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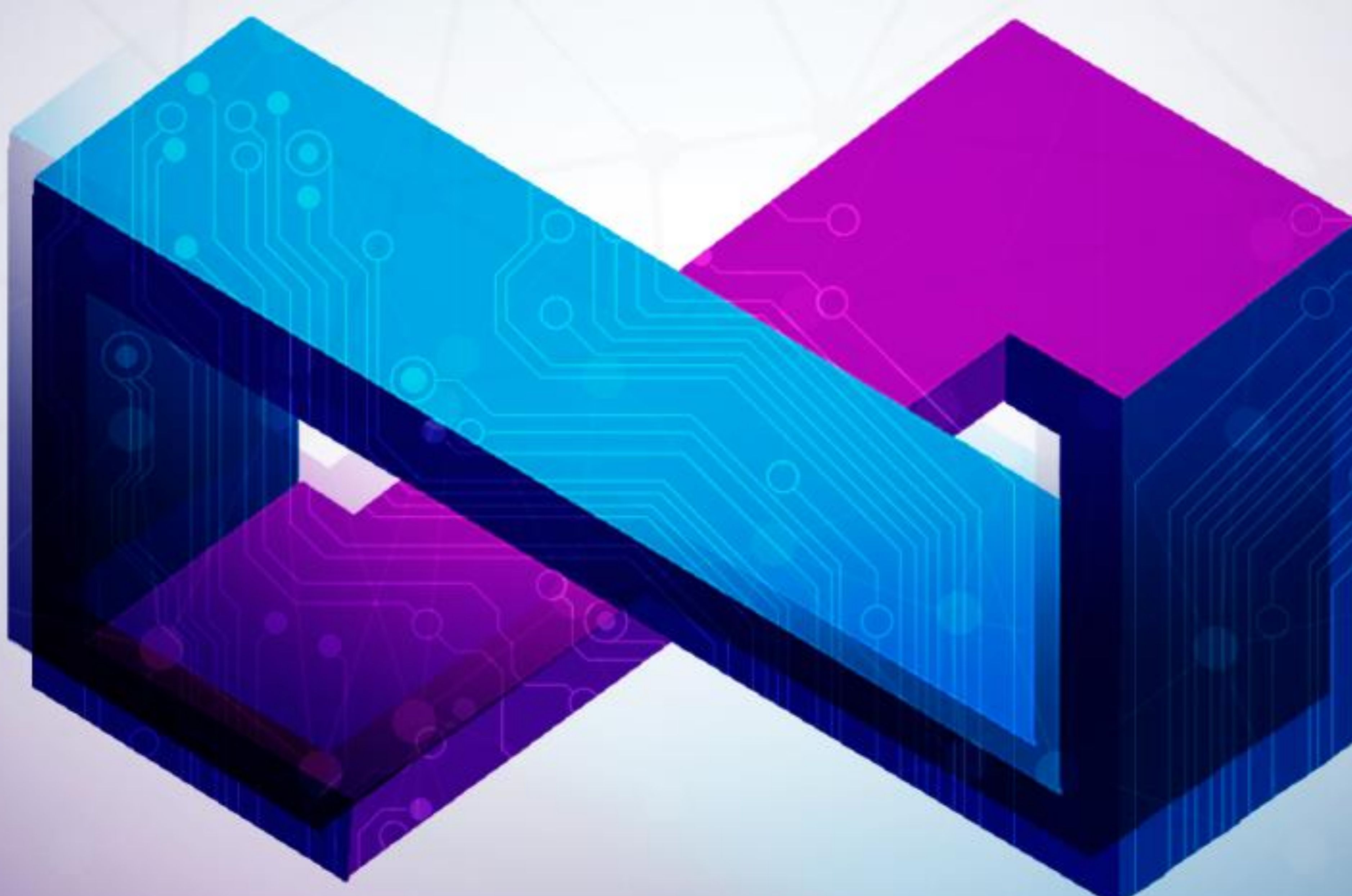

Universidad de los Andes

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Productos de alto impacto

Departamento de Ingeniería Industrial

Número 1

Universidad de los Andes

Período

2014/11/01 - 2015/06/30

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Productos Reconocidos

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1. Duque, D., Lozano, L., Medaglia, A. (2014). An exact method for the biobjective shortest path problem for large-scale road networks. European Journal of Operational Research. 242 (3): 788-797. Doi: 10.1016/j.ejor.2014.11.003

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3. Jimenez, A., Bocarejo, J. P., Zarama, R., Yerpez, J. (2015). A case study analysis to examine motorcycle crashes in Bogota, Colombia. Journal of Safety Research. 52: 29-38. Doi: 10.1016/j.jsr.2014.12.005

4. Cortez, V., Medina, P., Goles, E., Zarama, R., Rica, S. (2015). Attractors, statistics and fluctuations of the dynamics of the Schelling's model for social segregation. European Physical Journal B. 88 (1). Doi: 10.1140/epjb/e2014-50603-5

5. Lozano, L., Duque, D., Medaglia, A. (2014). An Exact Algorithm for the Elementary Shortest Path Problem with Resource Constraints. Transportation Science. Doi: 10.1287/trsc.2014.0582

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An exact method for the biobjective shortest path problem for large-scale road networks

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Discrete Optimization

An exact method for the biobjective shortest path problem for large-scale road networks

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ABSTRACT

The Biobjective Shortest Path Problem (BSP) is the problem of finding (one-to-one) paths from a start node to an end node, while simultaneously minimizing two (conflicting) objective functions. We present an exact recursive method based on implicit enumeration that aggressively prunes dominated solutions. Our approach compares favorably against a top-performer algorithm on two large testbeds from the literature and efficiently solves the BSP on large-scale networks with up to 1.2 million nodes and 2.8 million arcs. Additionally, we describe how the algorithm can be extended to handle more than two objectives and prove the concept on networks with up to 10 objectives.

1. Introduction

Consider a directed graph $\mathcal{G} = (\mathcal{N}, \mathcal{A})$ where $\mathcal{N} = \{v_1, \ldots, v_i, \ldots, v_n\}$ is the set of nodes and $\mathcal{A} = \{(i, j) | v_i \in \mathcal{N}, v_j \in \mathcal{N}\}$ is the set of arcs. For all arcs $(i, j) \in \mathcal{A}$ let there be two nonnegative weights denoted by c_{ij} and t_{ij}. Henceforth, and without loss of generality, we refer to c_{ij} and t_{ij} as the cost and time of traversing arc $(i, j) \in \mathcal{A}$, respectively. The *Biobjective Shortest Path Problem* (BSP) is the problem of finding paths $\mathcal{P}$ from the start node $v_s \in \mathcal{N}$ to the end node $v_e \in \mathcal{N}$ that minimize two different (often conflicting) objective functions. The BSP can be formally defined as follows:

$$\min \mathbf{z}(\mathbf{x}) = (c(\mathbf{x}), t(\mathbf{x})) \tag{1}$$

s.t.,

$$\mathbf{x} \in \mathcal{X} \tag{2}$$

where $\mathbf{x}$ is a path $\mathcal{P}$ represented by a vector of (binary) arc flows x_{ij}, $(i, j) \in \mathcal{A}$; $c(\mathbf{x}) \triangleq \sum_{(i,j)\in\mathcal{A}} c_{ij}x_{ij}$ is the cost of path $\mathbf{x}$; $t(\mathbf{x}) \triangleq \sum_{(i,j)\in\mathcal{A}} t_{ij}x_{ij}$ is the time of path $\mathbf{x}$; and $\mathcal{X}$ is the set of all paths from v_s to v_e. In (1) we (simultaneously) minimize the cost and time components of the vector function $\mathbf{z}(\mathbf{x})$. Since the existence of a path that simultaneously minimizes both objectives in (1) cannot be guaranteed, alternatively we seek for a set of paths with an acceptable tradeoff between the two objectives. Henceforth, we use functions $c(\cdot)$ and $t(\cdot)$ to represent the cost and time for complete solutions (i.e., a path $\mathcal{P}$ from v_s to v_e) or partial solutions (i.e., a path $\mathcal{P}$ from v_s to a certain node v_i), respectively.

This work aims to expand the body of knowledge of exact methods for the BSP. Our work shares its intuition with the *pulse algorithm* proposed by Lozano and Medaglia (2013) for the Constrained Shortest Path Problem (CSP), which has been successfully used as an algorithmic block for the multi-activity shift scheduling problem (Restrepo, Lozano, & Medaglia, 2012) and has been extended to the weight constrained shortest path problem with replenishment (Bolívar, Lozano, & Medaglia, 2014). To emphasize the fact that this work is an extension of a flexible solution framework, we purposely keep the *pulse* name in this paper.

The rest of the paper is organized as follows. Section 2 introduces relevant concepts for the BSP. Section 3 presents a literature review of the main solution strategies for the BSP. Section 4 introduces the pulse algorithm and the intuition behind it. Section 5 presents the core components of the algorithm. Section 6 compares the proposed algorithm against a top-performer algorithm by Raith (2010). Finally, Section 7 concludes the paper and outlines future work.

2. Basic concepts

This section introduces relevant concepts related to the biobjective shortest path problem. Let us recall that $\mathcal{X}$ is the set of all paths $\mathbf{x}$ from v_s to v_e. The image of any solution $\mathbf{x} \in \mathcal{X}$ on the objective space $\mathcal{Z}$ is a

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OR models with stochastic components in disaster operations management: A literature survey

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Survey

OR models with stochastic components in disaster operations management: A literature survey ☆

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ABSTRACT

The increasing number of affected people due to disasters, the complexity and unpredictability of these phenomena and the different problems encountered in the planning and response in different scenarios, establish a need to find better measures and practices in order to reduce the human and economic loss in this kind of events. However this is not an easy task considering the great uncertainty these phenomena present including the multiple number of possible scenarios in terms of location, probability of occurrence and impact, the difficulty in estimating the demand and supply, the complexity of determining the number and type of resources both available and needed and the intricacy to establish the exact location of the demand, the supply and the possible damaged infrastructure, among many others. Disaster Operations Management has become very popular and, considering the properties of disasters, the use of tools and methodologies such as OR have been given a lot of attention in recent years. The present work provides a literature review on the OR models with some stochastic component applied to Disaster Operations Management (DOM), along with an analysis of these stochastic components and the techniques used by different authors to cope with them as well as a detailed database on the consulted papers, which differentiates this research from other reviews developed during the same period, in order to give an insight on the state of the art in the topic and determine possible future research directions.

1. Introduction

The International Federation of Red Cross and Red Crescent Societies (IFRC) defines disaster as a sudden, calamitous event that seriously disrupts the functioning of a community or society and causes human, material, and economic or environmental losses that exceed the community's or society's ability to cope with using its own resources (IFRC, 2012). Since the beginning of the millennium, almost 2.7 billion people have been affected, 1.1 million killed and a damage of 1.3 trillion dollars has been reported worldwide due only to natural disasters (United Nations Office for Disaster Risk Reduction, 2012). The Indian Ocean Tsunami (2004), caused by an in-depth ocean earthquake, the Chilean earthquake (2010) and Japan's Earthquake (2011) are listed among the 10 largest earthquakes in the world since 1900 (USGS Earthquake Hazard Program, 2012). The Indian Ocean Tsunami (2004) is also considered as one of the deadliest disasters of the last century, leaving 280,000 deaths and causing the evacuation of 1.7 million people in 12 countries (BBC News, 2005). The Japan earthquake and Tsunami (2011), considered the world's costliest disaster since 1965, accounts for an estimated economic loss of 240 billion dollars, representing 4.1% of the country's GDP of that year and other disasters such as the European Heat Wave (2003) and Cyclone Nargis (2008) have also accounted for over 70,000 casualties each (IFRC, 2010).

On the other hand, technological disasters, which are the result of man-made product failures and are typically accidental, have accounted for additional thousands of affected and dead people. These can be categorized as transport system accidents (large-scale road, air and maritime accidents), collapse of constructions, large fires, and technological and toxic accidents (nuclear power plant accidents, leakage of hazardous substances) (Weisæth, Knudsen, & Tønnessen, 2002). Examples around the world include Japan's Fukushima nuclear power station failure after Japan's earthquake in 2011, which is still producing leakages of highly toxic water and whose total consequences cannot yet be known, the 2013 Savar building collapse in Bangladesh which accounted for 2500 injured people and 1129 deaths and Chernobyl nuclear disaster on April 26, 1986 which is considered the deadliest accidental structural failure in modern human history and probably the most remembered one (Weisæth & Tønnessen, 1995).

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A case study analysis to examine motorcycle crashes in Bogota, Colombia

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A case study analysis to examine motorcycle crashes in Bogota, Colombia

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ABSTRACT

Introduction: Contributory factors to motorcycle crashes vary among populations depending on several aspects such as the users' profiles, the composition and density of traffic, and the infrastructure features. A better understanding of local motorcycle crashes can be reached in those places where a comprehensive analysis is performed. This paper presents the results obtained from a case study analysis of 400 police records of accidents involving motorcycles in Bogota. *Method:* To achieve a deeper level of understanding of how these accidents occur, we propose a systemic approach that uses available crash data. The methodology is inspired by accident prototypical scenarios, a tool for analysis developed in France. *Results:* When grouping cases we identified three categories: solo motorcycle accidents, motorcyclist and pedestrian accidents, and accidents involving a motorcycle and another vehicle. Within these categories we undertook in-depth analyses of 32 groups of accidents obtaining valuable information to better comprehend motorcyclists' road crashes in a local context. Recurrent contributory factors in the groups of accidents include: inexperienced motorcyclists, wide urban roads that incite speeding and risky overtaking maneuvers, flowing urban roads that encourage high speed and increased interaction between vehicles, and lack of infrastructure maintenance. *Practical Applications:* The results obtained are a valuable asset to define measures that will be conveniently adapted to the group of accident on which we want to act. The methodology exposed in this paper is applicable to the study of road crashes that involve all types of actors, not only the motorcyclists, and in contexts different than those presented in Bogota.

1. Introduction

1.1. Motorcycles: use and accident rate

In Colombia, the representation of motorcycles in the total number of vehicles increased from 29.1% in 2003 to 49.6% in 2012 (RUNT, 2013). Some of the reasons that led to its growth are accessible prices, financing options, simple registration processes, work tools, the possibility of maneuvering in traffic jams, an alternative option to public transport in areas where coverage and frequency are deficient, and an alternative option in cities with circulation restrictions for private cars.

In 2010, motorcyclists represented 39% of the deaths from road crashes in Colombia, and in 2012 this percentage rose to 42% (INMLCF, 2013). On average, six motorcyclists died every day in Colombia. In 2011, fatalities collided mainly with a fixed object or the pavement (33.7%), car freight (18.2%), or a private vehicle (17.5%). The majority of motorcyclist fatalities (55%) occurred in urban areas (Universidad de los Andes y Corporación Fondo de Prevención Vial – CFPV, 2012).

The institutions that set road safety standards at rural and urban levels are municipal and urban offices, as well as the Ministry of Transportation. In Colombia, the National Transit Code (Ley 769 de, 2002), contains the regulations that motorcyclists must follow; and there are no specific differences regarding the cylinder capacity. There are two types of license: type A1 for driving motorcycles with a cylinder capacity of up to 125 c.c. or B1 for driving motorcycles, motorized bicycles and motorized tricycles with a cylinder capacity of more than 125 c.c. The average cylinder capacity in Colombia is comparatively minor than the capacity of the motorcycles circulating Spain or France. This aspect means that the types of hits that the motorcyclist receives, in case of accident or control loss, differ according to the context where they are studied.

According to official data of the motorcycles registered in Bogota, the number of motorcycles has a general growth trend; between 2002 and 2011 the number of motorcycles was multiplied by 20. Motorcycles currently represent 21% of the total number of motor vehicles in the capital city, while in 2003 motorcycles did not reach 3% of the total. There are 27 people per motorcycle in Bogota. Motorcycles in Bogota are relatively recent: 9.3% are before 2002, 20.8% are models from 2003 to 2007, and 69.8% are models from 2008 to 2013. In Bogota, 95.30% of the motorcycles have less than or equal to 250 c.c. cylinder capacity (*Alcaldía Mayor de Bogotá*, 2012). This is defined by its use as an everyday means of transportation and

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Attractors, statistics and fluctuations of the dynamics of the Schelling's model for social segregation

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Attractors, statistics and fluctuations of the dynamics of the Schelling's model for social segregation

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Abstract. Statistical properties, fluctuations and probabilistic arguments are shown to explain the robust dynamics of the Schelling's social segregation model. With the aid of probability density functions we characterize the attractors for multiple external parameters and conditions. We discuss the role of the initial states and we show that, indeed, the system evolves towards well defined attractors. Finally, we provide probabilistic arguments to explain quantitatively the observed behavior.

1 Introduction

In the early seventies Schelling considered the problem of social segregation as a consequence of a natural evolution of elementary local rules [1–3]. Perhaps the most striking feature of the model is that, despite the simplicity and the locality of the rules, there exists an emergence of a large scale pattern of segregation. A simplified version of Schelling's original model possesses two distinct kinds of individuals and it describes the willingness of an individual to stay or to move from his/her place of residence. The basic rules are: if an individual is surrounded by a majority of individuals of the opposite kind, then we say, that the individual is "unhappy" in his/her residence, hence he/she is willing to change with an individual of the opposite kind which must be also "unhappy".

Schelling's model and its variations have been studied extensively since the 70s in the context of many disciplines. More recently, a renewed interest in the Schelling segregation problem has arisen in the field of statistical physics and complexity, mainly, because of the similarities of social segregation with phase separation [4], the Ising model [5–8], and physics of interfaces [9]. In the same spirit, Grauwin et al. [10], used thermodynamical arguments to explain segregation transitions. From a more economic point of view, Pancs and Vriend [11], consider a *utility* function implying that despite the preference for a *perfect* integration of the individuals, segregation is the robust behavior of the system.

Two of us have, recently, re-examined the Schelling segregation model in the specific case of a square periodic regular lattice, with no empty sites [8]. The lattice sites may have a $+1$ if an individual, say $+$, lives in the site, or a -1, if the site is occupied by an individual of the opposite kind, -1. In reference [8] we have generalized the majority rule, originally considered by Schelling, by a threshold criteria: we say that an individual is unstable or unhappy if it is surrounded by θ or more individuals of the opposite state in its neighborhood. Though, the happiness criteria is completely deterministic, the swap among individuals of opposite state is a random process. That is, at a given time, we choose randomly two unhappy individuals of opposite states and we exchange them.

In reference [8], we have introduced a global quantity, namely an energy (see Eq. (2)), which, we think, quantitatively describes the segregation. We showed that this energy decreases strictly if $\theta > |V|/2$, where $|V|$ is the number of individual in the neighborhood. For instance, in the case of Moore's neighborhood, used in reference [8] and in the present paper, each individual has eight neighbors, i.e. $|V| = 8$. Moreover, for $\theta > |V|/2$, and because of the finiteness of the system, one has that the dynamic evolution of Schelling's algorithm stops in finite time.

Accordingly, we identified a phase diagram in terms of θ, and the further behavior of the energy in time. In particular we noticed that for a large θ, the energy of the final state is quite large, indicating only a slight segregation. On the other hand, as one gets closer to $\theta = 5$, the energy of the final state becomes smaller. Although, the statement indicates that the energy strictly decreases only if $\theta > 4$, we have observed as a general rule, for the cases $\theta = 4$ and $\theta = 3$, that the energy tends to decrease as time passes. Moreover, the lowest energy is not really observed for $\theta = 5$, but for $\theta = 4$. For $\theta = 3$ the energy is significantly smaller than the energy for the case $\theta = 5$, but slightly higher than the case of $\theta = 4$ and it fluctuates in time forever. For $\theta = 2$ the energy is significantly greater than the one of the cases $\theta = 4$ and $\theta = 3$.

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An exact algorithm for the elementary shortest path problem with resource constraints

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An Exact Algorithm for the Elementary Shortest Path Problem with Resource Constraints

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The elementary shortest path problem with resource constraints (ESPPRC) is an NP-hard problem that often arises in the context of column generation for vehicle routing problems. We propose an exact solution method that relies on implicit enumeration with a novel bounding scheme that dramatically narrows the search space. We embedded our algorithm within a column generation to solve the linear relaxation (root node) of the vehicle routing problem with time windows (VRPTW) and found that the proposed algorithm performs well when compared against state-of-the-art algorithms for the ESPPRC on the well-known Solomon's test bed for the VRPTW.

Keywords: vehicle routing; shortest path problem; column generation; vehicle routing problem with time windows
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1. Introduction

The elementary shortest path problem with resource constraints (ESPPRC) (Feillet et al. 2004, Irnich and Desaulniers 2005) arises as the backbone of branch-and-price procedures for several variants of the vehicle routing problem (VRP). One of the most widely known VRP variants closely tied to the ESPPRC is the vehicle routing problem with time windows (VRPTW) (Toth and Vigo 2002). The VRPTW consists of finding a set of routes of minimal total cost such that each customer in $\mathcal{N} = \{v_1, \ldots, v_i, \ldots, v_n\}$ is served (exactly once) within its time window $[a_i, b_i]$. The vehicles in the VRPTW begin and end their routes at the depot and are part of an unlimited homogeneous capacitated fleet. Under a column generation framework, it is common practice to use a set covering formulation, where Ω is the set of all feasible routes for the VRPTW and α_{ik} is a binary indicator that takes the value of 1 if route $k \in \Omega$ visits customer $v_i \in \mathcal{N}$ and takes the value of 0 otherwise. Let c_k denote the cost of route $k \in \Omega$ and let x_k be a binary variable that takes the value of 1 if route $k \in \Omega$ is used and 0 otherwise. The VRPTW can be formulated as follows:

$$\text{minimize} \quad \sum_{k\in\Omega} c_k x_k \tag{1}$$

$$\text{subject to} \quad \sum_{k\in\Omega} \alpha_{ik} x_k \geq 1 \quad \forall v_i \in \mathcal{N}, \tag{2}$$

$$x_k \in \{0, 1\} \quad \forall k \in \Omega. \tag{3}$$

The objective function (1) minimizes the total cost, the set covering constraints (2) ensure that each customer is visited by a route, and constraints (3) ensure that the decision variables are binary. Under a column generation scheme (Desrosiers and Lübbecke 2005), a restricted master problem solves the linear relaxation of the model considering a small subset of its variables. The ESPPRC arises as the subproblem of finding feasible routes (columns) with negative reduced cost that are iteratively added to the restricted master problem.

For the ESPPRC subproblem, consider a directed graph $\mathcal{G} = (\mathcal{N} \cup \{v_s, v_e\}, \mathcal{A})$, where v_s and v_e represent the depot and $\mathcal{A} = \{(v_i, v_j) \mid v_i \in \mathcal{N} \cup \{v_s\}, v_j \in \mathcal{N} \cup \{v_e\}, v_i \neq v_j\}$ denotes the set of arcs. Each node $v_i \in \mathcal{N}$ represents a customer with demand q_i, service time s_i, and a dual multiplier λ_i, associated with the corresponding set covering constraint (2) in the master problem. Each arc $(v_i, v_j) \in \mathcal{A}$ has a distance d_{ij}, a time t_{ij} that includes the service time s_i of node v_i, and a reduced cost contribution $r_{ij} = d_{ij} - \lambda_i$. We assume that the arc time and distance satisfy the triangle inequality, thus the set of arcs can be reduced using the time windows (Desrochers, Desrosiers, and Solomon 1992). Note that a path from start node $v_s \in \mathcal{N}$ to end node $v_e \in \mathcal{N}$ corresponds to a column (variable) in the restricted master problem, representing route $k \in \Omega$ with reduced cost $r_k = \sum_{(v_i, v_j)\in k} r_{ij}$. The ESPPRC consists of finding an elementary path $\mathcal{P}$ (i.e., ordered sequence of nonrepeating nodes) from start

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Exploring Transitions Towards Sustainable Construction: The Case of Near-Zero Energy Buildings in the Netherlands

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Abstract

This paper examines the use of qualitative information in the construction of an agent- based model in order to study the growth of near-Zero Energy Buildings (nZEB's) in the Netherlands through the innovation systems perspective. Drawing on desktop research and semi-structured interviews, this paper offers two major findings. First, we observed that the difficulties to the development of nZEB's have been shaped by interaction and institutional barriers: the inner complexity of the building sector has decisively impacted on the growth of nZEB's. Second, exploring interviewees' understanding of the system via an agent-based model has brought fresh insights about the problem. Overall, this is a call for an interdisciplinary approach to understand the changes required for nZEB's in their path for a successful adoption. Agent-based computational modelling, complemented with knowledge that was elicited from several stakeholders within the building sector, has helped to inspect the implication of common beliefs in the course of shaping possible futures toward a transition to nZEB's.

Keywords:
Agent-Based Model, Near-Zero Energy Buildings, Innovation Systems, Knowledge Elicitation, Systemigrams

Introduction

1.1 The EU (European Union) has developed the "Europe 2020" growth strategy, in which "climate change and energy sustainability" plays a crucial role as one of the five main targets (European Commission 2013). The EU has stated in "Europe 2020" the following ambitious goals: i) GHG (Greenhouse gas) emissions 20% lower in 2020 than in 1990; ii) 20% of energy from renewable resources; and iii) 20% increase in energy efficiency. From these objectives, both the first and the second ones have become a policy measure in the Netherlands (Verhagen 2012). The building sector accounts for 20% of the total energy consumption in the Netherlands (Menkveld & Beurskens 2009). Considering near-Zero Energy Buildings (nZEB's) as those with extremely low energy needs that largely depend on renewable resources, Directive 2010/31/EU Article 9 requests "Member States shall ensure that by 31 December 2020 all new buildings are nearly zero-energy buildings; and after 31 December 2018, new buildings occupied and owned by public authorities are nearly zero-energy buildings" (European Parliament 2010). Although the importance of energy-neutral housing is recognized by the Dutch government, in practice the construction of nZEB's has not become a reality (Faber & Hope 2013).

1.2 The transition from building traditional housing towards building nZEB's, however, is a difficult and complex process that goes beyond technological challenges. Furthermore, little is known about how this issue can be approached. Therefore, the challenges of nZEB development are numerous, including understanding the interests of the several actors that are part of the system. Not all actors involved in this transition discern problems in the same way (Newell 1990; Joma 2006; Rosales-Carreón 2012). Consequently, the perception of barriers that impede the transition towards more energy efficient buildings may differ significantly from one actor to another.

1.3 One of the challenges lies in understanding the knowledge that actors possess and share, which has important implications on either facilitating or hindering the transition towards the construction of nZEB's. This paper examines, first, the way different actors perceive barriers that hamper the transition towards construction of nZEB's in the Netherlands. Second, it provides insights on how this knowledge is disseminated within the system. Given the pluralistic nature of the problem, we have approached the study from an interdisciplinary perspective. Interdisciplinary research integrates perspectives from two or more bodies of specialised knowledge to solve problems whose solutions are beyond the scope of a single discipline (Schoot-Uiterkamp & Vlek 2007). Therefore, this paper aims at integrating several perspectives (knowledge management, systems innovation, energy efficiency, and agent-based modelling (ABM)). From information gathered from different actors in the construction sector, we built a simple computational model that served as a vehicle to explore different scenarios for nZEB diffusion. The next section explains the proposed approach, which ultimately aimed at formulating a model that represents how relevant actors involved in nZEB construction interact.

Approach

2.1 This paper considers a systematic way of incorporating knowledge from several actors into an agent-based (AB) model that helps to explore possible scenarios for the diffusion of nZEB's in the Netherlands. The purpose of the model is not to faithfully capture all aspects and details of the Dutch building system. Rather, the purpose of it is to enrich our understanding of the key knowledge-related processes that are present within the system. We propose to structure the development of an agent-based (AB) model around six steps. First, the system and its boundaries must be clearly defined. Second, knowledge regarding how different actors represent the building system has to be elicited. The third step consists in identifying the barriers that impede the progress towards the edification of nZEB's. Fourth, after discussing the qualitative findings among experts (e.g., researchers), the model is formulated. The model is then shared and discussed with some stakeholders. The fifth step consists in carrying out different simulations once the model has been (internally) validated. Finally, the results are discussed in order to disclose important implications for the deployment of the innovation system. Figure 1 depicts the steps needed to build an AB model based on elicited knowledge.

Influencia de la variabilidad climática en las enfermedades respiratorias agudas en Bogotá

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