Take-home Midterm Exam ENMP673
(due Saturday, March 17th, 2018)

1. Perspective Projection (25 pts)
   Write a MATLAB function, which implements the image formation process. Write a function x = project(X, R, T, K) which takes as input image coordinates of 3D points in the world coordinate frame and generates pixel coordinates of the projected points in the image, assuming that (R, T) is the displacement of the camera coordinate frame with respect to the world frame, K is the matrix of intrinsic image parameters, and X is a 3 × n vector of the coordinates of 3D points. To test the function consider a unit cube placed in the origin of the world coordinate system (specified by 8 vertices $[0, 0, 0]^T$, $[1, 0, 0]^T$, etc. Assume that the camera is translated along z-axis by some amount and rotated around x-axis by angle 20◦. Let the calibration matrix be K = [800, 0, 250; 0, 800, 250; 0, 0, 1]. Generate the image of the cube. Plot the vertices of the cube and connect them by lines for better visualization. Submit the MATLAB code and generated MATLAB figure. It is commonly assumed that in the coordinate system of the camera the z-axis if pointing towards the scene and y down and x to the right

2. Histogram Equalization (25 pts)
   If only a narrow range of the possible intensity values in an image is used, we say that the dynamic range (ie: contrast) of the image is compressed. In that case, an image can contain a significant amount of detail that is not apparent visually. To enhance the detail, use histogram equalization. The steps are as follows:
   First, generate a histogram H of the intensities in the image. Specifically, there is one bin for each intensity 0-255. The value in each bin is the number of pixels in the image with that intensity. Second, normalize the histogram such that the sum of the 256 values in bins 0-255 is 255. Third, generate a second histogram H' where H0 [i] = P 0≤j≤i H[j] for all 0 ≤ i ≤ 255 . Finally, create the destination image as: image[x, y] = H'[source image[x, y]]. Implement the transform on the image "low-contrast-ex.png. Submit your result as a PNG and the source code you used to generate it. Do not use MATLAB's built-in histogram equalization (histeq()).

3. Multiplying Rotation Matrices (10 pts)
   a. Point $P_A = [p1, p2, p3]^T$ expressed in a stationary frame A is rotated about axis Z_A by 30 degrees and then rotated around axis X_A by 45 degrees. Give the rotation matrix that accomplishes these two rotations. In this case, both of the rotations are around a stationary frame.

   b. Consider a frame B, which originally is coincident with frame A. We first perform a rotation about Z_B by 30 degrees. Then we rotate about the new X_B by *45* degrees. Give the rotation matrix that accomplishes this.

4. Stereo (40 pts)

Given the stereo pair of two scan-line aligned images (tsukuba_l.png and tsukuba_r.png) compute the disparity map of the stereo pair.
Submit the code and resulting color coded disparity maps and comment on the quality of your results.

a. Use SSD as a patch similarity measure with a fixed window of your choice.
b. Improve the baseline, using two possible techniques, such as adaptive choice of the window, dynamic programming, different similarity measures, region based matching or other ideas.