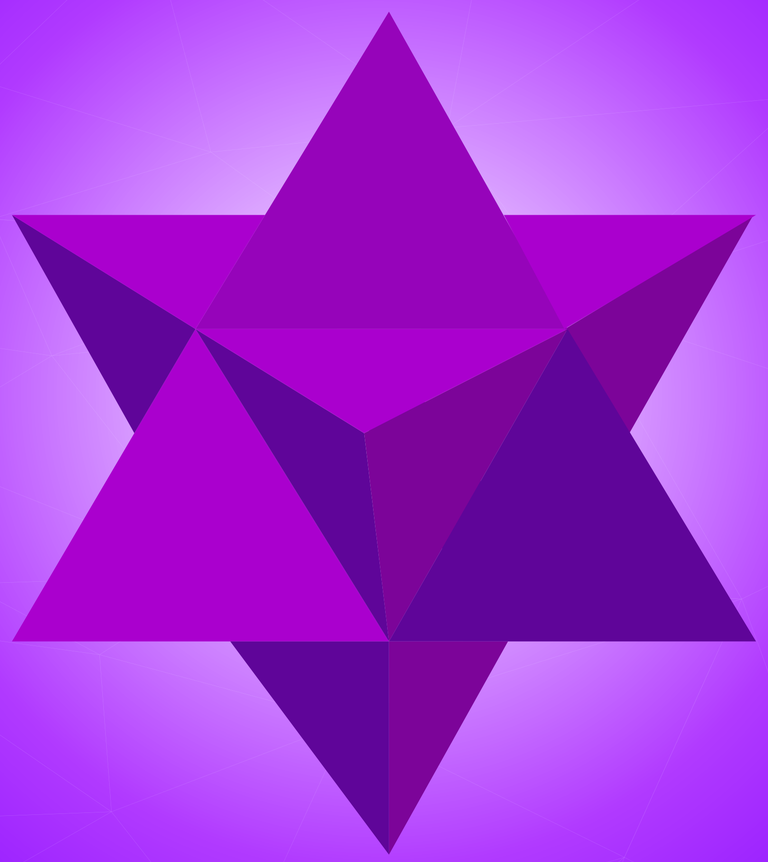
Período

2021/01/01 - 2021/12/31

Publicaciones de alto impacto

Departamento de Ingeniería Industrial

Número 8



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Reconocimiento como Universidad: Decreto 1297 del 30 de mayo de 1964.
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Publicaciones de Alto Impacto

Para el Departamento de Ingeniería Industrial es estratégico divulgar y compartir con el público general los resultados de investigación del más alto nivel realizados por nuestros profesores. Estos resultados son un motivo de especial orgullo para nuestro Departamento. La presente edición no. 8 cubre las publicaciones realizadas en el año 2021 y refleja la diversidad, el alcance, el impacto y las posibilidades de la ingeniería industrial. Para que estas publicaciones se incluyan en esta revista se requiere que cumplan con los criterios que Minciencias establece para la producción académica reconocida como “de alto impacto” y que se resumen a continuación:

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2. King, A.; Odunitan-Wayas, F.; Chaudhury, M:, Rubio, M.; Baiocchi; M.; Kolbe-Alexander, T:, **Montes, F**:; Banchoff, A.; Sarmiento, O; Bälter, K:; Hinckson, E.; Chastin, S:; Lambert, E.; González, S.; Guerra, A.; Gelius, P.; Zha, C.; Sarabu, C.; Kakar, P.; Fernes, P.; Rosas, L.; Winter, S.; McClain, E. & Gardiner, P. (2021). Community-based approaches to reducing health inequities and fostering environmental justice through global youth-engaged citizen science. International Journal of Environmental Research and Public Health. Jan 21;18(3):892. doi: 10.3390/ijerph18030892.
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Productos Reconocidos

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Productos Reconocidos

Dealing with complexity by using multilevel system boundary models

20/01/2021

Luis Pinzón
Juanita Bernal

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RESEARCH PAPER

SYSTEMS and BEHAVIORAL RESEARCH SCIENCE WILEY

Dealing with complexity by using multilevel system boundary models

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Abstract

Increasingly, researchers and practitioners operate in complex systems difficult to comprehend. In them, the multiplicity of perspectives, elements and relationships operating on multiple levels makes the practice of systems thinking and boundary critique considerably difficult. Drawing upon boundary critique and hierarchy theory, this paper presents ways of thinking in terms of multilevel boundary judgements models useful for addressing the aforementioned problem in all fields of study. A real example of the use of these models is presented. This paper also discusses how thinking in terms of multiple levels of boundary judgements is important to better deal with values and moral frameworks and to promote critical reflexivity in systemic interventions, while escaping the dangers of reductionism. Furthermore, a systemic way of exploring the role of moral frameworks in systems practice is discussed, contributing with new concepts useful to develop a deeper understanding of ethical issues in systems practice.

KEYWORDS

boundary critique, critical systems thinking, ethics, hierarchy theory, levels of organization

1 | INTRODUCTION

In a recent paper, Pinzon-Salcedo, Ramírez-Tovar, & Torres-Cuello (2018) took advantage of critical systems thinking to explore the structure of moral frameworks and judgements in negotiation practice, particularly in negotiations that are part of systemic interventions. They studied diverse moral frameworks used in negotiations and showed how boundary critique can be employed to deal more holistically and critically with moral judgements, while opening new possibilities to deal with the moral challenges of negotiation practice in a more informed way. In this paper, we draw upon these arguments, but also upon other notions of boundary critique, hierarchy theory, ethical theories and reflections made by other systems thinkers to propose new ideas on how to enrich the practice of boundary critique. Additionally, we illustrate how systems thinkers can develop better models of the ethical elements relevant to their interventions. These models can help them achieve an enhanced comprehension of these ethical elements as well as to reflect on them critically.

McBride (2015) argued that despite the fact that hierarchy theory has been used to understand natural phenomena, its potential for comprehending social systems has rarely been addressed. The few articles recently published that refer to hierarchy theory address only natural and technological issues (e.g., Allen, Allen, Malek, Flynn, & Flynn, 2009; Galbrun & Kijima, 2010) but no issue in the social arena. This paper intends to fill this gap. Moreover, it addresses hierarchy theory from the perspective of several prominent systemic authors that have not been explored recently in the systems thinking literature. Additionally, it proposes new ideas on how to

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Community-based approaches to reducing health inequities and fostering environmental justice through global youth-engaged citizen science

21/01/2021

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Article

Community-Based Approaches to Reducing Health Inequities and Fostering Environmental Justice through Global Youth-Engaged Citizen Science

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Abstract: Growing socioeconomic and structural disparities within and between nations have created unprecedented health inequities that have been felt most keenly among the world's youth. While policy approaches can help to mitigate such inequities, they are often challenging to enact in under-resourced and marginalized communities. Community-engaged participatory action research provides an alternative or complementary means for addressing the physical and social environmental contexts that can impact health inequities. The purpose of this article is to describe the application of a particular form of technology-enabled participatory action research, called the *Our Voice* citizen science research model, with youth. An overview of 20 *Our Voice* studies occurring across

An approach for the pallet-building problem and subsequent loading in a heterogeneous fleet of vehicles with practical constraints

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Cuellar-Usaquén
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David Álvarez.

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An approach for the pallet-building problem and subsequent loading in a heterogeneous fleet of vehicles with practical constraints

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C H R O N I C L E

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A B S T R A C T

This article presents a metaheuristic algorithm to solve the pallet-building problem and the loading of these in trucks. This approach is used to solve a real application of a Colombian logistics company. Several practical requirements of goods loading and unloading operations were modeled, such as the boxes' orientation, weight support limits associated with boxes, pallets and vehicles, and static stability constraints. The optimization algorithm consists of a two-phase approach, the first is responsible for the construction of pallets, and the second considers the optimal location of the pallets into the selected vehicles. Both phases present a search strategy type of GRASP. The proposed methodology was validated through the comparison of the performance of the solutions obtained for deliveries of the logistics company with the solutions obtained using a highly accepted commercial packing tool that uses two different algorithms. The proposed methodology was compared in similar conditions with the previous works that considered the same constraints of the entire problem or at least one of the phases separately. We used the sets of instances published in the literature for each of the previous works. The results allow concluding that the proposed algorithm has a better performance than the most known commercial tool for real cases. The proposed algorithm managed to match most of the test instances and outperformed some previous works that only involve decisions of one of the two problems. As future work, it is proposed to adapt this work to the legal restrictions of the European community.

1. Introduction

Moving products maximizing the utilization space at the lowest possible cost to the environment, and the company is one of the objectives of any carrier company. The complexity of this objective has increased with the preference of the volumetric weight pricing technique for commercial freight transport Viklund (2010). To reach this objective, logistics companies divide into two stages the packing operation. The first operation stage corresponds to the packing of a large assortment of three-dimensional goods (different sizes and weights) into pallets of the same size; this problem was named first by Ballew (2000) as the Three-Dimensional Distributor's Pallet Packing Problem (3D-DPPP). Formally in the improved typology of the cutting and packing problems proposed by Wäscher et al. (2007), this type of problem is known as the Three-Dimensional Single Stock Size Cutting Stock Problem (3D-SSSCSP). The second stage consists of the loading pallets into the available fleet of vehicles, and this problem belongs to the type of problem known as the Three-Dimensional Multiple Bin Size Bin Packing Problem (3D-MBSBPP). This article tackles the problem of packing operations inspired by the instance of a large logistics company located at Bogota-Colombia. On this company, goods already packed in boxes must be placed´ into identical pallets limited to a certain height that enabled the operators to accomplish the loading and unloading operations with the help of a

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Supporting Financial Inclusion with Graph Machine Learning and Super-App Alternative Data

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Andrés Rodríguez-Rey
Alejandro Correa-Bahnsen
Carlos Valencia

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Advances in Intelligent Systems and Computing

Supporting Financial Inclusion with Graph Machine Learning and Super-App Alternative Data

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Abstract. The presence of Super-Apps have changed the way we think about the interactions between users and commerce. It then comes as no surprise that it is also redefining the way banking is done. In this paper we evaluate the impact of graph-based techniques for credit risk assessment and how different interactions between users within a Super-App provide a new source of information to predict borrower behavior. To this end, five networks are built and two experiments using different graph-based methodologies are proposed, the first uses graph-based features as input in a classification model and the second uses graph neural networks. Our results show that variables of centrality, behavior of neighboring users and transactionality of a user constituted new forms of knowledge that enhance statistical and financial performance of credit risk models. Furthermore, opportunities are identified for Super-Apps to redefine the definition of credit risk by contemplating all the environment that their platforms entail, leading to a more inclusive financial system.

Keywords: Credit Score, Graph Machine Learning, Alternative Data, Super-App

1 Introduction

Super-Apps are platforms that offer a wide range of services such as food delivery, errands, booking of flights and hotel rooms, video games, a gambling platform, and even financial services like P2P transfers, bank transfers, money withdrawals, and payments with QR. A clear example is WeChat from the Chinese giant Tencent, that started as a messaging application and now offers personal financing solutions through its Fintech WeBank [1]. Given that these platforms have a high potential to become Fintechs, specifically focused on consumer loans, the importance of accurate descriptions of credit risk and loan allocation

MTConnect-based decision support system for local machine tool monitoring

22/02/2021

Carlos Felipe Erazo
Alejandro Echavarría
Sepideh Abolghasem
Giacomo Barbieri

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MTCONNECT-BASED DECISION SUPPORT SYSTEM FOR LOCAL MACHINE TOOL MONITORING

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ABSTRACT
Cyber-Physical Machine Tools (CPMT) are becoming ubiquitous parts of manufacturing sectors. CPMT offers immense potentials in the current CNC machine tool through integrating machine tool and the machining process using computation and networking to enhance interconnection and autonomy. This study uses MTConnect to address the challenges of data communication and management with CNC machine tool. Using MTConnect protocol, we gathered near real-time data from a CNC machine. Next, the collected data are utilized to develop a local monitoring system that facilitates the decision-making process with applications on: i) production planning, ii) preventive maintenance, and iii) energy consumption analysis. In each application, various analyses and visualization techniques are presented to show the capabilities of the decision support system (DSS) for the operator. Finally, the advantages of the local DSS to improve the interoperability of the CNC through MTConnect are discussed.
Keywords: Industry 4.0, Decision Support System, Machine tool 4.0, MTConnect

1. INTRODUCTION

Machine tools are indispensable components in the realm of manufacturing sector as their performances considerably affect the production efficiency as well as its effectiveness. Given this, there is no doubt that machine tools play vital roles in the development of Cyber-Physical Production Systems (CPPS) (Liu, Vengayil, Lu, and Xu 2019) and consequently Smart Factory (Liu, Vengayil, Lu, and Xu 2019). The evolution of machine tool technologies from the 19th century to date has extensively emulated that of industrial revolution. Such mirrored development asserts the claim that the machine tools are the ubiquitous components in the modern manufacturing systems. This is also confirmed by their iconic position in the context of industrial modernization (Liu and Xu 2017). Subsequently, in the context of industrialization, given the significant role of machine tools in this path, we recognize the urgent need to develop machine tools that are in accordance with the concept of Industry 4.0. In this direction, similar to the industrial revolution (Liu and Xu 2017), machine tools have passed through three stages of technological developments. Analogously, as we swing into the era of Industry 4.0, so do we to the epoch of Machine Tool 4.0 (Liu, Xu, Peng, and Zhou 2018).

Cyber-Physical Machine Tools (CPMT), which are founded on the developments in Information and Communication Technology including Cyber-Physical Systems (CPS), Big Data, Data Analytics, and Internet of Things (IoT), offer promising solutions for Machine Tool 4.0. CPMT involve deeply integrated machining processes and machine tool through computation and networking in which the employed computations allow for monitoring and control of the machining processes with by-directional feedback loops (Liu, Xu, Peng, and Zhou 2018). Such integrated system results in a highly interconnected, self-governing, and hence more intelligent system. However, development of CPMT is accompanied by challenges in enabling data communication, integration and management mainly due to the variety of manufacturing instruments and sensors in the system and thus the diversity in data transmission. This challenging task become highly visible if we consider the most common manufacturing process, machining. Currently, a major proportion of machining production is performed using computer numerical control (CNC) machine tools that utilize servomotors and stepper motors to generate the tool motion. The CNC machine tools count on the sensor feedbacks in order to control the cutting process. Thus, the output data originating from these sensors can be manipulated to examine the machining process in general. For instance, the sensor data can be analyzed to evaluate the production rate of the machine, its current status, and determination/prediction of potential problems with the machine, among others. However, collecting data from the various sensors of the machine tool may involve problems especially if the attempts is to integrate data from many different types of devices.

To address the aforementioned challenges, machine tool manufacturers have been embracing MTConnect as a viable choice for data transmission from various types of machine tools including CNC machines (Xiao, Huang, and Zhao 2018). MTConnect is an open-source, royalty-free communication protocol that facilitates the sensors data collection in a machine tool via a network connection (MTConnect Institute 2019). While the benefits from MTConnect implementation are numerous in many facilities, the literature lacks cost effective tools that could easily and rapidly be deployed to analyze the collected data through MTConnect for enhanced decision-making processes.

Effectively using the collected data requires the formation of a system that is capable of collecting,

A column-oriented optimization approach for the generation of correlated random vectors

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A column-oriented optimization approach for the generation of correlated random vectors

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Abstract
To induce a desired correlation structure among random variables, widely popular simulation software relies upon the method of Iman and Conover (IC). The underlying premise is that the induced Spearman rank correlation is a meaningful way to approximate other correlation measures among the random variables (e.g., Pearson's correlation). However, as expected, the desired a posteriori correlation structure often deviates from the Spearman correlation structure. Rooted in the same principle of IC, we propose an alternative distribution-free method based on mixed-integer programming to induce a Pearson correlation structure to bivariate or multivariate random vectors. We also extend our distribution-free method to other correlation measures such as Kendall's coefficient of concordance, Phi correlation coefficient, and relative risk. We illustrate our method in four different contexts: (1) the simulation of a healthcare facility, (2) the analysis of a manufacturing tandem queue, (3) the imputation of correlated missing data in statistical analysis, and (4) the estimation of the budget overrun risk in a construction project. We also explore the limits of our algorithms by conducting extensive experiments using randomly generated data from multiple distributions.

Keywords Correlated random vectors · Iman–Conover method · Spearman rank correlation · Pearson product-moment correlation · Kendall coefficient of concordance · Phi correlation coefficient · Relative risk · Simulation · Data imputation

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On the shortest alpha-reliable path problem

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ORIGINAL PAPER

On the shortest α-reliable path problem

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Abstract
In this variant of the constrained shortest path problem, the time of traversing an arc is given by a non-negative continuous random variable. The problem is to find a minimum cost path from an origin to a destination, ensuring that the probability of reaching the destination within a time limit meets a certain reliability threshold. To solve this problem, we extend the pulse algorithm, a solution framework for shortest path problems with side constraints. To allow arbitrary non-negative continuous travel-time distributions, we model the random variables of the travel times using Phase-type distributions and Monte Carlo simulation. We conducted a set of experiments over small- and medium-size stochastic transportation networks with and without spatially-correlated travel times. As an alternative to handling correlations, we present a scenario-based approach in which the distributions of the arc travel times are conditioned to a given scenario (e.g., variable weather conditions). Our methodology and experiments highlight the relevance of considering on-time arrival probabilities and correlations when solving shortest path problems over stochastic transportation networks.

Keywords Constrained shortest path problem · Pulse algorithm · Stochastic shortest path · Phase-type distributions · Spatial correlation · Chance constraints

Mathematical Subject Classification 90-08 · 90B15 · 90B06 · 90C35

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A GRASP/Path-Relinking algorithm for the traveling purchaser problem

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A GRASP/Path-Relinking algorithm for the traveling purchaser problem

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Abstract

The Traveling Purchaser Problem (TPP) is a generalization of the TSP that consists in choosing which nodes (markets) to visit to create a tour that allows to buy a set of products at minimum transportation and purchasing cost. The TPP has gained attention due to the computational challenges it poses and the potential applications it can support in today's technology-driven industry. This paper presents a GRASP-based methodology for the TPP based on three constructive procedures (*route-first*, *purchase-first*, and *purchase-and-route*) and two local search operators (*insert* and *remove*). The methodology is strengthened with a Path Relinking strategy to improve the GRASP performance by re-combining a set of elite solutions and with a Filtering strategy to improve the algorithm's efficiency by avoiding local search operations on the least promising solutions. The algorithm is tested with 855 instances of the asymmetric TPP and 190 instances of the symmetric TPP. Computational results prove the benefit of including the Path Relinking and Filtering strategies and suggest that the purchase-first constructive procedure is the most competitive in terms of objective function value with little extra effort in execution time with respect to the other constructive procedures. Our results outperform published results for the asymmetric TPP in a statistically significant way and show competitive performance for the symmetric TPP.

Keywords: GRASP; Path-Relinking; traveling purchaser problem

1. Introduction

The Traveling Purchaser Problem (TPP) considers a set of products to be purchased and a set of markets that offer the products at different prices. The objective is to find a tour that minimizes the cost of buying all the products and the cost of visiting the selected markets. Formally, consider a depot ($\{0\}$), a set M of markets, and a set K of products. The TPP can be defined on a graph

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Simulation of photo-voltaic power generation using copula autoregressive models for solar irradiance and air temperature time series

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Simulation of photo-voltaic power generation using copula autoregressive models for solar irradiance and air temperature time series

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ABSTRACT

We propose a methodology for synthetic generation of solar irradiance (shortwave flux) and air temperature time series using copula functions. The use of copulas for the simulation gives flexibility to represent the serial stochastic variability of the solar irradiation and the air temperature affecting the photo-voltaic (PV) panel energy output. Moreover, it allows to have more control on the desired properties of the time series, not only in the temporal and cross-dependencies, but also in the marginal distributions. We use mixtures of zero mass adjusted density distributions to assess the nature of solar irradiance, alongside vector generalized linear models for the bivariate time series time marginal distributions. We found that the copula autoregressive methodology used, including the zero mass characteristics of the solar irradiance time series, accurately models the stochastic phenomena. Experimental analysis with observed data substantiates the usage and convenience of the proposed methodology to model solar irradiance time series and solar energy across the northern hemisphere, southern hemisphere and equatorial zones. These results will improve the understanding of the fluctuating nature of solar irradiance and also help to understand the underlying stochastic process of photo-voltaic energy production.

1. Introduction

Renewable energy resources, such as wind and sunlight, are considered fundamental elements in the effort to diminish global warming and different environmental hazards. Many countries are shifting their energy production portfolio in order to accomplish with a new context of sustainability and reducing the environmental footprint. As such, photo-voltaic (PV) energy has become one of the most popular renewable energy sources around the world [1]. However, PV energy is still a highly volatile source. Around 15% of solar irradiance is transformed into electricity during the operation of the PV cells, as a consequence of their electrical efficiency being reduced by the significant increase of cell temperature during the absorption of solar irradiance [2,3]. Moreover, the natural variability in solar irradiance, air temperature, and other variables that also affect the output, makes difficult the forecast and planning of these resources.

One of the main difficulties of photo-voltaic energy for electricity generation is the inherent variability of solar irradiance on the surface of the Earth. For example, for the integration of solar energy into the electricity networks, photo-voltaic power generation depends on weather and atmospheric fluctuations that cannot be incorporated directly into energy production systems [4,5]. Accurately modeling the stochastic nature of the local solar variability is indispensable to estimate the solar photo-voltaic effect on an energy distribution grid [6,7]. In particular, reliable methods are necessary for synthetic generation and forecasting of short and long-term solar irradiance time series in order to improve the design of power systems and measurements of their risk of operation [8]. These simulated series can be used for numerical analysis of complex systems on a wide range of applications, in particular for the design of renewable energy systems that require long series of data [9,10]. In addition, although air temperature has less challenges in the modeling of its stochastic nature, a joint distribution approach for both time series would be precise in order to evaluate energy production.

Stochastic models of hourly solar irradiance time series are used to forecast future values of the series and to generate synthetic strings of data that can be used as artificial realizations that emulate the natural variability on which numerical analysis can be

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Network analysis of collaboration in networked universities

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Page 1 of 53 Kybernetes

Network Analysis of Collaboration in Networked Universities

Abstract

Structured Abstract:

Purpose: In Latin America and the Caribbean, the access of students to higher education has presented an extraordinary growth over the past fifteen years. This rapid growth has presented a challenge for increasing the system resources and capabilities while maintaining its quality. As a result, the Networked Universities (NUs) organized themselves as a collaborative network, and they have become an interesting model for facing the complexity driven by globalization, rapidly changing technology, dynamic growth of knowledge, and highly specialized areas of expertise. In this article, we studied the NU named Red Universitaria Mutis (Red Mutis) with the aim of characterizing the collaboration and integration structure of the network.

Design/Methodology: Network analytic methods (visual analysis, positional analysis, and a stochastic network method) were used to characterize the organizational structure and robustness of the network, and to identify what variables or structural tendencies are related to the likelihood that specific areas of a university would collaborate.

Findings: Red Mutis is a good example of regional NUs that could take advantage of the strengths, partnerships, information, and knowledge of the regional and international universities that form the network. Analyses showed that Red Mutis has a differentiated structure consisting of academic and non-academic university areas with a vertical coordination (by steering and management) of the different university areas.

Originality/value: The methodology could be used as a framework to analyze and strengthen other strategic alliances between Universities, and as a model for the development of other NU in local and global contexts.

Keywords: Collaboration, network analysis, complex systems, Networked Universities, inter-organizational relationships, Exponential Random Graph model.

Introduction

Over the last decade, Networked Universities (NUs) have emerged as a response to globalization and the increasing demand of higher education (Knobel *et al.*, 2013; Selingo, 2017). Alliances among universities in areas from academics to administrative management have become determinant for assuring quality of teaching and research. Other benefits of building NUs include: innovation, cost savings, strategic network solutions, benefits of size without increasing capacity and exchange of good practices. NUs can become more efficient as they share structures that capitalize on each university's strengths (Selingo, 2017). These network structures are particularly important to study due to their specific characteristics: an integrated culture (especially, innovation

Is the built-environment at origin, on route, and at destination associated with bicycle commuting? A gender-informed approach.

19/06/2021

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Is the built-environment at origin, on route, and at destination associated with bicycle commuting? A gender-informed approach☆

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ABSTRACT

There is limited evidence on the gender differences and location-specific built-environment factors associated with bicycling in Latin American cities. This study aimed to assess commuting in Bogotá by (1) analyzing the gender-specific trend of the standardized number of bicycle commuters during 2005–2017; and (2) assessing the socio-demographic, community, built-environment and natural factors associated with bicycle commuting stratified by gender. This secondary-data analysis included data from the Household Travel Surveys and Multipurpose Surveys to calculate the number of bicycle commuters per habitant from 2005 to 2017 by gender. We assessed the socio-demographic and built-environment factors fitting generalized additive models stratified by gender using the 2015 Household Travel Survey. Although both women and men increased the standardized number of bicycle commuters, male commuters show a steeper trend than women, evidencing the widening gender gap in bicycle commuting over time. Bicycle commuting was negatively associated with household motor vehicle ownership, steeper terrain slope, longer commute distance, and scarce low-stress roads at trip origin and route. Among women, the availability of bike paths at the trip destination was positively associated with bicycling, while age and being a student were negatively associated with bicycling. Among men, living in areas with the lowest socio-economic status was positively associated with bicycling, while having a driver's license and living close to bus rapid transit stations were negatively associated with bicycling. In conclusion, bicycle and transport infrastructure play different roles in commuting by bicycle by gender and trip stages (origin – route – destination).

1. Introduction

Bicycle commuting has multiple health benefits, including the promotion of physical activity (Fishman et al., 2015), the prevention of non-communicable diseases (Taddei et al., 2015), and the reduction of perceived stress (Avila-Palencia et al., 2017). Among women bicycling has been associated with improvements in self-esteem, empowerment, feelings of freedom and autonomy (Lira, 2020). Bicycling is one of the most resource-effective urban transport modes with small space usage, low costs of user-entry and public infrastructure (Pucher and Buehler, 2017; Tranter, 2018). Bicycling also contributes to reducing traffic congestion and car use (Fishman et al., 2014; Wang and Zhou, 2017). Moreover, bicycling is an environmentally and socially sustainable transport mode, contributing to reductions in greenhouse gas emissions (Buehler and Pucher, 2012; Lovelace et al., 2015; Verma et al., 2016). Several governments, public health agencies, and the United Nations have recognized the importance of the bicycle's in achieving the Sustainable Development Goals (The United Nations, 2018).

Despite the multiple benefits of bicycling, the assessment of socio-demographic and built-environment factors encouraging bicycling

☆ This study was approved by the Ethics Committee at Universidad de Los Andes (Acta No.806 – 2017).

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From causal loop diagrams to future scenarios: Using the cross-impact balance method to augment understanding of urban health in Latin America

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From causal loop diagrams to future scenarios: Using the cross-impact balance method to augment understanding of urban health in Latin America

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ABSTRACT

Urban health is shaped by a system of factors spanning multiple levels and scales, and through a complex set of interactions. Building on causal loop diagrams developed via several group model building workshops, we apply the cross-impact balance (CIB) method to understand the strength and nature of the relationships between factors in the food and transportation system, and to identify possible future urban health scenarios (i.e., permutations of factor states that impact health in cities).

We recruited 16 food and transportation system experts spanning private, academic, non-government, and policy sectors from six Latin American countries to complete an interviewer-assisted questionnaire. The questionnaire, which was pilot tested on six researchers, used a combination of questions and visual prompts to elicit participants' perceptions about the bivariate relationships between 11 factors in the food and transportation system. Each participant answered questions related to a unique set of relationships within their domain of expertise.

Using CIB analysis, we identified 21 plausible future scenarios for the system. In the baseline model, 'healthy' scenarios (with low chronic disease, high physical activity, and low consumption of highly processed foods) were characterized by high public transportation subsidies, low car use, high street safety, and high free time, illustrating the links between transportation, free time and dietary behaviors. In analyses of interventions, low car use, high public transport subsidies and high free time were associated with the highest proportion of factors in a healthful state and with high proportions of 'healthy' scenarios. High political will for social change also emerged as critically important in promoting healthy systems and urban health outcomes.

The CIB method can play a novel role in augmenting understandings of complex urban systems by enabling insights into future scenarios that can be used alongside other approaches to guide urban health policy planning and action.

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Estimation of prevalence and Incremental Costs of Systemic Lupus Erythematosus in a middle-income country using machine learning on administrative health data

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Economic Evaluation

Estimation of Prevalence and Incremental Costs of Systemic Lupus Erythematosus in a Middle-Income Country Using Machine Learning on Administrative Health Data

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ABSTRACT

Objectives: Systemic lupus erythematosus (SLE) is a chronic, autoimmune disease that may cause physical and functional disability. The objective of this study is to measure prevalence and estimate incremental cost of SLE treatment using information from administrative databases in Colombia.

Methods: We use data from the patients on the Colombian contributive health system with a period of study from 2015 to 2017. The incremental cost of SLE is estimated using a matched study by propensity score and multivariate balance of covariates. To reduce the effect of possible specification problems, we use Extreme Gradient Boosting, a flexible machine learning algorithm. We use paired *t* statistical comparison and Bootstrap to validate the robustness of the method. In addition, we use a machine learning regression approach on the cost of control patients to achieve double robustness and compare the results.

Results: SLE prevalence ranges between 41.65 and 54.47 (cases/100 000), which is lower than other Latin American countries. Using the operative definition of SLE, 5527 patients were selected. The potential control sample was composed of 1 942 253 patients. The total annual direct estimated cost per patient was US $2172. Adjusted incremental cost was US $1662. Considering 4 severity classes of SLE, the cost ranges from US $8823 for severe to US $447 for mild cases.

Conclusions: Incremental costs of SLE in Colombia are similar to those from other middle-income countries. Compared with high-income countries, the cost is lower; nevertheless, if it is calculated proportional to the per capita health expenditure, it is comparable.

Keywords: administrative databases, machine learning, medical cost, observational study, systemic lupus erythematosus.

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Introduction

Systemic lupus erythematosus (SLE) is a chronic, autoimmune disease, with a complex pathogenesis that potentially might cause physical and functional disability because of its multiple manifestations with different levels of severity and with multisystem effects.[1] Half of patients with SLE have a pattern of chronic disease activity,[2] whereas in others patients the disease manifests itself in a flare pattern, with an average annual flare per patient of one per year.[3] There is no cure for SLE; nevertheless, there are medical treatments to control the progression of the disease.[4]

Globally, SLE is more common in women than in men in a proportion of 9:1, and it is presented mainly in people between 15 and 45 years of age. Regarding ethnic factors, some studies have observed that prevalence of SLE changes for different groups. For example, it is greater in African, American, Asiatic, and aboriginal populations with the overall prevalence ranging from 3.2 per 100 000 in India[5] to 517.5 per 100 000 among Afro-Caribbean people living in the United Kingdom.[1,6] In Colombia, a recent study found an estimated SLE prevalence of 91.9 per 100 000, based on administrative databases. When considering sex, the prevalence was 204.3/100,000 for women and 20.2/100,000 for men.[7]

Regarding costs, the treatment burden of SLE is considered high. In the United States, it was estimated at $12 238 (adjusted to 2005 US dollars) as the incremental cost per year of a patient with SLE versus a patient without the disease.[8,9] Kan et al[10] also estimated a US $10 984 incremental annual cost in a US Medicaid population.[10] In contrast, it has been found that the severity of the disease, relapses, or flares have a direct impact in cost. The level of severity of the disease is considered high when a patient has an organ failure and chronic renal disease which may lead to renal replacement therapies and kidney transplantation.[8,9] In this regard, it was estimated that the medical annual cost for patients with SLE with renal insufficiency (nephritis) was US $46 862 greater than for non-SLE patients.[11]

In Colombia, a study from 2019 estimated the direct cost associated to SLE using claim data from 2 health insurers in the contributive health scheme (approximately 20% of the enrollees in

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Abstract

A substantial reform of undergraduate engineering education is necessary due to the increasingly complex and technologically driven workplace, political, and social arenas of the 21st century. Apart from technical skills, engineering students should acquire a broader set of essential skills through different student-centred learning approaches where engineering disciplines should be integrated with ethics and sustainability approaches in a more multidisciplinary environment. In response to these challenges, in this article we present a proposal for an undergraduate specialty in Society 5.0 for the School of Engineering at the University of Los Andes (Bogotá, Colombia). The specialty introduces students to the concept of Society 5.0 and provides essential and technical skills concerning selected technologies of the digital transformation age. The acquired knowledge is further applied to build prototypes for facing societal problems, and the proposed solutions are validated with respect to technical, ethical, and sustainability requirements. Given the deep social inequalities present in Colombia, and the increased ecological footprint in the country, we expect that the specialty increases the interest in the topic of Society 5.0, applies it in practice, and therefore contributes to the sustainable development of the country.

Keywords: Engineering education; Society 5.0; Ethics; Sustainability; Multidisciplinary education.

Kernel Joint Non-negative Matrix Factorization for Genomic Data

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Kernel Joint Non-Negative Matrix Factorization for Genomic Data

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ABSTRACT The multi-modal or multi-view integration of data has generated a wide range of applicability in pattern extraction, clustering, and data interpretation. Recently, variants of the Non-negative Matrix Factorization (NMF), such as joint NMF (jNMF), have allowed the integration of data from different sources and have facilitated the incorporation of prior knowledge such as the interactions between variables from different sources. However, in both NMF and jNMF, the factorization is carried out as a linear system, which does not identify non-linear patterns present in most real-world data. Therefore, we propose a new variant of jNMF called Kernel jNMF. This new method incorporates the factorization of the original matrices into a high-dimensional space. Applying our method to synthetic data and biological cancer data, we found that the method performed better in clustering and interpretation than the jNMF methods.

INDEX TERMS Data integration, kernel, joint matrix factorization, cancer.

I. INTRODUCTION

Integration of data from different sources has become an area of intense research. In health applications, for example, high-throughput omics technologies provide a wealth of information related to different types of molecular entities (e.g., DNAs, RNAs, proteins) about cells and organisms. The integration of this vast information for multiple individuals, such as those stored in The Cancer Genome Atlas (TCGA) [1] and The Cancer Cell Line Encyclopedia (CCLE) [2] projects, allows the identification of associations between different sources, and to find groups of related molecules across different layers of information. In addition, the use of machine learning methods to integrate these data opens a diverse field of possibilities to improve the discovery of patterns embedded in the original data [3], [4].

Among the strategies for multi-view integration of data, three main groups, based on dimension reduction and ensemble methods, stand out (early, intermediate, and late integration). In early integration, the matrices are concatenated to make feature selection or decomposed in principal components (PC) to create new variables used as input in some machine learning models. In intermediate integration, the data are initially processed individually, for example, using kernel functions to extract non-linear patterns of the data and use these patterns as input in an ensemble model. Finally, late integration consists of integrating ensemble models, where individual models are generated for each input, and then the results are integrated into a final model by voting or averaging strategies [5].

As in conventional machine learning, multi-view data integration can be classified as supervised or unsupervised methods. Among the unsupervised methods based on the Non-negative Matrix Factorization (NMF) technique, the joint NMF (jNMF) is the benchmark for intermediate integration [6]. While in the NMF, a matrix $\mathbf{X}$ is linearly factorized into two low-rank matrices (i.e., a base matrix $\mathbf{W}$ and a coefficient matrix $\mathbf{H}$), in the jNMF, this process is done simultaneously for different input matrices $\mathbf{X}_1, \ldots, \mathbf{X}_M$. The resulting factorized matrices correspond to a common base matrix $\mathbf{W}$ and as many coefficient matrices as the number of input matrices. The advantage of jNMF over NMF is that it allows finding the common centroids for all samples in the base matrix, whereas the clusters and co-clusters assignments in the coefficient matrix favor the interpretation of embedded patterns [7]. In addition, some extensions of jNMF may help the interpretation of clusters. This is the case of Orthogonal integrative NMF (iONMF), which uses an orthogonal-regularized penalty to avoid non-overlapping features within clusters providing interpretable models [8].

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A hybrid approach of simulation and metaheuristic for the polyhedra packing problem.

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A hybrid approach of simulation and metaheuristic for the polyhedra packing problem

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A B S T R A C T

This document presents a simulation-based method for the polyhedra packing problem (PPP). This problem refers to packing a set of irregular polyhedra (convex and concave) into a cuboid with the objective of minimizing the cuboid's volume, considering non-overlapping and containment constraints. The PPP has applications in additive manufacturing and packing situations where volume is at a premium. The proposed approach uses Unity® as the simulation environment and considers nine intensification and two diversification movements. The intensification movements induce the items within the cuboid to form packing patterns allowing the cuboid to decrease its size with the help of gravity-like accelerations. On the other hand, the diversification movements are classic transition operators such as removal and filling of pieces and enlargement of the container, which allow searching on different solution neighborhoods. All simulated movements were hybridized with a probabilistic tabu search. The proposed methodology (with and without the hybridization) was compared by benchmarking with all previous works solving the PPP with irregular items. Results show that satisfactory solutions were reached in a short time; even a few published results were improved.

1. Introduction

Cutting and packing problems (C&PP) have been an object of great interest within the computational geometry and operational research communities (Ma et al., 2018). These problems aim to maximize space utilization or minimize space waste when embedding a set of items within larger containers (Dyckhoff, 1990), and have numerous applications in 1D, 2D, and 3D, which may explain research communities' interest in solving them. Furthermore, applications of C&PP in 3D with irregular items happen in scenarios where the volume is limited and some components have to be tightly packed; for example, in automobiles' engineering design, for example, avionics (Romanova et al., 2018) and furniture transportation (Egeblad et al., 2010). An outstanding application of C&PP in 3D with irregular pieces is found in *additive manufacturing* (AM), in which the printing time is reduced when several pieces are placed within the AM machine's production volume (Egeblad et al., 2009). AM is also known as 3D printing and layer technology (Araújo et al., 2020); it is a set of technologies developed in the late 1980s (Wong and Hernandez, 2012), which allows the production of pieces with specific desired shapes. This is done by adding material layer-by-layer (Gebhardt and Hotter, 2016) without requiring other physical devices such as molds (Hague et al., 2004). This is a very time-consuming process; producing a piece can take hours or even days. However, production time can be decreased by printing several objects in one run of the machine. Thus, in order to minimize the production time, the placement of the pieces within the machine's production volume becomes a 3D packing problem. There is a lack of research in C&PP concerning 3D and irregularity in the items to be packed. Wäscher et al. (2007) found that there are fewer publications of C&PP in 3D than in 1D and 2D. Furthermore, Dyckhoff (1990) and Wäscher et al. (2007) found fewer publications of C&PP involving irregular shapes than regular ones. These differences in the number of publications may happen due to the complications that 3D and irregularity imply. 3D generally increases the solution space when compared to 2D and 1D, which increases the solution time. On the other hand, irregular shapes are more complicated to model than regular ones, which complicates the assessment of the interaction between items and makes it more time-consuming (Bennell and

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A Digital Twin Demonstrator to enable flexible manufacturing with robotics: a process supervision case study

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A *Digital Twin Demonstrator* to enable flexible manufacturing with robotics: a process supervision case study

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ABSTRACT

Manufacturing companies are facing different challenges. On the one hand, production is moving from mass-production to mass-customization and personalization. Reconfigurable-, adaptive- and evolving-factories are necessary to achieve the required flexibility. On the other hand, technology must be integrated with human skills to assist the operators in supervising and maintaining manufacturing plants with growing complexity. In line with the Industry 4.0 paradigm, a Digital Twin Demonstrator is proposed to support the supervision activity of the operator in the context of flexible manufacturing with robotics. The supervision is achieved through a Human-Computer-Machine Interaction (HCMI) enabled with the Digital Twin technology. The suggested demonstrator is implemented and validated using a lab case study where it is demonstrated how the proposed HCMI interaction enables 'close-to-real-time' supervision of the manufacturing system in its self-adaptation to production and environmental changes.

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Industry 4.0; flexible manufacturing; process supervision; Digital Twin; robotics

1. Introduction

Nowadays, production is moving from *mass-production* to *mass-customization and personalization* (lot-size-one) (Hu, 2013). *Manufacturing companies* are facing fierce pressure to cope with rapidly changing market demands for high product variety, small-lots of (mass-) customized products, and quick delivery requirements (Mindas & Bednar, 2016). Furthermore, the *economic sustainability* of manufacturing companies is based on the combination of high-performance and high-quality products with cost-effective productivity. Therefore, *reconfigurable-, adaptive-, and evolving-factories* are necessary to achieve small-scale productions in an economically viable way (Stump & Badurdeen, 2012).

Along with economic sustainability, social sustainability is considered a current challenge in modern manufacturing. One of the problems addressed by *social sustainability* is the one of integrating human skills with technology (Madonna et al., 2019). The

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Multi-project and Multi-profile joint Non-negative Matrix Factorization for cancer omic datasets

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Multi-project and Multi-profile joint Non-negative Matrix Factorization for cancer omic datasets

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Abstract

Motivation: The integration of multi-omic data using machine learning methods has been focused on solving relevant tasks such as predicting sensitivity to a drug or subtyping patients. Recent integration methods, such as joint Non-negative Matrix Factorization (jNMF), have allowed researchers to exploit the information in the data to unravel the biological processes of multi-omic datasets.
Results: We present a novel method called Multi-project and Multi-profile joint Non-negative Matrix Factorization (M&M-jNMF) capable of integrating data from different sources, such as experimental and observational multi-omic data. The method can generate co-clusters between observations, predict profiles and relate latent variables. We applied the method to integrate low-grade glioma omic profiles from The Cancer Genome Atlas (TCGA) and Cell Line Encyclopedia (CCLE) projects. The method allowed us to find gene clusters mainly enriched in cancer-associated terms. We identified groups of patients and cell lines similar to each other by comparing biological processes. We predicted the drug profile for patients, and we identified genetic signatures for resistant and sensitive tumors to a specific drug.
Availability and implementation: Source code repository is publicly available at https:/bitbucket.org/dsalazarb/mmjnmf/ - Zenodo DOI: 10.5281/zenodo.5150920.
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Supplementary information: Supplementary data are available at *Bioinformatics* online.

1 Introduction

Data fusion has become an area of interest in biological sciences (Nicora *et al.*, 2020) because it is possible to integrate data from different sources to describe and uncover new properties of an individual. For instance, consider a type of cancer known as low-grade glioma, a subtype of brain cancer caused by somatic mutations in glial cells. We can measure many molecules to obtain partial knowledge of the disease for that cancer, but a greater understanding of the system comes when a model integrates all the interactions between different sources.

Many machine learning strategies have been used to better understand the interactions of the various data sources. In general, these methods are focused on tasks such as drug repurposing, molecular interactions prediction, variable importance identification, etc (Subramanian *et al.*, 2020; Zitnik *et al.*, 2019; Huang *et al.*, 2017). Among these methods, non-negative matrix factorization (NMF), which factorizes a non-negative input matrix X into low-rank matrices known as the base matrix (W) and the coefficient matrix (H), have been used to integrate various types of data to solve the tasks mentioned above and others (Vitali *et al.*, 2018; Gligorijevic *et al.*, 2016; Yang and Michailidis, 2015; Zitnik and Zupan, 2015).

NMF methods have quite interesting properties for capturing patterns since they integrate a sparse and part-based representation of the data captured by two non-negative low-dimensional matrices (base and coefficient matrix). However, despite their usefulness, variants such as tri-factorization of non-negative matrices (NMTF) or joint factorization of non-negative matrices (jNMF) have taken a further step to include data from different sources and generate patterns or clusters based on this information, in addition to the possibility of predicting new links between

Optimal waterflooding management using an embedded predictive analytical model

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Optimal waterflooding management using an embedded predictive analytical model

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ABSTRACT

In the petroleum industry, there is an ever-increasing interest in oil recovery processes with high hydrocarbon extraction rates. One of the most common oil recovery processes is waterflooding, which involves the injection of water into a reservoir. This process is often challenging, as there is uncertainty in the reservoir's properties. In this paper, we propose an optimal waterflooding management methodology for setting the producer and injector wells conditions to maximize the net present value (NPV). Our methodology integrates a predictive analytical model, which models the reservoir performance and forecasts the production rates based on the producer and injector well operating conditions. We applied the methodology in an illustrative example with rock and fluid properties representative from a Colombian oil field. We compared the proposed methodology against two benchmark scenarios in which the bottom-hole pressure of the producer wells is kept low and constant over time, as it is a common operational practice in the oil fields. With the proposed methodology, the profit increases by 27.02%, the oil recovery factor increases by 12%, and the water cut reduces by 4%, over a ten-year planning horizon.

1. Introduction

From the total original oil in place (OOIP) worldwide, the average recovery factor (RF) is estimated to be 35% (Fragoso et al., 2018). Factors such as the depletion of the reservoir pressure and the rock and fluids properties (e.g., viscosity, capillarity, permeability) prevent the extraction of the 65% remaining oil (Walid Al Shalabi and Sepehrnoori, 2017). Increasing the RF by 5% would allow the extraction of 86,695 million barrels of oil from the current proven reserves (British Petroleum, 2019). This volume would represent 2.5 years of global supply with the current oil demand (British Petroleum, 2019). Therefore, to increase global oil reserves, it is critical to focus on improving the RF (Latil, 2015).

The hydrocarbon extraction process is classified into recovery stages according to the reservoir pressure and petrophysical properties (Kermit Brown, 1984). As shown in Fig. 1, there are three main categories: primary, secondary, and tertiary recovery. Primary recovery handles the oil flow by any natural drive mechanism to move the oil and gas to the wellbore using the reservoir energy (Ahmed, 2019b; Muskat, 1949). In secondary recovery, the injection of water or an immiscible gas is used to increase or maintain the reservoir pressure to displace the oil and gas to the wellbore (Ahmed, 2019a; Craig, 1971; Green and Willhite, 1998). Finally, in tertiary recovery, also known as enhanced oil recovery (EOR), an injected fluid is used to modify either the rock or fluid properties to increase oil and gas production and reservoir pressure (Ahmed, 2019a; Green and Willhite, 1998).

Each recovery process could extract different fractions of OOIP from the reservoir. Maričić et al. (2014) reported that the RF from primary, secondary, and tertiary recoveries range from 10%–30%, 25%–35%, and 5%–15%, respectively.

Although there exist different techniques to increase the RF, waterflooding has become the most common technique for secondary recovery (Walid Al Shalabi and Sepehrnoori, 2017). Its wide implementation is due to the availability of water for injection, the water displacement efficiency, the ease of the technique, and its high profitability (Castro et al., 2014). This recovery process might increase oil production rates that can reach RFs of up to 35% (Muggeridge et al., 2014). For example, in Bradford (Pennsylvania, US), the first field where waterflooding was applied, reported an additional 20% recovery

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Systems thinking concepts within a collaborative programme evaluation methodology: The Hermes Programme evaluation

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Systems thinking concepts within a collaborative programme evaluation methodology: The Hermes Programme evaluation

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Abstract

Introducing systems thinking concepts in the programme evaluation field has been mostly aimed at supporting the practice of evaluation, rather than towards making theoretical advancements in the evaluation field. This paper introduces ideas and principles from systems thinking at the theoretical and practical levels in the programme evaluation field as applied to a peace-building programme called the Hermes Programme in Colombia. This document demonstrates how systems thinking concepts and tools were used in the practice of evaluation. We show the theoretical development of the proposed evaluation and explain how its stages were carried out in evaluating the Hermes Programme. This paper also illustrates the benefits of using systems thinking in evaluation.

KEYWORDS

boundary critique, critical systems thinking, fourth generation evaluation, programme evaluation, systems thinking

1 | INTRODUCTION

As highlighted by several authors (e.g., Patton, 2017; Torres-Cuello et al., 2018), improvement of social conditions of individuals requires leaders and evaluators to develop critical evaluation thinking. Authors have acknowledged the need for 'thinking outside the box', noticing interconnectedness within systems, questioning boundaries, and moving from independence to interdependency (Patton, 2017). In satisfying the need for transformational change in evaluation and leadership, systems thinking—particularly Critical Systems Thinking (CST)—could make an important contribution.

Torres-Cuello et al. (2018) argue that efforts to introduce systems thinking concepts in evaluation, especially in programme evaluation, have been mostly directed towards supporting practice and not always towards creating theoretical advancements. The works of Burke (2006), Newman et al. (2003), Hart and Paucar-Caceres (2017) and Sharma and Gutierrez (2010) are practical examples of the use of systems thinking in evaluation. Writings of Imam et al. (2006), Reynolds (Reynolds, 2006; Reynolds, 2007), Cabrera & Colosi, 2008; Cabrera et al., 2008, 2015; Hummelbrunner (Hummelbrunner, 2006; Hummelbrunner, 2011), Patton (2011), Reynolds et al. (2012) and Williams and Van't Hof S. (2014) stand out among the several works that introduce theoretical advancements identifying systems thinking concepts and patterns to carry out evaluations more effectively. These concepts include perspectives, boundaries (or distinctions in terms of Cabrera), interrelationships and systems (see Torres-Cuello et al., 2018). Despite many noteworthy efforts to integrate evaluation theory into practice, and vice versa, an important gap persists (Christie, 2003; Christie et al., 2014; Miller & Campbell, 2006). Efforts to introduce systems thinking in evaluation are frequently perceived as incomplete or unclear (Gates, 2016). Additionally, there is a need for

Experimental evaluation and surface integrity analysis of cryogenic coolants approaches in the cylindrical plunge grinding

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Experimental evaluation and surface integrity analysis of cryogenic coolants approaches in the cylindrical plunge grinding

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Replacement of pollutant fluids with eco-friendly strategies in machining operations significantly contributes to protecting the environment, diminishing global warming, and ensuring a healthier workplace for employees. This study compares cryogenic coolants with conventional coolants in cylindrical plunge grinding using a Cubic Boron Nitride (CBN) wheel. Samples of 27MnCr5 steel used in the manufacture of automotive transmission components were ground using (i) Liquid Nitrogen (LN_2), (ii) a combination of LN_2 + Minimum Quantity Lubrication (MQL), and (iii) a conventional coolant. The effects of the different cooling methods on the surface integrity of the ground surfaces were examined in terms of surface roughness, microstructural defects, microhardness profiles, and residual stresses. In general, surface roughness was similar for the tested cooling systems, even after grinding three subsequent surfaces in which the process stability was analyzed. Interestingly, the use of eco-friendly cryogenic systems induced fewer microstructural defects than conventional systems, and particularly, LN_2+MQL lead to more compressive surface residual stresses that would improve the in-service performance of components. These results show opportunities for replacing conventional pollutant systems with eco-friendly cryogenic strategies for refrigerating/lubricating grinding processes to reduce harmful effects on the environment and pose health risks to operators.

Grinding is a finishing procedure used to achieve good dimensional accuracy and low roughness in mechanical components[1], especially for materials with challenging machining, like maraging steels, used in the automotive sector for powertrains[2] or aeronautics and astronautics applications like inertial navigation elements[3]. For this reason, grinding processes make up 25% of total machining operations[4]. The cost of finishing operations such as grinding is nearly 30% of the total manufacturing cost in a mechanical piece[1]. More importantly, from this 30%, between 7 and 17% of the cost is caused by coolant systems[5]. Traditional coolant systems are based on water-miscible cutting fluids, and their high spatial volume requires large storage capacity and high-powered pumps, which further increase the grinding costs[6]. In addition to this impact on the bottom line, coolant systems have a harmful effect on the environment and pose health risks to the operator. According to Hannu et al.[7], 80% of occupational medical issues correspond to the operator' contact with water-miscible coolant/lubricant fluids. Respiratory problems and skin diseases caused by contact with cutting fluids are the most common illnesses reported by machine operators[8].

To reduce these environmental, health, and cost issues in grinding operations, several approaches have been explored. For example, Minimum Quantity Lubricant (MQL) systems reduce the quantity of cutting oil used in the process by controlling the volume sprayed into the machining zone[9]. Other examples of eco-friendly solutions are the use of CO_2 and LN_2, in which some authors have found that the cryo-advantages of these solutions reduce temperature and forces in the grinding process without leaving contaminant fluids that are difficult to recycle[10]. For these reasons, cryogenic fluids applied to grinding processes are considered clean technologies[11]. Also, nowadays, the uses of Graphene Oxide (GO) nanosheets water-dispersible have been studied as a potential lubricant in abrasive processes[12].

Within this context, eco-friendly grinding has become more widespread over time because of stricter government environmental regulations to reduce global warming; these regulations have resulted in a significant

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Optimizing the metastability of high-strength ultrafine grained microstructure from large strain machining

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Optimizing the metastability of high-strength ultrafine grained microstructure from large strain machining

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Abstract

Ultrafine-grained (UFG) microstructure of Cu processed by large strain machining (LSM) is explored in order to create highly refined grain structures to achieve the highest strength while postponing the available nuclei for future recrystallization. The optimum solution is obtained theoretically using the Strength Pareto Evolutionary Algorithm (SPEA) and empirically using LSM. The thermal stability of the optimal solution is verified across the comparable LSM conditions using isothermal annealing curve. We also studied the kinetics of crystallization on the optimal solution using the Johnson–Mehl–Avrami–Kolmogorov (JMAK) theory. The optimal solution encountered leads to the latest time for the point where hardness start decline among a comparable sample conditions and lower the rate constant ($1/\tau$) among LSM conditions.

Keywords: Ultrafine grain; Severe plastic deformation; Microstructure; Stability

1. Introduction

Progressive microstructure refinement during Severe Plastic Deformation (SPD) follows the familiar progression through the creation of dislocation entanglements that involve small crystal misorientations. Progressive deformation leads to these interfaces that become increasingly refined and misoriented and thus, constituting effective barriers of dislocation slip, which strengthens the material. This strengthening at smaller levels of strain (usually < 4) is monotonic, but at larger strain values, saturates to characteristic values of yield strength and hardness. However, from a stability point of view, highly refined interfaces characterized by large misorientations are readily available nuclei for recrystallization when exposed to thermal agitation. Thermally induced growth of these nuclei leads to degradation of the material strength and compromises the utility of the Ultrafine Grained (UFG) and nanostructured materials from SPD. It is self-evident that postponing the nucleation and growth of the incipient nuclei is crucial for suppressing thermal degradation of material strength. Rampant of the nuclei during thermally induced coarsening microstructures leads to recrystallization of increasing fractions of the material, which involve large declines of material strength. According to this explanation, the question we seek to answer here is the possibility to create ultrafine-grained materials with maximize strength, but still suppressing the availability of nuclei for future recrystallization.

Nomenclature

b	burgers vector
B_ρ	constant
C_1	experimental constant
D_0	initial grain size
G	shear modulus
H	grain thickness in the normal direction

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Mapping the microstructure evolution of nickel deformed by orthogonal cutting

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Mapping the microstructure evolution of nickel deformed by orthogonal cutting

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Abstract

Severe plastic deformation prompted by orthogonal cutting is used to create deformed microstructures in commercially pure nickel machined under multiple cutting conditions. The resulting thermomechanical conditions, strain, strain rate, and temperature rise are calculated resulting in the final microstructure of the chip. The microstructure response is quantified for the generated defect during deformation, i.e. dislocation densities besides the microhardness. The dislocation density is measured using the X-ray diffraction peak broadening implementing the Williamson–Hall, and Williamson–Smallman methods. The microstructural consequences are examined through creating the rate-strain-microstructure (RSM) mappings using the Zener-Hollomon (Z) parameter. A 2D visualization of the microstructure response is acquired, and the effects of the strain and Ln(Z) on the measured dislocation densities and microhardness are discussed. The microstructural consequences are validated with the microstructure results reported in the literature over a wide range of Ln(Z) involving temperatures in the range from room temperature to 1420K.

Keywords: microstructure; dislocation density; machining; recrystallization; nickel alloys.

1. Introduction

High strength due to the highly refined microstructure is among the advantages that Severe Plastic Deformation (SPD) brings to the mechanical properties of metallic materials [1]. The hardened microstructure is constructed through the creation, movement, accumulation, and interaction of dislocations, in a substructure conformed of cell blocks defined by the cell diameter, the internal dislocation density, and the boundaries dislocation density [2]. The evolution of this structure is dictated by the deformation parameters, strain rate, and temperature, that stimulate the interactions of the dislocation substructure and defines the flow stress of the material. Although, the highly refined structure and the high strain produced by SPD also eases and promotes recrystallization. Despite the loss in strength that brings recrystallization, the advantages of the achievable structural heterogeneity are also of high value in the materials industry [3-5]. In [3] a review was made of the multiple structural designs that can be produced by SPD and Dynamic Plastic Deformation (DPD) followed by annealing treatment or partial recrystallization. Multiple structures can be created through complex processing methods, however, a strategy to design customized structures in metals from bulk samples is still incomplete.

A key step in the route to control the microstructure response is to understand and control the effects of the deformation parameters. Classical SPD processing methods have limited control of the imposed strain, strain rate, and temperature rise, besides the interactive effects of the strain rate and deformation temperature on the microstructure response. Alternatively, the deformation parameters accompanying machining make it a very interesting SPD process to analyze the microstructure response. Machining is recognized as a processing route to

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A methodology for temperature option pricing in the equatorial regions

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ABSTRACT

Weather derivatives are financial instruments that can be used by organizations or individuals to hedge risks associated with adverse weather conditions. Weather conditions can directly decrease profits by affecting the volume of sales or costs. This paper develops a methodology for temperature option pricing in equatorial regions. In this approach, temperature is forecast by combining deterministic and stochastic models. We find that forecasting daily temperature with a model that combines a truncated third-order Fourier series with a mean reversion stochastic process proves the most accurate for pricing the options. The methodology is calibrated with data gathered in Bogotá, Colombia, using Monte Carlo simulations.

1. Introduction

For over two decades, American, Asian, and European financial derivatives markets have traded weather derivatives, which hedge organizations and individuals against risks arising from different adverse weather conditions (Weber, 2009). Weather derivatives are used as part of risk management strategies to hedge the risk from non-catastrophic weather events (Alexandridis & Zapranis, 2012). The energy consumption, energy generation, agriculture, retail, travel, transportation, entertainment, government, and construction industries are the main economic sectors that use weather derivatives (Alexandridis & Zapranis, 2012; Chantarat et al., 2011; Elias et al., 2017; Islip et al., 2021; Jewson & Brix, 2005; Turvey, 2001).

The traditional choice for hedging risks has been the insurance market. However, in contrast to insurance contracts, weather derivatives are designed to (i) hedge against non-catastrophic weather events and (ii) avoid the usual hurdles of moral hazard issues (Alexandridis & Zapranis, 2012; Rappenglück et al., 2004).

In general, weather derivatives can be found in the form of futures, forward or option contracts, which depend on the values of underlying weather variables such as the temperature, rainfall, wind, solar irradiance, snowfall, and humidity (Cao & Wei, 2000).

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