Optimization of Travelling Salesman Models for Religious Tourism in India

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Abstract

Religious tourism is defined as travel centered on religious destination of the human faith and worship. The scope of this research study is about the 12 Jyotirlinga temples in India. This study aims to optimize a shortest path distance that links to the nearest railway and road ways destinations to these 12 shrines. A Traveling salesman model provides an optimum solution where the traveler visits a particular destination only once. The two matrices are built based on the railway distance as well as the express roadways distances. The connectivity to venerable destinations is the primary focus that can fulfill the supplements of any TSM model. The Google map connectivity can help to visualize the actual path of travel. The outcome of the end results can help the devotee to think for a systematic travel plan that can cover all these destinations in minimum time period and can be cost effective.

Keywords: Traveling Salesman Problem, Shortest path distance, Cost effective

Introduction

India is well-known for the pilgrimage destinations. Travel for religious purposes has existed since the ancient times. Among the well-known, there are Twelve Shrines of Jyotirlingams also called- Dwadasa Jyotirlingas, which are the most sacred sights of worship in Hinduism. The Twelve Shrine in India are listed below [1]-

Table 1. List of the Twelve Jyotirlinga in India

Sr. No.	Jyotirlinga	Place	State
1	Somnath	Gir	(GJ)Gujarat
2	Mallikarjuna	Srisailam	(AP)Andhra Pradesh
3	Mahakaleshwar	Ujjain	(MP)Madhya Pradesh
4	Omkareshwar	Khandwa	(MP)Madhya Pradesh
5	Baidyanath	Deoghar	(JH)Jharkhand
6	Bhimashankar	Pune	(MH)Maharashtra
7	Ramanathaswamy	Rameshwaram	(TN)Tamil Nadu
8	Nageshwar	Dwarka	(GJ)Gujarat
9	Kashi Vishwanath	Varanasi	(UP)Uttar Pradesh
10	Trimbakeshwar	Nasik	(MH)Maharashtra
11	Kedarnath	Rudraprayag	(UT)Uttarakhand
12	Ghrishneshwar	Aurangabad	(MH)Maharashtra

Following Figure 1 shows the demographics of the twelve shrines under consideration in the Indian map.

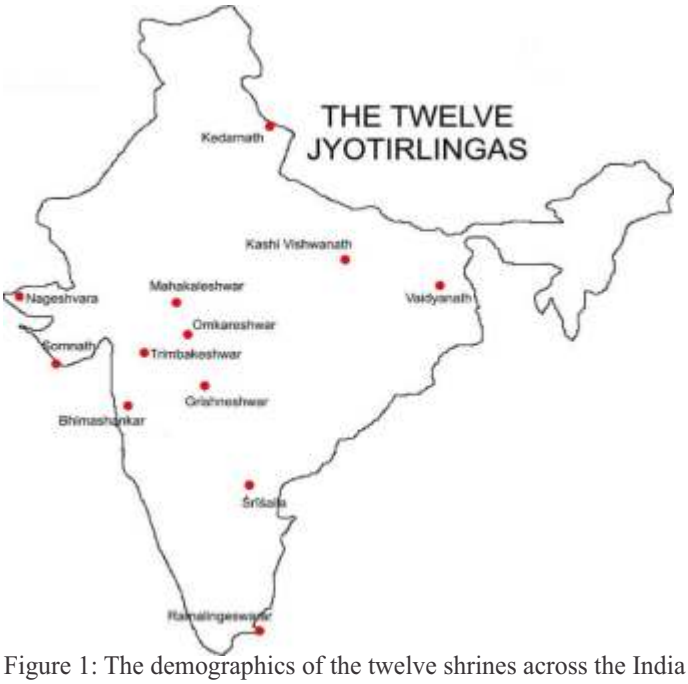

Figure 1: The demographics of the twelve shrines across the India

The existing mix mode of railways and roadways combination beginning from the four corners of the India are given below [2]-

From North: Kedarnath – Kashi Vishwanath :1014, Kashi Vishwanath – Baidyanath : 469, Baidyanath – Mahakaleshwar : 1361, Mahakaleshwar – Omkareshwar :140, Omkareshwar – Grishneshwar :580, Grishneshwar – Bhimashankar : 477, Bhimashankar – Tryambakeshwar : 235, Tryambakeshwar – Somnath : 860, Somnath – Nageshwar : 238, Nageshwar – Mallikarjuna :1821, Mallikarjuna – Rameshwaram : 1029, Rameshwaram – Kedarnath : 3124.

From South: Rameshwaram – Mallikarjuna : 1029, Mallikarjuna – Bhimashankar : 731, Bhimashankar - Grishneshwar: 477, Grishneshwar – Trimbakeshwar 228, Trimbakeshwar – Omkareshwar: 446, Omkareshwar – Mahakaleshwar : 140, Mahakaleshwar – Somnath : 787, Somnath – Nageshwar : 238, Nageshwar – Kedarnath : 1769, Kedarnath – Baidyanath : 1734, Baidyanath – Kashi Vishwanath : 469, Kashi Vishwanath – Rameshwaram: 2413.

From West: Nageshwar – Somnath: 238, Somnath – Trimbakeshwar : 860, Trimbakeshwar – Bhimashankar : 235, Bhimashankar – Grishneshwar : 477, Grishneshwar – Omkareshwar : 580, Omkareshwar – Mahakaleshwar :140, Mahakaleshwar – Baidyanath : 1361, Baidyanath – Kashi Vishwanath :469, Kashi Vishwanath – Kedarnath :1014, Kedarnath – Mallikarjuna :2220, Mallikarjuna – Rameshwaram :1029, Rameshwaram – Nageshwar :2546.

From East: Baidyanath – Kashi Vishwanath: 469, Kashi Vishwanath – Kedarnath : 1014, Kedarnath – Mahakaleshwar : 1323, Mahakaleshwar – Omkareshwar : 140, Omkareshwar – Grishneshwar : 580, Grishneshwar – Bhimashankar : 477, Bhimashankar – Trimbakeshwar : 235, Trimbakeshwar – Nageshwar : 910, Nageshwar – Somnath : 238, Somnath – Mallikarjuna : 1745, Mallikarjuna – Rameshwaram : 1029, Rameshwaram – Baidyanath : 2391

The research study is based on a primary objective to connect the twelve shrines by a Mathematical model of Travelling Salesman Problem and to find the shortest path in terms of railway rout and the roadways.

Literature Review

This segment is divided in two subsections. The first part talks about the religious tourism, rural development and government attempts and schemes. The next part deals with technical aspects and variations in the travelling salesman problem. According to Tulika Sharma (2019), religious tourism are some of the most powerful tools for developing India. Tourism is a significant enabler in the development of basic infrastructure and generates revenue for both the local community and the government. PRASAD (Pligrimage Rejuvenation and Spiritual Augmentation Drive) Scheme's missions to develop pilgrimage tourism, produce employment, economic development, provide facilities and good services to tourists, and improved infrastructure have been noted by the author. [3]. Ramgopal, Manpreet Singh and Sushil Kalra (2021), performed the literature survey on the available articles of past one decade, related to the religious tourism in India. The prospect of religious tourism in Harayan state was the primary objective of this study. The outcomes of the survey study states that the religious tourism requires a whole and independent area of

research so that to access the requirements of the customers and satisfy the religious needs in the accommodation industry [4]. Ritesh Sharma (2021), performed an empirical study on Pilgrimage Tourism Satisfaction with Reference to Prayagraj and Varanasi. The focus of this study was to find out the visitor's recognition, preferences & fulfilment with different type of services accessible in Varanasi and Prayagraj. In addition to find out the degree of fulfilment of pilgrims related to food, transport, darshan/seva accessibility and hygiene. The statistical figures of the visitors including the Indian as well as foreigners have benefited the local development and small-scale businesses in the region [5].

The Traveling Salesman Problem (TSP) was studied as a function of creating and optimising transportation networks (Slavomir Vukmirovi, Drago Pupavac, 2013).

The utilisation of object modelling and programming in Excel and VBA is a fundamental assumption of their research study. The key conclusion is that there are multiple ideal solutions for creating a flexible and adaptive transportation network [6]. (Amarbir Singh, 2016) investigated the many approaches to solving the problem of several travelling salespeople. The computing complexity is directly proportional to the number of cities. It is discovered in this study that meta-heuristics algorithms such as the genetic algorithm and stochastic optimization produce better outcomes for the task at hand [7]. The concept of using Google Maps came from (Ms. Nilofer and Dr. Mohd. Rizwanullah, 2017), a case study for Donimo's pizza centres in Jaipur. They used the Branch and Bound approach as well as the Two optimality method to compare the best solution for their TSP. In comparison to the other strategy, branch and bind produced a better answer [8]. By introducing the intermittent travelling salesman dilemma (Tu-San Pham and et al., 2018). It is based on the idea that a vertex may need to be visited multiple times, resulting in a time delay between two consecutive trips due to the temperature constraint.

The problem in this study is a simplification of the cooling strategies using linear functions in relation to their real-world situation [9].

Research Methodology

A. Travelling Salesman Approaches

The research study renders around three major approaches of the travelling salesman model. The details are as follows-

(i) Hungarian Method: This method is similar to assignment problem where a travelling salesman plans to visit n cities. He wishes to visit each city only once, and again arriving back to his home city from where he started. So that the total travelling distance is minimum. If there are n cities, then there are (n - 1)! possible ways for his tour. This iterative method is based on row reduction, column reduction and deleting zeros [10][11].

(ii) Branch and Bound Technique: All state-space search strategies in which all the children's nodes of an E–node is generated before any other live node may become the E–node is referred to as Branch and Bound. The E–node is the node that is being used up. Any algorithm, such as BFS or DFS, can use a state–space tree. Both start with the root node and build up from there. A live-node is a node that has been formed but has not yet expanded its offspring. A node that has been formed but cannot be expanded further is known as a dead node. In this strategy, we expand the most promising node, which is the node that promises to give us the best solution when expanded or chosen. As a result, we begin by preparing the tree's roots and then expand it [12].

(iii) Nearest Neighbourhood (NN) Approach: We can improve NN by running it for each city on our list of cities and keeping note of the shortest tour it generates. We can call this repeated nearest neighbour. Similarly, we can select a subset (or sample) of cities at random and run NN for each of them, returning the shortest tour. This is referred to as sampling repeated nearest neighbour. Both repetition and sampling enhance NN, however sampling is frequently nearly as good as repetition while being less expensive (quicker) - this, of course, is dependent on the sample size [13][14]

B. Data Preprocessing for Railway Route

It has been observed that the destinations of the twelve shrines do not have direct railway stations. So, identification of nearest railway station to well-connected major cities was the priority. Following Table 2 provide sample for source to destination calculations and time required in hours.

Table 2: Data pre-processing for Railway route

City	Distance	Time (hr)	City	Distance	Time (hr)	City	Distance	Time (hr)
Rameshwaram			Jashid	222	4	Indore	218	4
Chennai	665	13	Danapur	2699		Bhopal	-701	
ADI	1890	32	Jabalpur	-1995		Chennai	+2182	
Dwarka	470	10		704	12		1481	24
	3025	55	Indore	600	12	Rameshwaram	665	13
Rameshwaram			Ind-Jashid	1526	28	Ind-RAM	2364	37
Chennai	665	13	Indore			Bhopal	218	4
Nashik	1284	22	ADI	526	10	Aurangabad	696	11
	1949	35	Dwarka	470	10		914	15
Rameshwaram				996	20	Indore		
Chennai	665	13	Indore			Bhopal	218	4
Cstm (Mumbai)	1284	23	NDLS	824	14	Nashik	790	12
Aurangabad	435	7	Haridwar	253	4		1008	16
	2384	43		1077	18			

ADI is the railway station code for Ahmedabad, NDLS is for New Delhi station. Jashid is the nearest well-connected station to Deoghar (Baidyanath). Thus, all the Twelve shrines were connected by the railway station or break journey(s) to form the TSP payoff matrix.

A. Data Preprocessing for Roadways Route

In 21st century Indian roads are well connected express highways. Almost all the Twelve shrines can be visited by using the road transportation. Thus, for the data pre-processing for roadways route was to Identify the Shortest path of well-connected Highway by using Google map. Following Figure 2, is a sample for the longest path between two extreme ends of the India.

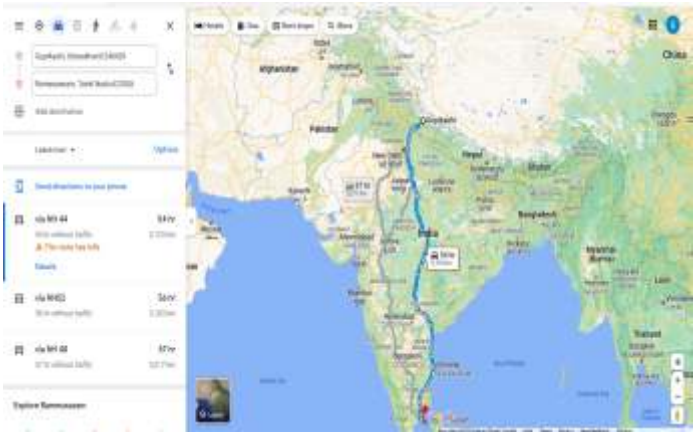

Figure 2: Google Map App for finding the shortest path between source to destination.

It can be observed that direct road to Kedarnathji start from Guptakashi. The blue curve reflects the shortest path. The Gray curves are alternative paths to reach the destination. Thus, all the Twelve shrines were connected by shortest path to form the TSP payoff matrix.

Data Analysis and Interpretation

Following Tables 3 and 4 provides the TSM 12x 12 payoff matrix for both railway routes as well as the roadways routes. The cell values are the outcomes of the connectivity individually in both the cases. The only constraint is the traveller is supposed to reach the nearest destination of the route to follow the TSM model [15].

Table 3. TSM Payoff matrix for railways route connectivity

From /To	Somnath, Gir (GJ)	Mallikarjuna, Srisailam (AP)	Mahakaleshwar, Ujjain (MP)	Omkareshwar, Khandwa (MP)	Baidyanath, Deoghar (JH)	Bhimashankar, Bhorgiri (MH)	Ramanathaaaamy, Rameshwaram (TN)	Nageshwar, Dwarka (GJ)	Kashivishwanath, Varanasi (UP)	Trimbakeshwar, Nasik (MH)	Kedarnath, Rudraparyag (UK)	Ghrishneshwar, Aurangabad (MH)
Somnath, Gir (GJ)	--	1678	883	962	2650	1120	2877	413	1869	1116	1663	1363
Mallikarjuna, Srisailam (AP)	1678	--	1241	1914	2052	790	1330	1694	1830	694	1972	507
Mahakaleshwar, Ujjain (MP)	883	1241	--	79	1502	890	2328	916	985	974	1052	880
Omkareshwar, Khandwa (MP)	962	1914	79	--	1526	972	2364	996	1130	1008	1077	914
Baidyanath, Deoghar (JH)	2650	2025	1502	1526	--	1975	2517	2676	450	1882	1425	1776
Bhimashankar, Bhorgiri (MH)	1120	790	890	972	1975	--	1763	1153	1535	386	1848	426
Ramanathaaamy, Rameshwaram (TN)	2877	1330	2328	2364	2517	1763	--	3025	2790	1284	1950	2384
Nageshwar, Dwarka (GJ)	413	1694	916	996	2676	1153	3025	--	1902	1148	1670	1395
Kashivishwanath, Varanasi (UP)	1869	1830	985	1130	450	1535	2790	1902	--	1324	794	1340
Trimbakeshwar, Nasik (MH)	1116	694	974	1008	1882	386	1284	1148	1324	--	1609	184
Kedarnath, Rudraparyag (UK)	1663	1972	1052	1077	1425	1848	1950	1670	794	1609	--	1793
Ghrishneshwar, Aurangabad (MH)	1363	507	880	914	1776	426	2384	1395	1340	184	1793	--

Table 4. TSM Payoff matrix for roadways route connectivity

From /To	Somnath, Gir (GJ)	Mallikarjuna, Srisailam (AP)	Mahakaleshwar, Ujjain (MP)	Omkareshwar, Khandwa (MP)	Baidyanath, Deoghar (JH)	Bhimashankar, Bhorgiri (MH)	Ramanathaaamy, Rameshwaram (TN)	Nageshwar, Dwarka (GJ)	Kashivishwanath, Varanasi (UP)	Trimbakeshwar, Nasik (MH)	Kedarnat, Rudrapary ag (UK)	Ghrishneshwar, Aurangabad (MH)
Somnat, Gir (GJ)	--	1745	787	864	2150	1040	2459	238	1695	860	1395	910
Mallikarjuna, Srisailam (AP)	1745	--	1232	1147	1647	731	1029	1821	1470	970	2220	764
Mahakaleshwar, Ujjain (MP)	787	1232	--	140	1361	658	2008	820	906	507	1323	434
Omkareshwar, Khandwa (MP)	864	1147	140	--	1424	418	1858	896	968	446	1301	580
Baidyanath, Deoghar (JH)	2150	1647	1361	1424	--	1947	2391	2423	469	1817	1735	1085
Bhimashankar, Bhorgiri (MH)	1040	731	658	418	1947	--	1674	1307	736	235	1833	477
Ramanathaaamy, Rameshwaram (TN)	2459	1029	2008	1858	2391	1674	--	2546	2413	1664	3124	1550
Nageshwar, Dwarka (GJ)	238	1821	820	896	2423	1307	2546	--	1745	910	1761	997
Kashivishwanath, Varanasi (UP)	1695	1470	906	968	469	736	2413	1745	--	1355	1014	1208
Trimbakeshwar, Nasik (MH)	860	970	507	446	1817	235	1664	910	1355	--	1682	228
Kedarnath, Rudraparyag (UK)	1395	2220	1323	1301	1735	1833	3124	1761	1014	1682	--	1609
Ghrishneshwar, Aurangabad (MH)	910	764	434	580	1085	477	1550	997	1208	228	1609	--

Shortest Path for Railway:

1] Hungerian method

Somnath → 413 Nageshwar → 916 Mahakaleshwar → 79 Omkareshwar→ 914 Grishneshwar → 184 Trimbakeshwar → 386 Bhimshankar → 790 Malikarjuna → 1330 Rameshwaram → 1950 Kedarnath → 794 Kashi Vishwanath→450 Baidyanath→2650 Somnath

Total Traveling Cost (413+916+79+914+184 +386 +790 +1330 +1950 +794 + 450+2650) =10856 km.

2] Branch & Bound approach

Infeasible solution as there were repetition found in the destination.

E→I→K→D→C→A→H→B→E→B→G→F→J→L→ B→E

Here E: Deoghar, I: Kashi Vishwanath according the sequence of the payoff matrix of Railways.

3] Nearest Neighbor method

If we start from Malikarjuna, then path is Malikarjuna→Grishneshwar=507, Grishneshwar → Trimbakeshwar =184, Trimbakeshwar → Bhimashankar=386, Bhimashankar→ Mahakaleshwar=890, Mahakaleshwar→Omkareshw=79, Omkareshwar→Somnath=962, Somnath→ Nageshwar =413, Nageshwar → kedarnath =1670, kedarnath →Kashi Vishwanath=794, Kashi Vishwanath→ Baidyanath =450, Baidyanath → Rameshwaram =2517, Rameshwaram → Malikarjuna=1330 and total distance = 10182 km.

If we start from Kashi Vishwanath, then path is Kashi Vishwanath → Baidyanath =450, Baidyanath → kedarnath =1425, kedarnath → Mahakaleshwar =1052, Mahakaleshwar → Omkareshwar =79, Omkareshwar → Grishneshwar =914, Grishneshwar → Trimbakeshwar =184, Trimbakeshwar → Bhimashankar =386, Bhimashankar → Malikarjuna =790, Malikarjuna → Rameshwaram =1330, Rameshwaram → Somnath =2877, Somnath → Nageshwar =413, Nageshwar → Kashi Vishwanath=1902 and total distance = 11802 km.

If we start from Trimbakeshwar , then path is Trimbakeshwar → Grishneshwar =184, Grishneshwar → Bhimashankar =426, Bhimashankar → Malikarjuna =790, Malikarjuna → Mahakaleshwar =1241, Mahakaleshwar → Grishneshwar =79, Omkareshwar → Somnath =962, Somnath → Nageshwar =413, Nageshwar → kedarnath =1670, kedarnath → Kashi Vishwanath =794, Kashi Vishwanath → Baidyanath =450, Baidyanath → Rameshwaram =2517, Rameshwaram → Trimbakeshwar =1284 and total distance = 10810 km.

Shortest Path for Roadways

1] Hungerian method

Somnath → 238 Nageshwar → 820 Mahakaleshwar → 140 Omkareshwar → 418 Bhimashankar → 235 Trimbakeshwar → 228 Grishneshwar → 764 Malikarjuna → 1029 Rameshwaram → 2391 Baidyanath → 469 Kashi Vishwanath → 1014 kedarnath → Somnath 1395

Total Traveling Cost (238 + 820 + 140 + 418 + 235 + 228 + 764 + 1029 + 2391 + 469 + 1014 +1395) =9141km.

2] Branch & Bound approach

Malikarjuna→Ramehwaram→Grishneshwar→ Trimbakeshwar→Omkareshwar→Mahakaleshwar→ Somnath→Nageshwar→Kedarnath→Kashi Vishwanath → Baidyanath → Mallikarjuna and total distance is 1029+1550+228+1147+140+787+238+1761+1014+469+ 1647= 10,010 km.

3] Nearest Neighbor method

If we start from Mahakaleshwar, then path is

Mahakaleshwar → Omkareshwar =140, Omkareshwar → Bhimashankar =418, Bhimashankar → Trimbakeshwar =235, Trimbakeshwar → Grishneshwar =228, Grishneshwar → Malikarjuna =764, Malikarjuna → Rameshwaram =1029, Rameshwaram → Baidyanath =2391, Baidyanath → Kashi Vishwanath =469, Kashi Vishwanath → kedarnath =1014, kedarnath → Somnath

=1395, Somnath Nageshwar =238, Nageshwar → Mahakaleshwar =820

and total distance = 9141 km.

If we start from D, then path is

Omkareshwar → Mahakaleshwar =140, Mahakaleshwar → Grishneshwar =434, Grishneshwar → Trimbakeshwar =228, Trimbakeshwar → Bhimashankar =235, Bhimashankar → Malikarjuna =731, Malikarjuna → Rameshwaram =1029, Rameshwaram → Baidyanath =2391, Baidyanath → Kashi Vishwanath =469, Kashi Vishwanath → kedarnath =1014, kedarnath → Somnath =1395, Somnath → Nageshwar =238, Nageshwar → Omkareshwar =896 and total distance = 9200 km.

If we start from J, then path is

Trimbakeshwar → Grishneshwar =228, Grishneshwar → Mahakaleshwar =434, Mahakaleshwar → Omkareshwar =140, Omkareshwar → Bhimashankar =418, Bhimashankar → Malikarjuna =731, Malikarjuna → Rameshwaram =1029, Rameshwaram → Baidyanath =2391, Baidyanath → Kashi Vishwanath =469, Kashi Vishwanath → kedarnath =1014, kedarnath → Somnath =1395, Somnath → Nageshwar =238, Nageshwar → Trimbakeshwar =910 and total distance = 9397 km.

In both the TSM cases Nearest Neighbourhood provides an optimal solution. Thus, any traveller can join on these routes either by railway the cheapest travelling mode in India. The roadies can also travel safely and cost effectively by using the optimal path of the twelve shrines.

Conclusion

Following are the major findings of this research study-

- Travelling Salesman model provides the optimum shortest path in both the cases of Railway route and Roadway route.
- The Nearest Neighbor method provides the better alternative to start the journey.
- The Devotees can connect to any one of the nearest destinations to start the journey.
- This research study provides a systematic travel plan that can cover all these destinations in minimum time period and can be cost effective.
- The outcome of this study can provide the development of the connected routes and new railways schedule for the benefits of the devotees.
- The future scope of this research study is to integrate the journey by both roads and the railways.

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