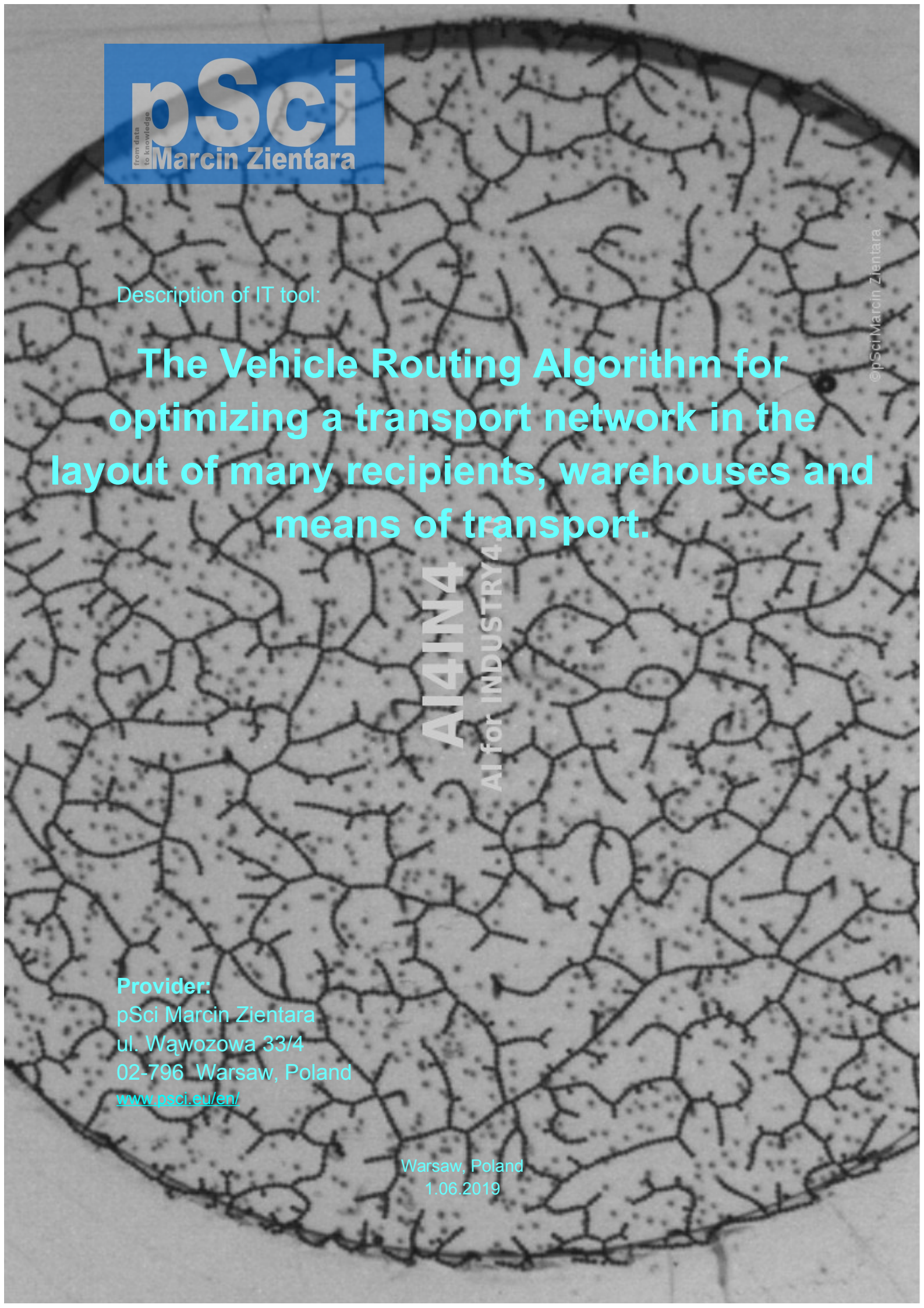

Description of IT tool:

The Vehicle Routing Algorithm for optimizing a transport network in the layout of many recipients, warehouses and means of transport.

Provider:
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Additional information

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I. Introduction

This brochure includes short information about IT tool offered by **pSci Marcin Zientara** companies for a resolving and an optimization of the Vehicle Routing Problem.

The offered **Vehicle Routing Algorithm** (**VRA**) is an IT tool for optimizing a transport network in the layout of many recipients, warehouses and means of transport. The described algorithm VRA solves the problem of the traveling salesman in the generalized form to the problem of many traveling salesmen.

II. About company

pSci Marcin Zientara is R&D company. Informal beginnings of the company date back to 2010 and in a formal way it has been operating since January 2015. The company was founded by a physicist, PhD Marcin Zientara, a long-term research worker of Polish and German scientific institutions. pSci creates advanced algorithms for analysis and modeling of data, phenomenon and processes. In the own work pSci applies Big Data, Artificial Intelligence and Data Science methods. The company products are the result of own R&D work and modern scientific knowledge in the field of physics, mathematics and related natural sciences (more details www.psci.eu/en/).

III. Description of the VRA

The **VRA** is a set of original programming libraries that uses the genetic algorithm to optimize the transport network in the N-warehouse, K-recipient and M - transport modes. He solves the Vehicle Routing Problem for different configurations. As a result of the operation, the algorithm calculates the optimal routes network (the number of cars with the right parameters) necessary for the effective and temporary delivery of goods from warehouses to recipients. The VRA can be used both for current routes planning in static or dynamic mode as well as for strategic analyzes related, for example, to the placement and the number of necessary warehouses. Thanks to the development of the original way of the recording routes information in the chromosomes of the genetic algorithm, the entire network of links is analyzed as an complex unity (warehouses - recipients - cars - delivery characteristics) and not as a set of individual subsequent elements of this structure. This approach allows to get the maximum efficiency at the minimum cost. The functionality of the VRA perfectly matches the concepts of Industry 4.0 and ecological transport.

The present functionality of the VRA includes such issues:

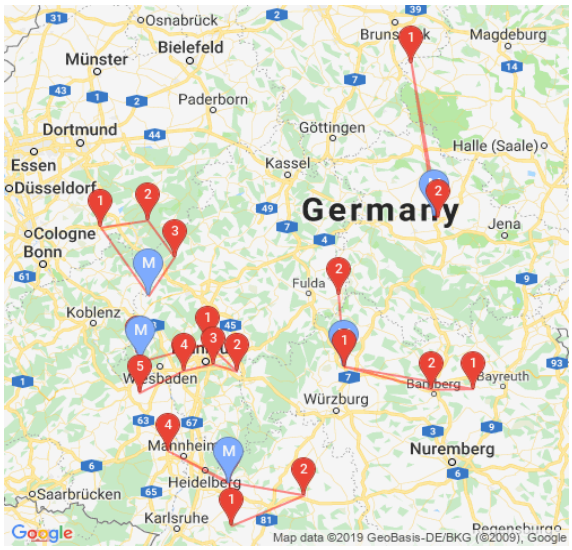
- VRPTW
- CVRPTW
- MDVRP and optimal location of depots
- DCVRP
- optimal number of cars

Other functionalities of the Algorithm can be implemented by a modification of the objective function.

An exemplary film with the operation of the VRA, for a very simple network case, can be found here https://www.psci.eu/en/ai-for-industry40/.

IV. The Vehicle Routing Algorithm applications

VRA can be used in the current activity to plan the optimal route network as well as to design - strategic - routes grid, eg for the analysis of the optimal warehouse layout. In the first case, based on the current list of deliveries / orders and available data on resources, VRA determines the optimal route network in terms of minimizing delivery costs and their time (criteria for basic functionality that can be extended). Such planning can be carried out dynamically adapting to changing conditions, for example from day to day, or statically planning routes for longer periods of use. In the second case, on the basis of information about the customer network, resources of transport means, the locations of optimal clusters of customers can be indicated. Then, based on these locations, test different configurations of the number and placement of the warehouses to determine their optimal layout.



A simple routs network - case 1.

Clustering of recipients - case 2.

The presented solution supporting the arrangement of transport network routes is **also helpful in solving and optimizing the working time of drivers on the road, especially with regard to the European Common Regulation (Regulation 561/2006 and others).**

Finally, it is worth emphasizing that **such tools as describing here will be indispensable in the rapidly approaching period of autonomous transport, autonomous trucks. Automatic, optimal route planning of such vehicles will be necessary to effectively use their high potential and rationalize costs and operation.**

Thanks to the flexible way of writing the VRA chromosome and the logical structure of the the VRA, it can be easily adapted to the implementation of various other optimization sentences, expanding its functionality and optimization criteria.

V. Who can use the VRA

The VRA algorithm can be used by companies from the TSL area, the basis of which is the network of transport connections. The wider this network is, the more complex the benefits of using VRA are.

By default, the algorithm is dedicated to a company involved in the transport of goods, however, after minor changes to the purpose function, you can also be used by companies involved in the transport of people to plan the network of connections and the location of its nodal points. VRA can be used by companies dealing with land, sea, air and inter modal transport. The universality of using the algorithm is related to its logical construction and flexibility of adapting the objective function to the given needs.

VI. Input and output data of the VRA

Input data to the VRA:

- a matrix of distance describing distances between particular points;
- a matrix of times defining travel times between network points - this matrix is consistent with the distance matrix;
- a delivery table containing the delivery characteristics to the collection point;
- a transport means table containing the characteristics of all available means of transport.

As a result of the actions, the VRA returns the set of routes / the number of cars necessary to serve the network of recipients. The table describing a single route contains information about the warehouse from which the route is served, pickup points, distances between them, times of reaching them and the car realizing the deliveries. The table is sorted according to the order of the visited points. Such tables, supplemented with geographical coordinates of delivery points, may constitute a load for the control and monitoring systems of vehicles performing deliveries.

VII. The most important features of the VRA

Main advantages of the VRA:

- a possibility of working in two modes: 1. ongoing management of the route network; 2. strategic modeling of route configurations, number of warehouses and the necessary number and type of cars to service this network;
- an overall analysis of the transport network - all routes in a given configuration of transport networks are tested simultaneously and not a route by a route. This approach allows to determine the optimal number of warehouses and cars needed to serve a given network of recipients;
- a possibility of using already existing routes configurations obtained by other methods, e.g. multiannual manual optimization by trial and error method;

- the universality of the optimization code allows it to be used to solve various optimization tasks. Specialization is achieved through the appropriate construction of the objective function. Currently, the goal function takes into account the cost of the car, the importance of the customer (or delivery price), mileage, delivery time, volume of the car which allows for the optimization of the number of cars and the length of the routes. Adding warehouse maintenance costs would optimize their network;
- the scalability of the solution - one can analyze networks of any size;
- the ability to run the VRA as a separate application at the client or in the cloud (recommended);
- an open form of the VRA, in the form of computing libraries, which allows to provide a user interface that meets the client's needs.

VIII. Tests of the VRA

The VRA in its current configuration has been tested on the supply network of one of the largest Polish pharmaceutical wholesalers. This network consists of several warehouses, over 1500 collection points and several dozen delivery vans. The obtained results were comparable with the results of the currently operating network, however, were obtained during several hours of simulation (simulation started from 'zero') against several-year manual optimization achieved by trial and error method. Thus, significant time savings were achieved in the process of determining the optimal supply network.

Other tests of the algorithm showed that depending on the optimization mode, the algorithm allows to obtain 100% delivery time or reduce the total length of routes in the network by 10% in relation to the route system generated by greedy methods. In mixed mode, the algorithm balances between the expected optimization criteria.

IX. Summary

The VRA presented shortly allows effective planning and management of optimal transport networks. Thanks to the flexible logic design and the original and innovative entry of route information, it can easily be adapted to various optimization tasks related to the current network management as well as its strategic planning.

By implementing our solution, you are able to solve current optimization problems as well as, very importantly, you will be prepared to solve problems that will occur in the future in the era of autonomous trucks.

It should be remembered that the structure of the supply network generated by the VRA is a model that should be approached as much as possible in everyday practice in order to achieve the assumed and calculated goals. Therefore, it should be treated as a reference allowing for rational and close to optimal delivery management.

Our solution has also been noticed by the bodies involved in the promotion of innovative technologies. Next to **the nomination letter for the Polish Smart Development Award**.

Created by *Marcin Zientara, Ph.D.*