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The Maximum k-Differential Coloring Problem ☆

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Abstract

Given an n-vertex graph G and two positive integers $d, k \in \mathbb{N}$, the (d, kn)-differential coloring problem asks for a coloring of the vertices of G (if one exists) with distinct numbers from 1 to kn (treated as *colors*), such that the minimum difference between the two colors of any adjacent vertices is at least d. While it was known that the problem of determining whether a general graph is $(2, n)$-differential colorable is NP-complete, our main contribution is a complete characterization of bipartite, planar and outerplanar graphs that admit $(2, n)$-differential colorings. For practical reasons, we also consider color ranges larger than n, i.e., $k > 1$. We show that it is NP-complete to determine whether a graph admits a $(3, 2n)$-differential coloring. The same negative result holds for the $(\lfloor 2n/3 \rfloor, 2n)$-differential coloring problem, even in the case where the input graph is planar.

1. Introduction

Several methods for visualizing relational datasets use a map metaphor where objects, relations between objects and clusters are represented as cities, roads and countries, respectively. Clusters are usually represented by colored regions, whose boundaries are explicitly defined. The 4-coloring theorem states that four colors always suffice to color any map such that neighboring countries have distinct colors. However, if not all countries of the map are contiguous and the countries are not colored with unique colors, it would be impossible to distinguish whether two regions with the same color belong to the same country or to different countries. In order to avoid such ambiguity, this necessitates the use of a unique color for each country; see Fig. 1.

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