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A Bibliometric Analysis of Graph Labeling Study Using VOSviewer

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A B S T R A C T S

Graph labeling is a well-known theme of graph theory that involves an assignment of integers to the domain elements such as vertices or edges, or both, subject to certain conditions. A bibliometric and descriptive quantitative approach is used in this study to conduct a bibliometric analysis on graph labeling by integrating mapping analysis with VOSviewer software. The data was obtained from a Google Scholar search using the keyword "graph labeling" that resulted in 980 articles published between 2018 and 2023, but only 375 of these articles were relevant to the subject. The results show that research on graph labeling changed from 2018 to 2023. To sum up, this work is the first to use VOSviewer for bibliometric analysis of a graph labeling study. It is hoped that this will make it a useful resource for future research on related issues.

A R T I C L E I N F O

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1. INTRODUCTION

In the mid-60s, a graph labelling theme of graph theory was introduced, and over 200 graph labelling methods have been explored during the intervening years, see (Gallian, 2022). An assignment of integers to domain elements, such as vertices or edges, or both, depending on particular requirements, is a basic idea in graph theory. Labelling is referred to as edge labelling or vertex labelling, depending on whether the domain is made up entirely of vertex or edge sets. On the other hand, if the domain consists of a collection of both vertices and edges, the labelling is known as total labelling. There are various types of graphs labelling, with many of these methods originating from (Rosa, 1967). In this study, four hierarchical series of valuation (or labelling) schemes were introduced, and among these, the β-valuation emerged as the most popular and extensively studied. This valuation was later termed 'graceful labelling' by (Golomb, 1972) a term commonly used today. This graph labelling enables the representation and analysis of various real-world systems and structures, facilitating the study of their properties and behaviours. By assigning specific attributes or characteristics to the components of a graph, graph labelling serves as a powerful tool for modelling and understanding complex networks, playing a pivotal role in solving real life problems, such as coding theory, X-ray crystallography, communication network addressing, and social networking. One important source regarding the use of graph labelling is the research done by (Bloom & Golomb, 1977). In this study, our aim is to conduct a bibliometric analysis of graph labeling study using VOSviewer to comprehensively understand the breadth of this field of study. The purpose of this analysis is to ascertain the volume and originality of the data. VOSviewer is a versatile tool used for conducting bibliometric analyses. Bibliometric maps can be created, visualized, and analysed with this program, which makes it possible to assess different kinds of bibliometric network data. These data include links between terms used in science and publications or journal citations, as well as cooperative relationships between researchers (Van Eck & Waltman, 2011). However, research on bibliometric analysis concerning graph labelling studies has not yet been investigated by researchers, in particular, doing mapping analysis with the VOSviewer program. Therefore, this research is intended to serve as a valuable resource for academics to facilitate and guide research directions, particularly in the context of graph labelling.

2. METHOD

The study used a combination of bibliometric and descriptive quantitative methodologies. For data collection, primary source such as the existing published papers were collected by using Google Scholar due to its convenient accessibility. Furthermore, a thorough literature analysis was carried out utilizing the Publish or Perish software, a tool that we utilized to locate bibliometric data for our investigation. (Al Husaeni, et al., 2022). The information gathered from the Publish or Perish initiative was then assembled into files that worked with the VOSviewer tool. Specifically, version 8 of Publish or Perish and version 1.6.17 of

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VOSviewer were used for data collection in this study. Moreover, a meticulous filtering process was applied, retaining exclusively pertinent studies related to graph labelling. The Publish or Perish software's "graph labelling" keyword made it easier to retrieve data from Google Scholar. Initially yielding 980 results, the subsequent refinement process yielded 375 relevant journals. The selected papers considered in this study were published between 2018 and 2023, and their bibliographic information was stored in *.ris format. Subsequently, the VOSviewer software generated the comprehensive visualizations and analysed trends in the form of bibliometric maps. These visualizations were generated using the database compiled during the preliminary stages. The data were analysed and categorized into three sections: network, overlay, and density visualizations. As a result, the phrases included in the VOSviewer mapping visualization were carefully filtered.

3. RESULTS AND DISCUSSION

3.1. Research developments in the study of graph labeling

Fig. 1. depicts the development of graph labelling research from 2018 to 2023. According to the data presented in Fig. 1, the research of graph labelling has experienced fluctuations from 2018 to 2023. Notably, the graph depicts an initial increase in research activity from 2018 to 2019, suggesting a growing interest in this field. However, this positive trend was followed by a significant decline of one- fourth in 2020, reflecting a sudden decrease in the research focus. Despite this setback, the research of graph. Labelling regained momentum in 2021, indicating a renewed interest and dedication within the research community. Nevertheless, the graph illustrates subsequent fluctuations, with another substantial drop observed in 2022 and a relatively steady level of activity maintained in 2023.

3.2. Visualization of graph labelling study using VOSviewer

As stated by Nandiyanto and Al Husaeni (Saputra, et al., 2022), the VOSviewer application requires a minimum of two terms to establish a relationship. In our study, we obtained a total of 10 items distributed across 3 clusters that are related to graph labeling research:

i) Cluster 1 comprises 4 items, namely graph, labeling, neural network, and paper (See Fig. 2).
ii) Cluster 2 comprises 3 items, namely edge, edge label, and vertex (See Fig. 3), and
iii) Cluster 3 comprises 3 items, namely graph, algorithm, application, and survey (See Fig. 4).

Red indicates Cluster 1, green indicates Cluster 2, and blue indicates Cluster 3.

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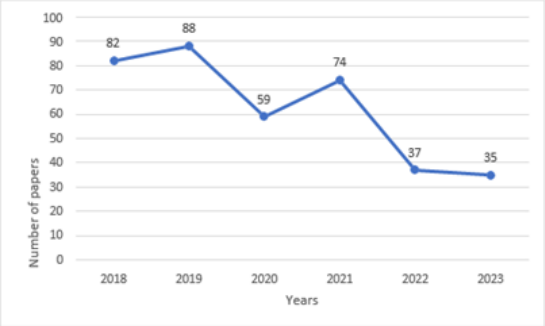

Fig. 1. Levels of development of research on graph labeling study

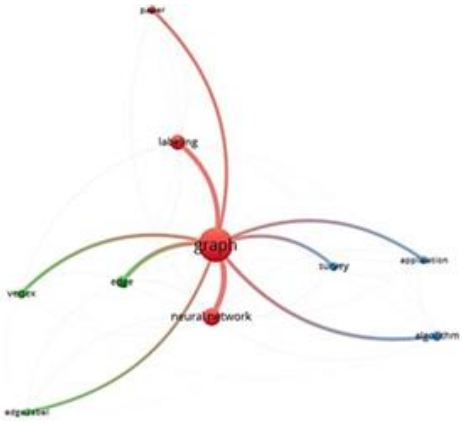

Fig. 2. Network visualization of graph labelling study for Cluster 1

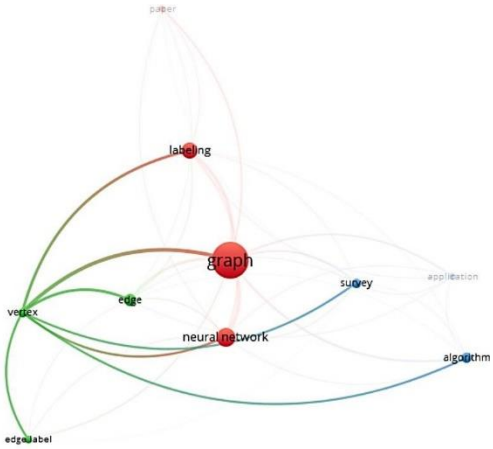

Fig. 3. Network visualization of graph labelling study for Cluster 2.

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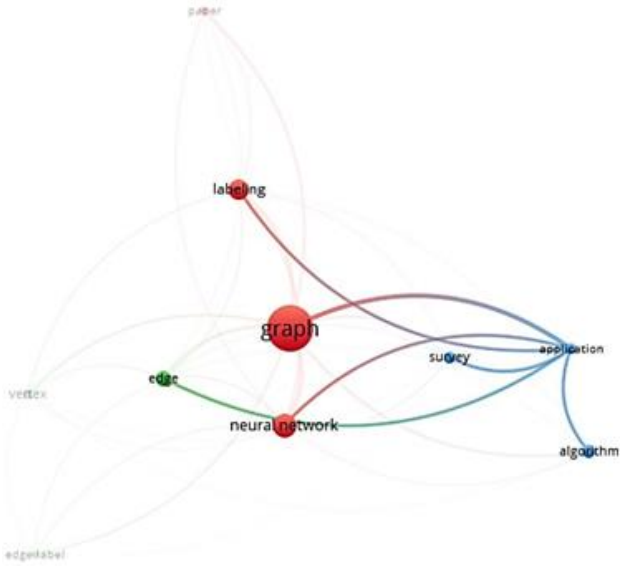

Fig. 4. Network visualization of graph labelling study for Cluster 3.

3.3. Network visualization of graph labelling study using VOSviewer

Network Visualization illustrates the relationships between terms through interconnected networks or lines on a map. Fig. 5 presents the Network Visualization for the term 'graph labelling' using the VOSviewer application. This depiction comprises all the clusters, totalling 10 distinct terms. Notably, the largest cluster, denoted as Cluster 1, highlights the term 'graph,' which demonstrates connections with nine other terms, underscoring its central role within the network.

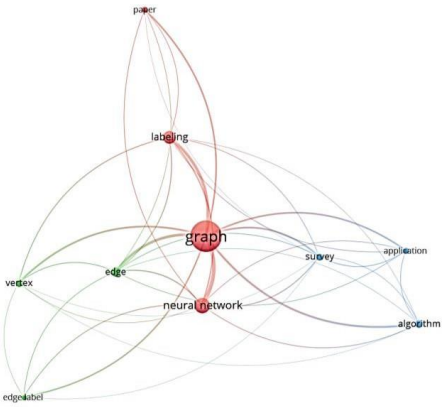

Fig. 5. Network visualization of graph labelling study.

3.4. Overlay visualization of graph labelling study using VOSviewer

Furthermore, the VOSviewer program offers an overlay mapping function that highlights the terms' uniqueness in the research. This overlay visualization is not only highlighting the popularity of terms across different years but also using distinct colours to indicate the temporal evolution of each term. Within this visualization, the darker hues, tending towards purple, signify that the research on a specific term was predominantly conducted around the year 2018. Conversely, the lighter shades, verging towards yellow, represent terms that have emerged more recently in contemporary research. Through Fig. 6, the contrasting colour spectrum effectively communicates the temporal significance and development of various terms,

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helping to create a thorough awareness of the changing landscape of research. The terms included in this study are graph, labelling, neural network, paper, edge, edge label, vertex, graph, algorithm, application, and survey.

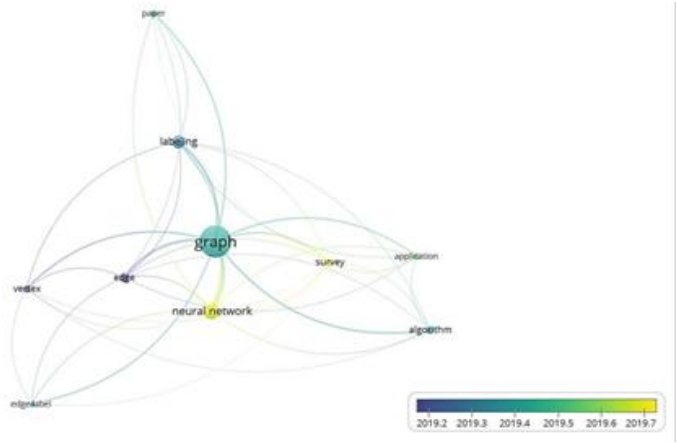

Fig. 6. Overlay visualization of graph labelling study.

3.5. Density visualization of graph labelling study using VOSviewer

Each term is categorized by the density visualization function of the VOSviewer application according to how frequently it appears in research, using a colour scheme to denote its significance. As the colour of a term becomes lighter, it signifies an increasing trend in its research popularity, while a darker or faded colour implies a decline in research frequency. Notably, in Fig. 8, the term 'graph' is represented by a prominent yellow with a larger circle diameter, indicating its frequent occurrence in various studies. Moreover, the density visualization presents a density map, reflecting the comprehensive analysis of all articles pertaining to the graph labelling study from 2018 to 2023. Within the map, the yellow patterns highlight denser keywords, with a larger circle diameter indicating their heightened prevalence. Conversely, the green colour defines a reduced frequency of keyword appearances, see (Al Husaeni & Nandiyanto., 2023; Gabriella, et al., 2021; Sott, et al., 2021). Further references to additional relevant studies can be found in (Abdollahi, et al., 2021; Al Husaeni & Nandiyanto, 2023; Ragadhita & Nandiyanto, 2022; Nandiyanto, et al., 2021; Nugraha & Nandiyanto, 2022; Fauziah & Nandiyanto, 2022; Al Husaeni & Nandiyanto, 2023; Shidiq, 2023; Wirzal & Putra, 2022; Al Husaeni, et al., 2023; Mulyawati & Ramadhan, 2021; Al Husaeni & Nandiyanto, 2023; Hamidah, et al., 2020; Setiyo, et al., 2021; Soegoto, et al., 2022; Nandiyanto, et al., 2023; Nordin, 2022; Bilad, 2022; Sudarjat, 2023; Shidiq, 2021; Luckyardi, et al., 2022)

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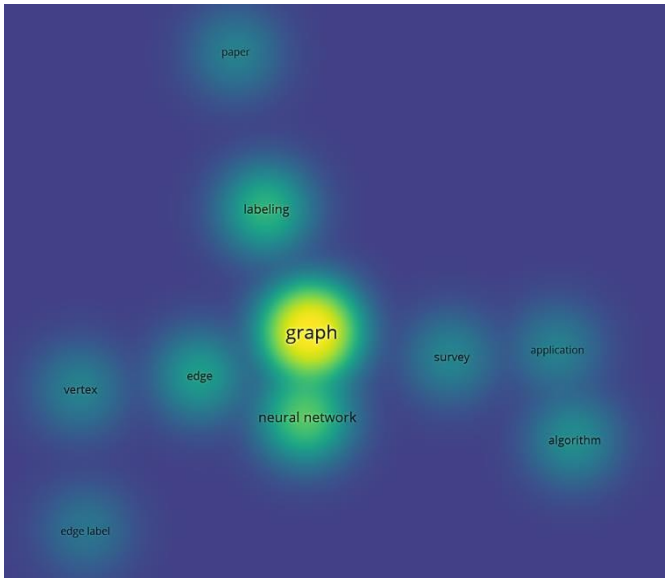

Fig. 7. Density visualization of graph labeling study.

4. CONCLUSION

This study has successfully conducted a comprehensive bibliometric analysis of graph labelling study using VOSviewer. The process of data extraction from Google Scholar was facilitated through the use of the keyword 'graph labelling' in the Publish or Perish software, initially yielding 980 results. After a careful refinement process, 375 relevant journals were identified for inclusion in this study. The selected papers considered for analysis were those published within the timeframe of 2018 to 2023. Leveraging the capabilities of VOSviewer software, this study generated comprehensive visualizations and analysed trends through various bibliometric maps, including network, overlay, and density visualizations. Through the analysis of these visualizations, notable fluctuations in graph labelling study from 2018 to 2023 were observed, and the term 'graph' emerging as a particularly popular focus within the field of graph labelling.

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