IMU and Encoders

Team project

Robocon 2016

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<u>IMU and Encoders</u>

Module Report

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1. Project Management Plan

Automated movement of robots requires some sort of localisation, using which the robot is able to identify the path. There are various methods of localisation for example GPS(Global Positioning System), Point-cloud localisation, Line following, Wall following etc. Inertial Measurement Unit (IMU) is very widely used sensor for localisation of robots and vehicles (e.g. auto navigation robot).

For Robocon ‘16 we were planning to localise our hybrid robot with IMU and encoders such that robot would know its orientation and coordinates in the game arena with a precision of 50 cm. By knowing its coordinates and orientation it is very feasible to automate the robot without hardcoding.

This whole project took almost 15 days to be completed.

2. Requirement Specification

Will be provided by the instructor.

3. Analysis

IMU (Inertial Measurement Unit) is a sensor that uses an inbuilt accelerometer, gyro and magnetometer to produce acceleration and orientation readings in real time.
Rotary Encoders are used to measure the angle turned and hence one can attach its axis to a wheel and calculate the distance traversed in the direction.
We used GY-87 10DOF IMU (3-axis Gyroscope + 3-axis Acceleration + 3-axis Magnetic Field + Air Pressure Module) and Rotary encoder autonics e40s.

4. Design

After calibrating the IMU we implemented Kalman filter to get less noisy acceleration values. Then travelled distance can be calculated by integrating acceleration twice.

Kalman Filter

Kalman filtering is an algorithm that uses a series of measurements observed over realtime(containing statistical noise and other inaccuracies) and produces estimates of unknown variables that tend to be more precise than those based on a single measurement alone.

The algorithm works in a two-step process. In the prediction step, the Kalman filter produces estimates of the current state variables, along with their uncertainties. Once the outcome of the next measurement (necessarily corrupted with some amount of error, including random noise) is observed, these estimates are updated using a weighted average, with more weight being given to estimates with higher certainty. The algorithm is recursive. It can run in real time, using only the present input measurements and the previously calculated state and its uncertainty matrix; no additional past information is required.

5. Implementation

For implementation of Kalman filter we used following C code respectively for prediction and updation part:

```
void predict(double *est_x, double *pk, double a)
{       (*est_x) = a * (*est_x);
          (*pk) = a * (*pk) * a + 10;
}

void update(double *pk, double * gk, double r, double *est_x, double *zk, double c)
{       (*gk) = (*pk) * c / (c * c * (*pk) + r);
        (*est_x) = (*est_x) + (*gk) * (*zk - (*est_x) * c);
        (*pk)=(1-(*gk)*c)*(*pk);
}
```

Where ,
est_x = estimated x
gk = gain
pk = prediction factor
zk = reading

For calculating distances from rotary encoder following C code is used :

```
angvelo = (encAngle[1] - encAngle[0])
encDist += angvelo * 0.01 * 0.3372;   //time 0.01 , radius of wheel = 0.3372
```

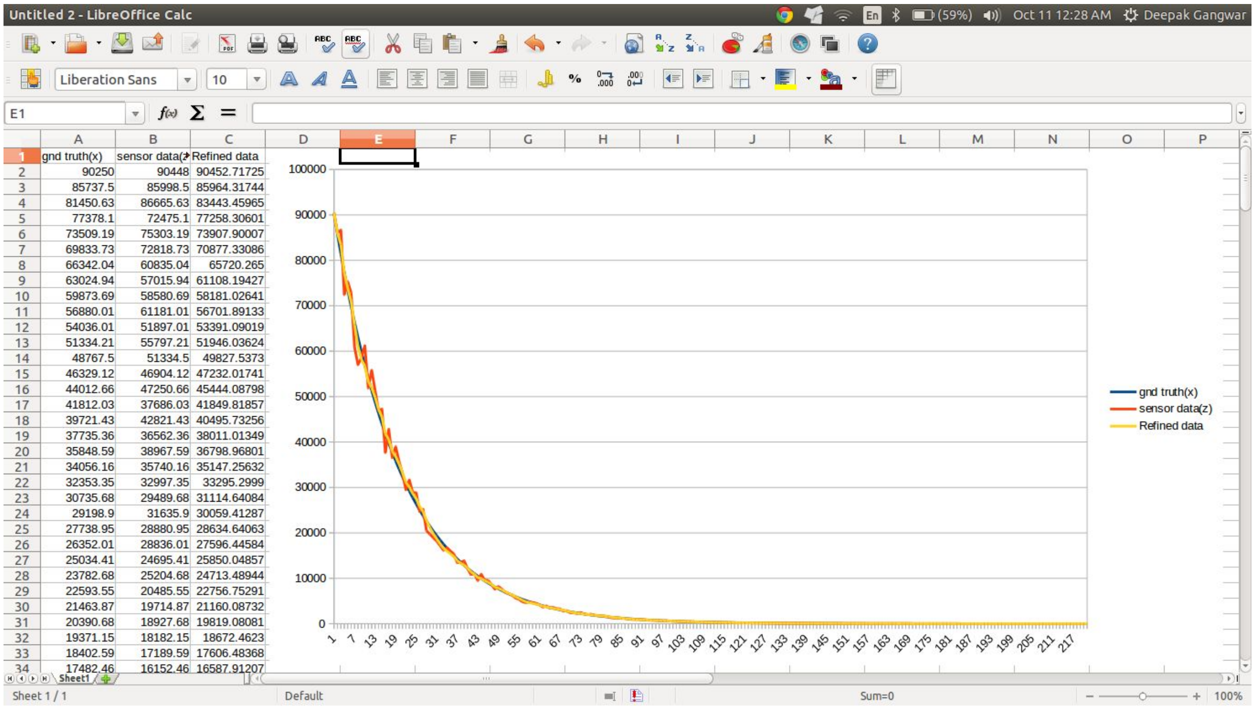
Where encAngle are the readings of angles obtained from encoders

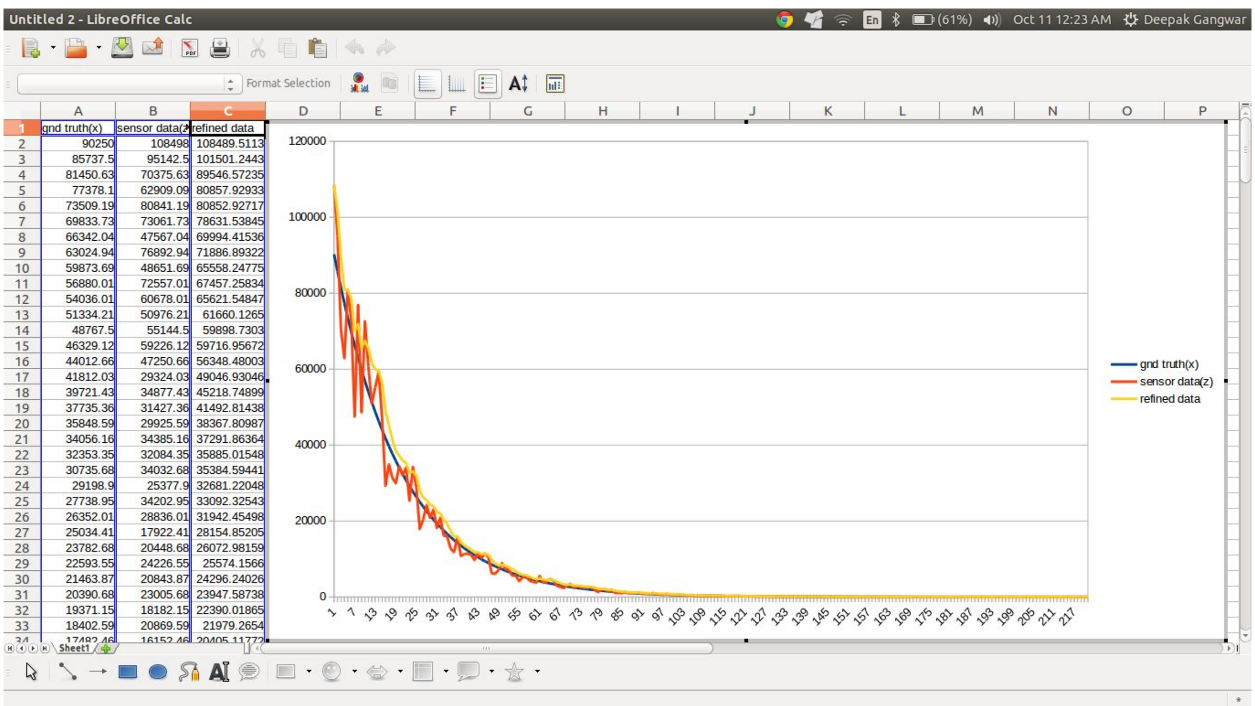
6. Test Documentation

Following are some results obtained from our testing

Synthesized data

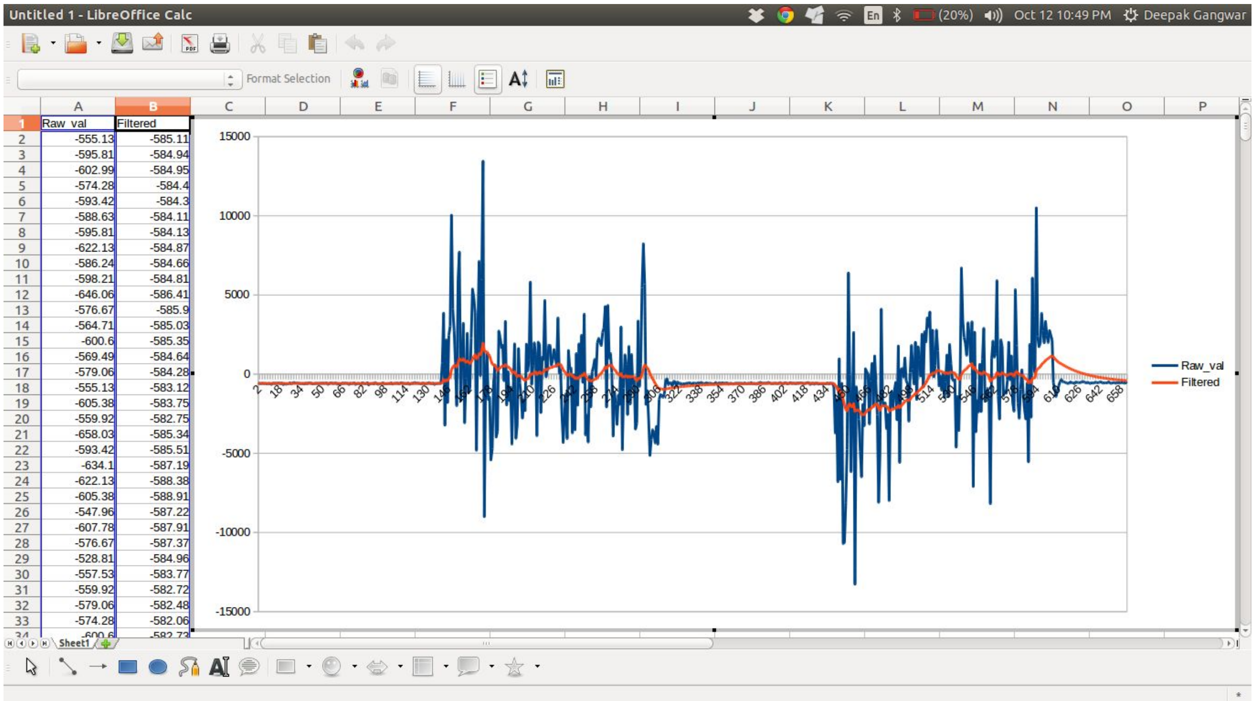
For 10% and 30% synthesize noise respectively





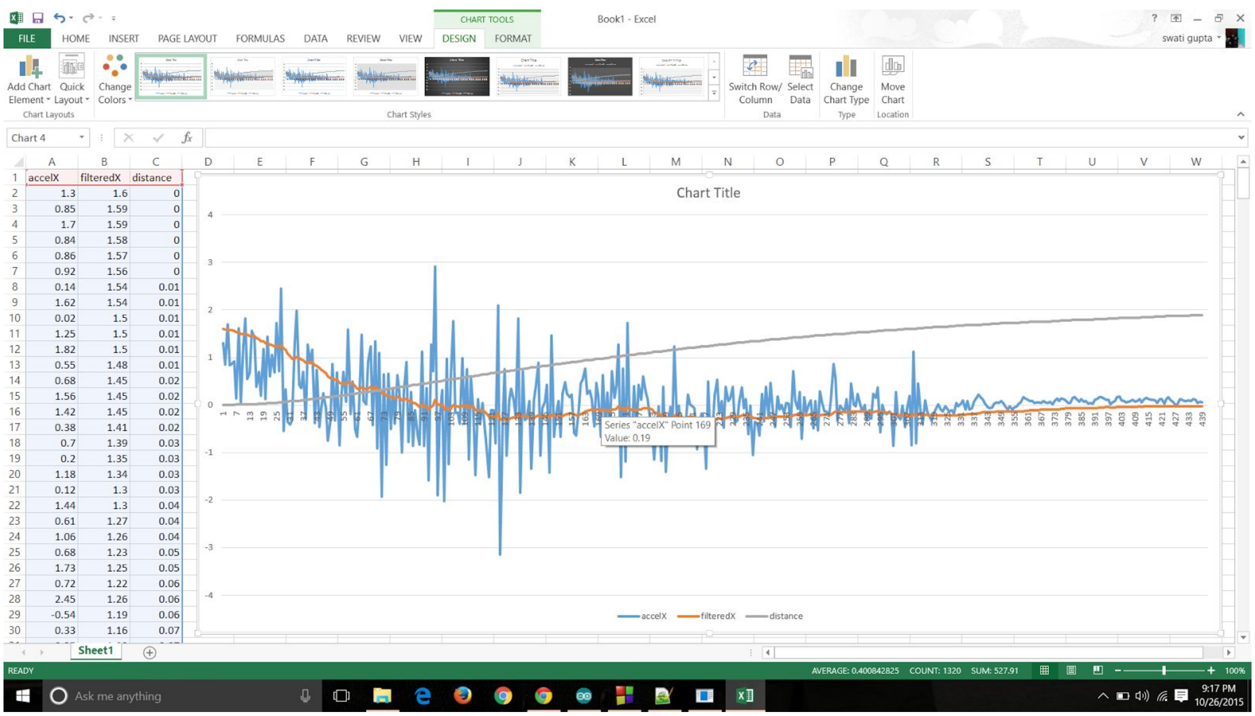
Real Time data

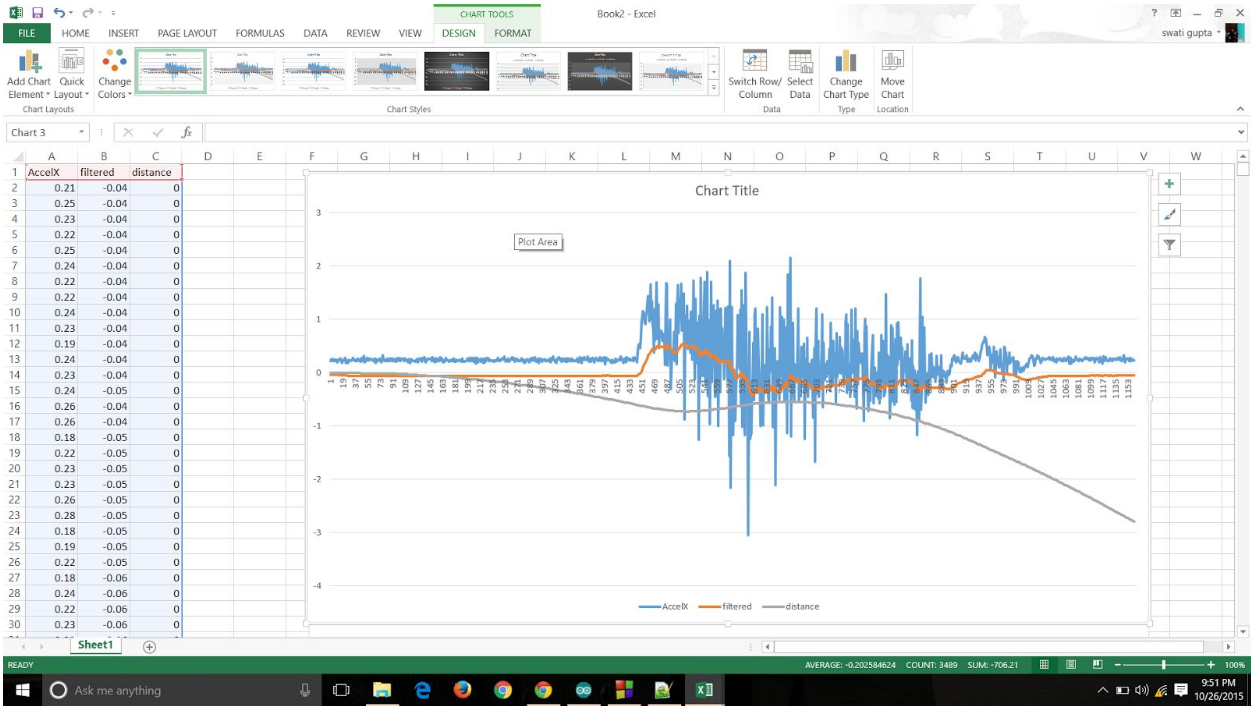
IMU was kept on a robot that stays put for 10s, then moves forward for 10s, stays put again for 10s and in the end goes back for 10s.



Real time distance calculation using IMU

These are the results of calculated distance from IMU in both forward and reverse directions respectively. We moved the robot 3 m and got 2.9 m calculated which is very good.




Book2 - Excel
CHART TOOLS
FILE HOME INSERT PAGE LAYOUT FORMULAS DATA REVIEW VIEW DESIGN FORMAT
swati gupta
Add Chart Element
Quick Layout
Change Colors
Chart Layouts
Chart Styles
Switch Row/ Column
Select Data
Data
Change Chart Type
Type
Move Chart
Location
Chart 3
AccelX filtered distance
0.21 -0.04 0
0.25 -0.04 0
0.23 -0.04 0
0.22 -0.04 0
0.25 -0.04 0
0.24 -0.04 0
0.22 -0.04 0
0.22 -0.04 0
0.24 -0.04 0
0.23 -0.04 0
0.19 -0.04 0
0.24 -0.04 0
0.23 -0.04 0
0.24 -0.05 0
0.26 -0.04 0
0.26 -0.04 0
0.18 -0.05 0
0.22 -0.05 0
0.23 -0.05 0
0.23 -0.05 0
0.26 -0.05 0
0.28 -0.05 0
0.18 -0.05 0
0.19 -0.05 0
0.22 -0.05 0
0.18 -0.06 0
0.24 -0.06 0
0.22 -0.06 0
0.23 -0.06 0
Chart Title
Plot Area
AccelX
filtered
distance
Sheet1
READY
AVERAGE: -0.202584624 COUNT: 3489 SUM: -706.21
100%
Ask me anything
9:51 PM
10/26/2015

Appendices

For basic tutorial on IMU you can go through my lecture presentation
https://docs.google.com/presentation/d/1sKFActMGCSR1DL5n2hOCsF_MsTidwE68sNDpWhtaUUk/edit?usp=sharing