Welcome from the President

Welcome to the 43rd Annual Conference of the *Operations Research Society of South Africa* (ORSSA). The venue for the 2014 conference is Stonehenge in Africa which is situated just outside of Parys in the Vredefort Dome - the largest and oldest known meteor impact site in the world.

The annual conference is a highlight in our Society's calendar and is organized this year by the Vaal Triangle Chapter of ORSSA. I would like to say a special thank you to Lieschen Venter, chair of the *Local Organizing Committee* (LOC) and her team for all the hard work and for organizing an excellent event.

The theme of the conference is *Accessible Analytics* and we have a full and exciting programme which promises to cater for every taste and preference. In addition to an impressive array of presentations we are also honored by three plenary keynote speakers; Professor Ted Ralphs from Lehigh University in Pennsylvania, Professor Andreas Bley from the University of Kassel in Germany and Professor Frans Waanders from the North-West University (Potchefstroom Campus) - a special word of welcome to these three speakers.

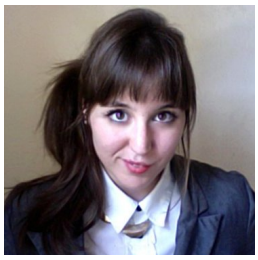
The LOC was able to secure a number of sponsorships and I would like to express my gratitude to those companies who generously helped to make the conference possible. Sponsorships were received from Sasol, Blue Stallion Technologies, OPSI Systems, AIMMS and the Centre for BMI at the North-West University in Potchefstroom.

I trust that you will all have a productive and enriching time at the conference and that you will also enjoy all the social aspects of the conference as well as the hospitality of Stonehenge in the historical Vredefort Dome.

Best wishes,

Hennie Kruger, President
Operations Research Society of South Africa

Welcome from the Chair of the Organising Committee



A warm and hearty welcome to the 43rd Annual Conference of the *Operations Research Society of South Africa* (ORSSA). I trust that you will have a fantastic time here on the banks of the Vaal River with old friends and new connections.

I extend a special welcome to our keynote speakers, Professor Ted Ralphs from Lehigh University in Pennsylvania and Professor Andreas Bley from the University of Kassel in Germany. Their talks will be based on the conference theme, *Accessible Analytics*. Professor Frans Waanders from North-West University will give us a greater appreciation of our location with his talk on the Vredefort Dome World Heritage area.

The conference program has a diverse tracklist and promises to cater for a wide range of interests while the social events will not disappoint thirsty networkers. The conference opens with a welcome function on registration day where sundowners will be served to delegates as they look out over the river. A mid-conference beer tasting function has been arranged from *The Dog and Fig Brewery*, a local brewery located on the *Klein Afrika* farm outside Parys. Five craft beers will be up for tasting: Wafferse (Wicked) Weiss, Baldadige (Boisterous) Buchu, an English IPA infused with the South African herb, Alternatiewe (Alternative) Alt, Aardige (Agreeable) Ale and the excellent Stewige (Sturdy) Stout. The social program will culminate in the award ceremony during the conference banquet where the ORSSA recognition awards and, of course, the Tom Rozwadowski Medal will be received.

I use the opportunity here to thank my Local Organizing Committee members for their tireless dedication during the past year. In this tiny team each individual spark of brilliance came together in perfect synergy to produce a fantastic outcome. Special thanks to our president, Hennie Kruger for his guidance and work on the conference proceedings and many thanks to our unofficial 7th committee member, Stephanie Greyling from *Stonehenge in Africa* without whom none of this would have been possible.

I hope that the conference exceeds your expectations and that you have a fantastic time in the Free State!

Best wishes,
Lieschen Venter
ORSSA 2014 Local Organising Committee

— *The ORSSA 2014 Local Organising Committee* —

1. Lieschen Venter, Chair (Sasol)
2. Fanie Terblanche (North-West University)
3. Esmi Conradie (Sasol)
4. Diki Langley (Sasol)
5. Michele Fisher (Sasol)
6. Preston Ferreira (Sasol)

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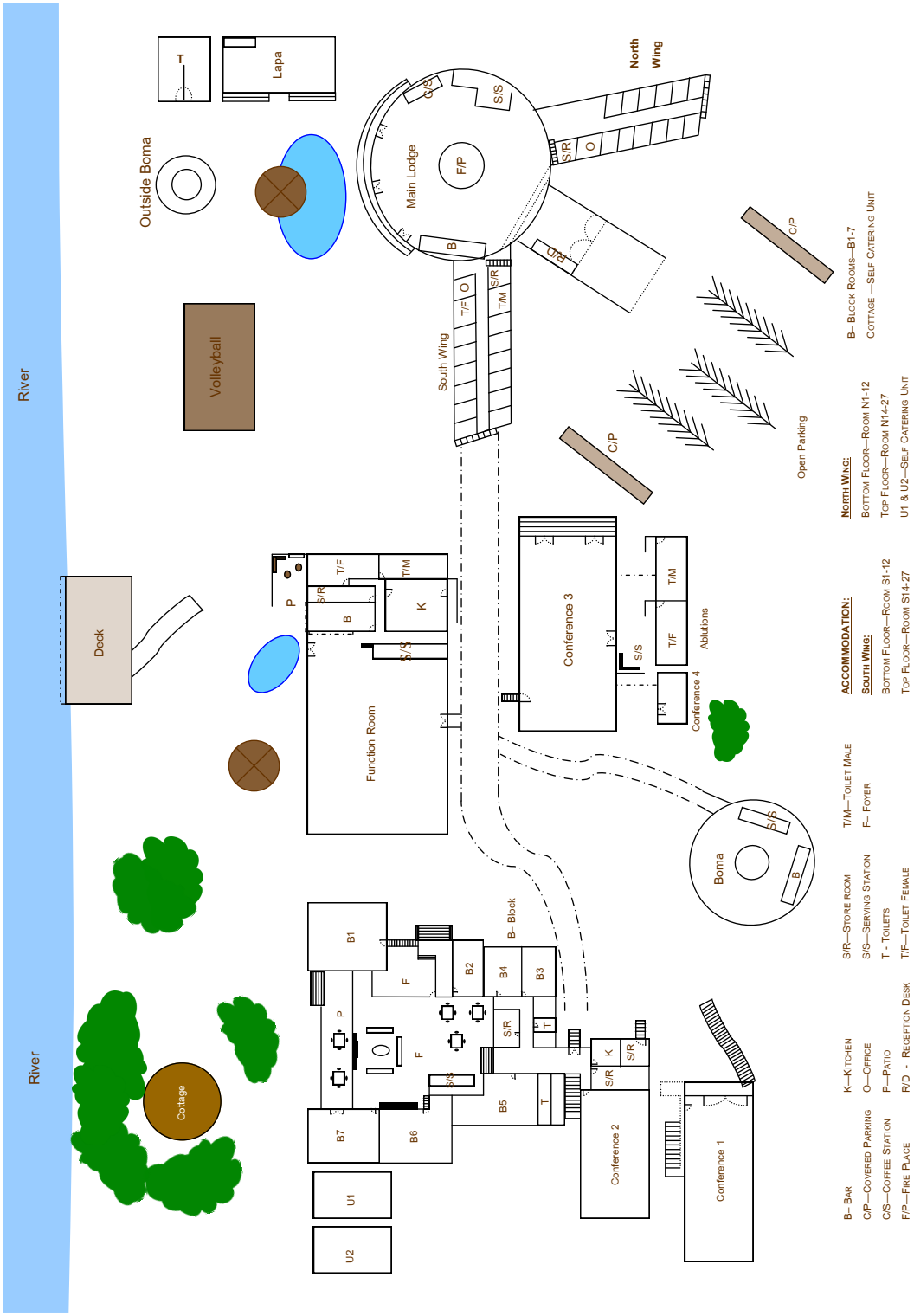

Monday 15 September 2014

08:00–08:30	*Onsite Registration (Main Lodge Foyer)*		
08:30–10:00	**Plenary Session A: Opening Keynote Address by Professor Ted Ralphs** (Conference 3)		
10:00–10:30	*Tea/Coffee (Conference 3 Serving Station)*		
10:30–12:00	I: OR in Development (Conference 1)	II: Maritime Applications (Conference 2)	III: Location & Scheduling Problems (Conference 3)
12:00–13:30	*Lunch (Main Lodge Serving Station)*		
13:30–15:30	IV: Optimization Under Uncertainty (Conference 1)	V: Energy & Sustainability (Conference 2)	VI: Forecasting (Conference 3)
15:30–16:00	*Tea/Coffee (Conference 3 Serving Station)*		
16:00–17:30	VII: Simulation (Conference 1)	VIII: ORSSA Executive Committee Meeting (Conference 2)	IX: Agriculture, Forestry & Land Use (Conference 3)
18:00–19:30	*Beer Tasting by The Dog and Fig Brewery (Lapa)*		

Tuesday 16 September 2014

08:30–10:00	X: Military Applications (Conference 1)	XI: Ecology & Environmental (Conference 2)	XII: Transport & Transportation (Conference 3)
10:00–10:30	*Tea/Coffee (Conference 3 Serving Station)*		
10:30–12:00	XIII: Production & Capacity Planning (Conference 1)	XIV: Heuristics & Metaheuristics (Conference 2)	XV: Combinatorial Optimization (Conference 3)
12:00–13:30	*Lunch (Main Foyer Serving Station)*		
13:30–15:30	XVI: Project Management & Finance (Conference 1)	XVII: Assorted Topics (Conference 2)	XVIII: ORSSA National Student Competition (Conference 3)
15:30–16:00	*Tea/Coffee (Conference 3 Serving Station)*		
16:00–17:30	**Plenary Session B: ORSSA Annual General Meeting** (Conference 3)		
19:00–	*Conference Banquet (Function Room)*		

Wednesday 17 September 2014

08:30–10:30	**Plenary Session C: Special Session with an Address by Professor Frans Waanders** (Conference 3)
10:30–11:00	*Tea/Coffee (Conference 3 Serving Station)*
11:00–12:30	**Plenary Session D: Closing Address by Professor Andreas Bley** (Conference 3)
12:30–13:30	*Lunch (Main Foyer Serving Station)*

— *Detailed Conference Programme* —

Sunday 14 September 2014

On-site Registration (13:00–17:00)
[Main Lodge Foyer]

Sunday 14 September 2014 (14:00–17:00)	
COIN-OR Optimization Suite Pre-Conference Tutorial [*Venue:* Conference 1]	
14:00–14:30	*Overview of the COIN-OR Optimization Suite*
14:30–15:30	*Formulating and solving LP's in Python (with PuLP and Coopr)*
15:30–15:45	**Coffee Break**
15:45–16:30	*Decomposition methods in Python (with DipPy)*
16:30–17:00	*Solver Studio in Excel*

Welcome Reception (15:00–18:00)
[The Deck]

Monday 15 September 2014

On-site Registration (08:00–08:30)
[Main Lodge Foyer]

Monday 15 September 2013 (08:30–10:00)	
Plenary Session A: Conference Opening *Chair:* Michele Fisher [*Venue:* Conference 3]	
08:30–08:40	**Lieschen Venter** (Chair, Local Organising Committee) *Welcome & announcements*
08:40–09:00	**Hennie Kruger** (ORSSA President) *Presidential address*
09:00–10:00	**Ted Ralphs** (Keynote Speaker) *Accessible Analytics* (p. 19)

Tea/Coffee (10:00–10:30)
[Serving station at Conference 3]

Monday 15 September 2013 (10:30–12:30)	
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10:30–11:00	**Lieschen Venter**, *Analysing the impact of intervention programs in education with the Inzalo Foundation Schools Leadership Model* (p. 22)
11:00–11:30	**Isabel Meyer**, *Decision support to enable sustainability in development projects* (p. 36)
11:30–12:00	**Marthi Harmse**, *Sustainability: From theory to practice* (p. 73)
Parallel Session II: Maritime Applications *Chair:* Stephan Visagie [*Venue:* Conference 2]	
10:30–11:00	**Jacques du Toit**, *Semi-automated maritime vessel activity detection using hidden Markov models* (p. 66)
11:00–11:30	**Alexandre Colmant**, *Solution representation for a maritime law enforcement response selection problem* (p. 70)
11:30–12:00	**Winnie Pelser**, *The role of "soft" methodologies in defence decision making* (p. 65)
Parallel Session III: Location & Scheduling Problems *Chair:* Danie Lötter [*Venue:* Conference 3]	
10:30–11:00	**Samuel van Loggerenberg**, *Decomposing the Connected Facility Location Problem* (p. 37)
11:00–11:30	**Berndt Lindner**, *Maintenance scheduling for the generating units of a national power utility* (p. 47)
11:30–12:00	**Andries Heyns**, *A multi-objective approach towards terrain-dependent facility location* (p. 52)

Lunch (12:00–13:30)
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Monday 15 September 2013 (13:30–15:30)	
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13:30–14:00	**Jean-Pierre Luhandjula**, *Mathematical programming problem with fuzzy random coefficients* (p. 48)
14:00–14:30	**Garebangwe Mabe-Madisa**, *A novel approach for multiobjective programming problems with fuzzy objective functions* (p. 54)
14:30–15:00	**Babooshka Shavazipour**, *Decision making with conflicting goals in an uncertain world* (p. 35)
15:00–15:30	**Johan Janse van Rensburg**, *Cognitive bias in decision-making* (p. 30)

Parallel Session V: Energy & Sustainability	
Chair: Mark Einhorn [*Venue:* Conference 2]	
13:30–14:00	**Mantombi Bashe**, *Analysing the South African generation fuel mix* (p. 23)
14:00–14:30	**John Dean**, *Analysis of Production Risk using the Energy Flow Simulator* (p. 24)
14:30–15:00	**Renée Koen**, *Developing long-term scenario forecasts to support electricity generation investment decisions* (p. 40)
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Parallel Session VI: Forecasting	
Chair: Margarete Bester [*Venue:* Conference 3]	
13:30–14:00	**Antoinette Erasmus**, *The size-mix problem for seasonal products: Stability of profiles and performance measures* (p. 69)
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Chair: Hennie Kruger [*Venue:* Conference 2]	
Parallel Session IX: Agriculture, Forestry & Land Use	
Chair: Anton de Villiers [*Venue:* Conference 3]	
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16:30–17:00	**Brian van Vuuren**, *Prerequisites for the design of an agent-based model for simulating the population dynamics of Eldana saccharina Walker* (p. 61)
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[Lapa]

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Tuesday 16 September 2013 (08:30–10:00)	
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Tuesday 16 September 2014 (10:30–12:00)	
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Tuesday 16 September 2013 (16:00–17:30)
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Conference Banquet (19:00–)
[Function Room]

Wednesday 17 September 2014

Wednesday, 17 September 2014 (08:30–10:30)	
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Tea/Coffee (10:30–11:00)
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— *List of Authors* —

— *Plenary Paper Abstracts* —

Opening Plenary: *Accessible Analytics*

Theodore K Ralphs
Industrial and Systems Engineering
Lehigh University, Bethlehem, PA
ted@lehigh.edu

Abstract

In the first part of this talk, we give an overview of the history and philosophy of the open source software movement, highlighting the ways in which it has increased accessibility of a wide variety of advanced technologies. In the second part, we discuss the evolution of the open source movement within the fields of Operations Research and Analytics, focusing on the COIN-OR project. To illustrate, we discuss some examples of the impact open source software has had on the field through case studies drawn from experience developing a number of open source software packages for solving operations research problems. These case studies demonstrate the power open source software has to enable creative problem-solving and to provide the means for individuals to effectively leverage existing state-of-the-art analytics methodologies in new and exciting ways.

Special Plenary:
The Vredefort Impact structure

Frans Waanders
School of Chemical and Minerals Engineering
North-West University, South Africa
frans.waanders@nwu.ac.za

Abstract

The impact structure of Vredefort is unique. A significant portion of the crater has been removed by erosion, but it still provides us with the only structurally intact exposure of a very large astrobleme. It affords the only mappable and restorable profile that illustrates the genesis and development of an astrobleme during the very short period of time after the impact. Vredefort shows a section that reaches from the rocks that once covered the crater floor, through the floor and down into the basement. It's about 2 023Ma old and is the largest crater on earth with a diameter of close to 380 kilometer. The central cone or "dome" must have reached a high of approximately 35 kilometer and exposed deep crustal rocks with an age of ca. 3 500 Ma and must have been the biggest single energy release event ever to occur on the surface of the earth. In 2005 UNESCO declared a representative portion of the Structure as a *World Heritage Site* (WHS). In this paper the history of formation and final declaration as a WHS will be discussed.

Closing Plenary:
Optimal Access - Recent advances in access network optimization

Andreas Bley
Mathematics and Natural Sciences
University of Kassel, Germany
andreas.bley@uni-kassel.de

Abstract

Todays societies heavily depend on functioning networks for traffic, telecommunication, electricity, and logistics, just to mention a few. The reliable and cost-effective functioning of these infrastructures has become an important factor for our economies and people, making efficient planning methodologies for these networks indispensable. In this talk, we discuss some of the recent advances in the methodologies for optimizing the access parts of these networks, which typically account for the bulk of the overall network cost.

Two of the major mathematical challenges in planning these networks arise from the often complex technical and operational restrictions that need to be respected and from the enormous size of the networks to be planned, which makes classical access network planning models invalid or computationally intractable. In the first part of the talk, we consider new variants of combined facility location and network design problems that include the most important structural constraints arising in telecommunication and logistics applications, such as modular and shared capacities and length restrictions. Combining techniques for approximating shallow-light Steiner trees, simultaneous approximation of shortest paths and minimum spanning trees, buy-at-bulk network design, and greedy coverings, we show how to efficiently compute solutions with proven quality guarantees for several fundamental variants of these problems.

In the second part of the talk, we present a computational solution approach based on integer linear programming and Lagrangian decomposition for one particular problem arising in the design of fiber optical telecommunication access networks. This approach enables practitioners to (approximately) solve very large problem instances with very little computing time. This of particular interest in the early stages of the long-term strategic network planning, when numerous planning scenarios with varying technological assumptions and demand, cost, or revenue predictions are evaluated in order to identify the most important parameters and make strategic decisions concerning technology vendors, the use of existing or new infrastructures, or the long-term evolution of the network. At this stage, fast computational methods are required to make optimization methodologies accessible to the practitioners.

— *Contributed Paper Abstracts* —

Adjusting the size-mix of products during stock allocation

Elmien Thom, Stephan E Visagie & Jason Matthews*
Stellenbosch University, South Africa
16036115@sun.ac.za, svisagie@sun.ac.za, & jmatthews@sun.ac.za

Abstract

Retailers typically order products from suppliers about six to ten months before they are available in the stores. After manufacturing, the products are shipped (usually from China or India) and transported to *Distribution Centres* (DCs) in South Africa. Distribution is then performed from the DCs to the different branches. Planning and allocation processes drive the movement of products through the distribution network. The planning process includes decisions about the order quantities and the size-mix of products, the order frequency of products and the distribution of products and product sizes to the different branches. During allocation, initial planning is adjusted using information of present sales that was not yet available during the planning phase. Decisions about how many units of each product to send to each branch, and more specifically, how many of each size of a product to send to each branch, are now finalised. Goal programming models are presented that can be used while making these allocation decisions. The objective is to ensure that each branch is sufficiently stocked with all sizes. Heuristic models were developed because computational times for exact formulations were too long. A case study from PEP, a major retailer in South Africa, will be presented.

Analysing the impact of intervention programs in education with the Inzalo Foundation Schools Leadership Model

*Lieschen Venter**
Decision Support
Sasol, South Africa
lieschen.venter@sasol.com

Marietjie M Vosloo
Inzalo Foundation
Sasol, South Africa
maria.vosloo@sasol.com

Abstract

The Sasol Inzalo Foundation is a public benefit organisation governed by an independent board of trustees. Its goal is to drive excellence in *science, technology, engineering and maths* (STEM) education at all levels of the education value chain.

The School Leadership program seeks to understand the effect of various school leadership and management intervention programmes by studying the effects of 10 very different programmes in different schools over the past 3 to 5 years. The schools are simulated by using a Systems Dynamics model where the model is initiated with a mix of narrative and quantitative data collected through so-called "learning clinics". Intervention programmes form the basis of what-if scenarios. Model results are used to illustrate the systemic nature of the education environment and school leaders are able to visualize the non-linearity, time dependence and interdependence of the impact of their decisions.

Analysing the South African generation fuel mix

Mantombi Bashe
Eskom, South Africa
bashem@eskom.co.za

Abstract

Markowitz's portfolio theory is applied to South Africa's electricity generation fuel mix. The results obtained suggest that SA's generation fuel mix is inefficient with high cost and high risk. It is proven that the reduction in the cost and risk of SA's generation fuel mix is linked to the reduction of the use of OCGTs.

Analysis of production risk using the Energy Flow Simulator

John F Dean & Gerhard L van Harmelen*
Enerweb EOH, South Africa
johndean@webafrica.org.za & gerhard@edd.eskom.co.za
V Ndlovu & Mantombi Bashe
Eskom, South Africa
ndlovuv@eskom.co.za & bashem@eskom.co.za

Abstract

This presentation describes a part of the Energy Flow Simulator software package currently being implemented by Enerweb (Pty.) Ltd for Eskom. Three modules were remodelled, namely the Production Planning module, a new Coal Delivery Module, and a revised Primary Energy module. The production plan produces the expected energy per station each week or month using a linear programming formulation. The delivery module creates monthly coal deliveries by station from the station coal burn and the Primary Energy module enables the effect of random risks in the station burns and deliveries to be modelled using a Monte Carlo simulation. As a result of this work, the risk of a coal stock-out at a station may be determined, and the outputs may be used in financial, as well as environmental calculation. These modules were integrated, and delivered to the user via the Shiny graphical web delivery framework of the R statistical computing language, being used to analyse scenarios such as a change in availability at one or more stations or the effect of a stock-out at a station on the rest of the system.

Application of stochastic and simulation modeling to resource utilization in a general ward at Lady Rodwell Maternity hospital in Zimbabwe

Amon Masache & Nelson Sibanda*
National University of Science and Technology, Zimbabwe
amon.masache11@gmail.com & nelsonsibbs78@yahoo.com

Abstract

Allocation of hospital beds presents an increasing challenge to hospital administrators. In order to minimize bed crises, managers and clinicians need a robust approach that can enable them to plan and provide appropriate health care to due pregnant women. In this study, weekly censuses of patients' admission and monthly length of stay were prospectively collected. A queuing model with a Coxian phase-type service distribution was developed to determine the general ward bed utilization, patients' rejection rate, expected floor beds and empty beds. The queuing model was validated by running a corresponding simulation model and results showed that bed utilization from both models were highly correlated (r=0.979). A scenario analysis was also performed to demonstrate how changing admission rates, length of stay and bed allocation influence bed utilization, rejection rates and cost incurred. An optimum bed utilization of 85% and expected floor bed of 1 with a rejection rate of less than 0.5% was found. A cost model was then built to obtain the average cost incurred so as to evaluate the cost effectiveness of using the queuing model developed. A recommendation was that if available beds were fully occupied then patients were to be transferred to a private ward where there was an average of five empty beds regardless of the cost incurred. It was concluded that Coxian phase-type service distributed queuing models can be used effectively and efficiently to minimize hospital bed crises.

Applications of Lazy Constraints in Mixed Integer Programming

Robert A Bennetto
OPSI Systems, South Africa
robert.bennetto.za@gmail.com

Abstract

Modelling complex optimization problems as tractable Mixed Integer Programs is a hard task. Lazy Constraints is a technique often used in heavily constrained optimization problems that does not require the explicit definition of all constraints apriori. This talk focuses on applications of this technique to variants of the Traveling Salesman Problem with discussion on the performance and quality of linear relaxations of the technique.

Applying the science of better on measuring and monitoring project performance

Ester J Vermaak
Decision Support
Sasol, South Africa
ester.vermaak@sasol.com

Abstract

Due to the changing and competitive environment of project management, companies may have to re-think their methods of measuring and monitoring the performance of large capital projects. Are traditional project management reporting techniques sufficient for monitoring and measuring complex, non-traditional projects? Can existing old-style project metrics detect a problem area early enough? Can modern monitoring techniques enhance project performance? The author will discuss these questions based on her experience of measuring project performance metrics at Sasol.

Automated radial basis function neural network topology selection for malicious URL detection

Dirk Snyman, Tiny du Toit & Hennie Kruger*
North-West University, South Africa
dirk.snyman@nwu.ac.za, tiny.dutoit@nwu.ac.za & hennie.kruger@nwu.ac.za

Abstract

Phishing attacks which employ URLs pointing to fraudulent resources are directed at end users in order to steal sensitive or identifying information. Attackers exploit many weaknesses of current methods used to detect malicious URLs. In this study malicious URLs are identified by a new automated RBF neural network construction algorithm. This technique uses an in-sample model selection criterion to determine the best neural network architecture. Example URLs from the Open Directory and Phishtank are utilized to train and test the neural network. Results obtained will be presented.

Binary programming for customer engagement plan optimisation

Colin A Phillips
OPSI Systems, South Africa
colin@opsi.co.za

Abstract

For a large company which sells multiple products to existing customers and the general public, Direct Marketing is often required. Given a universe of potential leads many orders of magnitude larger than can be activated, the decision of which customer to contact, which channel to use, and which product to sell quickly becomes intractable to solve manually or with rule-based approaches. A series of binary programming formulations is proposed, demonstrating several optimisations which were found to be necessary given time constraints.

Cognitive bias in decision-making

Johan Janse van Rensburg & Jan H van Vuuren*
Stellenbosch University, South Africa
johanjvrens@gmail.com & vuuren@sun.ac.za

Abstract

Decision-making is one of the basic cognitive processes by which a preferred option or a sequence of actions is chosen from among a set of alternatives based on certain criteria. Decision theories are widely applied in many disciplines encompassing cognitive informatics, computer science, operations research, economics, sociology, psychology, political science, and statistics.

A number of decision strategies have been used from different angles and application domains such as multi-criteria methods, maximum expected utility and the Bayesian approach to solve decision making problems.

However, there is still a lack of application of these methods to real world problems that also consider cognitive biases when making everyday decisions.

In the early 1970s, Amos Tversky and Daniel Kahneman introduced the term cognitive bias to describe peoples flawed patterns of responses to judgment and decision problems. Today there are now more than 93 known decision-making, belief, and behavioural biases, 49 know memory errors and memory related biases as well as 27 known social biases.

Examples of biases:

- The Framing effect drawing different conclusions from the same information, depending on how that information is presented.
- Anchoring the common human tendency to rely too heavily, or "anchor", on one attribute or piece of information when making decisions
- Contrast effect the enhancement or diminishing of a weight or other measurements when compared with a recently observed contrasting object.

This article presents a suggestion for how cognitive biases in the decision-making process can be minimized and how this can provide better results in conjunction with the mathematical model. The suggested process of decision-making may be applied in a wide range of decision-based systems such as decision support systems.

Comparing strategies for Risk

Pieter de Wet
Stellenbosch University, South Africa
15691640@sun.ac.za

Abstract

The game Risk has been a household favourite since 1959. It is a war based board game played on a map of the world divided into 42 territories. The game objective is to obtain global domination by conquering all 42 territories. Dice are used to determine the outcome of battles between players, therefore success is very dependent on luck. However, strategy still plays an important role in winning the game. The game is divided into different phases of play, each presenting multiple choices for the players to choose from, including which country to attack, how many dice to throw, where to place reinforcements, etc. These choices will be made according to each of the players' strategy of play. This study will identify and compare possible game strategies for a simplified version of Risk. This version will not incorporate all the variables of the original game, but will rather keep certain aspects fixed, thereby reducing the choices of the players and simplifying the game for easier analysis of the strategies. The strategies considered includes the initial placement of the soldiers, which continent to dominate first to increase chances of global domination, and when to trade in cards for extra reinforcements. The strategies will be compared by means of simulation modelling where artificial intelligence will be created to play according to each different strategy. The results of multiple simulation runs will be used to measure the success of the strategies and rank them accordingly. The simulation model and a summary of the results will be presented along with possible future work.

Comparison of multi-objective ranking and selection methods when doing simulation optimisation

Chantel von Saint Ange & James Bekker*
Stellenbosch University, South Africa
15675610@sun.ac.za & jb2@sun.ac.za

Abstract

Simulation optimisation can be both time-consuming and expensive, therefore efficiency in simulation remains a major area of research. Efficiency in simulation is essentially to obtain quality results with minimal effort. Ranking and selection procedures can improve simulation optimisation by minimising the number of simulation replications while ensuring the best system design. In most practical problems, more than one performance measure of a system is considered. This transforms the problem into a *Multi-Objective Ranking and Selection* (MORS) problem. Three methods have been identified in literature for MORS problems. These methods are the *Multi-objective Optimal Computing Budget Allocation* (MOCBA) algorithm, the *MOCBA with indifference-zone* (MOCBA_IZ) framework and the *two-stage-Pareto-set-selection* (TSPS) procedure. The MOCBA algorithm aims to maximise the probability of correct system design selection given a computing budget. The MOCBA_IZ framework incorporates the concept of an indifference-zone into the MOCBA. An indifference-zone is the smallest change in an objective function value that is significant to the stakeholder. An indifference-zone is not considered in MOCBA, resulting in a large amount of simulation budget being used to differentiate between designs that differ only slightly in their performances. From this issue arose the need to integrate the indifference-zone concept into the MOCBA algorithm. The TSPS procedure incorporates the indifference-zone concept to select a Pareto set of non-dominated solutions. The procedure minimises the required number of replications that will guarantee a desired probability that the solutions in the Pareto set are non-dominated. The purpose of this research is to apply and understand the current methods of MORS, and ultimately develop a new technique or adapt the current methods. This technique will be incorporated into the multi-objective optimisation using the cross-entropy method optimisation algorithm which currently does not utilize a ranking and selection approach to determine the best system design.

Complexity Theory and OR

Dave W Evans
MAC Consulting, South Africa
davevans@gmail.com

Abstract

Complexity theory provides interesting models of how organisations work. As most OR is carried out in an organisational setting to at least some degree, it is useful for OR practitioners to be aware of these models. This talk provides an introduction to complexity theory in the context of organisations and OR.

A computational and numerical analysis of stochastic programming heuristics across multiple software platforms

Thloni Masipa
Stellenbosch University, South Africa
thloni.masipa@rmb.co.za

Abstract

Decision making in any environment is typically filled with some level of uncertainty. Industry requires that decision makers accurately anticipate non deterministic factors that can affect their objectives. Stochastic programming is a mathematical framework for modelling optimisation problems that contain unknown parameters. The focus of this research is to evaluate heuristic algorithms that have been developed to solve stochastic programming problems and develop a new heuristic to solve a supply chain and a financial optimisationproblem. Supply chain and financial markets are two industries where optimisation is exposed to uncertainty, typically through uncertain demand or supply, random events or uncertain movements in prices. The newly developed algorithm will be tested across multiple software platforms in order to do a comparative numerical analysis of the solutions obtained and to refine the algorithm to the most suited computationally efficient version. The initial stage of the study is to do a thorough analysis of progressive hedging and Benders' decomposition techniques which are two fundamental algorithms used to evaluate multi stage stochastic programming problems. These two algorithms will be the benchmark algorithms from which the newly developed algorithm solutions will be compared. The software platforms to be used are C++, MATLAB and GAMS.

Decision-making with conflicting goals in an uncertain world

Babooshka Shavazipour & Theodor J Stewart*
Department of Statistical Sciences
University of Cape Town, South Africa
b.shavazipour@gmail.com & theodor.stewart@uct.ac.za

Abstract

In the past few decades, decision sciences under uncertainty, for example forecasting future market in significant competitive and unstable environments, has turned into a highly controversial issue amongst managers and policy makers. But what is the exact meaning of the uncertainty? How should we classify ranges of uncertainties? Can we develop deterministic models to solve the problems which have a different levels of uncertainty? How do we deal with high levels of uncertainties, when even probability spaces are not definable (deep uncertainty)?

It is contended by many authors that uncertainty takes on different meanings in various fields, needing different classifications.

On the other hand, multiple objectives with conflicting criteria create another area of complexity to be dealt with by decision makers. *Goal Programming* (GP) is a popular and powerful methodology for multiple objective decision making, especially during design and screening stages of strategy analysis. When decision makers face conflicting objectives in a context of substantial uncertainties, the complexity becomes much more extreme. Although a few GP-based approaches, such as stochastic goal programming and dynamic goal programming, have been proposed for addressing such complex problems, many of them are limited to the less deep areas of uncertainty.

This paper provides a review of goal programming methodologies in which uncertainty can be in both objective and constraint parameters. Furthermore, the different classifications of uncertainty in the afore-mentioned problems are introduced and compared in various real world applications. Some crucial issues and shortcomings of previous methods are highlighted and possible modifications are suggested.

Decision support to enable sustainability in development projects

*Isabel Meyer** & Mario Marais
Impact Advantage, South Africa
isabelmeyer@mweb.co.za & mmarais@csir.co.za

Abstract

A number of factors complicate the ability to deliver sustainably on development interventions. Multiple role players are involved, the performance of implementation agencies are measured over the short- to medium term and donors do not always take a holistic view of the long term impact of interventions on beneficiaries.

The development process is often presented in terms of a logic model, that consists of a chain of events from procurement of inputs, through translation of inputs to outputs, outcomes and impacts for the community. Along this chain, a number of implicit and explicit decisions affect the value that is ultimately delivered. These decisions are often uncoordinated, take place across multiple agencies and are guided by objectives that are not always explicitly linked to development outcomes. Throughout this process, scope exists to aid decision makers, through a simplistic set of decision models, to make better decisions. The emphasis is on decisions that support long-term value creation, and that enhance the sustainability of project outcomes. This paper explores the role of decision aiding in facilitating the sustainability of development projects. It focuses on the implementation of ICT interventions in rural South Africa, and the role of decision support for the selection of technology for rural education. It outlines the context of decision-making in rural education, the role and nature of technology selection decisions and the value addition of decision support tools for tablet selection.

Decomposing the Connected Facility Location Problem

Samuel van Loggerenberg, Melvin Ferreira & Leenta Grobler*
School of Electric, Electronic and Computer Engineering
North-West University, South Africa
20289278@nwu.ac.za, melvin.ferreira@nwu.ac.za &
leenta.grobler@nwu.ac.za

Fanie Terblanche
Centre for Business Mathematics and Informatics
North-West University
fanie.terblanche@nwu.ac.za

Abstract

With consumer internet bandwidth demand increasing at an exponential rate, telecommunication service providers are turning to cost effective fibre solutions, the most prominent of which is the *Passive Optical Network* (PON). Planning these networks are similar to solving the connected facility location problem, where a subset of interconnected deployed facilities, along with their respective allocated demand points, are chosen to minimise the overall deployment cost. This ILP problem proves to be NP-hard, with extensive computational effort required to solve even modestly sized networks, making it a good candidate for decomposition. Benders is used to decompose the problem into three parts: the ILP master problem and the feeder and distribution LP sub-problems. Both sub-problems are formulated using paths, and minimise the total capacity shortfall across all edges in the master, ensuring feasible routing. The distribution sub-problem ensures adequate capacity to route from a facility to a demand point, while the feeder sub-problem ensures the same for routes between the root node and opened facilities. Column generation is used to generate candidate routing paths for both sub-problems, further decreasing computational effort. Each sub-problem generates rows by separating metric inequality cuts derived from the dual, which are then added to the master problem at every node in the branch-and-cut tree with an integer incumbent solution. Early tests show promise of reducing computation time, as well as providing a minimal solution with feasible splittable flow routing.

Design of a detailed microscopic traffic simulation model

Mark D Einhorn & Jan H van Vuuren*
Stellenbosch University, South Africa
einhorn@sun.ac.za & vuuren@sun.ac.za

Abstract

There are numerous advantages to using simulation when investigating the effectiveness of novel traffic control strategies at signalised intersections. If the level of detail required for the investigation is not too demanding, a commercially available traffic simulation model may suffice. If, however, a high level of realism (such as the incorporation of explicit vehicle accelerations and decelerations, vehicle turning parameters, heterogeneous vehicle sizes) is required, it may be necessary to build a purpose-made traffic simulation model satisfying the specific requirements of the investigation. In this paper, a microscopic traffic simulation model is presented which may be employed as a stand-alone and customizable traffic simulation tool for testing the effectiveness of existing and novel self-organising traffic control algorithms, some of which require individual vehicle characteristics, such as vehicle speed, and their position on road segments as input data.

Determining optimal primary sawing and ripping machine settings in the wood manufacturing chain

Berndt G Lindner, PJ Vlok & Brand C Wessels*
Stellenbosch University, South Africa
15150526@sun.ac.za, pjvlok@sun.ac.za & cbw@sun.ac.za

Abstract

For wood manufacturers around the world, the single biggest cost factor is known to be its raw material. Thus maximum utilisation, specifically volume recovery of this raw material, is of key importance for the industry. The wood products industry consists of several interrelated manufacturing steps for converting trees into logs and logs into finished lumber. At most primary and secondary wood processors the different manufacturing steps are optimised in isolation or based on operator experience. This can lead to suboptimal decisions and a substantial waste of raw material. The objective of this study was to determine the optimal machine settings for two interrelated operations, namely the sawing and ripping operations which have traditionally been optimised individually.

A model, having two decision variables, was developed which aims to satisfy market demand at a minimal cost. The first decision was how to saw the log supply into different thicknesses by choosing specific sawing patterns. The second was to decide on a rip saw's settings, namely part priority values, which determines how the products from the primary sawing operation are ripped into products of a certain thickness and width. The techniques used to determine the machine settings included static simulation with the SIMSAW software to represent the sawing operation and mixed integer programming to model the ripping operation. A metaheuristic, namely the Population Based Incremental Learning algorithm, was the link between the two operations and determined the optimal settings for the combined process.

The model's objective function was formulated to minimise the cost of production. This cost included the raw material waste cost and the over- or under-production cost. The over-production cost was estimated to include the stock-keeping costs. The under-production cost was estimated as the buy-in cost of purchasing the under-supplied products from another wood supplier. The model performed well against current decision software available in South Africa, namely the Sawmill Production Planning System package, which combines simulation (SIMSAW) and mixed integer programming techniques to maximise profit. The model added further value in modelling and determining the ripping priority settings in addition to the primary sawing patterns.

Developing long-term scenario forecasts to support electricity generation investment decisions

Renée Koen & Thandulwazi Magadla*
Decision Support and Systems Analysis Research Group
CSIR, South Africa
rkoen@csir.co.za & tmagadla@csir.co

Abstract

Many decisions regarding capital investment in electricity generation technologies need to be made well in advance, usually when there is still a large amount of uncertainty regarding the favourability of future conditions.

There may be uncertainty about the amount of electricity required in future as well as the the variability in the demand, and both of these uncertainties can affect decisions pertaining to such capital investment decisions.

This paper presents an approach that uses multilevel models to develop scenario forecasts for South African load profiles (hour-to-hour changes in the electricity demand), which can then be used to support decisions regarding the electricity generation capacity required.

Although historical load profile patterns are known, there is uncertainty about how future patterns will deviate from historical ones.

By developing scenarios that represent different views about future load profile patterns, forecasts can be obtained for each scenario and, in turn, these scenario forecasts can be used to investigate the effect of changes in demand patterns on future electricity generation requirements.

The approach of using multilevel modelling to obtain long-term hourly forecasts for a particular scenario has not been seen elsewhere in the literature, but shows promise for providing appropriate support electricity generation expansion decisions.

Development of an optimiser for an energy flow simulator: Challenges and approach

Marc N Hatton & James Bekker*
Stellenbosch University, South Africa
hatton.mn@gmail.com & jb2@sun.ac.za

Abstract

An efficient energy generation capability is vital to any country's economic growth. Many strategic and operational decisions exist along the energy supply chain. Shortcomings in the South African energy production industry have led to the development of an *Energy Flow Simulator* (EFS). The simulator is claimed to incorporate all significant factors involved in the energy flow process, from coal to consumption. Production planning, weather bureau datum, primary energy supply, energy generation, consumption and system losses are included in the model. This paper serves three purposes: To summarise literature on simulation applied to energy generation, to provide an overview of the mathematical modelling techniques used in the EFS and to pave the path for the optimisation of the EFS. The primary objective of the optimiser is cost minimisation. The simulator has inherently complex, non-linear, stochastic, dynamic and combinatorial input. Therefore, the decision space becomes very large and exhaustive search methods become infeasible. Metaheuristics perform well in such environments as they are capable of achieving near optimal solutions within an acceptable time limit. This study applies the rapidly converging Cross Entropy Method metaheuristic. Initial results will be shown and the foundations to further optimisation will be laid.

EDC account placement optimization

Dewald F Engelbrecht & Werner S Britz*
RCS Group, South Africa
dewalde@rcsgroup.co.za & wernerb@rcsgroup.co.za

Abstract

The RCS Group (RCS) is a consumer finance business that offers its customers a range of financial services products under its own brand name and in association with a number of retailers in South Africa, Namibia and Botswana. The two primary business areas, in a highly competitive unsecure lending market, are cards and loans. Charged-off accounts are outsourced to an *External Debt Collector* (EDC) in an attempt to recover the amounts that are written off. The aim of this investigation is to review the allocation of these accounts at EDCs. Only first-time placements, which are newly charged-off accounts placed for the first time at an EDC, are considered. The main objective is to maximise the recoveries with consideration given to the number of charged-off accounts placed with each EDC. A linear-programming approach which results in a significant improvement in recoveries is presented.

Election 2014 Forecast

Hans W Ittmann
HWI Consulting, South Africa
hittmann01@gmail.com

Abstract

This paper will provide a brief overview of different types of elections and how these endeavour to represent electorates. A variety of election systems exist worldwide and these will also be outlined briefly. In addition the model that has been developed for forecasting the results of the South African natiotional and local elections will be discussed. The results of the national election as forecasted by the model in the most recent election in May 2014 will be analysed and compaired to the forecasts of previous elections. The impact of new parties, such as COPE in 2009 and the EFF in 2014, and the effect of these on the election forecasts will also be addressed.

The effect of combining reliability, availability and maintainability modelling and stochastic simulation modelling on production efficiency

F Jacques van der Westhuizen
Decision Support
Sasol, South Africa
jacques.vanderwesthuizen1@sasol.com

Abstract

For 60 years, Sasol has demonstrated its innovative spirit in the energy and chemicals sectors in South Africa and has grown to become the country's leading fuel provider and an international leader. Ensuring Sasol's success requires that complex operations be managed across value chains, business units, and sites. Sasol Technology's Decision Support Group applies a wide range of advanced analytics techniques including optimization, system dynamics, stochastic simulation, and *Reliability, Availability, and Maintainability* (RAM) modelling. Sasol is currently using these modelling techniques to good effect and has built numerous discrete-event simulation models. One of the major projects that contributed to Sasol's vision is its unique *gas to liquids* (GTL) value chain. Further, RAM modelling of key units in the production process, using Monte Carlo simulation, helps to minimize downtime of existing plants and supports decision making on new plants. Combining these two simulation techniques has provided an innovative way to support decisions. The value of these models has been repeatedly shown through improvements to the bottom line for many business units and sites. The two simulation techniques are stochastic modelling and RAM modelling. In essence, RAM modelling will be the input for stochastic modelling. This paper will prove that production efficiency is the sum of RAM modelling and stochastic simulation modelling.

Implementation challenges associated with a threat evaluation and weapon assignment system

Danie P Lötter & Jan H van Vuuren*
Stellenbosch University, South Africa
danielotter@sun.ac.za& vuuren@sun.ac.za

Abstract

A threat evaluation and weapon assignment system is typically employed in a militarysurface-based air defence environment to provide real-time decision support to fire controlofficers when they have to classify incoming aircraft as threats and evaluate the perceivedlevel of threat that they pose to defended assets on the ground. In addition, such a system isalso employed to aid the operator when he has to recommend the assignment(s) of availableweapon system(s) on the ground to neutralise these threats. In this paper, a brief reviewis given on the current state of a large research project in which a local threat evaluationand weapon assignment decision support system is designed for a surface-based air defenceenvironment. A number of shortcomings associated with this current system are identifiedand investigated. Possible ideas for overcoming these shortcomings are put forward.

An investigation into the effect of climatic factors on cotton output in Zimbabwe

Hausitoe Nare
National University of Science and Technology, Zimbabwe
hausitoenr@gmail.com

Abstract

This paper adopts the *Multivariate Adaptive Regression splines* (MARS) technique for prediction of cotton output in relation to climate variables namely temperature and rainfall. A trend and relationship between cotton and rainfall-temperature is studied and established. The percentage variation in cotton output attributed to rainfall and temperature is determined. The interactive combinations of rainfall and temperature that best give accurate estimates of cotton output are developed using MARS. An equation for prediction of cotton output using mean air temperature and mean annual precipitation based on MARS is developed. This study shows that the developed MARS is a robust model for prediction of cotton output in a rain-fed country like Zimbabwe.

Maintenance scheduling for the generating units of a national power utility

Berndt G Lindner & Jan H van Vuuren*
Stellenbosch University, South Africa
berndtlindner@gmail.com & vuuren@sun.ac.za

Abstract

Reliable energy provision is a major force in shaping the current and future economic welfare of South Africa. For a power utility one of the key focus areas is the planned preventative maintenance of the power generating units in its generation system so as to ensure that it is in a position to satisfy power demand in a reliable manner. In the *Generator Maintenance Scheduling* (GMS) problem, the objective is to find the schedule for the planned maintenance outages of generating units in a power system which minimises maintenance costs or maximises the probability of meeting a safety margin over and above the national power demand, which is a function of time. Previous work on the GMS problem includes the use of mixed integer programming and metahueristics, such as simulated annealing to find good generator maintenance schedules. This paper builds on previous work with the introduction of a decision support system design aimed at determining good generator maintenance schedules by taking into account the levels and qualities of coal stockpiles at generating units and unplanned loss factors, such as adverse weather conditions or transmission line failures.

Mathematical programming problem with fuzzy random coefficients

M Jean-Pierre Luhandjula
Department of Decision Sciences
University of South Africa, South Africa
luhanmk@unisa.ac.za

Abstract

We present a method for dealing with an optimization problem involving fuzzy random variables. A bridge is cast between fuzzy random variables and random sets. This correspondence allows us to obtain a stochastic optimization problem that is equivalent to our original mathematical program.This resulting stochastic program is then solved using Stochastic programming techniques. A numerical example is also presented for the sake of illustration.

Modelling approach for megaproject contingencies

Theodor J Stewart
University of Cape Town, South Africa
theodor.stewart@uct.ac.za

Abstract

It is a common if not universal phenomenon that large infrastructural problems experience substantial overruns of time and cost to completion. Such overruns invariably lead to severe criticism of responsible organizations and their project management. Recent experience in South Africa, such as the Medupi Power Station, illustrates such situations well. We shall review some literature on underlying causes. Although overruns may in part be due to inadequate (through lack of time or expertise or both) planning and allowance for the unexpected, another important contribution is seen to come from early pressures to trim cost estimates in order to improve acceptability of the proposal. In this paper, we describe the development of a systems dynamics modelling approach to understanding of the time and cost expenditure in projects such as power station construction in South Africa. The structure of the model is based partly on the literature we have reviewed, but also substantially on brain storming with local experts. Initial experience in model implementation and identification of data needs will be discussed.

Modelling biological control strategies for water hyacinth

Heléne van Schalkwyk
Stellenbosch University, South Africa
helenevschalkwyk@gmail.com

Abstract

The Amazonian water hyacinth, Eichhornia crassipes, has since the 1880s spread its roots across the USA and eventually the world, where it is now notorious for being the world's, as well as South Africa's, worst aquatic weed. One of the more successful methods of controlling this weed is biological control. Natural enemies are sought in the weed's native land, put through quarantine and then released in the new habitat where they feed on the weed, contributing to the suppression of populations. The direct release of *biological control agents* (BCAs) after quarantine is known as classical biological control. Another biological control method, making use of mass rearing technology once BCAs have been cleared from quarantine, has evolved. BCAs can be reared in very large numbers before they are released. In addition to this, this method also makes more frequent re-releases possible, speeding up biological control. In this study, a stage-structured plant-herbivore model is developed to mathematically describe the water hyacinth population growth and its interaction with the populations of the various life stages of the Neochetina eichhorniae weevil as BCA. The model is used to evaluate the cost effectiveness of mass rearing programs in biological control versus classical biological control, determining whether the faster decrease in water loss is worth the expenses pertaining to mass rearing programs. The model also provides guidance towards the optimal magnitude and frequency of BCA releases.

Modelling predator-prey interactions by cellular automata

Dirk J Human & Linke Potgieter*
Stellenbosch University, South Africa
dirk.human@gmail.com & lpotgieter@sun.ac.za

Abstract

In systems biology, one of the most well-known dynamics is the interaction between multiple species where some act as predators and the others as prey, known as predator-prey interactions. Modelling these interactions is important in fields such as conservation ecology as it would be significantly more cost-effective than traditional experimental observation. It alsoposes no actual threat to a real-life system which may be driven unstable by external influences. Since the first formal mathematical model introduced by Lotka and Volterra in the mid-1920s, several differential equation-based models have been developed to describethe predator-prey interaction. A key disadvantage in most of thesemodelsis that it isdifficult to add additional complexitiesandstill be able to analyse the results in a meaningful way. Also, although they give a good macroscopic view of a system, they are not well-suited for observing the microscopic interactions.

In recent years, with the increasing computational power brought by computers, predator-prey interactions have been modelled successfully using simulation models, making it possible to study more of the local interactions between individuals. A discrete simulation model known as a *cellular automaton* (CA) for modelling two-species predator-prey interactions is presented, specifically investigating the effect ofthebasic survival instincts known as predator pursuit and prey evasion. Individuals within the respective populations are given the ability to survey their surroundings and behave in such a way as to mimic evading a threat (prey evading predators) or actively seekdenseenergy sources (predators pursuing prey).

A summary of the most important results will also be presentedalong with ideas for future research.

A multi-objective approach towards terrain-dependent facility location

Andries M Heyns & Jan H van Vuuren*
Department of Logistics
Stellenbosch University, South Africa
andriesheyns@gmail.com & vuuren@sun.ac.za

Abstract

Facility location problems are well-documented in the Operations Research literature. The aim in these problems is to find an optimal allocation of facilities to candidate locations in order to maximise or minimise some objective function or set of objective functions typically minimising transportation costs and/or delivery times between the facilities and customer or service locations. Little or no consideration is usually given to the influence of surrounding terrain in existing facility location resolution techniques, since these are typically based on commercial and transportation modelling principles. It is, however, possible to adapt existing facility location techniques in order to accommodate placement criteria involving the physical terrain surrounding the facilities as well as a wide-ranging variety of environmental factors. These placement criteria may range from facility intervisibility or the individual or combined visibility of certain specified portions of terrain surface, to solar radiation potential, or even wind exposure based on historical data and terrain characteristics.

Terrain-dependent facility location problems documented in the literature typically involve only single-objective optimisation. The aim in this paper is, however, to model terrain-dependent facility location problems as a multi-objective decision problem. This model is then solved in the context of a realistic terrain-dependent facility location scenario in order to demonstrate its workability. This requires incorporating some subset of terrain and environment-dependent objectives into a multi-objective facility location decision framework and, as a proof of concept, solving the problem by approximating the Pareto-optimal front using a population-based metaheuristic search technique.

Multi-objective optimisation of a commercial vehicle complex network

Sumarie Meintjes & Johan J Joubert*
University of Pretoria, South Africa
sumarie.meintjes@gmail.com & johan.joubert@up.ac.za

Abstract

In this project we build on research that has been done by Joubert and Axhausen (2013), who built a commercial vehicle complex network for Gauteng. Two shortcomings are identified in the approach they followed. The first shortcoming is the approximations used to determine whether an activity formed part of a cluster. These approximations resulted in some activities to be assigned to the wrong clusters, and other activities to not be assigned to any cluster. The second shortcoming is that the completeness of the complex network was never explicitly considered when they evaluated the different combinations of input clustering parameters. We address the first shortcoming by generating a concave hull for each cluster. The concave hull envelopes all points in the cluster, and one can accurately determine whether an activity forms part of a cluster. To generate the concave hulls, we integrate the Duckham Algorithm with the existing clustering algorithm used by Joubert and Axhausen (2013). The first step of the Duckham Algorithm is to generate the Delaunay triangulation of the cluster. For some combinations of input clustering parameters, more than 2% of the clusters were degenerate. A degenerate Delaunay triangulation occurs when three or more points in a cluster are colinear (lie on a straight line), or when four points in a cluster are cocircular (lie on the circumference of a circle). No valid Delaunay triangulations can be generated for these clusters. We suggest to deal with these degeneracies by using the weighted average of the points as a reference to the cluster, instead of simply ignoring it.

We consider the completeness of the complex network as part of a multi-objective problem: we cannot maximise completeness without making a trade-off with computational complexity. We address this multi-objective problem by conducting a multiple response surface experiment and performing multi-objective evaluation by constructing two efficient frontiers. From the multiple response surface experiment, we found that the input clustering parameters (ϵ, p_{min}) that optimises the completeness of the complex network, while minimising the computational complexity, is (1, 2). From the multi-objective evaluation, we determined that in general, using $\epsilon = 1$ will result in an efficient point.

To conclude, we use input clustering parameters (1, 2) to build a commercial vehicle complex network in the Nelson Mandela Bay Municipality, and perform various network analyses on this network.

A novel approach for multiobjective programming problems with fuzzy objective functions

Garebangwe V Mabe-Madisa & M Jean-Pierre Luhandjula*
Department of Decision Sciences
University of South Africa, South Africa
mabemgv@unisa.ac.za & luhanmk@unisa.ac.za

Abstract

Many optimization problems in engineering and economics involve the challenging task of integrating simultaneously conflicting goals and imprecise data. In this paper we consider multiobjective programming problems where the picture is made complicated by the presence of fuzzy objective functions. A look at the literature reveals that existing approaches for handling these kinds of problems are computationally efficient but not effective. Here we propose an effective method for the above mentioned optimization problems. The main idea behind our approach is to take advantage of an Embedding Theorem for fuzzy numbers in a way to put the fuzzy problem into equivalent deterministic terms. The price for this effectiveness is quite high as the resulting deterministic program is computationally demanding. We then describe a Galerkin like scheme to tackle this complex deterministic optimization problem. A numerical example is also provided for the sake of illustration.

On q-criticality of graphs with respect to secure graph domination

Anton P de Villiers, Alewyn P Burger & Jan H van Vuuren*
Stellenbosch University, South Africa
14812673@sun.ac.za, apburger@sun.ac.za & vuuren@sun.ac.za

Abstract

A subset X of the vertex set of a graph G is a *secure dominating set* of G if X is a dominating set of G and if, for each vertex u not in X, there is a neighbouring vertex v of u in X such that the swap set $X\backslash\{v\} \cup \{u\}$ is again a dominating set of G.

The *secure domination number* of G is the cardinality of a smallest secure dominating set of G. Applications of the notion of secure domination are obvious: If the vertices of G denote locations on some spatial domain, and the edges modellinks between these locations along which patrolling guards may move,then a secure dominating set of G represents a collection of locations at which guards may be stationed so that the entirelocation complex modelled by G is protected in the sense that if asecurity concern arises at location u, there will either be a guard stationed at thatlocation who can deal with the problem, or else a guard dealing withthe problem from an adjacent location v will still leave thelocation complex protected after moving from location v to location$u$ in order to deal with the problem.

In this scenario the securedomination number represents the minimum number of guards requiredto protect the entire location complex. A graph G is *q-critical* if the smallest arbitrary subset of edges whose removal from G necessarily increases the secure domination number, has cardinality q. The notion of q-criticality is important in applications such as the one mentioned above, because it provides threshold information as to the number of edge failures (caused by an adversary) will necessitate the hiring of additional guards to secure the location complex.Denote the largest admissible value of q for any q-critical graph of order n as Ω_n. It has previously been established that $\Omega_2 = 1$, $\Omega_3 = 2$, $\Omega_4 = 4$, $\Omega_5 = 6$ and $\Omega_6 = 9$. In this paper we present a repository of all q-critical graphs of orders $4, 5, 6$ and 7 for all admissible values of q and we also establish the previously unknown values $\Omega_7 = 12$ and $\Omega_8 = 17$.

On the importance of behavioural Operational Research

Raimo P Hamalainen
Systems Analysis Laboratory
Aalto University Finland
raimo@hut.fi

Abstract

This talk points out the need for *Behavioral Operational Research* (BOR) inadvancing the practice of OR. So far,in OR behavioral phenomena have been acknowledged only in behavioral decision theory but behavioral issues are always present when supporting human problem solving bymodeling. Behavioral effects can relate to the group interaction and communication when facilitating with OR models as well as to the possibility of procedural mistakes and cognitive biases. The acknowledment of behavioural effects in modeling is of importance as OR methods are being increasingly used in addressing important problems of the whole mankind like climate change.

Optimisation modelling for energy efficiency at Sasol

Malcolm J Murray
Decision Support
Sasol, South Africa
malcolmjamesmurray@gmail.com

Abstract

Production units at Sasol Secunda use significant amounts of steam and electricity. Steam is produced from coal-fired boilers, and from some process units. Electricity is produced using steam-driven generators and natural gas turbines, and additional electricity is imported to make up any shortfall. Sasol is placing strategic emphasis on reducing energy consumption. Besides making equipment more efficient, savings can also be achieved by planning production with energy efficiency in mind. Sasol uses linear optimisation models implemented in Aspen PIMS for its production planning. A project was undertaken to overhaul the energy representation in these models, so that the overall optimal plan takes energy costs into account. This involved modelling hundreds of energy consumption relationships across the factory, and the way they all fit together. This presentation summarises some of the lessons learnt along the way.

Optimising returns by scheduling visits with the use of optimisation and clustering on a practical problem

Margarete J Bester
X*Tranda* University, South Africa
mbester@XTranda.com

Abstract

In 2012 X*Tranda* performed an investigative analysis as well as a route optimisation solution for a company called OTD that does the distribution of Media24 products. The *Retail Field Coordinator* (RFC) optimisation project was segmented into three sections. This talk forms part of the delivery of Phase B of the project. The purpose of this phase was to determine the number of visits that is needed per shop per day depending on the benefits of an RFC determined in Phase A of the project. In this Phase B, the optimal day to visit a shop was determined, thus minimizing the amount of travel and optimizing the results of the visits. GIS data was used to determine which shops should ideally be clustered together based on distance. RFCs were then assigned to clusters in an optimal manner. Each RFC was provided with routes for their scheduled days, which group the shops into clusters and assign the RFC unit to the optimal route. After running the model, it was determined that an improvement between 58% and 89% on service level agreements could be obtained from this project analysis. At the same time, the expected increase in sales levels is approximately 243%, which gives an increase in sales of around R 17.7 million per annum. A number of different scenarios were tested and decisions regarding implementation could be taken.

ORSSA Lean Analytics Meet-up

Angela Rademeyer
ORSSA, South Africa
angela.rademeyer@gmail.com

Abstract

Meet-ups bring people together to learn something, do something and share something. These meetings are arranged through a site called Meetup (www.meetup.com), and follow an agenda-less format developed in Seattle called Lean Coffee. The core idea is to be able to host peer discussions of between 5-10 people without necessarily requiring anyone to prepare or be in charge of the meeting itself. At the start, attendees submit topics they would like to discuss with the group. Each person then provides a short introduction to their topics, and then everyone votes on them in order to prioritise the order in which they will be discussed. The discussion then focusses on each topic in turn and runs for about 5 minutes, after which a quick visual poll is conducted to establish if the group should continue the discussion or move to the next one. This allows time to be spent on topics that people are finding the most interesting during the course of the 1.5-2 hour long meeting. This simple lightweight format provides a forum for people involved in Operations Research and Data Analytics to make contact with people who share a common curiosity and passion for the fields in which they work. Given the current hype around big data and the increasing sophistication of tools available, ORSSA has decided to take advantage of the current interest in these fields by hosting and facilitating a series of meet-ups around the country. This will enable people to find out about the role ORSSA plays in both academia and industry, and for ORSSA to understand and receive feedback on the issues faced by people engaged in problems which fall under its scope. This session will enable you to experience a meet-up and perhaps you'll decide to attend or even start one in your own area.

Prerequisites for the design of a threat evaluation and weapon assignment system evaluator

M Louw Truter & Jan H van Vuuren*
Stellenbosch University, South Africa
16057694@sun.ac.za & vuuren@sun.ac.za

Abstract

In a military air-defence environment, ground weapon systems are responsible for defending assets against hostile aerial threats. To be able to fulfill this purpose, the weapon systems are equipped with an array of sensors capable of detecting aerial threats. In this context, the purpose of a *threat evaluation and weapon assignment* (TEWA) system is to provide decision support to operators tasked with weapon system assignment decisions, enabling them to make optimal use the weapon systems. A TEWA system is responsible for evaluating the treats and consequently assigning relevant threat values to them. After the severity of a threat has been determined, these threat values are then used by the system to generate a recommended list of weapon system assignments in such a way that the cumulative survival probability of the aerial threats is minimized. A large number of TEWA systems are already in use around the world, but due to the confidential nature of this research area, the workings of these systems are not available in the open literature. Despite the critical role of these systems, there exist no standard methods in the open literature to evaluate the performance of TEWA systems. In this paper, the threat evaluation and weapon assignment subsystems of a TEWA system are briefly described, and this is followed by a proposed TEWA system architecture. Furthermore, various factors that potentially influence the effectiveness of a TEWA system are highlighted, and a methodology is proposed for evaluating the performance of a TEWA system within a simulation modelling paradigm.

Prerequisites for the design of an agent-based model for simulating the population dynamics of Eldana saccharina Walker

Brian J van Vuuren, Linke Potgieter & Jan H van Vuuren*
Stellenbosch University, South Africa
16057651@sun.ac.za, lpotgieter@sun.ac.za & vuuren@sun.ac.za

Abstract

Despite consistently ranking as one of the top sugar producing industries in the world, profit margins of the *South African Sugar Association* (SASA) are still threatened by *Eldana saccharina* Walker (Lepidoptera: Pyralidae). This stalk borer pest feeds on the internal tissues of the sugarcanestalks, causing yield losses in sucrose. Owing to the fact *E. saccharina* has specific preferences in egg-laying sites,an optimal heterogenous crop layout is sought for implementation in sugarcane fields to localize infestation effects. In order to determine an optimal layout to aid in pest supression, a simulation model of *E. saccharina* spatial behavioural patterns must be developed and tested in sugarcane of differing ages and varieties. To facilitate the design of an agent-based model which accurately simulates *E. saccharina* biology, various characteristics of the pest, such as feeding habits, mating behaviourand dispersal patterns, must be incorporated into the model framework. These characteristics of *E. saccharina*, as well as their impact and incorporation in the aforementioned model, are discussed in this paper. Furthermore, a suitable model framework is derived from these considerations.

A qualitative model of evolutionary algorithms

Francois Fagan & Jan H van Vuuren*
Stellenbosch University, South Africa
napoleon020389@gmail.com & vuuren@sun.ac.za

Abstract

Evolutionary Algorithms (EAs) are stochastic techniques, based on the idea of biological evolution, for finding near-optimal solutions to optimisation problems. Due to their generality and computational speed, they have been applied very successfully in a wide range of disciplines. However, as a consequence of their stochasticity and generality, very little has been rigorously established about their performance. Developing models for explaining and predicting algorithmic performance is, in fact, one of the most important challenges facing the field of optimisation. A qualitative version of such a model of EAs is developed in this thesis.

There are two paradigms for explaining why EAs are expected to converge toward an optimum. The traditional explanation is that of Universal Darwinism, but an alternative explanation is that they are hill climbing algorithms which utilise all possible escape strategies - restarting local search, stochastic search and acceptance of non-improving solutions. The combination of the hill climbing property and the above escape strategies leads to a fast algorithm that is able to avoid premature convergence.

Due to the difficulty in mathematically or empirically explaining the performance of EAs, terms such as exploitation, exploration, intensity and diversity are routinely employed for this purpose. Six prevalent views on exploitation and exploration are identified in the literature, each expressing a different facet of these notions. The coherence of these views is substantiated by their deducibility from the proposed novel definitions of exploitation and exploration. This substantiation is based on a novel hypothetical construct, namely that of a Probable Fitness Landscape (PFL), which both unifies and clarifies the surrounding terminology and our understanding of the performance of EAs.

The PFL is developed into a qualitative model of EAs by extending it to the notion of an Ideal Probability Distribution (IPD). This notion, along with the criteria of diversity and computational speed, forms a method for judging the performance of EA operators. It is used to explain why the principal operators of EAs, namely mutation and selection, are effective.

There are three main types of EAs, namely *Genetic Algorithms* (GAs), Evolution Strategies and Evolutionary Programming, each of which employ their own unique operators. Important facets of the crossover operator (which is particular to GAs) are identified, such as: opposite step vectors, genetic drift and ellipsoidal parent-centred probability distributions with variance proportional to the distance between parents. The shape of the crossover probability distribution motivates a comparison

with a novel continuous approximation of mutation, which reveals very similar underlying distributions, although for crossover the distribution is adaptive whereas for mutation it is fixed. The PFL and IPD are used to analyse the crossover operator, the results of which are contrasted with the traditional explanations of the Schema Theorem and Building Block Hypothesis as well as the Evolutionary Progress Principle and Genetic Repair Hypothesis. It emerges that the facetwise nature of the PFL extracts more sound conclusions than the other explanations which, falsely, attempt to prove GAs to be superior.

The use of facetwise and qualitative models are justified by their success in explaining the performance of EAs. It is argued that the best direction for EA research to progress is to refrain from competitive testing and attempts to model the so-called equations of motion, but to encourage the development of scientifically justifiable facetwise models of algorithmic performance.

Quantifying uncertainty in long-term forecasts of CO_2 emissions in South Africa

*Ian Durbach**
Department of Statistical Sciences
University of Cape Town, South Africa
iandurbach@gmail.com

Bruno Merven
Energy Research Centre
University of Cape Town, South Africa
bruno.merven@uct.ac.za

Abstract

Uncertainties in CO_2 forecasts are largely due to uncertainties in key drivers of CO_2 emissions: growth rates, commodity prices, and future technologies, for example. In this project, we assess uncertainty in these drivers using a combination of existing forecasting models and elicitation of probability distributions from experts. The resulting distributions are used as inputs to a Monte Carlo simulation of the South African energy system.

The role of "soft" methodologies in defence decision making

*Winnie C Pelser**
Armscor, South Africa
winnie.pelser@gmail.com

Abstract

Nature of Defence decisions is complex and in an uncertain environment. Such situations are often ill-structured and "messy". "Soft" methodologies can be utilised to provide insight, structure problems and provide key decision issues. What are defined as "soft" methodologies? The application of "soft" OR should be applied to enhance effective decisions. As such it complements traditional methods. "Soft" methodologies can be applied as part of a multi methodological approach. Success in such applications is not always guaranteed. Effective application in appropriate situations is vital. Good guidelines are necessary to enhance the use of such methodologies. This will enhance the use and provide better acceptance. It will be beneficial to the quality of Defence Decision making.

Semi-automated maritime vessel activity detection using hidden Markov models

Jacques du Toit
Stellenbosch University, South Africa
jacques@dip.sun.ac.za

Abstract

Maritime surveillance systems make use of a dearth of sensor data which often includes spatio-temporal vessel updates provided by vessels fitted with onboard self-reporting Automatic Identification Systems. These spatio-temporal updates supply low-level information to an operator tasked with observing the surveillance scene and identifying threatening or undesirable behaviour. In this situation, the operator is thus required to interpret the updates by attaching semantic or high-level information to these data. To this end, activity detection is pursued as a means to describe vessel motion patterns within the surveillance scene. In particular, the activity of travelling along a well-established route is investigated.

Spatial regions of interest are extracted from historical data using a simple spatial clustering technique. The resulting data set is further reduced by removing outliers subject to chosen features before the remaining patterns are clustered. With the assistance of an operator, who may attribute activities to clusters that have some geographical or behavioural meaning, this approach may contribute to a rudimentary understanding of the scene.

The motion patterns within these clusters provide the training data for hidden Markov models which are tasked with classifying newly observed motion patterns that engage in the suggested activity. This process of enriching the vessel updates with semantics is expected to lead to more effective decision making on the part of a maritime surveillance operator who may thus direct cognitive resources towards unknown activities.

Simulation and order planning of a spice processing plant

Rhynard Prins & James Bekker*
Stellenbosch University, South Africa
rhynard.prins@capetown.gov.za & jb2@sun.ac.za

Abstract

Planning and scheduling of orders as well as the forecasting for determining the best execution sequence for a set of orders has been and still is a major concern in modern manufacturing plants. The problem is addressed at an anonymous spice processing plant in Durban, South Africa. The plant stocks hundreds of products in a warehouse and mixes these in various combinations and proportions according to specific spices that must be produced.

An order is placed for a specific product to be manufactured. The specific raw materials are assembled for the order in a batchtainer. The assembled batchtainer then attempts to find its preferred mixer by moving along a conveyor line. Once the batchtainer reaches the preferred mixer, it must wait until the correct number of batchtainers are present for the specific order before it can proceed. The waiting time for batchtainers at the mixers are dependent on raw material and batchtainer availability. It is also possible for other batchtainers to pass the batchtainers currently waiting at the mixers. From the mixers the products move toward the packaging department where the orders exit the system.

The input parameters are in the form of Excel tables, which are called by and imported into the simulation code. The problem of determining the correct point in time to replenish the raw materials and determining the correct quantity to be replaced is also addressed in the simulation model.

The problem is defined as an $(s; S)$ Inventory Problem where the control variables are the reorder level and the reorder quantity of raw materials. This methodology will aim to minimise cost while trying to maximise the throughput rate.

The simulation program records the batchtainer number for a given order as well as the time the order spends in the system. The data is written to a comma separated values (CSV) file in Excel. Results are obtained by means of updating the order sequence, running the simulation model and then updating the order times. This process is repeated for each scenario.

Multi-objective optimisation using Pareto dominance ranking is used to determine the best sequence scenarios for a given order list. The main aim of the study is to enable experimentation with different order scheduling scenarios to determine the best execution sequence for a set of orders. The experimentation can be carried out in a relative short amount of time once a large order list is received.

A simulation of The Duck Farm's abattoir

Kimberly Bailey
Stellenbosch University, South Africa
kimbo.bail@yahoo.com

Abstract

This paper looks at simulating a slaughtering process of The Duck Farm for the increase in number of ducks slaughtered. A discrete event simulation was built, based on the real life system of the farm's abattoir. Simul8, software that is particularly designed for discrete event simulation, is the chosen medium. The choice was simplified by the fact that the software is inclusive of all the necessary features that will ensure that the simulation is a good representation of the real life process, while presenting minimal difficulty. In describing the process involved in solving the speciffic example of The Duck Farm this paper aims to enlighten readers on the process of discrete event simulation as well as queuing theory. Combined with statistical methods, these tools can be used to solve optimization problems when dynamic systems are considered. Simulation is powerful in incorporating a large number of variables and details about the scenario being studied. Thus, simulation has been seen to be advantageous when working with models that incorporate a dynamic system. The business owner has been implementing various changes to improve the slaughtering process and in this paper a new suggestion is put forth as to what can be adjusted in order to streamline the process even further.

The size-mix problem for seasonal products: stability of profiles and performance measures

Antoinette Erasmus & Stephan E Visagie*
Stellenbosch University, South Africa
antoinette@sun.ac.za & svisagie@sun.ac.za

Abstract

Six to eighteen months before seasonal products are on sale in apparel stores, planners need to determine the product styles, how many of each product style as well as the combination of sizes and the associated quantities that should be ordered for the upcoming season. Historical sales profiles are used to determine the profiles according to which orders are placed. Not all historical sales profiles can be used as is. The stability of the historical profiles as well as its performance, play a role and should first be evaluated. Based on these outcomes, the historical sales profiles used, are adapted. This presentation is on a case study of PEP Stores Ltd (PEP) and considers methods to determine the stability of historical sales profiles as well as relevant performance measures.

Solution representation for a maritime law enforcement response selection problem

Alexandre Colmant & Jan H van Vuuren*
Stellenbosch University, South Africa
15427498@sun.ac.za & vuuren@sun.ac.za

Abstract

Designing a *maritime law enforcement* (MLE) response selection decision support system requires, inter alia, an optimization methodology component in which solution search methods are used to provide the decision maker with a set of good alternatives to a particular problem instance. In order to facilitate this process, solutions are represented in very specific data formats which allow for easy evaluation of objective function values and tests for solution feasibility. Moreover, these solutions are typically morphed in certain ways to generate neighbouring solutions that feed the search process. The MLE response selection problem can, in essence, be formulated as a special kind of *vehicle routing problem* (VRP) in which the depot represents the base from whence MLE resources are dispatched, the fleet of vehicles represents the fleet of MLE resources at the disposal of the coastal nation and the customers represent the vessels of interest tracked at sea within the territorial waters of the coastal nation. This problem, however, differs from standard capacitated VRP formulations in the literature for a variety of reasons, such as the presence of a heterogeneous and distance-constrained fleet, asymmetric travel arcs, multiple depots, unfixed customer locations, customer visitation profits and general system dynamism. Furthermore, the operator should have the ability to configure the decision support system by including or extracting various stored model components every time the problem instance has to be resolved, so as to better suit a particular situation or subjective preference. The aim in this paper is to propose effective solution data representations that can be incorporated into a real-time MLE response selection decision support system.

Some applications of OR in the transport industry

L Paul Fatti
School of Statistics & Actuarial Science
University of the Witwatersrand, South Africa
paulfatti@gmail.com

Abstract

The talk will discuss two practical problems arising in the transport industry, requiring the application of both statistical and OR ideas toward their solution.

The first concerns the vehicle replacement policy for a transport company operating a large fleet of heavy-duty trucks on a long-distance route between South Africa and another African country. A fairly simple statistical analysis shows that the apparently obvious policy is not the optimal one.

The second problem concerns the monitoring process for vehicle maintenance and repair in a company running a very large fleet of vehicles throughout Southern Africa. The geographically disaggregated nature of the business makes it impractical to check each application for the maintenance or repair of a vehicle and the company is seeking a way of using its repair and maintenance database to identify the applications that can be automatically approved and those requiring investigation. The talk will discuss approaches towards achieving this in a way that is both computationally and operationally practical.

Support plant upgrade investment decisions by utilising integrated stochastic simulation models

Hentie van den Berg
Decision Support
Sasol, South Africa
hentie.vdberg@sasol.com

Abstract

Utilities are essential to sustain production at Sasol, and therefore the future supply situation is continuously monitored, to ensure that supply can meet the expected future demand. As plants age capability is reduced because of gradual deterioration. The utility plant's baseline has been updated to accommodate longer *general overhaul* (GO) periods, as well as lower maximum instantaneous rates due to ageing of critical equipment. Since the utility production system can be subject to an increasing risk of unplanned downtime, further restoration work on the old plant equipment should also be considered as a potential utility production impact. With the use of integrated stochastic models, the potential future supply demand roadmap of utilities could be compiled, and the appropriate plan could be developed to protect production with regard to maintenance and equipment renewal. A rigorous process was followed to properly review and validate the utility assumptions against actual plant performance and reliability data. The Sasol utility production capability was modelled by using a stochastic model incorporating the main components of the value chain. The stochastic model results were used to show: The current utility fleet maximum capability. The potential decreased throughput with different restoration scenarios pending on the number of restorations per annum. The required size of the new utility equipment to ensure reliable supply of utilities to Sasol in the long term. The comparative results of different proposed solutions and whether these solutions will meet the expected future demand. Comparative results with different proposed new equipment configurations.

Sustainability: From theory to practice

Marthi FP Harmse
Sasol Synfuels, South Africa
kmharmse@mweb.co.za

Abstract

Sustainability most often is defined in terms of sustainable development as formulated by the Brundtland Commission of the United Nations on 20 March 1987. This entails meeting the needs of the present without compromising the ability of future generations to meet their own needs. In the context of a Sasol programme that aims to ensure that labour sending areas are desirable locations for talented individuals while making a positive contribution to South Africa through partnerships with government and the rest of the community, sustainability could be defined as maximising the benefits derived from the programme for its targeted stakeholders, while ensuring that the impact created in terms of the stated objectives of the programme is experienced beyond its lifetime. This paper first outlines a high-level sustainability framework for the above programme, and then maps out activities and definitions of victory proposed in terms of this framework.

Using agent-based simulation to explore sugarcane supply chain transport complexities at a mill scale

*Catherine S Price**
School of Management, IT and Governance
University of KwaZulu-Natal, South Africa
pricec@ukzn.ac.za

Deshendran Moodley
School of Mathematics, Statistics and Computer Science
University of KwaZulu-Natal, South Africa
moodleyd37@ukzn.ac.za

Carel N Bezuidenhout
School of Engineering
University of KwaZulu-Natal, South Africa
bezuidenhoutc@ukzn.ac.za

Abstract

The sugarcane supply chain (from sugarcane grower to mill), along with many other agricultural supply chains, have particular challenges. One of these is that the growers have to deliver their produce to the mill before its quality degrades. The sugarcane supply chain typically consists of many growers and a mill. Growers deliver their cane to the mill daily during the milling season; the amount of cane they deliver depends on their farm size. Growers make decisions about when they burn and harvest the cane, and the number and type of trucks needed to deliver their cane. The mill wants the cane to be as fresh as possible, and wants a consistent cane supply over the milling season. Growers are sometimes affected by long queue lengths at the mill when they offload their cane. The mill keeps track of when there was no cane to crush.

A preliminary agent-based simulation model was developed in an iterative way to understand this complex system. The model inputs the number of growers, and the amount of cane they are to deliver over the milling season. Some of the growers' decisions are modelled stochastically. Several runs were made to test the robustness of the model. The model shows queue length at the mill, when the mill runs out of cane and how long the average harvest-to-crush delay is. The research shows the promise of agent-based models as a sense-making approach to understanding systems where there are many individuals who have autonomous behaviour, and whose actions and interactions can result in unexpected system-level behaviour.

Using a multiobjective harmony search algorithm to solve the in-core fuel management optimisation problem

Evert B Schlünz & Pavel M Bokov*
Necsa, South Africa
bernard.schlunz@necsa.co.za & pavel.bokov@necsa.co.za

Jan H van Vuuren
Stellenbosch University, South Africa
vuuren@sun.ac.za

Abstract

Nuclear research reactors typically operate in cycles of several weeks or months, each followed by a shutdown period. The reloading of fuel assemblies in the reactor core may occur during such a shutdown period. It is necessary to replace depleted fuel assemblies with fresh fuel assemblies in order to maintain sufficient levels of fissionable material in the reactor core. The loading position of any fuel assembly may then also be changed in order to satisfy prescribed safety and utilisation requirements. The *multiobjective in-core fuel management optimisation* (ICFMO) problem then refers to the problem of finding a Pareto optimal set of fuel reload congurations for a nuclear reactor core, subject to certain safety and/or utilisation constraints. The problem may be classified as a nonlinear assignment problem and it is computationally expensive because a reactor core calculation system (*i.e.* core simulator) is required for function evaluations. The SAFARI-1 nuclear research reactor is considered as a case study for the multiobjective ICFMO problem. The reactor is primarily utilised for scientific research, isotope production, irradiation services and material testing. A description of the multiobjective ICFMO problem for SAFARI-1 is given, as well as a description of a multiobjective harmony search algorithm that has been implemented to solve the problem approximately. The results that have been obtained from using the algorithm are also reported. The aim of this research is to develop an efficient decision support tool for a nuclear reactor operator tasked with designing fuel reload congurations.

Volatility modelling of the All Share Index at the JSE using a generalized autoregressive score model

Caston Sigauke
School of Statistics and Actuarial Science
University of the Witwatersrand, South Africa
csigauke@gmail.com

Abstract

In this paper we present a brief discussion of the *Generalized Autoregressive Score* (GAS) model. We use the GAS model in modelling the *All Share Index* (ALSI) at the Johannesburg Stock Exchange. The data used is for the years 2002 to 2013. GAS models are a new class of nonlinear models based on the conditional score function. GAS models developed by Creal, Koopman, and Lucas (2008) cater for time-varying parameters. A scaled score function is used in GAS models to drive the time variation of the parameters.

Wolfram Technology as applied to data analytics

Clemens Dempers
Blue Stallion Technologies, South Africa
dempers@bluestallion.co.za

Abstract

Wolfram Research has been developing the Wolfram Language for 25 years. It is an ideal tool for analizing and visualizing data, and then vreating interactive reports and GUIs.We will show live examples and give an overvew of the latest additions to this set of tools, including GIS, interactive graphics, statistics and optimization.

—*List of Delegates** —

1. **Bailey**, Kimberly (Stellenbosch University, South Africa)
2. **Bashe**, Mantombi (Eskom, South Africa)
3. **Bennetto**, Robert A (OPSI Systems, South Africa)
4. **Berkow**, Menachem Eliezer (OPSI Systems, South Africa)
5. **Bester**, Margarete Joan (X*Tranda*, South Africa)
6. **Beverin**, Aleksandra (Boehringer Ingelheim, South Africa)
7. **Bley**, Andreas (University of Kassel, Germany)
8. **Bothma**, Brahm (Imperial IT, South Africa)
9. **Breedt**, Jana (Eskom, South Africa)
10. **Cawood**, Ebert (Sasol, South Africa)
11. **Chauke**, Dorah M (Armscor, South Africa)
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