Institut für Erdmessung
- Positionierung und Navigation –
Prof. Dr.-Ing. Steffen Schön

Leibniz Universität Hannover

Inertial Navigation

-Exercise 3-

Strapdown Algorithm

Deadline: 17.01.2024

To navigate from a start to a target location with only an IMU, the motion differential equations of the platform have to be solved. There are several solutions possible, based on the integration method, the integration rate of the different parameters, as well as the target navigation system.
In order to solve the motion equations, the start conditions, i.e. integration constants, need to be defined, which is normally done by the Initial Alignment and the Initialisation. Both steps were already implemented in exercise 01. In this final exercise, the n-frame (NED) is used as target system, in order to implement and analyse a basic, yet complete variation of the strapdown algorithm.

<u>Tasks:</u>

Use the „ex03_matr#.mat“ dataset

Initial Alignment & Initialisation

1. a) Define the initial integration constants for velocity and position. Further use your static IMU measurement to estimate the Earth rotation rate, g-vector and latitude.
   b) Proceed with an Initial Alignment (direct DCM calculation) to estimate the initial integration constant for the orientation.

Strapdown Algorithm

2. a) Update the attitude, velocity and position of your vehicle frame in the target coordinate system for each IMU epoch from the kinematic dataset. Estimate the final position, velocity and orientation (Euler-angles).
   b) Plot the evolution of the orientation (Euler angles) and magnitude of the velocity over time. In a third diagram, show the trajectory of the vehicle on the tangential plane (n-frame). Based on the data, try to estimate the slope of the rooftop.

Performance Analysis

3. a) To estimate the performance of the algorithm in task 2, derive the **theoretical** velocity- and position error based on an acceleration bias and a turn-rate bias respectively (c.f. iMAR FSAS datasheet). We assume a horizontally levelled vehicle and a straight, non-accelerated trajectory in an **inertial** frame (with constant gravity field and neglected Coriolis term). Plot the position and velocity errors caused by each bias over time (2x2 graphs). Evaluate the results. Compare the final total **theoretical** error in position and velocity with the results of task 2. Are you happy with the performance of your strapdown algorithm?
   b) What errors would occur in short- and long term if instead of the i-frame, the tangential, Earth-centered n-frame from task 2 is chosen as target system? Do the position errors in the horizontal and vertical channel grow unbounded? Give a short statement!

c) Name and shortly explain an IMU-only technique that can be used to reduce (*re-set*) the velocity drift (other than calibration)?

4. Reduce your IMU datarate to 20Hz and solve the strapdown algorithm again. Plot the new trajectory and compare it with the one from task 2. How would you explain the difference?

5. Plot the transportation rate of the {x,y,z} channels in a common diagram. Evaluate, if it is really necessary to consider the transportation rate in this experiment. Explain what parameters have the biggest impact and state a realistic example in which the transportation rate is expected to be larger than the other systematics (e.g. Earth turn rate).

Please send your results (report, .csv and code) to:

weddig@ife.uni-hannover.de

Email subject:	Report_inav_ex03
Report name:	ex03_surname_name_matrikel.pdf
Results file:	ex03_matrikel.csv
Code:	ex03_matrikel.zip