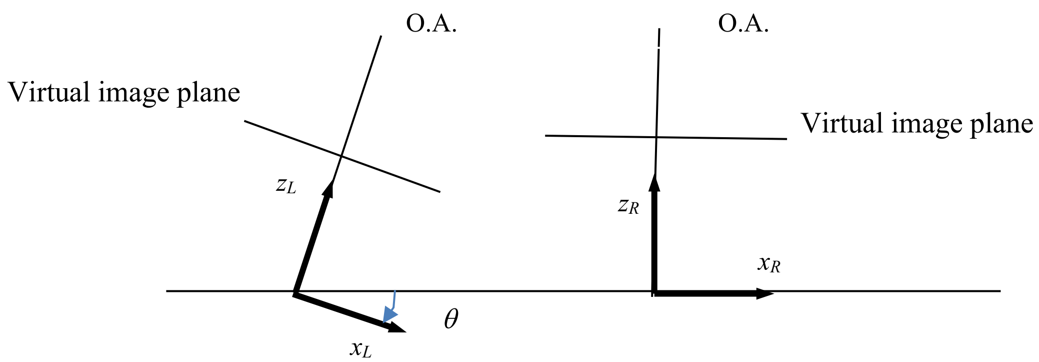
ECE 4554 / ECE 5554: Computer Vision: Homework 5

Fall 2023

Instructions

- This assignment is due at Canvas on December 4 before 11:59 PM. Late submissions are allowed (only up to the end of Dec. 6) at the cost of 1 token per 24-hour period. A submission received only a minute after the deadline will cost 1 token. Do not allow your token count to fall below 0.
- Please review the Honor Code statement in the syllabus. For this assignment, you may discuss general approaches to solving the problems with other students. You may discuss software libraries and syntax. Beyond that point, you must work independently. The work that you submit for a grade must be your own.
- The assignment consists of 4 problems. Problems 1-2 are analytical in nature, and are presented here. Problems 3-4 require work using Colab. Each problem is worth 10 points.
- Prepare an answer sheet that contains all of your written answers in a single file named `Homework4_Problems1-2_USERNAME.pdf`. (Use your own VT Username.) Handwritten solutions are permitted, but they must be easily legible to the grader. In addition, more files related to Python coding must be uploaded to Canvas. Details are provided at the end of this assignment.
- For problems 3-4 (the coding problems), the notebook file that you submit must be compatible with Google Colab. Your code should execute after the grader makes only 1 change to your file, which is the location of the working directory. If the notebook file does not execute, then the grader will be tempted to assign a grade of 0 for those problems.
- After you have submitted to Canvas, it is your responsibility to download the files that you submitted and verify that they are correct and complete. *The files that you submit to Canvas are the files that will be graded.*

Problem 1. The diagram below shows a common stereo camera arrangement, as viewed from above. This arrangement is similar to the stereo imaging set-up that we have discussed in lectures, except that the camera on the left has rotated inward by an angle θ. The two optical axes (O.A.) are coplanar, and both cameras have the same focal length *f*. Vertical axes for the two cameras, y_L and y_R, are not shown, and are perpendicular to this page. When the left camera rotates, the baseline distance *B* does not change.



a) Find the Essential Matrix for this stereo camera arrangement.

b) Solve for the location of the left epipole.

c) Solve for the location of the right epipole.

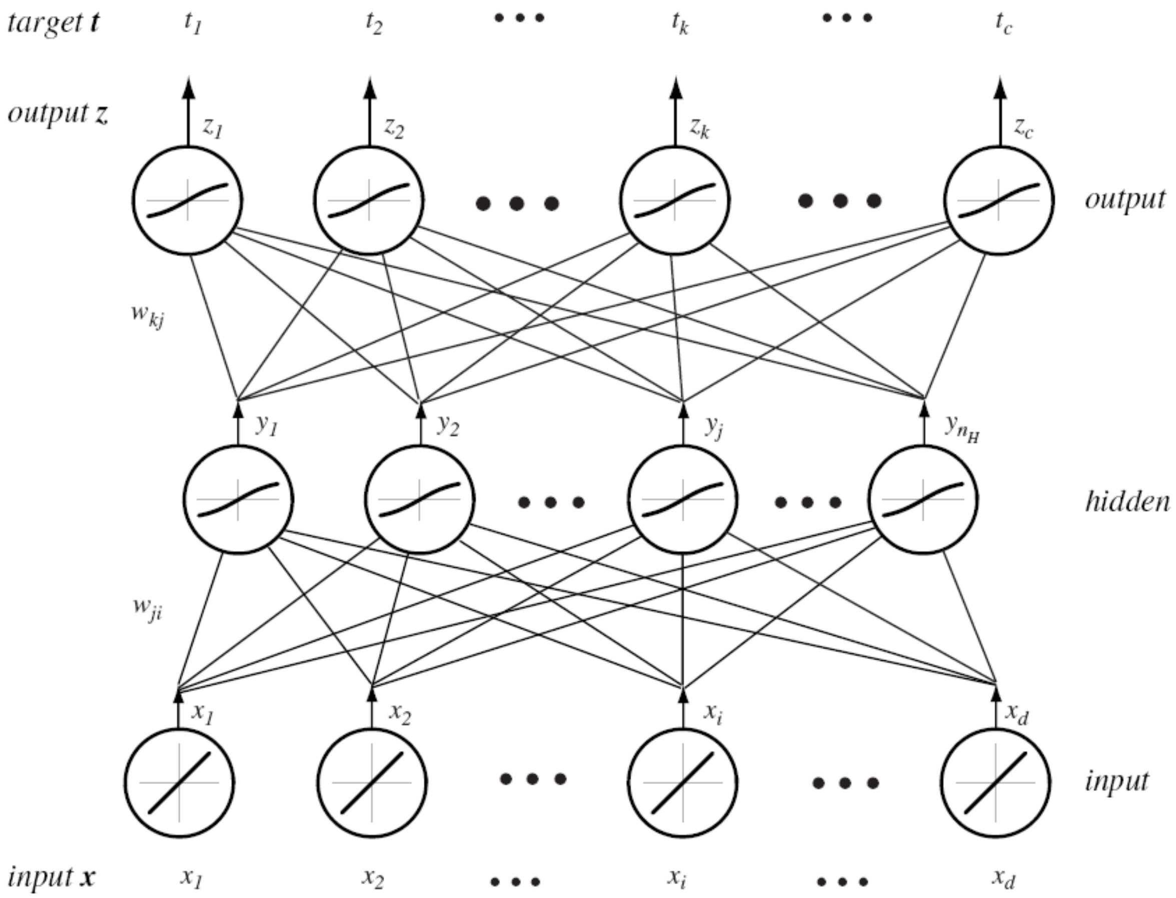
Problem 2. Consider the fully-connected artificial neural network that is shown on the next page. (The figure was taken from Duda, Hart, and Stork, 2012.) Assume that we want to train this network using the backpropagation algorithm. Assume that the goal will be to minimize L_2 loss, which was defined in a recent lecture as $J(\boldsymbol{w}) = \frac{1}{2}\sum_{k=1}^{c}(t_k - z_k)^2$. Signal z_k is the computed output from neuron *k* in the output layer; t_k is the desired output from that neuron; *c* is the number of network outputs; and $\boldsymbol{w}$ represents the set of all weights/parameters in the network. Also assume that the activation function for each neuron is the *sigmoid* function $f(s) = \frac{1}{1+e^{-s}}$.

Next, consider the particular parameter w_{kj}, which is the weight associated with the signal that passes from neuron j in the *hidden* layer to neuron k in the *output* layer. Let y_j be the output from neuron j. In a recent lecture we showed that the derivative needed to update w_{kj} during backpropagation is given by

$$\frac{\partial J}{\partial w_{kj}} = (z_k - t_k)(z_k)(1 - z_k)(y_j)$$

Let x_i represent input i, and let w_{ji} represent the weight that is applied to x_i by neuron j in the *hidden* layer. Show the derivative that is needed to update w_{ji} during backpropagation is given by the following expression:

$$\frac{\partial J}{\partial w_{ji}} = \left(-\sum_{k=1}^{c}(t_k - z_k)z_k(1 - z_k)w_{kj}\right)y_j(1 - y_j)x_i$$



Problems 3 and 4.
You have been given a Jupyter Notebook file `Homework5_USERNAME.ipynb`. Replace "`USERNAME`" with your Virginia Tech Username, and upload that file to Google Drive. Open that `ipynb` file in Google Colab, and follow the instructions that you will find there.

What to hand in: After you have finished, you will have created the following files. Upload these files to Canvas before the deadline. Do not combine them in a single ZIP file.

`Homework5_Problems1-2_USERNAME.pdf` ← Your solutions to problems 1 and 2.

`Homework5_USERNAME.ipynb` ← Your Jupyter Notebook file. (Don't zip it.)

`Homework5_Notebook_USERNAME.pdf` ← A pdf version of your Colab session.