Accurate Region-Growing Segmentation of Pleiades images

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Problem

Segmentation of very high resolution images like those delivered by the Pleiades satellites is a challenging task because of the memory constraints.
It represents a large volume of data and needs to be divided into tiles in order to be processed. Tile-wise processing of such images is then mandatory but region-growing segmentation methods do not cope well with it.
Resulting regions from each tile may be incoherent. This is highlighted by the mismatch of the regions on the borders of the tiles.
Some methods have been proposed to stitch them but this still remains an open issue.

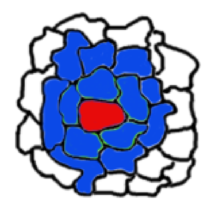
Contributions

A methodology is proposed to solve this discrepancy for region-growing segmentation such as the Baatz & Shape algorithm [2]. We introduce the concept of mutuality for region-growing methods which allows to define the area of influence of a region to consider in order to process it independently from other regions.
We define a processing method for large scale segmentation using this concept based on 3 steps:

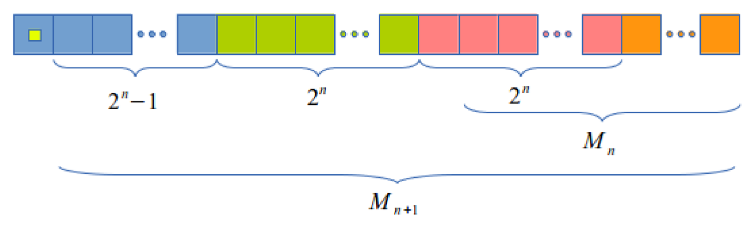
1. Tile based reduction step
2. Iterative reduction step
3. Completion of the segmentation

Concept of mutuality

A region R_1 merges with a neighboring region R_2 if R_2 is the best neighboring region according to the fusion criterion and if R_1 is the best neighboring region of R_2 according to the same fusion criterion

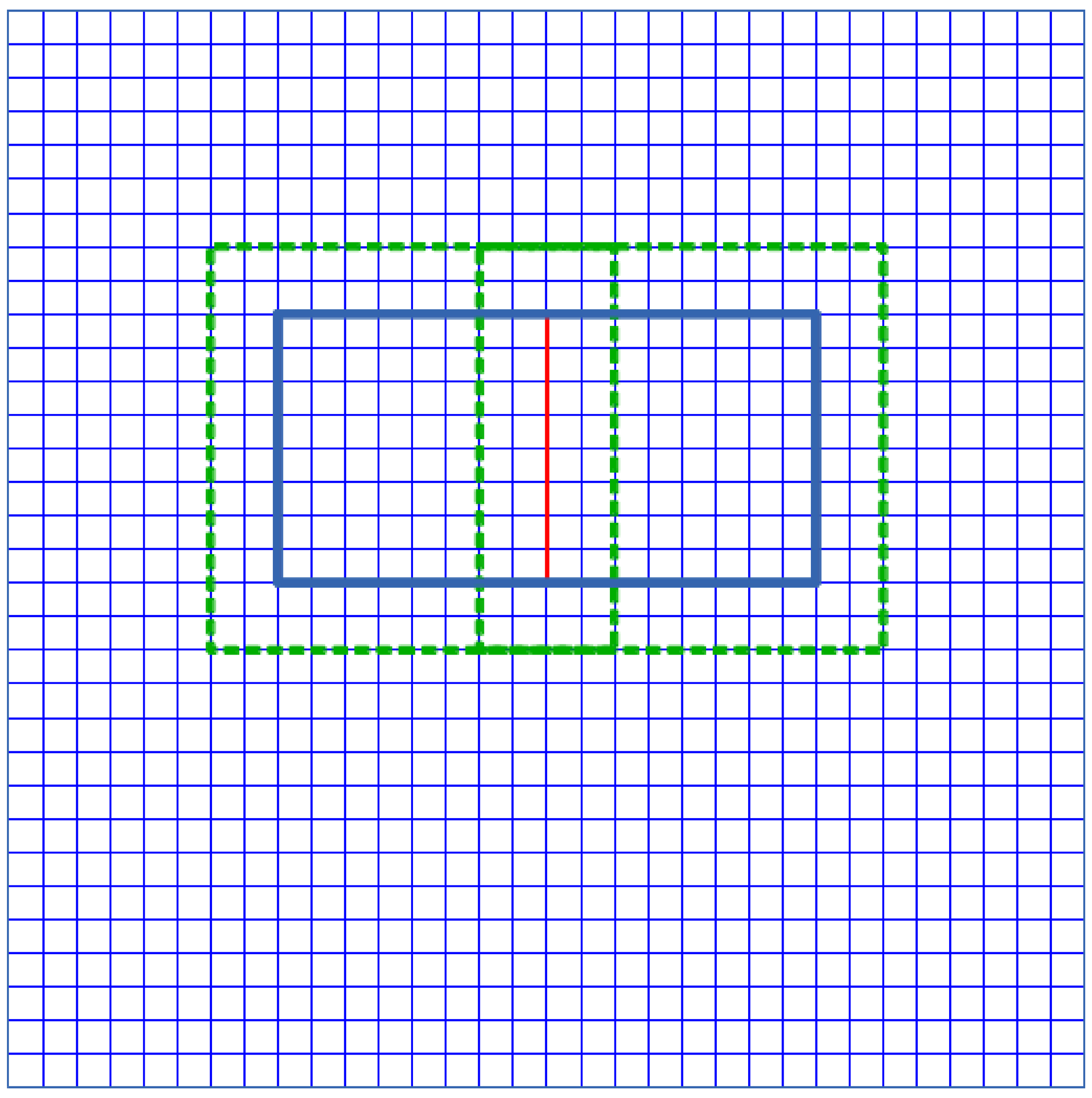


area of influence

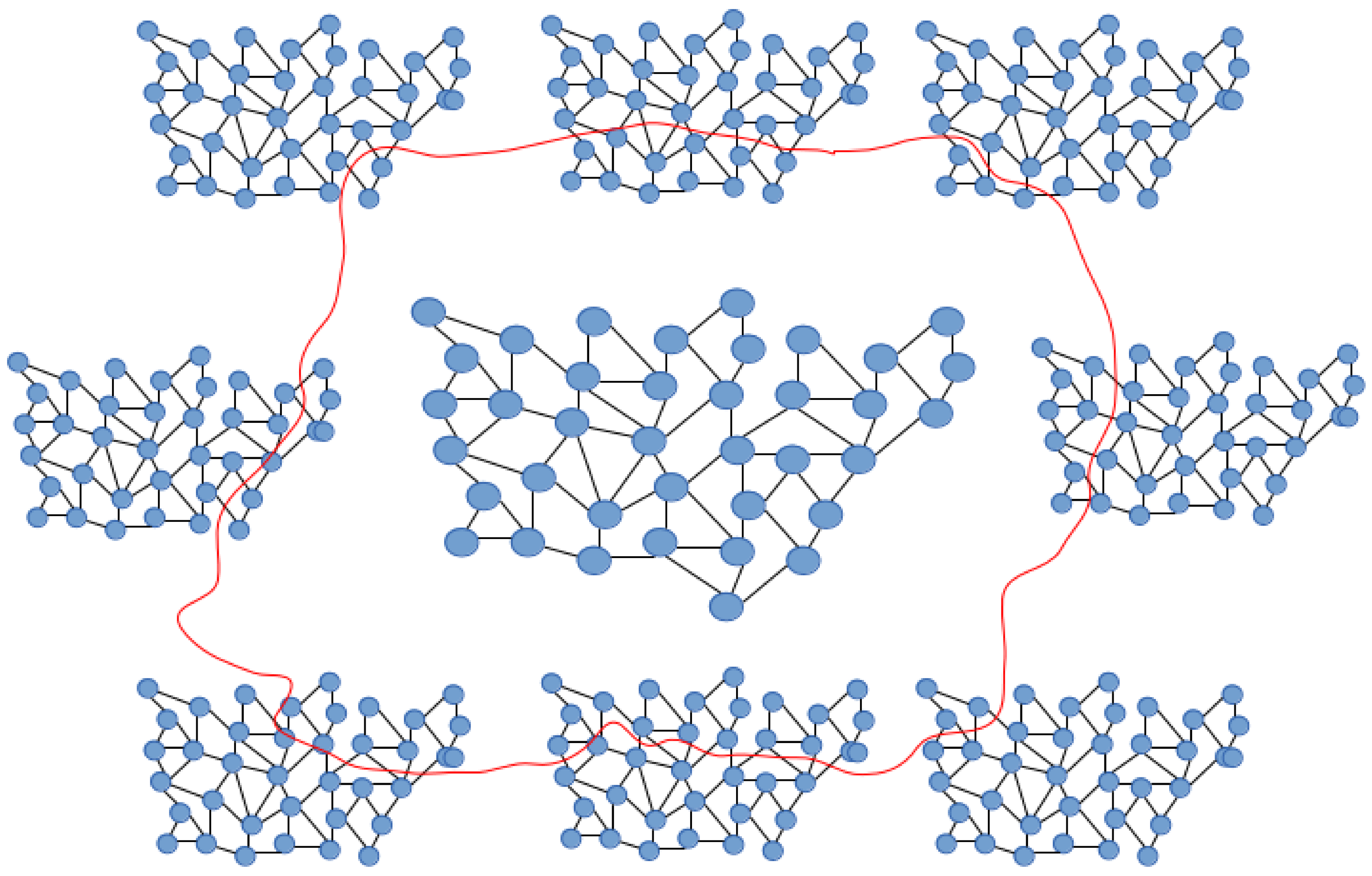


Stability margin in pixels according to the number of iterations n

Proposed methodology for large scale segmentation



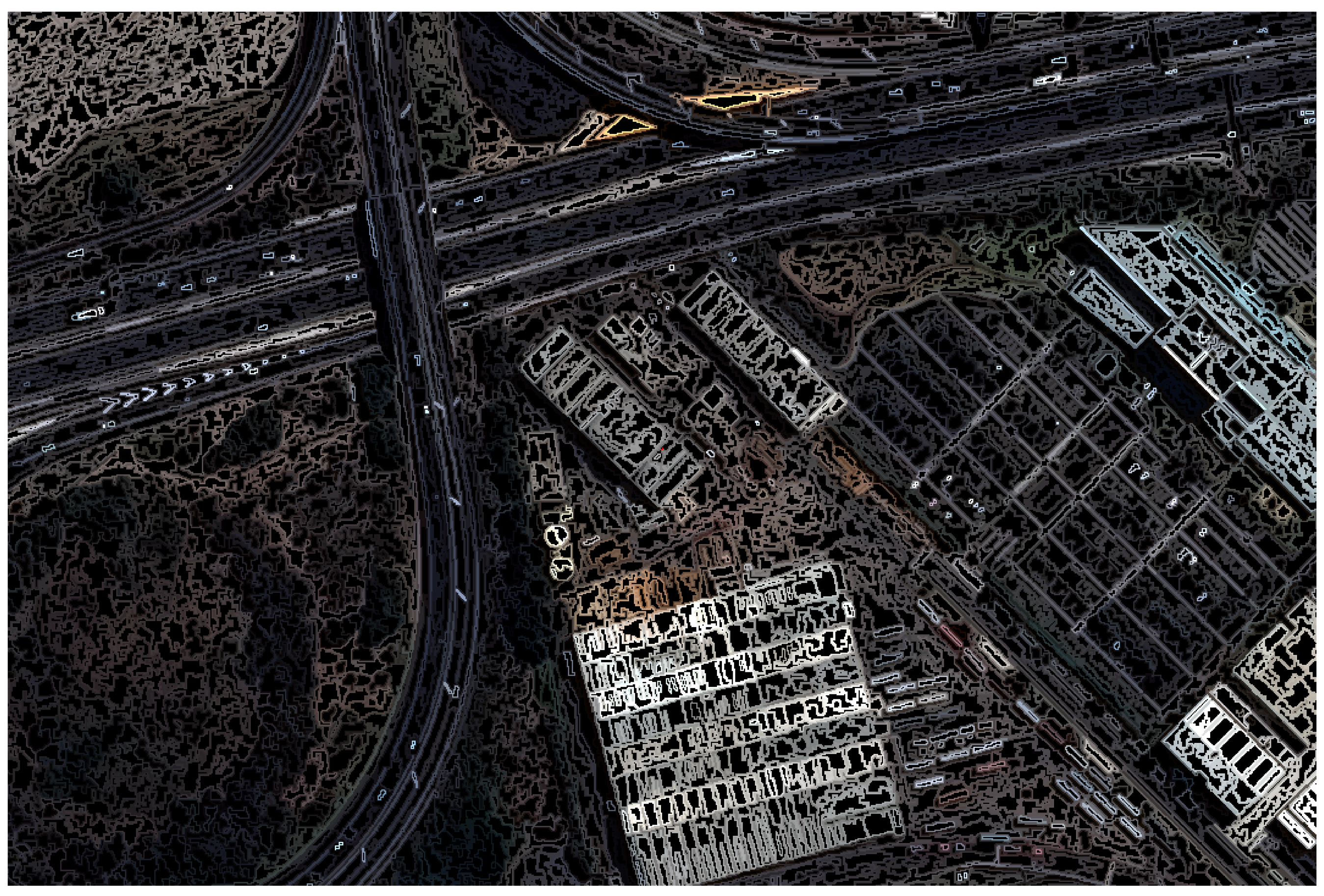
Tile-based reduction step
For each sequence of tiles of the image, each tile with its additional stability margin M_{n_1} is segmented sequentially with respect to n_1 iterations.



Iterative reduction step
For each sequence of tiles, the corresponding list of segmented regions with its area of influence is segmented with respect to one iteration. This process is repeated until we can store all the resulting regions of the image in memory.

Results

This methodology was applied to a 32768 × 16384 pixels extract of a pan-sharpened Pleiades scene of Melbourne, Australia. The region-growing algorithm uses the Baatz & Shape criterion. The segmentation was driven by an Intel(R) Xeon(R) quadricore CPU at 2.8 Ghz with 15 GB of memory. With these specifications, we propose to divide the image into sequences of 4 tiles of size 1024 × 1024 pixels. For the Tile-based reduction step we consider $n_1 = 8$ iterations and for the Iterative reduction step $n_2 = 12$ iterations. It has been determined experimentally that 20 iterations are sufficient to be able to store all the regions in memory. The first step took approximately 5 hours, the second step 6 hours and the completion of the segmentation 1 hour and half. No artifacts and a perfect match of the border regions across the tiles during the execution prove the correctness of the method.



Conclusion and future direction

The memory issue is overcome and it is now possible to segment Pleiades images without artifacts using time-wise computation. The efficiency issue still remains and a future direction is to parallelize this new approach.
The parallelism will be explored on two levels:

1. Low-level parallelism using multithreading and GPU
2. High-level parallelism using CPU clusters.

References

[1] Julien Michel, Manuel Grizonnet, Julien Malik & all Open tools and methods for large scale segmentation of very high resolution satellite images. In *Open Source and Geospatial Research and Education Symposium*, 2012.

[2] Martin Baatz, Arno Shape A multiresolution segmentation: an optimization approach for high quality multi-scale image segmentation In *XII Angewandte Geographische Informationsverarbeitung, WhichmannVerlag, Heidelberg*, 2000.