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Review of the PhD thesis entitled:

Feature-based Multi-resolution Topography

Submitted by Lukas Bruha, Department of Applied Geoinformatics and Cartography, Faculty of Science, Charles University in Prague.

This review is given by:

Associate Professor, PhD **Lars Bodum**, Department of Development and Planning, Aalborg University, Denmark.

Supervisor for the thesis has been:

Tomas Bayer, Department of Applied Geoinformatics and Cartography, Faculty of Science, Charles University in Prague.

Description of the thesis

This thesis presents an investigation into how both terrain and discrete objects can be represented on a topographic surface. How geographical space can be modelled with a specific focus on 2D and 3D representations and the vast amount of different solutions somewhere between 2D and 3D. The thesis serves as both a comprehensive review of different research projects and literature within this area and presents the research and developments made by the doctoral candidate himself. The concept of footprint is the most dominating new developed technology from the doctoral candidate and he demonstrates his research skills through the thorough documentation and argumentation of these new ideas. But it does not stop there. The doctoral candidate also documents the technological solutions for an integration of both features and terrain representation into one aggregated solution. Finally the developed solutions are demonstrated through an experiment with live

OpenStreetMap (OSM) data and the doctoral candidate conclude on his work and relates it to ideas and concepts for future research.

The structure of the thesis has been developed as a monography with a strong focus on the review of existing published research within this research field. It is made clear that this research is done while standing on the shoulders of strong developments done previously or at the same time as the developments from the doctoral candidate.

The visual presentation of the thesis stands out as a professional and well-illustrated publication. Both the English language and grammar holds very high quality and the thesis is well written and comprehensible for peers and professionals within the research area. The titles – that goes for both the main title and the titles of chapters and sections – are understandable and helps the reader to navigate between chapters and specific extracts of the thesis. The cross-referencing between the main text and the reference list in the back of the publication works flawlessly and gives the reader a valuable tool for immediate look-ups.

The work presented here fulfils the requirements in relation to form and structure that you would expect from a PhD. thesis in general.

Assessment of the thesis

It is very important to understand the concepts and the differences between various applications and solutions for modelling geographical space especially in 2+D and 3D. Within the last 10-15 years a huge number of tools and viewers have been promoted and launched that mainly focus on the visualisation and very simple queries in the form of look-ups and hyperlinks. If we want to model and represent real geographical space and be able to query and perform analytical work directly through a digital Earth system, we need to dedicate much more research time to the problems that emerge when we go into the world of 3D solutions. That is the main message from this thesis and from the work of the PhD candidate and I agree 100% with him.

The motivation behind and relevance of the main research question is well reasoned in the thesis. The main question is broken down into nine partial questions and the PhD candidate sets out on a long journey to answer these nine questions. Unfortunately, I find the wording and English grammar of many of these questions faulty. I will mention partial question three (3.) as an example: “How can be formally described what is multiple LOD environment?” (p. 5). In English this sentence makes very little sense! These questions play an important role as motivation for the investigations into the different theories and approaches. Therefore, I find it important that the research questions are formulated correct. The doctoral candidate should have checked both language and understanding of these questions before they were published.

Many of the partial questions are related to the design of the developed system. I would have preferred that the general questions related to theories and different approaches were put up first and answered as they are in the first two chapters. Then it would have been good to outline a conceptual design of the solutions proposed and conclude this with the last group of partial questions related to the specific design of the developments. That

way the doctoral candidate could have made a better distinction between the part of the thesis that referred to earlier work and the part where his own developments are presented.

In general, the doctoral candidate sets up an interesting framework for his research where important inspirational work are referenced and referred to throughout the thesis. That makes the material very conceivable and easy to understand. The doctoral candidate shows a remarkable experience within the research field of topographic mapping on Earth systems. His contributions to the field, especially in regard to the concept of footprints, are very useful and will help to clarify the subject of placing features onto the topography.

In the following I will give some individual comments to each of the chapters in the thesis:

Chapter 1 – Introduction

Good and valuable for the understanding of the research field. However, the sub-questions derived from the main research objective could need a clarification and reformulation so that they stand out more clear in their message. Otherwise very clear introduction to the research field and to the work done.

Chapter 2 – Research background

One of the strongest chapters of the thesis where main contributions to the field of research are presented and commented.

Chapter 3 – Conceptual requirements and theoretical foundations for the multi-resolution topography

This chapter presents the concepts and ideas around footprints and how features are represented in the system. The solution requires a strong commitment towards a genuine geospatial representation without speculations about the quality of the final visualisation. The important aspect is the availability of the original geometry of the object at all time. More requirements are stated and they are all very relevant for the definition of the solutions presented in the thesis.

Chapter 4 – Feature-based enhancement of multi-resolution topographic surface

This chapter holds the implementation and the formulation of the solution presented. Here the doctoral candidate shows his ability to handle not only the concepts and ideas but also shows computational, mathematical and programming competences. It was a pleasure to read this chapter and see the high quality of the work done here.

Chapter 5 – Terrain-aware generalization of features

The terrain and the features represented onto the terrain have to work in a relation. That means it will be necessary to generalise and adapt the features to the terrain and visa versa.

Chapter 6 – Experiment

The ideas and concepts are tested through an experiment where OSM data are imported into the system and visualised on terrain. It is very relevant to show that the ideas and developments can work and be implemented in a user-oriented geospatial solution.

Chapter 7 – Conclusions and future research

The doctoral candidate concludes on his research work and gives the readers some ideas about future work to be done. This is also a follow up on the research objectives that was presented in chapter one.

General remarks

The thesis is well organized in the structure of content. Language and grammar are generally well used, but there are exceptions as pointed out in this assessment.

Based on the aspects mentioned above it can be summarized that the positive, scientifically valuable contributions clearly predominate some shortcomings that occur.

Considerations for defence of the PhD degree

The reviewer would like to make some hints to relevant questions and the oral elaborations from the candidate during the defense that could strengthen the overall impression of the research done by him.

- What is the take home message or messages of the thesis? What should (international) research and others learn from the thesis?
- How do the doctoral candidate see the concept of footprints used in future applications – with more specific references to practical examples?
- Please elaborate a little more over the last sentence in chapter 7, where ideas about 4th and 5th dimension are introduced. Do the doctoral candidate see his work as a contribution to these thoughts and what is actually meant by 4th and 5th dimension?

Recommendation

I find the thesis highly acceptable for public defence that is scheduled for Wednesday 14 September 2016. I will also, in the light of this review, recommend that the PhD candidate is awarded the PhD degree from the Faculty of Science at Charles University in Prague.



Lars Bodum
Aalborg, 30/8 2016