Fig Proposed System Block Diagram

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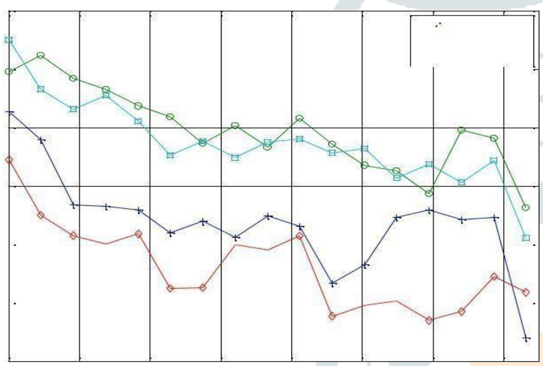
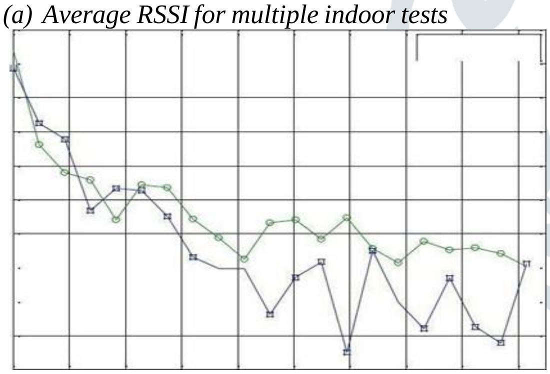


(a) Average RSSI for multiple indoor tests



(b) Average RSSI for multiple outdoor testsFig Average

RSSI results

Furthermore, the indoor environments with hallways (which functions as a wave guide for signal travel and have significant multipath effect) have considerably higher RSSI levels than outdoor environments. Moreover, the transmission power of 29 dbs. shows better RSS reading than 11 dbs. as expected. Duringthe outdoor testing, we noticed that harsh environmental conditions such as high winds changed the RSSIrapidly and it greatly affected the bandwidth and link quality. When we examine the 95% confidence levelgraphs Figure 3.6(a) and Figure 3.6(b) for RSSI, it can be seen that although individual RSSI values per reading vary, they are highly concentrated around the mean. Therefore, in designing localization algorithms and communication patterns we may not have to consider sudden variations of the RSSI.

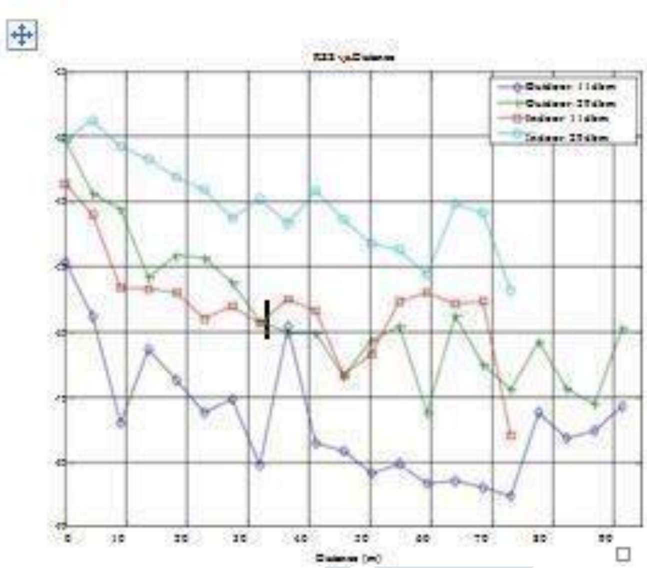


Figure: Average RSS for both environments

EIT: Outdoor Environment This test has a similar setup to the previous section, with the exception that weare taking 20 RSSI readings in an outdoor environment (Figure 3.9). We then perform this test twice, oncewith the testing unit on the robot and once with the testing unit o the robot, i.e.: no robot present during second test.

EIT: Indoor Environment because an oil and gas refinery consists of both outdoor and indoor environments, we decided to also test in an indoor environment. We chose the third door of Brown Building on the Colorado School of Mines campus to reduce the amount of interference from external

sources, i.e.: wind, track, or people. Brown building, Figure, is an academic building consisting of various class rooms and hallways. Minor foot track existed during this experiment

V. Results and Discussion

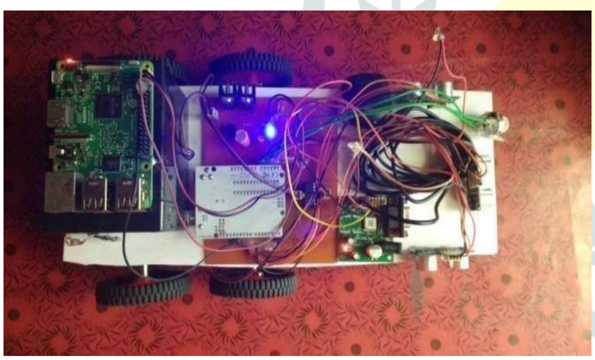


Fig: Hardware setup

The above figure shows the hardware setup of this paper consisting of arm , temperature, humidity, pressure, and CO sensors. In the wake of detecting the information from various sensor gadgets, which are set specifically range of intrigue. The Wi-Fi association must be set up to exchange sensors information to end client and furthermore send it to the cloud storage for future utilization. The detected information will be consequently sent to the web server, when a legitimate association is built up with server device. The detected information will be put away in cloud . The information put away in cloud canbe utilized for the examination of the parameter and consistent observing reason. The above demonstrates the temperature, humidity, pressure, rain and CO in air at customary time interims. All the data will be put away in the cloud, with the goal that we can give slanting of temperature, humidity, pressure, rain and CO levels in a specific territory at anytime of time.

VI. CONCLUSION

For a robotic system to autonomously navigate in an oil and gas refinery, it must be able to communicatewith the control room and also localize itself. In this work we define the kinds of communication requiredto deploy an autonomous robot. We study Wi-Fi signal propagation characteristics and apply the findingsto determine Wi-Fi AP placement. We also assign channels to interfering APs. Wi-Fi fingerprinting basedlocalization was implemented that achieves a reasonable accuracy when used alone and achieves desired accuracy (less than 1m) when combined with INS and fiducial marker based approach.

FUTURE SCOPE

Future Work. In this work we were able to localize to a sub-meter resolution by combining dead reckoning,Wi-Fi, and a ductal marker system; however, all of this work was performed in an indoor environment. Through the use of the work described in this thesis, it would be possible to expand it to an outdoor environment. The system would then be able to add GPS and compass, among other devices, into the Kaltman filter to determine a more accurate localization solution.

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