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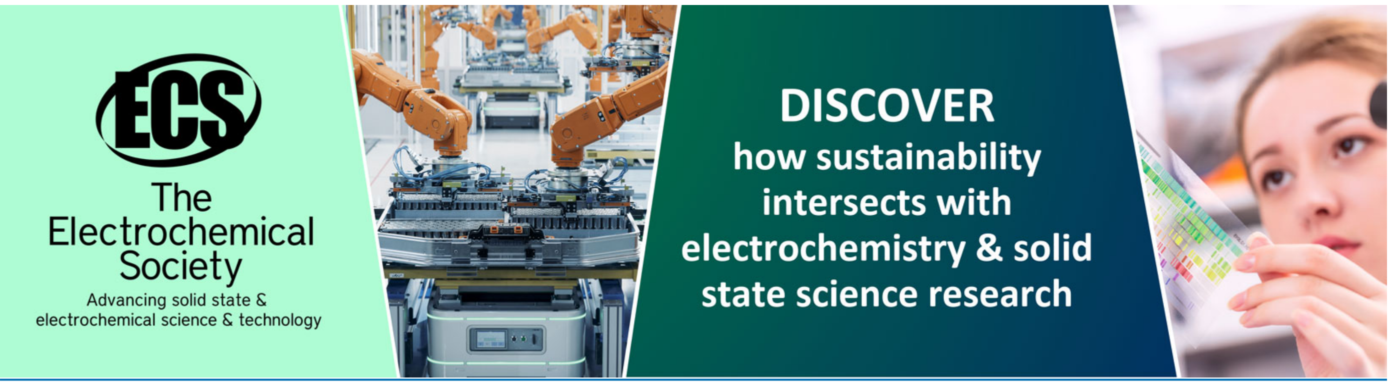

IOP Conf. Series: Earth and Environmental Science **526** (2020) 012227 doi:10.1088/1755-1315/526/1/012227

Transport Waste Separation and Recovery Trajectory Judged Based on Dijkstra's Algorithm

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Abstract. Urban waste classification and recycling is an important research node in people's livelihood, which is related to the corresponding relationship between efficiency and quality. The optimization of the recycling transportation path means that the cost is less. In the process of garbage transportation classification and recycling, optimizing and merging the routes of garbage transportation based on Dijkstra's algorithm can optimize the shared transportation resources, to achieve the result of saving operating costs. The immediate transportation recycling event is planned as the path planning optimization. Multi-source multi-object and multi-path planning problems, and rehearse the optimization model of the total length of the transport path set without repeated paths. When the scale of the transportation and recovery network grows to a set value, it is difficult to achieve a theoretical solution by accurately calculating the optimal value of the model through an optimization algorithm. An optimal path set selection algorithm based on a random walk is feasible. The effectiveness and operability of the method are verified by small experiments and simulation experiments. The path is the shortest, and compared with the summation algorithm, it not only has high accuracy, but also has high execution efficiency.

1. Introduction

Urbanization and the expansion of the urban economy will inevitably increase the output of urban solid waste. The management and recycling of urban solid waste have become one of the serious challenges facing urbanization [1]. Throughout the world, developed countries such as the United States, Japan, Germany, and Singapore have established corresponding laws and regulations on the management and recycling of urban waste. In the management and recycling of urban garbage, the classification and recycling of garbage are one of the key links. By sorting and recycling garbage, it can improve the reuse of resources and reduce the pollution caused by toxic and harmful substances. In the study of garbage recycling, the choice of recycling path is one of the most important research contents [2]. The traffic in the city is composed of a mesh structure. Various types of garbage are distributed in any corner of the mesh structure, and garbage collection points are often distributed at multiple nodes in the network according to the type of garbage collected. In the process of garbage recycling, not only the cost of transportation but also the time factor, such as the optimal disposal time of garbage, the potential harm caused by decay and deterioration, etc. In garbage collection, the most direct method is to find the shortest path between the garbage point and the recycling site. The result of this method is that the recycling path of a single site is the shortest, and the sum of the paths of all sites is not the shortest, thus increasing the cost of garbage collection. Besides, as urban traffic is becoming more and more complicated, and the types of recycling sites are increasing, this has caused great difficulties in the choice of garbage collection paths. This paper establishes an optimal path selection model with multiple endpoints for garbage classification and recycling. Different types of garbage are distributed in every corner of the city, and various types of garbage are set as a recycling site. By combining the recycling paths of each garbage, the sum of the garbage recycling paths is minimized, thereby saving the cost of garbage recycling.

2. Materials and methods

2.1. Optimal path model for classified recycling

The city's transportation network is represented by the graph $P = (C, V, G)$, where the node-set C is the intersection set or the end point set of the road, and the edge set $E \in C \times V$ is the specific road set in the city. G is a set of lengths of roads, and the relationship between V and G is correspondence. To facilitate discussion and analysis, let each garbage be generated at the nearest intersection or road-end. Assuming that all garbage can be divided into m categories, the garbage collection sites are located on different nodes in Fig.1 (the garbage collection site is located near the node, ignoring the distance between the garbage site and the node). The set of sites is represented by $Pc=\{Ci(r) \mid Ci(r) \in C, 1 \leq i \leq C\}$, and $Cr \in C$. For the *i-th* type($1 \leq i \leq C$)garbage, the recycling site is $Ci^{(r)}$, and the collection of this type of garbage in the city is $P = \{r1^{(i)}, r2^{(i)}\ r3^{(i)}\ ,,,\ , Rn^{(i)}\}$, the upper right mark of the element in *P1* identifies the type of garbage, and the lower right mark identifies the sequence number of the garbage in this type of garbage. The *i-th* type of garbage ri contains $\lvert R \rvert$ garbage, and each garbage $rj^{(i)}$ $(1i \leq j \leq \lvert R \rvert)$ has a unique place (node in the network), so there is $rj^{(i)} \in V$. Since a site can produce multiple similar garbage, so the elements in each *rj* may have duplicates. Also, different types of garbage can be generated in each location, that is, the same node appears in different types of garbage collection.

2.2. Construction and simulation of garbage transportation network

Given traffic network P, garbage collection site collection Pr, total garbage collection $P=\{r1^{(i)}, r2^{(i)}, r3^{(i)}, \ldots, r\lvert R \rvert^{(i)}, r1^{(2)}, r1^{(3)}, \ldots, r1^{(k)}, r2^{(k)}, r3^{(k)}, \ldots r\lvert R \rvert^{(k)}\}$. The goal of this article is to evaluate each element in Prn(k)($1 \leq i \leq k$, $1 \leq j \leq R$). Explore an optimized recycling path P(rj(i), v j(i)), (j(i)). In the path summation process, if multiple paths contain the same road, the paths can be merged, and the repeated roads are calculated only once. Take the paths *P(rj(i), v j(i)) and P(rp(q), v q(r))*as expmable. The combined path length is the sum of the lengths of the two paths minus the length of the common path in the two paths.

$$\sum_{c \subset (r_j^{(i)}, v_{i(r)})} \omega_c + \sum_{c \subset R(r_p^{(r)}, v_q^{(r)})} \omega_c - \sum_{c \subset \{r_i^{(j)}, \gamma^{(r)} \cap r(\rho_q^{(p)}, \gamma_p^{(q)})\}} \omega c \tag{1}$$

Note: ωe is the side length. To simplify the representation of the notation, let p be the initial point set, means $1|p|=|s|=|p|$. T is the end of the set. $|T|=|rV|R=k$. if $s \in S$, there is a unique value $\in T$, $r(s, t)$. Representative repeat both free path. The total set of paths is as follows:

$$R(P,T) = \{r(s,t) | \forall S \in S, \exists t \in R\} \tag{2}$$

$$E_P = \bigcup_{\rho(s,t) \subset \rho(S,T)} \{c \sum c \subset \rho(s,t)\} \tag{3}$$

3. Optimal path combination selection based on the random walk

3.1. Coupling and computational modeling of transportation routes

In the calculation process of formula (3), it is not feasible to enumerate all path combinations to find the minimum path combination. Because the number of paths between two points in the network increases exponentially with the size of the network [3]. Besides, in the garbage collection process, the amount of garbage is often of the same order of magnitude as the number of nodes in the network, which makes the number of combined paths become an order of magnitude of double exponents. If formula (3) is calculated by finding the shortest path between two points, the result obtained is not the optimal value. Taking Fig 1 as an example, the connection relationship between the nodes in the graph and the length of the edges is as shown in the figure. If the garbage generated at two points a and *b* is transported to *t*, the method of using the shortest path is to select $a \to t$ and $b \to y$ respectively the shortest path between *t*.

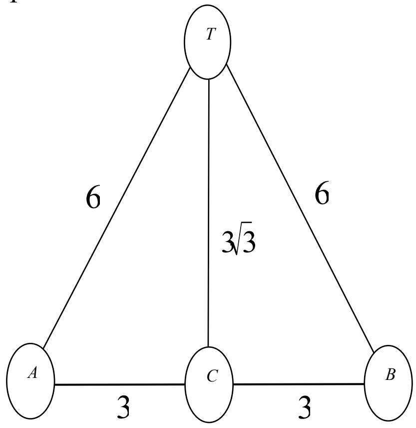

Fig.1 The Simple path of merge instance

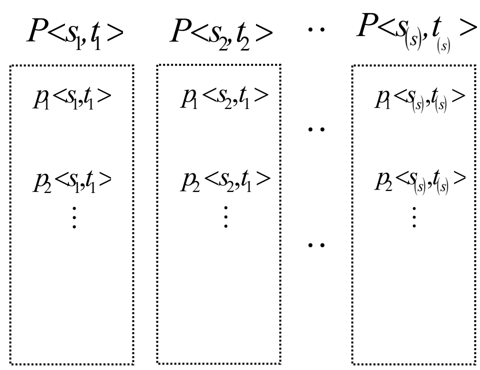

Fig. 2 The path of the array for the start to end process

3.2. Setting and optimization of the travel route

To obtain optimized results in a shorter time, this paper proposes an optimal path combination optimization algorithm based on the idea of the random walk. Random walks on the network with any node are the initial point and construct a random walk chain of length *l*. The size of l here determines the accuracy of the final result. $l \to +\infty$. The result produced is the optimal value. Given the graph $G = (R, P, W)$ and the initial point $s \in V$, the random walk process is as follows: start the random walk at the initial point *s*; let the current node be *v*, and randomize according to the weight ratio of the neighbors of *v* Go to one of the neighbor nodes *v*. The selection rule of neighbor node *v* is: select the set of neighbor nodes of *v*, and for all neighbor nodes $u \in N(v)$, randomly walk to this node according to probability. Repeat step 2 until a random walk chain of length l is generated.

After the random walk process, to give a random walk length l chain, $L=\{v1, v2, v3, v4,\dots vn\}$. And the distance between any two adjacent nodes *vi* and *vi + 1* in *L* is ω *(vi, vi + 1)*. For any $s \in S$, there is a unique $t \in T$ corresponding to it, so *s* and *t* constitutes a start-end pair<*s, t*>. For sets *S* and *T*, there are | *S* | start-end pairs. For all start-end pairs, <*s, t*>. *(1≤i≤ | S |)*, find all the paths between *si* and *ti* in *L*, and arrange them in ascending order according to the length of the path, then you can get *P (si, t≤pi (si, ti), p2 (si, ti),…* . For each process from the start point to the endpoint, a path sequence can be obtained, then for all *(s, t)* a path array as shown in Fig. 2 can be obtained *P<s1, t1> P<s2, t2>P<s|S|, t|S|...>p1<s1, t1>p1<s2, t2>p1<s|S|, t|S|>...p2<s1, t1>p2<s2, t2> p2<s|S|, t|S|>.*

3.3. The path is compared with all the path combinations in the above path array

The path combined with the global minimum defined by formula (3) is obtained. In the above path array construction process, all path lengths must satisfy the constraints. When constraining the path length, a constant can be set for all paths, or a constraint length λ can be set for each node-end pair <*s, t*>. Besides, when the value of *l* is large, or the network scale and the amount of garbage are large, it still requires a large amount of calculation to combine different start-end pairs in the node array. In this case, optimization algorithms such as the ant colony algorithm [4,5] and genetic algorithm [3,5] can be used for further optimization.

4. Experimental results and analysis

4.1. Analysis of experimental data

This article uses simulated data sets to evaluate the accuracy and performance of the algorithm. The experimental environment is a personal laptop computer with a multi-core computing server for calculation and analysis. In order to evaluate the optimal path planning algorithm proposed in this paper, the experimental simulation produced a distribution map of garbage generation locations and recycling sites in a certain area, and generated simulation Maps of the transportation network in the area. Use the following method to generate the data set required for the experiment. Generate several points uniformly and randomly in a grid of 100 × 100 unit length. Each point may generate garbage. Select 4 points at the four edges of the area as garbage collection sites. The distribution map contains 300 garbage generation points and 4 garbage collection sites. The black dots indicate the locations where the garbage may be generated, and the black dots are 4 garbage collection sites. In the experiment, the performance and efficiency of the algorithm are observed by adjusting the number of garbage generating locations and the proportion of garbage generating locations in the area. In order to simulate the traffic path between points, the simulation generates a corresponding traffic map. For each point in the area, 3 or 4 routes are randomly selected, where the other end of these routes is the point closest to the line in a straight line. The reason for choosing 3 or 4 routes is that most of the actual traffic routes are intersections or crossroads. In the generation of edges, select the straight-line distance between the two endpoints.

4.2. Model building comparison and path optimization

The algorithm proposed in this paper is compared with the method based on the shortest path summation, and the accuracy and operating efficiency of the algorithm are compared. The basic idea based on the shortest path summation algorithm is: For all start-end pairs $(s, t) \in (S, T)$, the Dijkstra algorithm is used to calculate the shortest path $p\ (s, t)$, get the result of the union of all the edges included in the shortest path and evaluate them, and finally find the weighted terms and evaluation values of these edges [6]. In the random walk method, let the length of each random walk chain be 20 (the nodes sample 20 times on average). A good path planning method should choose the shortest possible path, so the smaller the total length of the path set, the more accurate the method high. When 80% of the nodes in the area will randomly generate a type of garbage (0.8), the total path length changes of the two algorithms are observed by adjusting the number of nodes in the area. The results are shown in Fig 3. It can be seen from the figure that, because the method proposed in this paper considers the problem of path merging, the total path length obtained is smaller than the method based on the shortest path summation, and this advantage becomes more and more obvious as the number of nodes increases.

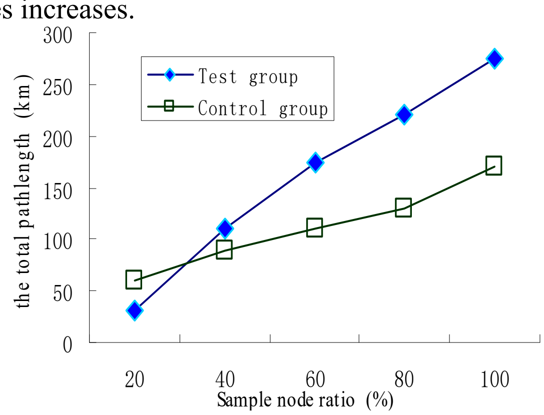

Fig 3.The total path length varies with the node size (α=0.78)

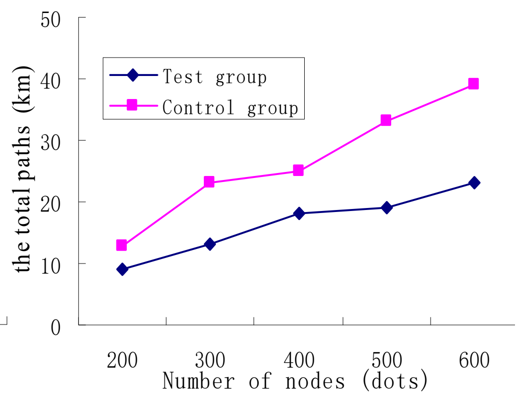

Fig 4. The total path length varies with the number of garbage collection nodes

4.3. Node construction and algorithm optimization

The calculation efficiency of the two algorithms is compared through experiments, and the time required for the algorithm from initialization to the total path length is used as the evaluation index. After setting the ratio of garbage nodes to 0.8, observe the running time of the algorithm by changing the number of nodes (in Tab 1).

Tab.1 The time of the algorithm with the response of nodes and garbage (α=0.8. K=300)

Number of garbage stations	Optimal paths time	Experimental method time	Proportion accounted node	Minimum time Sum time	Experimental method time
160(220)	<1	<1	60(0.4)	<1	<1
240(340)	1.72	<1	120(0.4)	<1	<1
320(460)	4.95	<1	180(0.6)	1.34	<1
400(480)	35.82	5.49	240(0.8)	1.87	<1
480(600)	1809	87.3	300(1.0)	2.28	<1

From the experimental results that when the number of nodes increases to 600, the running time of the shortest path summation method is about half an hour, while the method proposed in this paper only takes 1.5 minutes. To further compare the running efficiency of the algorithm, the number of nodes is taken as $k = 300$, and the running time of the algorithm changes with the proportion of garbage nodes. When $k = 300$, the running time of the method proposed in this paper is less than 1s, which is lower than the shortest path method (in Tab 2).

5. Discussion

The classification garbage collection path optimization method based on the random walk proposed in this paper can combine the recycling paths in the garbage classification collection, thus reducing the total path length required for recycling all garbage. Besides, since the random walk is a sampling method, this method can obtain ideal sampling results with a small number of samples, so the execution efficiency is very high. This paper studies the path optimization problem in sorted garbage collection. If the urban garbage collection and operation lines are not properly planned, the cost will be too high. In this paper, the logistics paths in the garbage recycling process are merged to reduce recycling costs in the case of sharing transportation resources. In classified garbage collection, different types of garbage correspond to garbage collection sites. The path planning problem of garbage classification and recycling is modeled as a multi-source and multi-object path planning problem, and the total length of the path collection without repeated edges is given. Optimize the model. In order to improve the computational efficiency of this model, an optimal path set selection algorithm based on the random walk is proposed. Simulation experiments show that the proposed method is not only more accurate than the shortest path summation algorithm based on Dijkstra's algorithm, but also has high execution efficiency.

Acknowledgments

Heilongjiang Provincial Department of Education Basic Research Project, China, (2018-KYYWF-0955); China Scientific and technological innovation projects in Jiamusi University, Heilongjiang Province, College students: 201910222007.

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