SI231B – Matrix Computations, Fall 2025
Course Project Specifications

1 Specifications

Some specifications for the project:

- The length should be at least 5 single-column pages with 10pt font. Be brief and to the point.
- The project should be written using LaTeX (use an IEEE paper style or similar) and submitted in PDF format (do not use Word!).
- Keep a PDF copy of all the cited references (submit them along with the final project).
- The student should read around 8 research papers on the chosen topic and cite at least 8 related papers.
- The project should start with a description of the problem: this should not be a separate overview of each of the papers one after another; instead, it should contain a unified problem formulation, explaining how each of the related papers fits within the general formulation.
- The related papers should be criticized: the student should have an opinion on the papers that he/she read; the student should be able to comment on the contributions and limitations of each paper.
- Independent research: after the problem formulation and overview of the state of the art, the student should try to propose something new that improves on the existing approaches based on the contents learnt from this course.
- Numerical simulations: the student should design numerical experiments in order to justify his/her points of view.
- No plagiarism or self-plagiarism is allowed. (The student is never allowed to reuse his/her own published or submitted papers as the final project.)

2 Structure of the Written Report

In order to make the evaluation of the project as objective as possible, the written report should strictly adhere to the following structure (a penalty will be applied if the report is not organized according to the guideline):

1. Introduction: 10% grade
2. Overview of existing work (with unified notation): 20% grade
3. Criticism of the existing works: 20% grade
4. New contributions (if any): 20% grade
5. Numerical results: 10% grade
6. Conclusions: 10% grade
7. References: 10% grade

3 Schedule and Submission

By January 8th, 2026 at 11:59 PM, submit your final report with all the cited references (required) and codes (optional) with filename `YourChineseName_YourStudentID.zip` to the link: https://epan.shanghaitech.edu.cn/l/tF3AGx. This is a strict deadline and there will be penalties for not respecting them. In particular, the final report late by 1 day will be penalized with 30% of the grade, late by more than 1 day will **receive 0 point**.

4 List of Topics

You need to choose a topic from the following list, and cite at least one paper below the topic.

- **Schur Complement:**
  - Y. Fan, T. Zhao, and G. Wang, "SchurVINS: Schur Complement-Based Lightweight Visual Inertial Navigation System," in *2024 IEEE/CVF Conference on Computer Vision and Pattern Recognition (CVPR)*, Seattle, WA, USA, 2024, pp. 17964–17973.
  - A. Ospanov, M. Jalali, and F. Farnia, "Scendi Score: Prompt-Aware Diversity Evaluation via Schur Complement of CLIP Embeddings," in *Proceedings of the IEEE/CVF International Conference on Computer Vision (ICCV)*, 2025, pp. 16927–16937.
- **Differentiable Linear Algebra:**
  - G. Darley and S. Bonnet, "A Unified Framework for Matrix Backpropagation," *IEEE Transactions on Neural Networks and Learning Systems*.
  - C. Ionescu, O. Vantzos, and C. Sminchisescu, "Matrix Backpropagation for Deep Networks with Structured Layers," in *2015 IEEE International Conference on Computer Vision (ICCV)*, Santiago, Chile, 2015, pp. 2965–2973.
- **Low-Precision Matrix Computations:**
  - N. J. Higham and T. Mary, "Mixed Precision Algorithms in Numerical Linear Algebra," *Acta Numerica*, 2025, vol. 31, pp. 347–414.
  - A. Buttari, T. Mary, and A. Pacteau, "Truncated QR Factorization with Pivoting in Mixed Precision," *SIAM Journal on Scientific Computing*, vol. 47, 2025, no. 2, pp. B382–B401.
- **Least Squares:**
  - L. Zhang, K. Li, E.-W. Bai, and G. W. Irwin, "Two-Stage Orthogonal Least Squares Methods for Neural Network Construction," *IEEE Transactions on Neural Networks and Learning Systems*, Aug. 2015, vol. 26, no. 8, pp. 1608–1621.
  - X. Chang, Y. Zhong, Y. Wang, and S. Lin, "Unified Low-Rank Matrix Estimate via Penalized Matrix Least Squares Approximation," *IEEE Transactions on Neural Networks and Learning Systems*, Feb. 2019, vol. 30, no. 2, pp. 474–485.
- **LTI System:**
  - M. Althoff and J. Rath, "Comparison of guaranteed state estimators for linear time-invariant systems," *Automatica*, 2021, vol. 130, p. 109662.
  - P. Borja, J. M. A. Scherpen, and K. Fujimoto, "Extended Balancing of Continuous LTI Systems: A Structure-Preserving Approach," *IEEE Transactions on Automatic Control*, Jan. 2023, vol. 68, no. 1, pp. 257–271.
  - M. Bolajraf, "Static Output Feedback Synthesis for MIMO LTI Constrained Positive Systems Using LP Approach," *IEEE Transactions on Automatic Control*, May 2025, vol. 70, no. 5, pp. 3425–3432.
- **Nonnegative Matrix Factorization:**
  - Y. Li, J. Chen, C. Chen, L. Yang, and Z. Zheng, "Contrastive Deep Nonnegative Matrix Factorization For Community Detection," in *ICASSP 2024 - 2024 IEEE International Conference on Acoustics, Speech and Signal Processing (ICASSP)*, Seoul, Korea, Republic of,

2024, pp. 6725–6729.

- V. Gligorijević, Y. Panagakis, and S. Zafeiriou, "Non-Negative Matrix Factorizations for Multiplex Network Analysis," *IEEE Transactions on Pattern Analysis and Machine Intelligence*, Apr. 2019, vol. 41, no. 4, pp. 928–940.

- **Projection:**
  - S. Pazos, M. Hurtado, C. H. Muravchik, and A. Nehorai, "Projection Matrix Optimization for Sparse Signals in Structured Noise," *IEEE Transactions on Signal Processing*, Aug. 1, 2015, vol. 63, no. 15, pp. 3902–3913.
  - T. Su, D. Feng, M. Wang, and M. Chen, "Dual Discriminative Low-Rank Projection Learning for Robust Image Classification," *IEEE Transactions on Circuits and Systems for Video Technology*, Dec. 2023, pp. 7708-7722.