*Review of a Doctoral Thesis at FIT BUT*

**Doctoral thesis** (hereinafter referred to as "thesis"), title of the thesis:

**AUTOMATIC POINT-FEATURE LABEL PLACEMENT**
**AUTOMATICKÉ UMÍSŤOVÁNÍ POPISU BODOVÝCH DAT**

**Name of the doctoral student** (hereinafter referred to as "student"), name and surname:

**Ing. PETR BOBÁK**

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**Name and institution of the reviewer** (full name of the reviewer, full name and country of the institution):

**Eduard Gröller**
**TU Wien**
**Institute of Visual Computing & Human-Centered Technology**
**Favoritenstr. 9-11 / E193-02**
**A-1040 Vienna**
**Austria - Europe**

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Please state your opinion on the following aspects of (I) the student's thesis and (II) the student's overall achievements, and (III) state your conclusion (a minimum of approx. 300 characters foreach item below is recommended):

## I. Thesis

### Appropriateness and relevance

Is the area addressed by the thesis appropriate to the particular scientific discipline of the thesis and does the thesis address relevant problems within the chosen area?

**The dissertation addresses the highly relevant and challenging topic of label placement within complex visualizations across domains like cartography, medical imaging, and emergency response management, aligning well with the scientific discipline of visual communication and spatial data representation in visualization and computer science at large. It targets critical problems in label placement, focusing on both internal (labels placed within visualization boundaries) and external (labels positioned outside the visualization with connecting lines) techniques. The thesis topics are very relevant and clearly address significant gaps in our research field.**

### A summary of the contributions of the thesis

From your point of view, please summarize what the goal of the thesis is, what the main contributions of the thesis are, and whether the thesis has achieved the chosen goal.

Please indicate also specific contributions of the student.

**The thesis consists of six chapters, an extensive bibliography, and detailed appendices. By addressing the stability, readability, and perceptual alignment of labels, the work tackles practical issues that directly impact the effectiveness of visual representations. The use of novel optimization methods for boundary label placements, machine learning for enhanced and complete label positioning, and**

**perceptual studies for user-preferred placement highlights an in-depth and appropriate approach to improving visual clarity and usability. The research is highly relevant as it fills significant gaps in dynamic and dense visualization environments, where traditional cartographic guidelines may be insufficient, thus contributing valuable insights and advancements to the field.**

Novelty and significance:

Please assess the level of novelty of the results and their significance for the given scientific area, for its further development, and if applicable for possible applications in practice.

**The thesis presents a series of novel contributions with significant implications for both the academic field of dynamic scene labeling and potential practical applications.**

**Chapter 1 opens with a concise introduction that establishes the topic's scientific importance. Chapter 2 delivers a thorough, systematic review of the current state-of-the-art, offering structured tabular overviews that reveal insights into the extensive body of prior research. This comprehensive overview is valuable enough to merit a separate publication.**

**In Chapter 3, the thesis introduces several interesting contributions to boundary labeling in dynamic scenes, including a stable offline labeling method, an innovative stable labeling method for interactive visualizations, expanded labeling terminology, visibility optimization based on feature prominence with smooth label transitions, and a comparative analysis validated by a detailed user study.**

**Chapter 4 marks a major innovation by presenting the first machine-learning-driven approach to point-feature labeling through reinforcement learning with a compact neural network model. This chapter is notable for its well-supported arguments for a multi-agent strategy, carefully considered design choices, and extensive ablation studies, which collectively demonstrate that this new approach apart from temporal performance considerations outperforms existing techniques in both quantitative and qualitative assessments.**

**Chapter 5 explores Position Priority Orders (PPOs) and introduces a user-centered variant, PerceptPPO, developed from global survey data. This study identifies an optimal map label density of 12.5% and demonstrates that PerceptPPO enhances user experience in visualizations over traditional methods. The meticulously crafted online study design supports objective and meaningful insights. Chapter 6 succinctly rounds off the thesis with summarizing the research outcomes, limitations, and future work.**

**The stated thesis goals have been very well achieved. Overall, the thesis makes relevant scientific contributions that advance dynamic scene labeling and establish novel ways for machine-learning-driven approaches in this domain. Its findings have clear implications for further research and potential applications in practical settings, particularly for user-centered visualization strategies.**

Evaluation of the formal aspects of the thesis:

Please evaluate formal qualities of thesis and its language level.

**The thesis is well-written, with high-quality language and clear, expressive figures and tables. Minor improvements could enhance readability: figures generally could have been larger, and in some cases, lengthy captions could be condensed, with details moved to the main text. Temporal performance**

**numbers appear throughout the thesis, though the hardware and software configuration details provided later would have been helpful earlier to give these numbers context. Certain heuristic parameters could benefit from further explanation (just a few examples: w_row, w_offset, and epsilon on pages 58, 81, and 82).**

**The supplementary material is detailed and supports reproducibility, though some small figures are difficult to perceive, where even zooming is limited by resolution constraints. These are minor points that do not detract from the overall high quality of the thesis. In conclusion, the thesis is notably well-structured, didactically sound, and easy to understand.**

Quality of publications

Has the core of the thesis been published at an appropriate level? Please judge the quantity and quality of the publications. When judging the quality, please take into account internationally recognized standards (WoS/Scopus quartiles, CORE ranks, specific knowledge of flagship publication channels of agiven community, etc.) in a way appropriate for the given area of the thesis.

**The thesis is well-supported by a series of high-quality publications that demonstrate significant contributions to the field.**

**The publication "Video Sequence Boundary Labeling with Temporal Coherence," has been presented at the Computer Graphics International Conference, one of the oldest and prestigious annual conferences in computer graphics. The proceedings from this conference were published by Springer, highlighting the publication's credibility.**

**The follow-up paper, "Temporally Stable Boundary Labeling for Interactive and Non-Interactive Dynamic Scenes," appeared in Computers & Graphics, a respected Elsevier journal dedicated to disseminating research and applications of computer graphics techniques. This publication further reinforces the thesis's foundation in high-level research.**

**The 2024 publication, "Reinforced Labels: Multi-Agent Deep Reinforcement Learning for Point-Feature Label Placement," stands out as the highlight among the dissertation publications. It introduces an innovative machine-learning-based approach to an important labeling problem and was published in the IEEE Transactions on Visualization and Computer Graphics (TVCG) journal. TVCG is considered the leading journal in the field of visualization and is known for its rigorous standards.**

**Additionally, the thesis is based on the publication "From Top-Right to User-Right: Perceptual Prioritization of Point-Feature Label Positions," which is currently under submission and available on arXiv. Given the interesting results presented, it is reasonable to anticipate that this submission will also lead to a publication in a high-quality journal or conference.**

**Overall, the dissertation is backed by a robust collection of publications in prestigious scientific journals and conferences, attesting to its significant contributions to the field.**

## II. Student's overall achievements

Overall R&D activities evaluation:

Does the student's thesis, the results included into it, and possible other scientific achievements listed in the list of scientific activities indicate that he/she is a person with scientific erudition and creative abilities?

**The thesis is a well-crafted scientific work with innovative contributions to a highly relevant research area. The candidate has participated in various research projects related to computer vision, enhanced reality, and machine learning, demonstrating a broad expertise across multiple computer science domains. Notable projects include work on computer vision and computer graphics algorithms and user interfaces.**

**The candidate has also engaged in science dissemination through presentations at international conferences, showcasing his research on multi-agent deep reinforcement learning and video sequence boundary labeling.**

**His professional experience includes multi-year expertise as researcher and engineer by participating at various university projects. Overall, the candidate's diverse activities and achievements indicate strong scientific expertise and creative abilities.**

Assessment of other characteristics (optional):

More characteristics of the student may be added here (e.g., awards, grant participation, international collaboration, etc.).

**The candidate has actively engaged in teaching and supervision at Brno University of Technology, since 2018. His roles include serving as a reviewer and opponent of Master's and Bachelor's theses, supervising student theses, and instructing the course on Computer Graphics Principles. These contributions highlight the candidate's commitment to education and mentorship.**

**During his doctoral studies, Petr Bobak collaborated with Bar-Ilan University in Tel Aviv on the international project "Deep-Learning Approach to Topographical Image Analysis" from July 2019 to June 2022. Two publications resulted from this collaboration and the candidate visited the Bar-Ilan University in November 2019 to present his findings.**

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## III. Conclusion

The conclusion should contain an explicit statement saying whether, in your opinion, the thesis and the student´s achievements until now meet the generally accepted requirements for the award of an academic degree (in accordance with Section 47 of Act No. 111/1998 Coll., on higher education institution).*

* Short overview of both the Act and corresponding internal BUT regulations is enclosed.

**The thesis is very well-written and easy to understand, providing significant contributions across multiple dimensions. It introduces several novelties, including new algorithms, innovative problem formulations—particularly relevant in a machine learning context—and presents comprehensive qualitative and quantitative evaluations. These evaluations are accompanied by detailed ablation studies in various sections, ensuring a thorough analysis.**

**Moreover, the evaluations do more than merely present data; they reveal a range of non-trivial insights that deepen the reader's understanding of the subject. Overall, the thesis and the student´s achievements until now fully meet the generally accepted requirements for the award of an academic degree (in accordance with Section 47 of Act No. 111/1998 Coll., on higher education institution).**

**Vienna 29.10.2024**

**Signature of the reviewer:**

**Univ.Prof. Dr. Eduard Gröller**

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