Research on the Optimization of Tourism Traffic Routes based on Ant Colony Algorithm

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Abstract

In order to reduce the energy consumption and improve the performance of tourism traffic routes, this paper researched on the optimization of tourism traffic routes based on ant colony algorithm. In this paper, the ant colony algorithm is used to reduce the energy consumption and improve the efficiency in the tourism traffic routes planning. The empirical tests show that without loss of results accuracy, the convergence speed of the ant colony optimization is significantly 40% faster than that of the traditional algorithm. The experiment results of this paper have a reference value for the application of ant colony algorithm in the design process of tourism traffic routes which can also promote the overall performance substantially.

Keywords: Consumption control, passive design optimization, tourism traffic routes, ant colony algorithm

1. INTRODUCTION

As part of the service sector, tourism is one of the world's largest industries, and it is predicted to be a main provider of job opportunities both directly and indirectly. Furthermore, it is also estimated that from the year 2015, emerging economies will receive over one billion arrivals till 2030, more than industrial economies, Asia and Pacific region will gain its place as getting most of the new tour arrival and becoming strongest growing outbound region according to a report by WTO in 2011 (Chicca et al., 2014; Devi et al., 2015).

Tourism is a sector that could inherit positive as well as negative outcomes for economy. In one hand it creates vast variety of jobs, increases the income of residents, stimulating capital investments as on new business formations that result to form new and strong SME sector in tourism. Although it has negative aspects oneconomic-social and environmental as such water, noise and environmental pollution, invasion of protected areas, property speculation, cultural issues by deteriorating cultural values, violence and related activities, changes on resident values and behavioural patterns. In developing country perspective, it has highlighted tourism as a potentially promising avenue for economic and human development, as new destinations highlighted with remarkable development in numbers of arrivals as well as revenues. Traditionally, tourism was placed under service sector, below manufacturing and / or agriculture, since it was not seen as a significant sector for agrowth of an economy (Venkata et al., 2015).

With nearly 20 years development, ant colony algorithm has successfully applied to the discrete combinatorial optimization, the continuous function optimization and clustering. However, there are the following four deficiencies for ant colony algorithm:

(1) The computation complexity for ant colony optimization is too high when Bayesian network structure is learned. And the running time is too slow.

(2) The effect is poor when the continuous optimization problems are solved by ant colony optimization.

(3) The effect is poor when constrained optimization problems are solved by ant colony optimization.

(4) The clustering effects are poor when ant colony clustering algorithm is applied to a number of benchmark data sets. In order to overcome the above four shortcomings, the following improvements for ant colony optimization are provided. Firstly, the constrained ant colony optimization is proposed for the discrete combinatorial optimization problem-learning Bayesian network structure. The add-edge-rule is designed base on
the local consistency score criterion in the new algorithm. And the rule is embedded in the framework of ant colony algorithm. Therefore, the new algorithm can use the heuristic to dynamically reduce the search space and reduce the running time during the search process. The empirical tests show that without loss of results accuracy, the convergence speed of the proposed algorithm is significantly 40% faster than that of ant colony optimization. In addition, the Bayesian classifier based on constrained ant colony algorithm is proposed for project’s risk prediction of real project in the stage of decision.

2. MATERIALS AND METHODS

2.1 Overview

After the 1950s, tourism was a phenomenal success story globally. The number of international arrivals experienced growth from an estimated 25 million in 1950 to an estimated 806 million in 2005 just 55 years later, corresponding to an average annual growth rate of 6.5% (Ko et al., 2015). According to the UNWTO figures, the significant growth of tourism marks it as one of the most remarkable economic and social phenomena of the past century. This follows a summary of the UNWTO Tourism 2020 Vision for international tourism over the first 20 years of the new millennium that “international arrivals are expected to reach nearly 1.6 billion by the year 2020”. The spread of destinations has also increased exponentially. For instance, in 1950, Europe and North America accounted for 97% of all arrivals; this number dropped to a mere 58% in 2014.

Europe has been receiving the largest number of international tourists worldwide, while the number of arrivals in other continents has been changing over time. For instance, in 2000 Europe received arrivals estimated to 403 million, followed by the Americas with an estimated 129 million, and the East Asia and Pacific region received 112 million. On the other hand, Africa and the Middle East received 27.6 and 20.6 million, respectively. In 2015, Europe still receives the largest number of international tourist arrivals with an estimate of 489 million, followed by Asia and the Pacific with an estimate of 184 million, while the Americas received 147 million. Conversely, Middle East and Africa received an estimated 55 and 47 million, respectively.

This study suggests that a detailed plan of consumer behaviour is one solution to the foundation of all marketing activities that aim at developing, promoting, and selling hospitality-based services. Marketing research suggests that the first step in optimizing the efficiency and effectiveness of marketing activities is identifying how consumers make their decisions with regard to purchasing hospitality services. The advantages of explaining consumer behaviour is that we can later also predict such behaviour. This is particularly significant to learn (1) whom to target at a specific time with a specific tourism product or service, (2) the time to intervene in the process to get the expected results, and (3) how to influence tourists to choose certain products or services that are designed effectively to meet their requirements and desires. Consumer behaviour in the hospitality industry is a continuous process that includes diverse yet inter correlated steps.

The popularity of the place as a tourist destination can be characterized by its reputation for high-quality safaris, plenty of wildlife, and other unique natural features. Another key attraction for the country is the culture, especially that of the people. Studies on market demand for tourism are needed in order to present data on potential visitors’ expected attractiveness, travel motivation, perceived constraints, tourist satisfaction level, attitudes, perceptions, vacation requirements, and other travel variables in relation to destination choice. Though we exclude the topic from this study, we understand the importance of Internet-based marketing strategies for influencing the international market.

There are various theories that are associated with tourism. Theoretical models of travel motivation largely originate from social psychology and sociology. Maslow’s theory is one of the popular theories of motivation in academics and among the general public. Originally, the hierarchy of needs theory was developed by Abraham Maslow in the USA in the 1940s and ‘50s, and is widely used in disciplines such as personal development management, training, and in understanding the motivation of human beings.

Maslow extended his original work in 1970, when he proposed that the human hierarchy of needs can be arranged into five groups (Yuan et al., 2014). These start with the biological and philological needs and end with self-actualization, ascending stepwise through the safety needs, belongingness and love needs, and the esteem needs. Maslow explained that the lowest need would dominate behaviour if no one of the needs in the hierarchy were satisfied in some contents.
The individual would move to the next step, safety needs, if the biological and physical needs were satisfied. An individual would move up to next step if safety needs were satisfied and continue to work up the hierarchy as the needs at each step were satisfied. Nevertheless, there are some cases when lower-step needs have not been met, yet higher-step needs predominate in an individual’s mind.

2.2 The model and ACO algorithm

Figure 1 shows the tourism network tree topology.

![Tourism Network Tree Topology](image)

**Figure 1.** The tourism network tree topology

We design the representation of algorithm solution, pheromone distribution model, state transition strategy, pheromone update rules and processing method of constraint conditions. Then, influence of algorithm performance to parameters is qualitatively analyzed. The results of one kind of benchmark test function with or without constraints show that, this algorithm is converged faster and has strong global optimization ability. According to the deep research of way and key technologies of submarine navigation planning in three dimensional spaces based on ant colony optimization, we design tourism navigation planning algorithms in three dimensional spaces, which is respectively based on space contraction ant colonies optimization algorithm and ant colony algorithm in continuous domain. These two algorithms for navigation planning not only can plan neatly optimization path with different characters, but also can deal with different constraints. It has strong searching ability and can work out the problem of submarine navigation planning in three dimensional spaces perfectly (Peng, 2015; Lee et al., 2014; Leidner, 1999; Yun et al., 2012).

The computation complexity for ant colony optimization is too high when Bayesian network structure is learned. And the running time is too slow. The effect is poor when the continuous optimization problems are solved by ant colony optimization. The effect is poor when constrained optimization problems are solved by ant colony optimization. The clustering effects are poor when ant colony clustering algorithm is applied to a number of benchmark data sets. In order to overcome the above four shortcomings, the following improvements for ant colony optimization are provided. Firstly, the constrained ant colony optimization is proposed for the discrete combinatorial optimization problem-learning Bayesian network structure. The add-edge-rule is designed base on the local consistency score criterion in the new algorithm. Let $\tau_{ij}(t)$ be the intensity of trail on edge (i, j) at time t. The basic equation is shown in the following formula (1):

$$\tau_{ij}(t+n) = \rho \tau_{ij}(t) + \Delta \tau_{ij}$$

(1)

Then we have equation (2):

$$\Delta \tau_{ij} = \sum_{k=1}^{n} \Delta \tau_{ij}^k$$

(2)
It is given by

\[
\Delta r_{ij}^k = \begin{cases} 
\frac{Q}{L_k} & \text{if } k \text{ th ant uses edge } (i, j) \text{ in its tour } \\
0 & \text{(between time } t \text{ and } t+n) \\
\text{otherwise}
\end{cases}
\]  

(3)

We have the equation (4)

\[
p_{ij}^k(t) = \begin{cases} 
\tau_{ij}^a(t) \cdot \eta_{ij}^\beta & j \in \text{allowed}_k \\
0 & s \in \text{allowed}_k \\
\text{otherwise}
\end{cases}
\]  

(4)

where

\[
\text{allowed}_k = \{N - \text{tabu}_k\}  
\]  

(5)

In traditional ACO Algorithm, the initialization of the pheromone matrix is equal. Ants need iterate many numbers to find the best tour. We can generate a large amount of tours (e. g. 100 tours), and then we choose some better tours (e. g. 30 tours). At last ants lay trail only on these better tours. These trails affect following ants.

\[
u_{p1}(X,Y) = \begin{cases} 
0 & X < 2\pi k + \pi - \alpha_i - \pi M \sin Y \\
\frac{E}{6} & X \geq 2\pi k + \pi - \alpha_i + \pi M \sin Y \\
& X < 2\pi k + \pi - \alpha_i + \pi M \sin Y \\
& X \geq 2\pi k + \pi - \alpha_i - \pi M \sin Y
\end{cases}
\]  

(6)

The double Fourier series of function \(u_{p1}(X,Y)\) is given:

\[
u_{p1}(X,Y) = \frac{A_{00}}{2} + \sum_{n=1}^{\infty} (A_{nn} \cos nX + B_{nn} \sin nY) + \sum_{n=1}^{\infty} \left[ A_{nn} \cos(mX + nY) + B_{mn} \sin(mX + nY) \right]
\]

In the above formula

\[
A_{mn} + jB_{mn} = \frac{2}{(2\pi)^2} \int_{-\pi}^{\pi} \int_{-\pi}^{\pi} u_{p1}(X,Y)e^{j(mX + nY)} dXdY
\]  

(7)

Take the formula (3) into formula (4)
\[
A_{mm} + jB_{mm} = \frac{E}{6\pi^2} \int_0^\pi \int_0^{2\pi} e^{j(mM + nY)} e^{j(nX + mY)} dX dY
\]

\[
= \frac{E}{j6m\pi} e^{j(m(n-a)\pi)} \left[ \frac{\pi}{\pi} \int_0^\pi e^{j(mM \pi \sin Y)} e^{jmY} dY - \frac{\pi}{\pi} \int_0^\pi e^{-j(mM \pi \sin Y)} e^{-jmY} dY \right]
\]

By Bessel function,

\[
\frac{1}{\pi} \int_0^\pi e^{jmM \pi \sin Y} e^{jmY} dY = J_n(mM \pi) \frac{e^{j\pi} - 1}{2} ; \quad \frac{1}{\pi} \int_0^\pi e^{-jmM \pi \sin Y} e^{-jmY} dY = J_n(mM \pi) \frac{1 - e^{-j\pi}}{2}
\]

Then,

\[
A_{mm} + jB_{mm} = \frac{E}{j6mn} e^{j(m(n-a)\pi)} \left[ J_n(mM \pi) \frac{e^{j\pi} - 1}{2} - J_n(mM \pi) \frac{1 - e^{-j\pi}}{2} \right]
\]

\[
= j \frac{E}{6mn} J_n(mM \pi) e^{j(m(n-a)\pi)} [1 - e^{j\pi}] \tag{8}
\]

When \(n=0\) or \(n\) is the even number, \(1 - e^{j\pi} = 0\). \(A_{mm} + jB_{mm} = 0\).

By the above derivation, we can get:

\[
u_{pt} = M \frac{E}{6} \sin \omega t + \frac{E}{3\pi} \sum_{m=1,2,\ldots}^{\infty} \sum_{n=1,2,\ldots}^{\infty} \frac{J_n(mM \pi)}{m} \cos m(\pi - \alpha_0) \sin[(mF + n)\omega_0 t] - \frac{E}{3\pi} \sum_{m=1,2,\ldots}^{\infty} \sum_{n=1,2,\ldots}^{\infty} \frac{J_n(mM \pi)}{m} \sin m(\pi - \alpha_0) \cos[(mF + n)\omega_0 t] \tag{9}
\]

When ant completes a tour, it always lays called trail on each edge visited. If the tour is worse, ant also lay the trail on each edge. These trails disturb the following ants, so the ACO algorithm's convergent speed is very slow. We can calculate the length of tour firstly and then we compare with the given value. If the length of tour is less than the given value, we update trail values. Otherwise don't update the trail values (Cherian, 2015; Shieh et al, 2015; Yang et al., 2015).

3. RESULTS AND DISCUSSION

In developing the tourism route algorithm, the network model presents the operating environment that consists of \(N\) deployed tourism nodes with one base station. Nodes are randomly deployed in an \(L \times L\) area with the base station located in the middle of the deployed monitored area. The tourism nodes sense the environment for fulfilling applied application scenario and send the monitored data to the sink node normally known as base station. While the base station is accountable for receiving data from nodes and provides the end-user a description about application so that appropriate action could be taken when required. The network model has the following properties:

1) All tourism nodes are identical (Homogeneous it means have similar capabilities of sensing, processing, and communication)

2) Deployed tourism nodes are energy constrained

3) Tourism nodes are deployed randomly.

4) As homogeneous so initial energy of the tourism Nodes are same or identical at the time of deployment
5) All tourism nodes and the base station are stationary after deployment phase.

6) The nodes are equipped with power control capabilities to vary their transmission power. It means nodes can change their transmitting range based on the requirement.

7) All nodes are aware about their position as equipped with GPS.

8) Base station need not to be located far away from the sensing region so positioned in the middle of deployed region (Ren and Yang, 2016).

Moreover, in spite of the energy constrain, all the nodes have enough energy directly addition communicate with any other deployed tourism nodes as well as the base station. Each node has enough processing power to prop up the different protocols and signal processing tasks. Same as those in most wireless tourism networks applications, nodes are left unattended after deployment. Therefore, battery recharge is not possible. The model includes several consumer behavior theoretical constructs and their sets of indicators. These are chosen as testable and depicted in a sequential order reflecting tourists' experiences from expected attractiveness of a destination and motivation into place dependence and place identity. These insights build the basis to conceptualize and propose a general theoretical framework. In addition, the model includes constraining factors that explain the process that leads to a particular choice of destination. The proposed order of the model is that perceived constraints and satisfaction depend on expected attractiveness and travel motivation and that these two constructs may further influence and predict place identity and place dependence.

The simulation results show that with increasing number of sub-groups, the optimization of tourism route planning has been extended. Fig. 2 shows the graphical representation of different number of sub-groups on equal number of deployed nodes. Fig. 3 illustrates the pictographic for number of live tourism nodes with respect to the number of rounds for MG-LEACH in support of the experiment data.

![Figure 2. Graphical representation of simulation results presenting effect of creating different sub-groups on network lifetime](image_url)

In the preceding paragraphs, comparative analysis of MG-LEACH and LEACH has been done. Simulation result shows that MG-LEACH performs better in extending life time. We will attempt to test out the result of different number of sub-groups on network life time in tile. Consider N number of deployed nodes that have been divided in to different sub-groups. In our Simulation platform we have taken N=500 nodes while the sub-groups ranges from 1 to 4.
In this section, we conduct a case study to demonstrate the effectiveness of the proposed algorithm. In a specific logistics, we set two distribution centres \((dc_1\) and \(dc_2\)), and \(dc_1, dc_2\) means a hub centre and a common distribution centre respectively. Furthermore, three kinds of vehicles are used for each distribution centre: a) large vehicle, b) medium vehicle and c) small vehicle, and the length, width and height of them are equal to \(11 \times 1.8 \times 1.6\) m, \(8 \times 1.7 \times 1.5\) m, and \(4 \times 1.6 \times 1.5\) m respectively. Moreover, there are three different types of boxes: a) large box, b) medium box and c) small box, and the length, width and height of them are set to \(1 \times 1.8 \times 0.8\) m, \(1 \times 0.8 \times 0.8\) m, and \(1 \times 0.5 \times 0.5\) m respectively. Transport fees per kilometre for large vehicle, medium vehicle and small vehicle are set to 3.8, 3.2 and 1.6 dollars respectively.

Firstly, we exploit a weight matrix to record distances between various locations. Assume that there are \(n\) locations, the weight matrix \((M)\) is defined as follows.

\[
M = \begin{bmatrix}
    l_{11} & l_{12} & \cdots & l_{1n} \\
    l_{21} & l_{22} & \cdots & l_{2n} \\
    \vdots & \vdots & \ddots & \vdots \\
    l_{n1} & l_{n2} & \cdots & l_{nn}
\end{bmatrix}
\] (10)

where \(l_{ij}\) denotes distance between the location \(i\) and \(j\).

Secondly, we assume that there are 10 locations this case \(\{l_1, l_2, \cdots, l_{10}\}\), and the distances between each location pair are illustrated in Table 1.

<table>
<thead>
<tr>
<th></th>
<th>(l_1)</th>
<th>(l_2)</th>
<th>(l_3)</th>
<th>(l_4)</th>
<th>(l_5)</th>
<th>(l_6)</th>
<th>(l_7)</th>
<th>(l_8)</th>
<th>(l_9)</th>
<th>(l_{10})</th>
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<tbody>
<tr>
<td>(l_1)</td>
<td>0</td>
<td>119</td>
<td>96</td>
<td>79</td>
<td>120</td>
<td>93</td>
<td>91</td>
<td>100</td>
<td>59</td>
<td>90</td>
</tr>
<tr>
<td>(l_2)</td>
<td>119</td>
<td>0</td>
<td>94</td>
<td>110</td>
<td>65</td>
<td>55</td>
<td>51</td>
<td>87</td>
<td>119</td>
<td>68</td>
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<td>(l_3)</td>
<td>96</td>
<td>94</td>
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<td>57</td>
<td>117</td>
<td>80</td>
<td>73</td>
<td>106</td>
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<td>110</td>
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<td>72</td>
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<td>56</td>
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<td>55</td>
<td>80</td>
<td>56</td>
<td>92</td>
<td>0</td>
<td>105</td>
<td>59</td>
<td>51</td>
<td>82</td>
</tr>
</tbody>
</table>

Table 1 Weight matrix in this experiment
Using the proposed settings, we utilize the proposed algorithm to optimize eight distribution tourisms (listed in Table 2). The comparison experiment result is shown in Table 3.

### Table 2. Experimental results for the given eight tourism route

<table>
<thead>
<tr>
<th>Tourism node ID</th>
<th>Vehicle type</th>
<th>Tourism route</th>
<th>Total fees</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>medium</td>
<td>L1→L3→L4→L5→L8</td>
<td>3105</td>
</tr>
<tr>
<td>2</td>
<td>small</td>
<td>L4→L2→L8→L9→L6→L3</td>
<td>2578</td>
</tr>
<tr>
<td>3</td>
<td>large</td>
<td>L4→L2→L6→L10→L9</td>
<td>3430</td>
</tr>
<tr>
<td>4</td>
<td>small</td>
<td>L1→L3→L5→L8→L2</td>
<td>2582</td>
</tr>
<tr>
<td>5</td>
<td>large</td>
<td>L5→L3→L6→L4→L9→L2→L8</td>
<td>3459</td>
</tr>
<tr>
<td>6</td>
<td>small</td>
<td>L3→L1→L8→L7</td>
<td>3304</td>
</tr>
<tr>
<td>7</td>
<td>small</td>
<td>L4→L10→L7→L8→L2</td>
<td>2845</td>
</tr>
<tr>
<td>8</td>
<td>medium</td>
<td>L4→L6→L5→L9</td>
<td>3264</td>
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</table>

### Table 3. The comparison experiment result

<table>
<thead>
<tr>
<th>Stage</th>
<th>Cluster Combined</th>
<th>Coefficients</th>
<th>Stage Cluster First Appears</th>
<th>Next Stage</th>
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</thead>
<tbody>
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<td>Cluster 1</td>
<td>Cluster 2</td>
<td>Stage Cluster First Appears</td>
<td>Cluster 1</td>
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</table>
4. CONCLUSION

With the rapid development of the tourism worldwide, the role of tourism in promoting employment, stimulating economic is becoming even more significant. In order to reduce the energy consumption and improve the performance of tourism traffic routes, this paper researched on the optimization of tourism traffic routes based on ant colony algorithm. In this paper, the ant colony algorithm is used to reduce the energy consumption and improve the efficiency in the tourism traffic routes planning. The development on tourism is an important symbol of a national and regional modernization, opening and the internationalization. The empirical tests show that without loss of results accuracy, the convergence speed of the ant colony optimization is significantly 40% faster than that of the traditional algorithm. Tourism industry has input and output function and the input-output relate to many industries, tourism industry has closely associated with the other industries. This paper analyses the relevance and optimize the route planning process. The experiment results of this paper have a reference value for the application of ant colony algorithm in the design process of tourism traffic routes which can also promote the overall performance substantially.

REFERENCES