MODEL OF DECISION MAKING IN THE FORMATION OF AN INDIVIDUAL TOUR

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Abstract
Development of tourism, to a large extent, depends on the condition of infrastructure, which forms the basis of the tourism industry. Nowadays its functioning is practically impossible without use of computer technologies. However, due to the development of Internet technologies, a large amount of available information often makes it difficult to take decisions during self-planning of individual and group tours, which is largely inherent in youth tourism. Choosing and agreeing on one or another route is rather complicated task. The paper proposes an algorithm which, in combination with the corresponding software, based on the priorities of a potential tourist and available information on the modes of operation of tourism infrastructure objects, creates the rational structure of the tour with its detailed program. When using such kind of interactive site, a potential traveller is offered possible tour options and tours, based on the criteria of quality and restrictions introduced.

Keywords: weighted graph, matrix, membership function, tourist rout.

INTRODUCTION
Recently, the tourism industry shows accelerated development due to increased demand for travel services. Travel and tours, due to economic, administrative, social, cognitive needs, gradually evolved into the motive power of self-development of the individual, which in turn intensified complex growth of cultural-historical and socioeconomic activity.

Today, tourism has acquired characteristics of a mass phenomenon, which requires quick processing of large arrays of concomitant information flows. Means of modern Internet technologies and information systems are an indispensable tool during planning, study and organization of practically any trip. In its turn, the complex improvement of tourism business information products is not possible without the use of economic and mathematical modelling.

Among the well-known Web sites that contain the most detailed information about different travel destinations, the following can be mentioned: Expedia.com, Travelocity.com, LonelyPlanet.com, Asiatravel.com, itncorp.com, eBookIt.com, thetrip.com, priceline.com. Online travel services are provided by airlines, well-known travel agencies, car rental agencies, hotels, tour companies. Travel guides publishers provide large amounts of relevant information on their Web sites. However, the growing availability of information often makes it difficult to make motivated decisions when choosing a tourprogram, especially when arranging a self-planned tour. The process of making up complex routes requires special knowledge and practical organization skills. The experience of professional tour operators can minimize the risks of their clients during the organization of excursion tours. However, during individual planning of individual or group tours, which is mainly inherent in youth tourism itself, the choice and coordination of one or another route is not an easy task. Therefore, the development of algorithms and related software is important for the development of interactive tourist sites, which, based on the priorities of a potential tourist and accessible information about tourist infrastructure, choose a rational program of an individual tourist route. When developing such algorithms, it is important to have the fullest possible coverage and unified mapping of tourist infrastructure objects and services in the simulation model and its ability to meet different consumer demands.

PREVIOUS RELATED RESEARCH

Problems of creating methodologies, mathematical models and information systems in tourism business were developed in the works of domestic scientists Melnychenko S.V., Pasichnyk V.V., Artemenko O.I., Lytvyn V.V., Savchuk V.V. and a number of others [1–4].

One of the main tasks of integrating the interests of both potential tourists and tour operators is the choice of optimal time and economic based tourist route. In this context, the approaches are associated with the use of ant algorithms are of particular interest [5] as well as modelling of a tourist route plan based on of bee colony behaviour [6].

However, despite a significant amount of theoretical and practical developments in methodological approaches to informed tourist routes choice using a variety of mathematical approaches, there still remain the promising areas for further improvement.

Structural model of any system characterizes its internal structure and describes the stable relationships between its elements. An effective mathematical modelling and researching tool for various structures is the theory of graphs. Structural model on the graphs consists of two types of objects: those which are described by the vertices of the graph, ones which characterize the connections between the vertices of the graph. Links between vertices are modelled by branches or directed edges. Different types of structural models can be created by computer and their construction can be formalized on it [8].

In paper [9], diagrams of routes are presented in the form of graphs for different types of routes – linear, circular, radial and combined. The route scheme is chosen depending on the transport system: the configuration of the transport network, its density and technical condition, the level of development of certain types of transport, the level of development of transport infrastructure, which ensures the reliability and safety of transport. At the same time, most often, the criterion for choosing the route is to minimize the time for moving between the main points of the route when trying to provide the greatest possible informativeness of the trip, that is, to cover as many objects of the display as possible to satisfy the cognitive goal. However, such a technique is focused on generalized priorities and does not always meet the needs and expectations of participants in individual tours.

The aim of the paper is to develop an algorithm for making reasoned decisions when choosing sustainable tourist routes by the criterion of usefulness for a potential tourist.

RESEARCH RESULTS AND DISCUSSION

The basis of the model is a database of tourist objects: historical and architectural monuments, religious buildings, spiritual centres, cultural and art monuments, nature monuments, recreation facilities, hotels and motels, restaurants, etc., as well as information on ways, means and accessibility of transport links. The indicated in the model tourist objects comprise the vertices of a weighted graph, A_i, $i = 1,2,...,m$ tied to the map, and are endowed with appropriate normalized indicators of attractiveness x_{ik} which reflect the preferences of a potential tourist when choosing a tourist product [10]. Indicators k are set up on the basis of surveys and expert assessments ranging from 0 to 1 according to criteria of historical and cultural value, architectural or natural attractiveness, sacred value, recreational opportunities, etc. Other vertices of the graph are service facilities A_i', $i = 1,...,m,...,n$, with standardized quality indicators x_{ik}', namely hotels and motels, restaurants and cafes, petrol and/or service stations, sports and recreational facilities, etc. For example, by the criterion of value the maximum value $x_{i1}' = 1$ will be a service with a minimum cost, the minimum value $x_{i1}' = 0$ is a service with the maximum value. By the criterion of prestige and convenience $x_{i2}' = 1$ takes the most comfortable place, $x_{i2}' = 0$, takes the least comfortable place.

The vertices of the graphs of tourist objects A_i have a higher priority than the vertices of graphs A_i' of the service providers and are being processed first by the program.

The weighted graph [*i, j*], correspondingly, is equal to the p_i – weigh of the *i*-vertex if $i = j$, and for the adjacent vertices is the weight of branch (edge) g_{ij} from vertex *i* at vertex *j*. Formalized description of *i*-objects of infrastructure with *k*-properties is given by the matrix of properties $M[x,k]$. The weight p_i of each vertex is determined by the normalized sum of indicators of objects attractiveness of and the quality of services [10].

$$p_i = \sum_{k=1}^{r} \alpha_k x_{ik} + \sum_{k'=1}^{r'} \alpha_{k'}' x_{ik'}' \qquad (1)$$

where r and r', accordingly, are the number of indicators characterizing the object and services provider;

α_k and α_k', accordingly, are normalized parameters, which specify the priority of customer choice of the object and service provider by the k (k')-characteristic; $\alpha_k = 1$ (and also $\alpha_k' = 1$), when the consumer has set his or her priority, that is, has set a criterion for evaluating a tourist object or service.

Evaluation parameters of the tourist objects x_{ik} and service providers' quality indicators x_{ik}' are set and modified by the site administrator, and the standardized parameters of priority α_k and α'_k of the consumer choice are set by him in an interactive mode.

The vertices of weighted graph are joined by branches, which can correspond geographically to the ways of communication, while the weight of which $g_{ij} = l_{ij}$ is given by normalized indicator, determined by the dependence:

$$l_{ij} = \beta_{ij}(1 - L_{ij} / L_{\max}), \quad (2)$$

where β_{ij} – the coefficient taking into account the condition of the roadway and affecting transfer time and quality,

L_{ij} – the length of the way between the objects on the map,

$L_{\max}$ – conventional maximum allowed way length, set by model constraints,

$l_{ij} = 1$, when the objects are maximally available and $l_{ij} = 0$ in case of their inaccessibility, for example, for tourists traveling by public transport in the absence of transport links.

In the case when the distance between the objects is determined by the roads length matrix, this graph is supplemented by a graph of transport connections routes by the route of the tours with vertices that coincide with the objects A_i and A'_i, as well as with vertices A_i^0, that are territorially corresponding to the branching of the roads (crossroads) with indicators of the attractiveness of the facilities and the quality of the services provided, respectively, $x_{ik} = 0$ and $x'_{ik} = 0$.

The implementation of decision-making algorithms is consistent in time from the start of the tour to its end. The availability of tourist and other facilities, for a certain time period $t_0 \le t \le t_1$ (for example, working time) according to the fuzzy sets theory, is taken into account by the corresponding membership function.

In the case of the tourist or service provider object have a clear opening and closing time $t_0 \le t \le t_1$, the membership function possesses the value $\mu_i = 1$ when the object is opened and $\mu_i = 0$ when it is closed.

For objects with a specific work schedule, the membership function is analytically described by the following dependency:

$$\mu_i = 0{,}5 \cdot [1 - \operatorname{sgn}((t - t_0)(t - t_1))]. \quad (3)$$

If the object is closed for a lunch (maintenance, etc.) for a certain time $t_{01} \le t \le t_{11}$, then the membership function μ_i possesses the value

$$\mu_i = 0{,}5 \cdot [1 - \operatorname{sgn}((t - t_0)(t - t_{01})(t - t_{11})(t - t_1))]. \quad (4)$$

A similar membership function $\mu'_i(t)$ describes the given time interval for receiving a service (lunch, hotel rest, etc.).

The time of service users (tourists) is distributed in the same way. If the time $t_{r0j} \le t_{rj} \le t_{r1j}$ allocated for the tour on the j-th day is clearly normalized, then the membership function of the user will look similar to (3):

$$\nu_j = 0{,}5 \cdot [1 - \mathrm{sgn}((t - t_{r0j})(t - t_{r1j}))] \quad (5)$$

The user's membership function that prioritizes time for breakfast ν_{jb}, lunch ν_{jd}, dinner ν_{jd}, or other needs, such as car refueling, etc., is also described similarly.

If the time allocated by the consumer to tourist services or needs is not strictly stipulated, but has some priority of benefits distribution, then the membership function of the user's benefit is described by the dependency [10]:

$$\nu_j(t) = 0{,}5 \cdot \{1 - th[\lambda_j (t - t_{r0j})(t - t_{u1j})]\}, \quad (6)$$

where λ_j – coefficient that takes into account the curve of the consumer benefit distribution in a given time interval.

In the case of a uniform distribution of received utility over time, $\lambda_i \to \infty$ ($\lambda_i = \lambda_{\max}$) and dependence (6) in turn becomes a dependency (5).

If the certainty of the start and end time of consumption of a particular service is different with, respectively, different level of the coefficient λ_j, then dependence (6) possesses the value

$$\nu_j(t) = 0{,}5 \cdot \{1 + th[\lambda_{0j}(t - t_{r0j}))]\}\{1 - th[\lambda_{1j}(t - t_{r1j}))]\}, \quad (7)$$

where λ_{0j} and λ_{1j}– coefficients that take into account the curve of the consumer benefit distribution at the beginning and end of the period of receving the service (beginning and end of the day of the tour).

The start time of the tour day can be more accurately predicted and the end time – less accurately. Then $\lambda_{1j} > \lambda_{0j}$.

The values of the membership functions levels are considered as: absoulately inadmissible – $\nu_j = 0$, admissible – $\nu_j = 0{,}5$, most convenient and possible under given circumstances – $\nu_j = 1$.

To implement the algorithm, the user must specify the choice of transport (mode of transportation) and enter the location of the beginning and end of his/her tour, as well as the consumer's priority parameters α_k and α'_k.

According to the algorithm, the first step is to select a hotel (accommodation) if this is foreseen the tour program. In the case of a multi-day tour, the option of accommodation in one hotel, offered according to the priority of the consumer with the subsequent realization of the tour with the choice of a ring, radial or combined route, according to the machine search of the vertices of the graphs, is considered as the basic one. In the case where the start and end points of the tour differ, the choice of a linear route is a priority.

The time to start visiting a tourist or service object is specified based on the distance to the property and the speed of the car. For example,

$$t_{101} = t_{01} + v \cdot l_{01}, \qquad (8)$$

where t_{101} – is the start time of a higher priority object A_1 inspection,

t_{01} – is the start time of the tour,

v – car speed,

l_{01} – the distance from the starting point of the tour (hotel), that is, the vertices of the graph A_0 to A_1.

For each vertex, the membership function of the object μ_i selection corresponds with the membership function of the user's benefit v_j according to the calculated time, assuming that the intersection of their sets must be an empty set, that is, the combined membership function ψ_j is calculated.

$$\psi_{ij} = \mu_i \cdot v_j \qquad (9)$$

The specified membership functions are limitations to the inclusion of the i-th vertex of a (tourist) object with a weight p_i in the objective function.

Otherwise, a request for service with a lower priority is generated. After that, variants of passing graph vertices are formed. Taking into account the given restrictions, the choice of options for the tour with optimization according to the criterion of utility for a potential tourist, given by the target function [10] is made.

$$F_{sj} = \sum_{i=1}^{m} p_i \int_{0}^{t_{\max}} \psi_{ij}(t)dt \qquad (10)$$

CONCLUSION

Thus, providing the use of the relevant interactive site, a potential tourist enters data about the tour duration, his/her preferences for each proposed option describing the tourist object and his requirements for receiving services, and also forms his own restrictions on the choice of the tour according to the list proposed. As a result of the algorithm implementation, the consumer is offered the possible variants of tours with a ranking on the criterion of its maximum usefulness and, if possible, the ways of improving the program by changing the time of the tour or time limits or consumer preferences.

The developers and administrators of the site are responsible for accurate information about the time of the objects' operation, the list of their services. In such case, the program will clarify the baseline average indicators of the tourist objects or services providers attractiveness online, depending on the needs and rating of the user.

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