ResearchGate

See discussions, stats, and author profiles for this publication at: https://www.researchgate.net/publication/278560757

An Application for Handheld Devices to Solve Capacitated Vehicle Routing Problems

Conference Paper · June 2015

READS

26

2 authors, including:

Carlos Carreto

Polytechnic Institute of Guarda

16 PUBLICATIONS **174** CITATIONS

SEE PROFILE

All in-text references underlined in blue are linked to publications on ResearchGate, letting you access and read them immediately.

Available from: Carlos Carreto

Retrieved on: 01 July 2016

An Application for Handheld Devices to Solve Capacitated Vehicle Routing Problems

Carlos Carreto[1], Ricardo Antunes[1]

[1] Unidade de Investigação para o Desenvolvimento do Interior
Instituto Politécnico da Guarda
Av. Dr. Francisco Sá Carneiro 50, 6300-559 Guarda, Portugal
ccarreto@ipg.pt, antenas963@hotmail.com

Abstract

This paper presents an application for handheld devices (smartphones and tablets), to solve capacitated Vehicle Routing Problems. The application implements a visual interactive solution method that integrates the insight and experience of the scheduler, and the power and precision of the heuristics, in an interactive environment. The solution method was implemented to make use of the interesting features and services of the current handheld devices. Results show that despite the restrictions on the processing power of these devices, their functionalities are very interesting to implement visual interactive methods, allowing the common user to easily solve vehicle routing problems.

1 Introduction

This paper presents the work in progress to develop an application for Android handheld devices (smartphones and tablets) to solve real-life capacitated Vehicle Routing Problems (VRP) [4], based on a visual interactive solution method implemented through a Greedy Randomized Adaptive Search Procedure (GRASP) [6]. The aim of the application is to take advantage of the features and resources of these devices, such as geographical map and location services and the visual interaction capabilities to allow the development of an advanced application that can be used by common users, which is capable of solving real life problems.

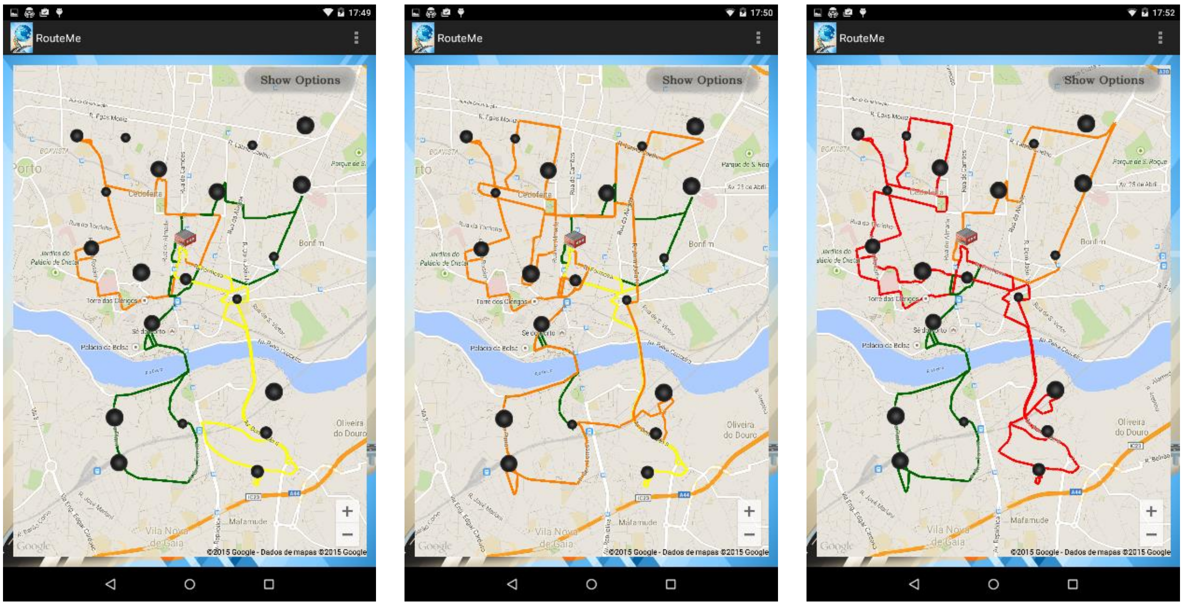
The motivation to use a visual interactive method is to integrate the insight and experience of the user, and the power and precision of the heuristics, in an interactive environment. Through interaction the user is able to control the solution process by selecting initial parameters, selecting algorithms and adjusting solutions. The user can also include special knowledge of the real life problem guiding the heuristics towards promising areas of the solution space. An interactive solution method also facilitates the inclusion of constraints and makes the solutions more acceptable because the user participates actively in the solution process.

Previous work [1] has shown that excellent results for the VRP can be obtained by a visual interactive method and GRASP. The method was later extended to tackle different variations of the VRP [2, 7], showing that the method is flexible and adaptable to different types of problems. The application developed uses an adapted version of this solution method, which takes into account the interesting features mentioned before, but also the limitations and restrictions of the handheld devices, especially in what concerns to processing power and memory capacity. A careful implementation of the visual interactive solution method is necessary in order to overcome those limitations.

The main contribution of this work is the implementation of a visual interactive solution method on an application for handheld devices that can solve basic vehicle routing problems. Although there are some examples of applications for this type of devices that solve routing problems, the authors could only find applications that can handle a unique route.

2 The Visual Interactive Solution Method

The visual interactive solution method has three different phases: *Seeds Selection*, *Routes Construction and Improvement*, and *Solution Refinement*. Figure 1 illustrates the three phases that are described in more detail below.



a) b) c)

Figure 1: Illustration of the three phases of the solution method; a) outline of routes after seeds selection; b) a solution obtained after route construction and improvement; c) a solution obtained after solution refinement

The solution method starts with a problem definition where the user creates a new problem instance and selects the locations of the customers and the depot directly in a real map, by using a simple touch interface, or by saving his/her actual location while traveling from one location to another. For each customer the user also gives the corresponding demand. The customers are represented on the map as circles with diameters proportional to their demands. After selecting the customers, the application uses the Google Maps services to get the distances and routes between the customers and the depot, used by the solution method.

In the *Seeds Selection* phase, with the customer locations displayed on a real map, the user selects one or more seed customers in the order that the user would expect them to be visited, to form an outline route. The seed customers are the customers that for some reason the user forces to be serviced by specific vehicles. The user selects the seed customers for each vehicle in accordance with his/her local knowledge and experience of a real life problem, or by identifying certain patterns such as clusters of customers, customers with very high demands or isolated customers. During the selection process the user is helped by the application, which checks for constraint violations related to the capacity of the vehicles. Figure 1 a) shows a typical outline of routes after selection seed costumers.

The *Routes Construction and Improvement* phase, constructs the routes by clustering the remaining customers according to the vehicles defined by the seeds. This clustering is done without user intervention and is implemented in the construction phase of the GRASP algorithm. The heuristic may find a feasible solution where all the customers have been allocated to the vehicles; or the clustering may result in an infeasible solution, because there was a violation of constraints.

The clustering heuristic allocates each customer to the position in a route where the insertion cost is minimized, giving allocation priority to customers with a more obvious insertion route (given by the difference between the second smallest and the smallest insertion cost), and to customers for which the number of routes they can go on is smallest, and while applying a 2-optimal heuristic [5] in order to reduce the total distance travelled by each vehicle. The clustering heuristic is followed by a local search phase that tries to improve the solution obtained by the clustering, if feasible. The GRASP local search phase implements a one-node interchange procedure with a first-improve policy, which immediately accepts the first interchange that gives a positive saving. In order to speed-up the local search phase, the algorithm implements a *p-Neighbourhood* strategy, similar to the one presented by Gendreau et al [3], that reduces significantly the number of interchanges to consider by selecting as destination routes of the interchanges, only those that are ”close” to the customer that is being repositioned. The ”closeness” is defined by a metric which corresponds to the distance on the map between customers. Figure 2 b) shows an example of a feasible solution obtained from the initial set of seeds. The solution obtained in the construction phase can be either feasible or infeasible. The solution method saves the best feasible solution at each iteration, but if the heuristic fails to find a feasible solution, it saves the best infeasible solution, which the user can try to improve in the solution refinement phase. The best infeasible solution is defined as the infeasible solution with the minimum total weight unallocated, as this is considered to provide the best potential for finding a feasible solution during the refinement phase.

In the *Solution Refinement* phase, the user can try to refine the solution in order to improve it (especially if it is infeasible), by using interactive tools. With no formal rules to follow, the interactive system we developed is sufficiently flexible to allow creativity and imagination from the user, and different refinement techniques are possible for using these tools. The interactive tools are implemented based on a simple touch interface. The simplest example consists of the removal of some customers from their current routes. This is followed by a new call to the construction and improvement heuristics, allowing these customers to be inserted into different routes. This is a very simple but effective procedure when there is some overlap between routes, and can lead to several different feasible solutions in a very short period of time. Figure 1 c) shows a possible final solution after applying the interactive tools.

The user has several interactive tools he can choose: remove selected customers from a route, delete a selected route, insert a customer in a selected route and return to the seeds configuration. The interactive tools are implemented base on the natural touch screen interface of the handheld devices.

3 Conclusions

The paper presented a visual interactive method to solve real-life capacitated vehicle routing problems. Interactive methods for vehicle routing are appealing because they integrate the insight and experience of the user, and the power and precision of heuristics in an interactive environment. The method was implemented in an application for handheld devices that is likely to appeal to schedulers who wish to retain some control over the routes that are adopted, especially if there are local constraints on route structure that need to be taken into consideration. Preliminary results show that despite the restrictions on the processing power of the current handheld devices, their functionalities are very interesting to implement visual interactive solution methods, allowing the common user to easily solve vehicle routing problems.

References

[1] Barrie Baker and Carlos Carreto. A visual interactive approach to vehicle routing. *Comput. Operations Research*, 30.3, pp. 321–337, 2003.

[2] Carlos Carreto and Barrie Baker. A GRASP interactive approach to the vehicle routing problem with Backhauls. In Celso Ribeiro and Pierre Hansen, editors, *Essays and Surveys on Metaheuristics*, pp. 185–200, Kluwer Academic Publishers, 2002.

[3] Michel Gendreau,, Alain Hertz and Gilbert Laporte. New insertion and postoptimization procedures for the traveling salesman problem. *Operations Research* 40.6, pp. 1086–1094, 1992.

[4] Paolo Toth and Daniele Vigo. The vehicle routing problem. Society for Industrial and Applied Mathematics, 2001.

[5] Shen Lin. Computer solutions of the traveling salesman problem. *Bell System Technical Journal*, 44, pp. 2245–2269, 1965.

[6] Thomas Feo and Mauricio Resende. Greedy randomized adaptive search procedures. *Journal of global optimization*, 6.2, pp. 109–133, 1995.

[7] Yazgi Tutuncu, Carlos Carreto and Barrie Baker. A visual interactive approach to classical and mixed vehicle routing problems with backhauls. *Omega*, 37.1, pp. 138–154, 2009.