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(Dedicated to Professor G. C. Sharma on His 85th Birth Anniversary Celebrations)

SHORTEST PATH ON INTERVAL-VALUED INTUITIONISTIC TRAPEZOIDAL NEUTROSOPHIC FUZZY GRAPHS WITH APPLICATION
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Abstract

In this article, stretch esteemed Interval Valued Intuitionistic Trapezoidal Neutrosophic Fuzzy Graph (IVITrNFG) of SPP, which is drew on trapezoidal numbers and IVITrNFG. Hear a genuine application is given an illustrative model for IVITrNFG. Additionally Shortest way is determined for this model. This present Dijkstra’s Algorithm briefest way was checked.

2010 Mathematics Subject Classification: 05C85
Keywords and Phrases: Interval-Valued Intuitionistic Fuzzy Number (IVIFN), Trapezoidal Fuzzy Number (TrFN), Shortest Path (SP), Interval-Valued Intuitionistic Trapezoidal Neutrosophic Fuzzy Graph(IVITrNFG).

1 Introduction


Here, in this paper disclosed the briefest way to India famous seven tourist places utilized the proposed calculation.
Section 2, introduces some basic concepts related to definitions. Section 3, introduces IVITrNFG proposed algorithm and find SPP using that proposed algorithm. Section 4, we apply real life application. The application has India famous seven tourist place and find its SPP using IVITrNFG proposed algorithm. Section 5, verifies shortest path on India famous seven tourist place with Dijkstrass algorithm. Conclusion is given in Section 6.

2 Methodology

In this section we explain some important definitions.

Definition 2.1. Let

\[ \bar{n}_1 = \langle \left( \left( t^L_a, t^L_b, t^L_c, t^L_d, t^L_e, t^L_f, t^L_g, t^L_h \right) \right), \left( \left( t^U_a, t^U_b, t^U_c, t^U_d, t^U_e, t^U_f, t^U_g, t^U_h \right) \right), \left( \left( i^L_a, i^L_b, i^L_c, i^L_d, i^L_e, i^L_f, i^L_g, i^L_h \right) \right), \left( \left( i^U_a, i^U_b, i^U_c, i^U_d, i^U_e, i^U_f, i^U_g, i^U_h \right) \right), \left( \left( f^L_a, f^L_b, f^L_c, f^L_d, f^L_e, f^L_f, f^L_g, f^L_h \right) \right), \left( \left( f^U_a, f^U_b, f^U_c, f^U_d, f^U_e, f^U_f, f^U_g, f^U_h \right) \right) \rangle \]

and

\[ \bar{n}_2 = \langle \left( \left( I^L_a, I^L_b, I^L_c, I^L_d, I^L_e, I^L_f, I^L_g, I^L_h \right) \right), \left( \left( I^U_a, I^U_b, I^U_c, I^U_d, I^U_e, I^U_f, I^U_g, I^U_h \right) \right), \left( \left( I^0_a, I^0_b, I^0_c, I^0_d, I^0_e, I^0_f, I^0_g, I^0_h \right) \right), \left( \left( I^L_a, I^L_b, I^L_c, I^L_d, I^L_e, I^L_f, I^L_g, I^L_h \right) \right), \left( \left( I^U_a, I^U_b, I^U_c, I^U_d, I^U_e, I^U_f, I^U_g, I^U_h \right) \right), \left( \left( I^0_a, I^0_b, I^0_c, I^0_d, I^0_e, I^0_f, I^0_g, I^0_h \right) \right) \rangle \]

both Interval-Valued Trapezoidal Neutrosophic Numbers. Therefore following procedure holds:

\[ \bar{n}_2 = \langle \left( \left( T^L_a, T^L_b, T^L_c, T^L_d, T^L_e, T^L_f, T^L_g, T^L_h \right) \right), \left( \left( T^U_a, T^U_b, T^U_c, T^U_d, T^U_e, T^U_f, T^U_g, T^U_h \right) \right), \left( \left( T^L_a, T^L_b, T^L_c, T^L_d, T^L_e, T^L_f, T^L_g, T^L_h \right) \right), \left( \left( T^U_a, T^U_b, T^U_c, T^U_d, T^U_e, T^U_f, T^U_g, T^U_h \right) \right), \left( \left( T^L_a, T^L_b, T^L_c, T^L_d, T^L_e, T^L_f, T^L_g, T^L_h \right) \right), \left( \left( T^U_a, T^U_b, T^U_c, T^U_d, T^U_e, T^U_f, T^U_g, T^U_h \right) \right), \left( \left( T^L_a, T^L_b, T^L_c, T^L_d, T^L_e, T^L_f, T^L_g, T^L_h \right) \right), \left( \left( T^U_a, T^U_b, T^U_c, T^U_d, T^U_e, T^U_f, T^U_g, T^U_h \right) \right) \rangle \]

We propose definition of score and accuracy functions for an Interval-Valued Trapezoidal Neutrosophic Number.

Definition 2.2. Let

\[ \bar{n}_1 = \langle \left( \left( t^L_a, t^L_b, t^L_c, t^L_d, t^L_e, t^L_f, t^L_g, t^L_h \right) \right), \left( \left( t^U_a, t^U_b, t^U_c, t^U_d, t^U_e, t^U_f, t^U_g, t^U_h \right) \right), \left( \left( i^L_a, i^L_b, i^L_c, i^L_d, i^L_e, i^L_f, i^L_g, i^L_h \right) \right), \left( \left( i^U_a, i^U_b, i^U_c, i^U_d, i^U_e, i^U_f, i^U_g, i^U_h \right) \right), \left( \left( f^L_a, f^L_b, f^L_c, f^L_d, f^L_e, f^L_f, f^L_g, f^L_h \right) \right), \left( \left( f^U_a, f^U_b, f^U_c, f^U_d, f^U_e, f^U_f, f^U_g, f^U_h \right) \right) \rangle \]

and be an Interval-Valued, Intuitionistic Trapezoidal Neutrosophic Number, then their score functions are defined as

\[
S(\bar{n}) = \frac{1}{3} \left[ \frac{2 + \frac{1}{8} \left[ t^U_a + t^U_b + t^U_c + t^U_d + t^U_e + t^U_f + t^U_g + t^U_h \right] - \left( t^L_a + t^L_b + t^L_c + t^L_d + t^L_e + t^L_f + t^L_g + t^L_h \right)}{8} \right], \quad \text{for } \bar{n} \in [-1, 1]
\]

where the higher value of \( S(\bar{n}) \), larger the Interval-Valued Intuitionistic Trapezoidal Number \( \bar{n} \).
3 Interval-Valued Intuitionistic Trapezoidal Neutrosophic Fuzzy Graph

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

**Step 3.1** Let

\[d_1 = \langle[(0, 0, 0, 0), (0, 0, 0, 0)], [(0, 0, 0, 0), (0, 0, 0, 0)], [(1, 1, 1, 1), (1, 1, 1, 1)], [(1, 1, 1, 1), (1, 1, 1, 1)]\rangle\]

and the source node as

\[d_1 = \langle[(0, 0, 0, 0), (0, 0, 0, 0)], [(0, 0, 0, 0), (0, 0, 0, 0)], [(1, 1, 1, 1), (1, 1, 1, 1)], [(1, 1, 1, 1), (1, 1, 1, 1)]\rangle\]

and the source node as

**Step 3.2** Find \(d_j = \text{minimum}\{d_i \oplus d_{ij}\}; j = 2, 3, \ldots, n\).

**Step 3.3** 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 3.4** 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 Interval-Valued Trapezoidal Neutrosophic Number.

**Step 3.5** 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 3.6** The shortest path can be procured by combined all the nodes by the **Step 3.5**.

4 Data Analysis

To find shortest path on India famous seven tourist place using Interval-Valued Intuitionistic Trapezoidal Neutrosophic Fuzzy Graph.

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**Figure 4.1:** The Beaches of Goa

**Figure 4.2:** Gateway of India

**Figure 4.3:** Mecca Masjid

**Figure 4.4:** Holy City of Varanasi

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Here we consider source node is The Beaches of Goa and destination node is Sri Harmandir Sahib. To find Shortest Path on The Beaches of Goa to Sri Harmandir Sahib. Here distance between one tourist place to another tourist place is calculated in kilometers. The numerical value of the distance is converted to $IVITrNFG$ with the help of through trapezoidal signed distance.

The given distance (kilometer) converted to neutrosophic number. We converted neutrosophic number as $(a_1, a_2, a_3, a_4)$ are membership function & $(a_1^*, a_2^*, a_3^*, a_4^*)$ are non-membership function. These functions converted to fuzzy trapezoidal numbers using trapezoidal signed distance $\frac{a_1 + a_2 + a_3 + a_4}{4}$. Finally
converted Interval-Valued Intuitionistic Trapezoidal Neutrosophic Fuzzy Number.
Here, Apply the IVIT-NFN in our algorithm to find shortest path to India famous seven tourist place.

<table>
<thead>
<tr>
<th>Edges</th>
<th>Interval-Valued, Intuitionistic Trapezoidal Fuzzy Neutrosophic Numbers</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-2</td>
<td>(((0.2, 0.29, 0.35, 0.56), (0.49, 0.59, 0.65, 0.87)), ((0.8, 0.71, 0.65, 0.44), (0.51, 0.41, 0.35, 0.13)), ((0.11, 0.13, 0.16, 0.2), (0.79, 0.83, 0.86, 0.92)), ((0.89, 0.87, 0.84, 0.8), (0.21, 0.17, 0.14, 0.08)), ((0.03, 0.05, 0.03, 0.08), (0.9615, 0.9699, 0.9705, 0.9801)), ((0.997, 0.995, 0.97, 0.92), (0.0385, 0.0301, 0.0295, 0.0199))</td>
</tr>
</tbody>
</table>
Iteration 4.1 Assume the initial value
\[ d_1 = \langle \{(0.0, 0.0, 0.0), (0, 0, 0.0), (0.0, 0.0, 0.0)\}, \{(0.1, 1.1, 1.1), (1.1, 1.1, 1.1)\}, \{(1.1, 1.1, 1.1), (1.1, 1.1, 1.1)\}, \{(1.1, 1.1, 1.1), (1.1, 1.1, 1.1)\} \rangle \]

Here we assume \( d_1 \) is the beaches of Goa.

Iteration 4.2 In this iteration was calculated through proposed algorithm from the tourist place The Beaches of Goa to Gateway of India. The labeled node is Gateway of India and minimum provided corresponding node is The Beaches of Goa.

<table>
<thead>
<tr>
<th>Minimum Node</th>
<th>Labeled Node</th>
<th>Path Node</th>
</tr>
</thead>
<tbody>
<tr>
<td>The Beaches of Goa</td>
<td>Gateway of India</td>
<td>\langle{(0.20, 0.29, 0.35, 0.56), (0.49, 0.59, 0.65, 0.87)}, {(0.8, 0.71, 0.65, 0.44), (0.51, 0.41, 0.35, 0.13)}, {(0.11, 0.13, 0.16, 0.2), (0.79, 0.83, 0.86, 0.92)}, {(0.89, 0.87, 0.84, 0.8), (0.21, 0.17, 0.14, 0.08)}, {(0.003, 0.005, 0.03, 0.08), (0.9615, 0.9699, 0.9705, 0.9801)}, {(0.997, 0.995, 0.97, 0.92), (0.0385, 0.0301, 0.0295, 0.0199)}\rangle</td>
</tr>
</tbody>
</table>

Iteration 4.3 The node Mecca Masjid was forerunner node of The Beaches of Goa. Here the labeled node is Mecca Masjid and the minimum provided corresponding node is The Beaches of Goa.

<table>
<thead>
<tr>
<th>Minimum Node</th>
<th>Labeled Node</th>
<th>Path Node</th>
</tr>
</thead>
<tbody>
<tr>
<td>The Beaches of Goa</td>
<td>Mecca Masjid</td>
<td>\langle{(0.91, 0.92, 0.94, 0.99), (0.02, 0.04, 0.06, 0.12)}, {(0.09, 0.08, 0.06, 0.01), (0.98, 0.96, 0.94, 0.88)}, {(0.52, 0.55, 0.6, 0.69), (0.35, 0.4, 0.42, 0.47)}, {(0.48, 0.45, 0.4, 0.31)}, {(0.65, 0.6, 0.58, 0.53)}, {(0.09, 0.12, 0.15, 0.24)}, {(0.80, 0.83, 0.86, 0.91)}\rangle</td>
</tr>
</tbody>
</table>

Iteration 4.4 The node Holy City of Varanasi has two forerunner node, they are Mecca Masjid and Gateway of India. IVITrNSP is calculated to Holy City of Varanasi from Mecca Masjid and Gateway of India. Here, the labeled node is Holy City of Varanasi and the minimum provided corresponding node is Gateway of India.

<table>
<thead>
<tr>
<th>Minimum Node</th>
<th>Labeled Node</th>
<th>Path Node</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gateway of India</td>
<td>Holy City of Varanasi</td>
<td>\langle{(0.856, 0.901, 0.928, 0.96), (0.535, 0.635, 0.695, 0.895)}, {(0.836, 0.751, 0.688, 0.499), (0.956, 0.935, 0.915, 0.835)}, {(0.0187, 0.093, 0.0938, 0.064), (0.5689, 0.6308, 0.6794, 0.7452)}, {(0.7387, 0.696, 0.6468, 0.544), (0.0588, 0.0408, 0.0294, 0.0152)}, {(0.00042, 0.0008, 0.0054, 0.0192)}, {(0.7596, 0.7856, 0.8055, 0.833)}, {(0.8574, 0.8358, 0.7954, 0.6092)}, {(0.008, 0.0057, 0.005, 0.0209)}\rangle</td>
</tr>
</tbody>
</table>

Iteration 4.5 The node Taj Mahal has two forerunner node, they are Gateway of India and Holy City of Varanasi. IVITrNSP is calculated to Taj Mahal from Gateway of India and Holy City of Varanasi. Here,
the labeled node is Taj Mahal and the minimum provided corresponding node is Gate Way of India.

<table>
<thead>
<tr>
<th>Minimum Node</th>
<th>Labeled Node</th>
<th>Path Node</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gate Way of India</td>
<td>Taj Mahal</td>
<td>(((0.94, 0.96, 0.97, 0.99), (0.5, 0.6, 0.67, 0.88)), (0.816, 0.73, 0.66, 0.45), (0.99, 0.98, 0.96, 0.93)), (0.035, 0.051, 0.072, 0.128), (0.387, 0.432, 0.4988, 0.5612)), (0.6052, 0.531, 0.462, 0.288), (0.107, 0.0816, 0.0588, 0.0312)), ([0.000033, 0.00029, 0.0024, 0.0128), (0.8644, 0.8913, 0.8958, 0.9324)], (0.986, 0.936, 0.892, 0.773), (0.00389, 0.0024, 0.0023, 0.00097))</td>
</tr>
</tbody>
</table>

**Iteration 4.6** The node The Golden City was forerunner node of Gate Way of India. Here the labeled node is The Golden City and the minimum provided corresponding node is Gate Way of India.

<table>
<thead>
<tr>
<th>Minimum Node</th>
<th>Labeled Node</th>
<th>Path Node</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gate Way of India</td>
<td>The Golden City</td>
<td>(((0.872, 0.9, 0.9285, 0.9868), (0.5257, 0.6269, 0.6885, 0.8921)), ([0.832, 0.75, 0.6885, 0.4568], (0.9657, 0.947, 0.928, 0.852)), ([0.011, 0.026, 0.048, 0.12], (0.316, 0.581, 0.688, 0.828)), ([0.801, 0.696, 0.588, 0.32], (0.126, 0.051, 0.028, 0.008)), ([0.00063, 0.00125, 0.0081, 0.028], (0.6249, 0.6886, 0.718, 0.8036]], ([0.787, 0.746, 0.708, 0.598], (0.0135, 0.0087, 0.0077, 0.0036))]</td>
</tr>
</tbody>
</table>

**Iteration 4.7** The node Sri Harmandir Sahib has two forerunner node, they are Taj Mahal and The Golden City. \( IVIT_{NSP} \) is calculated to Sri Harmandir Sahib from Taj Mahal and The Golden City. The labeled node is Sri Harmandir Sahib and the minimum provided corresponding node is Taj Mahal.

<table>
<thead>
<tr>
<th>Minimum Node</th>
<th>Labeled Node</th>
<th>Path Node</th>
</tr>
</thead>
<tbody>
<tr>
<td>Taj Mahal</td>
<td>Sri Harmandir Sahib</td>
<td>(((0.9874, 0.9944, 0.9967, 0.9998), (0.53, 0.636, 0.7096, 0.9052)], ([0.8546, 0.7678, 0.6974, 0.461], (0.9994, 0.9982, 0.9952, 0.9853)], ([0.014, 0.0255, 0.0432, 0.1152], (0.0774, 0.1296, 0.1995, 0.3928)], ([0.36312, 0.2655, 0.1848, 0.0288], (0.0856, 0.05712, 0.03528, 0.00936)], ([0.000002145, 0.000024, 0.0003, 0.0035], (0.6828, 0.72195, 0.77, 0.9134)], ([0.9219, 0.856, 0.779, 0.559], (0.0008, 0.00045, 0.000322, 0.0000194))]</td>
</tr>
</tbody>
</table>

Since Sri Harmandir Sahib is the destination node.
We calculate $SP$ to destination node to source node. Since

<table>
<thead>
<tr>
<th>Labeled Node</th>
<th>Minimum Node</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sri Harmandir Sahib</td>
<td>Taj Mahal</td>
</tr>
<tr>
<td>Taj Mahal</td>
<td>Gate Way of India</td>
</tr>
<tr>
<td>Gate Way of India</td>
<td>The Beaches of Goa</td>
</tr>
</tbody>
</table>

Therefore the seven wonders Interval-Valued Nether Trapezoidal Neutrosophic Fuzzy Graph Shortest Path is

![Diagram of shortest path](image)

*Figure 4.9: $SP$ from The Beaches of Goa to Sri Harmandir Sahib*

5 **Shortest Path On Dijkstra’s Algorithm**

In the above real life application, we clarify another method of $SPP$ using Dijkstra’s algorithm. In this $SPP$, we use direct method of Dijkstra’s algorithm and we assume edge weight is India famous seven tourist place km.

![Diagram of shortest path](image)

*Figure 5.1: $SP$ for Dijkstra’s Algorithm*

Here, we verify India famous seven tourist place shortest path through Dijkstra Algorithm. We have the paths are

$$1 \rightarrow 2 \rightarrow 5 \rightarrow 7$$
Here these two paths Interval-Valued Intuitionistic Trapezoidal Neutrosophic Fuzzy Graphs and Dijkstra’s Algorithm are same. The shortest path is

\[ 1 \rightarrow 2 \rightarrow 5 \rightarrow 7 \]

6 Conclusion
In this article, discovering \( SP \) on India famous seven tourist place using Interval-Valued Intuitionistic Trapezoidal Neutrosophic Fuzzy Graph. A genuine application is given to act as an IVITrNFG. Finally checked most brief way \( SP \) on India famous seven tourist place with Dijkstra’s algorithm.

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