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An Autonomous Mobile Robot 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 refinary. In order to augment how human operators interact with this environment, a mobile robotic platform is developed. This paper focuses on the use of WiFi 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.**

Key Words: **Autonomous Robot; WIFI; Oil Refineries;**

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 WiFi. For more details on the design of the system, interested readers may refer to our paper [3]. In this paper, we focus on the WiFi aspects when using a mobile robotic platform in an oil refinery. More specifically, we consider the problem of WiFi 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, WiFi 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, WiFi based localization becomes essential. It complements localization methods using other sensors built in a robotic system.

II. RELATED WORK

In this section, we only discuss related work in providing wireless communication in an oil refinery. We defer the discussion of the work related to specific aspects of WiFi communication and localization to later sections. Previous work [1] proposes to use wireless sensor networks (WSNs) for remote monitoring to detect leaks of harmful by-products of oil refineries. While WSNs are capable of being equipped with an array of sensors, the major deficiency of WSNs is battery life as well as their

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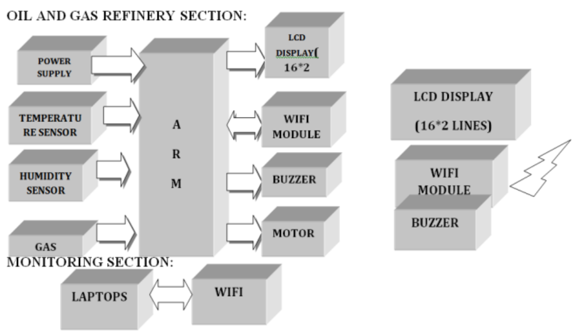
failure prone nature. A robotic mobile platform is developed [2] to provide secure and reliable two-way wireless communication at a lower cost and less maintenance than a WSN.

III. WIFI COMMUNICATION

Two types of data are communicated between the robot and the control station. Control information has the higher priority as it informs the robot how to act and react, i.e.: whether it is direct movement commands through teleoperation or more general commands such as informing the robot of a new destination for inspection. Tele-operation and emergency stop are two operations that require realtime communication and must be executed by the robot regardless of the state of sensor information. For example, if the operator receives a report describing low humidity in a tank, the robot should be able to drive upstream of the tank, begin to transmit acoustic information, and then drive along the pipe. If the communication between the robot and control station times out, the robot halts - this is to ensure safety of the surrounding environment and of the robot itself. Therefore, communication between the systems must be reliable. Since an oil refinery typically does not have WiFi infrastructure available, we need to determine the minimum number of WiFi APs needed and where to deploy them so that the entire region is covered. When multiple APs are located close to each other, we need to determine how different Channels should be used by each AP to avoid interference. The following subsections describe the algorithms used for these purposes.

BLOCK DIAGRAM



IV. DESCRIPTION

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.

V. CONCLUSIONS

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 WiFi signal propagation characteristics and apply the findings to determine WiFi AP placement. We also assign channels to interfering APs. WiFi fingerprinting based localization will be proposed to achieves a reasonable accuracy when used alone and achieves desired accuracy (less than 1m).

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