Summarizing Shortest Distance among all branches of Nutan Maharashtra Vidya Prasarak Mandal Pune in Maharashtra State using Minimum Spanning Tree Algorithm

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Abstract:

Minimum Spanning Tree is very effective algorithm to find minimum distance which covers all nodes. There are various algorithms to find Minimum Spanning Tree of the given data. Kruskal's and Prim's algorithms are widely used to find minimum spanning tree of the given tree graph. In this research paper we have to find minimum spanning tree for NMVPM's campus. For evaluating minimum spanning tree, we consider all the main locations as nodes and the distance between two nodes as edge having weight as its distance. Kruskal's algorithm is used for finding Minimum Spanning Tree which has less Time Complexity, minimum distance and also it is simple to execute.

Keywords*: Kruskal's algorithm, Spanning Tree, vertices, Time Complexity.*

1 Introduction:

In graph theory Kruskal's algorithm is a foundational algorithm which is basically used to find the minimum spanning tree (MST) proposed by Joseph Kruskal's in 1956.This algorithm effectively form MST by adding minimum weighted edge until it covers all nodes without forming loop.

Spanning Tree: A subgraph T of a graph G is said to be spanning tree if T is a tree and T passes through each vertex of G.

Minimum Spanning Tree (MST): Minimum Spanning Tree is a set of edges and vertices having minimum weight which covers all vertices of graph without forming loop. In MST all the edges should be different. There may be different MST of same length. There are different algorithms to find MST, Namely Kruskal's Algorithm, Prim's Algorithm.

Prim's Algorithm: In this algorithm, we have to maintain two empty sets of vertices. First we have to initialize the starting arbitrary vertex. From this vertex we have to find its adjacent minimum weighted edge connected to vertex. Again find minimum weighted edge adjacent to both vertices. Repeat this process until all the vertices are covered. At the end we get the MST which covered all the vertices present in the graph by using Prim's Algorithm. [1]

Kruskal's Algorithm: In this algorithm, we have to ensure that the smallest edges will get selected first. After that next less weighted edges will be inserted into the solution graph. If the cycle is forming by

any of the edge it should be neglected. Continue this process, until all the vertices get covered into the solution graph. At the end, we get the MST which covered all the vertices present in the graph by using Kruskal's Algorithm which has less time complexity than Prim's Algorithm. [5]

2. Comparisons between Kruskal's Algorithm and Prim's Algorithm

This concept of minimum spanning tree is very integral in many applications ex. network design, circuit design as well as clustering. By selecting smallest edge and adding it avoiding cycle and covering all nodes Kruskal's algorithm finds the optimal solution.

Because of its easy implementation as well as less time complexity, Kruskal's algorithm plays an important role in the field of mathematics for solving complex graph-related problems.

- Advantages of Kruskal's algorithm –
- Resulting tree has smallest total weight from all available spanning tree of the graph.
- This is very efficient algorithm.
- Kruskal's algorithm use greedy approach while selecting the least weighted edge.
- It is very flexible as it can apply in various graphs.
- Does not requires any prior knowledge for applying Kruskal's algorithm.
- This algorithm requires less memory as compare to prim's MST algorithm.
- The main advantage of this algorithm is, it is easy to implement.

- Let's see the comparison between Kruskal's and Prim's algorithm [6]by using some key points:

	Kruskal's Algorithm	**Prim's Algorithm**
Multiple MST's	Resulting MST's in efficient manner.	Resulting MST's might be difficult.
Implementation	Simple to Implement.	Difficult to Implement.
Requirements	It requires Disjoint set.	It requires Priority queue.
Time Complexity	O(E.log(V))	O(E+V.log(V))

3. Literature Review

Minimum Spanning Trees have many application of graph theory in today's world specially in building a road networks, Railway lines and Optic fiber cable network. The shortest spanning tree can be inverted from the research paper on 'Minimum Spanning Tree of Stations On Proposed Pune City to Nashik City Railway Route Network in Maharashtra State' published in International Advanced Research Journal in Science, Engineering and Technology [1]. Kruskal's algorithm is explained details in paper of Paryati and Krit Salahddine the Implementation of Kruskal's Algorithm for Minimum Spanning Tree in a Graph. Comparison of Kruskal's and Prims algorithm are seen in paper of Sheikh Irfan Akbar, Shahid-ul-Islam, Minimum Spanning Tree Algorithms and Techniques. Tree and spanning tree are very much explained in research paper of George Delfiya L, Dr.A. Arockia Lancy, Spanning Tree and Minimum Spanning Tree. Latitude and longitude are taken from online software.

4. Scope:

Minimum Spanning Tree algorithm is very useful in constructing or forming road networks, railway line networks, TV cable lines, telephone lines, electric lines, fibre optic cable lines for connecting

number of roads and objects. Kruskal's algorithm gives minimum spanning tree with simple steps. This study is useful to design the network that connects all required locations with minimum constructing cost [2].

- Network design: complexity is increasing widely in telecommunication, social system and transportation. With the help of Kruskal's algorithm we can contribute to reduce the complexity.
- Internet of things (IOT): Requirement of effective communication and exchange of data among IOT devices Kruskal's algorithm can establish better solution.
- We can apply Kruskal's algorithm to find out minimum length of optic cable, pipeline, Electric cable required for each node of NMVPM's campus.

5. Research Methodology:

Algorithmic Research Methodology is used to find shortest distance among the branches of institute taken for case study. Data collection method is also used in this study. We have collected distances among different locations of Samarth Sankul of NMVPM's by Latitude-Longitude method. Kruskal's Algorithm is applied among different locations of Samarth Sankul results in to a minimum spanning tree having all nodes.

6. Discussion

- **Algorithm:**

Kruskal's algorithm is of greedy type algorithm which is used to find the minimum spanning tree of the connected or undirected graph. The procedure of Kruskal's algorithm is given in the following steps:

Step1: - **Initialize**: start with a graph *G* having of *V* vertices and *E* edges.

Step2: - **Sort Edges**: Sort all the edges in increasing order of their weights. This step ensures that the smallest edges will select first.

Step3: - **Initialize MST**: Create an empty set *T* which will represent the minimum spanning tree.

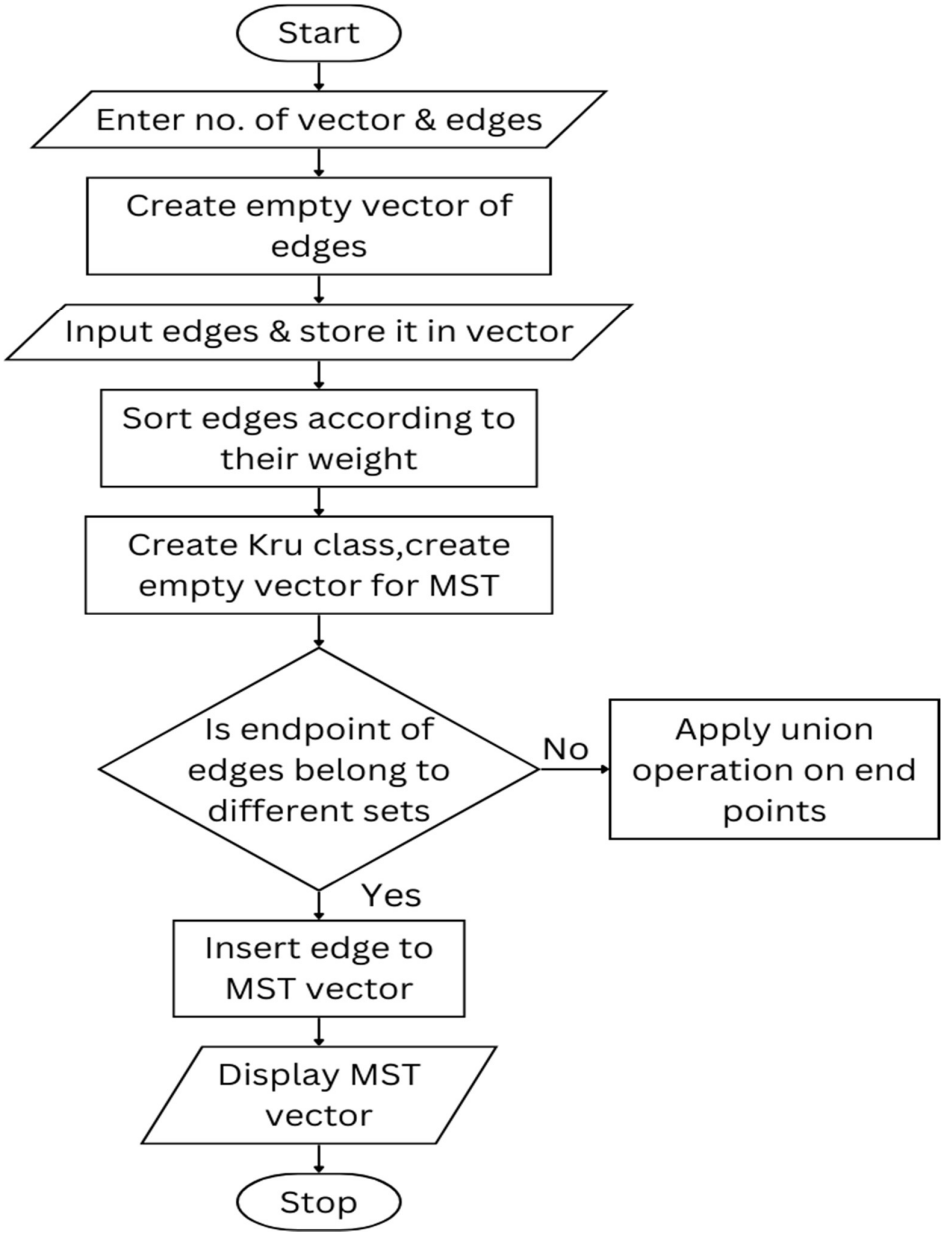
Step4: - **Iterate Over Edges**: Cycle through all the sorted edges.

Step5: - Check for Cycle: check if the adding edge will create cycle or not. If adding the new edge to the MST does not create a cycle then add it to the MST T, otherwise skip it.

Step6: - **Repeat**: Repeat above steps 4 and 5 up to T covers all vertices from the original graph.

Step7: - Output MST: Set T gives us the minimum spanning tree of our original graph. [5][6]

- **Flowchart for execution of Kruskal's Algorithm:**



7. Case Study:

Using Kruskal's algorithm we find Minimum Spanning Tree for Samarth Sankul, Vishnupuri, Nutan Maharashtra Vidya Prasarak Mandal's different institutes which are located on Chakan Talegaon Highway at city Talegaon Dabhade, Maval, Pune India.In the case study we consider places of institute as nodes(vertices) and distances among them as weighted edges [1]

Method of Data Collection:

The data used for this research paper is generated using Longitude / Latitude Converter software which make use of Longitude and Latitude of Samarth Sankul, Vishnupuri, Nutan Maharashtra Vidya Prasarak Mandal's different institutes. The distance between two locations is approximate distance having error up to 10 meter. Different Institutes and schools of Samarth Sankul, Vishnupuri, Nutan Maharashtra Vidya Prasarak Mandal's are NMVPM's Main Gate, Garden Control Room, NCER Security Cabin, NCER College, Stationary, NMIET Ground, Café, NMIET Security Cabin, Mamasaheb Khandge English Medium School, NMIET Gym, NCER Workshop, Navin Samarth Vidyalaya, Vishnupuri Post Office, Paisa fund Primary School, Lord Shiva Temple, NMIET Server Room, NMIET Workshop, Boy's Hostel, Girl's Hostel, Mess, New Boy's Hostel. [1]

- We assigned numbers for each point of location to make our graph easier to understand and reduce complexities of visualisation. Vertices of a graph are given as below :

1. NMVPM's Main Gate
2. Garden Control Room
3. NCER Security Cabin
4. NCER College
5. Stationary
6. NMIET Ground
7. Café
8. NMIET Security Cabin
9. Mamasaheb Khandge English Medium School
10. NMIET Gym
11. NCER Workshop
12. Navin Samarth Vidyalaya
13. Vishnupuri Post Office
14. Paisa fund Primary School
15. Lord Shiva Temple
16. NMIET Server Room
17. NMIET Workshop
18. Boys Hostel
19. Girls hostel
20. Mess
21. New Boys Hostel

NOTE: 1. NMVPM- Nutan Maharashtra Vidya Prasarak Mandal.

2. NMIET- Nutan Maharashtra Institute of Engineering and Technology, Pune

3. NCER- Nutan College of Engineering and Research, Pune.

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TABLE 1: Longitude and Latitude of locations in NMVPM's campus

Sr.No	Name of Locations	Longitude	Latitude
1.	NMVPM's Main Gate	18.73266667	73.66377778
2.	Garden Control Room	18.73102778	73.66425
3.	NCER Security Cabin	18.7308410	73.6642605
4.	NCER College	18.73086111	73.66380556
5.	Stationary	18.73016667	73.66444444
6.	NMIET Ground	18.73022222	73.664
7.	Café	18.73	73.6645
8.	NMIET Security Cabin	18.7295976	73.6642913
9.	Mamasaheb Khandge English Medium School	18.72967	73.66262
10.	NMIET Gym	18.72934	73.66344
11.	NCER Workshop	18.72834	73.66281
12.	Navin Samarth Vidyalaya	18.72952	73.66366
13.	Vishnupuri Post Office	18.72861	73.66383
14.	Paisa Fund Primary School	18.72866	73.66373
15.	Lord Shiva Temple	18.72811	73.66411
16.	NMIET Server Room	18.72906	73.66469
17.	NMIET Workshop	18.72870	73.66521
18.	NMVPM Boys Hostel	18.72815	73.66447
19.	NMVPM Girls hostel	18.7280	73.6648
20.	NMVPM Mess	18.72794	73.66474
21.	NMVPM New Boys Hostel	18.72793	73.66447

TABLE 2: Location -to- Location Road Showing Distance in Meter

Location	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1		**190**																			
2			**20**																		
3				**50**	**50**																
4																					
5						**50**	**20**														
6																					
7								**50**													
8									**70**			**70**				**70**					
9											**150**										
10												**70**									
11																					
12													**100**								
13														**10**	**60**						
14																					

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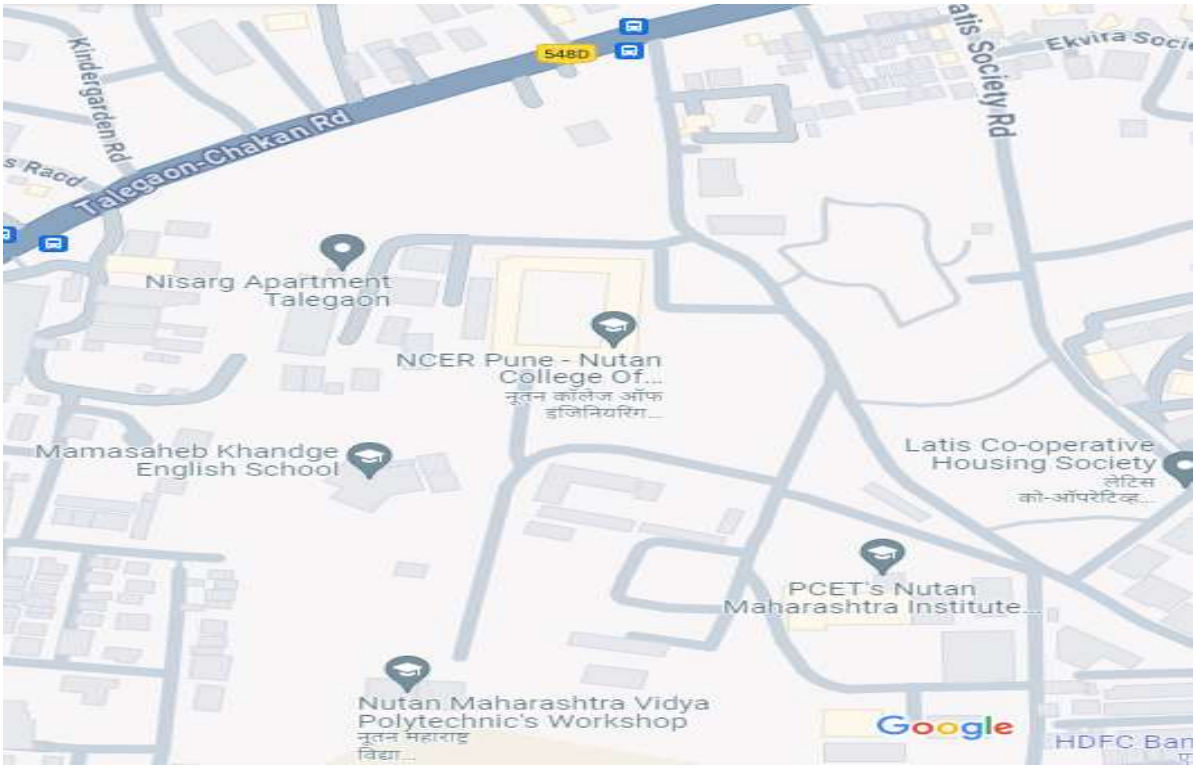
15																				
16																**70**				
17																		**40**		
18																				**20**
19																			**20**	
20																				**20**
21																				

Google Map Location of Samarth Sankul, Vishnupuri, Nutan Maharashtra Vidya Prasarak Mandal, Talegaon Dabhade Pune, Maharashtra India



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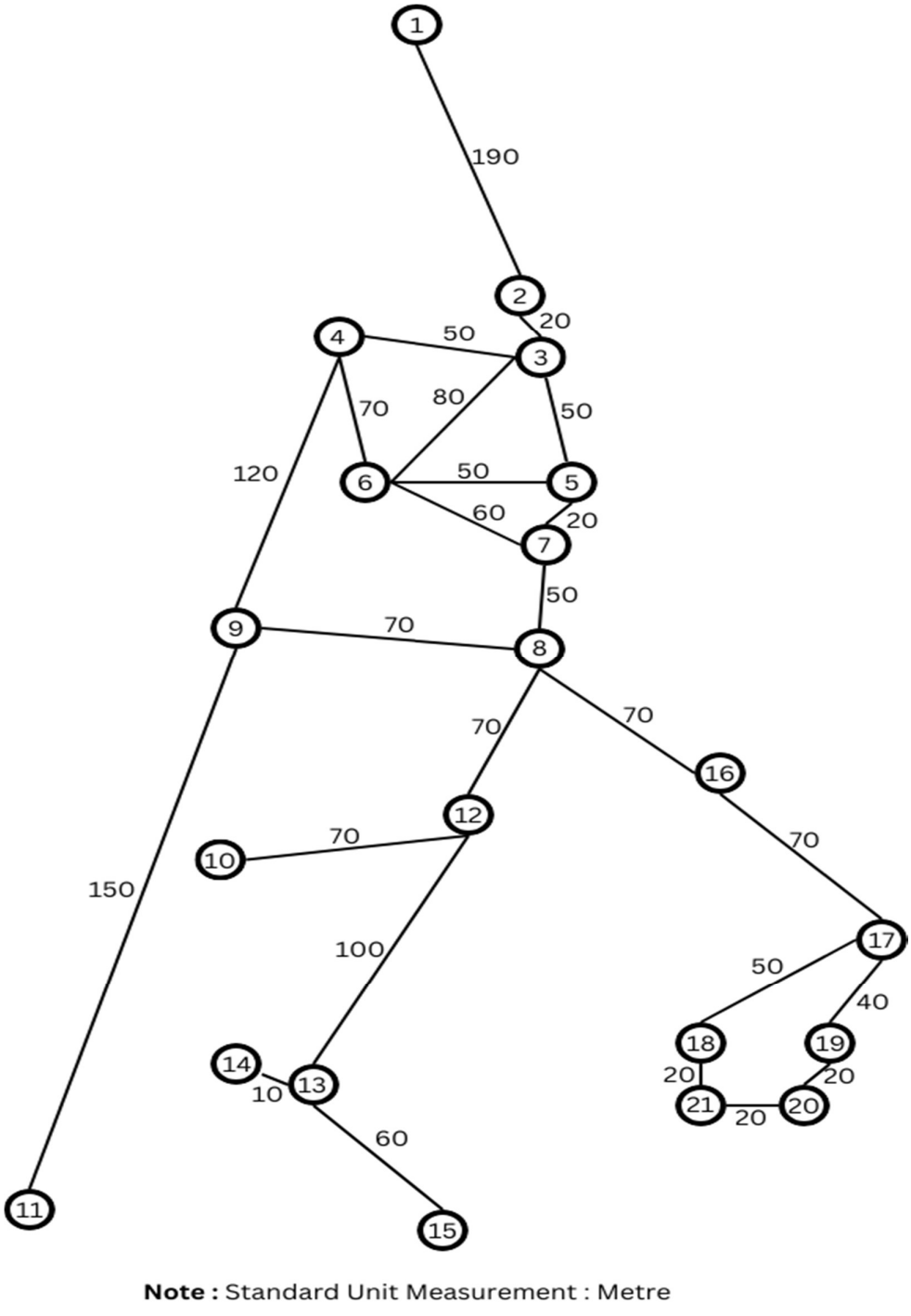

Figure 1: Existence ways among locations

Minimum spanning tree Solution for NMVPM campus using Kruskal's Algorithm

Step1: Minimum weight is of 10 i.e. edge 13-14. Add edge 13-14 in T

Step2: The Next minimum weight is of 20 i.e. edges 2-3, 5-7, 20-21, 19-20, 18-21
Add edges 2-3,5-7,20-21,19-20,18-21 in T

Step 3: Next minimum weight is of 40 i.e. edge 17-19 Add edge 17-19 in T

Step 4: Next minimum weight is 50. i.e. edges 3-4, 3-5, 5-6 ,7-8 17-18.
We cannot add edge 17-18 as it will create loop. Add edges 3-4,3-5,5-6,7-8 in T

Step 5: Next minimum weight is 60.i.e. edge 13-15 Add edge 13-15 in T

Step 6: Next minimum weight is 70.i.e edges .8-9 8-16 ,8-12 16-17,12-10
Add edges 8-9,8-16,8-12,16-17,12-10 in T

Step 7: Next minimum weight is 100. i.e. edge 12-13
Add edge 12-13 in T

Step 8: Next minimum weight is 150. i.e. edge .9-11Add edge 9-11 in T

Step 9: Next minimum weight is 190. i.e. edge 1-2 Add edge 1-2 in T

Minimum Spanning tree set T = {1-2,2-3,3-4,3-5,5-6,5-7,7-8,8-9,9-11,8-12,12-10,12-13,13-14,13-15,8-16,16-17,17-19,19-20,20-21,18-21}

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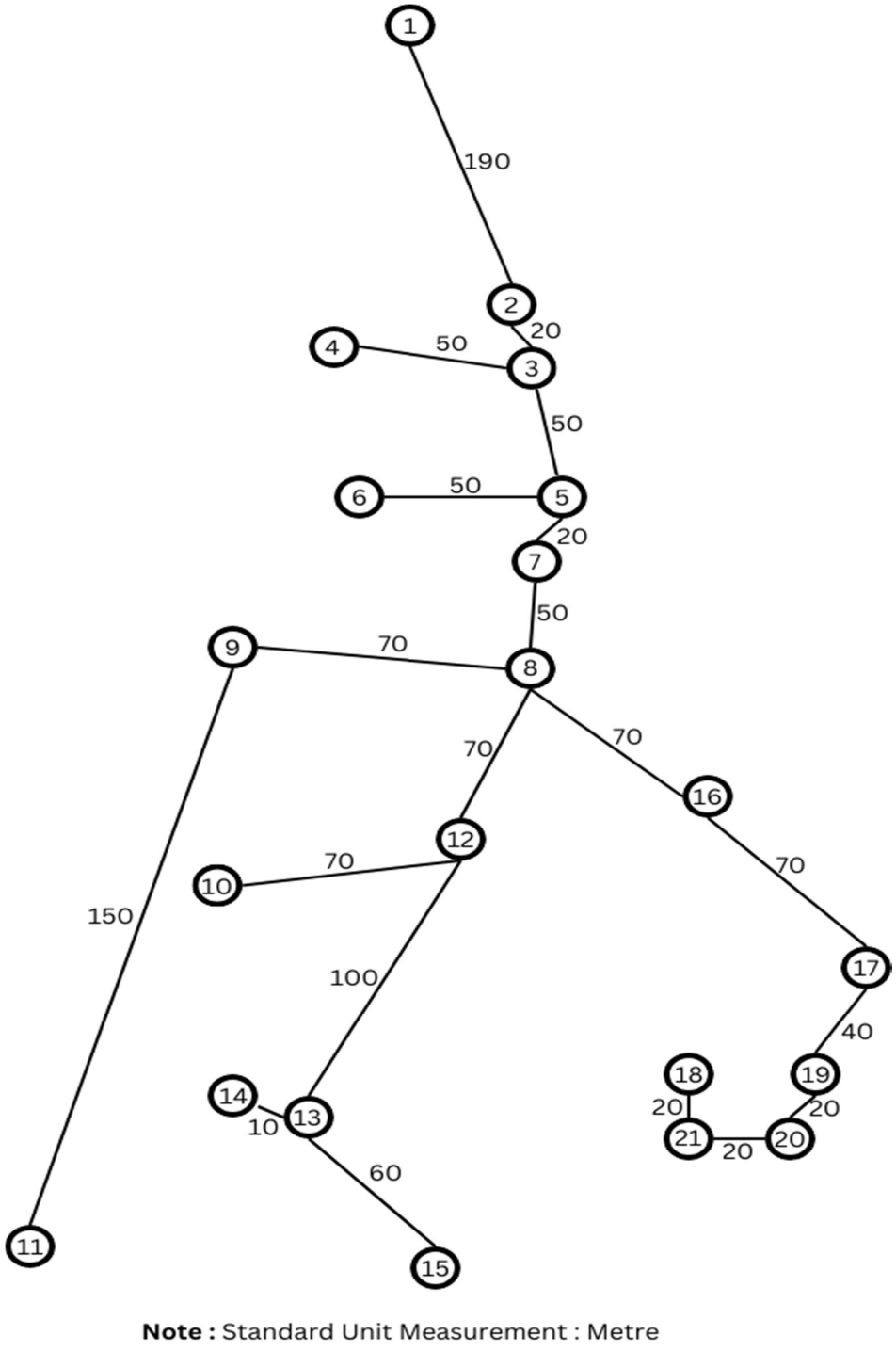

Figure 2: Shortest path in NMVPM's campus using Kruskal's algorithm

8. Result:

The result of applying Kruskal's algorithm to the graph of Fig.1 is as shown in Fig.2. The total number of vertices are 21. The Total numbers of edges are 25. Among them only 20 edges are required in a MST by using Kruskal's algorithm. The Total distance in an all institutes in NMVPM's Sankul is **1580 metres** considering following vertices: NMVPM's Main Gate, Garden Control Room, NCER Security Cabin, NCER College, Stationary, NMIET Ground, Café, NMIET Security Cabin, Mamasaheb Khandge English Medium School, NMIET Gym, NCER Workshop, Navin Samarth Vidyalaya, Vishnupuri Post Office, Paisa Fund Primary School, Lord Shiva Temple, NMIET Server Room, NMIET Workshop, Boy's Hostel, Girl's Hostel, Mess, New Boy's Hostel.

After applying Kruskal's Algorithm the Minimum Spanning Tree is of length**1200 metres** by considering NMVPM's Main Gate, Garden Control Room, NCER Security Cabin, NCER College, Stationary, NMIET Ground, Café, NMIET Security Cabin, Mamasaheb Khandge English Medium School, NMIET Gym, NCER Workshop, Navin Samarth Vidyalaya, Vishnupuri Post Office, Paisa Fund Primary School, Lord Shiva Temple, NMIET Server Room, NMIET Workshop, Boy's Hostel, Girl's Hostel, Mess, New Boy's Hostel are the vertices to be covered while finding MST.

9. Conclusion:

The shortest route is of length 1200 metres for Samarth Sankul (NMVPM's) obtained using Kruskal's Algorithm having less distance as compared to total distance. Minimised distance can be helpful for everyone in various application purposes. This Minimum Spanning Tree algorithm can be also administered in the following situations: Road networks, Internal road connectivity, Water pipe line networks, TV cable lines, Telephone lines, Electric lines, Fibre Optic Cable lines and internet lines and other related applications.

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