Chapter XXXVII
Building Distribution Networks Using Cooperating Agents

Neil Urquhart
Napier University, Scotland

ABSTRACT

This chapter examines the use of emergent computing to optimize solutions to logistics problems. The chapter initially explores the use of agents and evolutionary algorithms to optimise postal distribution networks. The structure of the agent community and the means of interaction between agents is based on social interactions previously used to solve these problems. The techniques developed are then adapted for use in a dynamic environment planning the despatch of goods from a supermarket. These problems are based on real-world data in terms of geography and constraints. The author hopes that this chapter will inform researchers as to the suitability of emergent computing in real-world scenarios and the abilities of agent-based systems to mimic social systems.

INTRODUCTION

The design and optimisation of urban distribution networks used to facilitate the delivery of goods to households is a non-trivial problem. Such problems exist within an urban environment where routes must take into account a complex real-world road network. These problems are not solved by building single routes in isolation, but require networks consisting of routes each of which must satisfy local constraints pertaining to that route. The network should also satisfy global constraints that may conflict with local constraints. The principle tools to be used are: agents coordinated by economic and social metaphors, and evolutionary algorithms. Unlike much previous work in this area, which has utilised datasets based on Euclidean distances between arbitrary points, the problems in this chapter are based on real-world street topologies.

This chapter initially reviews existing work in the areas of scheduling and routing, with particular emphasis on the use of emergent

computing (EC). It subsequently describes the use of EC methods, notably evolutionary algorithms and agents to solve a real-world urban routing problem, specifically the distribution of post within urban areas in the City of Edinburgh.

The techniques utilised for the postal problem are then developed for use in planning the despatch of goods from supermarkets to individual houses, this being a dynamic problem with fluctuating demand. Finally, conclusions are drawn as to the effectiveness of EC-based techniques on the problems discussed.

REVIEW OF EXISTING WORK

Multi-vehicle routing is a combinatorial problem that normally involves the division of work (deliveries) between vehicles, as well as the optimisation of each vehicle's route. Traditionally such problems have used one of two representations: they either utilise a permutation-based approach or represent the problem as a network of arcs. The former representation is traditionally used to solve the travelling salesman problem (TSP); in this case the size of the search space is n!/2n. Alternatively the graph-based approach may be utilised, the graph being based on real-world street topology, with deliveries being achieved through the traversal of a set of arcs.

Techniques used to solve routing problems may be subdivided into three main categories: exhaustive algorithms, heuristics, and meta-heuristics. Exhaustive algorithms seek to evaluate the entire search space; they have the property of always producing an optimal solution, but given the size of the search spaces, the time taken can be prohibitive. Such methods may be hybridised with techniques such as linear programming (Ladányi, Ralphs, & Trotter, 2001). The approach taken used branch and cut techniques combined with linear pro-

gramming. The time cost was overcome by distributing the problem over multiple CPUs.

A number of researchers have opted to solve vehicle routing problems with the use of heuristics. Many of the simpler heuristics such as 2-opt (Croes, 1958) are applied iteratively to solve the problem in small stages. Heuristics such as the Lin-Kernighan heuristic (Lin & Kernighan, 1973) have been used with success to solve the TSP (Cook, Cunningham, Pulleyblank, & Schrijver, 1998).

Meta-heuristic techniques have been used to solve the vehicle routing problem (VRP); these include ant-colony optimisation (Gambardella & Dorigo, 2000), simulated annealing (Czech & Czarnas, 2002), and evolutionary algorithms. Considerable research into solving the travelling salesman problem using EAs has been undertaken (Freisleben & Merz, 1996); Tamaki, Kita, Shimizu, Maekawa, & Nishikawa, 1994; Homaifar, Guan, & Liepins, 1993; Whitley, Starkweather, & Shaner, 1991; Mathias & Whitley, 1992). Investigation into the use of EAs to solve the vehicle routing problem has also been undertaken, notably in Thangiah (1999), Blanton and Wainright (1993), Thangiah, Vinayaamoorthy, and Gubbi (1993), and Homaifar et al. (1993). The integration of the Lin-Kernighan heuristic and an evolutionary algorithm has been explored in Freisleben and Merz (1996), and Baraglia, Hidalgo, and Perego (2002). The problem of routing garbage collection using EAs is explored in Bousonvile (2001); the authors use an arc-routing EA to construct routes for a real-world garbage collection problem. Garbage collection is essentially an arc-routing-based problem, each street requiring collection being represented by an arc on the graph. Work on the construction of postal delivery routes has been discussed in Urquhart, Ross, Paechter, and Chisholm (2002a, 2002b) and Urquhart, Paechter, and Chisholm (2001). The earlier work concentrated on the

Related Content

On Technological Specialization in Industrial Clusters
H. Dawid (2007). *Handbook of Research on Nature-Inspired Computing for Economics and Management (pp. 367-378).*
www.irma-international.org/chapter/technological-specialization-industrial-clusters/21140

Deep Learning for Trilingual Character Recognition
M. Yashodha, SK Niranjanand V. N. Manjunath Aradhya (2019). *International Journal of Natural Computing Research (pp. 52-58).*
www.irma-international.org/article/deep-learning-for-trilingual-character-recognition/219801

Knowledge-Driven, Data-Assisted Integrative Pathway Analytics
Padmalatha S. Reddy, Stuart Murrayand Wei Liu (2011). *Handbook of Research on Computational and Systems Biology: Interdisciplinary Applications (pp. 225-247).*
www.irma-international.org/chapter/knowledge-driven-data-assisted-integrative/52318

Towards Automated Verification of P Systems Using Spin
Raluca Lefticaru, Cristina Tudoseand Florentin Ipate (2014). *Natural Computing for Simulation and Knowledge Discovery (pp. 159-170).*
www.irma-international.org/chapter/towards-automated-verification-of-p-systems-using-spin/80063

Neuromodeling and Natural Optimization of Nonlinear Devices and Circuits
Paulo H. da F. Silva, Rossana M. S. Cruzand Adaildo G. D'Assunção (2011). *System and Circuit Design for Biologically-Inspired Intelligent Learning (pp. 326-348).*
www.irma-international.org/chapter/neuromodeling-natural-optimization-nonlinear-devices/48902