Advanced Control Laboratory (085705)
ROS #4: Triangulation & 3D Reconstruction

This lab focuses on aspects of Triangulation & 3D Reconstruction using real-data, recorded from the Pioneer mission at ANPL.

Everything should be submitted in a single PDF file to the Moodle course site

1. (10%) Repeat Lab#3 Q.3
   - The projected results should be very close to the original pixels.
   - For the translation between camera to robot frame in camera coordinates use $[0.08, 0.08, -0.15]'_{[m]}$
   - Remember that the robot coordinate system is different than the camera coordinates.
   - Mind the units, be consistent.
2. (5%) Determine image correspondence for the entire database
   (a) Fill-in the following table with "1" for visible and "0" otherwise:

$Timestep$	L_1	L_2
t_0	1	0
t_1	0	1
$\vdots$	$\vdots$	$\vdots$
t_n	1	1

   In this example we can see that in the first frame only the first landmark is visible, in the second frame only the second landmark is visible, and in the last frame both landmarks are visible

   (b) Plot a single graph showing
      i. the estimated path of the robot
      ii. the ground truth of the robot
      iii. the ground truth of the landmarks
      iv. a connection between the landmarks and the posses they are visible from, using a simple line.
3. (20%) Create the following MATALB function:
   (a) The function header should look like this: [T_global2cam] = GetTranslationMat(FrameIndx,Database,odo
   mocap)
   (b) The function gets a frame index, access to the experiment database and a flag stating if to use odom or mocpa, and the transformation matrix from the global system to the camera coordinate system in the desired frame index.
   (c) The variable "T_global2cam" is a transformation matrix $\epsilon\,\mathbb{R}^{4x4}$.
   (d) The variable "FrameIndx" is an integer, expressing the pose number stored inside the database.
   (e) The variable "Database" is the rosbag data file.
   (f) The variable "odomORmocap" is a boolean flag, denoting "1" for the use of odometry data and "0" for the use of mo-cap data.

   - remember that the mo-cap is turned by $+90.6^0$ around $z$axis, in reference to the robot's coordinate system.
4. (35%) Triangulate a landmark

(a) Choose three different images in which L_2 is visible, and display them in Matlab in different figures (using the command `imshow`).

(b) Extract manually image coordinates that correspond to Landmark's 3D point[1] observed in the images (you can use the Matlab command `ginput` for that). Save these coordinates in matrix arrays `pix1` `pix2` and `pix3`.

(c) Reconstruct the observed 3D location of L_2 using the odometry via triangulation, in respect to the global frame[2]..

(d) Reconstruct the observed 3D location of L_2 using the mo-cap via triangulation, in respect to the global frame.

(e) Calculate the location of the landmark's ground truth in respect to the global frame.

(f) On a single plot show: The ground truth location of L_2, the odometry triangulation of L_2, the mo-cap triangulation of L_2. Don't forget to state which is which.

(g) Calculate the 3D location error of L_2 for both odometry and mo-cap results.

5. (30%) The importance of diversity

   (a) Repeat Section 4, four[3] more times with the following adjustments:

   - each time **pick three frames** that see the landmark from different distances.
   - For each run make sure to store the following:
     - number of frames used, along with indices.
     - 3D location error from odometry triangulation.
     - 3D location error from mo-cap triangulation.
   - Make sure that as you go along, the frames you add are farther away from each other along the robot's path, i.e. frame indices are increasing.

   (b) Find and plot the impact of variety in poses used for triangulation. Plot a graph of the 3D triangulation error as a function of the weighted normalized difference between used frames.

   (c) Plot a graph showing

   i. the estimated path of the robot
   ii. the ground truth of the robot using mo-cap data
   iii. the ground truth of the landmarks
   iv. the odometry triangulations [4].
   v. the mo-cap triangulations [5].
   vi. mark the frames that you used for triangulation for each run.

[1] The Landmark's 3D point refers to the mid top part of the white colored foam, be sure to remember it when choosing the pixel location of the landmarks.

[2] Global frame is defined as the position of the robot when turned-on

[3] make the computer repeat it for you

[4] In proper coordinate system.

[5] In proper coordinate system.