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MOBILE ROBOT WITH WIFI BASED COMMUNICATION FOR REFINERY INSPECTION

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Abstract: Industrial safety is one of the main aspects of industry specially refining industry. To avoid any types of unwanted phenomena all refining industry follows some basic precaution and phenomena. Communication is the main key factor for any industry today to monitor different parameters and take necessary actions accordingly to avoid any types of hazards. To implement a robotic system to autonomously navigate in an oil and gas refinery and it must be able to communicate with the control room and also localize it and alert workers in hazardous leakages and other accidents. Oil and gas refineries can be a dangerous environment for numerous reasons, including heat, gasses and humidity at the refinery. 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. All the algorithms implemented are tested in real world scenarios with the robot developed and results are promising.

Keywords: Autonomous Robot; Wi-Fi; Refineries inspections.

I. INTRODUCTION

Removing humans from inhospitable environments is often desirable. For instance, in the oil and gas industry, during inspection, maintenance, or repair of facilities in a refinery, people may be exposed to severely high temperatures (+50_C) for an extended period of time, to gasses. One way to remove human exposure from these types of situations is to instrument an oil refinery with a wireless sensor network [1], which attaches a wireless sensor on every gauge and valve. Unfortunately, this approach is expensive and labor-intensive, let alone wireless sensors are failure prone. Hence, maintenance of the network and reliably collecting data from the network are extremely challenging. We, therefore, resort to a different approach that aims to augment how the human operators interface with the physical world. A mobile robotic platform is a rational analog to a physical human - it can move through an environment either autonomously or through tele-operation while sensing its surroundings with an array of sensors. However, further constraints are applied when introducing Physical systems into an oil and gas environment. All devices deployed must meet the specified standards set by the industry. A detailed explanation of these standards applied to a mobile robot is stated in [2]. In our interdisciplinary project that aims to automate oil and gas processes using a mobile robot, we have built Blaster (Fig. 1), a mobile robot capable of both tele-operation and autonomous control. Blaster is capable of path planning, path tracking, obstacle avoidance, and auto inspection autonomously. A network camera, a sensor for humidity and a methane gas identification. Temperature Sensor to identify the temperature and humidity sensor for identify the moisture level in the refinery and the control station occurs over Wi-Fi. For more details on the design of the system, interested readers may refer to our paper [3]. In this paper, we focus on the Wi-Fi aspects when using a mobile robotic platform in an oil refinery. More specifically, we consider the problem of Wi-Fi communication and localization. First, while the robot is mobile, an operator must be able to communicate with it to receive sensor data collected from the refinery as well as send it various commands that either turn the robot to left or Right, request certain specific information, or ask it to move in a certain way; however, most refineries lack a wireless network infrastructure. Therefore, Wi-Fi access points (APs) must be strategically placed throughout an environment to minimize the number of units required to achieve full coverage needed for communication. Second, in order for a robotic system to be autonomous, it must have an accurate understanding of its location. Since an oil refinery often is comprised of tall structures made of steel, GPS may not always be available; Wi-Fi based localization becomes essential. It complements localization methods using other sensors built in a robotic system.

II. THE HARDWARE SYSTEM

Microcontroller: This section forms the control unit of the whole project. This section basically consists of a Microcontroller with its associated circuitry like Crystal with capacitors, Reset circuitry, Pull up resistors (if needed) and so on. The Microcontroller forms the heart of the project because it controls the devices being interfaced and communicates with the devices according to the program being written.

ARM7TDMI: ARM is the abbreviation of Advanced RISC Machines, it is the name of a class of processors, and is the name of a kind technology too. The RISC instruction set, and related decode mechanism are much simpler than those of Complex Instruction Set Computer (CISC) designs.

Liquid-crystal display (LCD) is a flat panel display, electronic visual display that uses the light modulation properties of liquid crystals. Liquid crystals do not emit light directly. LCDs are available to display arbitrary images or fixed images which can be displayed or hidden, such as preset words, digits, and 7-segment displays as in a digital clock.

III. DESIGN OF PROPOSED HARDWARE SYSTEM

The proposed system is divided into two sections. A mobile robotic platform is a rational analog to a physical human - it can move through an environment either autonomously or through tele-operation while sensing its surroundings with an array of sensors. A microcontroller is used with the sensors to receive the sensor outputs and to take the necessary decision. Once temperature is more than the safety level preprogrammed at microcontroller, microcontroller decodes beep alarms through controller once the measured humidity value is more than the safety level preprogrammed at microcontroller; it decodes different type of beep alarms. Similarly when gas concentration crosses the safety level, microcontroller decodes siren alarms. Different sensors values are displayed in the LCD of refine workers section. In control station the information is received by WIFI and the status of the sensors is monitored in the laptops and required action is performed by sending signals to Microcontroller. The controller here we are using ARM7 LPC2148, Sensors like Humidity Gas and Temperature. For the purpose of Communication we are using WIFI Module. Controller is used to transfer the information about Sensors when the value exceeded the threshold level which is described. For movement of robot we are using Motors along with motor driver IC L293D.Based on the directions given by WIFI Access point the robot will move according to the directions and sense the information about various sensor based operations.

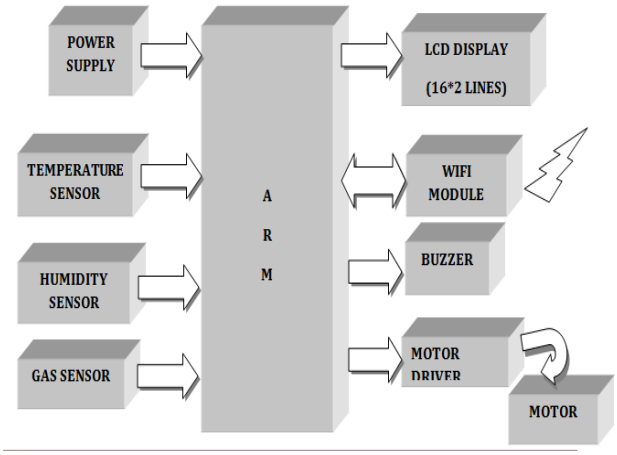

Fig 1: Refinery Section

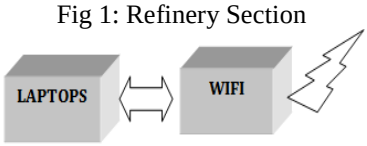

Fig 2: Monitoring Section

IV. SYSTEM HARDWARE REQUIREMENTS

Temperature sensor: A thermistor is a type of resistor whose resistance is dependent on temperature. Thermistors are widely used as inrush current limiter, temperature sensors (NTC type typically), self-resetting over current protectors, and self-regulating heating elements. The TMP103 is a digital output temperature sensor in a four-ball wafer chip-scale package (WCSP). The TMP103 is capable of reading temperatures to a resolution of 1°C.

Fig 3: Temperature Sensor

Alcohol sensor: Sensitive material of MQ-3 gas sensor is SnO2, which with lower conductivity in clean air. When the target alcohol gas exist, the sensor's conductivity is higher along with the gas concentration rising. Please use simple electro circuit, Convert change of conductivity to correspond output signal of gas concentration. MQ-3 gas sensor has high sensitivity to Alcohol, and has good resistance to disturb of gasoline, smoke and vapor. The sensor could be used to detect alcohol with different concentration; it is with low cost and suitable for different application.

Fig 4: Alcohol Sensor

Humidity sensor: Humidity sensor is a device that measures the relative humidity of in a given area. A humidity sensor can be used in both indoors and outdoors. Humidity sensors are available in both analog and digital forms. An analog humidity sensor gauges the humidity of the air relatively using a capacitor-based system. The sensor is made out of a film usually made of either glass or ceramics. The insulator material which absorbs the water is made out of a polymer which takes in and releases water based on the relative humidity of the given area. This changes the level of charge in the capacitor of the on board electrical circuit. A digital humidity sensor works via two micro sensors that are calibrated to the relative humidity of the given area. These are then converted into the digital format via an analog to digital conversion process which is done by a chip located in the same circuit. A machine made electrode based system made out of polymer is what makes up the capacitance for the sensor. This protects the sensor from user front panel (interface).

Fig 5: Humidity Sensor

DC Motor: A DC motor relies on the fact that like magnet poles repels and unlike magnetic poles attracts each other. A

coil of wire with a current running through it generates an electromagnetic field aligned with the center of the coil. By switching the current on or off in a coil its magnetic field can be switched on or off or by switching the direction of the current in the coil the direction of the generated magnetic field can be switched 180°.

Fig 6: DC Motor

WIFI: Wi-Fi is the name of a popular wireless networking technology that uses radio waves to provide wireless high-speed Internet and network connections. A common misconception is that the term Wi-Fi is short for "wireless fidelity," however this is not the case. Wi-Fi is simply a trademarked phrase that means IEEE 802.11x. Wi-Fi works with no physical wired connection between sender and receiver by using radio frequency (RF) technology, a frequency within the electromagnetic spectrum associated with radio wave propagation. When an RF current is supplied to an antenna, an electromagnetic field is created that then is able to propagate through space.

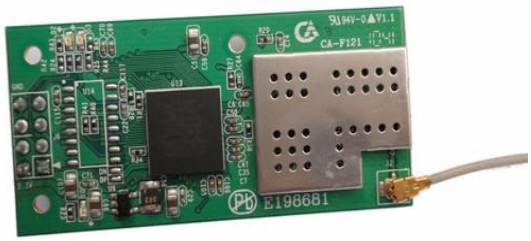

Fig 7: WIFI Module

The cornerstone of any wireless network is an access point (AP). The primary job of an access point is to broadcast a wireless signal that computers can detect and "tune" into. In order to connect to an access point and join a wireless network, computers and devices must be equipped with wireless network adapters Wi-Fi is supported by many applications and devices including video game consoles, home networks, PDAs, mobile phones, major operating systems, and other types of consumer electronics. Any products that are tested and approved as "Wi-Fi Certified" (a registered trademark) by the Wi-Fi Alliance are certified as interoperable with each other, even if they are from different manufacturers. For example, a user with a Wi-Fi Certified product can use any brand of access point with any other brand of client hardware that also is also "Wi-Fi Certified". Products that pass this certification are required to carry an identifying seal on their packaging that states "Wi-Fi Certified" and indicates the radio frequency band used (2.5GHz for 802.11b, 802.11g, or 802.11n, and 5GHz for 802.11a). VSD03 is the new third-generation embedded Uart-Wifi modules studied by VSD TECH. Uart-Wifi is an embedded module based on the Uart serial, according with the Wi-Fi wireless WLAN standards, It accords with IEEE802.11 protocol stack and TCP / IP protocol stack and it enables the data conversion between the user serial and the wireless network module through the Uart-Wifi module, the traditional serial devices can easily access to the wireless network. VSD03 does a comprehensive hardware and software upgrades based on the products its main features include:

Interface:

- 2*4 pins of Interface: HDR254M-2X4
- The range of baud rate: 1200 ~ 115200bps
- RTS / CTS Hardware flow control
- Single 3.3V power supply

Wireless:

- Support IEEE802.11b/g wireless standards
- Support the range of frequency: 2.412~2.484 GHz
- Support two types of wireless networks:
  - Ad hoc and Infrastructure
- Support multiple security authentication mechanisms:
  - WEP64/WEP128/ TKIP/CCMP(AES)
  - WEP/WPA-PSK/WPA2-PSK
- Support quick networking
- Support wireless roam

Buzzer: A buzzer or beeper is a signaling device, usually electronic, typically used in automobiles, household appliances such as a microwave ovens, & game shows. The word "buzzer" comes from the rasping noise that buzzers made when they were electromechanical devices, operated from stepped-down AC line voltage at 50 or 60 cycles. Other sounds commonly used to indicate that a button has been pressed are a ring or a beep.

The "Piezoelectric sound components" introduced herein operate on an innovative principle utilizing natural oscillation of piezoelectric ceramics. These buzzers are offered in lightweight compact sizes from the smallest diameter of 12mm to large Piezo electric sounders. Today, piezoelectric sound components are used in many ways such as home appliances, OA equipment, audio equipment telephones, etc. And they are applied widely, for example, in alarms, speakers, telephone ringers, receivers, transmitters, beep sounds, etc.

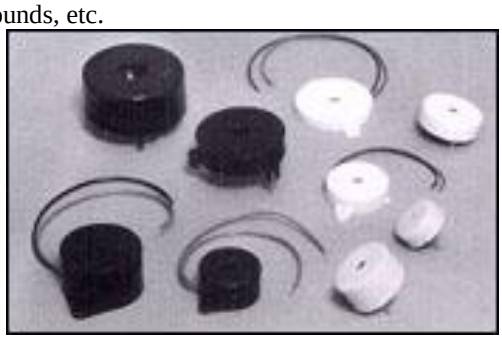

Fig 8: Types of Buzzers

V. CONCLUSION

For a robotic system to autonomously navigate in an oil and gas refinery, it must be able to communicate with the control room and also localize itself. In this work we define the

kinds of communication required to deploy an autonomous robot. We study Wi-Fi signal propagation characteristics and apply the findings to determine Wi-Fi AP placement. We also assign channels to interfering APs. Wi-Fi fingerprinting based localization will be proposed to achieve a reasonable accuracy when used alone and achieves desired accuracy (less than 1m).

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