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

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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.

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].

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 kinebt, 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 have integrated 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

| Arcuclned Angle (radian) | Map based EKF   | $A_x$ | $A_y$ | $A_z$ | $G_x$ | $G_y$ | $G_z$ |
|-------------------------|-----------------|-------|-------|-------|-------|-------|-------|
| 0°-15°                  | 3.03 to 5.06    | -6181.2 | -7097.1 | 12093.1 | 684.7 | -193.8 | 652.0 |
| 15°-30°                 | 2.71 to 4.57    | -6789.6 | -4824.0 | 15563.6 | 855.9 | -1234.1 | -522.2 |
| 30°-45°                 | 2.6 to 4.3      | -6940.0 | -8200.0 | 12792.6 | 2421.5 | -1712.9 | -752.8 |
| 45°-60°                 | 2.18 to 4.16    | -6715.7 | -5360.0 | 13015.2 | 2976.7 | -3472.1 | 587.1 |
| 60°-75°                 | 2.4 to 4.05     | -6592.0 | -7492.0 | 13743.2 | 1985.8 | -519.7 | -1027.0 |
| 75°-90°                 | 1.72 to 3.88    | -1211.3 | -7001.3 | 11262.7 | -3730.1 | 3379.4 | -6670.8 |
| 90°-105°                | 1.6 to 3.64     | -5283.6 | -4775.1 | 14116.8 | -2108.4 | 7849.9 | 255.4 |
| 105°-120°               | 1.55 to 3.43    | -3858.1 | -1701.6 | 15417.0 | -9221.6 | -4008.8 | -133.9 |
| 120°-135°               | 1.31 to 3.27    | 1433.8 | -1277.2 | 16018.6 | 13225.3 | 10504.0 | -7951.9 |
| 135°-150°               | 1.1 to 3.13     | 6711.6 | 6987.5 | -1305.6 | -6750.7 | -104.0 | 4013.1 |
| 150°-165°               | 1.01 to 2.86    | 1849.1 | -6381.1 | 26866.5 | -2989.6 | -5175.8 | -124.4 |
| 165°-180°               | 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 |  |  |  |  |
|-------------------------|---------------|------------------|------------------|------------------|------------------|------------------|
|                         | Accelerometer | Gyroscope        |                   |                   |                   |                   |
|                         | A_x           | A_y             | A_z             | G_x             | G_y             | G_z             |
| 0°-15°                  | 3.03 to 5.06  | -865            | -4738           | -17081          | 509             | 432             | -209            |
| 15°-30°                 | 2.71 to 4.57  | -820            | -4761           | -17064          | 511             | 458             | -210            |
| 30°-45°                 | 2.6 to 4.3    | -772            | -4892           | -16952          | 519             | 456             | -200            |
| 45°-60°                 | 2.18 to 4.16  | -889            | -4916           | -17141          | 521             | 414             | -201            |
| 60°-75°                 | 2 to 4.05     | -894            | -4681           | -17226          | 527             | 416             | -206            |
| 75°-90°                 | 1.72 to 3.88  | -816            | -4704           | -17154          | 529             | 436             | -207            |
| 90°-105°                | 1.6 to 3.64   | -820            | -4746           | -17238          | 540             | 439             | -183            |
| 105°-120°               | 1.55 to 3.43  | -877            | -4770           | -17145          | 543             | 461             | -184            |
| 120°-135°               | 1.31 to 3.27  | -881            | -4681           | -17230          | 531             | 463             | -194            |
| 135°-150°               | 1.1 to 3.13   | -796            | -4704           | -17113          | 533             | 402             | -195            |
| 150°-165°               | 1.01 to 2.86  | -800            | -4827           | -17197          | 533             | 404             | -215            |
| 165°-180°               | 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°, 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](image)

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

REFERENCES

1. James McLurkin, Jennifer Smith Distributed Algorithms for Dispersion in Indoor Environments Using a Swarm of Autonomous Mobile Robots. In Distributed Autonomous Robotic Systems pp 399-408, 2007
2. www.csc.kth.se/~aydemir/thesis_virgile_hog_man.pdf
3. https://www.mrpt.org/List_of_SLAM_algorithms
4. Udo Frese, Per Larsson “A Multilevel Relaxation Algorithm for Simultaneous Localization and Mapping”, IEEE Transactions On Robotics, Vol. 21, No. 2, April 2005
5. Nitin Kumar Dhiman, Dipi Doedhare et.al “Where am I? Creating spatial awareness in unmanned ground robots using SLAM: A survey”
6. Rohit, Nidhi et.al “Localization and Impulse Analysis of Experimental Bot using chronos cs430” in Applications of Computing, Automation and Wireless Systems in Electrical Engineering, Lecture Notes in Electrical Engineering, vol 553. Springer, Singapore, June 2019
7. Rohit,Nidhi et.al “Exploration of designed Robot in Non Linear Movement using EKF SLAM and its stability on Loose Concrete Surface”, in International journal of Engineering Advanced Technology, pp 875-878 Volume 9 Issue 1,October 2019.

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