University of Oulu
FunSTA 2022

Homework 1

1. (65/100 pts) A cheap IMU sensor must be calibrated to provide more accurate readings. In the file "measurements.csv", there are raw three-axis accelerometer measurements from the sensor. You also have access to the ground truth of the acceleration readings, from a "perfect" IMU, which are in the file "groundtruth.csv". You may use your preferred coding language (for example, MATLAB, Python) and necessary libraries to solve this problem.

   (a) Consider an affine correction function $\vec{y} = A\vec{r} + \vec{b}$ that maps a measurement $\vec{r}$ to a more accurate reading $\vec{y}$, in which A is a 3-by-3 matrix and $\vec{b}$ is a 3-by-1 vector. Use least squares minimization to find A and $\vec{b}$ that would provide the best possible correction function for the given data.

   (b) What is the resulting sum-of-squares error after applying the correction function to the measurements? Is it zero? If not, why?

   (c) Comment on the resulting computed correction function. Which corrections does it make in terms of offset, scale, rotation, and shear (non-orthogonality of the axes) ?

2. (35/100 pts) Based on the definition given in the lectures and in Fraden Chs. 1 and 2, which of the following items are sensors? If it is a sensor, write its characteristics (active/passive, simple/complex, absolute/relative). There may not be an absolute right answer. Therefore, state your reasoning clearly.

   (a) Radar (for air traffic control) active, complex, absolute

   (b) Electron microscope active, complex, absolute

   (c) Magnifying glass

   (d) Smoke detector passive, simple, relative

   (e) The Large Hadron Collider

   (f) Metal detector (as in airport security) active, complex, relative

   (g) Pocket radio