Variable Neighbourhood Decent for Parking Allocation Problem

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Résumé : *Searching for available parking lots presents a mayor problem in urban areas. Massive unorganized pursuit for parking provokes traffic congestion, financial losses, negative environmental effects, among others. Most studies on this topic base their research on simulations due to the large set of non-deterministic input. In this paper we propose an approach where each vehicle that is looking for a parking lot is equipped with GPS device. Based on this assumption, the static Parking allocation problem (PAP) can be modeled as a variant of Generalized assignment problem (GAP). Here we also discuss inclusion of the static model into a dynamic real-world circumstances. Moreover, we developed a heuristic based on sequential Variable Neighborhood Decent (VND) to solve static PAP. It uses two neighborhood structures : reallocation and interchange. It appears that the deviation of VND based heuristic, compared with the optimal solutions, are always less than 0.1%.*

Mots-clés *: Parking allocation problem, Variable neighborhood descent, General assignment*

1 Introduction

Assume that n vehicles equipped with GPS system are searching for the parking lot in a city at time t_0. Assume further that there are m parkings, each having known capacity $q_j, j = 1, ..., m$, i.e., the number of parking lots at each parking is known. Drivers have to enter their final destination, and after all drivers have done it, the GPS system is able to find two types of estimated time or distance (matrices) :

— t'_{ij} - estimated time of vehicle i to reach parking j, $\forall i, j$;

— t''_{ji} - estimated (walking) time from parking j to final destination of driver $i, \forall j, i$.

Additional input information is also necessary regarding the estimated number of free spaces v_{jt} at each moment t, $t = 1, ..., T$. Note that $T = \max_{ij} \{t'_{ij}\}$, and also that the time moment $t = 1$ corresponds to the moment t_0.

Therefore, we want to find allocation variable $x = (x(1), \ldots, x(n))$ (or partition x of n vehicles into the number of groups less or equal to m) that minimizes the total time spent by vehicles from their initial positions to their parking lot :

$$(\min_{x \in \mathcal{P}}) f = \sum_{i=1}^{n} (t'_{i,x(i)} + t''_{x(i),i}). \tag{1}$$

Note that $x(i)$ represents the index of parking where the vehicle i is allocated in a feasible partition of vehicles $\mathcal{P}$. Feasibility of the partition $\mathcal{P}$ is satisfied if the following two conditions are satisfied :

— the number of vehicles parked at parking j should be less than its capacity q_j, for all j and for all t ;

— the number of vehicles parked in moment t at parking j should be less or equal to v_{jt}.

Since the real world problems are not static, our basic idea to include time into consideration consists in running the static code very often, let us say once in a minute. By doing that, we are able to avoid many unpredictable situations that no static or dynamic model can fully include. Let us mention some of them :

(i) the driver who is already allocated to the parking, finds free parking at the street ;

(ii) the driver decides to change his destination ;

(iii) GPS system stops functioning in some vehicles,

(iv) the time vehicle stays at a parking lot is unpredictable, and using queuing theory in this case would be too unprecise and noisy, etc.

The elegant way to cover many such unpredictable (random) circumstances is simply to solve problem with the new current input.

2 VND for the Static PAP

Obviously, several neighborhood structures could be constructed for this combinatorial optimization problem. Since our heuristic should be fast, in this paper we propose just two :

— **Reallocation** : given a solution x and thus (i, x_i) connections ; each vehicle i changes its parking lot $x_i \in \{1, \ldots, m\}$.

— **Interchange** : given a solution x, let (i_1, j_1) and (i_2, j_2) denote two vehicles-parking pairs. Assume that vehicles i_1 and i_2 exchange their parking lots, so we have pairs (i_1, j_2) and (i_2, j_1) instead, in the new solution y. 1-interchange neighborhood $N_1^{int}(x)$ consists of all such interchanges. It is clear that not all such interchanges are feasible since one of those vehicles could come at the time moment when not all parking lots are available.

In our Sequential VND we use these two neighborhoods one after another, until local minimum with respect to both is reached. In addition, the realocation neighborhood is reduced to just p (a parameter) closest parking facilities. It uses *best improvement* search strategy, while *Interchange* implements the *first improvement.*

Each line in Table 1 reports averages of 10 randomly generated instances in the plane (with the same values of n, m and Q) ; the value of parameter p is set to 4. Initial solution is obtained with *Greedy* heuristic.

			Average runtime		Objective value		%DEV
n	m	Q	CPLEX	VND	CPLEX	VND	
	10	600	8.09	1.28	322514.80	322887.0	0.001%
2000	20	300	16.41	2.29	295038.50	295404.9	0.001%
	30	200	28.67	2.44	283583.10	283938.7	0.001%
	10	1200	35.75	6.23	632474.50	633076.1	<0.001%
4000	20	600	84.70	9.57	589809.00	590480.4	0.001%
	30	400	156.07	10.60	563081.30	563481.7	<0.001%
	10	1500	52.80	8.45	814090.00	814660.2	<0.001%
5000	20	750	158.96	18.40	723350.40	723957.2	<0.001%
	30	500	470.52	21.79	708334.10	709012.3	<0.001%

TAB. 1 – Computational average results over 10 different vehicle positions

It appears that the results obtained with our VND based heuristic are of very good quality.

Références

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