ECE 510: Mathematical Foundations of Machine Learning **Spring 2019**

Demo: Low-Rank Matrix Completion

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Introduction

One of the main goals of this class is that you be able to read a research paper of interest and implement the proposed algorithm. You are already doing this as part of your course project, but today's (not) demo will give you another opportunity. Your task is to implement the sIRLS-p algorithm for matrix completion described in the paper *Iterative Reweighted Algorithms for Matrix Rank Minimization* by Karthik Mohan and Maryam Fazel.

Task 1: Implement sIRLS-p

Search for and download the paper above. Your first task is to implement sIRLS-p by completing the included `sIRLSp.m` function. You may wish to test your algorithm using `syntheticTest.m`. You may wish to follow a variant of Algorithm 1 below to help you in the process of understanding and implementing the algorithm.

Algorithm 1 Suggested algorithm for implementing sIRLS-p algorithm

Input: The specified paper and a desire (or requirement from professor) to implement the sIRLS-p algorithm
Output: Completed `sIRLSp.m` function for matrix completion using IRLS
while not completed `sIRLSp.m` **do**
  for $ii \in \mathcal{S} \subset \{1, \dots, 7\}$, in most helpful order for you **do**
    1) Read abstract
    2) Read §1 and §1.1 to understand the general problem
    3) Read §2 to understand how IRLS fits the general problem
    4) Read §4 to understand how IRLS fits the matrix completion problem
    5) Read §5 for the description of the sIRLS-p algorithm
    6) Read §6.1 for a description of how to set the tuning parameters
    7) Code, debug, and test your algorithm
  end for
end while

Task 2: Test sIRLS-p on Images

Congratulations! If your reach this task, you have just read (portions of) a research paper and implemented the described algorithm, which ideally is something you could not do prior to taking this course. Raise your hand and state how empowered you feel.

- 0: not at all empowered
- 1: somewhat empowered
- 2: very empowered

Once your sIRLS-p implementation is complete, your next task is to perform matrix completion on the included `cameraman` and `mandrill` images. These are common benchmark images that are included with Matlab.

- Using the random mask from `syntheticTest.m`, run your matrix completion function for several sampling rates on each image. How much missing data can each image tolerate?
- Try manually creating deterministic sampling masks such as a straight line, diagonal line, or a box where data is missing. How does your recovery compare?

Task 3: Understand Theoretical Results

If time allows, read the theoretical results given in §3 and try to gain an understanding of what is shown. Some questions to ask are below.

- What (if any) topics from class are used in the algorithm, either in its development or in the actual pseudo-code?
- What (if any) topics from class are used in the theoretical results?
- Do the results guarantee that the problem of interest is solved? Under what conditions?
- Do the results guarantee that the algorithm converges? To a local or global minimum?
- What assumptions are made for the theoretical results to hold?
- Are there any portions of the paper that you could not have understood prior to taking this course that now make (at least some) sense to you?
- What aspects of the paper do you still not understand? Are these beyond the scope of ECE 510, or are they parts of the class that you still don't understand? Be honest please :)