Publicaciones de alto impacto

Departamento de Ingeniería Industrial

Número 5

Universidad de los Andes

Publicaciones

Departamento de Ingeniería Industrial

Número 5

Universidad de los Andes

Fondo de Reconocimiento de Excelencia en Productos (FREP)

El Fondo de Reconocimiento de Excelencia en Productos (FREP) reconoce los productos de la más alta calidad según lo establecido por Colciencias:

• Artículos de investigación en revistas catalogadas en los cuartiles Q1 y Q2 de los sistemas de indexación ISI-JCR y Scopus (Journal Metrics);

• Libros de investigación que cumplan con la definición de productos de alta calidad de Colciencias y que hayan sido citados en alguna ocasión en revistas indexadas en ISI-JCR o Scopus;

• Patentes de invención o modelos de utilidad para los cuales se cuente con título y número de registro, ya sea que estos hayan sido tramitados a través del tratado de cooperación de patentes (PCT) o haciendo uso de las vías tradicionales;

• Regulaciones, normas o reglamentos que hayan logrado implementación a nivel internacional y que cuenten con certificado de la entidad que emitió el producto, especificando la participación del grupo de investigadores;

• Software con certificación de la entidad productora en el que se haga claridad sobre el nivel de innovación y que cuente con número de registro ante la Dirección Nacional de Derechos de Autor.

Productos Reconocidos

Ordenado por fecha de aparición en línea:

1.   Acero, A; Ramírez, M.; Peralta, M.; Payán, L.; Espinosa, E. (2018). "Participatory design and technologies for sustainable development: an approach from action research". SYSTEMIC PRACTICE AND ACTION RESEARCH. Vol 32, No. 2, Pág 167–191. DOI: https://doi.org/10.1007/s11213-018-9459-6

2.   Abolghasem, S.; Basu, S.; Shekhar, S.; Shankar, M. (2018). "Mapping dislocation densities resulting from severe plastic deformation using large strain machining". Journal of Materials Research. Vol 33, No. 22, Pág 3762-3773. DOI: 10.1557/jmr.2018.264

3.   Torres, F.; García-Díaz, C. (2018). "Evolutionary dynamics of two-actor VMI-driven supply chains". Computational and Mathematical Organization Theory. Vol 24, No. 3, Pág 351–377. DOI: https://doi.org/10.1007/s10588-017-9259-z

4.   Pinzón, L.; Ramírez, S; Torres, M. (2018). "Examining moral frameworks in negotiation practice: a critical systems perspective".Systems Research and Behavioral Science.Vol 36,No. 4,Pág 395-403.DOI:https://doi.org/10.1002/sres.2554

5.   Torres, M.; Pinzón, L.; Gerald M. (2018). "Developing a systemic program evaluation methodology: a critical systems perspective". Systems Research and Behavioral Science. Vol 35, No. 5, Pág 538-547. DOI: https://doi-org.ezproxy.uniandes.edu.co:8443/10.1002/sres.2561

6.   Gómez, C.; Baker J. (2018). "An optimization-based decision support framework for coupled pre- and post-earthquake infrastructure risk management". Structural Safety. Vol 77, Pág 1-9. DOI: https://doi.org/10.1016/j.strusafe.2018.10.002

7.   Huertas J., Donoso Y. (2018). "Multi-Objective Tabu Search to balance multihoming loads in heterogeneous wireless networks". International Journal of Computers Communications & Control. Vol 13, No. 6, Pág 956-971. DOI: https://doi.org/10.15837/ijccc.2018.6.3360

8.   Velasco, P.; Camacho, G.; Cuellar, D.; Álvarez, D. (2018). "Solving the two-dimensional knapsack problem considering cutting-time and emission of particulate matter in the metalworking industry". IEEE Latin America Transactions. Vol 16 , No. 12, Pág 2888 - 2895. DOI: 10.1109/TLA.2018.8804253

9.   Medina, P.; Ariza, N.; Navas, P.; Rojas, F.; Parody, G.;Valvidia, J.; Zarama, R.; Penagos, J. (2018). "An unintended effect of financing the university education of the most brilliant and poorest colombian students: the case of the intervention of the Ser Pilo Paga Program". Complexity. Artículo ID 3528206, 9 pág. DOI: https://doi.org/10.1155/2018/3528206

10. Flórez, M.; Ramírez, M.; Payán, L.; Peralta, M.; Acero, A. (2018). "A systemic methodology for the reduction of water consumption in rural areas". Kybernetes. Vol 48 No. 1, Pág 163-182. DOI: https://doi.org/10.1108/K-10-2017-0406

11. Ramírez, M.; Navas, L.; Delgado, A. et al. (2019). "Promoting entrepreneurship through a community learning model- case study: Green Business". Systemic Practice and Action Research. Pág 1-15. DOI: https://doi.org/10.1007/s11213-019-9477-z

12. Abolghasem, S.; Mehdi, T.; Amézquita, S. (2019). "Cross-efficiency evaluation in the presence of flexible measures with an application to healthcare systems". Health Care Management Science. Pág 1–22. DOI: https://doi.org/10.1007/s10729-019-09478-0

13. Forero M.; Herrera, S.; Ávila, J.; Franco, C.; Rasmussen, J.; Nielsen, J. (2019). "Color classification methods for perennial weed detection in cereal crops". Lecture Notes in Computer Science. Vol 11401. DOI: https://doi.org/10.1007/978-3-030-13469-3_14

14. Franco, C.; Rodríguez, J.; Montero, J.; Gómez, D.; Yager, R. (2019). "Ambiguity measures for preference-based decision viewpoints". Lecture Notes in Computer Science. 7th International Symposium on Integrated Uncertainty in Knowledge Modelling and Decision Making (Vol 11471 LNAI, Pág 38-49). DOI: https://doi.org/10.1007/978-3-030-14815-7_4

Ordenado por fecha de aparición en línea:

15. Olaya, C. (2019). "The Experimenting University". Kybernetes. DOI: https://doi.org/10.1108/K-05-2018-0276

16. Amorocho-Daza, H.; Cabrales, S.; Santos, R.; Saldarriaga, J. (2019). "A new multi-criteria decision analysis methodology for the selection of new water supply infrastructure". Water. Vol 11, No. 4, Pág 805 - 828. DOI: https://doi.org/10.3390/w11040805

17. Soriano, E; Valencia, C., Rodríguez, J. (2019). "Study of the spatiotemporal correlation between sediment-related blockage events in the sewer system in Bogotá (Colombia)". Water Science and Technology. Vol 79, No. 9, Pág 1727-1738. DOI: https://doi.org/10.2166/wst.2019.172

18. Huertas, J.; Duque, D.; Segura-Durán, E.; Akhavan-Tabatabaei, R.; Medaglia, A. (2019). "Evacuation dynamics: a modeling and visualization framework". Operations Research (SPECTRUM). Pág 1-31. DOI: https://doi.org/10.1007/s00291-019-00548-x

19. Gómez, C.; González A.; Baroud, H.; Bedoya-Motta, C. (2019). "Integrating operational and organizational aspects in interdependent infrastructure network recovery". Risk Analysis. Pág 1-17. DOI: https://doi.org/10.1111/risa.13340

Participatory design and technologies for sustainable development: an approach from action research

Andrés Acero;
Catalina Ramírez;
Mauricio Peralta;
Luisa Payán;
Edier Espinosa

Systemic Practice and Action Research

CrossMark

ORIGINAL PAPER

Participatory Design and Technologies for Sustainable Development: an Approach from Action Research

Andrés Esteban Acero López[1] ·
María Catalina Ramirez Cajiao[1] ·
Mauricio Peralta Mejia[2,3] ·
Luisa Fernanda Payán Durán[4] ·
Edier Ernesto Espinosa Díaz[5]

Abstract This paper explores the relevance of the action research for design of technological solutions that lead to both systemic sustainable development and active involvement of the community. The paper shows how this idea was implemented in a project for water resource conservation with educational institutions of rural areas in Colombia. Through the use of technology, a reduction in water consumption increases in awareness about the use of this natural resource, and the active involvement of the community were sought. Additionally, social processes related to the conservation of natural resources were addressed through a socio-technical approach for analysis and design. During the application of the Soft Systems Methodology (SSM), the participants and researchers created technological prototypes that allowed to: 1) give visibility to the community's initiatives, and 2) save water in the households. This paper focuses on the importance of the design process of innovative solutions for social and environmental issues through the participative approach of action research.

Keywords Drinking water conservation · Participatory action research · Technology design · Participation

✉ Andrés Esteban Acero López
  Ae.acero539@uniandes.edu.co

[1] School of Engineering, Universidad de los Andes, Bogotá, Colombia

[2] Business Administration, Swiss Management Center, Zug, Switzerland

[3] Parque Científico de Innovación Social, Corporación Universitaria Minuto de Dios, Bogotá, Colombia

[4] Interdisciplinary Development Studies, CIDER, Universidad de los Andes, Bogotá, Colombia

[5] School of Economics, Universidad de los Andes, Bogotá, Colombia

 Springer

Mapping dislocation densities resulting from severe plastic deformation using large strain machining

Sepideh Abolghasem;
Saurabh Basu;
Shashank Shekhar;
M. Ravi Shankar

Mapping dislocation densities resulting from severe plastic deformation using large strain machining

Sepideh Abolghasem[a)]
Department of Industrial Engineering, Universidad de los Andes, Bogotá, Colombia

Saurabh Basu
Department of Industrial and Manufacturing Engineering, Pennsylvania State University, University Park, Pennsylvania 16802, USA

Shashank Shekhar
Materials Science and Engineering, Indian Institute of Technology Kanpur, Kanpur, Uttar Pradesh 208016, India

M. Ravi Shankar
Department of Industrial Engineering, University of Pittsburgh, Pittsburgh, Pennsylvania 15261, USA

The multiplication of dislocations determines the trajectories of microstructure evolution during plastic deformation. It has been recognized that the dislocation storage and the deformation-driven subgrain formation are correlated—the principle of similitude, where the dislocation density (ρ_i) scales self-similarly with the subgrain size (δ): $\delta\sqrt{\rho_i} \sim$ constant. Here, the robustness of this concept in Cu is probed utilizing large strain machining across a swathe of severe shear deformation conditions—strains in the range 1–10 and strain-rates 10–10^3/s. Deformation strain, strain-rate, and temperature characterizations are juxtaposed with electron microscopy, and dislocation densities are measured by quantification of broadening of X-ray diffraction peaks of crystallographic planes. We parameterize the variation of dislocation density as a function of strain and a rate parameter R, a function of strain-rate, temperature, and material constants. We confirm the preservation of similitude between dislocation density and the subgrain structure across orders-of-magnitude of thermomechanical conditions.

I. INTRODUCTION

Microstructure evolution trajectories of metallic crystalline materials undergoing plastic deformation are governed by generation, movement, and storage of dislocations.[1] The microstructure fields resulting from the aforementioned interplay of dislocations are critical determinants of the mechanical and functional response of the resulting products[2–5] This response is mediated through defect characteristics such as grain and subgrain boundaries that are in turn composed of dislocation distributions. Therefore, high fidelity process-oriented microstructure tailoring frameworks must encapsulate the holistic evolution of how dislocations and their assemblies evolve as a function of the thermomechanical deformation parameters.

How dislocation densities are accumulated during plastic deformation are relatively well understood at low strain-rates ($<10^2$/s) and modest strain range ($\ll 1$). Standard practices have been developed for probing their constitutive behavior in these subsections of dynamic deformation conditions. These include Hopkinson plastic deformation technique for high range of strain-rate ($>10^3$/s) and low strains (<1), hot torsion experimentation or rolling at relatively modest strain-rate ($<10^2$/s) and high strain (>4).[6–9] Unfortunately, the dynamic microstructure transformations particularly at high strain ($\gg 1$) and high strain-rates ($>10^2$/s) are less than well understood. Prior investigations by the authors of the present work have examined the evolution of microstructural parameters including grain size,[10] subgrain size,[11] crystallographic texture,[12] grain boundary characteristics such as fraction of low angle grain boundaries,[10] and the progression of dynamic recrystallization.[13] The aforementioned efforts include capturing and quantifying the evolution of microstructure transformation (specifically grain[10] and subgrain[11] sizes) in the high strain and high strain-rate regime. However, these studies have ignored the role dislocation densities, which (i) are central to the microstructural evolution under the severe deformation conditions and (ii) play a deterministic role in determining the constitutive response of the resulting materials. An explicit delineation of the evolution of dislocation densities resulting from large strain/strain-rate, thermomechanically coupled deformation remains a challenge.[14,15]

Evolutionary dynamics of two-actor VMI-driven supply chains

Fidel Torres;
César García-Díaz

07

Computational and Mathematical Organization Theory

CrossMark

Evolutionary dynamics of two-actor VMI-driven supply chains

Fidel Torres[1] · César García-Díaz[1]

Abstract The strategy of integration known as vendor-managed inventory (VMI), which allows the coordination of inventory policies between producers and buyers in supply chains, has long been considered a strategy for inventory cost reduction. Although the literature acknowledges the importance of understanding the dynamics of VMI implementation through evolutionary games, research in this topic still remains scarce. This paper studies the dynamics of strategic interaction of a producer–buyer supply chain under a newly developed VMI scheme, which makes use of a synchronization mechanism between the buyer and the producer replenishment cycles. By using this alternative VMI representation, we obtain the mathematical conditions that determine the degree of stability of evolutionarily stable strategies. As other evolutionary game theoretical approaches, we also find a lower bound for penalty costs that ensures a VMI contract, but most importantly, we also find how a VMI implementation might depend on the difference between production and demand rates, regardless of any penalty costs.

✉ César García-Díaz
ce.garcia392@uniandes.edu.co

Fidel Torres
ftorres@uniandes.edu.co

[1] Department of Industrial Engineering, Universidad de los Andes, Carrera 1 Este No. 19A–40, (ML-710), Bogotá, Colombia

 Springer

Examining moral frameworks in negotiation practice: a critical systems perspective

Luis Pinzón;
Silvia Ramírez;
María Alejandra Torres

09

Systems Research and Behavioral Science

■ *Research Paper*

Examining Moral Frameworks in Negotiation Practice: A Critical Systems Perspective

Luis Arturo Pinzon-Salcedo* ⓘ, Silvia Elena Ramírez-Tovar and Maria Alejandra Torres-Cuello

Engineering School, Universidad de los Andes, Bogota, Colombia

Negotiations are part of systemic interventions. Because moral frameworks affect goal setting and decision-making processes in negotiation, they can have an important effect in systemic interventions. In this paper, we use critical systems thinking to improve our understanding of the structure of moral frameworks and judgments in negotiation. We explore several moral frameworks that are applied in negotiation, and we demonstrate how boundary critique can be employed to understand and deal more reflexively and holistically with moral judgments that are part of negotiations in systemic interventions. By adopting a critical perspective of our assumptions and rationality in negotiation practice, we attempt to show how to open negotiations that are part of systemic interventions to more reflexive and informed possibilities. This can help us to avoid implementing changes in a systemic intervention that promote moral perspectives, which are not based on a holistic and reflexive exploration of the stakeholders' moral frameworks. © 2018 John Wiley & Sons, Ltd.

Keywords critical systems thinking; negotiation; moral frameworks; ethics; reflexivity

INTRODUCTION

We face negotiation throughout our professional lives and while carrying out systemic interventions. Some negotiations are formal, but many more are informal, less obvious negotiations. Systemic methodologies, methods and techniques that attempt to reveal, actively shape and transform the social world rely on negotiations specifically used to achieve definite goals. Negotiation is frequently a part of systemic problem structuring methods (e.g. soft systems methodology, interactive planning, viable system diagnosis and critical systems heuristics) as well as of other systemic methodologies (e.g. systems dynamics and team syntegrity). Problem structuring methods use models to structure stakeholder engagement (Midgley et al., 2013): 'the model plays a key role

*Correspondence to: Luis Arturo Pinzon-Salcedo, Engineering School, Universidad de los Andes, Cra 1a Este No. 19A-40, Bogota, Colombia. E-mail: lpinzon@uniandes.edu.co

Developing a systemic program evaluation methodology:
a critical systems perspective

María Alejandra Torres;
Luis Pinzón;
Gerald Midgley

11

■ *Research Paper*

Developing a Systemic Program Evaluation Methodology: A Critical Systems Perspective

Maria Alejandra Torres-Cuello[1]*, Luis Pinzon-Salcedo[1] and Gerald Midgley[2]

[1] *Universidad de los Andes, Bogota, Colombia*
[2] *University of Hull, Centre for Systems Studies, Hull, UK*

In recent years, there has been an increased interest within the program evaluation field for introducing systems thinking concepts. However, most of these attempts have been primarily directed towards supporting the practice of evaluation and not towards making theoretical advancements. This article is focused on introducing systems thinking, and specifically perspectives and concepts from the work in critical systems thinking (CST), at a theoretical level in the program evaluation field, towards a reframing of the Fourth Generation Evaluation methodology. The process for carrying out such reframing is introduced, as well as describing the major changes produced in the evaluation methodology by incorporating the CST perspective. A new model is proposed, and how this model may be beneficial for conducting an evaluation is discussed with recommendations made for future developments. © 2018 John Wiley & Sons, Ltd.

Keywords systems thinking; program evaluation; boundary critique; Fourth Generation Evaluation (FGE)

INTRODUCTION

In the American Evaluation Association Conference held in 2017, Michael Quinn Patton along with other panellists addressed the need for leaders and evaluators for developing critical evaluation thinking in order to achieve the

United Nations Sustainable Development Goals. This need was not only recognized to be applicable to the Sustainable Development Goals but to the practice of evaluation in other fields as well. By these means, they recognized the need of 'thinking outside the box', joining leadership with evaluation, and the demand for capacity building in trading for evaluation building across the globe by posing the following question: How do you use evaluation to improve the life of

*Correspondence to: Maria Alejandra Torres-Cuello, Universidad de los Andes, Bogota 11001000, Colombia.
E-mail: aletorrescuello@hotmail.com

An optimization-based decision support framework for coupled pre- and post-earthquake infrastructure risk management

Camilo Gómez;
Jack W. Baker

13

Structural Safety

An optimization-based decision support framework for coupled pre- and post-earthquake infrastructure risk management

Camilo Gomez[a,*], Jack W. Baker[b]

[a] Centro para la Optimización y Probabilidad Aplicada (COPA), Departamento de Ingeniería Industrial, Universidad de los Andes, Bogotá, Colombia
[b] Department of Civil and Environmental Engineering, Stanford University, Room 283, Y2E2, 473 Via Ortega, Stanford, CA 94305, USA

ARTICLE INFO

ABSTRACT

In the context of infrastructure resilience and risk management, key decisions occur in the aftermath of adverse events (e.g., immediate response and later repair of damage), but preemptive decisions must be made under uncertainty about the specific disaster realization to face in the future (e.g., strengthening components, or allocating resources for post-event activities). This paper proposes an optimization framework to address problems in which preemptive decisions are coupled with those eventually required to respond to an uncertain adverse event. Specifically, strategic decisions are pursued regarding whether to proactively retrofit or reactively repair bridges in a transportation network under seismic hazards, with the objective of minimizing the cost of maintaining a target network performance metric throughout a set of possible adverse scenarios. A two-stage stochastic programming approach is presented, which relates pre- and post-event decisions, accounting for the uncertainty throughout scenarios. The proposed approach implies a decomposition of the optimization problem that enables the analysis of large sets of scenarios, which is advantageous when dealing with complex networks as the ones addressed in infrastructure engineering practice. The methodological framework is presented along with an analysis of the San Francisco Bay Area transportation network, as an instance of a realistic, complex infrastructure network. Results evidence the potential of the approach to provide risk-informed decision support, while being able to deal with large sets of components and scenarios under an exact optimization approach, and solving problems with large number of variables and constraints.

1. Introduction

This paper proposes a decision support framework that integrates probabilistic risk assessment of complex infrastructure networks and stochastic programming to determine cost-optimal actions for pre- and post-disaster stages, while guaranteeing acceptable performance throughout a set of scenarios describing hazards. Instances of risk management problems that motivate a framework for coupled decisions in two stages include: first, how to allocate relief resources before a disastrous event in order to maximize the efficiency for their distribution when a disaster occurs, thus, contributing to prompt recovery [1]; and second, how to determine which network components require preemptive investments (e.g., enhancing arcs' fragility, or flow capacity), and which ones may be intervened only when disastrous events occur, without compromising pre-specified performance targets.

The proposed framework provides computational support for these problems when dealing with large infrastructure networks, for which weighing costs of individual investments versus acceptable system performance throughout many scenarios becomes highly expensive. To illustrate the proposed framework, this paper focuses on whether to preemptively retrofit bridges or repair damage *a posteriori* (which implies actions of higher cost than retrofitting, but which occur with lower probability). An optimization problem is formulated with the objective of minimizing the cost of retrofit actions, and the expected cost of repair actions (and other expected consequences), while constraining a set of performance metrics within a pre-specified acceptable range.

Three complexity drivers make the proposed problem challenging: first, the size of the network and the intricacy of its connections, which makes performance assessments computationally expensive; second, the many possible combinations of decision options that are being evaluated, since their effect on performance must be assessed; and third, the number of scenarios describing the hazard(s) of interest, all of which require performance evaluations involving the previous two items as well. Since our focus is on integrating optimization and comprehensive risk assessment, it will be critical to address the complexity related to the number of scenarios. A stochastic programming

Multi-Objective Tabu Search to balance multihoming loads in heterogeneous wireless networks

Jorge Huertas;
Yezid Donoso

Multi-Objective Tabu Search to Balance Multihoming Loads in Heterogeneous Wireless Networks

J. A. Huertas, Y. Donoso

Jorge A. Huertas
Center for Optimization and Applied Probability (COPA)
Industrial Engineering Department
Universidad de los Andes, Bogotá, Colombia
huertas.ja@uniandes.edu.co

Yezid Donoso*
Computing and Systems Engineering Department
Universidad de los Andes, Bogotá, Colombia
*Corresponding author: ydonoso@uniandes.edu.co

Abstract: The advantages of the increasing usage of mobile devices that operate under the multihoming scheme are changing the communications world drastically. Therefore, next generation networks operators have the challenging task to distribute connections of mobile devices efficiently over their access networks, creating a big heterogeneous wireless network for telecommunications. We present a mixed integer-linear programming (MILP) model to balance the load of multiple services over wireless networks taking into account three key indicators: connection loads of access networks, connection costs, and battery consumption of connections. To solve the multi-objective problem, we propose a multi-objective Tabu Search procedure that is capable to find non-supported solutions in the online efficient set. To test the performance of our multi-objective Tabu Search, we tested it over four instances of the literature. In the first instance, a small instance, our procedure finds the true efficient set of solutions. For the other three instances, large instances with over a thousand mobile devices, our procedure finds good online efficient sets of solutions in less than 30 seconds. Finally, using appropriate multi-objective metrics, we compare the results of our multi-objective Tabu Search against the results of a *state of the art* multi-objective genetic algorithm in the literature for the same problem, outperforming the genetic algorithm in every instance tested.

Keywords: Heterogeneous networks, Multihoming, Vertical handover, Optimization, Multi-objective, Tabu Search.

1 Introduction

Multihoming refers to the ability mobile devices have to connect to different access networks at a time through multiple network interfaces [12]. On the other hand, vertical handover (VHO) is the ability to change the access network that provides any service, while maintaining its quality [10]. Multihoming facilitates VHO, making it more seamless to the user [11]; and enhances the flow of data of multiple services across various network interfaces [2], allowing prioritized data to flow through next generation networks (e.g., 4G), and less important data to flow through legacy networks. This behaviour converges towards heterogeneous wireless networks (HWNs).

Thanks to the exponential growth of mobile devices that operate under a multihomming scheme, authorities operating access networks must rely on tools capable to perform VHO processes, while ensuring users' quality of service (QoS). Standards such as IEEE 802.21 MH provide only the framework for performing VHO, yet the decision-making algorithms to do so are an open

Solving the two-dimensional knapsack problem considering cutting-time and emission of particulate matter in the metalworking industry

Paula Velasco;
Guillermo Camacho;
Daniel Cuellar;
David Álvarez

Solving the Two-Dimensional Knapsack Problem Considering Cutting-Time and Emission of Particulate Matter in the Metalworking Industry

P. Velasco-Carvajal, G. Camacho, D. Cuellar-Usaquen, and D. Álvarez-Martínez

Abstract—This article presents a metaheuristic to solve the two-dimensional knapsack problem on applications of metalworking industries. The proposed algorithm is based on a GRASP procedure and its performance is assessed through comparison of the solutions computed for the knapsack problem. We have used two references for comparison: instances reported in the literature and experimental data obtained with two variations on the cutting method. The first reference allows us to conclude about the used area and the computational time. The second reference let us to explore the performance of the solutions with respect to the cutting-time and the amount of particles emitted. The methodology is composed by four steps: (1) selection of the instances, (2) design and implementation of the algorithms for optimization and post-optimization, (3) computing of the solutions and registering of cutting-times and particles emitted for each solution and (4) performance validation through comparison of solutions. The results permit to conclude a good behavior of the proposed algorithm reaching the performance reported in some instances and improving others. Additionally, the algorithm exhibits a stable computational time even for large-scale instances. It is emphasized that the post-optimization stage reduces the cutting-times without incrementing the emission of particulate matter. As future work we propose: to include a vision system to close the cutting loop; to consider partial damages on the plate; and to contemplate an exact approach for the sequencing cutting problem.

Index Terms—GRASP, Industrial Robotics, Knapsack Problem, Particulate Matter.

I. INTRODUCCIÓN

EL problema de la mochila bidimensional consiste en el corte ortogonal de un conjunto de piezas a partir de una pieza contenedora o placa original, de tal forma que se seleccionen y se corten las piezas que maximizan el beneficio, garantizando las restricciones de cortar únicamente las piezas con sus tamaños demandados y sin llegar a exceder los límites de la placa.

Este problema descrito en [1] y [2], tiene como objetivo maximizar el beneficio asociado a las piezas cortadas o minimizar el desperdicio de material. En este trabajo se presenta la adaptación del algoritmo GRASP [3] para resolver el problema de la mochila bidimensional y se explora el efecto de las soluciones sobre la emisión de material particulado.

La adaptación implementada consiste en un procedimiento iterativo en dos fases: una fase de construcción, realizada por un algoritmo voraz en donde se obtiene una solución factible a partir de la adición incremental de piezas, que son seleccionadas pseudo-aleatoriamente de una lista restricta de mejores candidatos y una fase de mejora, realizada por un algoritmo de búsqueda local, donde se busca mejorar la solución obtenida por la fase de construcción, a través de la remoción de piezas y un rellenado determinístico. El algoritmo cuenta con un esquema de autoajuste de parámetros, en especial el tamaño de la lista restricta de candidatos y el criterio de selección de soluciones promisorias para entrar a la etapa de mejora. El desempeño del algoritmo propuesto se evalúa en instancias clásicas reportadas en la literatura. Los resultados obtenidos son comparados con las mejores soluciones publicadas teniendo en cuenta los criterios de: calidad de la solución y tiempo computacional. El algoritmo presenta un comportamiento sobresaliente logrando mejorar algunas soluciones reportadas.

Usualmente los trabajos en la literatura solo velan por alcanzar los patrones de corte óptimos, en este trabajo estos patrones son integrados con un sistema automático de corte basado en el uso de robots industriales, con el fin de analizar y modelar restricciones del problema en aplicaciones de la industria metalmecánica. De forma tal que al reducir el desperdicio de material se explore el desempeño del sistema respecto al tiempo de ejecución de la tarea y la cantidad de partículas emitidas que ponen en riesgo la seguridad de los operadores. Para esto, se propone una etapa de post-optimización que logra mejorar los tiempos de ejecución, sin aumentar la cantidad de partículas emitidas y sin perder la calidad de solución en términos de desperdicio.

El desarrollo computacional involucrado en este proyecto consiste en un módulo de software que permite resolver el problema de optimización, un módulo hardware que permite automatizar las tareas de corte a través de manipuladores industriales, sistemas de comunicación que integran las tareas de optimización y automatización, y un sistema de información

P. Velasco-Carvajal, Departamento de Ingeniería Industrial, Universidad de La Salle, Colombia, pvelasco15@unisalle.edu.co

G. A. Camacho, Facultad de Ingeniería, Universidad del Valle, Colombia, guillermo.camacho@correounivalle.edu.co

D. Cuellar-Usaquen, Departamento de Ingeniería Industrial, Universidad de Los Andes, Colombia, dh.cuellar@uniandes.edu.co.

D. Álvarez-Martínez, Departamento de Ingeniería Industrial, Universidad de Los Andes, Colombia, d.alvarezm@uniandes.edu.co.

An unintended effect of financing the university education of the most brilliant and poorest colombian students: the case of the intervention of the Ser Pilo Paga Program

Pablo Medina;
Natalia Ariza;
Pablo Navas;
Fernando Rojas;
Gina Parody;
Juan A. Valvidia;
Roberto Zarama;
Juan Felipe Penagos

WILEY | Hindawi

Research Article

An Unintended Effect of Financing the University Education of the Most Brilliant and Poorest Colombian Students: The Case of the Intervention of the *Ser Pilo Paga* Program

Pablo Medina [iD],[1,2] Natalia Ariza,[2] Pablo Navas,[2,3] Fernando Rojas,[2,4] Gina Parody,[2] Juan Alejandro Valdivia,[1,2,5] Roberto Zarama,[2,6] and Juan Felipe Penagos[2,6]

[1] *Departamento de Física, Facultad de Ciencias, Universidad de Chile, Santiago, Chile*
[2] *CeiBA Complexity Research Center, Bogotá, Colombia*
[3] *President, Universidad de los Andes, Bogotá, Colombia*
[4] *Fondo de Financiamiento de Infraestructura Educativa, Ministerio de Educación Nacional, Bogotá, Colombia*
[5] *Center for Development of Nanoscience and Nanotechnology (CEDENNA), Santiago, Chile*
[6] *Departamento de Ingeniería Industrial, Universidad de los Andes, Bogotá, Colombia*

Correspondence should be addressed to Pablo Medina; pab-medi@uniandes.edu.co

In this paper, we show an unintended effect of the program *Ser Pilo Paga* (SPP) that was a flagship program of the Colombian government between 2014 and 2018. It was designed as an intervention in the Colombian Higher Education System (CHES) by awarding, in the steady state, individual funding to about 40,000 students. Every year, 10,000 new students were chosen from the best applicants in the top decile of the population in the entrance exam to higher education in Colombia that also came from families that live under the level of poverty according to a national survey. Our approach, based on an intensive study of the changes in the statistical distributions of the exam scores during these four years, provides evidence of student performance improvements not only of the beneficiaries of the program, but also of the whole student population. This shows that the program opened similar opportunities for all the students, especially for the poorest ones. The program drove a reduction in the gap between students of the upper strata of the population and those of the lowest strata that usually did not access a high quality institution of higher education due to the lack of funding. This result has opened a debate about the optimal way of funding higher education.

1. Introduction

In October 2014, the President of Colombia announced the program Ser Pilo Paga (SPP for the Spanish acronym) (the name of the program uses the Colombian adjective "pilo" that denotes a particular characteristic of a person, which will be explained later in the introduction). SPP is one of the programs designed and implemented by the Minister of Education (Gina Parody, coauthor of this paper) to contribute to the objective of turning the country into the most educated country in Latin America by 2025. SPP focuses on a specific group of academically high achievers that had no access to a higher education due to their low income [1–3].

In this manuscript, we report an unintended effect in the Colombian education system that was produced by this program. As we will analyze below, the SPP program has had some direct and some indirect effects in the Colombian Higher Education System (CHES), such as a clear improvement in the results of the entrance examination to the CHES, not only of the SPP students, but also of the whole student population.

SPP is the result of a previous research, conducted by the authors of this article, that concluded with the design and implementation of the program. The design of the program articulates efforts from the following four institutions of the Colombian system: (i) the Colombian agency (ICETEX)

A systemic methodology for the reduction of water consumption in rural areas

María Paula Flórez;
Catalina Ramírez;
Luisa Payán;
Mauricio Peralta;
Andrés Acero

A systemic methodology for the reduction of water consumption in rural areas

María Paula Flórez
Industrial Engineering Department,
Universidad Sergio Arboleda, Bogotá, Colombia

María Catalina Ramírez
Industrial Engineering Department, Universidad de los Andes,
Bogotá, Colombia

Luisa Fernanda Payán-Durán
Interdisciplinary Center for the Study of Development, Universidad de los Andes,
Bogotá, Colombia

Mauricio Peralta
Scientific Park of Social Innovation, Corporación Universitaria Minuto de Dios,
Bogotá, Colombia, and

Andres Esteban Acero Lopez
School of Engineering, Universidad de Los Andes, Bogotá, Colombia

Abstract

Purpose — This study aims to present a systemic methodological proposal for the reduction of water consumption in rural areas, based on participatory tools.

Design/methodology/approach — A theoretical framework was constructed based on the importance of stakeholders' participation in the adequate use of the hydro resources, technologies to save water and modeling the adoption of possible water-saving technologies. After that, it was proposed a methodology for the reduction of water consumption in rural areas. This methodology was tested in a participatory study case, including the system dynamics model.

Findings — This study proposes a participatory systemic methodology — PAWAME — participation-water waste-adoption-model-empowerment, which consists of four steps: identify stakeholders and the activities related with the waste of water in the study site and establish their values, measure the adoption that the technology would have based on the awareness generated, relate in a model the variables of the water-consuming activities and the variables of the technology and its adoption to analyze possible future behaviors and empowerment of the technology to reduce water consumption.

Practical implications — In Colombia, part of the population has the wrong perception about the abundance of the hydro resource, and for this reason, people do not use water in a correct way. The inclusion of a participatory systemic methodology was fundamental to apprehend the dynamic aspects of users' behaviors, as well as of the management of the water resource. The model addresses the complexity of the situation, allowing exploring future scenarios of environmental protection.

Originality/value — This study advances the knowledge in participatory systemic methodology to design and adopt a local technology to save water.

Keywords Stakeholders, Participation, Water consumption

Paper type Research paper

Promoting entrepreneurship through a community learning model- case study: Green Business

Catalina Ramírez;
Libia Navas;
Ángela Delgado;
Miguel A. González;
Luis C. Caicedo;
Mauricio Peralta

ORIGINAL PAPER

CrossMark

Promoting Entrepreneurship through a Community Learning Model – Case Study: Green Businesses

María Catalina Ramírez[1] · Libia Alejandra Navas Castaño[1] · Ángela Delgado[2] ·
Miguel Angel González[3] · Luis Camilo Caicedo[4] · Mauricio Peralta[3]

Abstract

This article presents a community learning model formulated by Engineers Without Borders Colombia with the aim of providing communities with tools to create sustainable productive solutions which have relevancy for members and for potential customers. The goal of this formulation is to promote learning processes that are guided by decisions made by community members to propose sustainable and replicable initiatives. The model applicability is evidenced through a case study devoted to strengthening community-led green businesses in the Guavio Province, Colombia by collecting lessons and conclusions. Ultimately, this collection will prove useful in replicating the learning model in other similar rural communities.

Keywords Green businesses · Organizational learning · Green entrepreneurship · Guavio region Colombia · Engineers without Borders Colombia

✉ Libia Alejandra Navas Castaño
la.navas251@uniandes.edu.co

[1] Department of Industrial Engineering, University of Los Andes, Bogota, Colombia

[2] University of Exeter (2016), Exeter, UK

[3] Social Innovation Science Park, Minuto de Dios Corporate University, Bogota, Colombia

[4] Engineering Faculty, University of los Andes, Bogota, Colombia

Cross-efficiency evaluation in the presence of flexible measures with an application to healthcare systems

Sepideh Abolghasem;
Mehdi Toloo;
Santiago Amézquita

Health Care Management Science

Cross-efficiency evaluation in the presence of flexible measures with an application to healthcare systems

Sepideh Abolghasem[1] · Mehdi Toloo[2] · Santiago Amézquita[1]

Abstract

In recent years, most countries around the world have struggled with the consequences of budget cuts in health expenditure, obliging them to utilize their resources efficiently. In this context, performance evaluation facilitates the decision-making process in improving the efficiency of the healthcare system. However, the performance evaluation of many sectors, including the healthcare systems, is, on the one hand, a challenging issue and on the other hand a useful tool for decision- making with the aim of optimizing the use of resources. This study proposes a new methodology comprising two well-known analytical approaches: (i) data envelopment analysis (DEA) to measure the efficiencies and (ii) data science to complement the DEA model in providing insightful recommendations for strategic decision making on productivity enhancement. The suggested method is a first attempt to combine two DEA extensions: flexible measure and cross-efficiency. We develop a pair of benevolent and aggressive scenarios aiming at evaluating cross-efficiency in the presence of flexible measures. Next, we perform data mining cluster analysis to create groups of homogeneous countries. Organizing the data in similar groups facilitates identifying a set of benchmarks that perform similarly in terms of operating conditions. Comparing the benchmark set with poorly performing countries we can obtain attainable goals for performance enhancement which will assist policymakers to strategically act upon it. A case study of healthcare systems in 120 countries is taken as an example to illustrate the potential application of our new method.

Keywords Data envelopment analysis · Cross-efficiency · Flexible measure · Healthcare · Data science · Clustering

1 Introduction

Healthcare overheads own predominant roles in assessing the performance of countries because it is directly correlated to the level of economic growth. An upward trend in the necessity of public services urges countries to enhance the performance of their healthcare systems, educational systems, research and development (R&D) systems, or, succinctly, their economy level. Thus, healthcare expenditures (health system costs) have been recognized as an increasing burden for economic development level in most nations and hence a principal factor on the determination of country development balance (Hadad et al. [29]).

Nevertheless, the spending resources on public sectors are rigorously restricted. Spending more capital on healthcare systems signifies that fewer capitals would be spent on other public activities, such as educational institutions, transportation, and social security among others. Optimal use of limited resources is a challenging issue, which is especially more pronounced in low- and middle-income countries. This is specifically truer in under-developed countries, but it is also true in developed countries; for instance, Shinjo and Aramaki [55] argued that the need to provide adequate healthcare services in Japan has become one of the biggest challenges. Additionally, the lack of resources is recognized as the first problem among the most important health-funding problems of the countries in The World Bank [61]. In this context, it is

✉ Mehdi Toloo
    mehdi.toloo@vsb.cz; m_toloo@yahoo.com;
    http://homel.vsb.cz/~tol0013/

    Sepideh Abolghasem
    ag.sepideh10@uniandes.edu.co

    Santiago Amézquita
    sj.amezquita11@uniandes.edu.co

[1] Department of Industrial Engineering, Universidad de los Andes, Bogotá, Colombia

[2] Department of Systems Engineering, Faculty of Economics, VŠB-Technical University of Ostrava, Sokolská třida 33, 702 00 Ostrava, Czech Republic

Ⓐ Springer

Color classification methods for perennial weed detection in cereal crops

Manuel Forero;
Sergio Herrera;
Julián Ávila;
Camilo Franco;
Jesper Rasmussen;
Jon Nielsen

Color Classification Methods for Perennial Weed Detection in Cereal Crops

Manuel G. Forero[1]([✉]) [iD], Sergio Herrera-Rivera[1],
Julián Ávila-Navarro[1], Camilo Andres Franco[2], Jesper Rasmussen[3],
and Jon Nielsen[3]

[1] Facultad de Ingeniería, Universidad de Ibagué, Ibagué, Colombia
{manuel.forero,sergio.herrera,
julian.avila}@unibague.edu.co
[2] Departamento de Ingeniería Industrial, Universidad de los Andes,
Bogotá, Colombia
[3] Department of Plant and Environmental Sciences, University of Copenhagen,
Copenhagen, Denmark

Abstract. *Cirsium arvense* is an invasive plant normally found in cold climates that affects cereal crops. Therefore, its detection is important to improve crop production. A previous study based on the analysis of aerial photographs focused on its detection using deep learning techniques and established methods based on image processing. This study introduces an image processing technique that generates even better results than those found with machine learning algorithms; this is reflected in aspects such as the accuracy and speed of the detection of the weeds in the cereal crops. The proposed method is based on the detection of the extreme green color characteristic of this plant with respect to the crops. To evaluate the technique, it was compared to six popular machine learning methods using images taken from two different heights: 10 and 50 m. The accuracy obtained with the machine learning techniques was 97.07% at best with execution times of more than 2 min with 200×200-pixel subimages, while the accuracy of the proposed image processing method was 98.23% and its execution time was less than 3 s.

Keywords: Automated weed classification · Machine learning ·
Deep learning · Image processing · Cereal crops

1 Introduction

The presence of *Cirsium arvense*, also known as Canadian thistle, and other types of weeds in organic cereal crops is a major concern in Nordic countries such as Norway and Denmark [2], primarily because they result in significant losses in crop efficiency, causing an average of 29.2% production losses worldwide if weed control is not applied [3]. Therefore, there is a need to identify areas with weeds so that farmers can take the appropriate actions. These weeds are usually controlled via the application of glyphosate before or after harvest [4], which can sometimes lead to the indiscriminate use of these chemicals, increasing production costs, soil depletion, and environmental contamination [5, 6].

Ambiguity measures for preference-based decision viewpoints

Camilo Franco;
J. Tinguaro Rodríguez;
Javier Montero;
Daniel Gómez;
Ronald Yager

Ambiguity Measures for Preference-Based Decision Viewpoints

Camilo Franco[1]([✉]), J. Tinguaro Rodríguez[2], Javier Montero[2],
Daniel Gómez[3], and Ronald R. Yager[4]

[1] Department of Industrial Engineering, Andes University, Bogotá 111711, Colombia
c.franco31@uniandes.edu.co
[2] Department of Statistics and Operational Research,
Complutense University, 28040 Madrid, Spain
{jtrodrig,monty}@mat.ucm.es
[3] Statistics and Data Science, Complutense University, 28040 Madrid, Spain
dagomez@estad.ucm.es
[4] Machine Intelligence Institute, Iona College, New Rochelle, NY 10801, USA
yager@panix.com

Abstract. This paper examines the ambiguity of subjective judgments, which are represented by a system of pairwise preferences over a given set of alternatives. Such preferences are valued with respect to a set of reasons, in favor and against the alternatives, establishing a complete judgment, or *viewpoint*, on how to solve the decision problem. Hence, viewpoints entail particular decisions coming from the system of preferences, where the preference-based reasoning of a given viewpoint holds according to its *soundness* or *coherence*. Here we explore such a coherence under the frame of *ambiguity measures*, aiming at learning viewpoints with highest preference-score and minimum ambiguity. We extend existing measures of ambiguity into a multi-dimensional fuzzy setting, and suggest some future lines of research towards measuring the coherence or (ir)rationality of viewpoints, exploring the use of information measures in the context of preference learning.

Keywords: Ambiguity · Fuzziness · Rationality ·
Preference structures

1 Introduction

Any subjective decision process requires considering the formation of opinions, like preferences over a given set of possible choices. Examples of such a process can be political elections, an investment project competition, or much simpler

The Experimenting University

31

01/04/2019

Camilo Olaya

The experimenting university

Camilo Olaya

*Department of Industrial Engineering, Faculty of Engineering,
Universidad de los Andes, Bogota, DC, Colombia*

Abstract

Purpose – What has been called "the McDonaldization of universities" (another name for top-down and strong corporate managerialism) has gained momentum as a model for governing and managing universities. This trend exacerbates the traditional tension between academic freedom and managerial control – a major challenge for the administration of academic institutions. The ideas of Charles Darwin represent an opportunity for overcoming such a challenge. However, traditional managerial models show inadequate, pre-Darwinian assumptions for devising organizational designs. This paper aims to show not only the opportunities but also the challenges of embracing a Darwinian paradigm for designing social systems. The case of managerialism in universities is an illustrative example. The paper proposes evolutionary guidelines for designing universities capable of maintaining managerial control while warranting academic freedom.

Design/methodology/approach – The paper proposes to understand the tension between academic freedom and managerial control in universities as the same tension between freedom and control that Karl Popper identified as successfully handled by evolutionary processes. The paper uses Darwinian theory, understood as a broader theory for complex systems, as a heuristic for designing social systems – universities in this case – able to adapt to changing environmental conditions while handling equilibrium between freedom and control. The methodology articulates the Popperian model of knowledge with the Darwinian scheme proposed by David Ellerman known as "parallel experimentation" for suggesting organizational forms in which university administrators and faculty can interact for generating free innovations in *pseudo*-controlled organizational arrangements.

Findings – A salient characteristic of strong managerialism is its pre-Darwinian understanding of survival and adaptation; such an approach shows important flaws that can lead universities to unfit designs that changing environments can select for elimination. As an alternative, the philosophy behind the ideas of Charles Darwin provides guidelines for designing innovative and adaptive social systems. Evolutionary principles challenge basic tenets of strong managerialism as Darwinian designs discard the possibility of seeing managers as knowledgeable designers that allegedly can avoid mistakes by allocating resources to "one-best" solutions through *ex ante* exhaustive, top-down control. Instead, a Darwinian model requires considering survival as a matter of adaptability through continuous experimentation of blind trials controlled by *ex post* selection. The key is to organize universities as experimenting systems that try new and different things all the time and that learn and improve by making mistakes, as an adaptive system.

Research limitations/implications – Governing and managing universities require to acknowledge the uniqueness of academic institutions and demand to look for appropriate forms of organization. The proposal of this paper opens possibilities for exploring and implementing action-research initiatives and practical solutions for universities. Studies in management and administration of higher-education institutions must take into account the characteristics of this type of organizations and should consider wider spectrums of possibilities beyond the core ideas of managerialism.

Practical implications – University managers face a special challenge for achieving equilibrium between managerial control and academic freedom. Darwinian models of management invite to reconsider several management creeds, for instance, that "errors are bad things" – instead of innovation triggers and learning opportunities or that "one solution must fit all" – instead of considering bottom-up, different and adaptive solutions triggered by local academic units, each facing different environments.

Originality/value – Currently, there is no clear picture for governing universities. This paper introduces principles and guidelines for facing the current challenge that strong managerialism represents if universities are expected to maintain academic freedom and also survive in volatile environments.

Keywords University, Control, Adaptation, Evolution, Popper, Academic freedom,
Social systems design, Evolutionary design

Paper type Conceptual paper

A new multi-criteria decision analysis methodology for the selection of new water supply infrastructure

Henry Amorocho-Daza;
Sergio Cabrales;
Raquel Santos;
Juan Saldarriaga

Article

A New Multi-Criteria Decision Analysis Methodology for the Selection of New Water Supply Infrastructure

Henry Amorocho-Daza [1], Sergio Cabrales [2], Raquel Santos [3] and Juan Saldarriaga [4,*]

[1] Water Distribution and Sewerage Systems Research Center (CIACUA), Universidad de los Andes, Carrera 1 Este No. 19A-40, Bogotá 111711018, Colombia; hd.amorocho1052@uniandes.edu.co

[2] Department of Industrial Engineering, Universidad de los Andes, Carrera 1 Este No. 19A-40, Bogotá 111711018, Colombia; s-cabral@uniandes.edu.co

[3] Centre for Energy, Petroleum and Mineral Law and Policy CEPMLP, University of Dundee, Ninewells Drive, Dundee DD1 9SY, UK; r.santosramos@dundee.ac.uk

[4] Department of Civil and Environmental Engineering, Water Distribution and Sewerage Systems Research Center (CIACUA), Universidad de los Andes, Carrera 1 Este No. 19A-40, Bogotá 111711018, Colombia

* Correspondence: jsaldarr@uniandes.edu.co

check for updates

Abstract: Reliable and safe access to drinking water is necessary to ensure the economic and social sustainable development of human communities. This task requires a multi-criteria decision analysis (MCDA) methodology to select alternatives for new water supply infrastructure. These alternatives represent significant financial resources and are established for a long lifespan. To support decision-making in the context of building new water supply infrastructure, this study developed an MCDA methodology that integrates a hierarchy of non-economic benefits and the expected costs into a global index. Our methodology was implemented in the city of Santa Marta, Colombia. This city currently has a 60% drinking water shortage, and urgently needs to expand its capacity to satisfy the increasing water demand. The results of this study support the implementation of the best alternative for addressing Santa Marta's water supply problem by considering the preferences of stakeholders.

Keywords: multi-criteria decision analysis; analytical hierarchy process; water supply infrastructure

1. Introduction

Providing access to drinking water is a global challenge; it guarantees the quality of life and economic development [1]. The United Nations [2] stated that "the right to safe drinking water and sanitation is a human right essential to the full enjoyment of life and all human rights," and, therefore, states and international organizations must provide the necessary financial resources to guarantee them. Conversely, UNICEF and the World Health Organization (WHO) [3] estimate that 1.8 billion people have access to water that is unfit for human consumption, 663 million people do not have access to safe drinking water sources, and 2.4 billion people lack access to basic sanitation. As a result, major challenges exist to guaranteeing this right to a significant portion of the global population, particularly in developing nations [4].

Currently, more than 2 billion people in the world have significant restrictions on the access to potable water supply [5]. First, the availability of water over time is derived from the relationship between supply and demand; increases in demand relative to supply put pressure on the resource availability. Therefore, a relevant approach to quantifying the pressure on water sources is the ratio between the water withdrawn for different purposes (agriculture, industry, and domestic) and the total renewable water resources. A higher proportion of use indicates that the pressure on the resource increases, and it is substantially more difficult to satisfy an increasing demand for water [6].

Study of the spatiotemporal correlation between sediment-related blockage events in the sewer system in Bogotá (Colombia)

Eliana Soriano;
Carlos Valencia;
Juan P. Rodríguez

Study of the spatiotemporal correlation between sediment-related blockage events in the sewer system in Bogotá (Colombia)

Eliana Soriano Pulido, Carlos Valencia Arboleda and Juan Pablo Rodríguez Sánchez

ABSTRACT

The planning and scheduling of maintenance operations of large conventional sewer systems generate a complex decision-making environment due to the difficulty in the collection and analysis of the spatiotemporal information about the operational and structural condition of their components (e.g. pipes, gully pots and manholes). As such, water utilities generally carry out these operations following a corrective approach. This paper studies the impact of the spatiotemporal correlation between these failure events using Log-Gaussian Cox Process (LGCP) models. In addition, the association of failure events to physical and environmental covariates was assessed. The proposed methods were applied to analyze sediment-related blockages in the sewer system of an operative zone in Bogotá (Colombia). The results of this research allowed the identification of significant covariates that were further used to model spatiotemporal clusters with high sediment-related failure risk in sewer systems. The LGCP model proved to be more accurate in comparison to those models that build upon a fundamental assumption that a failure is equally likely to occur at any time regardless of the state of the system and the system's history of failures (i.e. a homogeneous Poisson process model).

Key words | intensity of failures, Log-Gaussian Cox Process, sediment-related blockages, sewer systems, spatiotemporal correlation

Eliana Soriano Pulido
Carlos Valencia Arboleda
Centro para la Optimización y Probabilidad
  Aplicada (COPA), Departamento de Ingeniería
  Industrial,
Universidad de los Andes,
Bogotá,
Colombia

Juan Pablo Rodríguez Sánchez (corresponding
  author)
Centro de Investigaciones en Ingeniería Ambiental
  (CIIA), Departamento de Ingeniería Civil y
  Ambiental,
Universidad de los Andes,
Bogotá,
Colombia
E-mail: pabl-rod@uniandes.edu.co

INTRODUCTION

Urban drainage systems provide fundamental services to the health and well-being of populations, as well as to the protection of the environment (Santos *et al.* 2017). However, it is well known that wastewater and urban runoff transport a variety of solid particles that can create obstructions in the sewer system, thus deteriorating its operation. Sediment-related blockages may result in the release of raw sewage into the environment due to a reduced hydraulic capacity that increases the probability of local surcharge and/or combined sewer overflow events (Xie *et al.* 2017). The malfunctioning of the sewer system and subsequent flooding constitute a risk to human health as a result of

exposure to potential water-borne pathogens (ten Veldhuis *et al.* 2010; Collender *et al.* 2016). Furthermore, the release of untreated wastewater (e.g. via sewer overflows) into water bodies such as rivers and lakes negatively alters the water quality and health of fluvial and lacustrine ecosystems, affecting fish and other types of aquatic life (Munawar *et al.* 1993; Rodríguez-Jeangros *et al.* 2018). In general, the consequences of these contaminated water flow releases range from mild disruption for a small number of residents to events that may seriously damage the environment (Xie *et al.* 2017).

Urban drainage services account for a significant portion of the built infrastructures, which require large investments for their construction, protection, and maintenance (Santos *et al.* 2017). In different studies, it has been stated that blockage events account for a significant proportion of reported failures in sewer systems (Jin & Mukherjee 2010; Xie *et al.* 2017). These blockages are

Evacuation dynamics: a modeling and visualization framework

03/06/2019

Jorge Huertas;
Daniel Duque;
Ethel Segura-Durán;
Raha Akhavan-Tabatabaei;
Andrés Medaglia

Operations Research (SPECTRUM)

REGULAR ARTICLE

Evacuation dynamics: a modeling and visualization framework

Jorge A. Huertas[1] · Daniel Duque[2] · Ethel Segura-Durán[3] ·
Raha Akhavan-Tabatabaei[4] · Andrés L. Medaglia[1]

Abstract

Evacuation mock drills are critical to emergency preparedness and to stress test the infrastructure capacity. Even though drills are expensive in terms of the involved resources, recognizing critical points of the infrastructure can guide decisions to improve the dynamics during a real evacuation, resulting in saving lives. In this paper, we present a modeling and visualization framework that provides useful insight and information of the evacuation dynamics to the decision makers of complex facilities. Using an optimization-based simulation approach, the framework recreates real evacuation scenarios, provides useful statistics of the evacuation dynamics, and allows for *what-if* analyses. To do so, our framework solves multiple linear optimization models with an underlying network structure that models the topography and resources of the given facility. A dual analysis of the optimization model allows us to identify critical points during an evacuation. In addition, the framework integrates with geographical information systems to produce rich visualizations of the evacuation dynamics. To illustrate the application of this framework, we evaluate two real evacuation scenarios on a university campus, located in Bogotá (Colombia), and provide insight to improve the decisions taken by the campus administration.

Keywords Evacuation dynamics · Optimization · Networks flows · Simulation

1 Introduction

With nearly eight million inhabitants, Bogotá is the Colombia's largest city and the fourth largest city in the Americas (CityMayors 2017); it is located at 2600 m above the sea level and is surrounded by the Andes mountain range. On February 2, 2016, the historic city center was forced to evacuate due to the smoke of a wildfire on the surrounding mountains. A yellow alert provoked a massive evacuation of several gov-

✉ Andrés L. Medaglia
 amedagli@uniandes.edu.co

Extended author information available on the last page of the article

Springer

Integrating operational and organizational aspects in interdependent infrastructure network recovery

Camilo Gómez;
Andrés González;
Hiba Baroud;
Claudia Bedoya-Motta

39

Integrating Operational and Organizational Aspects in Interdependent Infrastructure Network Recovery

Camilo Gomez [ID],[1,*] Andrés D. González,[2] Hiba Baroud [ID],[3] and Claudia D. Bedoya-Motta[1]

Managing risk in infrastructure systems implies dealing with interdependent physical networks and their relationships with the natural and societal contexts. Computational tools are often used to support operational decisions aimed at improving resilience, whereas economics-related tools tend to be used to address broader societal and policy issues in infrastructure management. We propose an optimization-based framework for infrastructure resilience analysis that incorporates organizational and socioeconomic aspects into operational problems, allowing to understand relationships between decisions at the policy level (e.g., regulation) and the technical level (e.g., optimal infrastructure restoration). We focus on three issues that arise when integrating such levels. First, optimal restoration strategies driven by financial and operational factors evolve differently compared to those driven by socioeconomic and humanitarian factors. Second, regulatory aspects have a significant impact on recovery dynamics (e.g., effective recovery is most challenging in societies with weak institutions and regulation, where individual interests may compromise societal well-being). And third, the decision space (i.e., available actions) in postdisaster phases is strongly determined by predisaster decisions (e.g., resource allocation). The proposed optimization framework addresses these issues by using: (1) parametric analyses to test the influence of operational and socioeconomic factors on optimization outcomes, (2) regulatory constraints to model and assess the cost and benefit (for a variety of actors) of enforcing specific policy-related conditions for the recovery process, and (3) sensitivity analyses to capture the effect of predisaster decisions on recovery. We illustrate our methodology with an example regarding the recovery of interdependent water, power, and gas networks in Shelby County, TN (USA), with exposure to natural hazards.

KEY WORDS: Infrastructure resilience; optimization; sociotechnical systems

1. INTRODUCTION

Infrastructure systems are becoming increasingly interdependent, posing new challenges in addressing their vulnerability to natural and human-made hazards. Disruptive events can produce cascading failures throughout multiple infrastructure systems and economic sectors, ultimately impacting the communities that rely on the functionality of these systems. Logistically and financially efficient response and recovery strategies are necessary to mitigate the impacts of disruptions while maximizing

[1] Centro para la Optimización y Probabilidad Aplicada (COPA), Departamento de Ingeniería Industrial, Universidad de los Andes, Bogotá, Colombia.
[2] School of Industrial and Systems Engineering, University of Oklahoma, Norman, OK, USA.
[3] Department of Civil and Environmental Engineering, Vanderbilt University, Nashville, TN, USA.
*Address correspondence to Camilo Gomez, Centro para la Optimización y Probabilidad Aplicada (COPA), Departamento de Ingeniería Industrial, Universidad de los Andes, Bogotá, Colombia; gomez.ch@uniandes.edu.co.

Universidad de
los Andes
Colombia