

# Simultaneous Localization and Mapping of Indoor Robot

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**Abstract**— The Simultaneous Localization and Mapping (SLAM) of indoor wireless mobile robotics. Localization, map building and wireless communication are essential tasks for an autonomous mobile robot's in unknown environments. Simultaneous Localization and Mapping is a strategy that utilized for making a 2D, 3D maps of an unfamiliar environment from the sensor's information which will make the task of knowing the position of the robot and the position of the different obstacle. Through mapping, the robot will have a vision of the surroundings. Localization is the process of estimating a pose of the robot relative to the map. Simultaneous update of robot pose and linear feature estimates is performed through hybrid algorithm and this can be achieved by comparing the most important solutions in position and using a low cost Microsoft Kinect sensor, Arduino microcontroller as embedded system, Inertial Measurement Unit(IMU), Laptop and Robot operating system to verify the feasibility of the proposed methods as a indoor wireless mobile robot communicating with various indoor devices.

**Keywords**—Arduino microcontroller, Kinect sensor, Robot operating system

## I. INTRODUCTION

The Simultaneous Localization and Mapping (SLAM) has been one of the most studied subjects in Robotics. Because of their capabilities rapidly expand and improves the increasing amount of research are dedicated towards making mobile robots. The better capable of handling everyday human tasks, such as driving a car around in a city, go to the supermarket, cleaning the house, etc It is a fundamental process in mobile robotics, since it is responsible for building maps and at same time estimate the robot position in the environment. Once a map of the area is created and the mobile robot knows its position with respect to the map, the next step, the navigation and route planning step, can take place. As a third step, smart decisions, dependent on the information available for the mobile robot, can be made and the mobile robot may then be regarded as truly autonomous. Due to its importance, the number of SLAM approaches increased significantly in the last years.

Several algorithms are simulated and investigated using open source robot operating system. When an obstacle is detected on the path then robot should detect and localize it. Again it investigates the feasibility of the integration of ROS and the Microsoft Kinect on a mobile robot platform for SLAM.

## II. SYSTEM ARCHITECTURE

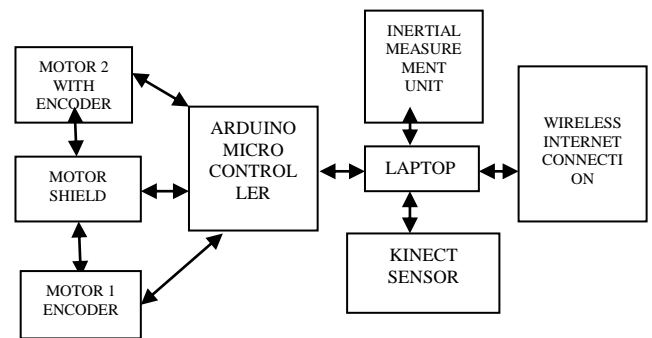


Fig 1: Block Diagram of the system

In Fig 1. The robot's movement is controlled by two Direct Current (DC) gear motors with an encoder. The two motors are driven using a motor driver. The motor driver is interfaced into an embedded controller board, which will send commands to the motor driver to control the motor movements. The encoder of the motor is interfaced into the controller board for counting the number of rotations of the Motor shaft. This data is the odometry data from the robot. There are kinect sensors, which are interfaced into the PC for taking 3D image.

There is an IMU sensor to improve odometry calculation. The embedded controller board is interfaced into a PC, which does all the high-end processing in the robot. Vision and sound sensors are interfaced into the PC and Wi-Fi is attached for remote operations.

## III. HARDWARE IMPLEMENTATION

The different components used in the system is as given below with the specification of the hardware components,

### Hardware Requirement

1. kinect Sensor
2. 2 Wheels
3. 1 Caster wheel
4. Robot
5. Arduino microcontroller

### 1. ARDUINO MICROCONTROLLER

The Arduino Mega 2560 Microcontroller is in our project. It is an open-source platform used for building electronics

projects. Arduino consists of both a physical programmable circuit board (often referred to as a microcontroller) and a piece of software, or IDE (Integrated Development Environment) that runs on your computer, used to write and upload computer code to the physical board. Unlike most previous programmable circuit boards, the Arduino does not need a separate piece of hardware (called a programmer) in order to load new code onto the board – you can simply use a USB cable.

Table 1.-Arduino Mega2560 technical specification

Microcontroller	ATmega2560
Operating Voltage	5V
Input Voltage (recommended)	7-12V
Input Voltage (limit)	6-20V
Digital I/O Pins	54 (of which 15 provide PWM output)
Analog Input Pins	16
DC Current per I/O Pin	20 Ma
DC Current for 3.3V Pin	50 mA
Flash Memory	256 KB of which 8 KB used by boot loader
SRAM	8 KB
EEPROM	4 KB
Clock Speed	16 MHz
Length	101.52 mm
Width	53.3 mm
Weight	37 g

### 2. KINECT SENSOR

The Kinect sensor is a peripheral for Microsoft’s Xbox 360 video game system. It is a 3D vision sensor, mainly used in 3D vision application and motion gaming. We are using kinect for 3D vision. Using kinect, the robot will get the 3D image of its surroundings. The 3D images are converted to finer points called point cloud. The point cloud data will have all 3D parameters of the surrounding. The main use of kinect on the robot is to mock the functionality of a laser scanner. The laser scanner data is essential for an algorithm called SLAM, used for building a map of the environment.

The Kinect has two built-in cameras. It has an IR camera associated with an IR projector to produce a “depth image” of the scene in front of it. Each pixel does not show the color of the object but instead the distance from the sensor. This way a scene can be described three-dimensionally, as each pixel has a position but also a distance. The second is a RGB

camera, where each pixel captures the color of the light that reaches the camera from that part of the scene. This camera has a digital sensor that is similar to the one in many web cams and small digital cameras.

### 3. ROBOT CHASIS

*Bottom Acrylic plate:*

Bottom Acrylic plate is used to place all circuit and Microsoft Kinect. Two DC encoder motors are also connected to bottom plate.

Bottom Plate

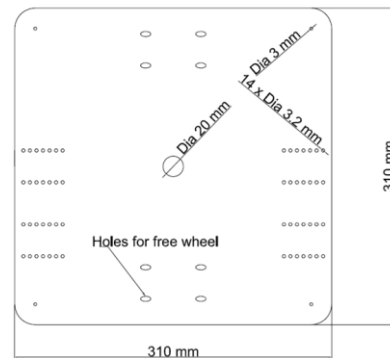


Fig 2: Bottom Plate

### TOP ACRYLIC PLATE:

Top acrylic plate is used to place laptop.

Top Plate

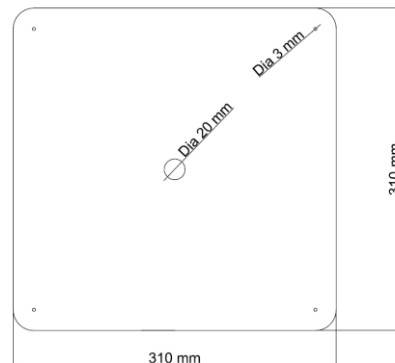


Fig 3: Top Plate

### Four Supporting Acrylic Bars:

Four supporting acrylic bars are used to support upper plate from lower plate.

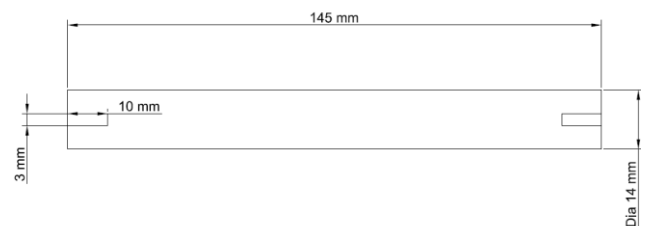


Fig 4: Vertical Supporting Acrylic Bars

#### 4. DESIGNING AND BUILDING OF MOBILE ROBOT

##### 4.1 Selection of DC Motor with encoder

The robot that we are going to design is a differential drive robot with two wheels, so we require two DC motors for its locomotion. Each motor consists of quadrature encoders to get the motor rotation feedback. A motor driver or motor controller is a circuit that can control the speed of the motor. Controlling motors means that we can control the voltage across the motor and can also control the direction and speed of the motor. Motors can rotate clockwise or counter clockwise, if we change the polarity of motor terminal. H-bridge circuits are commonly used in motor controllers. H-bridge is an electronic circuit that can apply voltage in either direction of load. It has high current handling properties and can change the direction of current flow

##### 4.1.1 Selection of speed of DC MOTOR with encoder

Due to their ease of use, high torque, speed, and continuous drive this type of motor is optimal for a drive system's motor. The most common of these motors is the geared DC motor, and it can come in many shapes and sizes. First you must be able to calculate your needed torque and speed to choose a DC motor.

Assume the required robot's speed as 0.25 m/s. Generally the speed of indoor robot is within 0.25 m/s to 1 m/s. Ground clearance should be greater than 2.5 cm for indoor robot. So take radius of wheel to be 4.5 cm. We can calculate the RPM of motors using following formula

$$RPM = \frac{60 \times \text{speed}}{2\pi \times \text{Radius of Wheel}}$$

$$RPM = \frac{60 \times 0.3}{2\pi \times 0.045}$$

RPM = 63.66 Revolutions per minute

For 0.3 m/s speed and 4.5 cm radius of differential drive robot we consider 80 rpm as standard value.

##### 4.1.2 Selection of Torque of DC Motor with encoder

Differential drive robot has three wheels. But DC Motor is attached to only two wheels and third wheel is free or caster wheel, so while doing calculations we take only two wheels. Total numbers of wheels are three and total numbers of drive motors are two.

Total weight of robot (approximate) = 5 kg (self weight) + 5 kg (payload) = 10 kg

Take coefficient of friction between wheel and ground surface as 0.6 and radius of wheel is 4.5 cm.

Total weight of robot is carried by three wheels of which only two drive wheels drive the robot. So for torque calculation only two wheels are required. Robot requires maximum torque when it starts moving to overcome friction. Equation of torque is

$$T = \frac{\mu m g r}{2}$$

$$T = \frac{0.6 \times 10 \times 9.81 \times 0.045}{2} = 1.3243 \text{ Nm} = 13.24 \text{ Kg cm}$$

So we selected 18 kg cm and 80 rpm motor for our robot.

##### 4.1.3 Two-channel Hall effect encoder

A Two-channel Hall Effect encoders is used to sense the rotation of a magnetic disk on a rear protrusion of the motor shaft. The quadrature encoder provides a resolution of 64 counts per revolution of the motor shaft when counting both edges of both channels. The motor/encoder has six color-coded leads. The following table describes the wire functions of DC motor with encoder.

#### IV SOFTWARE IMPLEMENTATION

1. Matlab
2. ROS( Robot operating system)

Robot Operating System (ROS) is a framework that is widely used in robotics. It provides a set of tools, libraries and drivers in order to help develop robot applications with hardware abstraction. ROS enables researchers to quickly and easily perform simulations and real world experiments. ROS provides standard operating system facilities such as hardware abstraction, low-level device control, implementation of commonly used functionalities, message passing between processes, and package management.

ROS are the libraries which gives a powerful set of tools to work with ROS easily. Of these, navigation library, gmapping library, rviz visualizer, simulators, and debugging tools are the most important ones.

#### V. RESULTS

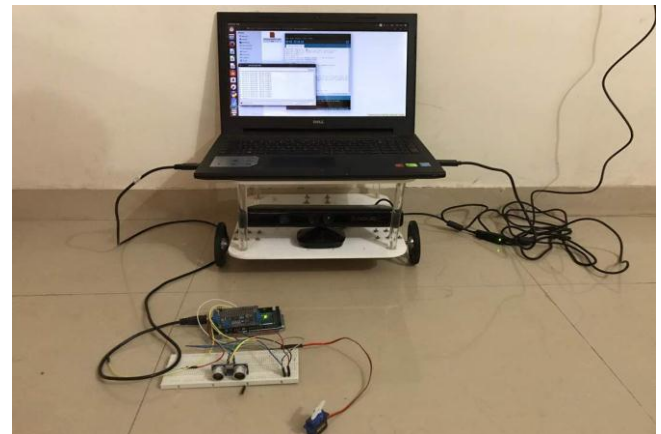


Fig 5: Actual setup of total proposed system

The actual setup of the proposed system is shown in the Figure 5. All Kinect sensor and Arduino microcontroller are connected to the laptop and we run the program in the laptop and we get the output which is displayed on the laptop.

#### CONCLUSION

Simultaneous Localization and Mapping of an unknown environment were successfully conducted resulting in the robot achieving its goal while identifying and mapping obstacles.

Since the field-of-view of the Microsoft Kinect is relatively narrow compared to a laser range scanner, the results obtained in this thesis research could be improved upon with the help of high cost laser scanner. Three-dimensional SLAM could be another interesting way ahead with this project platform.

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