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INSTITUT FÜR
INFORMATIK

UNIVERSITÄT BONN · Prof. Dr. Anne Driemel · 53012 Bonn

Prof. Dr. Anne Driemel

Abteilung V
Algorithmen und Komplexität

Friedrich-Hirzebruch-Allee 5
53115 Bonn
Tel.: 0228/73-69683
driemel@cs.uni-bonn.de
http://anne.driemel.net

prof. Zdeněk Doležal
Faculty of Mathematics and Physics
Charles University

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Review of the habilitation thesis titled

Topological drawings of graphs

by Jan Kynčl, Charles University, Prague

This letter is in response to your request to review the habilitation thesis of Jan Kynčl with the title "Topological drawings of graphs". I do not know Jan Kynčl personally and I have not worked together with him in the past. In the following, I give my evaluation of the thesis towards a recommendation to the habilitation committee.

The thesis is comprised of 6 journal papers [P1]-[P6] and one conference paper [P7]. The journals are all highly reputable international journals with papers of excellent quality in the areas computational geometry and combinatorics. The conference is the leading conference in the field of computational geometry. The thesis also contains an introduction into the main research topics and three additional chapters that put the main results of the thesis into context.

One of the main topics of the thesis are characterizations of planar graphs via the Hanani-Tutte theorem. In its most basic form the Hanani-Tutte theorem says that a graph is planar if and only if it has a drawing with an even number of crossings between every pair of edges. These characterizations have implications for planarity testing, but they are also interesting in their own right. There are many variants of the theorem, some of them making weaker assumptions on the set of pairs of edges to be considered and some of them giving stronger implications on the combinatorial structure of an existing crossing-free drawing.

[P5] contains a unified Hanani-Tutte theorem that is strictly stronger than previous versions. It makes weaker assumptions and at the same time gives stronger implications. In addition it also has a simplified proof. The thesis contains several extensions of this theorem to other notions of planarity. In [P4] the authors extend the theorem to clustered planarity. A clustered graph is a graph together with a hierarchical clustering of its vertices. Clustered planarity means that the graph has a crossing-free drawing where every cluster is separated from the remaining vertices by a topological disk. It is a very useful concept that has many different applications. The extended Hanani-Tutte theorem has important implications for testing clustered planarity.

In [P6] the authors consider drawings of graphs on surfaces. Here, instead of planarity, one speaks of the genus of a graph, as the smallest number g such that the graph has crossing-free drawing on the surface of genus g. The picture is more subtle here. While an extension of the weak Hanani-Tutte theorem to every orientable surfaces exists, the paper gives a counter-example to an extension of the strong Hanani-Tutte theorem on the surface of genus 4, disproving a conjecture by Schaefer and Štefankovič.

Another central topic of the thesis are crossing numbers and minimizing the number of crossings in a drawing of a graph. The crossing number of a graph is the smallest number of crossings of a drawing of the graph in the plane. Hill's conjecture, if true, gives a closed-form expression for the crossing number of the complete graph of n vertices. The conjecture has been verified for small n up to 14, but in general it is still open. In [P1] the conjecture is verified for a special class of drawings where all edges are drawn x-monotone. This paper had quite an impact. After the publication, more classes of drawings were shown to satisfy Hill's conjecture.

The paper [P1] also shows the same closed-form expression for other variants of the crossing number, giving a more precise characterization of monotone drawings of complete graphs. A useful concept in this context are simple drawings. In a simple drawing, every pair of edges crosses at most once (also counting vertices). [P1] contains a characterization of all simple monotone drawings of the complete graph of n vertices in terms of a finite list of forbidden configurations.

In the single-authored [P2] Jan Kynčl shows a very useful theorem about the realizability of a complete abstract topological graph as a simple drawing which reduces the problem to checking all subgraphs of at most 6 vertices.

In [P3] the authors work towards facilitating the application of the knowledge on simple drawings of complete graphs to drawings of general graphs. To this end, they define the notion of saturated drawings. These are drawings where adding an edge destroys the simplicity. They study the minimum number of edges that such a saturated simple drawing of n vertices can have.

These works clearly show that the Jan Kynčl is an independent and matured researcher who has developed an academic standing in his own field, someone who is actively engaged in the scientific discourse by pushing the state of the art and whose works have impact in the wider research community.

For this reason I strongly recommend to accept the habilitation thesis.

I was asked to comment on the plagiarism check of the turnitin reports that accompanied the thesis. The plagiarism check found many matches with the papers that are included in the thesis and that have been published already as independent works. This is not surprising. I have no reason to doubt that the works included in the thesis and the thesis itself constitute original research by the author(s).

Anne Driemel