Main steps to create and run algorithms for the paper: Orientation Estimation Using a Quaternion-Based Indirect Kalman Filter With Adaptive Estimation of External Acceleration

Instructions:

- Use the **Matlab help** at each time you need to verify the syntax of a specific function.
- Comment your Matlab files (use % to write a text in Matlab)
- When you finish, zip your folder and send to hassen.fourati@gipsa-lab.fr
- **Final goal after Question 28:** Obtain same results as in Fig. 9 in the proposed paper, for the attitude estimation with the IKF.

Question 1. Create a folder with the following name “your first name_your last name_IKF”. Add to this folder the Matlab files (.m): “dcm2quaternion”, “quaternion2euler”, “quaternionmul”, “vec2product” and “quaternion2dcm”.
Complete the two files “vec2product” and “quaternion2dcm” based on the skew symmetric matrix and eq. (1) in the paper.

Question 2. Add to this folder the Matlab file (.m): “Main_Program” and the IMU data file (.mat): “IMU_Data.mat”.

Question 3. In this file “Main_Program”, write a code to read the IMU data from “IMU_Data.mat” using the “load” Matlab function. Define and explain the variables that are in this file (.mat) and give the size and unit of each variable.

Question 4. In this file “Main_Program”, plot these variables (when it is possible) using “subplot” Matlab function. Don’t forgot to add titles, legends, titles of axes, etc. for each figure.

Question 5. In this file “Main_Program”, create the three noise error covariance matrices for gyroscope data “Rg”, accelerometer data “Ra” and magnetometer data “Rm”, as given in Section V of the paper.

Question 6. In this file “Main_Program”, write the following line:
[q4, eulercom4, bahat, bghat] = Compute_Attitude(yg,ya,ym,tt,Rg,Ra,Rm);
Comment this function and its outputs.

Question 7. Add to the folder the Matlab file (.m): “Compute_Attitude”.

Question 8. In the file “Compute_Attitude”, create $\tilde{g}$ and $\tilde{m}$.

Question 9. In the file “Compute_Attitude”, create the bias covariance matrices Q_{b_g} , Q_{b_a} and Q

Question 10. In the file “Compute_Attitude”, create an initial state error covariance matrix $\mathrm{P} = \mathrm{Diag}\left\{0.01*\mathrm{I}, 0.000001*\mathrm{I}, 0.000001*\mathrm{I}\right\}$.

Question 11. In the file "Compute_Attitude", create an intial $\Omega = \begin{bmatrix} 0 & -\omega_x & -\omega_y & -\omega_z \\ \omega_x & 0 & \omega_z & -\omega_y \\ \omega_y & -\omega_z & 0 & \omega_x \\ \omega_z & \omega_y & -\omega_x & 0 \end{bmatrix}$ (from eq. (18) in the paper) with first angular velocity measurements in the file "IMU_Data.mat".

Question 12. In the file "Compute_Attitude", create the sampling period T.

Question 13. In the file "Compute_Attitude", create matrix A (eq. (9) in the paper and don't forgot to subtract estimated gyro bias from angular velocity measurements in A).

Question 14. In the file "Compute_Attitude", create Φ_k , obtained in eq. (15) in the paper after discretization.

Question 15. In the file "Compute_Attitude", create Q_d (from eq. (16) in the paper).

Question 16. In the file "Compute_Attitude", create P^- (from eq. (17) in the paper).

Question 17. In this file "Compute_Attitude", create $\Omega = \begin{bmatrix} 0 & -\omega_x & -\omega_y & -\omega_z \\ \omega_x & 0 & \omega_z & -\omega_y \\ \omega_y & -\omega_z & 0 & \omega_x \\ \omega_z & \omega_y & -\omega_x & 0 \end{bmatrix}$ with next angular velocity measurements.

Question 18. In the file "Compute_Attitude", create a quaternion from eq. (18) in the paper.

Question 19. In the file "Compute_Attitude", create H_a and z_a in eq. (19) in the paper.

Question 20. In the file "Compute_Attitude", create K_a in eq. (19) in the paper.

Question 21. In the file "Compute_Attitude", create $\hat{x}_a$ in eq. (19) in the paper.

Question 22. In the file "Compute_Attitude", create P_a in eq. (19) in the paper.

Question 23. In the file "Compute_Attitude", write eqs. (20) in the paper.

Question 24. In the file "Compute_Attitude", create H_m and z_m in eq. (22) in the paper.

Question 25. In the file "Compute_Attitude", write eqs. (21) in the paper.

Question 26. In the file "Compute_Attitude", write eqs. (20) in the paper, a second time.

Question 27. In the file "Compute_Attitude", convert the estimated quaternion to Euler angles.

Question 28. In the file “Main_Program”, plot the true and estimated Euler angles using “subplot” Matlab function.