UNIVERSITAT POLITÈCNICA DE CATALUNYA
BARCELONATECH
Department of Signal Theory and Communications

UPC - Campus Nord
C/ Jordi Girona 1-3
Building D5 – office 202
08034 Barcelona (SPAIN)

Tel. +34 93 405 40 30
http://imatge.upc.edu

Philippe Salembier
philippe.salembier@upc.edu

RAPPORT DE THESE

Auteur: Ravi Kiran
Titre: Energetic-Lattice based optimization
Rapporteur: Philippe Salembier

Global evaluation

The major goal of this thesis is to propose a theoretical framework based on lattice theory to deal with optimization on hierarchies of partitions. This work is really timely as hierarchical segmentation has emerged in the last decade as one of the major and most successful approach to image segmentation. The starting point of the work is the observation of previous results in the literature where authors were defining optimization criteria for partitions either based on additive contribution of regions or supremum composition. The author manages to propose a complete lattice-based theory for partition optimization and even realizes that the theory goes beyond pure hierarchies of partition and can be generalized to set of regions organized in a new structure called “braids”. This represents a very significant theoretical contribution which not only explains precisely why previous authors were able to deal with the same kind of optimization algorithms with additive or supremum composition rules but that will very likely trigger the study of new optimization criteria in the future. It is therefore an excellent work.

The thesis is somewhat overwhelming by its density and the number of different topics it tackles. A selection of the most important issues could have been done and would possibly have left space for a more detailed experimental evaluation of the outcome of the theory and its comparison with more classical state of the art approaches. The reading of the manuscript is very interesting but not very easy. The text could have been structured in a simpler way and with fewer digressions. Moreover, quite a few spelling errors, syntax errors or missing words prevent a smooth reading. On the formal aspects, one may note that some figures are not referenced nor commented in the text, some chapters are concluded by a section summarizing the highlights of the discourses and others are not. The text may need some polishing in view of the creation of the final version of the manuscript.

In the sequel, we highlight the major points of the thesis.

Chapter 1: Braids and Energetic lattices

After a brief reminder on lattices, partitions and hierarchies, this chapter develops the theoretical tools necessary for the rest of the thesis, namely the energetic lattice. This is probably the core of the thesis as this is where the concepts of braids (generalizing hierarchical partitions), and the fundamental energy properties called "singularity", "scale increasingness" and finally "h-increasingness" are presented.

Section 1.3 introduces the notion of braids of partition. This very interesting notion generalizes the notion of partition tree and is the basis of an important part of the thesis. It would have been useful to discuss more examples of braids and how they can be created. Note that Propositions 1.5 and 1.6 are the same. Then section 1.4 introduces an energetic order and a lattice for braids.

Then the notions of "scale-increasingness" and then "h-increasingness" of energy functions is introduced. "h-increasingness" is probably the most important notion in this work as it is the one that gives the conditions under which dynamic programming approach can be used for the optimization. It justifies algorithm previously used involving additive or supremum composition of energies evaluated on regions.

In terms of writing, the text is rather difficult to read. There quite a few spelling or grammatical errors. The structure and writing do not help to highlight nor summarize the milestones of the discourse. Figures as the ones appearing in the conclusions could be helpful to guide the reader. Some notions are used without previous definition (climbing energy for example in section 1.7.1.1.). Beside these writing issues the content of the chapter is excellent and open the door for other researchers to study and propose original "h-increasing" energies.

Chapter 2: Constrained optimization

This second chapter focuses on constrained optimization. It starts by reminders on lagrangian optimization in the context of rate-distortion and on the theory behind Lagrangian formulation of optimization problem under constraints. Then, section 2.3 discusses the limitations of the traditional lagrangian cut and shows, in particular, that these cuts are mainly lower-bounds of the optimization problem. Finally, the author proposes to study this optimization problem in the framework of energetic lattice, which moreover allows extension of lagrangian cut to braids. The discourse is fundamental and proposes notions such as "Inf-modularity" which plays a role similar to sub-additivity in optimization on hierarchies.

Here also the technical quality of the manuscript is excellent but the discourse is not easy to follow, as there are quite a few digressions. The theory is very impressive, but at the end of the chapter, the reader wonders about its practical impact. It would have been interesting to present, analyze and discuss practical and concrete examples and clearly illustrate what can be done today that was not possible with previous state of the art approaches.

Chapter 3: Applications of Energetic lattice

This chapter concludes the main section of the thesis dealing with energetic lattice. It starts with a discussion on various examples of h-increasing energies used for segmentation: Mumford-Shah energy, modified Mumford-Shah energy where the contour perimeter term is changed to deal with convexity, energies for color image segmentation with various data fidelity and regularization terms. The work is quite interesting and would have deserved a more precise experimental exploration. For example, in terms of segmentation, the community has agreed on a certain methodology to work

with ground truth segmentation results and to assess the performance of segmentation tools in a classification framework through Precision and Recall curves. Therefore, it would have been interesting to use this kind of methodology to analyze the segmentation results. Note that section 3.1.4 does not seem to be complete.

Section 3.2 focuses on ground truth related energies. This is a very interesting topic. The author proposes to defined similarity between regions based on a localized version of the Hausdorff distance. This is a good proposal that fits well in the energetic lattice framework. A few examples are presented but it would have been interesting to more deeply understand the relation of this measure with the already large set of measures used for segmentation assessment and also see its application for the evaluation of current state of the art segmentation algorithms.

Section 3.3 deals with superpixel. This section seems somewhat disconnected from the rest and its goal is not quite clear. Section 3.4 heavily relies on the notion of intersection graphs. Here, it is difficult to precisely identify the thesis contribution with respect to the state of the art. Finally, the goal of section 3.5 is imprecise as the similarity between optimal cut and flow maximization seems rather classical.

Overall this chapter is quite interesting but in order to really understand the gain or advantage provided by the energetic lattice, it would have been useful to concentrate on one or two applications and to go deeper in the experiments and the analysis work.

Chapter 4: Hierarchies and Saliency function

Conceptually, this last chapter is somewhat disconnected for the rest of the thesis. It does not involve the notion of braid of partition anymore and introduces a hierarchical model based on Jordan curves. A lattice structure is proposed for these curves. In this approach, the notion of saliency plays a central role. Finally, "net opening" are proposed and studied in this lattice. Net opening basically removes part of unclosed contours.

Section 4.7 focuses on applications of the so-called Jordan-net approach. For example the author discusses how to use of the framework for comparison with a ground truth hierarchy. This section is quite interesting but it would also have been interesting to see the advantage and inconvenient of the proposed saliency-based approach to other approaches (such as P. Arbelaez, J. Pont). Similar comments can be made about section 4.8 which mainly present potential uses of net opening but remains rather superficial in terms of experiment and analysis.

Overall, the author has proposed a truly excellent and innovative framework for optimization problems involving regions. Furthermore, he has demonstrated a great ability to theoretically develop the framework and propose essential ideas concerning energetic lattices. Although the experimental aspects of the work could have been extended and the text would benefit from some polishing, this work is pioneering and will be seminal for many future research activities. It is really going to be of great interest to many researchers in the field. For all these reasons, I recommend the thesis be presented without any reservation.

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Philippe Salembier
Catedrático de Universidad
Universitat Politècnica de Catalunya