Introduction

Kruskal's algorithm is a greedy algorithm used to find the Minimum Spanning Tree (MST) of a weighted, undirected graph. The MST of a graph is the tree that spans all the vertices of the graph, has the minimum total weight, and does not contain any cycles.

The algorithm was first published by Joseph Kruskal in 1956 and has since become one of the most popular methods for finding MSTs. Kruskal's algorithm is simple, efficient, and guarantees that the MST it finds is optimal.

Kruskal's algorithm works by sorting the edges of the graph in increasing order of weight and then adding each edge to the MST if it does not create a cycle. The algorithm starts with an empty set of edges and gradually adds edges to the set until all vertices are connected. The algorithm uses a disjoint-set data structure to keep track of the connected components in the graph and ensure that the added edges do not create cycles.

The algorithm works as follows:

1. Sort the edges of the graph in increasing order of weight.

2. Initialize an empty set of edges and a disjoint-set data structure to keep track of the connected components in the graph.

3. For each edge in the sorted list of edges, add the edge to the MST if it connects two disjoint sets.

4. Repeat step 3 until all vertices are connected.

The time complexity of Kruskal's algorithm is O(E log E), where E is the number of edges in the graph. This is because the algorithm requires sorting the edges in the graph, which takes O(E log E) time, and performing the find and merge operations of the disjoint-set data structure, which take O(log E) time in the worst case.

Paper 1 (<https://iopscience.iop.org/article/10.1088/1757-899X/1047/1/012089/meta> )

The development of the topology of extremely large communication networks with a large number of vertices is the main topic of the paper. The goal is to build a set of edges with the least amount of weight, though in real-world applications, this is not the only goal. Although two tasks have been proposed in earlier papers, their high complexity prevents Kruskal's algorithm from being used in a direct manner. To address this problem, the paper offers two iterations of Kruskal's algorithm as well as two heuristics. Both heuristics can be used to solve problems beyond the original task, and one of them has demonstrated promising results in computational experiments. In order to solve problems with large data dimensions, the paper emphasizes the necessity of heuristics.

Paper 2 (<https://ieeexplore.ieee.org/abstract/document/10031889> )

Agriculture in my nation has difficulties relating to modernization, economic efficiency, and sustainable development as globalization and agricultural modernization advance in richer nations. This research provides a target detection system for agricultural economic production efficiency based on the Kruskal algorithm to better comprehend these difficulties. The experimental setting, data set, and system testing are all covered in the study. Findings reveal that compared to other algorithms, the Kruskal algorithm offers a system that is more stable and has lower rates of instability. The algorithm is better appropriate to the target detection system of agricultural economic output efficiency because it is reasonably steady even when the similarity value varies. This study clarifies the issues that my nation's agriculture is experiencing as well as some prospective solutions that might increase sustainability and economic effectiveness.

Paper 3 (<https://ieeexplore.ieee.org/abstract/document/9077616> )

In this paper, Kruskal's and Prim's algorithms for locating the least spanning tree in combinatorial optimization issues like network design are implemented and compared. To evaluate the algorithms' effectiveness, the road network of Nigeria's 36 states is used. Results of the implementation are described, but since this work is a part of an ongoing research effort, the computational complexity of the algorithms will be disclosed in a subsequent article. Many real-world uses exist for the smallest spanning tree, including cable-laying networks, roadways, and electrical and telephone systems.

Paper 4 (<https://openaccess.thecvf.com/content_CVPR_2020/html/Zhang_4D_Association_Graph_for_Realtime_Multi-Person_Motion_Capture_Using_Multiple_CVPR_2020_paper.html> )

The real-time multi-person motion capture technique described in this paper uses multiple video inputs and is innovative. The difficult part is to retain efficiency while optimizing for severe occlusions and closely coupled motions in each view. The suggested technique makes use of a 4D association graph to combine per-view parsing, cross-view matching, and temporal tracking into a unified optimization framework. The approach suggests 4D limb bundle parsing based on heuristic searching, followed by a bundle Kruskal's algorithm, to solve the 4D association graph effectively. The technique allows for a real-time, 30 frames per second motion capture system to be used on a five-person scene with five cameras. The suggested method delivers high-quality online pose reconstruction quality, beating state-of-the-art methods quantitatively without employing high-level appearance information. It is robust to noisy detection due to severe occlusions and near interaction motions.

Paper 5 (<https://openaccess.thecvf.com/content_CVPR_2020/html/Zhang_4D_Association_Graph_for_Realtime_Multi-Person_Motion_Capture_Using_Multiple_CVPR_2020_paper.html> )

This study suggests a deployment approach for vehicle-to-infrastructure (V2I) communication that combines roadside units with cable connections (c-RSUs) and RSUs aided by unmanned aerial vehicles (UAVs) (u-RSUs). The u-RSUs are a dependable addition to the ground RSUs since they may change their position in response to traffic density and emergencies. The suggested approach, called TLIGA, employs a two-layered improved greedy algorithm to deploy cables and c-RSUs in the first layer and choose the right number and flight plan for u-RSUs in the second layer. Simulation findings show that the suggested approach, while remaining within a predetermined budget bound, can greatly improve the effective traffic coverage ratio (ETCR) compared to existing methods. By giving automobiles access to real-time traffic information, c-RSUs and u-RSUs can considerably increase driving safety and comfort.

Paper 6 (<https://www.ripublication.com/irph/ijert20/ijertv13n12_181.pdf> )

With the development of large-scale networks and improvements in GIS applications, the use of minimal spanning trees has assumed growing significance. It is usual practice to find the smallest spanning tree for a given graph using Kruskal and Prim's techniques. This study compared the computational speed complexity of the two algorithms and discovered that Kruskal's algorithm performed better than Prim's approach. To simulate both techniques, road network datasets with growing numbers of nodes were employed. While many studies have concentrated on enhancing these algorithms, very few have examined their complexity. This study offers significant insights into the computationally best MST algorithm, which is crucial for effective network analysis in GIS applications.

Applications of Kruskal's Algorithm

Kruskal's algorithm has many important applications in various fields, including network design, transportation planning, and computer graphics. Some of the applications of Kruskal's algorithm are:

* Network Design: In network design, Kruskal's algorithm can be used to find the minimum cost of connecting all the nodes in a network. For example, it can be used in designing a telecommunications network or in the routing of data packets in computer networks.
* Image Processing: In image processing, Kruskal's algorithm can be used to identify and extract the most relevant features in an image. It can also be used to segment images into different regions, based on their similarities or differences.
* Transportation Planning: In transportation planning, Kruskal's algorithm can be used to find the most efficient routes for transportation, such as roads or railways. It can also be used in optimizing the scheduling of transportation vehicles, such as buses or planes.
* Electrical Grid Design: In electrical grid design, Kruskal's algorithm can be used to find the minimum cost of connecting all the nodes in a power grid. This can be used to minimize the cost of building new power lines and to optimize the distribution of electricity in a region.
* Molecular Biology: In molecular biology, Kruskal's algorithm can be used to analyze gene expression data and identify the most relevant genes that are involved in a particular biological process. It can also be used to identify the most relevant pathways that are involved in a disease or a biological process.

In summary, Kruskal's algorithm has wide-ranging applications in various fields, including network design, image processing, transportation planning, electrical grid design, and molecular biology. It provides an efficient way of solving problems that involve finding the minimum spanning tree of a weighted undirected graph.

References

1. B F Melnikov and Y Y Terentyeva 2021 IOP Conf. Ser.: Mater. Sci. Eng. 1047012089
2. Y. Zuo, "Target Detection System of Agricultural Economic Output Efficiency Based on Kruskal Algorithm," 2022 IEEE 2nd International Conference on Mobile Networks and Wireless Communications (ICMNWC), Tumkur, Karnataka, India, 2022, pp. 1-5, doi: 10.1109/ICMNWC56175.2022.10031889.
3. P. Ayegba, J. Ayoola, E. Asani and A. Okeyinka, "A Comparative Study Of Minimal Spanning Tree Algorithms," 2020 International Conference in Mathematics, Computer Engineering and Computer Science (ICMCECS), Ayobo, Nigeria, 2020, pp. 1-4, doi: 10.1109/ICMCECS47690.2020.240900.
4. Yuxiang Zhang, Liang An, Tao Yu, Xiu Li, Kun Li, Yebin Liu; Proceedings of the IEEE/CVF Conference on Computer Vision and Pattern Recognition (CVPR), 2020, pp. 1324-1333
5. R. Cai, Y. Feng, D. He, Y. Xu, Y. Zhang and W. Xie, "A Combined Cable-Connected RSU and UAV-Assisted RSU Deployment Strategy in V2I Communication," ICC 2020 - 2020 IEEE International Conference on Communications (ICC), Dublin, Ireland, 2020, pp. 1-6, doi: 10.1109/ICC40277.2020.9149122.
6. Ayegba, P.O., Okeyinka, A.E., Adebiyi, M., Asani, E.O., Ayoola, J.A. and Ben, G.C., Comparative Performance Analysis of Kruskal and Prim MST Algorithms.