Image Processing (EE 5720)
Midterm Examination

Instructor: Chia-Hsiang Lin
November 5, 2020. Time: 15:10∼18:00

Total score 100 points

The topic is to solve the so-called "mixed pixel" phenomenon using a fully unsupervised approach:

1. As discussed, a hyperspectral pixel can be modeled as $\mathbf{x}[n] = s_1[n]\mathbf{a}_1 + s_2[n]\mathbf{a}_2 + \cdots + s_N[n]\mathbf{a}_N \in \mathbb{R}^M$, where n is the pixel index, M is the number of spectral bands, $\mathbf{a}_i$ is the hyperspectral signature of the ith material, and $s_i[n]$ is the proportion of the ith material at the nth pixel. In other words, each pixel would be a mixture of several material spectra. The aim is to estimate the signatures $\mathbf{a}_1, \ldots, \mathbf{a}_N$ (for material identification) and the proportions $s_1[n], \ldots, s_N[n]$ (for material quantification) from a given hyperspectral dataset $\{\mathbf{x}[1], \ldots, \mathbf{x}[L]\}$.

2. Please let TAs know your team members before October 22, 2020. (24 teams with 3 members; 12 teams with 2 members.) Otherwise, we will randomly assign your group members.

3. Please contact TAs for obtaining your hyperspectral dataset, which is generated by $N = 3$ U.S. Geological Survey (USGS) signatures with $M = 224$ spectral bands. The dataset will be saved as a 3D cube in MATLAB format with dimension $100 \times 100 \times 224$ (i.e., $L = 10,000$ pixels with $M = 224$ bands). As the team members are determined, you can get your imaging dataset after October 23, 2020.

4. What you need to do:

   - Implement the hyperplane-based Craig simplex identification (HyperCSI) algorithm introduced in my lecture notes. (Set $\eta := 1$, as your imaging dataset will not be corrupted by noise.)
   - Process the imaging dataset (you get from TAs) using HyperCSI that you implemented.
   - Give an oral presentation (8 minutes) on November 5, 2020, followed by an Q&A session (2 minutes). *(See below for how to prepare your slides.)*

5. What you need to submit:

   - A "Group_t.pptx" file ($t \in \{1, \ldots, 36\}$ is your team number), including a set of slides organized as follows:
     - (Page 1) A cover page showing what "each" group member has done.
     - (Page 2) Show $N = 3$ figures, each containing one material signature.
     - (Page 3) Show $N = 3$ figures, each containing one material abundance/distribution map. The ith map should be presented as a 100×100 grayscale image with the nth position being $s_i[n]$. *(That's why the dataset is provided in a 3D format in order to preserve the spatial information.)*
     - (Pages 4 to *End*) Detailed discussion. *[e.g., a) list all difficulties you have encountered when implementing HyperCSI, b) explain how you solve those difficulties, c) share any novel idea or new algorithm designed by yourself, etc.]*

     If you need more slides for "insightful" discussion, feel free to do so, but keep in mind that you get only "8 minutes" for your oral presentation.
   - A completed "HyperCSI_t.m" file (i.e., the MATLAB code that you have implemented).

   Please submit both files to Jhao-Ting Lin (christtlin870117@gmail.com) and Pang-Yu Lin (brian1997081@gmail.com) by the end of October 30, 2020. Please use "Midterm Examination EE 5720 (Group t)" as the email title.

6. What we will do after receiving your files:

   - We will process the dataset "data_t.mat" (we provided) using the MATLAB code of "HyperCSI_t.m" that you implemented, to make sure that the outputs are indeed the signatures/maps (you provided) in pages 2 to 3 of your slides "Group_t.pptx", for all $t \in \{1, \ldots, 36\}$.
   - We will read your code to judge whether it is implemented by yourself.

7. If you achieve (some of) the following goals, you will be graded with high scores:

   - Propose a *new* idea for unmixing the hyperspectral pixels, or an idea to upgrade the HyperCSI algorithm. You need to *clearly* and *concisely* illustrate your idea during your oral presentation. A graphical illustration (without math details) would also be good.
   - Implement your new idea with successful experimental results to prove that your idea is implementable. If you opt to do so, you need to submit your implementation to TAs as well.
   - Demonstrate that your implementation (i.e., "HyperCSI_*t*.m") runs even faster than ours (and yields correct results).

   If you achieve any of these goals, please explicitly mention it during the oral presentation.

8. Plagiarism is not allowed, and if found midterm gets 0%.

9. Both "HyperCSI_*t*.m" and "Group_*t*.pptx" must be handed in by the deadline, so that we have sufficient time to evaluate your works. Your score will be multiplied by a factor of 0.9 per day passing the deadline.

10. If you have any question, please let us know by email or just come to Lab 92A53 or Lab 92931 (EE Building) for a discussion.