# The shortest path problem on chola period built temples with Dijkstra's algorithm in intuitionistic triangular neutrosophic fuzzy graph

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**Abstract.** In this article, Intuitionistic Triangular Neutrosophic Fuzzy Graph of Shortest Path Problem was Inaugurated, which is drew on triangular numbers and Intuitionistic Neutrosophic Fuzzy Graph. Real-world application is given as an illustrative model for Intuitionistic Triangular Neutrosophic Fuzzy Graph. Here we introduced famous chola period temples. These types of temples builted in various king of cholas. Here we assume only seven types of temples as vertices of Intuitionistic Triangular Neutrosophic Fuzzy Graph. Use of fuzzification method, edge weights of this Graph was calculated. Score function of Intuitionistic Triangular Neutrosophic Fuzzy Graph is inaugurated, with the help of this score function in the proposed algorithm, shortest way is determined.. This present Chola period temples Shortest Path Problem. Obtained shortest path is verified through Dijkstra's Algorithm with the help of Python Jupyter Notebook (adaptation) programming.

**Keywords:** Intuitionistic Fuzzy Number (IFN), Triangular Fuzzy Number (TFN), Shortest Path (SP), Intuitionistic Triangular Neutrosophic Fuzzy Graph(ITNFG).

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## 1. Introduction

The creators of, Ahuja [1] examined systematic execution of Dijkstra's calculation. Arsham [2] introduced another crucial arrangement calculation which permits affectability examination without utilizing any counterfeit, slack or surplus factors. Anusuya [3] apply positioning capacity for briefest way issue. Broumi [4] proposed for extend esteemed Neutrosophic Number. Broumi [5] presented Neutrosophic charts with most limited way issues. Broumi [6] proposed calculation gives Shortest way issue on single esteemed Neutrosophic charts. Broumi [7] proposed the Shortest way under Bipolar Neutrosophic setting. Broumi [8] gave the Shortest way issue under span esteemed Neutrosophic setting. Chiranjibe Jana [9] Presented Trapezoidal Neutrosophic aggregation operators and its application in multiple attribute decision making process. De [10] Computation of Shortest Path in a Fuzzy organization. De [11] Study on Ranking of Trapezoidal Intuitionistic Fuzzy Numbers. Enayattabar [12] introduced Dijkstra calculation for briefest way issue under Pythagorean Fuzzy climate. Jana [13] presented stretch esteemed Trapezoidal Neutrosophic Set. Jayagowri [14] discover Optimized Path in a Network utilizing Trapezoidal Intuitionistic Fuzzy Numbers. Kalaiarasi [15] determine fuzzy optimal total cost and fuzzy optimal order quantity obtained by Ranking function method and Kuhn-tucker method for the proposed Inventory model. Kalaiarasi [16] constructed Inventory parameters that are Fuzzy using Trapezoidal Fuzzy Numbers. Kumar [17] proposed to tackling briefest way issue with edge weight. Kumar [18] introduced Algorithm for most limited way issue in an organization with span esteemed Intuitionistic Trapezoidal Fuzzy Number. Kumar [19] presented the SPP from an underlying hub to an objective hub on Neutrosophic chart. Majumdar [20] introduced an Intuitionistic Fuzzy most brief way organization. Nagoor Gani [21] looking Intuitionistic Fuzzy most brief organization. Ojekudo Nathaniel akpofure [22] tended to the most brief way utilizing Dijkstra's calculation. Said broumi [23] processing the most brief way Neutrosophic Information. Smarandache [24] summed up the Fuzzy rationale and presented two Neutrosophic ideas. Victor christianto [25] gave a Neutrosophic approach to futurology. Wang [26] contributed Neutrosophic sets with their properties. Xu [27] introduced a strategies for amassing span esteemed Intuitionistic Fuzzy data, Yang [28] introduced rectangular hindrance subject to various improvement capacities regarding the quantity of curves. Ye [29] proposed a Trapezoidal Fuzzy Neural Computing and Applications. Ye [30] developed of the Multi models dynamic strategy utilizing shape liking measure, Ye [31] presented a Prioritized aggregation operators of Trapezoidal Intuitionistic Fuzzy Sets and their Application.

Fuzzy graph theory is finding an increasing number in developing real time applications in modeling systems with accuracy varying at different levels of infor mation. The fuzzy set theory can play a significant role in this kind of decision making environment to tackle the unknown or the vagueness about the time du ration of activities in a project network. To effectively deal with the ambiguities involved in the process of linguistic estimate times. In the applied field, the success of the use of fuzzy set theory depends on the choice of the membership function that we make. However, there are applications in which experts do not have precise knowledge of the function that should be taken. In these cases, it is appropriate to represent the membership degree of each element of the fuzzy set by means of an interval. From these considerations arises the extension of fuzzy sets called the theory of interval-valued fuzzy sets. That is, fuzzy sets such that the membership degree of each element of the fuzzy set is given by a closed subinterval of the interval [0,1]. Replacing the membership function of vertices and edges in fuzzy graphs by interval-valued fuzzy sets such that they satisfy some particular conditions, interval valued fuzzy graphs (IVFG) were defined. Thus IVFG provide a better description of vagueness and uncertainty within the specific interval than the traditional fuzzy graph.

**Triangular intuitionistic fuzzy numbers**

Triangular intuitionistic fuzzy numbers (TIFNS) are a special kind of intuitionistic fuzzy sets (IFSS) on a real number set. TIFNs are useful to deal with ill-known quantities in decision data and decision making problems themselves.

**Dijkstra's Algorithm**

The shortest path algorithm is given a weighted graph or digraph $G = (V, E, W)$ and two specified vertices $V$ and $W$; the algorithm finds a shortest path from $V$ to $W$. The distance from a vertex $V$ to a vertex $W$ (denote $d(V, W)$) is the weight of a shortest path from $V$ to $W$. Dijkstra's shortest path algorithm will find the shortest paths from $V$ to the other vertices in order of increasing distance from $V$. The algorithm stops when it reaches W.

Here, in this paper disclosed the briefest way to Chola period temples utilized the proposed calculation.

Intuitionistic fuzzy number gives more accuracy than fuzzy numbers. So that intuitionistic fuzzy numbers are used for finding shortest path of a graph. In this paper Dijkstra's algorithm is the only algorithm suitable for verifying our real world problem, because of the edge weight of fuzzy graph, rather than other algorithms.

## 2. Methodology

In this section, we explain important notions of Intuitionistic Fuzzy Sets.

**Definition 2.1** ([9]). *Let* $\overline{n_1} = [(t_1, t_2, t_3), (t_4, t_5, t_6)], [(i_1, i_2, i_3), (i_4, i_5, i_6)], [(f_1, f_2, f_3), (f_4, f_5, f_6)]$ *and* $\overline{n_2} = [(T_1, T_2, T_3), (T_4, T_5, T_6)], [(I_1, I_2, I_3), (I_4, I_5, I_6)], [(F_1, F_2, F_3), (F_4, F_5, F_6)]$. *Therefore, the conditions are*

1. $\overline{n_1} \oplus \overline{n_2} = \langle [(t_1 + T_1 - t_1T_1, t_2 + T_2 - t_2T_2, t_3 + T_3 - t_3T_3),$
$(t_4 + T_4 - t_4T_4, t_5 + T_5 - t_5T_5, t_6 + T_6 - t_6T_6)],$
$[(i_1I_1, i_2I_2, i_3I_3), (i_4I_4, i_5I_5, i_6I_6)],$
$[(f_1F_1, f_2F_2, f_3F_3), (f_4F_4, f_5F_5, f_6F_6)]\rangle.$

2. $\overline{n_1} \otimes \overline{n_2} = \langle [(t_1T_1, t_2T_2, t_3T_3), (t_4T_4, t_5T_5, t_6T_6)],$
$[(i_1 + I_1 - i_1I_1, i_2 + I_2 - i_2I_2, i_3 + I_3 - i_3I_3),$
$(i_4 + I_4 - i_4I_4, i_5 + I_5 - i_5I_5, i_6 + I_6 - i_6I_6)],$
$[(f_1 + F_1 - f_1F_1, f_2 + F_2 - f_2F_2, f_3 + F_3 - f_3F_3),$
$(f_4 + F_4 - f_4F_4, f_5 + F_5 - f_5F_5, f_6 + F_6 - f_6F_6)]\rangle.$

3. $\lambda\overline{n_1} = \langle [(1 - (1 - t_1)^\lambda), (1 - (1 - t_2)^\lambda), (1 - (1 - t_3)^\lambda), (1 - (1 - t_4)^\lambda), (1 - (1 - t_5)^\lambda), (1 - (1 - t_6)^\lambda)],$
$[((i_1)^\lambda, (i_2)^\lambda, (i_3)^\lambda), ((i_4)^\lambda, (i_5)^\lambda, (i_6)^\lambda)],$
$[((f_1)^\lambda, (f_2)^\lambda, (f_3)^\lambda), ((f_4)^\lambda, (f_5)^\lambda, (f_6)^\lambda)]\rangle$, *for* $\lambda > 0$.

4. $n_1^\lambda = [((t_1)^\lambda, (t_2)^\lambda, (t_3)^\lambda), ((t_4)^\lambda, (t_5)^\lambda, (t_6)^\lambda)],$
$[1-(1-i_1)^\lambda, (1-(1-i_2)^\lambda), (1-(1-i_3)^\lambda), (1-(1-i_4)^\lambda), (1-(1-i_5)^\lambda), (1-(1-i_6)^\lambda)],$
$[(1 - (1 - f_1)^\lambda), (1 - (1 - f_2)^\lambda), (1 - (1 - f_3)^\lambda), (1 - (1 - f_4)^\lambda), (1 - (1 - f_5)^\lambda), (1 - (1 - f_6)^\lambda)]\rangle$, *for* $\lambda > 0$.

**Definition 2.2** ([9])**.** *Let* $\overline{n} = [(t_1, t_2, t_3), (t_4, t_5, t_6)], [(i_1, i_2, i_3), (i_4, i_5, i_6)], [(f_1, f_2, f_3), (f_4, f_5, f_6)]$ *be an intuitionistic triangular neutrosophic number, then defined as their score functions*

$$S(\overline{n}) = \frac{1}{3}\left\{2 + \left(\frac{t_4 + 2t_5 + t_6}{4} - \frac{t_1 + 2t_2 + t_3}{4}\right)\right.$$
$$\left. - \left(\frac{i_4 + 2i_5 + i_6}{4} - \frac{i_1 + 2i_2 + i_3}{4}\right) - \left(\frac{f_4 + 2f_5 + f_6}{4} - \frac{f_1 + 2f_2 + f_3}{4}\right)\right\}, \tag{1}$$
$$S(\overline{n}) \in [-1, 1],$$

*where the higher value of* $S(\overline{n})$ *larger the intuitionistic triangular number* $\overline{n}$.

## 3. Intuitionistic triangular neutrosophic fuzzy graph

### Advantages of the proposed Algorithm

It is easy to understand a step wise representation and not dependent on any programming language. So we introduce Intuitionistic Triangular Neutrosophic Fuzzy Graph algorithm.

**Merits of Proposed Algorithms:**

1. It is a step-wise representation of a solution to a given problem, which makes it easy to understand.
2. An algorithm uses a definite procedure.
3. It is not dependent on any programming language, so it is easy to understand for anyone even without programming knowledge.
4. Every step in an algorithm has its own logical sequence so it is easy to debug.
5. By using algorithm, the problem is broken down into smaller pieces or steps hence, it is easier for programmer to convert it into an actual program.

**Demerits of Proposed Algorithms:**

1. Alogorithms is Time consuming.
2. Difficult to show Branching and Looping in Algorithms.
3. Big tasks are difficult to put in Algorithms.

**Algorithm:**
In this research, we using proposed algorithm for finding shortest path.

**Step 1.** Let $d_1 = \langle[(0,0,0),(0,0,0)],[(1,1,1),(1,1,1)],[(1,1,1),(1,1,1)]\rangle$ the source node as $d_1 = \langle[(0,0,0),(0,0,0)],[(1,1,1),(1,1,1)],[(1,1,1),(1,1,1)]\rangle$.
**Step 2.** Find $d_j = minimum\{d_i + d_{ij}\}$, $j = 2,3,...,n$.
**Step 3.** If the minimum value of $i$. i.e., $i = r$ then the label node $j$ as $[d_j, r]$. If minimum arise related to more than one values of $i$. Their position we choose minimum value of $i$.
**Step 4.** Let the destination node be $[d_n, l]$. Here source node is $d_n$. We conclude a Score function and we finds minimum value of Intuitionistic Triangular Neutrosophic Number.
**Step 5.** We calculate Shortest Path Problem between source and destination node. Review the label of node 1. Let it be as $[d_n, A]$. Now review the label of node $A$ and so on. Replicate the same procedure until node 1 is procured.
**Step 6.** The Shortest Path can be procured by combined all the nodes by the step 5.

## 4. Data analysis

To find Shortest Path on Chola period built temples using Intuitionistic Triangular Neutrosophic Fuzzy Graph.

In this chapter, AST denotes AmarasundreashwararTemple, GKCT denotes Gangai konda cholapuram Temple, TKT denotes Thiruvanai Kovil Temple, MKT denotes Moovar Kovil Temple, SST denotes Shri Suryanar Temple, BT denotes Brihadeeswarar Temple, and SAT denotes Shri Airavatesvara Temple.

Here, each node is converts as ITNFN.

Here, we consider source node is Amarasundreashwarar Temple and destination node is Airavatesvara temple. To find shortest path on Amarasundreashwarar Temple to Airavatesvara temple.

| | | |
|---|---|---|
| Node 1 | = | AmarasundreashwararTemple |
| Node 2 | = | Gangai konda cholapuram Temple |
| Node 3 | = | Thiruvanai Kovil Temple |
| Node 4 | = | Moovar Kovil Temple |
| Node 5 | = | Shri Suryanar Temple |
| Node 6 | = | Brihadeeswarar Temple |
| Node 7 | = | Shri Airavatesvara Temple |

The distance (km) between temples are considered as the edges of the graph. Considered distance are converted as Intuitionistic Triangular Neutrosophic Fuzzy Graph using the score function(fuzzification) of Intuitionistic Triangular Neutrosophic Fuzzy Graph.

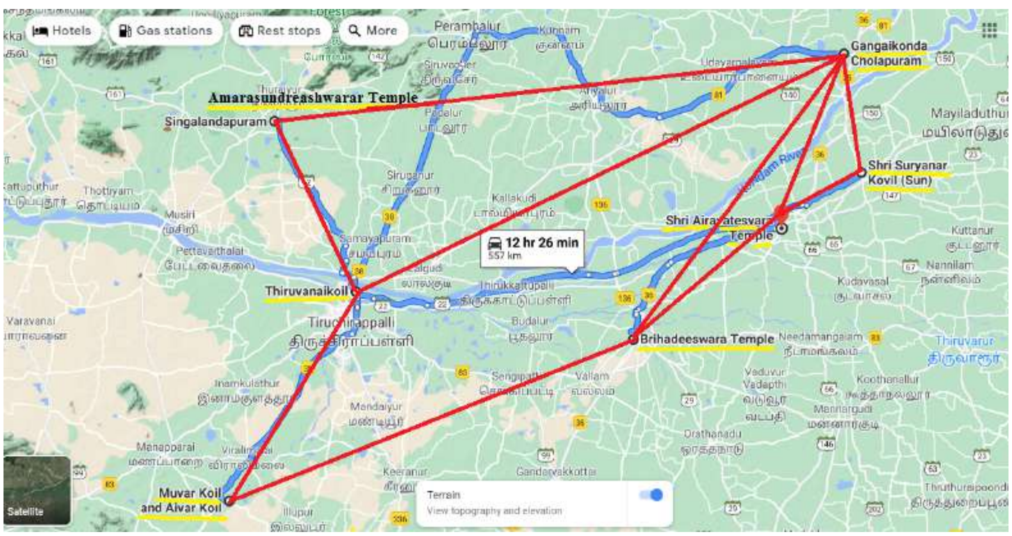



Figure 1: A graph of Chola period temples

Here, distance between one temple to another temple is calculated in kilometers. The numerical value of the distance is converted to Intuitionistic Triangular Neutrosophic Fuzzy Graphs with the help of through Neutrosopic Score function and trapezoidal signed distance.

The given distance ( kilometer) converted to neutrosophic number $\frac{2+T-I-F}{3}$ (using score function). We converted neutrosophic number as $(a_1, a_2, a_3)$ are membership function & $(a_1^*, a_2^{*\prime}, a_3^{*\prime})$ are non-membership function. These functions converted to fuzzy triangular numbers using triangular signed distance $\frac{a_1+2a_2+a_3}{4}$. Finally, converted Intuitionistic Triangular Neutrosophic Fuzzy Number.

Here, Apply the Intuitionistic Triangular Neutrosophic Fuzzy Number in our algorithm to find shortest path to Chola period temples. In this application, many paths have chola period temples. To calculate Shortest Path using score function( Definition 2.1 and 2.2). An algorithm is used to apply a definite procedure and the process has been expensive and time consuming. Here node 1-2 = 117 km

This km changed to neutrosophic number use neutrosophic score function, and each neutrosophic number converted to fuzzification method, so we get fuzzy number. Finally we convert membership and non-membership from fuzzy number because of Intuitionistic fuzzy number, and use triangular signed distance to membership and non-membership functions. At last we get Intuitionistic Triangular Neutrosophic Fuzzy Number.

| | | |
|---|---|---|
| 820 | 340 | 131 |
| 0.82 | 0.34 | 0.131 |
| (0.82,0.18) | (0.34,0.66) | (0.131,0.869) |

$$\Big\langle [(0.65, 0.82, 0.99), (0.11, 0.18, 0.25)], [(0.16, 0.34, 0.52), (0.57, 0.66, 0.75)],$$
$$[(0.07, 0.131, 0.192), (0.813, 0.869, 0.925)] \Big\rangle$$

1-3=35 km

| | | |
|---|---|---|
| 350 | 142 | 105 |
| 0.85 | 0.142 | 0.105 |
| (0.35,0.65) | (0.142,0.858) | (0.105,0.895) |

$$\Big\langle [(0.21, 0.35, 0.49), (0.49, 0.65, 0.81)], [(0.088, 0.142, 0.196), (0.744, 0.858, 0.972)],$$
$$[(0.018, 0.105, 0.192), (0.835, 0.895, 0.955)] \Big\rangle$$

2-3=125 km

$$\begin{array}{ccc} 955 & 425 & 157 \\ 0.955 & 0.425 & 0.157 \\ (0.955,0.045) & (0.425,0.575) & (0.157,0.843) \end{array}$$

$$\Big\langle [(0.911, 0.955, 0.999), (0.029, 0.045, 0.061)], [(0.229, 0.425, 0.621), (0.425, 0.575, 0.725)],$$
$$[(0.013, 0.157, 0.301), (0.722, 0.843, 0.964)] \Big\rangle$$

2-5=24 km

$$\begin{array}{ccc} 316 & 172 & 74 \\ 0.316 & 0.172 & 0.074 \\ (0.316,0.684) & (0.172,0.828) & (0.074,0.926) \end{array}$$

$$\Big\langle [(0.128, 0.316, 0.504), (0.556, 0.684, 0.812)], [(0.011, 0.172, 0.333), (0.721, 0.828, 0.935)],$$
$$[(0.049, 0.074, 0.099), (0.873, 0.926, 0.979)] \Big\rangle$$

2-6=71 km

$$\begin{array}{ccc} 650 & 330 & 109 \\ 0.65 & 0.33 & 0.109 \\ (0.65,0.35) & (0.33,0.67) & (0.109,0.891) \end{array}$$

$$\Big\langle [(0.59, 0.65, 0.71), (0.17, 0.35, 0.53)], [(0.17, 0.33, 0.49), (0.51, 0.67, 0.83)],$$
$$[(0.035, 0.109, 0.183), (0.826, 0.891, 0.956)] \Big\rangle$$

3-4=48 km

$$\begin{array}{ccc} 465 & 220 & 103 \\ 0.465 & 0.22 & 0.103 \\ (0.465,0.535) & (0.22,0.78) & (0.103,0.897) \end{array}$$

$$\Big\langle [(0.395, 0.465, 0.535), (0.455, 0.535, 0.615)], [(0.11, 0.22, 0.33), (0.71, 0.78, 0.85)],$$
$$[(0.011, 0.103, 0.195), (0.821, 0.897, 0.973)] \Big\rangle$$

4-6=95 km

| | | |
|---|---|---|
| 950 | 435 | 232 |
| 0.95 | 0.435 | 0.232 |
| (0.95,0.05) | (0.435,0.565) | (0.232,0.768) |

$$\Big\langle [(0.91, 0.95, 0.99), (0.02, 0.05, 0.08)], [(0.333, 0.435, 0.537), (0.505, 0.565, 0.625)],$$
$$[(0.149, 0.232, 0.315), (0.733, 0.768, 0.803)]\Big\rangle$$

5-6=54 km

| | | |
|---|---|---|
| 650 | 320 | 170 |
| 0.65 | 0.32 | 0.17 |
| (0.65,0.35) | (0.32,0.68) | (0.17,0.83) |

$$\Big\langle [(0.51, 0.65, 0.79), (0.24, 0.35, 0.46)], [(0.17, 0.32, 0.47), (0.6, 0.68, 0.76)],$$
$$[(0.09, 0.17, 0.25), (0.69, 0.83, 0.97)]\Big\rangle$$

5-7=20 km

| | | |
|---|---|---|
| 180 | 72 | 50 |
| 0.18 | 0.072 | 0.05 |
| (0.18,0.82) | (0.072,0.928) | (0.05,0.95) |

$$\Big\langle [(0.09, 0.18, 0.27), (0.71, 0.82, 0.93)], [(0.045, 0.072, 0.099), (0.869, 0.928, 0.987)],$$
$$[(0.03, 0.05, 0.07), (0.93, 0.95, 0.97)]\Big\rangle$$

6-7=20 km

| | | |
|---|---|---|
| 640 | 330 | 201 |
| 0.64 | 0.33 | 0.201 |
| (0.64,0.36) | (0.33,0.67) | (0.201,0.799) |

$$\Big\langle [(0.56, 0.64, 0.72), (0.28, 0.36, 0.44)], [(0.2, 0.33, 0.46), (0.59, 0.67, 0.75)],$$
$$[(0.069, 0.201, 0.333), (0.737, 0.799, 0.861)]\Big\rangle$$

In this iteration SPP was calculated through the proposed algorithm, the concept of the Chola period temples shortest path calculated from Amarasundreashwarar Temple to Shri Airavatesvara Temple.

Let $n = 7$ is the destination node, since there are totally 7 nodes.

**Iteration 1.** Assume the source node is Amarasundreashwarar Temple. Here we assume $d_1 = \langle[(0,0,0),\ (0,0,0)],\ [(1,1,1),\ (1,1,1)],\ [(1,1,1),\ (1,1,1)]\rangle$ and label of source node is $\{\langle[(0,0,0),(0,0,0)],[(1,1,1),(1,1,1)],[(1,1,1),(1,1,1)]\rangle,--\}$ the value of $d_j, j = 2,3,4,5,6$ is succeeding. Here we assume $d_1$ is the Amarasundreashwarar Temple.

**Iteration 2.** The node Gangai konda cholapuram Temple has only node Amarasundreashwarar Temple as the predecessor. Intuitionistic Triangular Fuzzy Neutrosophic Shortest Path is calculated from Gangai konda cholapuram Temple to Amarasundreashwarar Temple. Since node 2 has only node 1 as the predecessor. So fix $i = 1$ and $j = 2$ we apply step 2 at proposed algorithm

$$
\begin{aligned}
d_2 &= minimum\{d_1 \oplus d_{12}\}\\
&= minimum \left\{ \begin{array}{r} \langle[(0,0,0),(0,0,0)],[(1,1,1),(1,1,1)],[(1,1,1),(1,1,1)]\rangle\oplus \\ \langle[(0.65,0.82,0.99),(0.11,0.18,0.25)],[(0.16,0.34,0.52), \\ (0.57,0.66,0.75)],[(0.07,0.131,0.192),(0.813,0.869,0.925)]\rangle \end{array} \right\}\\
&= \left\{ \begin{array}{r} \langle[(0.65,0.82,0.99),(0.11,0.18,0.25)],[(0.16,0.34,0.52), \\ (0.57,0.66,0.75)],[(0.07,0.131,0.192),(0.813,0.869,0.925)]\rangle \end{array} \right\}
\end{aligned}
$$

Therefore, minimum value $i = 1$, corresponding to label node 2 as

$$
\begin{aligned}
&= \left\{ \begin{array}{r} \langle[(0.65,0.82,0.99),(0.11,0.18,0.25)],[(0.16,0.34,0.52), \\ (0.57,0.66,0.75)],[(0.07,0.131,0.192),(0.813,0.869,0.925)]\rangle,1 \end{array} \right\}\\
d_2 &= \left\{ \begin{array}{r} \langle[(0.65,0.82,0.99),(0.11,0.18,0.25)],[(0.16,0.34,0.52), \\ (0.57,0.66,0.75)],[(0.07,0.131,0.192),(0.813,0.869,0.925)]\rangle \end{array} \right\}
\end{aligned}
$$

The labeled node is Gangai Konda Cholapuram and minimum provided corresponding node is Amarasundreashwarar Temple.

| Minimum Node | Labeled Node | Path Node |
|---|---|---|
| AST | GKCT | $\langle[(0.65,\ 0.82,\ 0.99),\ (0.11,\ 0.18,\ 0.25)],$ $[(0.16,\ 0.34,\ 0.52),\ (0.57,\ 0.66,\ 0.75)],$ $[(0.07,\ 0.131,\ 0.192),\ (0.813,\ 0.869,\ 0.925)]\rangle$ |

**Iteration 3.** The node Thiruvanai Kovil Temple has two predecessors node, they are node Amarasundreashwarar Temple and node Gangai konda cholapuram Temple. Intuitionistic Triangular Fuzzy Neutrosophic Shortest Path is calculated to Thiruvanai Kovil from Amarasundreashwarar Temple and Gangai konda cholapuram. Since node 3 has two predecessors node 1 and node 2. So fix $i = 1, 2$ and $j = 3$ we apply step 2 at proposed algorithm.

$d_3 = minimum\{d_1 \oplus d_{13}, d_2 \oplus d_{23}\}$

$$= minimum \left\{ \begin{array}{r} \langle[(0,0,0),(0,0,0)],[(1,1,1),(1,1,1)],[(1,1,1),(1,1,1)]\rangle\oplus \\ \langle[(0.21,0.35,0.49),(0.49,0.65,0.81)],[(0.088,0.142,0.196), \\ (0.744,0.858,0.972)],[(0.018,0.105,0.192),(0.835,0.895,0.955)]\rangle \\ \langle[(0.65,0.82,0.99),(0.11,0.18,0.25)],[(0.16,0.34,0.52) \\ (0.57,0.66,0.75)],[(0.07,0.131,0.192),(0.813,0.869,0.925)]\rangle\oplus \\ \langle[(0.911,0.955,0.999),(0.029,0.045,0.061)],[(0.229,0.425,0.621) \\ (0.425,0.575,0.725)],[(0.013,0.157,0.301),(0.722,0.843,0.964)]\rangle \end{array} \right\}$$

$$= minimum \left\{ \begin{array}{r} \langle[(0.21,0.35,0.49),(0.49,0.65,0.81)],[(0.088,0.142,0.196), \\ (0.744,0.858,0.972)],[(0.018,0.105,0.192),(0.835,0.895,0.955)]\rangle, \\ \langle[(0.9688,0.9919,0.999),(0.1358,0.217,0.2957)],[(0.0366,0.1445,0.323), \\ (0.2422,0.3795,0.5437)],[(0.0009,0.0205,0.0577),(0.5869,0.7325,0.8917)]\rangle \end{array} \right\}$$

Using equation (2.1),we have

$$S \left\{ \begin{array}{r} \langle[(0.21,0.35,0.49),(0.49,0.65,0.81)],[(0.088,0.142,0.196), \\ (0.744,0.858,0.972)],[(0.018,0.105,0.192),(0.835,0.895,0.955)]\rangle \end{array} \right\}$$

$S(\overline{n}_1) = 0.2647$

$$S \left\{ \begin{array}{r} \langle[(0.9688,0.9919,0.999),(0.1358,0.217,0.2957)],[(0.0366,0.1445,0.323), \\ (0.2422,0.3795,0.5437)],[(0.0009,0.0205,0.0577),(0.5869,0.7325,0.8917)]\rangle \end{array} \right\}$$

$S(\overline{n}_2) = 0.0978$

Therefore minimum value $i = 2$, corresponding to label node 3 as

$$\left\{ \begin{array}{r} \langle[(0.9688,0.9919,0.999),(0.1358,0.217,0.2957)],[(0.0366,0.1445,0.323), \\ (0.2422,0.3795,0.5437)],[(0.0009,0.0205,0.0577),(0.5869,0.7325,0.8917)]\rangle, 2 \end{array} \right\}$$

$$d_3 = \left\{ \begin{array}{r} \langle[(0.9688,0.9919,0.999),(0.1358,0.217,0.2957)],[(0.0366,0.1445,0.323), \\ (0.2422,0.3795,0.5437)],[(0.0009,0.0205,0.0577),(0.5869,0.7325,0.8917)]\rangle \end{array} \right\}$$

Here, the labeled node is Thiruvanai Kovil and the minimum provided corresponding node is Gangai konda cholapuram.

| Minimum Node | Labeled Node | Path Node |
|---|---|---|
| GKCT | TKT | ⟨[(0.9688, 0.9919, 0.999), (0.1358, 0.217, 0.2957)], [(0.0366, 0.1445, 0.323), (0.2422, 0.3795, 0.5437)], [(0.0009, 0.0205, 0.0577), (0.5869, 0.7325, 0.8917)]⟩ |

**Iteration 4.** The node Moovar Kovil has only node Thiruvanai Kovil as the predecessor. Intuitionistic Triangular Fuzzy Neutrosophic Shortest Path is calculated to Moovar Kovil from Thiruvanai Kovil. Since node 4 has only node 3 as

the predecessor. So fix $i = 3$ and $j = 4$ we apply step 2 at proposed algorithm.

$$d_4 = minimum\{d_3 \oplus d_{34}\}$$

$$= minimum \left\{ \begin{array}{r} \langle[(0.9688, 0.9919, 0.999), (0.1358, 0.217, 0.2957)], [(0.0366, 0.1445, 0.323), \\ (0.2422, 0.3795, 0.5437)], [(0.0009, 0.0205, 0.0577), (0.5869, 0.7325, 0.8917)]\rangle\oplus \\ \langle[(0.395, 0.465, 0.535), (0.455, 0.535, 0.615)], [(0.11, 0.22, 0.33), \\ (0.71, 0.78, 0.85)], [(0.011, 0.103, 0.195), (0.821, 0.897, 0.973)]\rangle \end{array} \right\}$$

$$= \left\{ \begin{array}{r} \langle[(0.98, 0.995, 0.999), (0.529, 0.636, 0.728)], [(0.004, 0.032, 0.107), \\ (0.172, 0.296, 0.462)], [(0.000009, 0.002, 0.011), (0.482, 0.657, 0.868)]\rangle \end{array} \right\}$$

Therefore minimum value $i = 3$, corresponding to label node 4 as

$$= \left\{ \begin{array}{r} \langle[(0.98, 0.995, 0.999), (0.529, 0.636, 0.728)], [(0.004, 0.032, 0.107), \\ (0.172, 0.296, 0.462)], [(0.000009, 0.002, 0.011), (0.482, 0.657, 0.868)]\rangle, 3 \end{array} \right\}$$

$$d_4 = \left\{ \begin{array}{r} \langle[(0.98, 0.995, 0.999), (0.529, 0.636, 0.728)], [(0.004, 0.032, 0.107), \\ (0.172, 0.296, 0.462)], [(0.000009, 0.002, 0.011), (0.482, 0.657, 0.868)]\rangle \end{array} \right\}$$

Here, the labeled node is Moovar Kovil and the minimum provided corresponding node is Thiruvanai Kovil.

| Minimum Node | Labeled Node | Path Node |
| --- | --- | --- |
| TKT | MKT | ⟨[(0.98, 0.995, 0.999), (0.529, 0.636, 0.728)], [(0.004, 0.032, 0.107), (0.172, 0.296, 0.462)], [(0.000009, 0.002, 0.011), (0.482, 0.657, 0.868)]⟩ |

**Iteration 5.** The node Shri Suryanar Temple has only node Gangai konda cholapuram as the predecessor. Intuitionistic Triangular Fuzzy Neutrosophic Shortest Path is calculated to Shri Suryanar Temple from Gangai konda cholapuram. Since node 5 has only node 2 as the predecessor. So fix $i = 2$ and $j = 5$ we apply step 2 at proposed algorithm.

$$d_5 = minimum\{d_2 \oplus d_{25}\}$$

$$= minimum \left\{ \begin{array}{r} \langle[(0.65, 0.82, 0.99), (0.11, 0.18, 0.25)], [(0.16, 0.34, 0.52), \\ (0.57, 0.66, 0.75)], [(0.07, 0.131, 0.192), (0.813, 0.869, 0.925)]\rangle\oplus \\ \langle[(0.128, 0.316, 0.504), (0.556, 0.684, 0.812)], [(0.011, 0.172, 0.333), \\ (0.721, 0.828, 0.935)], [(0.049, 0.074, 0.099), (0.873, 0.926, 0.979)]\rangle \end{array} \right\}$$

$$= \left\{ \begin{array}{r} \langle[(0.695, 0.877, 0.995), (0.605, 0.741, 0.859)], [(0.002, 0.058, 0.173), \\ (0.411, 0.546, 0.701)], [(0.003, 0.0096, 0.019), (0.709, 0.805, 0.906)]\rangle \end{array} \right\}$$

Therefore minimum value $i = 2$, corresponding to label node 5 as

$$= \left\{ \begin{array}{r} \langle[(0.695, 0.877, 0.995), (0.605, 0.741, 0.859)], [(0.002, 0.058, 0.173), \\ (0.411, 0.546, 0.701)], [(0.003, 0.0096, 0.019), (0.709, 0.805, 0.906)]\rangle, 2 \end{array} \right\}$$

$$d_4 = \left\{ \begin{array}{r} \langle[(0.695, 0.877, 0.995), (0.605, 0.741, 0.859)], [(0.002, 0.058, 0.173), \\ (0.411, 0.546, 0.701)], [(0.003, 0.0096, 0.019), (0.709, 0.805, 0.906)]\rangle \end{array} \right\}$$

Here the labeled node is Shri Suryanar Temple and the minimum provided corresponding node is Gangai konda cholapuram.

| Minimum Node | Labeled Node | Path Node |
|---|---|---|
| GKCT | SST | ⟨[(0.695, 0.877, 0.995), (0.605, 0.741, 0.859)], [(0.002, 0.058, 0.173), (0.411, 0.546, 0.701)], [(0.003, 0.0096, 0.019), (0.709, 0.805, 0.906)]⟩ |

**Iteration 6.** The node Brihadeeswarar Temple has three predecessors node, they are node Gangai konda cholapuram, node Moovar Kovil and node Shri Suryanar Temple. Intuitionistic Triangular Fuzzy Neutrosophic Shortest Path is calculated to Brihadeeswarar Temple from Gangai konda cholapuram, Moovar Kovil and Shri Suryanar Temple. Since node 6 has three predecessors . The predecessors are node 2, node 4 and node 5. So fix $i = 2, 4, 5$ and $j = 6$ we apply step 2 at proposed algorithm.

$$d_6 = minimum\{d_2 \oplus d_{26}, d_4 \oplus d_{46}, d_5 \oplus d_{56}\}$$

$$= minimum\left\{\begin{array}{r}\langle[(0.65, 0.82, 0.99), (0.11, 0.18, 0.25)], [(0.16, 0.34, 0.52),\\ (0.57, 0.66, 0.75)], [(0.07, 0.131, 0.192), (0.813, 0.869, 0.925)]\rangle\oplus\\ \langle[(0.59, 0.65, 0.71), (0.17, 0.35, 0.53)], [(0.17, 0.33, 0.49),\\ (0.51, 0.67, 0.83)], [(0.035, 0.109, 0.183), (0.826, 0.891, 0.956)]\rangle\\ \langle[(0.98, 0.995, 0.999), (0.529, 0.636, 0.728)], [(0.004, 0.032, 0.107),\\ (0.172, 0.296, 0.462)], [(0.000009, 0.002, 0.011), (0.482, 0.657, 0.868)]\rangle\oplus\\ \langle[(0.91, 0.95, 0.99), (0.02, 0.05, 0.08)], [(0.333, 0.435, 0.537),\\ (0.505, 0.565, 0.625)], [(0.149, 0.232, 0.315), (0.733, 0.768, 0.803)]\rangle\\ \langle[(0.695, 0.877, 0.995), (0.605, 0.741, 0.859)], [(0.002, 0.058, 0.173),\\ (0.411, 0.546, 0.701)], [(0.003, 0.0096, 0.019), (0.709, 0.805, 0.906)]\rangle\oplus\\ \langle[(0.51, 0.65, 0.79), (0.24, 0.35, 0.46)], [(0.17, 0.32, 0.47),\\ (0.6, 0.68, 0.76)], [(0.09, 0.17, 0.25), (0.69, 0.83, 0.97)]\rangle\end{array}\right\}$$

$$= minimum\left\{\begin{array}{r}\langle[(0.856, 0.937, 0.997), (0.2613, 0.467, 0.647)], [(0.0272, 0.1122, 0.2548),\\ (0.291, 0.442, 0.6225)], [(0.0024, 0.014, 0.035), (0.671, 0.774, 0.884)]\rangle,\\ \langle[(0.998, 0.9997, 0.99999), (0.538, 0.654, 0.749)], [(0.001, 0.014, 0.057),\\ (0.087, 0.167, 0.289)], [(0.000001, 0.0005, 0.003), (0.353, 0.504, 0.697)]\rangle\\ \langle[(0.85, 0.956, 0.999), (0.699, 0.832, 0.9238)], [(0.0003, 0.0185, 0.0813),\\ (0.247, 0.371, 0.322)], [(0.0003, 0.002, 0.005), (0.489, 0.668, 0.879)]\rangle\end{array}\right\}$$

Using equation (2.1),we have

$$S\left\{\begin{array}{r}\langle[(0.856, 0.937, 0.997), (0.2613, 0.467, 0.647)], [(0.0272, 0.1122, 0.2548),\\ (0.291, 0.442, 0.6225)], [(0.0024, 0.014, 0.035), (0.671, 0.774, 0.884)]\rangle\end{array}\right\}$$

$$S(\overline{n}_1) = 0.149$$

$$S\left\{\begin{array}{c}\langle[(0.998,0.9997,0.99999),(0.538,0.654,0.749)],[(0.001,0.014,0.057),\\(0.087,0.167,0.289)],[(0.000001,0.0005,0.003),(0.353,0.504,0.697)]\rangle\end{array}\right\}$$

$S(\overline{n}_2)=0.32662$

$$S\left\{\begin{array}{c}\langle[(0.85,0.956,0.999),(0.699,0.832,0.9238)],[(0.0003,0.0185,0.0813),\\(0.247,0.371,0.322)],[(0.0003,0.002,0.005),(0.489,0.668,0.879)]\rangle\end{array}\right\}$$

$S(\overline{n}_3)=0.3032$

Therefore minimum value $i=2$, corresponding to label node 6 as

$$\left\{\begin{array}{c}\langle[(0.856,0.937,0.997),(0.2613,0.467,0.647)],[(0.0272,0.1122,0.2548),\\(0.291,0.442,0.6225)],[(0.0024,0.014,0.035),(0.671,0.774,0.884)]\rangle,2\end{array}\right\}$$

$$d_3=\left\{\begin{array}{c}\langle[(0.856,0.937,0.997),(0.2613,0.467,0.647)],[(0.0272,0.1122,0.2548),\\(0.291,0.442,0.6225)],[(0.0024,0.014,0.035),(0.671,0.774,0.884)]\rangle\end{array}\right\}$$

Here, the labeled node is Brihadeeswarar Temple and the minimum provided corresponding node is Gangai konda cholapuram.

| Minimum Node | Labeled Node | Path Node |
|---|---|---|
| GKCT | BT | ⟨[(0.856, 0.937, 0.997), (0.2613, 0.467, 0.647)], [(0.0272, 0.1122, 0.2548), (0.291, 0.442, 0.6225)], [(0.0024, 0.014, 0.035), (0.671, 0.774, 0.884)]⟩ |

**Iteration 7.** The node Shri Airavatesvara Temple has two predecessors node, they are node Shri Suryanar Temple and node Brihadeeswarar Temple. ITNSP is calculated to Shri Airavatesvara Temple from Shri Suryanar Temple and Brihadeeswarar Temple. Since node 7 has two predecessors node 5 and node 6. So fix $i=5,6$ and $j=7$ we apply step 2 at proposed algorithm.

$$d_7=minimum\{d_5\oplus d_{57},d_6\oplus d_{67}\}$$

$$=minimum\left\{\begin{array}{r}\langle[(0.695,0.877,0.995),(0.605,0.741,0.859)],[(0.002,0.058,0.173),\\(0.411,0.546,0.701)],[(0.003,0.0096,0.019),(0.709,0.805,0.906)]\rangle\oplus\\\langle[(0.09,0.18,0.27),(0.71,0.82,0.93)],[(0.045,0.072,0.099),\\(0.869,0.928,0.987)],[(0.03,0.05,0.07),(0.93,0.95,0.97)]\rangle\\\langle[(0.856,0.937,0.997),(0.2613,0.467,0.647)],[(0.0272,0.1122,0.2548),\\(0.291,0.442,0.6225)],[(0.0024,0.014,0.035),(0.671,0.774,0.884)]\rangle\oplus\\\langle[(0.56,0.64,0.72),(0.28,0.36,0.44)],[(0.2,0.33,0.46),\\(0.59,0.67,0.75)],[(0.069,0.201,0.333),(0.737,0.799,0.861)]\rangle\end{array}\right\}$$

$$=minimum\left\{\begin{array}{r}\langle[(0.722,0.899,0.996),(0.885,0.953,0.99)],[(0.00009,0.004,0.017),\\(0.357,0.507,0.692)],[(0.00009,0.0005,0.0013),(0.659,0.765,0.8788)]\rangle,\\\langle[(0.93,0.977,0.999),(0.468,0.659,0.802)],[(0.005,0.037,0.1172),\\(0.172,0.296,0.467)],[(0.0002,0.003,0.012),(0.494,0.618,0.761)]\rangle\end{array}\right\}$$

Using equation (2.1),we have

$$S\left\{\begin{matrix}\langle[(0.722,0.899,0.996),(0.885,0.953,0.99)],[(0.00009,0.004,0.017),\\(0.357,0.507,0.692)],[(0.00009,0.0005,0.0013),(0.659,0.765,0.8788)]\rangle\end{matrix}\right\}$$

$S(\overline{n}_1) = 0.26339$

$$S\left\{\begin{matrix}\langle[(0.93,0.977,0.999),(0.468,0.659,0.802)],[(0.005,0.037,0.1172),\\(0.172,0.296,0.467)],[(0.0002,0.003,0.012),(0.494,0.618,0.761)]\rangle\end{matrix}\right\}$$

$S(\overline{n}_2) = 0.2665$

Therefore minimum value $i = 5$, corresponding to label node 7 as

$$\left\{\begin{matrix}\langle[(0.722,0.899,0.996),(0.885,0.953,0.99)],[(0.00009,0.004,0.017),\\(0.357,0.507,0.692)],[(0.00009,0.0005,0.0013),(0.659,0.765,0.8788)]\rangle,5\end{matrix}\right\}$$

$$d_3 = \left\{\begin{matrix}\langle[(0.722,0.899,0.996),(0.885,0.953,0.99)],[(0.00009,0.004,0.017),\\(0.357,0.507,0.692)],[(0.00009,0.0005,0.0013),(0.659,0.765,0.8788)]\rangle\end{matrix}\right\}$$

The labeled node is Airavatesvara Temple and the minimum provided corresponding node is Shri Suryanar Temple.

| Minimum Node | Labeled Node | Path Node |
|---|---|---|
| SST | AT | $\langle[(0.722,\ 0.899,\ 0.996),\ (0.885,\ 0.953,\ 0.99)],\ [(0.00009,\ 0.004,\ 0.017),\ (0.357,\ 0.507,\ 0.692)],\ [(0.00009,\ 0.0005,\ 0.0013),\ (0.659,\ 0.765,\ 0.8788)]\rangle$ |

Since Airavatesvara Temple is the destination node.We calculate SP to destination node to source node. Since

| Labeled Node | Minimum Node |
|---|---|
| Shri Airavatesvara Temple | Shri Suryanar Temple |
| Shri Suryanar Temple | Gangai konda cholapuram |
| Gangai konda cholapuram | Amarasundreashwarar Temple |

Therefore, the Chola period built temples Intuitionistic Triangular Neutrosophic Fuzzy Graph Shortest Path is

$$AST \to GKCT \to SST \to SST$$

## 5. The shortest path on Dijkstra's algorithm

Edge weight suitable algorithm is Dijkstra's algorithm. So here we conclude same type of Shortest Path through Dijkstra's Algorithm.

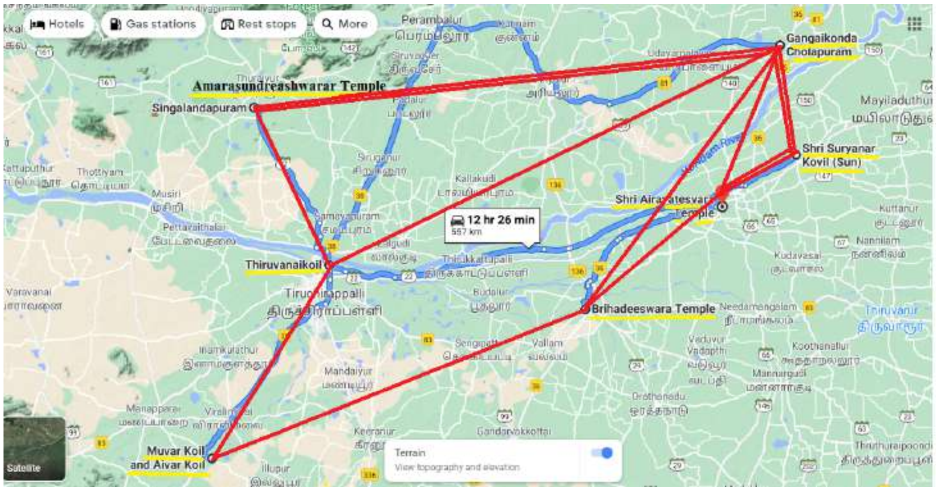



Figure 2: SP from Amarasundareshwarar Temple to Airavateswara Temple

In the above real life application, we clarify another method of Shortest Path Problem using Dijkstra's algorithm. In this Shortest Path Problem, we use direct method of Dijkstra's algorithm and we assume edge weight is Chola period temples km.

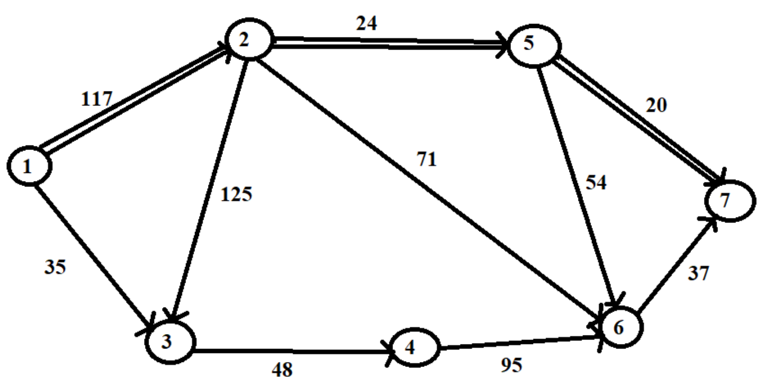


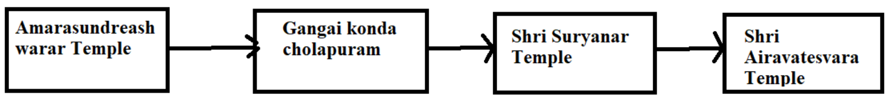

Figure 3: SP for Dijkstra's Algorithm

Here, we verify Chola period buildted temples shortest path through Dijkstra's Algorithm. We have the paths are

$$1 \to 2 \to 5 \to 7$$

Here, the intuitionistic triangular Neutrosophic fuzzy graphs and Dijkstra's Algorithm are same. The shortest path is

$$1 \to 2 \to 5 \to 7$$




## DIJKSTRA'S ALGORITHM PYTHON PROGRAM

Python program has been used to verify the result of Dijktra's Algorithm. It can be accessed earily and checked properly.

```
import sys

def to_be_visited():
global visited_and_distance
v = -10

for index in range(number_of_vertices):
if visited_and_distance[index][0] == 0 and
(v < 0 or visited_and_distance[index][1]
<= visited_and_distance[v][1]):
v = index
return v

vertices = [[0,1,1,0,0,0,0],
            [0,0,1,0,1,1,0],
            [0,0,0,1,0,0,0],
            [0,0,0,0,0,1,0],
            [0,0,0,0,0,1,1],
            [0,0,0,0,0,0,1],
            [0,0,0,0,0,0,0]]
edges =  [[0,117,35,0,0,0,0],
            [0,0,125,0,24,71,0],
```

```
            [0,0,0,48,0,0,0],
            [0,0,0,0,0,95,0],
            [0,0,0,0,0,54,20],
            [0,0,0,0,0,0,37],
            [0,0,0,0,0,0,0]]

number_of_vertices = len(vertices[0])

visited_and_distance = [[0, 0]]
for i in range(number_of_vertices-1):
visited_and_distance.append([0, sys.maxsize])

for vertex in range(number_of_vertices):

to_visit = to_be_visited()
for neighbor_index in range(number_of_vertices):
if vertices[to_visit][neighbor_index] == 1 and
visited_and_distance[neighbor_index][0] == 0:
new_distance = visited_and_distance[to_visit][1] +
edges[to_visit][neighbor_index]

if visited_and_distance[neighbor_index][1] > new_distance:
visited_and_distance[neighbor_index][1] = new_distance
visited_and_distance[to_visit][0] = 1

i = 0

for distance in visited_and_distance:
print("The shortest distance of ",chr(ord('a') + i), "
from the source vertex a is:",distance[1])
i = i + 1


Output for the above program
-----------------------------

The shortest distance of  a  from the source vertex a is: 0
The shortest distance of  b  from the source vertex a is: 117
The shortest distance of  c  from the source vertex a is: 35
The shortest distance of  d  from the source vertex a is: 83
The shortest distance of  e  from the source vertex a is: 141
The shortest distance of  f  from the source vertex a is: 178
The shortest distance of  g  from the source vertex a is: 161
```

## 6. Conclusion

In this article, discovering Shortest Path on Chola period temples using Intuitionistic Triangular Neutrosophic Fuzzy Graph. We use Neutrosophic score function and Triangular signed distance for fuzzification of membership and non-membership function. Intuitionistic Triangular Neutrosophic Fuzzy Number Score function is used to calculate Shortest Path of Intuitionistic Triangular Neutrosophic Fuzzy Graph. A genuine application is given to act as an Intuitionistic Triangular Neutrosophic Fuzzy Graph. Finally most brief way Shortest Path on Chola period buildted temples verified with Dijkstra's algorithm through the long last Python Jupyter Notebook (form) programming.

### Futuristic work

In future shortest path problem can be applied by using Kruskal's Algorithm. We can verified by applying transportation Problem and Decision making problem. All weightage fuzzy number will be incorporated to find the shortest route of traffic or human intervention practical problem.

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