AUTONOMOUS STANDALONE FIRE ENGINE WITH LIDAR-ROS

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Abstract*: In recent year fire accidents increased rapidly. Firefighting and rescue, is very dangers for firefighters engaged in the field. So robots intended for firefighting have been introduced. However, Robots mobility is limited so it is difficult for them to directly approach fire sources. Here we proposed a solution by designing an autonomous firefighting robot with help of Lidar technology. Lidar can map surrounding environment and create a map of the locality using this pre-map robot can navigate the area by comparing current input from the Lidar. Here each node can be considered as a location point and every building is embedded with number of sensors for fire detection if fire is detected this information is sent to robot. Robot then activates and finds the location by itself and navigate to this location to extinguish fire. The robot-using camera also does fire detection tracking autonomously and water is sprinkled until fire is extinguished.

***Keywords*: Autonomous mobile robot, lidar, raspberry pi.**

1. INTRODUCTION

Mostly firefighting and rescue, is hazards for firefighters engaged in that field. Many robots are invented for firefighting. Firefighting presuppose the work of trained manpower that are continually required to take very important decisions based on rapidly changing circumstances [1]. Firefighting professionals must take these decisions while doing formidable physical activities using substantial equipment and painful preservative garments under life scarring conditions. From 1995 to 2007, there were 1,345 on-duty fire fighter mortalities[2][3]

In extinguishing activity during fire, it is advisable to pour water straightly on the fire origin by firefighters positioned away from the fire. Even though, it is tough to directly approaches the fire origin[4]. Especially, when big scale of fire, it is difficult for a firefighter to quench the fire inside a premises where it has lay out. In that situation, the main aim is none other than stopping the fire from spreading outside of the premises [5].

2. ROS MECHANISM

To build any Robot applications we need a set of software's libraries and tools. The Robot Operating system (ROS) consists of these libraries and tools. ROS consists of powerful developer tools and drivers to state-of-the art algorithms. It is fully open source. The LIDAR, now used as an acronym of light detection and ranging (light imaging, detection, and ranging are also called sometimes), was originally a portmanteau of light and radar. Lidar is commonly used to make high-resolution maps, with applications in geodesy, geomatics, archaeology, geography, geology, geomorphology, seismology, forestry, atmospheric physics, laser guidance, airborne laser swath mapping (ALSM), and laser altimetry. The technology is also used in control and navigation for some autonomous cars.

a. Receive data from your LiDAR

In order to connect the LiDAR to you PC, you must first take care of the power supply. Depending of your device, it may require 5V DC or 12/24V DC, for instance. A USB connector plugged into your PC usually supports 5V DC supply voltage, you just have to wire it and the LiDAR will be ready to spin. For higher supply voltage, you need an external alimentation (low frequency generator), a transformator converter wired to main supply, or a battery.Once you have connected your LiDAR with its power supply, you need to connect the data transmitter.It could be through the same cable as USB supplier, with a different one, with a Rx/Tx cable, a UART cable or an Ethernet cable. Usually, an adapter is sold with the LiDAR

b. RPLIDAR A3

Indoor robotic SLAM application, RPLIDAR sensor is suitable because it is low cost. It provides 5.5 Hz / 10Hz rotating frequency and 360-degree scan field, guaranteed 8-meter ranger distance. Sensor distance 16m for A2 and 25m for A3. Robots consumer and hardware hobbyist RPLIDAR sensor reduces cost because RoboPeak provides high-speed image processing; therefore the design cost is reduced. RPLIDAR A3 provides very high-speed distance estimation with more than 16K samples per second; RPLIDAR A2 performs high-speed distance estimation with more than 4K/8K samples per second, RPLIDAR A1 provides 2K/4K samples per second. Each scan provides 360 samples per rotation, the 10 Hz scanning frequency can be attained. Consumers can able to vary the scanning frequency from 2 Hz to 10 Hz freely by control the speed of the scanning motor. Current Scanning speed will automatically self-adapt by RPLIDAR. [6].

c. **LiDAR Working**

LiDAR principal of operation is very simple. It is measure of time taken to shine a small light at a surface and return to its source. This will be similar to shine a torch light on a surface what we are actually seeing is the light being reflected and returning to our retina. Traveling speed of light is about 300,000 kilometres per second, 186,000 miles per second or 0.3 metres per nanosecond so instantaneous turning a light. The instrument needed to estimate this needs to working extremely fast. By modern computing technology advancements this become possible[7].

The calculation of measurement is done by how far a returning light photon travelled to and from a target.

$$\rho = (\upsilon \times \tau) / 2$$

where ρ is distance
υ is speed of light
τ is time of flight

The LiDAR measuring device generates rapid pulses of laser light from its surface, some pulses up to 150,000 p/s. Light travels at a constant speed so LiDAR measuring device will calculate the travelling interspace between itself and the target object with very high precision. By repeating this in fast sequence the measuring device constructs up a composite 'map' of the facet it is measuring. To ensure accuracy of collecting data airborne LiDAR is used. Ground based LiDAR a single GPS location can be added for every location where the measuring device is build up. Normally two ways of LiDAR detection methods are there. Incoherent detection is also known as Direct energy detection and Coherent detection. Doppler or phase sensitive calculations and Optical heterodyne detection generally coherent systems are best. This method gives them to working on much less power but has the expense of high complex transceiver requirements.

Two main pulse models: micropulse and high-energy systems are used in both types of LiDARs. More powerful Computers with high computational capabilities Micropulse systems have been developed. Atmospheric research applications High energy systems are commonly used. Atmospheric parameters such as the cloud particles properties, temperature, pressure, height, wind, layering and density of clouds, humidity and trace gas concentration.

d. 3D-LiDAR

Lidar sensor measures target distance by illuminating laser light to target and reflected light. Time differences are calculated by illumination and reflected time. Wavelengths can then be used to calculate digital 3-D representations of the target. Lidar sometimes is called 3D laser scanning, a special combination of a 3D scanning and laser scanning. It has terrestrial, airborne, and mobile applications.

3. PROPOSED METHOD

In this proposed system new way of the method to reduce the cost, we used every basic model of hardware like Raspberry Pi as the core of ROS and using RpLiDAR A1 model which also a 360-degree functional LIDAR. For Robot control, we are simply using Arduino interfaced with HC-05 Bluetooth to receive commands from the laptop. In addition, rest of the functionalities like Algorithms like SLAM,

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Destination Marking, Path Planning and Path following are developed in Matlab using Robotic Operating System in Software Package of the Matlab. By using ROS Network configurations ROS is communicated from the Matlab.

- Here robot can navigate to the fire location on its own using LiDar
- In the proposed system, the camera is used for the detection of the fire.

The block diagram illustrate model of the Robot as shown in Figure 1. Robot can navigate to fire and extinguish it by using camera input.

The Fire Node block diagram was shown in Figure 2.

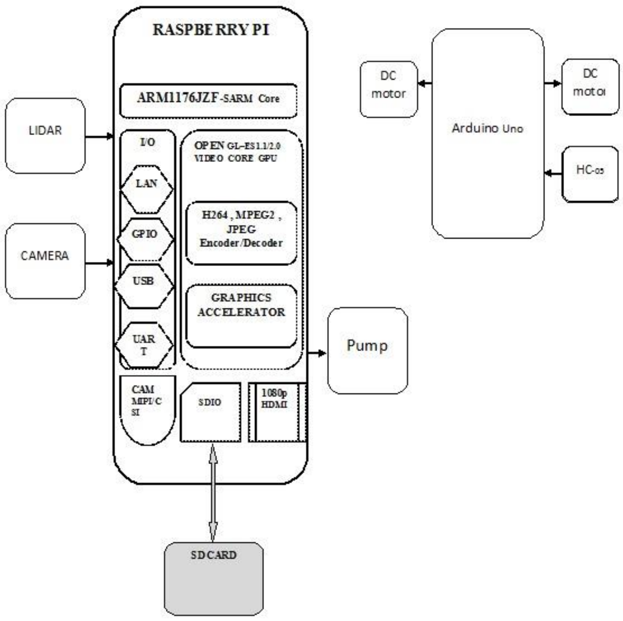

Fig. 1.Block diagram of the Robot

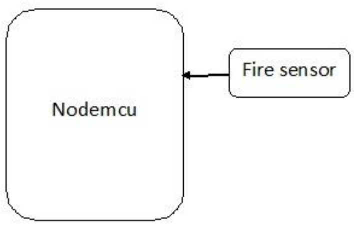

Fig. 2.Block diagram of the Fire Node

4. OPERATION

The hardware features with an open-source hardware board designed around an 8-bit Atmel AVR microcontroller or a 32-bit Atmel ARM. Current models consists a USB interface, 6 analog input pins and 14 digital I/O pins that allows the user to attach various extension boards. The Arduino Uno board is a microcontroller based on the ATmega328. It has 14 digital input/output pins in which 6 can be used as PWM outputs, a 16 MHz ceramic resonator, an ICSP header, a USB connection, 6 analog inputs, a power jack and a reset button. This contains all the required support needed for microcontroller. In order to get started, they are simply connected to a computer with a USB cable or with a AC-to-DC adapter or battery. Arduino Uno Board varies from all other boards and they will not use the FTDI USB-to-serial driver chip in them. It is featured by the Atmega16U2 (Atmega8U2 up to version R2) programmed as a USB-to-serial converter.

5. NODE MCU

Node MCU is an open source IoT platform. Which includes firmware, which runs on the ESP8266 Wi-Fi Module from Espress if Systems, and hardware, which is based on the ESP-12 module. The term "Node

MCU" by default refers to the Firmware rather than the dev kits. Node MCU firmware was developed so that AT commands can be replaced with Lua scripting making the life of developers easier. So it would be redundant to use AT commands again in Node MCU.

6. RESULT AND DISCUSSION

a. LiDar Mapping

Lidar mapping process involves the of possession framework drawing generation. The method involves an group of cells alienated into grids which utilize a procedure to accumulate the height values when lidar data falls into the respective grid cell. Fig 3 show the LiDar Map. A binary map is then created by applying a particular threshold to the cell values for further processing. The next step is to process the radial distance and z-coordinates from each scan to identify which 3-D points correspond to each of the specified grid cell leading to the process of data formation.

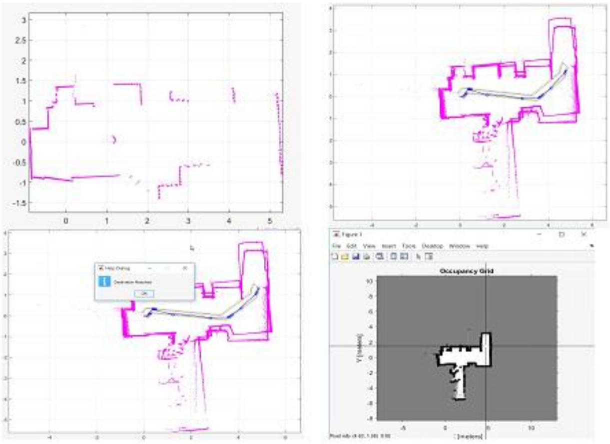

Fig. 3.LiDar Map

b. Robot Movement

If any smoke generated means, the Node MCU detect the smoke by the Fire sensor and send the signal to the Robot. The Robot received the signal from Node MCU, it start moving from its position based on the LiDar map to where the signal generated Node MCU located. It shows in Fig 4(a). Once the destination is reached, it start fighting with fire. This is shown in Fig 4 (b)&(c). When the Obstacle will be there in the path it change the path based on the LiDar Map.

Fig. 4.a) Robot Reached the Destination, b)Robot sensing the Fire, c) Robot Fighiting with Fir and d) Obstacle Detection

7. CONCLUSION

Robot fights fire using lidar mapping and obstacle detection and obstacle avoiding. Mapping can be done only in closed areas using lidar. .This model cannot be used in open areas like grounds or roads. The floor in an office or schools or hospitals have to be mapped using lidar technology.Once mapped the robot can finds its way when the fire outbreaks. This method of fire fighting will provide better efficiency. Many fire fighting techniques are there but using robot is the better way of preventing casualities. Lidar based fire fighting is the new way of efficient fire fighting. Thus this robot provides efficient fire fighting in all aspects.

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