CSE 398-012 Advanced Topics in Mobile Robotics
The DARPA Urban Challenge

Homework 1: Ground Plane (GP) Stereo for Obstacle Detection
Report Due Date: Tuesday, 24 Apr 07 at the beginning of class

A. Objective: Test the viability of using GP Stereo as a vision modality for obstacle detection

Figure 1: Sample Program Output

B. Requirements:

1. You *must* use Matlab to complete this assignment.
2. This is an individual assignment. Each student is required to submit his/her own work in order to receive credit.
3. This assignment is worth ~10% of your grade. Please treat it as such.

C. Instructions:

1. Download the Matlab shell program and the test image from the course webpage. You *must* use this shell program.
2. All camera parameters are included in the shell program.
3. Write a function `gp_stereo_hwk.m` that takes as an input the original rectified color images, returns a modified version of the left image where suspected obstacle pixels are highlighted. A sample homework output is provided at Figure 1.
4. To test the similarity of the two stereo images, you are to use block-matching with sum of squares difference (SSD) as a similarity metric.
5. Use both a 1-D (1x11) and 2-D (3x11) support regions for this assignment. Provide sample output in both cases.
6. SSD operations will be conducted on *grayscale images*.

7. There will be at least 2 sets of images (one for vehicle detection and one for pedestrian detection). You are to run your code and present results for each image set.
8. Follow the steps outlined during lecture and in the 17 Apr 07 class notes. In summary, these are
    a. From the camera calibration, predict the disparities for the image for minimum and maximum ground-plane distances of 10-30 meters, respectively.
    b. Update the right image to account for these disparities.
    c. Use block matching with SSD to determine how consistent the left image and revised right image are.
    d. Threshold the SSD image to detect obstacles
    e. Highlight the appropriate obstacles on the original left image.

D. Turn in: In addition to your Matlab source code (your code should execute properly, as I *will* run it), your report must answer the following questions:

1. What was the range of y-pixel coordinates that you examined to test for the ground-plane at ranges from 10-30 meters? Be specific!
2. Did you note any difference in performance when you used a 1-D vs. 2-D support region?
3. What range of thresholds were reasonable for the 1-D support region task? How robust were these thresholds compared to the "noise" levels for the actual ground plane?
4. Lower your thresholds until you start admitting significant noise in the image. What parts of the image are misclassified as obstacles? Do you have any ideas on how you might eliminate these? Sample images would be useful in explaining these.
5. Assume that instead of cartesian coordinates, we are using spherical coordinates in the camera frame where elevation angles are about the x-axis and azimuth angles are about the y-axis. For fixed elevation angle, is the predicted disparity the same regardless of the azimuth angle?