Optimizing Terraria Pylon Networks Using Minimum Spanning Tree Algorithms

Maharani Puan Satira - 13525137
Program Studi Teknik Informatika
Sekolah Teknik Elektro dan Informatika
Institut Teknologi Bandung, Jalan Ganesha 10 Bandung
E-mail: maharanipuansatira@gmail.com , 13525137@std.stei.itb.ac.id

***Abstract*—Terraria provides various types of pylons that allow players to travel efficiently between different biomes through teleportation. However, determining an optimal network structure connecting multiple pylon locations can be viewed as a graph optimization problem. In this study, the Terraria Pylon Network is modeled as a weighted graph, where each biome is represented as a vertex and the Euclidean distance between pylon locations is used as the edge weight. Coordinate data were collected from a selected Terraria world and used to construct a complete weighted graph. Kruskal's Algorithm was then applied to determine the Minimum Spanning Tree (MST) of the network. The resulting MST successfully connected all biome vertices while minimizing the total connection cost and avoiding cycles. The analysis demonstrates that graph theory concepts and MST algorithms can be effectively applied to optimize transportation networks in virtual environments. This study also illustrates a practical application of discrete mathematics in video game systems and network design.**

Keywords—graph theory, minimum spanning tree, Kruskal's algorithm, Terraria, weighted graph, network optimization.

I. INTRODUCTION

Terraria is a sandbox, action-adventure, role-playing, and platformer video game. It offers gameplay that revolves around exploration, building, crafting, combat, survival, and mining, without any set goals. Terraria offer wide range of exploration and adventure by giving players with different types of biomes, such as space, forest, glowing mushroom, ocean, desert, snow, underworld, dungeon, and the hallow.

In Terraria, there is one item that is important and used by many players, Pylons. Pylons are placeable items that appear as a large crystal hovering and rotating above a biome-themed stand. Its function is to facilitate players to travel around the world with teleportation instead of manually walking, flying, or using transportation. Pylons can only be placed once in each biome. There are 11 types of Pylons: Forest Pylon, Snow Pylon, Desert Pylon, Jungle Pylon, Cavern Pylon, Ocean Pylon, Hallow Pylon, Mushroom Pylon, and Universal Pylon that can be used anywhere.

Although pylons provide fast transportation between biomes, determining an efficient network structure remains an interesting optimization problem. Each pylon location can be modeled as a vertex in a graph, while the distance between two pylons can be represented as a weighted edge. By applying graph theory concepts and Kruskal's Algorithm, a Minimum Spanning Tree (MST) can be constructed to connect all pylon locations with the minimum total distance. Therefore, this study aims to model the Terraria Pylon Network as a weighted graph and analyze its optimal structure using Kruskal's Algorithm.

II. THEORITICAL FRAMEWORK

A. Graph

1) Definition of Graph

A graph is an ordered pair $G = (V, E)$ consisting of nonempty set of:

- V (called the vertices) = $\{v_1, v_2, v_3, \ldots, v_n\}$
- E (called the edges) of two-element subsets of V = $\{e_1, e_2, e_3, \ldots, e_n\}$

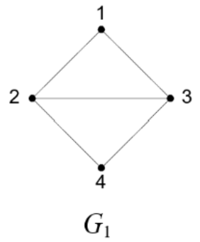

Figure 1. Graph Example

From Figure 1 we know that V = {1, 2, 3, 4} and E = {(1, 2), (1,3), (2, 3), (2, 4), (3, 4)}.

2) Connected Graph

A graph is connected if for any two vertices $x, y \in V(G)$, there is a path whose endpoints are x and y.

A connected graph G is called 2-connected, if for every vertex $x \in V(G)$, $G - x$ is connected.

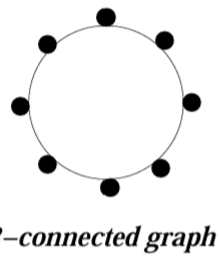

Figure 2. 2-Connected Graph

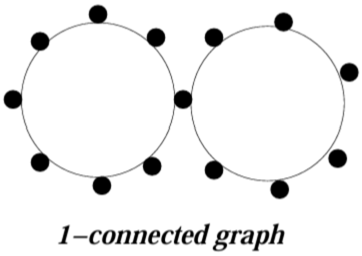

Figure 3. 1-Connected Graph

B. *Tree*

1) *Definition of Tree*

A tree is an undirected graph that is connected and contains no circuits (cycles). This means there is a path between every pair of vertices, and no path forms a closed loop. As a result, there is exactly one unique path between any two vertices in a tree. Trees are widely used to represent hierarchical relationships and network structures.

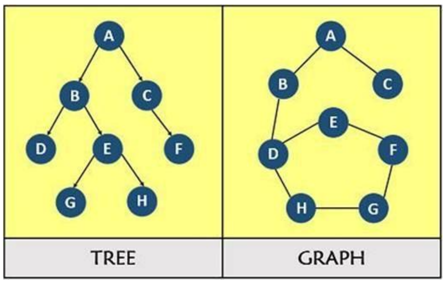

Figure 4. Difference of Tree and Graph

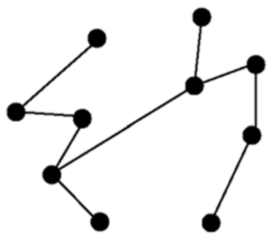

Figure 5. Tree Example

2) *Spanning Tree*

A spanning tree of a graph on n vertices is a subset of n-1 edges that form a tree (Skiena 1990, p. 227). For example, the spanning trees of the cycle graph C_4 diamond graph, and complete graph K_4 are illustrated below.

Figure 6. Spanning Tree Example

3) *Minimum Spanning Tree*

A spanning tree of a graph G is a connected acrylic subgraph of G that contains every node of G. A minimum spanning tree (MST) of a weighted graph G is a spanning tree of G which has the weight sum on its edges.

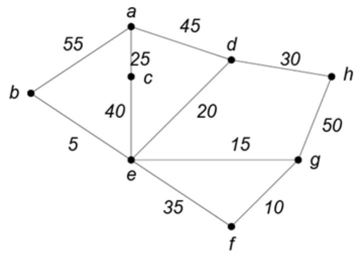

Figure 7. Weigthed Example

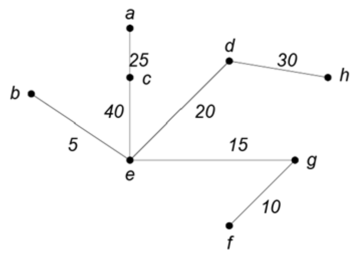

Figure 8. Minimum Spanning Tree

This minimal spanning tree isn't unique; there may be another acceptable solution.

4) *Kruskal's Algorithm*

Kruskal Algorithm is an algorithm for finding a graph's spanning tree of minimum value.

- Step 0: The edges of the graph are sorted in ascending order of their weights – from small to large.
- Step 1: T is still empty.
- Step 2: Choose an edge (u, v) with minimum weight that does not form a circuit in T.
- Step 3: Repeat step 2n – 1 times.

C. *Euclidean Distance*

1) *Definition of Euclidean Distance*

Euclidean distance is a measure of the shortest straight-line distance between two points in Euclidean space. In a coordinate plane, this distance is computed using a formula derived from the Pythagorean theorem. As a result, Euclidean distance is widely used to quantify the separation between points represented by Cartesian coordinates.

In this study, Euclidean distance is used to determine the weight of edges connecting different biomes in the Terraria Pylon Network. The distance between two biomes is calculated based on their coordinates within the game world.

III. ANALYSIS

A. Modeling the Terraria Pylon Network

In this study, each biome in Terraria is represented as a vertex in a graph. The selected biomes include Forest, Snow, Desert, Jungle, Cavern, Underworld, Ocean, Hallow, Mushroom, and Aether. However, the Underworld and Aether biomes were excluded from the analysis because pylon placement in these biomes is impractical and does not represent common player transportation routes. Therefore, the graph model consists of the remaining eight biome vertices.

Vertex	Biomes
V_1	Forest
V_2	Snow
V_3	Desert
V_4	Jungle
V_5	Cavern
V_6	Ocean
V_7	Hallow
V_8	Mushroom

Table 1. List of Vertex

In the graph model, an edge represents a possible connection between two pylon locations. These connections form the basis for constructing a weighted graph that will later be optimized using the Minimum Spanning Tree algorithm.

To simplify the modeling process and focus on the graph-theoretic aspects of the Terraria Pylon Network, several assumptions are adopted in this study:

1) Terrain obstacles such as mountains, caves, and structures are ignored when measuring distances between biomes.

2) The travel cost between two biomes is assumed to be proportional to their Euclidean distance.

B. Constucting the Weighted Graph

1) Pylon Placement Strategy

To obtain representative coordinates for the graph model, pylons were placed near the central area of their respective biomes. This approach was chosen to ensure that each pylon location accurately represents the biome rather than its boundaries. The Forest Pylon was placed near the world spawn point, while the Snow, Desert, Jungle, Ocean, Hallow, Mushroom, Cavern, and Underworld Pylons were placed within the central regions of their corresponding biomes. The Universal Pylon was excluded from the study because its unrestricted placement capability would significantly alter the resulting network structure and the Hallow Pylon is excluded because it's uncommon

Figure 9. Pylon Placement Used for Graph Construction

2) Coordinate Collection

Based on the pylon placement strategy described previously, the coordinates of each pylon location were collected from the selected Terraria world. These coordinates were then used to construct the weighted graph and calculate the distances between vertices.

Biome	x	y
Forest	0	0
Snow	1774	206
Desert	-115	220
Jungle	-2277	84
Cavern	-35	986
Ocean	3644	178
Hallow	-619	154
Mushroom	-3663	910

Table 2. Coordinates of Pylon Locations

3) Distance Calculation

The distance between two vertices is calculated using the Euclidean distance formula. The resulting distance is used as the edge weight in the weighted graph.

$$d = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2}$$

For example, the distance between Forest and Snow is:

$$d(Forest, Snow) = \sqrt{(1774 - 0)^2 + (206 - 0)^2} = \sqrt{(1774)^2 + (206)^2} \approx 1785.920$$

The same calculation procedure was applied to all pairs of pylon locations to obtain the complete set of edge weights. These weights were then used to construct the weighted graph for the Minimum Spanning Tree analysis.

C. Graph Analysis and MST Construction

1) Graph Visualization

Using the collected coordinates and calculated distances, a weighted graph was constructed. Each vertex represents a pylon location, while each edge represents a connection between two pylon locations with a weight equal to their Euclidean distance.

Edge	Weight
Forest—Snow	1785.920
Forest—Desert	248.244
Forest—Jungle	2278.549
Forest—Cavern	986.621
Forest—Ocean	3648.345
Forest—Hallow	637.869
Forest—Mushroom	3774.344
Snow—Desert	1889.052
Snow—Jungle	4052.837
Snow—Cavern	1969.995
Snow—Ocean	1870.210

Snow—Hallow	2393.565
Snow—Mushroom	5482.389
Desert—Jungle	2166.273
Desert—Cavern	770.166
Desert—Ocean	3759.235
Desert—Hallow	508.303
Desert—Mushroom	3614.471
Jungle—Cavern	2416.644
Jungle—Ocean	5921.746
Jungle—Hallow	1659.477
Jungle—Mushroom	1613.466
Cavern—Ocean	3766.684
Cavern—Hallow	1016.504
Cavern—Mushroom	3628.796
Ocean—Hallow	4263.068
Ocean—Mushroom	7343.574
Hallow—Mushroom	3136.474

Table 3. Euclidean Distances Between Pylon Locations

Based on the Euclidean distance calculations presented in Table 3, a weighted graph was constructed to represent the Terraria Pylon Network. In this graph, each vertex corresponds to a biome containing a pylon, while each edge represents a possible direct connection between two biomes. The weight assigned to each edge is equal to the Euclidean distance between the corresponding pylon locations. Since every biome can theoretically be connected to every other biome through the pylon network, a complete weighted graph was formed. Figure 10 illustrates the resulting graph, where all vertices and weighted edges are shown prior to the application of Kruskal's Algorithm.

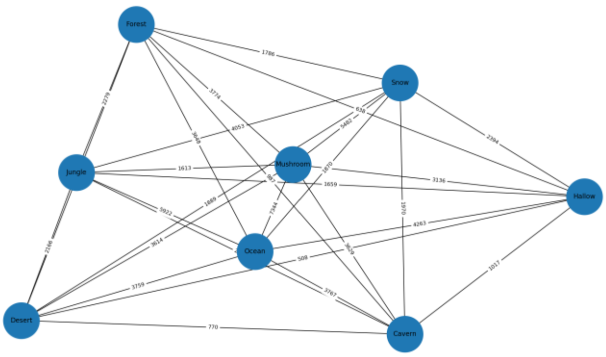

Figure 10. Complete Weighted Graph of the Terraria Pylon Network

2) Application of Kruskal's Algorithm

After constructing the complete weighted graph shown in Figure 10, Kruskal's Algorithm was applied to determine the Minimum Spanning Tree (MST) of the Terraria Pylon Network. The algorithm begins by sorting all edges in ascending order based on their weights. The smallest edge is then selected iteratively, provided that its inclusion does not create a cycle in the graph. This process continues until all vertices are connected by a spanning tree.

Edge	Weight	Decision
Forest— Desert	248.244	Selected
Desert—Hallow	508.303	Selected
Forest—Hallow	637.869	Rejected (Cycle)
Desert—Cavern	986.621	Selected
Forest—Cavern	1016.504	Rejected (Cycle)
Cavern—Hallow	1613.466	Rejected (Cycle)
Jungle—Mushroom	1659.477	Selected
Jungle—Hallow	1785.920	Selected
Forest—Snow	1870.210	Selected
Snow—Ocean	1889.052	Selected
Snow—Desert	1969.995	Rejected (Cycle)
Snow—Cavern	2166.273	Rejected (Cycle)
Desert—Jungle	2278.549	Rejected (Cycle)
Forest—Jungle	2393.565	Rejected (Cycle)
Snow—Hallow	3136.474	Rejected (Cycle)
Jungle—Cavern	3614.471	Rejected (Cycle)
Hallow—Mushroom	3628.796	Rejected (Cycle)
Desert—Mushroom	3614.471	Rejected (Cycle)
Cavern—Mushroom	3648.345	Rejected (Cycle)
Forest—Ocean	3759.235	Rejected (Cycle)
Desert—Hallow	3766.684	Rejected (Cycle)
Forest—Mushroom	3774.344	Rejected (Cycle)
Snow—Jungle	3766.684	Rejected (Cycle)
Ocean—Hallow	4052.837	Rejected (Cycle)
Snow—Mushroom	4263.068	Rejected (Cycle)
Snow—Mushroom	5482.389	Rejected (Cycle)
Jungle—Ocean	5921.746	Rejected (Cycle)
Ocean—Mushroom	7343.574	Rejected (Cycle)

Table 4. Edge Selection Process Using Kruskal's Algorithm

As shown in Table 4, edges with the smallest weights were selected whenever they did not form a cycle. Several edges, such as Forest–Hallow and Forest–Cavern, were rejected because their inclusion would have created cycles within the network. The algorithm terminated after selecting seven edges, which is consistent with the property of a spanning tree containing $n-1$ edges for a graph with eight vertices. The selected edges form the Minimum Spanning Tree are shown in the following section.

3) Resulting Minimum Spanning Tree

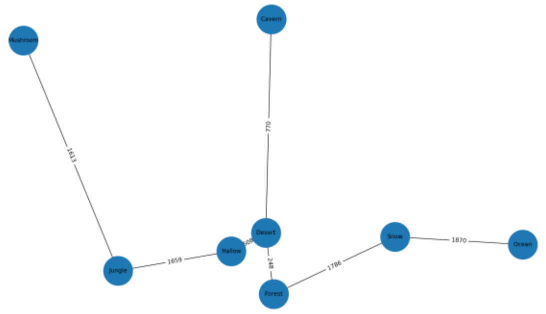

Figure 11. Minimum Spanning Tree of the Terraria Pylon Network

Figure 11 presents the Minimum Spanning Tree (MST) obtained by applying Kruskal's Algorithm to the weighted graph of the Terraria Pylon Network. The resulting MST connects all eight biome vertices using only seven edges, satisfying the fundamental property of a spanning tree. By selecting the minimum-weight edges while avoiding cycles, the algorithm successfully produces a network with the lowest possible total connection cost.

The resulting network reveals several important relationships between biomes. The Desert Pylon serves as a central connection point, linking the Forest, Hallow, and Cavern biomes. Meanwhile, the Ocean and Mushroom biomes appear as leaf vertices because of their relatively isolated locations. The MST preserves connectivity among all biomes while significantly reducing the number of required connections compared to the complete weighted graph, demonstrating the effectiveness of Kruskal's Algorithm in optimizing transportation networks.

D. Discussion

The resulting Minimum Spanning Tree provides several insights into the structure of the Terraria Pylon Network. First, the Desert biome acts as an important intermediary vertex because it connects multiple regions of the network, including Forest, Hallow, and Cavern. This indicates that its geographical location allows it to serve as a bridge between several nearby biomes.

In contrast, the Ocean and Mushroom biomes appear as leaf vertices in the MST. Their positions are relatively far from most other biomes, making it more efficient for the algorithm to connect them through a single neighboring biome rather than through multiple direct connections.

Compared to the complete weighted graph, the Minimum Spanning Tree significantly reduces the number of edges while preserving full connectivity among all biome vertices. The complete graph contains 28 weighted edges, whereas the MST contains only 7 edges. This reduction demonstrates how Kruskal's Algorithm can simplify a network while maintaining efficient connectivity.

Although the MST minimizes the total connection cost, it does not necessarily minimize the travel distance between every pair of biomes. Therefore, alternative graph optimization methods could be explored in future studies if different optimization objectives are desired.

E. Limitation of the Model

Several limitations should be noted in this study. First, distances were measured using Euclidean distance and therefore do not consider actual terrain obstacles such as mountains, caves, or structures that may affect player movement. Second, the analysis was performed using data collected from a single Terraria world, meaning that different world generations may produce different coordinate distributions and MST structures. Finally, the Universal Pylon was excluded because its unrestricted placement capability would significantly alter the resulting network topology.

IV. Conclusion

This study modeled the Terraria Pylon Network as a weighted graph, where each biome was represented as a vertex and the Euclidean distance between pylon locations was used as the edge weight. By collecting coordinate data from selected biome locations, a complete weighted graph was constructed to represent all possible connections within the network.

Kruskal's Algorithm was then applied to determine the Minimum Spanning Tree (MST) of the graph. The algorithm successfully selected the minimum set of edges required to connect all vertices while avoiding cycles and minimizing the total connection cost. The resulting MST preserved full connectivity among all biome locations while significantly reducing the number of connections compared to the complete weighted graph.

The results demonstrate that graph theory and Minimum Spanning Tree algorithms can be effectively applied to optimize transportation networks in virtual environments such as Terraria. This study also highlights how mathematical concepts can be used to analyze and improve in-game travel systems through efficient network design.

V. Appendix

Program's source codes and executables can be accessed from the link below: https://github.com/Rani-design-art/Matematika-Diskrit_Optimizing-Terraria-Pylon-Networks-Using-Minimum-Spanning-Tree-Algorithms.git

Video Link at YouTube

Link Video Youtube: https://youtu.be/wVDwsZC2z3o

Acknowledgment

The author would like to express sincere gratitude to the lecturer of the Discrete Mathematics course for providing valuable guidance and knowledge throughout the learning process. The author also thanks Institut Teknologi Bandung for providing the academic environment and resources that supported the completion of this study. Finally, the author

appreciates all references and resources that contributed to the development of this paper.

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PERNYATAAN

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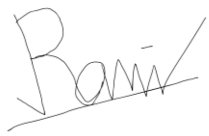
Bandung, 19 Juni 2025



Maharani Puan Satira dan 13525137