THE SEARCH FOR THE SHORTEST ROUTE FOR TOURISTS VISITING SIGHTSEEING OBJECTS OF THE RAZNA NATIONAL PARK

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Abstract. *The aim of the paper is to popularize the Razna National Park's tourist attractions. The opportunity to choose the shortest route to visit all the most interesting potential sightseeing objects is offered. The authors continue their research on the theoretical and practical aspects of searching for the shortest route. Theoretical research has been carried out and mathematically the shortest route has been calculated for various sightseeing objects of the Razna National Park. The paper also provides mapping of these objects and an analysis of the locations of the sightseeing objects at different levels. The main goal of the paper is to show the possibilities of applying mathematical models in solving practical tasks – to determine the shortest route between the sightseeing objects. This research describes an optimization method called Simulated Annealing. The Simulated Annealing method is widely used for various combinatorial optimization tasks. Simulated Annealing is a stochastic optimization method that can be used to minimize the specified cost function given a combinatorial system with multiple degrees of freedom. In this paper, the application of the Travelling Salesman Problem is demonstrated, and an experiment aimed to find the shortest route between the Razna National Park sightseeing objects is performed. Common research methods are used in this research: the descriptive research method, the statistical method, mathematical modelling.*

Keywords: *optimization, Razna National Park, Simulated Annealing, tourism objects, Travelling Salesman Problem.*
JEL code: *C61, R15*

Introduction

The Razna National Park (RNP) is a "Natura 2000" territory located in Rezekne municipality, Makonkalns, Chornaja, Kaunata, and Luznava parishes, in Dagda municipality, Andzeli, Andrupene, and Ezernieki parishes, and in Ludza municipality, Rundeni parish. The park occupies an area of 59 615 ha. It was created to protect the natural values of the Lake Razna and the surrounding areas, as well as the cultural and landscape environment characterising Latgale in the entire Latgale territory. There are many lakes in the park area. For instance, the Lake Razna with its 57.56 square kilometres surface area is the second largest lake in Latvia. Due to its sandy beaches, it is also called the Latgale Sea. The Lake Ezezers is unique – about

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70 isle-type elevations are counted there. However, about half of them are reedy shallow places. The lake is said to have 33 – 36 isles.

There is also the third highest hill in Latvia in the RNP area – the Great Liepukalns (289 m above the sea level), which is distinguished for its impressive relative height for the Latvian environment – 86 metres. The Hill Makonkalns (248 m above the sea level), located next to the Lake Razna still has the preserved fragments of the practically inaccessible Volkenberg's Stone Castle built by the Livonian Order in the 13th century. It is really worth visiting Latvia's youngest national park not only to be impressed with the amazing landscapes, but also to get acquainted with the special charm of the Latgale region (Razna, 2018).

The paper offers the analysis of the locations of the RNP sightseeing objects by their availability. The theoretical research has been performed and the shortest path between different RNP sightseeing objects is calculated mathematically, the mapping of these objects and the calculation of the shortest route between RNP sightseeing objects are offered, starting from Rezekne or Daugavpils.

The software is developed that allows finding the shortest path between different RNP sightseeing objects, with the aim to optimize and determine the shortest path between the sightseeing objects. The research study was carried out using Visual Studio capabilities in programming. The aim of the paper is to work out recommendations for potential tourists in developing a RNP sightseeing route thus popularizing the Razna National Park tourist attractions.

Common research methods are used in the research: the descriptive research method, the statistical method, mathematical modelling.

The background of the research study

Simulated Annealing (SA) is a stochastic optimization method used for the optimization of an objective function (energy). It allows finding the global extreme for the function that has local minimums. The SA principle was announced in a classical work (Kirkpatrick et al., 1983) and developed in other works (Laarhoven & Aarts, 1987), (Otten & Ginneken, 1987), (Granville et al., 1994), (Ingber, 1993).

Further, the well-known combinatorial task – the Traveling Salesman Problem (TSP) – will be offered as the SA algorithm application.

The TSP task is to find the minimum route between N cities – entering each city only once and, in the end, returning to the original city. This is a well-known combinatorial task that can be solved with a variety of combinatorics or graph theory techniques. In literature, TSP solving methods with the SA algorithm are also provided (Cook, 2011), (Coughlin & Baran,

1985), (Applegate et al., 2006), (Grabusts, 2000).

The authors have already done some research on SA and TSP (Grabusts & Musatovs, 2017), so a complete mathematical description in this paper is no longer needed.

Experimental part

In order to realize and verify the operation of the SA algorithm, the following task was selected: the GPS coordinates of RNP sightseeing objects were given. The TSP-12 problem with the help of the SA method has to be solved (i.e., the shortest distance between the RNP sightseeing objects should be determined).

All the information about the RNP sightseeing objects is taken from the Nature Conservation Agency website (Dabas aizsardzības pārvalde, 2018) (see Fig.1).

Fig. 1 RNP sightseeing objects (in Latvian)
(Source: Dabas aizsardzības pārvalde, 2018)

Juguli stone. The stone's dimensions: height – 3.6 m, length – 6.5 m, width – 1.8 m. Grey granite with garnet inclusions. The stone is located in the territory of Kaunata parish, Juguli village. Juguli stone is sometimes called Kozulis stone.

Pilor oak grove surrounds one of the countless Ezezers bays. Ezezers is the richest lake in the Baltic States with its islands and peninsulas. The recreation area on the shore of the lake welcomes visitors to have a rest in the shadow of the centuries-old oaks and please the eyes with a magnificent lake landscape. The oak grove is the most beautiful in spring when the trees leaf out – in late April and early May – when a lot of spring plants bloom in the forest undergrowth. A pontoon footbridge runs into the lake.

The Nature Education Centre "Razna" has found its home in the Administration building of Makonkalns parish, Rezekne municipality, on the shore of the Lake Razna.

The museum “Andrupene Farmhouse” is a Latgalian house complex of the beginning of the 20th century, which includes dwelling house, barn, bathhouse, granary, and smithy. Tools, household items, and furniture create a special rural atmosphere and ambience that tells about life and farming in the countryside during the first years of Latvia's independence and during the Soviet rule.

The Luznava manor is a pearl of Art Nouveau in Latgale – Luznava manor castle was built in the early 20th century from bricks and broken boulders in historicism and Art Nouveau style. Its owners were Polish noblemen Kerbedzi. The building is surrounded by a 23.7 hectare landscape park with the pond system and the Madonna statue. An 850 m long walking path in the park was renovated. The park has a large variety of tree species. Here you can see a snake fir, a multitrunk lime-tree, a walnut, a Siberian larch. After the restoration, the Tourist Information Centre of the Rezekne Municipality Council are housed in the palace. This place also has exhibition and concert halls.

The best way to get acquainted with the traditions of Latgale pottery is at the workshop of the founder of “Pottery school” E. Vasilevskis, in Akminisi. The work of the master is based on the idea of careful use of the natural resources and the share of ecological footprint a person leaves on the earth.

Ezezers is the lake richest with islands in the Baltic States. There are more than 33 islands. The largest is the Great Bear island (45 ha). The lake is located in the nature reserve area of the Razna National Park.

The Jaundome Manor Environmental Education Centre – the Environmental Education Centre and the Exposition Hall are located in the renovated Jaundome Manor barn, which was built in the early 19th century. The Environmental Education Centre offers water flora and fauna expositions, nature cognitive outdoor classes, equipment rental for bird watching, seminar rooms, interactive materials about Ezezers, and guided excursions around Jaundome Manor.

Makonkalns, also known as the Hill Padebesi (249 m above sea level), is located near the Lake Razna. There is the tourist trail around Makonkalns, the Volkenberg castle ruins can be seen. The top of the mountain offers scenic views of the Lake Razna and the vast forest. The Volkenberg Castle, literally – Cloudcastle – is on the top of the Hill Padebesi, or Makonkalns. The castle with masonry walls was built by the Livonian Order in the 13th century. It consisted of the fortress and the main castle, which had a trapezoidal form with wings of 62 and 52 meters in length. It is reported that before there was a Latgalian wooden castle. The Volkenberg medieval castle and castle ruins are the state archaeological and architectural monument.

Vecsloboda castle mound is one of the largest castle mounds of its time in Latgale. The highest hill (222.1 m above sea level) in the neighbourhood

was chosen for its building. The archaeological findings indicate that the castle mound was inhabited in the second half of the 1st century and in the first part of the 2nd century A.D. The antiques found during the research expeditions are kept in the museums of Rezekne, Riga, and Vilnius. Vecsloboda castle mound is an archaeological monument of national importance, which plays an important role in understanding the traditions of inhabitants of the eastern part of Latvia. The castle mound is overlooking Lake Razna and the Latgale heights.

The Great Liepukalns is the third highest point in Latvia – 289.3 meters above the sea level. At the top of the hill, there is the highest wooden viewing tower in Latvia (34 m) offering spectacular views of the surrounding landscape – the hills, Razna and other lakes. The tower has nine viewing platforms at different levels, so everyone can climb as high as they want. From the parking lot to the viewing tower, there is an 830 m long nature trail with information stands.

The GPS coordinates of RNP objects are given in Table 1.

Table 1 Denotations and GPS coordinates of the sightseeing objects
(Source: Google maps)

No.	Name of objects	Latitude	Longitude
1	Juguli stone	56.333312	27.604050
2	Pilor oak grove	56.187634	27.607759
3	Nature Education Centre "Razna"	56.290257	27.437406
4	Andrupene Farmhouse	56.190369	27.397211
5	Luznava manor	56.354874	27.252533
6	Pottery school	56.298230	27.540769
7	Lake Ezezers	56.181674	27.656084
8	Jaundome Manor Environmental Education Centre	56.143531	27.593839
9	Makonkalns	56.279185	27.415190
10	Vecsloboda castle mound	56.342567	27.578539
11	Great Liepukalns	56.271042	27.654441
12	Rezekne, Hotel Latgale	56.505808	26.330464

The SA algorithm in this case was carried out in 1000 steps. The algorithm was used to calculate the shortest route – 168 km (see Figure 2). Attachment of the RNP objects to the map is shown in Figure 3.

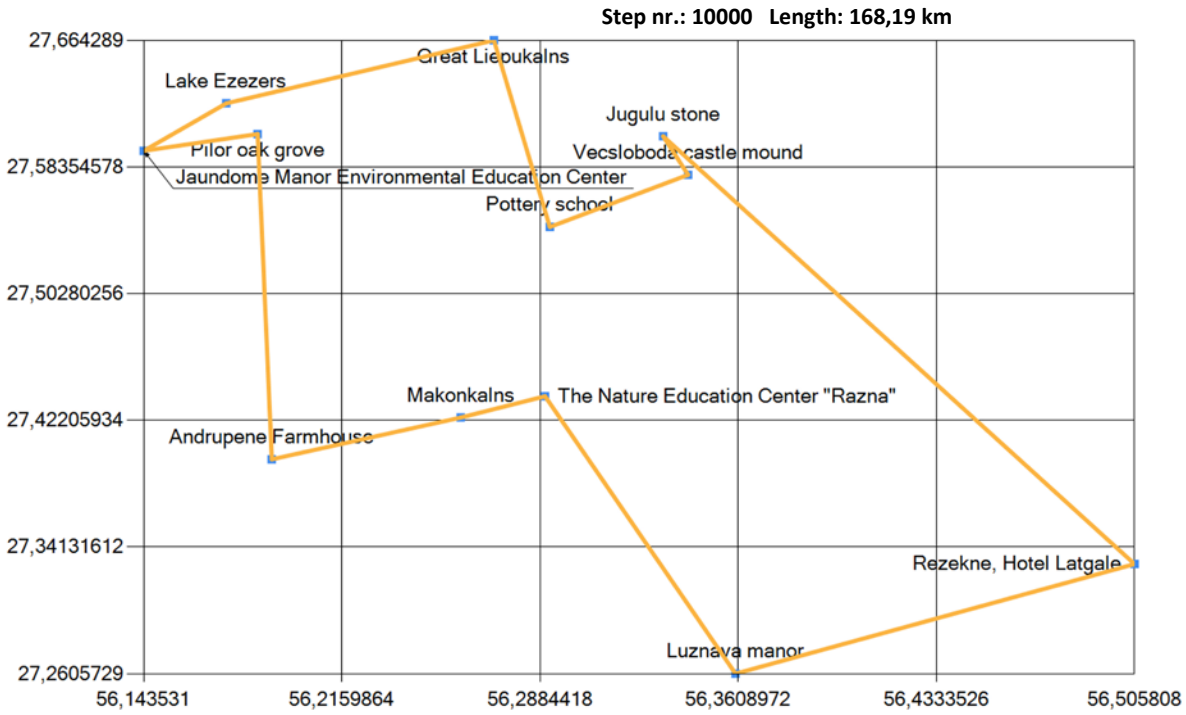

Fig. 2 The shortest path between the RNP objects computed using SA algorithm (a route from Rezekne) *(Source: the authors' construction)*

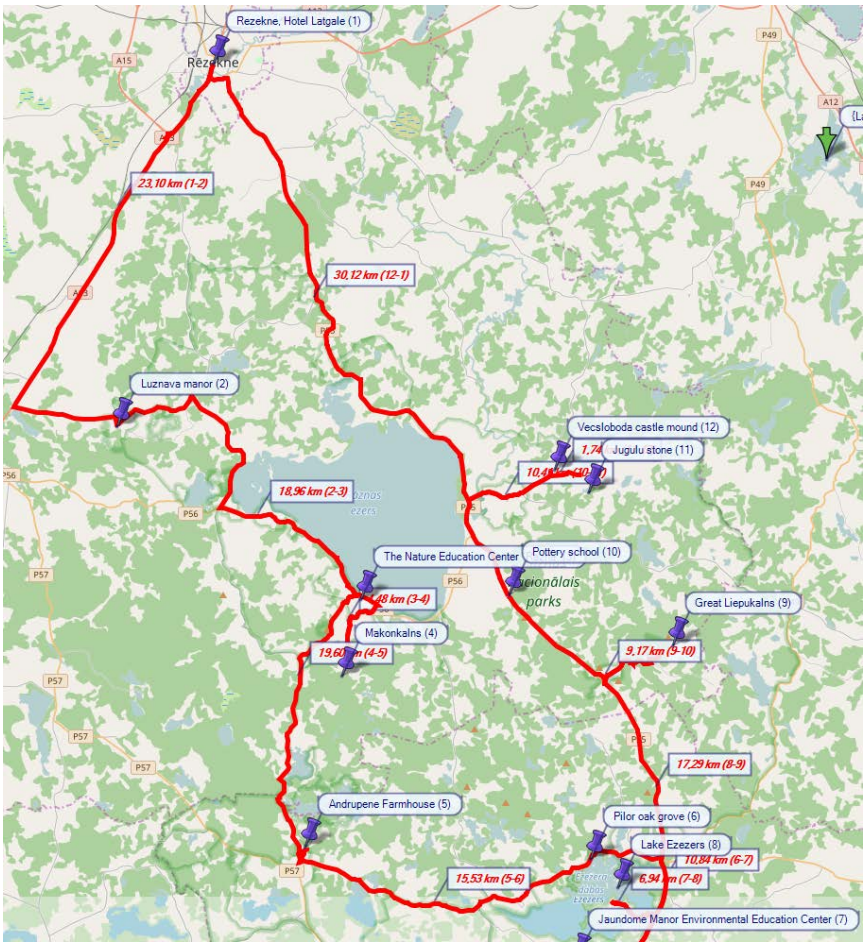

Fig. 3 The attachment of the shortest path among the RNP objects to Google maps (route from Rezekne) *(Source: compiled by the authors)*

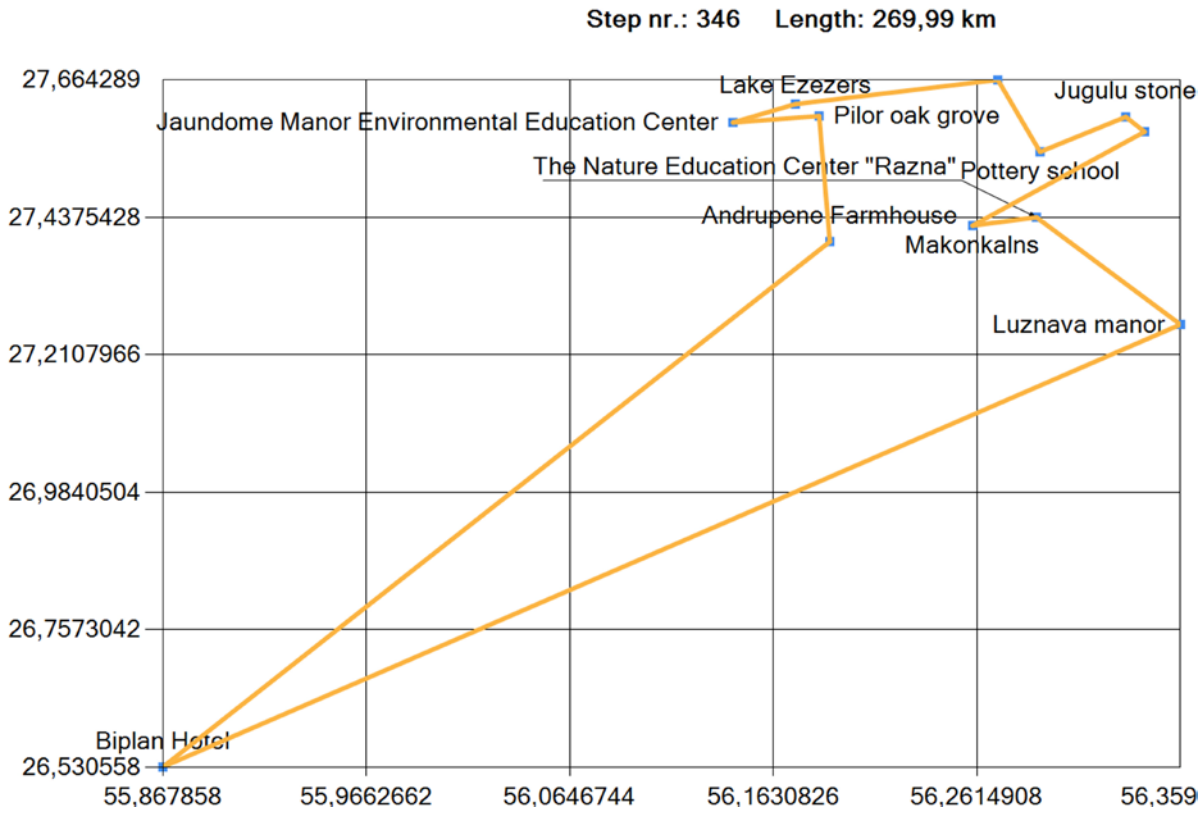

Fig. 4 The shortest path between the RNP objects computed using SA algorithm (route from Daugavpils) *(Source: compiled by the authors)*

Similarly, tourists from Daugavpils can plan a route through the RNP sightseeing objects – in this case, it should be taken into account that the way will be longer (270 km).

The SA algorithm in this case was carried out in 346 steps. The algorithm was used to compute the shortest route – that is 270 km (see Figure 4). The attachment of the RNP objects to the map is shown in Figure 5.

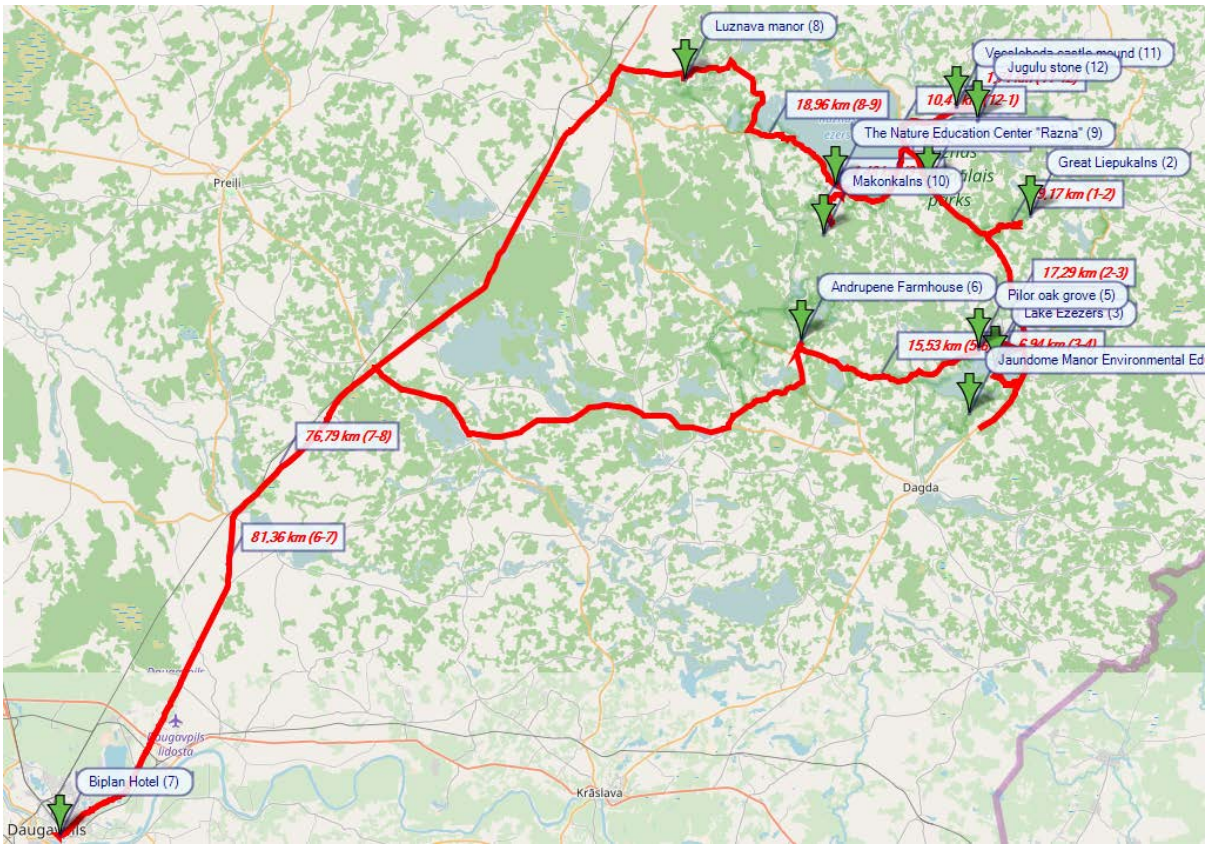

Fig. 5 The attachment of the shortest path between the RNP objects to Google maps (route from Daugavpils) *(Source: compiled by the authors)*

In such a way, the route from anywhere can be planned – including the RNP sightseeing objects. This would allow tourists to save their time and money in route planning.

Conclusions

The paper describes the SA method and gives an example of its application for solving the TSP problem.

The authors propose that their simulation's result should be simplified, however, in the case it is needed to exclude the sightseeing objects from the existing network of the RNP object list, it would allow simulating the overlapping of the sightseeing objects on the map and determining the potentially shortest route to the chosen RNP objects.

In this paper, the software that allows finding the shortest way or route between different objects of the RNP with the purpose to optimize and determine the shortest route among tourist sightseeing objects has been developed.

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