論文内容の要旨

博士論文題目　Algorithms for Independent Set in Some Kinds of Graphs and Its Applications
（ある種のグラフにおける独立集合を求めるためのアルゴリズムとその応用）

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In this dissertation, we discuss algorithms for independent set in some kinds of graphs and its applications.

This dissertation consists of 5 Chapters, and a representation diagram for maximal independent sets of a co-comparability graph is taken up in Chapter 1, and algorithms for generating maximum weight independent sets in intersection graphs are described in Chapter 2, and Chapter 3 and Chaper 4 describe online edge-coloring algorithms for degree bounded bipartite graphs, and application of transitive graph for education support system in Chapter 5.

We are discussing the relation of each chapter from a common problem of independent set respectively. The outline of each chapter is described here.
Chapter 1 : Let $H = (V(H), E(H))$ be a directed graph with distinguished vertices s and t. An st-path in H is a simple directed path starting from s and ending at t. Let $\mathcal{P}(H)$ be defined as $\{S \mid S$ is the set of vertices on an st-path in H (s and t are excluded)$\}$. For an undirected graph $G = (V(G), E(G))$ with $V(G) \subseteq V(H) - \{s, t\}$, if the family of maximal independent sets of G coincides with $\mathcal{P}(H)$, we call H an MIS-diagram for G. In this chapter, we provide a necessary and sufficient condition for a directed graph to be an MIS-diagram for an undirected graph. we also show that an undirected graph G has an MIS-diagram iff G is a cocomparability graph. Based on the proof of the latter result, we can construct an efficient algorithm for generating all maximal independent sets of a cocomparability graph.
Chapter 2 : In this chapter we propose an algorithm for generating maximum weight independent sets in a circle graph, that is, for putting out all maximum weight independent sets one by one without duplication. The time complexity is $O(n^3 + \beta)$, where n is the number of vertices, β output size, i.e., the sum of the cardinalities of the output sets. It is shown that the same approach can be applied for spider graphs and for circular-arc overlap graphs.
Chapter 3 : we consider an edge coloring game of a graph by two persons who are an adversary and an edge-painter. The former strategy is to add or to delete edges in the graph successively. The strategy is called input. The latter colors the edge as soon as an edge is added in the graph. Then it is never changed the color of edges colored. The latter is not given any further information of the adversary's. we call the coloring strategies of the painter online edge-coloring algorithm. In this chapter the painter is allowed arbitrary amount of colors and colors all of edges added in the graph. A

maximum ratio which is a ratio between the number of colors used of an online edge-coloring algorithm A for adversary's family of input and that of offline edge-coloring algorithm is called a competitiveness coefficient of an online edge-coloring algorithm A. we have proved that a competitiveness coefficient of arbitrary randomized online edge-coloring algorithm is greater than $\frac{2k-1}{k}$ where k is maximum degree.
Chapter 4 : A kind of online edge-coloring problems on bipartite graphs is considered. The input is a graph (typically with no edges) and a sequence of operations (edge addition and edge deletion) under the restriction that at any time the graph is bipartite and degree-bounded by k, where k is a prescribed integer. At the time of edge addition, the added edge can be irrevocably assigned a color or be left uncolored. No other coloring or color alteration is allowed. Coloring can be done only at the time of addition of the edge; no color can be assigned afterward (unless the edge is once deleted). The problem is to assign colors as many times as possible using k colors. Two algorithms are presented: one with competitiveness coefficient $\frac{1}{4}$, and one with competitiveness coefficient between $\frac{1}{4}$ and $\frac{1}{2}$ with the cost of requiring more random bits than the former algorithm, also against oblivious adversaries.
Chapter 5 : It is reported an education support system to take required credits from entrance to graduation in a college. This system is applied by a directed graph that subjects are vertices and relations among subjects are edges. we present an st-digraph that entrance and graduation are vertex s and vertex t respectively and subjects from the entrance to the graduation are vertices. These relations among subjects are transitive by adding some edges. Then, if there are minimal st-separators of the st-digraph, those are the required credits from entrance to graduation. we propose a method to decide the required credits for graduation.
keywords:
independent set, comparability graph, intersection graph, competitiveness coefficient, education support system

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（論文審査結果の要旨）

本論文は、ある種のグラフにおける独立頂点集合に関するアルゴリズムという情報科学の基礎的問題を解決する研究成果をまとめたものである。

この研究成果は、以下の３点に集約される。

まず、極大独立頂点集合に関する生成問題について論じ、無向グラフがMIS-diagramであるための有向グラフに対する必要十分条件と、無向グラフがMIS-diagramを持つための必要十分条件は、GがCo-comparabilityグラフであることを示されている。また、正の重みを持つ場合に、MIS-diagramから重み付MIS-diagramを得る方法も示されている。

つぎに、最大値重みを持つ独立頂点集合に関するアルゴリズムについて、いくつかのインターセクショングラフに関して記述し、頂点数が n、最大重みを持つ独立頂点集合の頂点数の総和をβとしてとき、サークルグラフの最大重みを持つ独立頂点集合を重複なしに列挙するアルゴリズムが、$O(n^3+\beta)$の時間オーダであることが示されている。

さらに、オンライン辺彩色アルゴリズムの使う色とオフライン辺彩色アルゴリズムの使う色との比の最大値を、オンライン辺彩色アルゴリズムのcompetitiveness係数というが、使われる色の最大数をkとしたとき、competitiveness係数が$(2k-1)/k$となることを証明している。また、バイパーダイトグラフでは、kを制限したときには、1/4より大きく、1/2より小さくなるアルゴリズムがあることを示している。

以上述べたように、本論文は、情報科学研究の基礎的問題を解決する上で重要なアルゴリズムを提供し、グラフ理論を画像処理技術や情報科学一般の学習プログラム作成に応用する上で有用であることを検証した実証的基礎研究である。これらの研究成果は、学会論文誌４件、査読付国際学会２件として公表されているほか、専門的啓蒙書３冊の実績などを鑑みると、情報科学の基盤としてのグラフ理論研究を展開する上で、学術面での貢献は大きいと認めることができる。

よって、本論文は博士（工学）の学位論文として価値あるものと認める。