Middle East Technical University - Department of Computer Engineering

CENG 371

Scientific Computing

Fall' 2024-2025

Homework 4

Due Date: 03 January 2025, Thursday, 23:55
Late Submission Policy will be explained below

Question 1 (40 points)

Implement the randomized low-rank approximation algorithm using $p = 5$ as your safety parameter. (Signature: `[`u_k, σ_k, v_k` ] = approximate_svd.m(A, k)`)

Question 2 (60 points)

For this question you will work with the image files `cameraman.jpg` and `fingerprint.jpg`. Let $u_k, \sigma_k v_k$ be the matrices retuned by `approixmate_svd`, $u'_k, \sigma'_k v'_k$ be the matrices returned by svds (Matlab built-in), and U, Σ, V be the matrices returned by svd (Another Matlab built-in). Acquire these matrixes for $kin\{1 \dots n\}$ where n is the rank of the matrices representing the images.

1. Plot the relative errors $\frac{\left\|(u_k, \sigma_k v_k^T - U\Sigma V^T\right\|_2}{\|U\Sigma V^T\|_2}$ and $\frac{\left\|(u'_k, \sigma'_k v'^T_k - U\Sigma V^T\right\|_2}{\|U\Sigma V^T\|_2}$ vs. k for both of the images. Discuss your observations.
2. Plot the run times of `approixmate_svd` with `svds` vs. k for both of the images. Discuss your findings
3. After these quantitative discussions, conduct *qualtitative* comparisons/discussions. To achieve this, compose the output matrices (given k) back to an image and display these. You are free to choose any k value(s) you think is helpful for your discussions.
4. Suggest use cases for `approixmate_svd` based on your discussions.

> The built-in Matlab functions `imgread, im2double, imshow, imsave` are useful for reading and displaying images.

Regulations and Submission

- **Programming Language:** You can use any programming language, **however Matlab is recommended**. Other good choices are Python (via Numpy package), and Octave (open source alternative to Matlab). Students can download Matlab (please refer to this link).
- Most of the points will be granted to the **explanation/discussion parts** of the questions. Make sure you **reflect your reasoning** cleanly and concisely.
- Most of your points will come from the PDF text, however; you should submit your code as well.
- Please make sure that your reports are readable, clean, and concise. **Note that the organization of your PDF will also be subject to grading**. You can get bonus/penalty points based on it.
- Uploaded codes should be clean and understandable similar to the PDFs. The codes will not be graded rigorously (such as black-box testing) since there aren't standard language or script arguments. However, these will be visually inspected.
- **Late Submission Policy:** Accepted with a deduction of $5 \times d^2$; where d is the number of late days submitted.
- Submission will be done via Odtuclass, (odtuclass.metu.edu.tr).
- Please upload both your code and your findings (as a PDF) to the system in a zip file.