Course 049064: Variational Methods in Image Processing

Final Project

Project due on 13.3.2017. Presentations (mandatory) on Monday, 27.2.2017 at 14:30, room 354 (changes will be announced by mail).

General

- Goal: the final project is a main milestone in the course. It is designed to evaluate the student's ability to conduct a complete research task related to the course on a small scale.
- The work can be done in pairs.
- Selecting the project: each group (single student or pair) will need approval of their requested project. One group works on each project (on the basis of first come, first served).
- The submission involves "mid-term" presentation in class and submission of a final report and code.

Presentation

A short presentation of **6-10 slides** (up to 10 minutes talk). On the slides you should give background on your project, explain the model, analyze it and put emphasis on your creative part.

Project Report

The report will be **up to 20 pages** (somewhere between 10-20 pages is reasonable). Where applicable (depending on the project), here are some topics that should be covered:

- *Background.* Describe the problem and some previous suggested solutions.
- *Suggested model.* Why the model was chosen? include both the authors views and your views.
- *Single problem.* If the paper suggests many models or variations - select one of them and investigate this model thoroughly.
- *Implementation.* Implement the selected single problem - either by the implementation suggested in the paper or using your own method (if the numerical part is not a critical aspect of the paper).
- *Analysis.* Analyze the paper (the selected problem), use at least 4 test images. Try various parameters, check robustness to noise. If you know of a simple naive solution to the problem - compare the two solutions.
- *Creative and suggested Improvements.* Suggest an improvement to the model. Following your analysis, see where the model fails, or is less accurate and try to correct it. This is an important part of the project where you can show creativity and abilities to perform research. Illustrate your solution with examples showing:
    1. Your solution is at least slightly better than the original paper on some images.
    2. Your solution does not degrade the performance on other images (such as the ones shown on the analysis part).
- *Conclusion.* Summarize the goal, your analysis and suggested improvement.
- *References.* Bibliography cited within the report.

Grading

1. Presentation - **10 points**.
2. Report and code - **90 points**:
    (a) Analysis and implementation of the paper - **50 points**.
    (b) Creative parts and suggested improvements - **40 points**,

Submission

Please send a PDF file containing the report and the Matlab files folder to Guy Gilboa, guy.gilboa@ee.technion.ac.il. The subject of the mail should be **"Final Project"**. In the mail please write the full names + ID of the participants

List of Projects

Spectral TV

In this project one should first read, understand and summarize the main points of the paper: G. Gilboa, "A total variation spectral framework for scale and texture analysis". SIAM J. Imaging Sciences, 7(4), pp. 19371961, 2014. In addition the following creative directions are suggested (choose one):

1. Application: suggest an image-processing application which can benefit from the spectral TV representation.
2. Apply a similar transform to an alternative regularizer which is one-homogeneous but not TV (such as total-generalized-variation or infimal convolution). Analyze and check its spectral properties.
3. 3D processing. Implement sepctral TV on depth maps (2D matrices with the distance Z as the value). You can use data from the web like the Middlebury database (http: //vision.middlebury.edu/stereo/data/). Check if there is a separation (in the scale t) to noise, textures and larger objects.

Papers

Base your project on any of the following papers:

1. De los Reyes, Juan Carlos, and Carola-Bibiane Schnlieb. "Image denoising: Learning the noise model via nonsmooth PDE-constrained optimization." Inverse Probl. Imaging 7.4 (2013): 1139-1155.
2. Chen, Yunjin, Rene Ranftl, and Thomas Pock. "Insights into analysis operator learning: From patch-based sparse models to higher order MRFs." IEEE Transactions on Image Processing 23.3 (2014): 1060-1072.
3. Ochs, Peter, Jitendra Malik, and Thomas Brox. "Segmentation of moving objects by long term video analysis." IEEE transactions on pattern analysis and machine intelligence 36.6 (2014): 1187-1200.

4. Kunisch, Karl, and Thomas Pock. "A bilevel optimization approach for parameter learning in variational models." SIAM Journal on Imaging Sciences 6.2 (2013): 938-983.

5. Strekalovskiy, Evgeny, and Daniel Cremers. "Real-time minimization of the piecewise smooth Mumford-Shah functional." European Conference on Computer Vision. Springer International Publishing, 2014.

6. Laude, E., Mllenhoff, T., Moeller, M., Lellmann, J., Cremers, D. "Sublabel-Accurate Convex Relaxation of Vectorial Multilabel Energies". CVPR 2016.

7. Xu, L., J. Jia, and Y. Matsushita. "Motion detail preserving optical flow estimation." PAMI, IEEE Transactions on 34.9: 1744-1757, 2012.

8. Hung, C. H., Xu, L., Jia, J. Consistent binocular depth and scene flow with chained temporal profiles. Int. J. of Computer Vision, 102(1-3), 271-292, 2013.

9. Valgaerts, L., Bruhn, A., Zimmer, H., Weickert, J., Stoll, C., and Theobalt, C. "Joint estimation of motion, structure and geometry from stereo sequences." ECCV 2010, 568-581.

10. Zollhfer, M., Niener, M., Izadi, S., Rehmann, C., Zach, C., Fisher, M., ... Stamminger, M. Real-time non-rigid reconstruction using an rgb-d camera. ACM Transactions on Graphics, TOG, 4, 2014.

Additional papers are possible - following approvement by the lecturer.