Review of the Dissertation Thesis

**Interactive Processing of Volumetric Data**

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In his dissertation thesis, Jan Kolomazník concerns himself with interactive visualization and segmentation of volumetric data using GPU acceleration, namely segmentation workflow, minimal graph-cut search, formalism for massively parallel algorithms based on cellular automata. The topic is not new nevertheless it is up to date as methods producing visualization and segmentation of volumetric remain computationally too expensive for rendering in interactive environment. Thus, each incremental technique which successfully strives to push the state of the art either towards quality or towards lower computational demands is worthwhile.

The main contribution – CUGIP Library based on NVIDIA CUDA framework using cellular automata formalism with proposed extensions, analysis of the bottlenecks, the novel 2D transfer function – was published in two WoS publications [Horacek 2015, 2011] and conferences [Kolomazník 2012, 2015] and is summarized in Chapter 4 and partially in Chapter 5 of the thesis.

The thesis is structured into 7 chapters having 121 pages including the list of references consisting of 76 items that are not adequate because there are missing new scientific papers from 2014. After the Introduction, a (25 pages) survey and introductory part of the thesis follows. As a contribution of the thesis the author summarizes large body of related state-of-the-art on transfer functions in Chapter 2, cellular automata and watershed transformation in Chapter 3 and minimal graph-cut in Chapter 4. Unfortunately, limitations of the surveyed methods and the relation to the author’s work remain often unclear. Sometimes the details of the equations their parameters are not clear because the text does not explain the idea corresponding to equation. Some equations are not used in my opinion in the implementation because they are not suitable for parallelism. For example, Chapter 6 is mostly a summary of active contour models ACM but the contribution is minor, the implementation was not done on GPU. Chapter 7 is a summary and description of the entire workflow.

The part describing author’s contributions is rather briefly scattered at the end of Chapters 3.3.3, 4.1.4 - 4.1.7, 5.4.2. The proposed ideas are 1. To precompute the eigenvalues of Hessian matrix and compute the objectness measure on the fly based on interactive tuning of parameters α, β, γ [Horacek 2015]; 2. The most interesting for me was the idea of extension of cellular automata formalism with hidden updates, the global state, and cell pointers and application to watershed transformation [Kolomazník 2012]. 3. Design of parallel version of the Goldberg’s push-relabel algorithm, which can be utilized for non-grid graphs [Kolomazník 2012]. 4. The use of statistical models for initialization of ACM models in 2D/3D segmentation [Kolomazník 2015].

Page 31 benchmarks: Comparison is not adequate, it’s better to compare to some other parallel implementation. Eq. 3.22 Have used the equation in the implementation and how?

Def. 4.9: Missing {S,Null} before Sp in rule extension?

Fig. 4.4 – 4.5 are useless images because noise is not important here but the problem is parallelism and efficiency.
How to understand the meaning of v, l, d in CA rule 4.3 page 69?

An example if simple graph and the exact filled data in scheme will improve the understanding of Fig. 5.4. CUDA implementation of some of Algorithms 11-15 could help.
Eq. 6.15 what is the relation between S, and C and Φ in Eq. 6.22?
Mismatch in CA rule 4.6.

Chapter "Future work" lists non-trivial problems and I think the author did the intensive investigation to find the good parallel implementations.

Publication activity:

Most of the authors publications are presented on international conferences. Author published two papers included in Web of Science (WoS) the conferences DICTA and IMAGAPP, another two at international conferences VISI-GRAPP 2015 and CE-CG-CV. According to my knowledge author didn't publish a single journal article! Nevertheless, international community had enough chances to adequately evaluate the authors contribution and results.

Questions:

I'm curious to understand how to convert the CA rules into a CUDA code on a simple example. What will need to be changed to generate OpenCL code to get the multiplatform parallel implementation? Can OpenCL solve some future work problems automatically like unified memory, memory allocation in kernels and dynamic parallelism?

Can you comment more on comparison and testing the ACM models with other parallel implementations if you have done the parallelization? What was the main idea behind the parallelization and memory handling?

Conclusion:

The weak spot of the thesis resides in that the author compares often the results obtained serial implementations and not with results obtained by other parallel algorithms (Page 31, Fig. 4.4., 4.5). Algorithm in Chapter 5.6 has too many drawbacks listed such as no speed gain, bottlenecks, limited PGU memory but you claim you have the optimized version in CUDA. Algorithms in Chapter 6 (statistical methods and ACM) have not been parallelized nor compared to other parallel implementations. The concept of CA was not used at all in Chapers 5, 6. The scientific novelty and contribution of presented content is mostly in implementation and parallelization of serial algorithms. The novel results are not easily distinguishable from the previous work. Regarding these shortcomings, author proved the ability to do the highly scientific research and I recommend the thesis for the defense and honor RNDr. Ján Kolomazník the PhD title.
Please contact me in case of any further questions.

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