

論文 / 著書情報
Article / Book Information

題目(和文)	直交半直線交差グラフとその応用に関する研究
Title(English)	Study of Orthogonal Ray Graphs with Applications
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出典(和文)	学位:博士(工学), 学位授与機関:東京工業大学, 報告番号:甲第9787号, 授与年月日:2015年3月26日, 学位の種別:課程博士, 審査員:上野 修一,國枝 博昭,高橋 篤司,一色 剛,原 祐子,高橋 俊彦
Citation(English)	Degree:., Conferring organization: Tokyo Institute of Technology, Report number:甲第9787号, Conferred date:2015/3/26, Degree Type:Course doctor, Examiner:,,,,,
学位種別(和文)	博士論文
Category(English)	Doctoral Thesis
種別(和文)	要約
Type(English)	Outline

Study of Orthogonal Ray Graphs with Applications

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[Ph.D Thesis]

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February 2015

Abstract

Orthogonal ray graphs are the intersection graphs of axis-parallel rays (closed half-lines) in the plane, which are introduced by Shrestha et al. (2009) in connection with the defect-tolerant design of nano-PLAs. This paper deals with structure of orthogonal ray graphs, and some applications to efficient algorithms and compact representations of orthogonal ray graphs.

A 3- and 2-directional orthogonal ray graph is an orthogonal ray graph with rays in 3 and 2 directions, respectively. Various characterizations and a polynomial-time recognition algorithm are known for 2-directional orthogonal ray graphs. A tree is called a (3- or 2-directional) orthogonal ray tree if it is a (3- or 2-directional) orthogonal ray graph. Several characterizations and a linear-time recognition algorithm are also known for 2-directional orthogonal ray trees.

We first show some necessary conditions of orthogonal ray graphs and 3-directional orthogonal ray graphs. We also show several characterizations and a linear-time recognition algorithm for orthogonal ray trees. Moreover, we show that any tree is a 3-directional orthogonal ray tree if and only if it is a 2-directional orthogonal ray tree.

The class of unit grid intersection graphs is a proper superclass of the class of orthogonal ray graphs. We next show that the recognition problem is NP-complete for unit grid intersection graphs. We also show that any grid graph is a unit grid intersection graph. It follows that various combinatorial problems are NP-hard for unit grid intersection graphs.

We then investigate the complexity of some combinatorial problems for orthogonal ray graphs and related graphs by using the structure of these graphs. We deal with the feedback vertex set problem, dominating set problem, and induced matching problem. Applications of the problems can be found in the area of circuit design and network design.

In applications to the design of nano-PLAs, we have to handle large graphs so that the usual representations by adjacency lists or adjacency matrices are infeasible. OBDD representation of graphs is considered as a promising way to deal with such large graphs. We finally show the space complexity of OBDD representation of orthogonal ray graphs and related graphs.