



深蓝学院  
shenlanxueyuon.com

## 多传感器融合第六章作业思路分享



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第一部分：代码实现

第二部分：IMU仿真与结果分析

首先是UpdatePose函数:

```
---// move forward ---
---// NOTE: this is NOT fixed. you should update your buffer accordingly

--- double delta_t;
--- Eigen::Vector3d delta;
--- Eigen::Matrix3d R_curr;
--- Eigen::Matrix3d R_prev;

--- if(GetAngularDelta(1, 0, delta, false))
--- {
---     UpdateOrientation(delta, R_curr, R_prev);
--- }
--- else
--- {
---     return false;
--- }

--- if(GetVelocityDelta(1, 0, R_curr, R_prev, delta_t, delta, false))
--- {
---     UpdatePosition(delta_t, delta);
--- }
--- else
--- {
---     return false;
--- }

--- imu_data_buff_.pop_front();
}
```

GetAngularDelta和GetVelocityDelta函数（欧拉法和中值法实现）：

```
if(Is_Euler)
{
    angular_delta = delta_t*angular_vel_prev;
}
else
{
    angular_delta = 0.5*delta_t*(angular_vel_curr + angular_vel_prev);
}
```

```
if(Is_Euler)
{
    velocity_delta = delta_t*linear_acc_prev;
}
else
{
    velocity_delta = 0.5*delta_t*(linear_acc_curr + linear_acc_prev);
}
```

IMU仿真程序修改参考雍川老师分享的manual\_trajectory.py.py文件

# 纲要

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第一部分：代码实现

第二部分：IMU仿真与结果分析

# IMU仿真与结果分析

IMU仿真设置参数如下（默认参数对应静止状态）：

匀速运动：

```
ini lat (deg),ini lon (deg),ini alt (m),ini vx_body (m/s),ini vy_body (m/s),ini vz_body (m/s),ini yaw (deg),ini pitch (deg),ini roll (deg)
32,120,0,1.0,0,0,0,0,0
command type,yaw (deg),pitch (deg),roll (deg),vx_body (m/s),vy_body (m/s),vz_body (m/s),command duration (s),GPS visibility
1,0,0,0,0,0,0,360,1|
```

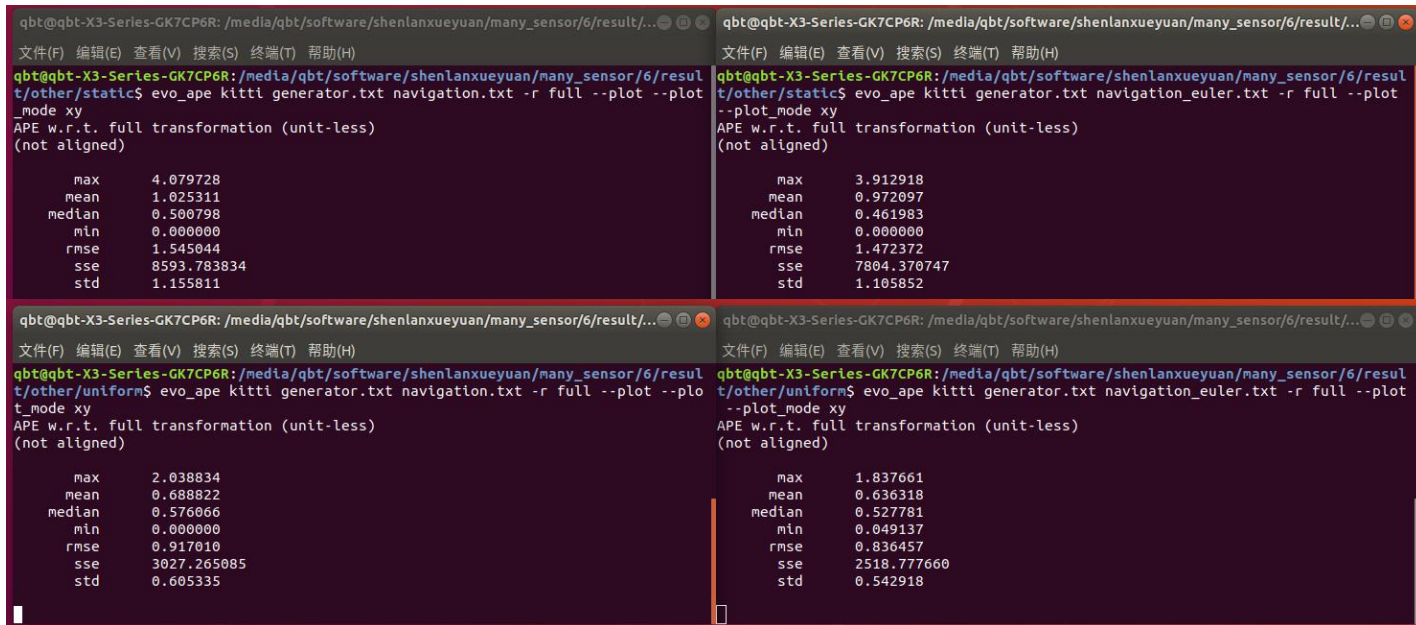
加减速运动：

```
ini lat (deg),ini lon (deg),ini alt (m),ini vx_body (m/s),ini vy_body (m/s),ini vz_body (m/s),ini yaw (deg),ini pitch (deg),ini roll (deg)
32,120,0,-18.0,0,0,0,0,0
command type,yaw (deg),pitch (deg),roll (deg),vx_body (m/s),vy_body (m/s),vz_body (m/s),command duration (s),GPS visibility
1,0,0,0,1.0,0,0,360,1
```

# IMU仿真与结果分析

精度对比如下（取10s的数据）：

## 1. 静止和匀速运动：



The image displays four terminal windows arranged in a 2x2 grid, showing the output of the APE (Average Position Error) calculation for static and uniform motion. Each window is titled 'qbt@qbt-X3-Series-GK7CP6R: /media/qbt/software/shenlanxueyuan/many\_sensor/6/result/...' and contains the following text:

```
文件(F) 编辑(E) 查看(V) 搜索(S) 终端(T) 帮助(H)
qbt@qbt-X3-Series-GK7CP6R: /media/qbt/software/shenlanxueyuan/many_sensor/6/result/...
t/other/static$ evo_ape kitti generator.txt navigation.txt -r full --plot --plot_mode xy
APE w.r.t. full transformation (unit-less)
(not aligned)

    max    4.079728
    mean    1.025311
    median    0.500798
    min    0.000000
    rmse    1.545044
    sse    8593.783834
    std    1.155811
```

The top-left window shows results for static motion. The top-right window shows results for uniform motion (navigation\_euler.txt):

```
qbt@qbt-X3-Series-GK7CP6R: /media/qbt/software/shenlanxueyuan/many_sensor/6/result/...
t/other/static$ evo_ape kitti generator.txt navigation_euler.txt -r full --plot --plot_mode xy
APE w.r.t. full transformation (unit-less)
(not aligned)

    max    3.912918
    mean    0.972097
    median    0.461983
    min    0.000000
    rmse    1.472372
    sse    7804.370747
    std    1.105852
```

The bottom-left window shows results for static motion (navigation.txt):

```
qbt@qbt-X3-Series-GK7CP6R: /media/qbt/software/shenlanxueyuan/many_sensor/6/result/...
t/other/uniform$ evo_ape kitti generator.txt navigation.txt -r full --plot --plot_mode xy
APE w.r.t. full transformation (unit-less)
(not aligned)

    max    2.038834
    mean    0.688822
    median    0.576066
    min    0.000000
    rmse    0.917010
    sse    3027.265085
    std    0.605335
```

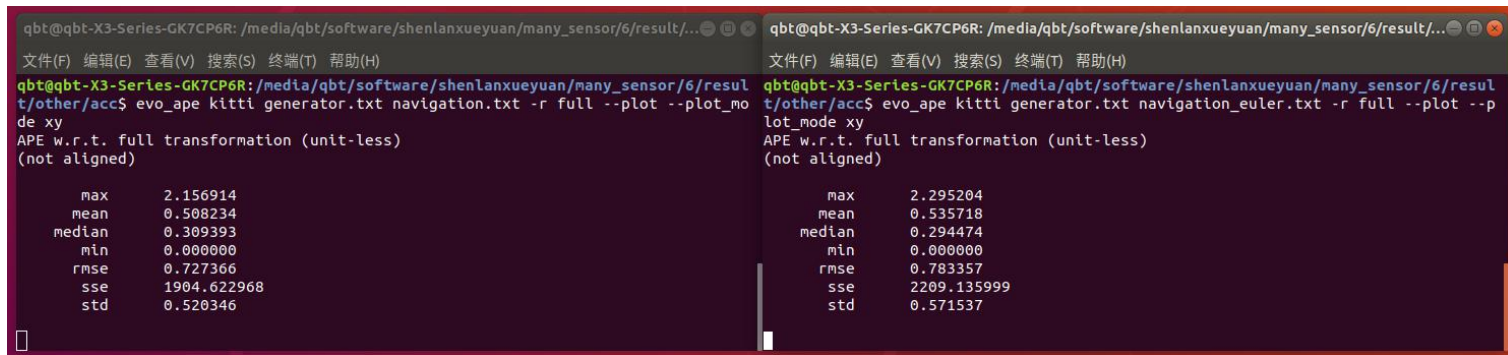
The bottom-right window shows results for uniform motion (navigation\_euler.txt):

```
qbt@qbt-X3-Series-GK7CP6R: /media/qbt/software/shenlanxueyuan/many_sensor/6/result/...
t/other/uniform$ evo_ape kitti generator.txt navigation_euler.txt -r full --plot --plot_mode xy
APE w.r.t. full transformation (unit-less)
(not aligned)

    max    1.837661
    mean    0.636318
    median    0.527781
    min    0.049137
    rmse    0.836457
    sse    2518.777660
    std    0.542918
```

# IMU仿真与结果分析

## 2. 加减速运动:



```
qbt@qbt-X3-Series-GK7CP6R: /media/qbt/software/shenlanxueyuan/many_sensor/6/result/...
文件(F) 编辑(E) 查看(V) 搜索(S) 终端(T) 帮助(H)
qbt@qbt-X3-Series-GK7CP6R: /media/qbt/software/shenlanxueyuan/many_sensor/6/result/...
t/other/acc$ evo_ape kitti generator.txt navigation.txt -r full --plot --plot_mode xy
APE w.r.t. full transformation (unit-less)
(not aligned)

    max    2.156914
    mean    0.508234
    median   0.309393
    min     0.000000
    rmse     0.727366
    sse     1904.622968
    std      0.520346

qbt@qbt-X3-Series-GK7CP6R: /media/qbt/software/shenlanxueyuan/many_sensor/6/result/...
文件(F) 编辑(E) 查看(V) 搜索(S) 终端(T) 帮助(H)
qbt@qbt-X3-Series-GK7CP6R: /media/qbt/software/shenlanxueyuan/many_sensor/6/result/...
t/other/acc$ evo_ape kitti generator.txt navigation_euler.txt -r full --plot --plot_mode xy
APE w.r.t. full transformation (unit-less)
(not aligned)

    max    2.295204
    mean    0.535718
    median   0.294474
    min     0.000000
    rmse     0.783357
    sse     2209.135999
    std      0.571537
```

旋转误差（单位为度）和平移误差（单位为m）进行对比（RMSE值）：

	中值法旋转误差	欧拉法旋转误差	中值法平移误差	欧拉法平移误差
静止	0.086195	0.084752	1.545043	1.472371
匀速	0.052085	0.050980	0.917009	0.836456
加减速	0.057043	0.057194	0.727365	0.783356



一般说来，imu的角速度精度高，线性加速度精度低

1. 对于静止和匀速运动（加速度为0），中值法精度比欧拉法低

原因：imu测得的线性加速度和角速度并不为0，由于imu的角速度变化量小，所以误差较小，欧拉法和中值法效果差不多。而通过线性加速度计算得到的速度会累积误差，中值法取平均值会加大位置的误差（相对欧拉法）。

2. 对于加减速运动，中值法精度比欧拉法高

原因：在变速运动下中值法取平均值就比较合理，而且角加速度和线性加速度绝对值越大，欧拉法误差会越大。

感谢各位聆听 !  
Thanks for Listening

