Analysis and approximation of some PDE models for 3D vision and image segmentation

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The mathematical modeling of classical problems in image processing and 3D reconstruction has a growing importance in many areas of application including e.g. biomedical images, security and astronomical images. New models based on non linear partial differential equations and on variational methods have been proposed in the last 20 years and their analysis has been developed introducing new tools which have greatly improved previous results. In this short course I will present some of those contributions with a particular focus on the level-set method for segmentation problems and on 3D reconstruction via the Shape-from-Shading problem.

Outline

1. An introduction to some classical problems in image processing
2. The PDEs zoo for image processing
3. A short introduction to viscosity solutions for Hamilton-Jacobi equations
4. Numerical methods for Hamilton-Jacobi equations
5. 3D reconstruction via the Shape-from-Shading problem
6. Image segmentation via the level-set method
7. Recent results and open perspectives

References

[1] E. Carlini, M. Falcone, R. Ferretti, *Numerical Techniques for Level Set Models: an Image Segmentation Perspective*, preprint, 2018, submitted

[2] E. Carlini, M. Falcone, A. Festa, *A brief survey on semi-Lagrangian schemes for Image Processing*, in M. Breuss, A. Bruckstein, P. Maragos "Innovations for Shape Analysis: Models and Algorithms", Proceedings of Dagstuhl Seminar 11142, Springer Verlag, 2013, pp. 191-218.

[3] J.D. Durou, M. Falcone, M. Sagona, *Numerical Methods for Shape from Shading: a new survey with benchmarks*, Computer Vision and Image Understanding, Elsevier, (2008) 109, 22-43.

[4] M. Falcone, R. Ferretti, Semi-Lagrangian Approximation Schemes for Linear and Hamilton-Jacobi Equations, SIAM, 2013.

[5] S. J. Osher, R. P. Fedkiw, Level Set Methods and Dynamic Implicit Surfaces, Applied Mathematical Sciences, 153, Springer-Verlag, New York, 2003.

[6] J.A. Sethian, Level Set Methods and Fast Marching Methods: Evolving Interfaces in Computational Geometry, Fluid Mechanics, Computer Vision, and Materials Science, Cambridge University Press, Cambridge Monograph on Applied and Computational Mathematics, 1999.