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Hee-Kap Ahn · Chan-Su Shin (Eds.)

Algorithms and Computation

25th International Symposium, ISAAC 2014
Jeonju, Korea, December 15–17, 2014
Proceedings

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Preface

The papers in this volume were presented at the 25th International Symposium on Algorithms and Computation (ISAAC 2014), held in Jeonju, South Korea, during December 15–17, 2014. In the past, ISAAC was held in Tokyo (1990), Taipei (1991), Nagoya (1992), Hong Kong (1993), Beijing (1994), Cairns (1995), Osaka (1996), Singapore (1997), Taejon (1998), Chennai (1999), Taipei (2000), Christchurch (2001), Vancouver (2002), Kyoto (2003), Hong Kong (2004), Hainan (2005), Kolkata (2006), Sendai (2007), Gold Coast (2008), Hawaii (2009), Jeju (2010), Yokohama (2011), Taipei (2012), and Hong Kong (2013) over 25 years from 1990 to 2014.

ISAAC is an acclaimed annual international symposium that covers a wide range of topics in algorithms and theory of computation, and that provides a forum for researchers where they can exchange ideas in this active research community. In response to the call for papers, ISAAC 2014 received 171 submissions from 38 countries. Each submission was reviewed by at least three Program Committee members with the assistance of 189 external reviewers. Through extensive discussion, the Program Committee selected 60 papers for presentation in ISAAC 2014. Two special issues, one of *Algorithmica* and one of *International Journal of Computational Geometry and Applications*, are prepared for some selected papers among the presented ones in ISAAC 2014.

The best paper award was given to “Concentrated Hitting Times of Randomized Search Heuristics with Variable Drift” by Per Kristian Lehre and Carsten Witt. Two eminent invited speakers, Ulrik Brandes from University of Konstanz, Germany and Giuseppe F. Italiano from Università di Roma “Tor Vergata”, Italy, gave interesting invited talks at the conference.

We would like to thank all Program Committee members and external reviewers for their excellent work in the difficult review and selection process. We would like to thank all authors who submitted papers for our consideration; they all contributed to the high quality of the conference. We would like to thank Conference Chair Kunsoo Park and Organizing Committee members for their dedicated contribution. Finally, we would like to thank our conference volunteers, sponsor SRC-GAIA (Center for Geometry and Its Applications), and supporting organizations KIISE (The Korean Institute of Information Scientists and Engineers) and SIGTCS (Special Interest Group on Theoretical Computer Science) of KIISE for their assistance and support.

December 2014

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Invited Talks

Biconnectivity in Directed Graphs^{*}

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Edge and vertex connectivity are fundamental concepts in graph theory with numerous practical applications. Given an undirected graph $G = (V, E)$, an edge is a *bridge* if its removal increases the number of connected components of G . Graph G is 2-edge-connected if it has no bridges. The 2-edge-connected components of G are its maximal 2-edge-connected subgraphs. Two vertices v and w are 2-edge-connected if there are two edge-disjoint paths between v and w : we denote this relation by $v \leftrightarrow_{2e} w$. Equivalently, by Menger’s Theorem, v and w are 2-edge-connected if the removal of any edge leaves them in the same connected component. Analogous definitions can be given for 2-vertex connectivity. In particular, a vertex is an *articulation point* if its removal increases the number of connected components of G . A graph G is 2-vertex-connected if it has at least three vertices and no articulation points. The 2-vertex-connected components of G are its maximal 2-vertex-connected subgraphs. Two vertices v and w are 2-vertex-connected if there are two internally vertex-disjoint paths between v and w : we denote this relation by $v \leftrightarrow_{2v} w$. If v and w are 2-vertex-connected then Menger’s Theorem implies that the removal of any vertex different from v and w leaves them in the same connected component. The converse does not necessarily hold, since v and w may be adjacent but not 2-vertex-connected. It is easy to show that $v \leftrightarrow_{2e} w$ (resp., $v \leftrightarrow_{2v} w$) if and only if v and w are in a same 2-edge-connected (resp., 2-vertex-connected) component. All bridges, articulation points, 2-edge- and 2-vertex-connected components of undirected graphs can be computed in linear time essentially by the same algorithm based on depth-first search.

While edge and vertex connectivity have been thoroughly studied in the case of undirected graphs, surprisingly not much has been investigated for directed graphs. Given a directed graph G , an edge (resp., a vertex) is a *strong bridge* (resp., a *strong articulation point*) if its removal increases the number of strongly connected components of G . A directed graph G is 2-edge-connected (resp., 2-vertex-connected) if it has no strong bridges (resp., strong articulation points and has at least three vertices). The 2-edge-connected (resp., 2-vertex-connected) components of G are its maximal 2-edge-connected (resp., 2-vertex-connected) subgraphs. Similarly to the undirected case, we say that two vertices v and w are 2-edge-connected (resp., 2-vertex-connected), and we denote this relation by

^{*} Work partially supported by the Italian Ministry of Education, University and Research, under Project AMANDA (Algorithmics for MAssive and Networked DATA).

$v \leftrightarrow_{2e} w$ (resp., $v \leftrightarrow_{2v} w$), if there are two edge-disjoint (resp., internally vertex-disjoint) directed paths from v to w and two edge-disjoint (resp., internally vertex-disjoint) directed paths from w to v . (Note that a path from v to w and a path from w to v need not be edge-disjoint or vertex-disjoint). It is easy to see that $v \leftrightarrow_{2e} w$ if and only if the removal of any edge leaves v and w in the same strongly connected component. Similarly, $v \leftrightarrow_{2v} w$ implies that the removal of any vertex different from v and w leaves v and w in the same strongly connected component. We define a *2-edge-connected block* (resp., *2-vertex-connected block*) of a directed graph $G = (V, E)$ as a maximal subset $B \subseteq V$ such that $u \leftrightarrow_{2e} v$ (resp., $u \leftrightarrow_{2v} v$) for all $u, v \in B$. It can be seen that, differently from undirected graphs, in directed graphs 2-edge- and 2-vertex-connected blocks do not correspond to 2-edge-connected and 2-vertex-connected components.

Furthermore, these notions seem to have a much richer (and more complicated) structure in directed graphs. Just to give an example, we observe that while in the case of undirected connected graphs the 2-edge-connected components (which correspond to the 2-edge-connected blocks) are exactly the connected components left after the removal of all bridges, for directed strongly connected graphs the 2-edge-connected components, the 2-edge-connected blocks, and the strongly connected components left after the removal of all strong bridges are not necessarily the same.

In this talk, we survey some very recent work on 2-edge and 2-vertex connectivity in directed graphs, both from the theoretical and the practical viewpoint.

Social Network Algorithmics^{*}

Ulrik Brandes

Computer & Information Science, University of Konstanz

Network science is a burgeoning domain of data analysis in which the focus is on structures and dependencies rather than populations and independence [1]. Social network analysis is network science applied to the empirical study of social structures, typically utilizing observations on social relationships to analyze the actors involved in them [2].

Methods for the analysis of social networks abound. They include, for instance, numerous centrality indices, vertex equivalences, and clustering techniques, many of which are applied on networks in other disciplines as well. For substantively oriented analysts, however, it is often difficult to choose, let alone justify, a particular variant method. Similarly, it is difficult for researchers interested in computational aspects to understand which methods are worthwhile to consider and whether variants and restrictions are meaningful and relevant.

In an attempt to bridge the gap between theory and methods, and drawing on a substantial record of interdisciplinary cooperation, we have developed a comprehensive research program, *the positional approach to network analysis*. It provides a unifying framework for network analysis in the pursuit of two closely related goals:

1. to establish a *science* of networks, and
2. to facilitate mathematical and algorithmic research.

The first caters to methodologists and social scientists: by embracing measurement theory, network-analytic methods are opened up for theoretical justification and detailed empirical testing. The second caters to mathematicians and computer scientists: by structuring the space of methods, gaps and opportunities are exposed.

After a brief introduction and delineation of network science and social network analysis, the main elements of the positional approach are introduced in this talk. I will then concentrate on exemplary instantiations for analytic concepts such as centrality, roles, and cohesion. Particular emphasis is placed on resulting combinatorial and algorithmic challenges involving, for instance, partial orders, graphs, and path algebras.

^{*} I gratefully acknowledge financial support from DFG under grant Br 2158/6-1.

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