

Vertices Coloring Technique Using Graph Methods For Determining Map Colors

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Vertices Coloring Technique Using Graph Methods For Determining Minimal Map Colors

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Abstract. Coloring vertices is to give color the vertices of a graph so that no two neighboring nodes are of the same colors. The minimal number of colors used to color vertices is called the graph chromatic number. The problem of coloring vertices in this study is applied on the map of the district of Sidoarjo. It is also to determine the minimal colors on the Sidoarjo region map so that the boundary between the sub-districts in Sidoarjo becomes clearer with minimal colors. In this research, First Graph is assumed to be a complete graph and Second Graph is the path, while nodes or vertices are the sub-districts and the edge of the sub-district is assumed to be neighboring sub-districts between the districts with each other. The result of the analysis shows that the join of two graphs produces a wheel graph, which has a maximum chromatic number of 4 pieces of color for the odd result and 3 pieces of color for even result. Thus, the map of the original Sidoarjo region has more than 9 colors can be given the minimum color of 4 colors can be distinguished between the district one with other district.

1. Introduction

A graph is containing dots, called nodes, and lines connecting a node called edge, define $G=(V,E)$, where V is a collection of vertices and E is a collection of edges. Each edge connects exactly two vertices, and each node can have multiple connecting edges with the other node [1]. From the definition of the graph, in addition in the application in a real life, there are many fields associated with the graph, among others, the problem of dimensional partition, dimension metrics, as well as problems of chromatic number graph, one of which is coloring vertices. There are three kinds of coloring graph, such as coloring vertices, coloring edges, and coloring region [2]. In a previous study, Guangrong Li and Limin Zhang (2006) have found chromatic numbers on one graph of join operation on G side coloring. Some operations within the graph include corona, amalgamation, union, and join graph. The problem discussed in this research is to find the chromatic number in Sidoarjo district map and to determine the minimal coloring on Sidoarjo area map so that the boundary between sub-district in Sidoarjo becomes clearer with minimal colors.

The purpose of this research is determining the chromatic number or minimal colors between join operation of two graphs which is applied on Sidoarjo Map and get the relation between this research compare to the color on the boundary Area in Sidoarjo map. In this study, discussed the required chromatics number between join operations of two graphs. For example G is the complete graph K_n , and H is a path P_m . Joining of complete graph and path will be applied to analyze the map of Sidoarjo region in determining minimal colors. The terminology in the graph that will be used to analyze the map



includes neighboring and trajectory. Two vertices are said to be neighbors when they are connected directly by a side. While the degree of a node in a non-directional graph is the number of sides attached to the node, denoted by $d(v)$ [3]. A path is called a simple path if all the vertices are difference, and a closed path if the path start and finish on the same vertices. Otherwise, A path is called open path if the path not start and finish to the same path. A Path with n vertices and $n - 1$ edges denoted by P_n [3].

2. Complete and Bipartite Graphs

A complete graphs is a simple graph which each vertex has each edge to all other vertices and denoted by K_n . A complete graph has the number of vertices and each side is formulated by

$$V(K_n) = n \text{ and } |K_n| = \frac{n(n-1)}{2}$$

A bipartite graph G is a graph whose vertex set of V can be partitioned into two subsets U and W , such that each side of G has one endpoint at U and one endpoint in W . The pair U, W is called a bipartition node of G , U and W are called bipartition sets or can be said as partition class. While bipartite graphs are complete if the bipartite graph is simple so that each vertex in one sub bipartition is connected to each node on another bipartition [4].

2.1. Complete Bipartite Graphs

The complete bipartite graphs has a node of one subset and n vertices on the other subset, denoted by K_{mn} . The operation of the graph is divided into two in general, ie operations involving only one graph itself or more than one graph, and graphs requiring other graphs in operation or binary. Here is a graph that is operated more than one is complement graph, dual graph. Otherwise binary operation, ie join graph, deletion of vertices and sides, graph differences, and combined graphs [4].

2.2. Coloring of Vertices Graphs

The vertex coloring is to give color to the vertices of a graph so that no two neighboring nodes have the same color (Gross, 2006). In a graph, each neighboring node is given a different color. In writing, the vertex coloration can be represented by giving different colors, giving 1,2,3, ..., or different letters a, b, c, ..., in accordance with the principle of searching for the chromatic number of the graphs. The first coloring problem in graph theory is 150 years old. It is the famous four-color problem. In Figure 1, we show the vertex coloration represented by the number, and the chromatic number is 3 [5].

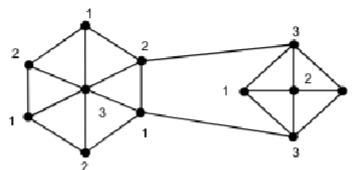


Figure 1. Coloring Vertices

Two edges in a graph are said to be adjacent if they are both incidents with the same vertex. An edge coloring of a graph G is an assignment of colors to the edge of G . In figure 2, shows a proper edge coloring of a graph.

2.3. Coloring

In This Study, discussed the required chromatics number between join operations of two graphs for vertex coloring. For example G is the complete graph K_n , and H is a path P_m . Joining of complete graph and path will be applied to analyze the map of Sidoarjo region in determining minimal colors. The terminology in the graph that will be used to analyze the map includes neighboring and trajectory. Two vertices are said to be neighbors when they are connected directly by a side. While the degree of a node in a non-directional graph is the number of sides attached to the node, denoted by $d(v)$. A path is called a simple path if all the vertices are difference, and a closed path if the path start and finish on the same

vertices. Otherwise, A path is called open path if the path not start and finish to the same path. A Path with n vertices and $n - 1$ edges denoted by P_n [5].

2.3.1. **Edges coloring.** Two edges in a graph are said to be adjacent if they are both incident with the same vertex. An edge coloring of a graph G is an assignment of colors to the edge of G . In figure 2, shows a proper edge coloring of a graph [6].

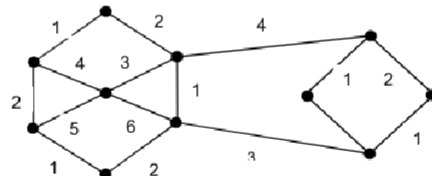


Figure 2. Edges Coloring

2.3.2. **Example in Figure 2.** The differences from vertex colorings, where adjacent vertices must receive different colors. For an edge coloring, no restriction is made on the colors of adjacent edges. A proper edges edge coloring is an edge coloring with the additional property that no two adjacent edges receive the same colors. According to the theorem before, If G be a graph. The number of colors required for a proper edge coloring of G is greater than or equal to [7].

3. Research Methods and Data Analysis

At this stage, identification of the problem by finding references that support the research. Studying and understanding substances relating to the graph especially regarding the types of graphs especially on the triangular free graph, an operation of joining two graphs, and the chromatic number of graphs. The Data is looking for the latest map of Sidoarjo region as well as other things that support the research activities. Below is the reseach methods:

- Study Literature
- Identification and problem formulation
- Determination of Researck Objective
- Analysis of chromatic numbers and map data collection (Sidoarjo Map Area)
- Graph Application
- System simulation
- Comparison of simulation result with analysis
- Stage of decision making
- Conclusion and recomendations

4. Discussion

This chapter discusses the analysis of chromatic integer models for two independent graphs of each of its constituent graphs, evaluates the proof of the model, analyzes the theorem and the Lemma that has been done in the previous study, and the interpretation of the results obtained when applied to the map.

4.1. Model Complete Graph Joining The Path

The mathematical model of the calculation of the number of vertices and sides of each graph is derived from the previous discussion of previous research by Gross (2006) and Wilson (1990). The complete graph has the number of vertices and edges of each $V(K_n) = n$ and $|E(K_n)| = n(n-1) / 2$. Thus, each node in K_n is adjacent to another node in K_n , this causes the node in K_n to have the

same number of edges $d(K_n) (v) = n-1$ and the different staining on each of each node is the number Chromatic in the complete graph $\chi(K_n) = n$ [8].

Table 1. The calculation of the complete join graph operation with three vertices and the path given as follows :

	Chromatic Number triangle graph joining the path	
Chromatic 1	Triangle free graph	Number of chromatic is 2
Chromatic 2	Path	Number of chromatic is 2
Chromatic 3	Path and Triangle free graph	Number of chromatic is 4
Chromatic 4	Path joining Triangle free graph	Number of chromatic is 4
Chromatic 5	Free triangle on joining	Number of chromatic is 2

4.2. Model Path Graph

In this chapter, we discuss the graph model path P_n joining of path P_m with $n > 2$ and $m > 2$. The initial requirement is that the graph should be determined free triangle graph. Because the path does not contain a circle, so the graph is the triangular free graph. However, the joins of two paths must still be analyzed whether they contain triangle subgraphs or not. The path model is a graph model whose sides are traversed once, or in other words, trajectory used is an open path that each side does not begin and ends at the same node, the lane graph with n vertices and $n-1$ sides denoted by P_n . It is known that the path is the line between the vertices and the intermittent edge of the node since it is a path, the chromatic number of the path is known to be 2. In other words, the chromatic number of the constituent graph is 4. While the join path is done by trial and analysis to determine whether the resulting graph contains a triangular subgraph or graph has formed a triangular free graph. The chromatic number of all bipartite graphs is 2 in accordance with the previously proven Gross (2006).

5. Model n Path Joining m Path

In Figure 3, it is known that the join chromatic number of two free triangular trajectory graphs is 2. This is done by forming all the graphs of the joining operation into a triangular free graph that is the bipartite graph. It is known that the ratio of the chromatic number between the two path joints to each composing graph is $(P_n + P_m) \leq (P_n) + (P_m)$. While the triangular free graph is obtained from the removal of the connecting side of the P_n path graph with $n-1$ removal of the side and the removal $(m-1)$ side of the graph of path P_m , so that the elimination of the side of the graph of the join operation of two graphs of path P_n join P_m is $(n-1) + (m-1)$. Footnotes should be avoided whenever possible. If required they should be used only for brief notes that do not fit conveniently into the text.

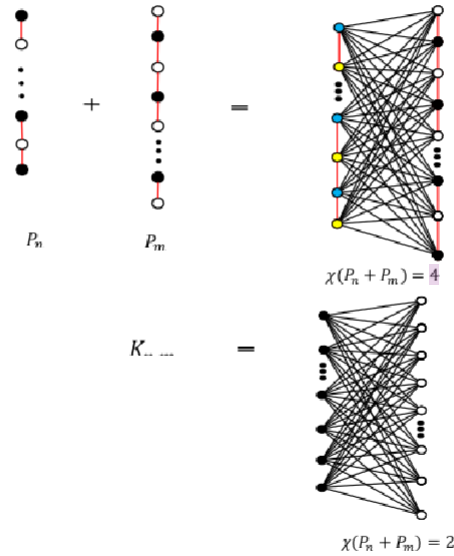


Figure 3. Model n Path

6. Equations

The following mathematical term used in this study are :

$G = (V, E)$ is A graph contain dots, called nodes, and lines connecting a node called edge.

G is a graph G .

K_n is a complete graph with n vertex.

H is a graph H .

P_m is a path with m vertex.

$d(v)$ is the degree of a node in a non-directional graph is the number of sides attached to the node.

$\chi(K_n)$ is a complete graph that has the number of vertices.

W is called a bipartition node of G , U and W are called bipartition sets or can be said as partition class.

$K_{m,n}$ is a Bipatite graph that has m and n vertice.

χ is the chromatic number

$\chi(K'_3)$ is the chromatic number of triagle-free complete graph that has 3 vertex.

$\chi(P_m)$ is the chromatic number of Path that has m vertex.

6.1. Calculation Of The Complete Join Graph Operation

The In the Table 2. The result of the join between two complete graphs (K_3+K_2) resulted in minimal coloration on Sidoarjo district map of 4 colors or $\chi(K_3+K_2) = 4$, while the chromatic numbers in the sum of their respective graphs are $\chi(K_3)$ and $\chi(K_2)$ is 5. Thus, either a triangular free graph or a graph containing subgraph K_3 has a chromatic number $\chi(K_n + K_m) \leq \chi(K_n) + \chi(K_m)$ thus Lemma is proven true and the district of Sidoarjo gets minimal colors. The calculation of the complete join graph operation with three vertices and the path given as follows :

Table 2 . The Calculation of the complete join graph operation with three vertices and the path given as follows :

	Chromatic Number triangle graph joining the path	
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Chromatic 2	Path	Number of chromatic is 2
Chromatic 3	Path and Triangle free graph	Number of chromatic is 4
Chromatic 4	Path joining Triangel free graph	Number of chromatic is 4
Chromatic 5	Free triangle on joining	Number of chromatic is 2

7. Conclusions

On the map of the region of Sidoarjo regency applied Lemma 3 in previous research that is complete graph join track. In the complete graph model of K_n join complete K_m graph, with $n \geq 2$ da $m \geq 2$, we find the formula that the complete graph of K_m contains the triangular subgraph. For a complete graph to be a triangular free graph, a minimal edge removal is performed. However, on the map, it does not apply, because if the removal of the edges of the territory or sub-district boundary becomes not in accordance with the real area. This is because the region of the capital district is considered as a vertex while the edge is a subdistrict area adjacent to one district with other districts. The complete chromosome graph of K_n in the application of the map is that K_3 has a minimum color of $\lambda(K_3) = 3$ and a complete graph or path K_2 having at least $\lambda(K_2) = 2$. The result of the join between two complete graphs ($K_3 + K_2$) resulted in minimal coloration on Sidoarjo district map of 4 colors or $\lambda(K_3 + K_2) = 4$, while the chromatic numbers in the sum of their respective graphs are $\chi(K_3)$ and $\chi(K_2)$ is 5. Thus, either a triangular free graph or a graph containing subgraph K_3 has a chromatic number $\chi(K_n + K_m) \leq \chi(K_n) + \chi(K_m)$ thus Lemma is proven true and the district of Sidoarjo gets minimal colors. Map of Sidoarjo Area first have more than 9 colors, and now with the research, the map can be colored at 4 colors enough.

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