

# An Exploration of Force Exerted on Moving Robot in Arcuated Path on Different Surface using Standard SLAM Algorithm



Rohit Mittal, Nidhi Mishra, Vibhakar Pathak, Geeta Chhabra Gandhi

**Abstract:** *The paper investigate the pressure applied during navigation of robot on arcuated prefab and smooth/marble path using non linear EKF (map based). The analysis part uses experiments on 6DoF robot using (vMicro) as meta software on .Net framework and XCTU multiplatform, which was not considered in Compressed EKF SLAM. In this paper, analysis on pressure exerted on smooth surface and prefab surfaces in Z direction which gives conclusive results for determination of surfaces.*

**Keywords:** SLAM, prefab surface, pressure

## I. INTRODUCTION

SLAM is one of the important algorithms for navigation of autonomous robot. SLAM is divided into two sub criteria's which has significant importance for a robotic application. Mapping criteria in SLAM declares region of geographic area in which robot can navigate. In this paper, author discusses about arcuated movement of robot which classified robotic path among two categories viz; marble flooring called as surface 1 and loose prefab which is known as surface 2. In this respect, some research had been done in which navigation of robot on stochastic path was observed but previously authors were not unwrap about arcuate movement of robot on both surfaces. Therefore, these robotic paths were analyzed using (Simultaneous Localization & Mapping) based techniques. SLAM algorithms are based on viz Gmapping based Extended Kalman Filter MonoSLAM algorithm and Full SLAM algorithm.

Experiments on SLAM algorithms (Gmapping based EKF) were conducted in way that when robot navigate on experimental arcuate path the data received from robot on different forces applied and observed by on board accelerometer, Gyroscope based on real time duplex communication. For simulation of results Vmicro Meta software (it has same libraries, the development code and tools [7].

Vmicro is an extension which allows making our results, compiled and building to any Arduino BSP package in lieu of taking advantages of features of Visual Studio 2015.

Authors in this paper compute arcuate Error Probability of robot during its movement on loose prefab and marble surface, it is localization probability in map when robot move on arcuate path with respect from actual position in different angles.

Section II describes about the literature review done on SLAM techniques, different types of sensors used by authors and features, landmarks detection techniques.

In section III authors discusses about arena used for navigation of robot like; marble flooring, loose prefab surface including the experimental setup includes hardware and software used to design robot with computation of SLAM algorithms with respect to AEP (Arcuate Error Probability). Last section discusses about the results achieved so far during movement of robot on arcuated path with non visual sensors linked along with Gmapping (EKF) based SLAM algorithm which is followed by conclusion.

## II. PREVIOUS WORK

Most of the previous work on implementation of SLAM algorithms are for dispensing maps to various number of robots in indoor environment only in which they maintain network connectivity and allow robots for communication, for that robots need UID, light sensors, camera, modem etc [1][3] which produces burden to network which results in slow down in response.

Most of previous work was based on Range Only-SLAM uses the approach of Rao-Blackwellized Particle Filter (RBPF) which consists of robotic path and the map. The path is estimated by various set of particles with conditional distributions on them. [2] [3].

Most of the researchers had reported work on CEKF (compressed Extended Kalman Filter) as it takes advantage of the systems structure giving an estimation that is identical to the standard EKF but dramatically reducing the computational complexity, but increase system dependency. Large sequences of predictions and observations steps are function of a reduced set of states (i.e. they are independent of most of the elements of the states vector. The CEKF can easily manage high frequency sequences of predictions and updates avoiding the expensive cost of the full EKF estimation approach [3].

Previously researchers had talked about Multilevel Relaxation algorithm which optimizes the map at multiple levels of resolution; frames formed in a sequence like robot's trajectory using sparse matrix [4].

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\* Correspondence Author

**Rohit Mittal\***, Research Scholar, Department of Computer Science & Engineering Poornima University Jaipur,

**Nidhi Mishra**, Associate Professor, Department of Computer Science & Engineering, Presidency University, Bangalore

**Vibhakar Pathak**, Professor, Department of Computer Science & Engineering, Arya college of Engineering & I.T., Jaipur,

Geeta Chhabra Gandhi, Associate Professor, Poornima University, Jaipur

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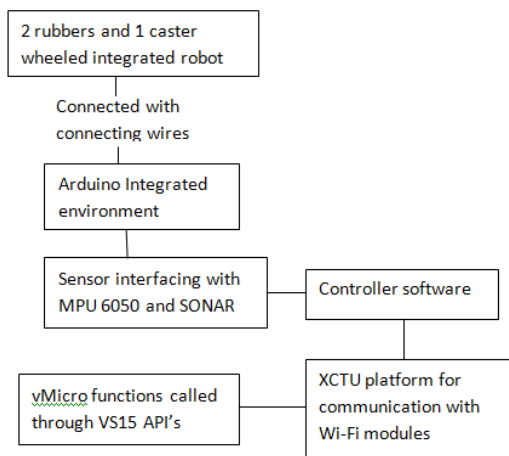
For Real Time Appearance based Mapping (RTAB-MAP) algorithm uses OpenCV to extract the features from image to obtain visual words; it generates 3D cloud map and 2D data from kinect, but the finding with the same is that objects shows ghosting in map [5].

It has been shown that in these researchers have talked about visual sensors as prime parameters But there is gap in use of other sensors; and navigation on varied surfaces.

### III. METHODOLOGY USED

In this paper, authors has integrate robot with some more functionality with the help of non visual sensors like SONAR sensor on top of Arduino UNO board, MPU 6050 (3 axis accelerometer and 3 axis gyroscope), Node MCU ESP8266, wires and com port cable [6] [7].

#### Experimental design of robot



**Fig.1 Flowchart for designing of robot**

The robot is navigated in such a way that it has localize and mapped itself in its experimental pathway. In this experiment, authors take observation on various forces

applied (accelerometer, gyro) on robot's motion on arcuate path which mentioned in introduction section. Our robot is equipped with MPU 6050 (3 axis accelerometer

and 3 axis gyroscope), Node MCU ESP8266 so we get the observed accelerometer and gyro values can be captured by navigating the robot in arena of marble flooring called as surface 1 and loose prefab which is called as surface 2 shown in figure 2.



**Fig 2 Movement of robot on smooth and prefab surface**

Experiments were carried out, at 12 successful runs by captured data using MPU 6050 (3 axis accelerometer and 3 axis gyroscope) sensor to their observed data on CPU at real time.

After interfacing VS2.0 with Vmicro, Node MCU ESP8266, SONAR sensor, capture API's (Application Program Interface) along with XCTU has interaction with wifi modules. These provide the functions to COM interfaces for call methods (vMicro) which let users to do programming on various Board Specific Package's (Arduino).

### IV. RESULTS

**Table 1 Movement of robot on Prefab surface**

Arcuated Angle (radian)	Map based EKF	A <sub>x</sub>	A <sub>y</sub>	A <sub>z</sub>	G <sub>x</sub>	G <sub>y</sub>	G <sub>z</sub>
		Accelerometer			Gyroscope		
0 <sup>0</sup> -15 <sup>0</sup>	3.03 to 5.06	-6181.2	-7097.1	12093.1	684.7	-193.8	652.0
15 <sup>0</sup> -30 <sup>0</sup>	2.71 to 4.57	-7896.6	-4824.0	15563.6	855.9	-1234.1	-522.2
30 <sup>0</sup> -45 <sup>0</sup>	2.6 to 4.3	-6940.0	-8200.0	12792.6	2421.5	-1712.9	-752.8
45 <sup>0</sup> -60 <sup>0</sup>	2.18 to 4.16	-6715.7	-5360.0	13015.2	2976.7	-3472.1	587.1
60 <sup>0</sup> -75 <sup>0</sup>	2 to 4.05	-6592.0	-7492.0	13743.2	1985.8	-519.7	-1027.0
75 <sup>0</sup> -90 <sup>0</sup>	1.72 to 3.88	-1211.3	-7001.3	11262.7	-3730.1	3379.4	-6670.8
90 <sup>0</sup> -105 <sup>0</sup>	1.6 to 3.64	-5283.6	-4775.1	14116.8	-2108.4	7849.9	255.4
105 <sup>0</sup> -120 <sup>0</sup>	1.55 to 3.43	-3858.1	-1701.6	15417.0	-9221.6	-4008.8	-133.9
120 <sup>0</sup> -135 <sup>0</sup>	1.31 to 3.27	1433.8	-1277.2	16018.6	13225.3	10504.0	-7951.9
135 <sup>0</sup> -150 <sup>0</sup>	1.1 to 3.13	6711.6	6987.5	-1305.6	-6750.7	-104.0	4103.1
150 <sup>0</sup> -165 <sup>0</sup>	1.01 to 2.86	1849.1	-6381.1	26866.5	-2989.6	-5175.8	-124.4
165 <sup>0</sup> -180 <sup>0</sup>	0.96 to 2.63	-6181.2	-7097.1	12093.1	688.0	-193.8	648.8

**Table 2 Movement of robot on smooth/marble surface**

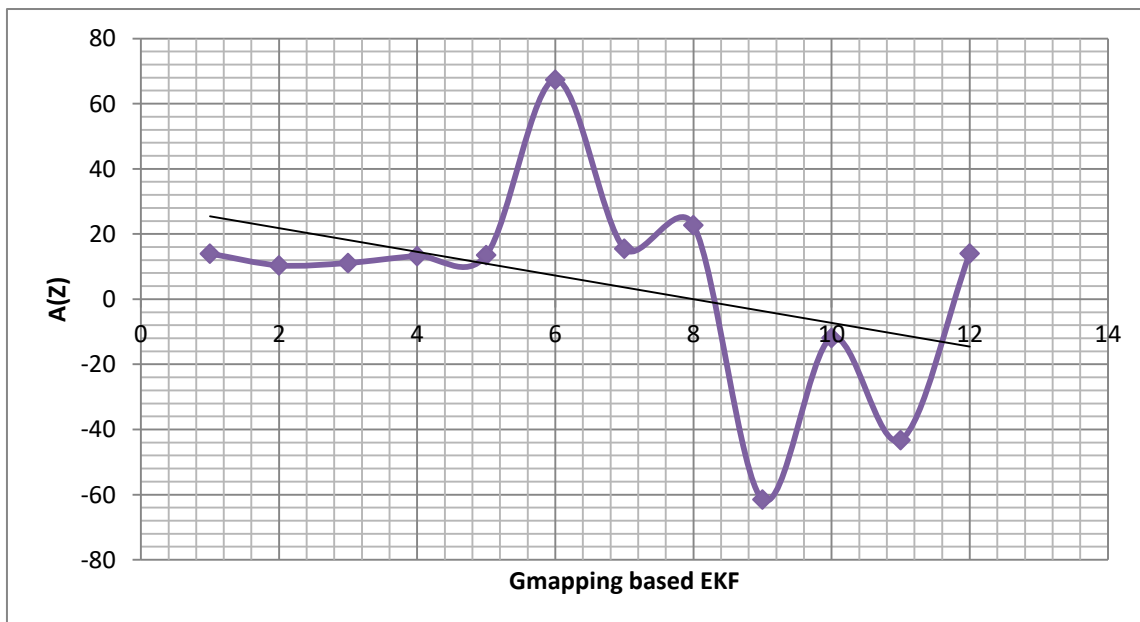
Arcuated Angle (radian)	Map based EKF	A <sub>x</sub>	A <sub>y</sub>	A <sub>z</sub>	G <sub>x</sub>	G <sub>y</sub>	G <sub>z</sub>
		Accelerometer			Gyroscope		
0 <sup>0</sup> -15 <sup>0</sup>	3.03 to 5.06	-865	-4738	-17081	509	432	-209
15 <sup>0</sup> -30 <sup>0</sup>	2.71 to 4.57	-820	-4761	-17064	511	458	-210
30 <sup>0</sup> -45 <sup>0</sup>	2.6 to 4.3	-772	-4892	-16952	519	456	-200
45 <sup>0</sup> -60 <sup>0</sup>	2.18 to 4.16	-889	-4916	-17141	521	414	-201
60 <sup>0</sup> -75 <sup>0</sup>	2 to 4.05	-894	-4681	-17226	527	416	-206
75 <sup>0</sup> -90 <sup>0</sup>	1.72 to 3.88	-816	-4704	-17154	529	436	-207
90 <sup>0</sup> -105 <sup>0</sup>	1.6 to 3.64	-820	-4746	-17238	540	439	-183
105 <sup>0</sup> -120 <sup>0</sup>	1.55 to 3.43	-877	-4770	-17145	543	461	-184
120 <sup>0</sup> -135 <sup>0</sup>	1.31 to 3.27	-881	-4681	-17230	531	463	-194
135 <sup>0</sup> -150 <sup>0</sup>	1.1 to 3.13	-796	-4704	-17113	533	402	-195
150 <sup>0</sup> -165 <sup>0</sup>	1.01 to 2.86	-800	-4827	-17197	533	404	-215
165 <sup>0</sup> -180 <sup>0</sup>	0.96 to 2.63	-869	-4851	-17166	536	434	-216

Table 1 and Table 2 shows pressure applied on robot with the help of non visual sensors is random which is in case of prefab surface, also there is presence of friction due to wheels in robot (rubber and caster) is in decreasing mode as shown in fig 4.

In other case, the pressure applied on robot with the help of non visual sensors is constant on smooth flooring till 75<sup>0</sup>, this is due to the force implied in Z direction only.

There is percentage change of +67 unit on smooth flooring, and then there is decrease of 16 unit, this can be due to existence of dust particles on surface.

Similarly it is shown from figures 3 and 4 that there is change in gyro, due to prefab surface, as the friction decreases the movement of robot gets distorted from 90-105 it is -72 unit and after that there is hike of 137 unit, after which at 120-135 there is decrease of 135 unit from the average.



**Fig 3 Robot’s movement on prefab surface**

There is not much percentage change on the pressure applied from 0 to 60<sup>0</sup> as surface textures remain same in starting.

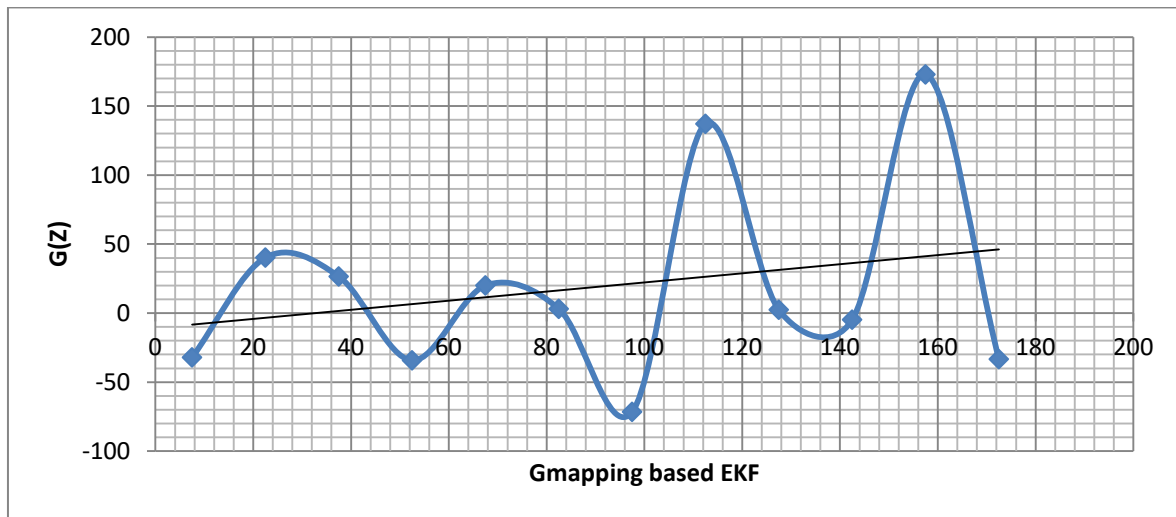


Fig 4 Robot’s movement on smooth/marble surface

## V. CONCLUSION

It has been conclude from above results that robot’s navigation observed random pressure is random if the chosen surface is prefab using map based algorithm.

In future, the accelerometer and gyroscopic data can be improvised in X and Y direction if caterpillar chains are used in designed robot instead of rubber tires.

This is because, these chains have capability to distribute the pressure that robot exerts over whole prefab surface and robot navigates in smoother manner.

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## AUTHORS PROFILE



**Rohit Mittal**, is research scholar in department of Computer Science & Engineering at Poornima University, Jaipur. He has published research papers in various international journals. His research interest are Cloud computing, Robotics.



**Dr. Nidhi Mishra**, is an Associate Professor in department of Computer Science & Engineering at Presidency University, Bangalore. She did her PhD in Computer Science & Engineering from Banasthali University Jaipur in 2016. She has published 33 research papers in various international journals and conferences.

Her current research interests are Natural language Processing, data mining, machine learning & data science.



**Dr. Vibhakar Pathak**, is Professor department of Computer Science & Engineering at Arya College of Engineering & I.T., Jaipur. He has published research papers in field of Data Center Network, cloud computing, Robotics. His keen interest in cloud and hybrid robotic applications using IoT and Collaborative computing.



**Dr. Geeta Chhabra Gandhi**, is Associate Professor in Poornima University and having more than 15 years of experience of teaching in different colleges and universities. She had done PhD in 2017 in Computer Science in which she has worked onto the prediction of cognitive ability of a human being and utilized this feature to differentiate between a human and robot, which has given an optimum solution to network security. She has also published more than seven research papers in different recognized Journals and Conferences. Her interest areas are network and information security, ANN, Data mining etc. She has lot of interest in domain of programming also.