Digital Video Processing (EE392J)
Department of Electrical Engineering
Stanford University

Problem Set No. 5

Issued: Monday, February 11, 2002
Due: Wednesday, February 20, 2002. You may also turn this problem set in on Friday, February 22, if you need extra time to talk with us about your project proposal.
Office hours: John: Mon and Wed after class, and Tues from 4:00-?. Prashant: Tues, 1:15-2:30, and Wed (Feb 13 only) 11:00-12:30, in Packard 106. Please feel free to stop by office hours to talk about possible projects.

Problem l. Constraint-based Signal Recovery: POCS when each constraint is a subspace

This problem considers constraint-based signal recovery in the special case where each constraint corresponds to a subspace. Assume that the desired solution satisfies a linear equation of the form $a_1x_1 + a_2x_2 + ... + a_Nx_N = 0$. This equation can be equivalently expressed as $\mathbf{a}^T\mathbf{x} = 0$ where $\mathbf{a} = [a_1, a_2, ..., a_N]^T$ and $\mathbf{x} = [x_1, x_2, ..., x_N]^T \in R^N$. Therefore, the solution must lie in the $(N-1)$-dimensional subspace defined by $\mathbf{a}^T\mathbf{x} = 0$.

(a) Determine an expression that describes how to compute the orthogonal projection of an arbitrary point $\mathbf{x}$ onto the subspace. The orthogonal projection of an arbitrary point $\mathbf{x}$ onto a subspace is the point in the subspace that is closest (in Euclidean distance) to the point $\mathbf{x}$. (Hint: Think projection theorem or least squares.)

(b) Assume that the desired solution satisfies two linear equations of the type shown above. Also assume that the corresponding subspaces intersect. Is there a unique solution? If not, what is the form of the solution, e.g. what is its dimension?

(c) Assume you perform alternating orthogonal projections to determine an element in the solution set. How does the convergence rate depend on the "angle" between the subspaces? (Hint: Consider the analogous case of two 1-D subspaces in a 2-D space, i.e. when you have two linear equations in two unknowns. What happens when the subspaces are orthogonal? What happens when the angle between them is very small?)

(See Back)

Problem 2. Project Proposal

Submit a one or two page proposal describing the final project that you will like to do for this course. Example final projects are described on the class web page. Additional projects involving video processing or the processing of multiple images may also be possible – feel free to propose relevant alternate topics/problems that interest you. A project may be performed by a single student or a group of two or three students; see the class web page for further details. We will provide a number of video test sequences which may be useful for different projects.

The project proposal should include the following:

1. Name and description of project
2. Individual project or group project?
3. Why is this project interesting?
4. What problem(s) must be overcome in this project?
5. What methods are you considering to solve these problem(s)?
6. How familiar are you with these problems?
7. What useful references have you found in regard to these problems? Do you need additional references?
8. Is additional equipment necessary (besides a computer)? If so, do you have access to this equipment or do you need help getting access to this equipment?

The ideal goal is to find a project that is both highly educational and fun. We're available to meet and discuss any possible projects, as well as to help you identify potential problems within the project and approaches to overcome these problems.

Office hours (John): Monday and Wednesday after class, and Tuesday 4:00-5:00 (2nd floor lounge, Packard Building). Please feel free to stop by office hours to talk about possible projects.