

Welcome from the President



It is with great pleasure that I welcome all delegates to the 42nd Annual Conference of the *Operations Research Society of South Africa* (ORSSA) — the highlight in our Society's calendar year, this year held at the Protea Hotel Technopark, Stellenbosch.

I would like to thank Danie Lötter, chair of *Local Organising Committee* (LOC) of the conference, as well as his entire team for the hard work they have put in on many fronts and in various capacities over many months in order to bring this meeting here to the beautiful winelands of the Western Cape.

Our conference programme this year boasts an impressive array of diverse presentations on the development of new theory, on the application of operational research techniques in business and industry, on topical issues in operations research, and on the philosophy, teaching and marketing of operations research. This rich programme, comprising seventy four papers and a panel discussion, has been organised into three plenary sessions and twenty-four contributed sessions, running in three parallel streams for our entire stay at the Protea Hotel Technopark. This exciting scientific programme promises to cater for every delegate, no matter what their particular tastes and preferences!

We welcome, in particular, our keynote speaker, Emeritus Professor Theodor Stewart (University of Cape Town), who needs little introduction at ORSSA events and who will be delivering both the opening and closing plenary lectures of the conference on the fascinating topics of *Multicriteria Decision Analysis — An Integrating Framework for OR* and on *Multicriteria Decision Aid to OR for Development*.

We also welcome Mr Oliver Bastert, Frank Haeger and Kavinesh Singh, who represent our main conference sponsor, FICO. We thank FICO for their generous sponsorship which has helped to make this conference possible, and we draw the attention of delegates to the post-conference workshop that FICO will presenting on optimisation directly after the close of the conference here at the Protea Hotel Technopark (details on page 11 of this programme).

In addition to interesting and engaging scientific content, I hasten to mention that ORSSA conferences have, of course, also been famous for decades now for their thoroughly enjoyable social aspects of the conference programme, and this conference promises to be no exception! I trust that all delegates will have a productive few days here in Stellenbosch, exchanging valuable and inspiring ideas, learning new tricks of our diverse and complex trade, renewing old acquaintances, and making new friends and colleagues. May you enjoy a memorable conference!

Best wishes,

Jan van Vuuren, President
Operations Research Society of South Africa

Welcome from the Chair of the Organising Committee



A warm welcome to the 42nd Annual Conference of the Operations Research Society of South Africa. It is a privilege to welcome you to the heart of the Cape Winelands that is Stellenbosch and its beautiful surroundings.

We are honoured to have Professor Theodor Stewart (Emeritus Professor at the University of Cape Town) as our conference keynote speaker. This year marks Theo's 70th birthday, which he will be celebrating during the course of the conference. Professor Stewart has served the Society in a variety of capacities over the past decades and needs no introduction in the Operations Research community.

Apart from the impressive scientific aspect of the conference programme, we have managed to line up a number of social events as networking opportunities for our fellow Operations Research colleagues. The social programme of the conference kicks off with a welcome function on registration day during which delegates may become acquainted with one another. A fantastic mid-conference wine tasting function has also been arranged during which the top wines from seven well-known local wine estates will be on offer. These estates are *Alto*, *Flat Roof Manor*, *Hill and Dale*, *Le Bonheur*, *Neethlingshof*, *Uitkyk* and *Stellenzicht*. A personal highlight of the conference for me is the conference banquet during which the contributions of ORSSA members are acknowledged. I am very excited to announce that this year's banquet marks the introduction of two new medals for the student competitions (the *Gerhard Geldenhuys Medal* for the best 4th year or honours project and the *Theodor Stewart Medal* for the best masters thesis). This year's event will be extra special since Gerhard and Theo will be presenting these medals in person to the winners of the respective competition categories. Apart from the presentation of the normal ORSSA recognition awards and the Tom Rozwadowski Medal, a fourth category of recognition awards (for upcoming operations research practitioners) will also be awarded for the first time during this year's banquet.

Finally, I would like to extend a special word of thanks to my fellow colleagues who shared the privilege of serving on the local organising committee. Without your help and support we would have achieved nothing. I would also like to specially thank Jan van Vuuren for the sterling job he and his team has done with the compilation of this year's conference programme. And last but but not least, I would like to thank Nirene Fortuin and her team from the Protea Hotel for organising what promises to be a memorable conference indeed.

We trust that you will have a pleasant and relaxing time in the Cape winelands!

Best wishes,

Danie Lötter, Chair
ORSSA 2013 Local Organising Committee

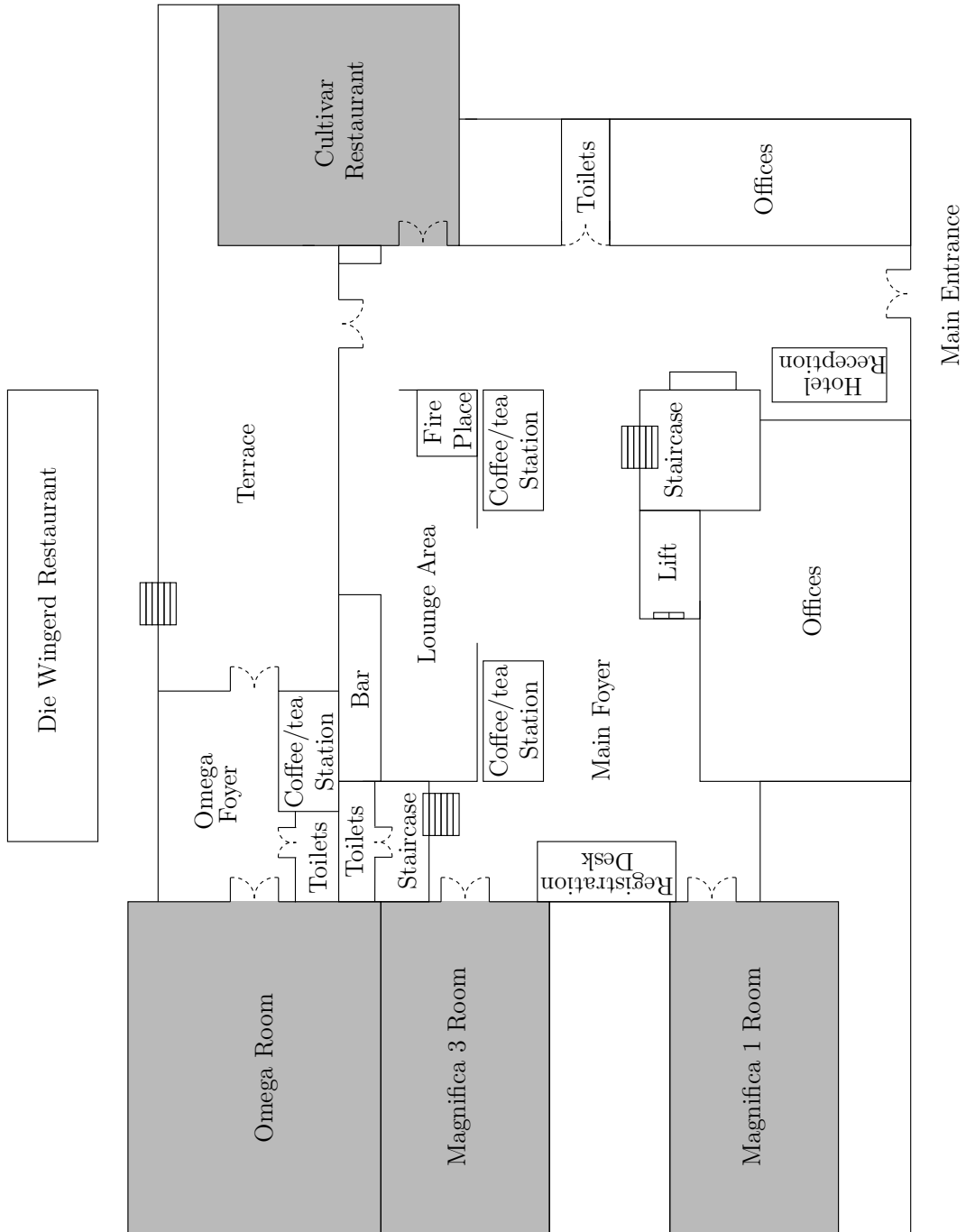
— *The ORSSA 2013 Local Organising Committee* —

- (1) Danie Lötter, Chair (Stellenbosch University)
- (2) Alexandre Colmant (Stellenbosch University)
- (3) Anton de Villiers (Stellenbosch University)
- (4) Mark Einhorn (Stellenbosch University)
- (5) Antoinette Erasmus (Stellenbosch University)
- (6) Tanya Lane-Visser (Stellenbosch University)
- (7) Michelle van der Merwe (WiGroup, Cape Town)
- (8) Jan van Vuuren (Stellenbosch University)

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— *Map of Conference Facilities* —



— Programme at a Glance —

Monday 16 September 2013

08:00–08:30	<i>Onsite Registration (Main Foyer)</i>	
08:30–10:00	Plenary Session A: Opening Keynote Address by Emeritus Professor Theodor Stewart (Omega Room)	
10:00–10:30	<i>Tea/Coffee (Foyers of all the Venues)</i>	
10:30–12:30	I: Heuristics & Metaheuristics (Omega Room)	III: Allocation & Selection Problems (Magnifica 3)
12:30–13:45	<i>Lunch (Cultivar Restaurant)</i>	
13:45–15:15	IV: Anniversary Session Dedicated to Theodor Stewart (Omega Room)	VI: Linear & Stochastic Programming (Magnifica 3)
15:15–15:45	<i>Tea/Coffee (Foyers of all the Venues)</i>	
15:45–18:15	VII: Multiobjective Optimisation (Magnifica 1)	IX: ORSSA Executive Committee Meeting (Cultivar Restaurant)
18:30–19:30	<i>Cheese and Wine Tasting (Omega Room)</i>	

Tuesday 17 September 2013

08:30–10:00	X: OR in Mining & Manufacturing (Omega Room)	XI: Combinatorial Optimisation (Magnifica 1)	XII: OR in Industry (Magnifica 3)
10:00–10:30	<i>Tea/Coffee (Foyers of all the Venues)</i>		
10:30–12:30	XIII: ORSSA National Student Competition (Omega Room)	XIV: Timetabling & Tournament Scheduling (Magnifica 1)	XV: Transport & Transportation (Magnifica 3)
12:30–13:45	<i>Lunch (Cultivar Restaurant)</i>		
13:45–15:45	XVI: Assorted Topics (Omega Room)	XVII: Human Resources: Fairness & Performance (Magnifica 1)	XVIII: Panel Discussion on Demand Forecasting (Magnifica 3)
15:45–16:15	<i>Tea/Coffee (Foyers of all the Venues)</i>		
16:15–18:00	Plenary Session B: ORSSA Annual General Meeting (Magnifica 3)		
19:00–	<i>Conference Banquet (Omega Room)</i>		

Wednesday 18 September 2013

08:30–10:00	XIX: Simulation (Omega Room)	XX: Sustainability & Contingency Planning (Magnifica 1)	XXI: Agriculture, Forestry & Land Use (Magnifica 3)
10:00–10:30	<i>Tea/Coffee (Foyers of all the Venues)</i>		
10:30–11:30	XXII: Large-scale Parallel Computing (Omega Room)	XXIII: Models in Finance (Magnifica 1)	XXIV: Maritime Law Enforcement (Magnifica 3)
11:40–13:00	Plenary Session C: Closing Keynote Address by Emeritus Professor Theodor Stewart (Omega Room)		
13:00–14:15	<i>Lunch (Cultivar Restaurant)</i>		
14:30–17:30	FICO Post-conference Workshop on Optimisation		

— *Detailed Conference Programme* —

Sunday 15 September 2013

On-site Registration (14:00–16:00)
[Main Foyer]

Welcome Reception (15:00–18:00)
[The Patio (weather permitting, or else the Main Foyer)]

Monday 16 September 2013

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

Monday 16 September 2013 (08:30–10:00)	
Plenary Session A: Conference Opening <i>Chair:</i> Hans Ittmann [<i>Venue:</i> Omega Room]	
08:30–08:40	Daniel Lötter (Chair, Local Organising Committee) <i>Welcome & announcements</i>
08:40–09:00	Jan van Vuuren (ORSSA President) <i>Presidential address</i>
09:00–10:00	Theodor Stewart (Keynote Speaker) <i>Multicriteria decision analysis — An integrating framework for operations research</i> (p. 21)

Tea/Coffee (10:00–10:30)
[Foyers of all the Conference Venues]

Monday 16 September 2013 (10:30–12:30)	
Parallel Session I: Heuristics & Metaheuristics <i>Chair:</i> Barbara Swart [<i>Venue:</i> Omega Room]	
10:30–11:00	Robert Bennetto , <i>What your parents never told you about genetic algorithms and genetic programs</i> (p. 95)
11:00–11:30	Ian Campbell , <i>Heuristics and solution methods for the Dial-A-Flight Problem</i> (p. 45)
11:30–12:00	Aderemi Adewumi , <i>Metaheuristics for a parallel machine problem</i> (p. 58)
12:00–12:30	Arasomwan Martins , <i>An investigation into the performance of particle swarm optimisation with various chaotic maps</i> (p. 52)

Parallel Session II: Retailing and Warehousing <i>Chair: Isabelle Nieuwoudt [Venue: Magnifica 1]</i>	
10:30–11:00	Johanita Nel , <i>The Shoprite Storage Volume Problem for fresh produce</i> (p. 82)
11:00–11:30	Antoinette Erasmus , <i>The Size-mix Problem for seasonal apparel</i> (p. 83)
11:30–12:00	Elmien Thom , <i>Adjusting the size-mix of products</i> (p. 24)
12:00–12:30	Stephan Visagie , <i>Assortment planning of new retail stores</i> (p. 29)

Parallel Session III: Allocation and Selection Problems <i>Chair: Ian Durbach [Venue: Magnifica 3]</i>	
10:30–11:00	Jason Matthews , <i>On storage assignment in a zoned order picking system with unidirectional picking lines</i> (p. 66)
11:00–11:30	Louzanne Oosthuizen , <i>Determining an optimal basis for allocating operating room time under uncertainty</i> (p. 37)
11:30–12:00	Daniel Lötter , <i>A weapon assignment subsystem for real-time decision support in a ground-based air defence environment</i> (p. 94)
12:00–12:30	Annette van der Merwe , <i>Solving the diet problem using expert system technology and mathematical programming techniques</i> (p. 85)

Lunch (12:30–13:45)
[Cultivar Restaurant]

Monday 16 September 2013 (13:45–15:15)	
Parallel Session IV: Anniversary Session Dedicated to Theo Stewart <i>Chair: Gerhard Geldenhuys [Venue: Omega Room]</i>	
13:45–14:15	Hans Ittmann , <i>A review of the Tom Rozwadowski medal</i> (p. 78)
14:15–14:45	Ian Durbach , <i>Operational research(ers) in development: Growing a new generation</i> (p. 67)
14:45–15:15	Jan van Vuuren , <i>The Evolutionary Spatial Prisoner's Dilemma on a cycle</i> (p. 40)

Parallel Session V: Location and Scheduling Problems in Industry <i>Chair: Angela Rademeyer [Venue: Magnifica 1]</i>	
13:45–14:15	Andries Heyns , <i>Facility location subject to proximity and terrain-induced visibility constraints</i> (p. 42)
14:15–14:45	Martin Kidd , <i>Real-time rescheduling in case of large disruptions in railway networks</i> (p. 76)
14:45–15:15	Nqobile Mabaso , <i>Scheduling of environmental monitoring in a biopharmaceutical facility</i> (p. 80)

Parallel Session VI: Linear and Stochastic Programming <i>Chair: Mark Einhorn [Venue: Magnifica 3]</i>	
13:45–14:15	Rowan Gouws , <i>Aligning a legacy model to current reality and improve the predictive power of linear programming unit models</i> (p. 26)
14:15–14:45	Stephanus Terblanche , <i>Optimal liquidity execution planning using stochastic programming and robust optimisation</i> (p. 70)
14:45–15:15	Mantepu MaseTshaba , <i>A linear programming approach to business process optimisation: Application to a South African bank</i> (p. 54)

Tea/Coffee (15:15–15:45)
[Foyers of all the Conference Venues]

Monday 16 September 2013 (15:45–18:15)	
Parallel Session VII: Multiobjective Optimisation <i>Chair: Theodor Stewart [Venue: Magnifica 1]</i>	
15:45–16:15	Hennie Kruger , <i>The reconciliation of conflicting QoS goals in wireless networks: A linear response surface analysis approach</i> (p. 77)
16:15–16:45	Evert Schlünz , <i>Preliminary results of a multiobjective cross-entropy method applied to solve the In-core Fuel Management Optimisation Problem</i> (p. 74)
16:45–17:15	Nina Uys , <i>Investigation of a hybrid renewable energy system to meet South Africa's baseload energy demand using a multiobjective PBIL optimisation algorithm</i> (p. 53)
17:15–17:45	Timm Engelbrecht , <i>Multiobjective optimisation of inventory control selection</i> (p. 61)
17:45–18:15	No Talk Scheduled

Parallel Session VIII: Machine Learning and Classification <i>Chair: Jacques du Toit [Venue: Magnifica 3]</i>	
15:45–16:15	Machteld Fick , <i>A machine learning approach to hyphenation in Afrikaans</i> (p. 56)
16:15–16:45	David Hutton , <i>The use of machine learning techniques to optimise admission requirements at a higher education institution</i> (p. 92)
16:45–17:15	Jaco du Toit , <i>On-load tap changer classification using supervised learning on the latest Eskom Reg-D data</i> (p. 64)
17:15–17:45	Douw Breed , <i>The use of different clustering algorithms and distortion functions in semi-supervised segmentation</i> (p. 91)
17:45–18:15	Kanshukan Rajaratnam , <i>Decision making in consumer loan acquisition with multiple binomial classifiers</i> (p. 34)

Parallel Session IX: ORSSA Executive Committee Meeting

Chair: Jan van Vuuren [*Venue:* Cultivar Restaurant]

Cheese and Wine Tasting (18:30–19:30)

[Omega Room]

Tuesday 17 September 2013

Tuesday 17 September 2013 (08:30–10:00)

Parallel Session X: OR in Mining and Manufacturing

Chair: Ian Campbell [*Venue:* Omega Room]

08:30–09:00	Wim Gevers , <i>Risk budgeting in a mining house</i> (p. 79)
09:00–09:30	Frank Ortmann , <i>Optimising circuits for superconducting super-computers</i> (p. 69)
09:30–10:00	Wayne Bossenger , <i>2D irregular strip packing at Kohler Signs</i> (p. 23)

Parallel Session XI: Combinatorial Optimisation

Chair: Alewyn Burger [*Venue:* Magnifica 1]

08:30–09:00	Adriana Roux , <i>An algorithm for $\langle \mathbf{r}, \mathbf{s} \rangle$-domination of a network</i> (p. 27)
09:00–09:30	Anton de Villiers , <i>A binary programming approach towards achieving effective network protection</i> (p. 31)
09:30–10:00	Mamane Ibrahim , <i>A family of valid inequalities for some classical combinatorial optimisation problems</i> (p. 43)

Parallel Session XII: OR in Industry

Chair: Mantombi Bashe [*Venue:* Magnifica 3]

08:30–09:00	Ian Durbach , <i>An agent-based model of the role of theft in plant conservation problems</i> (p. 25)
09:00–09:30	Cilliers Prins , <i>Face milling with indexable round inserts: An analytical model for optimisation production parameters with TI-6AL-4V machining</i> (p. 41)
09:30–10:00	Kolentino Mpetta , <i>Applying operations research in the fast food industry</i> (p. 28)

Tea/Coffee (10:00–10:30)

[Foyers of all the Conference Venues]

Tuesday 17 September 2013 (10:30–12:30)	
Parallel Session XIII: ORSSA National Student Competition <i>Chair: Margarete Bester [Venue: Omega Room]</i>	
10:30–11:00	Lumardt Groeneveld , <i>A decision support tool to locate and operate a DC in the Western Cape for MediClinic</i> (p. 35)
11:00–11:30	Robert Hagspihl , <i>The number of pickers and SKU arrangement on a unidirectional picking line</i> (p. 63)
11:30–12:00	Robert Bennetto , <i>Dynamic bulk freight train scheduling in an uncongested rail network</i> (p. 38)
12:00–12:30	Sivashan Chetty , <i>Studies in heuristics for the Annual Crop Planning Problem</i> (p. 88)
Parallel Session XIV: Timetabling and Tournament Scheduling <i>Chair: Martin Kidd [Venue: Magnifica 1]</i>	
10:30–11:00	Dewald Engelbrecht , <i>On the fairness of a Super 15 schedule</i> (p. 65)
11:00–11:30	Aderemi Adewumi , <i>Population-based local search heuristics for the Travelling Tournament Problem</i> (p. 73)
11:30–12:00	Nelishia Pillay , <i>A comparative study of genetic algorithms using a direct and indirect representation in solving the South African School Timetabling Problem</i> (p. 32)
12:00–12:30	Nelishia Pillay , <i>A study of cell depletion in the developmental approach for the Uncapacitated Examination Timetabling Problem</i> (p. 89)
Parallel Session XV: Transport and Transportation <i>Chair: Tanya Lane-Visser [Venue: Magnifica 3]</i>	
10:30–11:00	Colin Phillips , <i>An investigation into the causes of transportation inefficiency</i> (p. 51)
11:00–11:30	Hans Ittmann , <i>Freight transport modelling and its application within Transnet</i> (p. 44)
11:30–12:00	Mark Einhorn , <i>Developing an understanding of the fundamentals of vehicle delay at signalised intersections using analytic and numeric models</i> (p. 36)
12:00–12:30	No Talk Scheduled

Lunch (12:30–13:45)
[Cultivar Restaurant]

Tuesday 17 September 2013 (13:45–15:45)

Parallel Session XVI: Assorted Topics

Chair: David Lubinsky [*Venue:* Omega Room]

13:45–14:15	Aderemi Adewumi , <i>A soft computing framework for modelling transmission dynamics of HIV/AIDS under combined use of male and female condoms in heterosexual populations</i> (p. 84)
14:15–14:45	Mardi Jankowitz , <i>Nonlinear smoothing: A comparison of median, hybrid and LULU smoothers</i> (p. 62)
14:45–15:15	Tiny du Toit , <i>Comparing radial basis function networks and generalised additive neural networks for spam detection</i> (p. 33)
15:15–15:45	Isabel Meyer , <i>Influencing the future: Open access horizon scanning in Africa?</i> (p. 49)

Parallel Session XVII: Human Resources: Fairness and Performance

Chair: Stephan Visagie [*Venue:* Magnifica 1]

13:45–14:15	Lieschen Venter , <i>Human resources decision support using Sasol Technology's Employment Equity Target Assessment Model</i> (p. 48)
14:15–14:45	Marvel Mandaza , <i>Partially multi-skilled back office workforce assignment optimisation: An operations management decision support tool for AOMi[®] simulation training</i> (p. 72)
14:45–15:15	Margarete Bester , <i>How to get the best out of your analytical teams</i> (p. 47)
15:15–15:45	Keamogetse Setlhare , <i>Optimal time interval between screening tests for promotions in manpower planning</i> (p. 68)

Parallel Session XVIII: Panel Discussion on Demand Forecasting

Chair: Danie Payne [*Venue:* Magnifica 3]

13:45–15:45	Danie Payne & Jana Breedt , <i>Long-term electrical demand forecasting for strategic transmission network planning</i> (p. 55)
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Tea/Coffee (15:45–16:15)

[Foyers of all the Conference Venues]

Tuesday 17 September 2013 (16:15–18:00)

Plenary Session B: ORSSA Annual General Meeting

Chair: Jan van Vuuren [*Venue:* Magnifica 3]

Conference Banquet (19:00–)

[Omega Room]

Wednesday 18 September 2013

Wednesday 18 September 2013 (08:30–10:00)	
Parallel Session XIX: Simulation <i>Chair:</i> Aderemi Adewumi [<i>Venue:</i> Omega Room]	
08:30–09:00	Gerrit Streicher , <i>A stochastic simulation model of a continuous value chain operation with feedback streams and optimisation</i> (p. 87)
09:00–09:30	Robert Hagspihl , <i>Modelling systems with autonomous agents</i> (p. 60)
09:30–10:00	Prenitha Pooren , <i>Using stochastic simulation to assess operability and availability of a unique new chemical plant</i> (p. 93)
Parallel Session XX: Sustainability and Contingency Planning <i>Chair:</i> Lieschen Venter [<i>Venue:</i> Magnifica 1]	
08:30–09:00	Mantombi Bashe , <i>Megaprojects contingency determination</i> (p. 57)
09:00–09:30	Martha Harmse , <i>Sustainability: From theory to practice</i> (p. 90)
09:30–10:00	No Talk Scheduled
Parallel Session XXI: Agriculture, Forestry and Land Use <i>Chair:</i> Frank Ortmann [<i>Venue:</i> Magnifica 3]	
08:30–09:00	Berndt Lindner , <i>A model to optimise the linked sawing and ripping decisions in the South African pine cutting chain</i> (p. 59)
09:00–09:30	Chantal von Saint Ange , <i>Optimisation of land use in the Sand-spruit catchment to mitigate impacts on water resources</i> (p. 71)
09:30–10:00	Linke Potgieter , <i>A spatio-temporal model for the control of Eldana saccharina Walker</i> (p. 86)

Tea/Coffee (10:00–10:30)

[Foyers of all the Conference Venues]

Wednesday 18 September 2013 (10:30–11:30)	
Parallel Session XXII: Large-scale Parallel Computing <i>Chair:</i> Tiny du Toit [<i>Venue:</i> Omega Room]	
10:30–11:00	Oliver Bastert , <i>How the Cloud will put optimisation within the reach of many more organisations</i> (p. 46)
11:00–11:30	Johannes Benadé , <i>The enumeration of mutually orthogonal Latin squares</i> (p. 39)
Parallel Session XXIII: Models in Finance <i>Chair:</i> Wim Gevers [<i>Venue:</i> Magnifica 1]	
10:30–11:00	Lehlohonolo Masipa , <i>The sensitivity of a unit trust fund in a volatile market: Adjusting for changes</i> (p. 81)
11:00–11:30	Barbara Swart , <i>Information theory in financial modelling</i> (p. 50)

Parallel Session XXIV: Maritime Law Enforcement <i>Chair: Mardi Jankowitz [Venue: Magnifica 3]</i>	
10:30–11:00	Jacques du Toit , <i>Automated maritime vessel activity detection using hidden Markov models</i> (p. 30)
11:00–11:30	Alexandre Colmant , <i>Prerequisites for the design of a maritime law enforcement resource assignment decision support system</i> (p. 75)

Wednesday 18 September 2013 (11:40–13:00)	
Plenary Session C: Conference Closing <i>Chair: Hennie Kruger [Venue: Omega Room]</i>	
11:40–12:40	Theodor Stewart (Keynote Speaker) <i>Multicriteria decision aid to OR for development</i> (p. 22)
12:40–12:55	Gerhard Geldenhuys, Wim Gevers & Hans Ittmann <i>Reflection on papers read at the conference</i>
12:55–13:00	Jan van Vuuren (ORSSA President) <i>Final announcements, thank yous & good bye</i>

Lunch (13:00–14:15)
[Cultivar Restaurant]

Wednesday 18 September 2013 (14:30–17:30)	
FICO Post-conference Optimisation Workshop	
14:30–15:00	<i>Introduction to FICO analytics and optimization</i>
15:00–16:00	<i>Xpress optimization in detail</i>
16:00–16:14	Coffee Break
16:15–17:15	<i>Highlight: Optimization application deployment & accessibility</i>
17:15–17:30	<i>How to become a FICO partner</i>

— *List of Sessions & Chairs* —

Session	Day	Time Slot	Topic	Chairperson	Venue	Page
A	Mon	08:30–10:00	Opening Plenary	Hans Iltmann	Omega Room	4
B	Tue	16:15–18:00	ORSSA Annual General Meeting	Jan van Vuuren	Magnifica 3	9
C	Wed	11:40–13:00	Closing Plenary	Hennie Kruger	Omega Room	11
I	Mon	10:30–12:30	Heuristics & Metaheuristics	Barbara Swart	Omega Room	4
II	Mon	10:30–12:30	Retailing & Warehousing	Isabelle Nieuwoudt	Magnifica 1	5
III	Mon	10:30–12:30	Allocation & Selection Problems	Ian Durbach	Magnifica 3	5
IV	Mon	13:45–15:15	Anniversary Session Dedicated to Theo Stewart	Gerhard Geldenhuys	Omega Room	5
V	Mon	13:45–15:15	Location & Scheduling Problems in Industry	Angela Rademeyer	Magnifica 1	5
VI	Mon	13:45–15:15	Linear & Stochastic Programming	Mark Einhorn	Magnifica 3	6
VII	Mon	15:45–18:15	Multiobjective Optimisation	Theodor Stewart	Magnifica 1	6
VIII	Mon	15:45–18:15	Machine Learning & Classification	Jacques du Toit	Magnifica 3	6
IX	Mon	15:45–18:15	ORSSA Executive Committee Meeting	Jan van Vuuren	Cultivar	7
X	Tue	08:30–10:00	OR in Mining & Manufacturing	Ian Campbell	Omega Room	7
XI	Tue	08:30–10:00	Combinatorial Optimisation	Alewyn Burger	Magnifica 1	7
XII	Tue	08:30–10:00	OR in Industry	Mantombi Bashe	Magnifica 3	7
XIII	Tue	10:30–12:30	ORSSA National Student Competition	Margarete Bester	Omega Room	8
XIV	Tue	10:30–12:30	Timetabling & Tournament Scheduling	Martin Kidd	Magnifica 1	8
XV	Tue	10:30–12:30	Transport & Transportation	Tanya Lane-Visser	Magnifica 3	8
XVI	Tue	13:45–15:45	Assorted Topics	David Lubinsky	Omega Room	9
XVII	Tue	13:45–15:45	Human Resources: Fairness & Performance	Stephan Visagie	Magnifica 1	9
XVIII	Tue	13:45–15:45	Panel Discussion on Demand Forecasting	Danie Payne	Magnifica 3	9
XIX	Wed	08:30–10:00	Simulation	Aderemi Adewumi	Omega Room	10
XX	Wed	08:30–10:00	Sustainability & Contingency Planning	Lieschen Venter	Magnifica 1	10
XXI	Wed	08:30–10:00	Agriculture, Forestry & Land Use	Frank Ortman	Magnifica 3	10
XXII	Wed	10:30–11:30	Large-scale Parallel Computing	Tiny du Toit	Omega Room	10
XXIII	Wed	10:30–11:30	Models in Finance	Wim Gevers	Magnifica 1	10
XXIV	Wed	10:30–11:30	Maritime Law Enforcement	Mardi Jankowitz	Magnifica 3	11

— *List of Papers* —

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— *Plenary Paper Abstracts* —

Opening Plenary:

Multicriteria decision analysis — An integrating framework for operations research

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Abstract

Multicriteria Decision Analysis (MCDA) is sometimes viewed as a tool or technique of operations research, such as linear programming or simulation. But MCDA is much more than that — it is a framework for thinking about complex decision problems, and in that sense is a framework for carrying out operations research. We shall start by looking at the role of MCDA, and will seek to dispel some common myths and misconceptions. We shall then discuss the close parallels and synergies between the problem structuring methods of what is often termed “soft OR” and MCDA. It is argued that MCDA is in the first instance a problem structuring approach, but one which does not stop with structuring problems; it facilitates the process of moving towards resolution of the underlying problematical situation. We shall outline the commonalities and distinctions between different “schools” of MCDA, and their underlying models, and provide some guidance as to the problem settings for which each school is appropriate. Throughout the discussion we shall suggest how other tools and techniques of operations research can effectively be harnessed as part of the decision analysis, providing an integrated view of MCDA.

Closing Plenary:
*Multicriteria decision aid to operations research
for development*

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Abstract

The concept of *Operations Research in (or for) Development* (ORD) has received considerable attention in the IFORS and EURO communities. ORSSA has provided a substantial degree of leadership in these thrusts, as is appropriate for the leading OR grouping in Africa. We have previously argued that the distinguishing features of ORD include more diverse and conflicting objectives, and higher levels of uncertainty than in conventional OR applied in the developed world. These features are precisely those which are addressed by *Multicriteria Decision Analysis* (MCDA) in the broad sense, as discussed during opening plenary lecture. Here again, MCDA provides a structured framework for incorporating both soft and hard operations research into the structuring and resolution of problems of development. In motivating and developing this theme, we shall draw on experience at the University of Cape Town in addressing problems such as water resources planning, food banking, fisheries rights allocation and energy planning.

As many uncertainties inherent in ORD problems are not fully quantifiable, we shall also discuss the role of scenario planning in ORD, and the manner in which this can be incorporated into the MCDA approach.

— *Contributed Paper Abstracts* —

2D irregular strip packing at Kohler Signs

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Abstract

Kohler Signs (Pty) Ltd is a sign production company located in Cape Town, South Africa. They manufacture and install signs for the City of Cape Town and private companies as well as manufacture advertisement signs to be placed on vehicles. Steel sheets are cut to the appropriate size and bent to match the appropriate road sign. The image design is cut from a roll of vinyl and applied to the steel sheet. The completed sign is either installed or delivered to the client. The image design for each sign that must be cut from the vinyl consists of letters, numbers and shapes, and are categorised as irregular items. The problem is to place the items on the vinyl in such a manner as to minimise the waste. For example, some letters like an ‘A’ and a ‘V’ can be placed adjacent to each other favourably, whereas an ‘A’ and an ‘M’ necessarily waste some vinyl between them. The items that are packed are irregular and thus regular *two-dimensional* (2D) strip packing algorithms cannot be used. However, the items are regular in one dimension and so in this talk 2D regular strip packing ideas are used in conjunction with image processing methodologies to develop a new packing algorithm for this specific problem.

Adjusting the size-mix of products

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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 on 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. A model is presented that can be used while making these allocation decisions. The main objective is to ensure that each branch is sufficiently stocked with all sizes. A case study from *Pep Stores Ltd* (Pep), a major retailer in South Africa, will be presented.

An agent-based model of the role of theft in plant conservation problems

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Abstract

Agent-based modelling (ABM) is a simulation-based approach for modelling interactions between individual entities with the goal of assessing their effects on the system as a whole. This presentation gives an introduction to ABM and describes an application investigating the harmful effects of tree theft on the viability of small populations of two long-living plant species, *aloe dichotoma* (the quiver tree) and *aloe pilansi*, found in Southern Africa.

Aligning a legacy model to current reality and improve the predictive power of linear programming unit models

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Abstract

Aligning models to current reality is an important step in ensuring that the models are valid. In most petrochemical companies, a *linear programming* (LP) model is used to determine what the solution is for a company that will yield the best profit. Managers are more willing to accept models if there is an alignment with the plant data. The back-casting process is used to validate the yields sets used in such an LP model, by comparing actual data to LP model predictions. The simplicity of an LP model plays an important role when handing over to the users and for further development of the model. A good statistical analysis goes beyond just developing regressions and the delta-base model — the classical approach — of fixing everything and varying one factor at a time. The use of experimental design techniques to develop new models capable of yielding better solutions.

An algorithm for $\langle \mathbf{r}, \mathbf{s} \rangle$ -domination of a network

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Abstract

Consider a network facility location problem that is modelled by a network on n nodes labelled v_1, \dots, v_n . Let $\mathbf{r} = [r_1, \dots, r_n]$ and $\mathbf{s} = [s_1, \dots, s_n]$ be vectors of non-negative integers and consider the problem of locating the minimum number of units of some commodity on the nodes of the network such that at least s_i units are located in the vicinity (*i.e.* closed neighbourhood) of v_i , with no more than r_i units placed at the node v_i itself, for all $i = 1, \dots, n$. The smallest number of units that may be placed on the nodes of the network satisfying the above requirements is called the $\langle \mathbf{r}, \mathbf{s} \rangle$ -domination number of the network. In this paper we present an exponential-time algorithm which requires polynomial space for determining the $\langle \mathbf{r}, \mathbf{s} \rangle$ -domination number of an arbitrary network.

In the proposed algorithm the problem of finding the $\langle \mathbf{r}, \mathbf{s} \rangle$ -domination number of a network is modelled by the *set multicover with multiplicity constraints* (SMCM) problem. The only known exact algorithm for solving the SMCM problem appears in [1] and solves the SMCM problem in exponential time using exponential space. Its high memory usage renders the algorithm impractical and inspired us to pursue the more practical algorithm put forward in this paper.

Our proposed algorithm follows a branch-and-reduce approach similar to the approach adopted for determining the classical domination number of a network (*i.e.* in the case where $\mathbf{r} = [1, \dots, 1]$ and $\mathbf{s} = [1, \dots, 1]$) by Van Rooij and Bodlaender [2] and employs a number of reduction rules that improve the running time of the algorithm considerably.

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Applying operations research in the fast food industry

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Abstract

For a business venture to prosper there is need for management to have adequate information about the performances of the *decision making units* (DMUs). In that case performances of the DMUs must be closely monitored. Purposeful and effective business management cannot take place in the absence of properly compiled information with regards to the DMUs. Companies have relied on market research to find out how their business is behaving. It has, however, been noted that very few quantitative analyses have been carried out to observe relationships that exist among the DMUs from the same peer group and their performance trends. In most cases these analyses have either overestimated or underestimated the real potential of the DMUs of a company. This paper seeks to analyse how *data envelopment analysis* (DEA) can be used in the fast food industry to quantitatively study the performances of the DMUs so as to achieve the efficient frontier, taking Inncor Africa Limited as a case study.

Assortment planning of new retail stores

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Abstract

The purpose of assortment planning is to meet customers' demands by specifying a balanced variety of products as well as the quantities of each product. Since assortment planning impacts significantly on the sales and profit of retailers, it is important to address complex and strategic decisions in this regard efficiently and effectively.

The focus of this presentation is on the assortment planning of new stores to be opened by *Pep Stores Ltd* (Pep). Currently the decision making process of opening a new store is based on an existing store. To some extent, this decision making process resembles that of a self-fulfilling prophecy which might limit the potential performance of a new store.

In this presentation, alternative approaches to perform assortment planning for new stores will be discussed. The approaches are based on identifying groups of stores on which to base the assortment planning.

Automated maritime vessel activity detection using hidden Markov models

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Abstract

The self-reporting *Automatic Identification System* employed in the maritime domain provides real-time positional updates and a wealth of historical vessel motion patterns. These spatio-temporal updates supply low-level information to an operator who may be tasked with observing a 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. Automation of this process may, however, allow operators the opportunity to direct their attention elsewhere within the surveillance picture. To this end, activity detection is pursued in this presentation. A clustering method is used to partition motion patterns into categories of similar constituent elements. 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 required training data for hidden Markov models aimed at classifying newly observed motion patterns as engaging in the attributed 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.

A binary programming approach towards achieving effective network protection

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Abstract

In this presentation we adopt an integer programming approach towards computing five **NP**-hard parameters which frequently appear in the graph theoretic literature on the protection or safeguarding of networks. These parameters are the *domination number*, the *total domination number*, the *Roman domination number*, the *weak Roman domination number* and the *secure domination number* of a network. In applications, the vertices of the network denote physical entities that are typically geographically dispersed and which have to be secured or monitored, while the network edges model links between these entities along which patrolling guards stationed at the vertices may monitor entities or move to entities in order to resolve security threats that may occur at the entities. The five parameters mentioned above represent the minimum number of guards required to protect the entire network of entities under different conditions (*i.e.* for different definitions of the notion of protection). We investigate the effectiveness of a binary programming approach towards determining these parameters for small networks (with at most 99 vertices), medium-sized networks (with between 100 and 999 vertices) and large networks (1 000 vertices or more). The first three parameters above are classified as being applicable in a static protection framework, while the latter two apply to dynamic protection strategies. It is found that the three static parameters may be computed within a reasonable time for small and medium-sized networks by a state-of-the-art commercial integer programming solver, while the two dynamic parameters may thus be computed within a reasonable time for small networks only. For large networks more sophisticated solution approaches (*e.g.* column generation or (approximate) metaheuristic solution approaches) are required to determine the exact values of or upper bounds on all five parameters.

A comparative study of genetic algorithms using a direct and indirect representation in solving the South African School Timetabling Problem

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Abstract

Previous work applying genetic algorithms to solve the School Timetabling Problem have generally used a direct representation, in which each chromosome represents a timetable directly. This study proposes and evaluates a genetic algorithm employing an indirect chromosome representation. Each chromosome is a string consisting of instructions which are used to build a timetable. The fitness of each chromosome is a function of the hard and soft constraint violations of the timetable constructed using the chromosome. Tournament selection is used to choose parents to which the mutation and crossover operators are applied in order to create successive generations. The performance of the genetic algorithm using an indirect representation (IGA) was compared to that using a direct representation (DGA) in solving the School Timetabling Problem for a South African primary and high school. Both genetic algorithms were able to produce feasible timetables of good quality with the IGA performing better than the DGA. The difference in performance was found to be statistically significant.

Comparing radial basis function networks and generalised additive neural networks for spam detection

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Abstract

Spam has developed from an irritating characteristic of electronic mail to a time-consuming and costly resource problem. In this research the performance of the relatively unknown *generalised additive neural network* (GANN) applied to spam detection is compared to that of a radial basis function neural network. The GANN has previously shown promise as a feasible spam filtering technique. The radial basis function neural network is best known in classification applications and has not been applied extensively to spam detection. Results obtained will be discussed.

Decision making in consumer loan acquisition with multiple binomial classifiers

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Abstract

A topic of recent interest is optimal decision making when acquiring consumer loan accounts. Decisions are generally made by considering multiple but conflicting objectives, such as maximising profits, maximising market share, and minimising risk. Generally, past studies consider the case of a portfolio manager with a single binomial classifier to rank the risk profile of applicants. In this work, we consider the case of a portfolio manager with multiple, binomial classifiers. For example, a portfolio manager of a revolving credit facility (such as a credit card portfolio) could have access to a classifier that differentiates the propensity to default and another that differentiates transactors from revolvers. For such a case of a portfolio manager with multiple, binomial classifiers, we demonstrate methods for constructing the efficient frontier in the expected profit-loss-volume space.

A decision support tool to locate and operate a DC in the Western Cape for MediClinic

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Abstract

Currently MediClinic South Africa does not use *distribution centres* (DCs) in their supply chain. Instead, each hospital is responsible for its own stock buying and stock levels within the hospital pharmacy. In order to investigate the possibility of implementing a DC in the Western Cape, this final year project provides a decision support system with regard to locating the DC and determining a delivery schedule and operation strategy for the vehicles servicing the hospitals. The way in which this was completed is through the use of linear programming and heuristic methods to solve for these two decision problems.

A study on the *Facility Location Problem* (FLP) was completed to determine the most appropriate form of this problem which could be applied to solve for the location of the DC. The final formulation applied is the Uncapacitated Facility Location Problem. Data were collected from various sources in order to solve for the location. The best location chosen was Bellville due to having the shortest distance to all hospitals and also having the lowest fixed cost.

The second phase was to determine the routing of the delivery vehicles. A study on the *Vehicle Routing Problem* (VRP) was performed and the most applicable formulation relevant to MediClinic's case is the Distance Constrained Capacitated Vehicle Routing Problem. Again data were collected and received from MediClinic in order to solve this problem. The solution for both the FLP and the VRP were done in MS Excel due to its accessibility and ease of use. The *Solver* tool was used to solve for the FLP and the greedy algorithm heuristic was coded in Visual Basic to solve for the VRP. The decision support system is therefore a combination of the solutions to both these problems and all variables and constraints can be edited or inserted by the user in two basic user form sheets.

The outcome of this project is therefore a single Excel file which allows the user to enter relevant variables and constraints concerning the location of the DC and the routing of the delivery vehicles. The result is that the user can make informed decisions concerning these two problems with confidence. It also allows MediClinic to partially assess what the expected cost of operating such a DC would be and therefore support in the decision of whether or not to implement a DC strategy.

Developing an understanding of the fundamentals of vehicle delay at signalised intersections using analytic and numeric models

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Abstract

One of the most important performance measures considered when determining the effectiveness of a traffic control technique implemented at a signalised intersection is the vehicle delay occurring as a result of the traffic signal timings. For this reason it is imperative to have a thorough understanding of the dynamics of vehicle delay at a signalised intersection as well as factors influencing this delay. In this paper, vehicle delay at a signalised intersection is modelled analytically, first for deterministic inputs, and then for more realistic, stochastic inputs. A model is derived for determining an optimal cycle length and green time allocation for a fixed, n -phase cycle regime, in terms of minimising overall delay while maintaining an individual driver-focused level of service. For both deterministic and stochastic inputs, these optimal signal timings are used to gauge the effectiveness of self-organising traffic control techniques proposed in the literature.

Determining an optimal basis for allocating operating room time under uncertainty

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Abstract

The allocation of procedures to operating rooms is a popular operational research topic within healthcare. There is often only a short period of time available within which to make the scheduling decisions. Operating rooms are associated with a number of high costs (the cost of having the operating room ‘open’ or operational for the day, the cost of having a surgeon available, the cost of the team who run the operating room) and consequently there is a particular focus on efficiency in this area. The scheduling problem is often complicated by a number of factors. The problem investigated here involved two operating rooms, each with its own surgical team, and one surgeon who moves between these two areas. Uncertainty due to variation in the time that it takes to (i) prepare a patient, (ii) perform surgery and (iii) clean up the operating room after surgery (the activity durations) for each type of procedure further complicates decision making in this area. This investigation focussed on developing a static modelling technique that uses a particular set of time values for the activity durations to solve the Operating Room Allocation Problem. Different possible activity durations were then used in the modelling to generate different recommended schedules. Finally, each of these schedules were tested by substituting a range of different possible activity durations into each schedule and then evaluating the performance of the schedule under each of these possible conditions. It was shown that, for the problem setup evaluated in this paper, a hospital would obtain the best results in the long term if it based its operating room schedules on either the 75th percentile values or the maximum values of the procedure time lengths.

Dynamic bulk freight train scheduling in an uncongested rail network

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Abstract

Many academic works in the train scheduling environment concentrate on optimising movements of resources through the physical network. To optimise bulk freight lines, algorithms must provide a feasible schedule given the available resources, basic operational constraints and varying demand while ensuring resource allocations that minimise total cost. To be usable the algorithm must run within reasonable time limits. This dissertation focuses on the Bulk Freight Train Scheduling Problem of full loads without track congestion, but extends to cover operational constraints as well as flexible resource allocation and hubs. A problem outline is given in which the constraints and decision variables are well defined followed by a review of current literature. An exact formation of the problem is given with benchmarking on small data sets. A genetic algorithm is used to solve for schedules on larger problem data sets. The algorithm was successfully implemented on the 60Mt Coal Line in South Africa which provided notable improvements in efficiencies. Discussion and results are provided.

The enumeration of mutually orthogonal Latin squares

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Abstract

Latin squares and sets of *mutually orthogonal Latin squares* (MOLS) have application to various scheduling problems, from providing effective ways to access parallel memory structures to scheduling transmissions from sensor arrays. MOLS, specifically, also play an important role in sports tournament scheduling where every structurally distinct MOLS provides the scheduler with additional planning freedom.

The existence (or otherwise) of MOLS has been resolved for all orders of Latin squares, except for order 10. We consider a backtracking algorithm for the enumeration of structurally different MOLS that partitions the search space in such a way that it is possible to estimate bounds for the enumeration of higher order MOLS. A contribution towards the celebrated question of the existence of a 3-MOLS of order 10 is made by investigating the feasibility of using this algorithm in conjunction with specific computing paradigms in search of such a design.

The Evolutionary Spatial Prisoner's Dilemma on a cycle

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Abstract

In this presentation we consider the *Evolutionary Spatial Prisoner's Dilemma* (ESPD) in which players are modelled by the vertices of a cycle representing a spatial or organisational structure amongst the players. During each round of the ESPD every pair of adjacent players in the cycle play a classical prisoner's dilemma against each other, and they update their strategies from one round to the next based on the perceived success achieved by the strategies of neighbouring players during the previous round. In this way players are able to adapt and learn from each other's strategies as the game progresses without being able to rationalise good strategies.

We characterise the steady states of the game as well as the structures of those initial states that lead to the emergence of persistent substates of cooperation over time. We finally determine analytically (*i.e.* without using computer simulation) the probability that the game's states will evolve from a randomly generated initial state towards a steady state which accommodates some form of persistent cooperation. More specifically, we show that there exists a range of game parameter values for which the likelihood of the emergence of persistent cooperation increases to almost certainty as the length of the cycle increases.

This paper is dedicated to Theodor Stewart on the occasion of his 70th birthday.

Face milling with indexable round inserts: An analytical model for optimisation of production parameters with TI-6AL-4V machining

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Abstract

Titanium alloys are increasingly being utilised in aerospace components due to its high melting point, low density and relatively high elasticity. However, due to these qualities, titanium is classified as a superalloy that is difficult to machine. During machining, its low thermal conductivity causes a concentration of heat at the cutting edge. This causes cutting tools to overheat during machining, which leads to increased machining costs. When titanium alloys, such as Ti-6Al-4V, reach temperatures in excess of 500°C during machining, there is a distinct possibility of alpha case layer formation due to Ti-6Al-4V's high reactivity with oxygen. The alpha case layer, even if present only as minute islands, form fatigue crack initiation sites under typical aerospace operating conditions such as cyclical or vibration loading. In aircraft components, fatigue crack propagation ultimately causes failure at unpredictable times, often resulting in accidents and fatalities. However, empirical research results repeatedly show that machining temperature can be controlled by adjusting parameters such as the cutting force, cutting speed and material removal rate in a face milling process for instance. The aim of this presentation is to contribute towards the prevention of having machining temperatures exceed their critical thresholds by limiting temperature rise at the tool-chip interface through management of the process parameters. Although the prediction of machining temperature has been modelled before, little attention has been given to constructing an analytical model that will inform on how to minimise the temperature rise in the work material rather than the tool surface, while maximising the material removal rate. Such a model is developed and discussed in this paper. The model is verified through experimental face milling runs and temperature measurement is performed by means of thermocouples embedded in the work piece.

Facility location subject to proximity and terrain-induced visibility constraints

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Abstract

The placement of facilities, such as radar, telecommunication towers, telescopes, surveillance cameras and watchtowers, requires careful planning. To operate optimally, these facilities have to be placed according to their capabilities or specific requirements. When placed in a networked environment (which may include different types of facilities), the placement requires consideration of the surrounding terrain and other constraints. In this presentation the results of utilising different terrain modelling techniques and their effects on the accuracy of terrain-related computations are investigated. These computations include *line-of-sight* (LOS) and terrain surface area visibility queries (which are LOS-dependent) that are utilised as facility location constraints. LOS techniques are well documented for gridpost-based solutions as well as for triangulated ones leading to the proposal of a novel hybridised LOS technique which aims to reduce computation time. A facility location problem is formulated which illustrates the implementation of such a model, considering proximity and terrain-related visibility constraints.

A family of valid inequalities for some classical combinatorial optimisation problems

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Abstract

In this paper, we present a large family of valid inequalities for combinatorial optimisation problems in graphs. Particularly, we consider paths, trees and cycles problems in graphs or directed graphs. The problem of separation of such valid inequalities is **NP**-hard. That is, in view to exploit them, we resort to lifting techniques. Through our experiments carried out on randomly generated graphs, we propose that lifted inequalities can be used in a cutting plane algorithm to strengthen the linear relaxations of mixed integer linear programming models of paths, trees and cycles problems.

Freight transport modelling and its application within Transnet

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Abstract

The movement of freight is an integral part of any country's economy. Sufficient, appropriate and reliable transport remains an essential element for sustained economic growth. The production and consumption of goods and services are usually physically separated, which requires that the distance between the two needs to be bridged by using at least one mode of transportation.

Providing the necessary capacity for the different modes of transport requires careful and proper planning. In this regard the forecasting of future demand is a critical component of the planning function. This paper will endeavour to present a short review of freight transport modelling and then discuss the use and application of different models within Transnet. As the single provider of rail services, Transnet has developed various tools to assist in the planning of future rail capacity and infrastructure.

Heuristics and solution methods for the Dial-A-Flight Problem

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Abstract

The Dial-A-Flight Problem has become important with the emergence of very light jet taxi services in the USA, and helicopter taxi services in Brazil. This work was inspired by a tourist taxi airline in Botswana. Heuristics and valid inequalities are presented for the problem. Three techniques for obtaining good solutions, using integer linear programming, are presented.

How the Cloud will put optimisation within the reach of many more organisations

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Abstract

Today most organisations are optimising their business practices. This typically means they have an initiative to improve on the *status quo* and not yet the use of advanced analytic technologies to achieve optimal decision making. In the course of this presentation we want to analyse the reasons for the lack of adoption and also discuss a way to bring more advanced analytics to more organisations.

The OR community offers a wealth of experts who are ready to create high-performance optimisation models and algorithms. On the other side, commercial users today have high expectations for software with respect to usability, collaboration capabilities and enterprise integration.

This leaves us with a number of gaps: How do companies get access to the most suitable experts and how do these experts turn their ideas into easy-to use and functionally rich enterprise applications? Also, how to achieve this at an affordable price and with limited time to see results?

In this context, the cloud has the potential to be much more than just a way of making cheap computation/optimisation resources available. It can be a platform to share (market and consumer) expertise and to host next-generation optimisation applications. We have created an optimisation application framework which supports rapid development and seamless deployment in the cloud. We will discuss our experiences and how OR experts can participate.

How to get the best out of your analytical teams

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Abstract

Analytics forms an integral part of business today. However, the majority of analytical teams do not function optimally. There are a number of reasons why managements struggle to get the most out of their analytical teams. During this presentation the following topics will be covered and discussed in some detail:

- Current challenges,
 - Team structure,
 - Enhancing the overall skills of the team,
 - Knowledge management, and
 - Training plans.
-

Human resources decision support using Sasol Technology's Employment Equity Target Assessment Model

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Abstract

Sasol Technology recognizes that employees are a company's greatest asset and it is committed to the effective implementation of employment equity, affirmative action and diversity management programmes. Sasol Technology has used Operations Research, planning and forecasting models for several years to provide human resources decision support. The Employment Equity Target Assessment Model has produced valuable decision support for managerial actions regarding recruitment, promotion, separations and retirements. The model uses a system dynamics approach to reflect evolving and interrelated staff movements. An auxiliary systems dynamics model, the Bursar Diversity Model, is used to analyse and forecast graduate output from tertiary education institutions in degrees of interest to Sasol Technology. Future workforce profiles are assessed against targets. The impact of levers and scenarios are investigated.

Influencing the future: Open access horizon scanning in Africa?

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Abstract

Horizon scanning is a futures methodology that aims to identify weak signals in the environment, and use these to inform strategic planning. Horizon scanning is a people-driven process, which may or may not include the use of expert opinion. The outcome is inevitably influenced by the world view and priorities of the scanners. A number of organisations have been performing horizon scanning in Africa over the recent past, and the extent to which such work can identify trends and influence strategic thinking in a developing context, is of interest. Successful, large-scale horizon scanning projects have been undertaken in the developed world, and have in most cases been driven by specific organisational or government goals and funding. With respect to poverty and development, the question is posed whether or not it is possible to do horizon scanning in an open access fashion, *i.e.* to produce information that is independent of specific goals, available to all for free, and of sufficient value to result in the broad uptake of futures thinking and the ubiquitous use of futures products to influence decision making. By its very nature, an assessment of the quality of any futures work is difficult. This paper reviews some of the recent African horizon scans at a process as well as a content level. It considers the strategic use of horizon scanning information in developing contexts, and the potential thereof to influence decision making for poverty reduction and development. The viability of open access horizon scanning in developing countries is also considered.

Information theory in financial modelling

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Abstract

We investigate the application of information theory in the analysis of payout structures in financial decision-making. The resulting framework can incorporate volatility and liquidity issues, and provide a way of describing optimal payout structures.

An investigation into the causes of transportation inefficiency

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Abstract

In the process of implementing a routing and scheduling tool, a major retailer discovered unexpected challenges. Even after these challenges were addressed, the new system suggested plans which were counter-intuitive. An investigation was conducted as to the causes of this incongruity, and it was discovered that the incentive structure of the various business units was driving the business to underperform. Once new performance metrics were established, the business realised significant cost reductions without any changes to their fleet or staff.

An investigation into the performance of particle swarm optimisation with various chaotic maps

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Abstract

A close look at the *particle swarm optimisation* (PSO) algorithm shows that randomness plays a very useful role in effectiveness of the algorithm. Randomness comes into play at the point of initialising the particles in the solution space and in updating the velocities of particles at each iteration of the algorithm. This random feature has contributed immensely to the performance of PSO. However, to further enhance the performance of PSO, randomness was introduced into the inertia weight strategy of PSO, leading to the introduction of a *random inertia weight* (RIW) strategy. Some further work led to two other inertia weight strategies, the *chaotic random inertia weight* (CRIW) strategy and the *chaotic decreasing inertia weight* (CDIW) strategy, which brought in chaos as a feature into PSO, with improved optimizing capability as a result of better global search mobility. This paper further investigates the effect of nine other chaotic maps on the performance of the PSO algorithm to ascertain the best among them in comparison with the CDIW and CRIW strategies. Some benchmark mathematical problems were used to verify the effectiveness of each of the chaotic maps.

Investigation of a hybrid renewable energy system to meet South Africa's baseload energy demand using a multi-objective PBIL optimisation algorithm

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Abstract

South Africa's current baseload energy demand is met by electricity produced from coal and nuclear fuel. The demand for electricity is growing and the concern is that this dependence on fossil fuels will have an irreversible adverse environmental impact. Introducing renewable energy sources into the energy system can address this issue. However, renewable energy technologies are intermittent in nature because of their dependence on the climate and limited storage capability. It is also due to this fluctuating supply that renewable energy technologies have traditionally only been used for peaking, and not baseline, power demands. Combining various technologies in an integrated system can possibly result in stable supply. In this study, the multi-objective optimisation of an integrated, large-scale hybrid renewable energy system is investigated, replacing some of the traditional fossil fuel baseload power stations in an economically feasible way. The aim is thus to minimise the dependency on traditional fossil-fueled baseload stations and also to minimise the cost of the system. Using the data from national feasibility studies and climate data, the electricity supply potential of a combination of wind, solar photovoltaic, concentrated solar power, pumped storage and hydro power sites is modelled and measured against the national demand curve of mid-winter, when electricity demand is at its highest. To achieve optimisation and conversion, the *population-based incremental learning* (PBIL) algorithm is used. The Pareto front results show the baseload requirement for a given expenditure. This model can be expanded to include factors such as grid stability and seasonal climate fluctuations in order to aid national renewable energy policy making.

A linear programming approach to business process optimisation: Application to a South African bank

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Abstract

Business process optimisation (BPO) entails (re)designing the business process for the underlying service composition to fit a given constraint, *i.e.* taking into account some constraints for a specific service infrastructure. It involves optimising process flows of all sizes, crossing any application, company boundary and connects process design and process maintenance. It entails adapting the business process to improve the process execution in order to reach a higher quality of service level for a specific service composition. As a result, BPO is considered a ticket to competitive advantage. BPO has so far been performed from an intuitive perspective. It has, however, components that can be expressed linearly, either directly or by some transformation, which facilitates a mathematical approach of optimisation. Due to the perceived linear nature of the relationship with its factors, an attempt is made in this study to model BPO using a linear optimisation approach, the *linear programming* (LP) method. This study intends to use LP (and related methods, such as integer programming and mixed-integer programming) to model BPO.

Panel Discussion:
Long-term electrical demand forecasting for strategic transmission network planning

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Abstract

The electrical networks and power stations are modelled as a transshipment problem which provides a basis to debate forecasts on different levels of the model. The debates provide a better understanding on future expected demand growths in the complex and highly uncertain environment Eskom is operating in. Simple rules and graphical displays are used to analyse the historical demand flows for a better understanding of the current demand trends and cycles. An understanding of the current demand trends and cycles combined with a comprehensive market intelligence system provides more informative forecasts and insight on the future expected demand growths. The expected demand growths are spatially modelled to support the long-term electrical network studies and to ensure long-lasting and optimal network solutions expanding the transmission network.

A machine learning approach to hyphenation in Afrikaans

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Abstract

In this talk, the results of a study to determine the level of success achievable with a purely pattern-based approach to hyphenation in Afrikaans will be discussed. The machine learning techniques *neural networks*, *decision trees* and the algorithm used by T_EX were investigated. A lexicon of Afrikaans words was extracted from a corpus of electronic text ($\pm 183\,000$ words). Words in this lexicon were syllabified and compound words were decomposed to obtain training and testing data for both syllabification and decomposing of Afrikaans words. Optimal syllabification and decomposing models were developed for each of the techniques. Testing showed that the T_EX algorithm performed best on both the syllabification and decomposing tasks and we concluded that it can be used for hyphenation with little chance of errors in text. The performance of the neural network was lower, but still acceptable, while the decision tree was found to be too risky to use for either of the tasks. A combined algorithm was developed from the optimal neural network model and the T_EX patterns, with promising results.

Megaprojects contingency determination

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Abstract

Project cost estimate has two components, the baseline estimate and contingency estimate. The sum of these two estimates forms an initial cost estimate for the project. Contingency cost is added to make provision for uncertainties. Final project cost often exceeds the initial cost estimate. Similarly, the final project schedule often exceeds the initial schedule. The deviation of the final cost from the initial cost comes as a result of poor contingency determination. The following techniques are usually used to estimate contingencies: traditional percentage, Monte Carlo (risk analysis), artificial neural networks, regression analysis, expert judgement, and case-based reasoning. Regression methods are widely used, because of the belief that this technique performs better compared to others. When there is no direct historical data, regression methods become useless. To overcome the data challenges, system dynamics and Dirichlet process techniques are proposed.

Metaheuristics for a parallel machine problem

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Abstract

This paper considers the Due Window Scheduling Problem of minimising the number of early and tardy jobs on identical parallel machines ($Pm||\sum(U_j + V_j)$). This problem is known to be **NP**-complete and finding an optimal solution is unlikely. Three metaheuristics and their hybrids are proposed with extensive computational experiments conducted. The overall best among them is a simulated annealing hybrid. Detailed comparative tests were also conducted to analyze the different heuristics.

A model to optimise the linked sawing and ripping decisions in the South African pine cutting chain

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Abstract

In this presentation we consider modelling and linking two important cutting operations in the South African pine wood industry. The model is proposed to help answer the following question: Given the current log supply — what should some of the decisions, specifically machine settings, be for two cutting centres to try and meet market demand at a minimal cost. The first decision is how to saw up the log supply into its different thicknesses by choosing certain cutting patterns; the second is to decide on a rip saw's settings (priority values), which determines how the products from operation one are cut into products of a certain demanded thickness and width. The objective function to minimise includes the raw material waste cost, and an over/under-production cost. The over-production cost is estimated to represent the stock keeping costs. The under-production cost is estimated as the buy-in cost of purchasing the raw material from another wood supplier. The modelling tools used in this paper are the *probability-based incremental learning* (PBIL) algorithm and *mixed integer programming* (MIP), and the modelling software used are **Simsaw** and **AIMMS**. The model performs well against current decision software available in South Africa, namely the *Sawmill Production Planning System* (SPPS) package, which combines simulation (**Simsaw**) and MIP techniques to maximise profit. The model adds further value in modelling and determining the ripping priority settings linked to the chosen cutting patterns.

Modelling systems with autonomous agents

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Abstract

Agent-based modelling and simulation (ABMS) is a relatively new and lesser-used tool that is very useful in modelling the dynamic nature of a complex system with a collection of autonomous decision making agents. The main objective of this presentation is to introduce ABMS, compare it to other simulation techniques, and show how it can be used to model dynamic systems. Furthermore, a brief case study will be presented which illustrates the usefulness of ABMS, demonstrating how one can assess the effects that agents have on the system and through this make deductions for the sake of optimisation.

Multiobjective optimisation of inventory control selection

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Abstract

Tracking inventory levels is a common problem in large manufacturing companies. The human resources required to actively control every single item in stock is very expensive. The resultant decision to control only certain items is usually based solely on reducing capital commitment costs. This paper shows that the rental fees for containers, boxes and other packaging materials in the warehouse sometimes exceed the capital commitment costs. Furthermore, the delivery reliability of each supplier should have an impact on the stockholding period of each item, to ensure continuous production. It is thus recommended that both cost factors, as well as vendor reliability, should be considered in inventory control decisions. In this study, an optimisation model is developed to inform the decision on which parts to control and to determine the optimal stockholding periods subject to this control decision. A trade-off is found between the increase in the risk of production down-time due to low inventory levels and the increase in cost as a result of maintaining high stock levels. The cross-entropy algorithm for multiple-objective optimisation was applied to identify the optimal selection of controlled parts that will minimise inventory carrying cost, as well as the production down-time risk. The algorithm was applied to a real-life case study with 543 different stock items. In a compromise solution, it was found that capital commitment and packaging costs can be reduced by 7.6% whilst the production down-time risk was reduced by 13.1%.

Nonlinear smoothing: A comparison of median, hybrid and LULU smoothers

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Abstract

Structural stability is very important in time series since future estimation is based on it. If unstable relationships are used for estimation, the forecasts can be biased, inaccurate and not meaningful at all. Structural changes can occur as outliers (spikes), a single shift or fluctuations. In the literature these are also called change points, break points, step changes or jumps, and most research has focussed on statistical quality control. In the field of engineering it is known as edge detection and edge preservation, and applied in the areas of signal processing, image processing, computer graphics, pattern recognition, geology, *etc.* For nonlinear smoothers, it was found that the standard moving median removes outliers and preserves shifts from a constant signal, but the smoothed values deteriorate if a trend is present. *Finite impulse response median hybrid* (FMH) smoothers also preserve shifts and are more flexible, but are more vulnerable to outliers. It was found that the repeated median, an application of robust regression, removes subsequent outliers from a signal with trend. *Lower-upper-lower-upper* (LULU) smoothers were introduced by C.H. Rohwer in 1989. These smoothers are compositions of the extreme selectors — the minima and the maxima. They also have very attractive mathematical properties, such as their way of dealing with impulsive noise in the form of block pulses. The median, repeated median, hybrid and LULU smoothers were applied to time series with trend, and their performance is compared via simulations. The results will be discussed.

The number of pickers and SKU arrangement on a unidirectional picking line

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Abstract

A picking line is often the single largest expense in a *distribution centre* (DC). In the case of the Durban DC of *Pep Stores Ltd* (Pep), the picking line is also a significant bottleneck in overall efficiency and inventory flow. The number of pickers in a picking line and the initial *stock keeping unit* (SKU) arrangements are two known factors that affect the picking line efficiency. The main objective of this study was to model the picking line with an agent-based simulation that describes the individual behaviour of pickers, and furthermore, through the simulation, provide analysis on the stated efficiency factors. The simulation, through verification and validation, was shown to model the real-world picking line to a satisfactory degree.

Analysis of the simulation runs revealed that the density of a picking line, which refers to the average distance between SKU picks, is a significant factor in choosing a good number of pickers for a picking line. A lookup table is presented to provide decision support for the choice of a good number of pickers for a specific picking line.

The initial SKU arrangement on a picking line is shown to be a factor that can affect the level of congestion and the total completion time. The *greedy ranking and partitioning* (GRP) SKU arrangement technique from the literature and the historical SKU arrangements used by the Pep Durban DC were compared against the proposed *classroom discipline algorithm* (CDH) SKU arrangement technique. The CDH was shown to provide a more even spread of SKUs that are picked most frequently, thus decreasing congestion and total completion time.

On-load tap changer classification using supervised learning on the latest Eskom Reg-D data

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Abstract

The goal of this study was to explore the possibility of creating a trivial statistical model of a live 66kV-11kV 20MVA transformer, in an effort to validate the significance of recently accumulated Reg-D relay substation data. Power transformer data were obtained from a live substation over a period of one month, and used to develop a model with which to predict the transformer's mechanical tap position. Both multi-class logistic regression and artificial neural network methodologies were implemented, tested, and the results compared. The results indicate a significant performance advantage in favour of a neural network implementation with regard to the specific data set and particular parameter selections. Central to this study is the general knowledge gained from the practical implementation of machine learning on Eskom data, with emphasis on current data acquisition techniques and practices within the industry. The aim of this investigation is to help identify and educate possible key implications with regards to future optimisation, prediction, and modelling strategies, within the utility industry, from a data science perspective. Data will inevitably form the underpinnings of a future Smart Grid system, since it influences essential prior knowledge needed to support concrete decision-making algorithms in future electrical grid automation.

On the fairness of a Super 15 schedule

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Abstract

Super 15 rugby is not only one of the most popular rugby tournaments in the world, but also a profitable business. Determining a feasible schedule for the tournament is a challenge, and calculating a fair schedule even more so. A number of different, often conflicting, measures of fairness must be considered. In this presentation we introduce the concept of fairness with particular reference to this tournament. Measures such as travel, distribution and assignment of bye games, lengths of sequences of home and away games, times between playing the same team and balance of the number of games in each country per week are considered. A mixed integer programming approach is also presented to determine a schedule.

On storage assignment in a zoned order picking system with unidirectional picking lines

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Abstract

An order picking System in a *distribution centre* (DC) owned by *Pep Stores Ltd* (Pep) and located in Durban is investigated. This order picking system utilizes 12 unidirectional cyclical picking lines for break bulk picking and a central inventory planning approach. Thus all product allocations to branches are planned at central office and branches typically do not request stock from the DC. When a *stock keeping unit* (SKU) is sent to a branch, it must be placed in and processed on a picking line. In this way the picking lines form a dynamic zoned forward pick area which has a changing SKU profile. These operations have created a system which is unique in the literature. The DC functions in a deterministic environment due to the centralised planning during each planning period (typically a day). However, consideration must be given to potential scenarios in the next planning period, such as the out-of-DC deadlines for SKUs. When managing this order pick system there are four major decisions which need to be made, each of which impact on the efficiency of the picking lines:

- (1) Which SKUs should be picked on a specific day given the picking line capacity?
- (2) Which SKUs should be grouped together on the same picking line?
- (3) To which locations should each SKU be allocated in the picking line?
- (4) In which sequence should orders be picked by pickers?

Both decisions (3) and (4) were resolved by reducing the total distance walked by pickers. Here a new concept of a *maximal cut* is introduced to linearise the cyclical nature of the walking distances of pickers. When considering decisions (3) and (4), several additional objectives become important, such as deadlines, carton sizes and department clustering. In this presentation, a brief discussion is given on the solution approaches to decisions (3) and (4). A description of the complexities of, as well as preliminary results related to, decisions (1) and (2) is also presented.

Operational research(ers) in development: Growing a new generation

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Abstract

This paper explores the theme of training *operational research* (OR) practitioners in South Africa by critically evaluating a Masters Program in *Operational Research in Development* (ORD), launched in 2005 at the University of Cape Town. This program was specifically focused on applying OR to the problems of the developing world in general and Africa in particular. We describe the program and review the practical work undertaken by students participating in the program. Topics range widely across domains, including health (antimalarial drug resistance), poverty (food banking), governance (NGO management structures and monitoring of local government performance) and sustainable livelihoods (spaza shop operations). We use the review to highlight strengths and weaknesses of the program, as well as challenges faced in OR education in South Africa at a postgraduate level.

This paper is dedicated to Theodor Stewart on the occasion of his 70th birthday.

Optimal time interval between screening tests for promotions in manpower planning

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Abstract

In manpower planning systems, recruitment and promotion of staff are an ongoing process to maintain the required staff strength. Neither recruitment nor promotion can be undertaken too frequently since they result in high costs. Many stochastic models dealing with promotions are available in the literature. Promotion of persons based on their satisfactory performance is a screening test which is a common procedure in many organisations.

Failure by an organisation to match manpower needs and resources can result in qualified staff leaving the organisation. Wastages left to accumulate over longer periods of time will expose the organisation to a breakdown. Hence, organisations should timely embark on screening tests to select deserving staff for promotions within the system. With a view to minimize the costs involved, the use of compartmental models in manpower planning is considered in this paper to determine the optimal time interval between successive screening tests. Numerical examples are given to illustrate various aspects of the model considered for the expected time.

Optimising circuits for superconducting supercomputers

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Abstract

Large-scale computing installations, including supercomputers and data centres, consume a large amount of power. In 2011, data centres alone used as much power as the whole of Spain. Semi-conductors will continue to improve their efficiency, but they face physical limitations. Superconductors have been identified as the technology most likely to replace semi-conductors in certain key areas, especially where power efficiency is paramount. The manufacturing process introduces some variability to the components of superconducting circuits. By carefully selecting the sizes of the components, the risk of the manufacturing process can be mitigated. We considered three measures of circuit performance, namely yield, critical margin and leakage. With the use of metaheuristics and multi-criteria decision analysis we optimised a DRO-cell as a proof-of-concept.

Optimal liquidity execution planning using stochastic programming and robust optimisation

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Abstract

The new Basel III framework sets out higher and better-quality capital, better risk coverage, the introduction of a leverage ratio as a backstop to the risk-based requirement, measures to promote the build-up of capital that can be drawn down in periods of stress, and the introduction of two global liquidity standards. These liquidity standards focus on testing the short- and long-term solvency of banks, namely the *liquidity coverage ratio* (LCR) and the *net stable funding ratio* (NSFR). The fundamental characteristics of high-quality liquid assets are:

- Low credit and market risk,
- ease and certainty of valuation,
- low correlation with risky assets, and
- listing in a developed and recognized exchange.

Apart from managing a dedicated portfolio of these high-quality liquid assets and attaining short-term (LCR) and long-term (NSFR) liquidity ratios of above 100%, banks must also consider strategising their responses to liquidity crises in advance, including developing plans for liquidity execution. We investigate optimisation techniques for resource allocation in the liquidity execution process. We propose a stochastic programming model and a robust optimisation model assessing uncertainty and worst cases in terms of “market depth” and liquidity stress. We will discuss the formulation of these models, which minimise the cost of the liquidity execution, and discuss how they can be used in liquidity execution planning.

Optimisation of land use in the Sandspruit catchment to mitigate impacts on water resources

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Abstract

Changes in land cover and land use along a river have an impact on the river's water quality as well as the catchment's water balance. An example may be found at the Sandspruit catchment, a water management area in the Western Cape Province of South Africa. Researchers investigating dryland salinity impacts on Western Cape Rivers found that dryland salinity in the Sandspruit catchment was extensive as a result of current land use and geology changes. As a result, the water is unsuitable for domestic, agricultural, recreational or industrial purposes. The J2000 hydrological model has been applied to this catchment for a detailed view and simulation of its hydrological behaviour. This paper is concerned with managing and minimising the high salinity levels in the Sandspruit catchment. At present, land use changes need to be manually input into the hydrological model using a scenario analysis approach to determine the impacts of proposed land use alternatives. This paper aims to replace these manual scenarios with an optimisation model that communicates with and automatically feeds the hydrological model to optimise the land use configuration of the catchment. The cross entropy-method is used to evaluate the solutions from the hydrological model and optimise the land use catchment area assignment for minimum salinity. The solution provides guidelines for regulating land use in an attempt to reduce the mobilisation of salts to the Berg River, which is an important source of freshwater in the Western Cape.

Partially multi-skilled back office workforce assignment optimisation: An operations management decision support tool for AOMi[®] simulation training

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Abstract

The AOMi[®] Simulation Training programme is an industry leading business simulation training programme that aims at giving the participant an appreciation of prescribed strategic and tactical best practices on operations management. While the business simulation game makes excellent recommendations on the qualitative level there is little explicit effort placed on the application of robust quantitative methods on the implementation of the qualitative recommendations brought forward. The purpose of this work was therefore to fill one of these gaps by developing a partially multi-skilled workforce assignment and allocation optimisation utility as a decision support tool for use on the AOMi[®] Simulation Training programme. The optimisation model formulated aims to strike a balance on three key performance indicators, namely *cost*, *service* and *quality*. Staffing assignment and allocation is identified as having a major impact on cost and consequently also on quality and service level. Variables on skill levels and importance factors for each are defined and quantified through an implicitly implied data envelopment analysis and analytical hierarchy process. The optimisation model is built on actual experiences and data gleaned from the experiences of the authors while on the AOMi[®] Simulation Training programme. Metaheuristics are well suited for finding near globally optimum solutions to large-scale multivariate and multi-objective optimisation problems where most conventional Excel-based solvers fall short. Optimisation has also found numerous areas of application in the management of back office operations, including workforce assignment, allocation and scheduling optimisation. As such, we put forward the particle swarm optimisation algorithm as one way of efficiently solving the integer programming model applied in the utility.

Population-based local search heuristics for the Traveling Tournament Problem

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Abstract

The Sport Fixture Scheduling Problem seeks to produce a fixture schedule that reduces the travel distance for the fans and players. This problem is essentially a minimisation problem which must satisfy the constraints set by the governing sport association. Most practical cases have considered the problem from a developed countries or continents perspective, such as the European League, and have proposed various metaheuristics for solving the problem. This paper proposes a population-based implementation of single-solution heuristic techniques for solving the Traveling Tournament Problem. Results obtained are compared with the raw implementation of the underlying techniques and that obtained from similar solutions and benchmark data from the literature.

Preliminary results of a multiobjective cross-entropy method applied to solve the In-core Fuel Management Optimisation Problem

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Abstract

Nuclear reactors are typically operated at power for a given duration, followed by a shut-down period. One of the tasks that occur during the shut-down period is the reloading of fuel assemblies in the core, in preparation for the next cycle. Typically, a number of depleted fuel assemblies are removed from the core and replaced by fresh fuel assemblies. The loading positions of all the fuel assemblies in the core may then be reconfigured in order to satisfy the prescribed safety and utilisation requirements. The *In-core Fuel Management Optimisation* (ICFMO) Problem refers to the problem of finding an optimal fuel reload configuration for a nuclear reactor core. The ICFMO problem is typically multiobjective, nonlinear and combinatorial in nature. Furthermore, a reactor core calculation system is used to evaluate the objective functions and constraints of the ICFMO problem for a given reload configuration, which entails computation of the temporal, spatial and spectral distributions of neutron fluxes in the reactor model. A description of the ICFMO problem will be given in the context of the *South African Fundamental Atomic Research Installation 1* (SAFARI-1), South Africa's research reactor. SAFARI-1 is primarily utilised for scientific research, radiopharmaceutical and isotope production, irradiation services and material testing, thus giving rise to a multiobjective ICFMO problem. A multi-objective cross-entropy method is implemented to solve the problem approximately and a description of the method, as well as the results that were obtained, will be reported. The aim of this research is to develop an efficient decision support tool for a nuclear reactor operator tasked with designing reload configurations.

Prerequisites for the design of a maritime law enforcement resource assignment decision support system

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Abstract

In a maritime law enforcement environment, a coast guard operator is typically required to make counter-threat decisions following the detection and evaluation of threats at sea. These decisions reside within a so-called *resource assignment* process, where maritime law enforcement resources, such as patrol vessels, military vessels, and armed helicopters, have to intercept vessels which are deemed potential threats. Because the number and nature of potential maritime threats can be overwhelming, it is believed that the quality of resource assignment decisions can be improved by providing maritime surveillance operators with computerised decision support. However, evolving patterns of threat behaviour render the problem less structured than it might appear, suggesting that the resource assignment process is by no means a repetitive clerical task, but that an element of learning and adaptation is present. Following a review of the research into maritime threat evaluation and threat detection systems, the aim in this presentation is to propose a generic approach towards designing an automated decision support system to be used by human operators as a tool assisting in maritime law enforcement resource assignment decision making situations.

Real-time rescheduling in case of large disruptions in railway networks

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Abstract

Relatively large disruptions in railway networks frequently require infrastructure managers and railway operators to update the timetables of the trains, the rolling stock assignments and the crew schedules in real-time in order to compensate for the loss of network capacity. In the operations research literature these three components are usually considered separately in terms of developing decision support tools, and little work has been done on how to integrate them. We consider the problem of train timetable rescheduling at a macroscopic level, and propose some ideas as to how this problem may be integrated with the problem of timetable rescheduling at a microscopic level (which considers additional infrastructure details, such as track switches, train speeds, platform assignments, rolling stock compositions, *etc.*) and also with the problems of re-assigning rolling stock and rescheduling crew duties. We develop an integer programming model which aims at constructing a new timetable in case of a large disruption by cancelling/delaying as few trains as possible, subject to infrastructure and rolling stock capacity constraints, which are modelled with a low level amount of detail. The model is tested using real data on a part of the Dutch railway network, and results obtained show promise in terms of real-time use of the algorithm for recovering from disruption situations.

The reconciliation of conflicting QoS goals in wireless networks: A linear response surface analysis approach

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Abstract

Quality of service (QoS) generally refers to a collection of techniques applied in a network in order to ensure predictable results for the network. Well-known QoS metrics include throughput, jitter, delay and packet loss. The importance of QoS, linked to the increased use and importance of wireless networks, implies that it should be evaluated regularly using a reliable instrument in order to improve or maintain QoS levels. It is often the case that QoS goals are in conflict with each other. For example, an increase in delay would result in a decrease in throughput, and *vice versa*, which implies that a specific level or goal in delay will have an impact on the desired throughput level (goal). We suggest the use of a linear response surface analysis model to investigate and reconcile these types of conflicts in QoS in wireless networks. With the aid of a constrained linear programming model it is shown how these special relationships can be handled in cases where pre-determined QoS levels are required. Empirical results will be presented.

A review of the Tom Rozwadowski medal

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Abstract

The Tom Rozwadowski medal is the most prestigious award of the *Operations Research Society of South Africa* (ORSSA). The award, first presented in 1971, was established in honour of one of ORSSA's founding members. Initially the medal was to be presented to a member of the society for a paper of most outstanding merit, but the rules were subsequently adapted and currently the medal is awarded to the best paper published by a member of the society during the previous calendar year. This review endeavours to present an analysis of all the award-winning papers since its inception. The aim is three-fold, namely:

- to present a historical review,
- to detect any trends within *Operations Research* (OR) in South Africa, and
- to present a view of OR in the country.

The analysis indicates that these award-winning papers are very diverse in nature, which certainly epitomises OR in South Africa, but the sample is small and thus not representative enough to be used to draw strict conclusions about the evolution of OR in South Africa. The papers, in general, exhibit originality, quality and clarity of exposition while there is clear interaction between theory and practice.

This paper is dedicated to Theodor Stewart on the occasion of his 70th birthday.

Risk budgeting in a mining house

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Abstract

The budgeting process is an integral part of the annual business cycle of most organisations. The budget consists of numerous uncertain inputs, which are frequently used to produce a single EBIT figure. This implies that there is a risk of not achieving the budget that is not quantified and apparent from the prepared budget. In this paper, the differences between the budgets of two business units of a large mining house were analysed using simulation to gain a better understanding of the information hidden beyond the figures quoted on the surface.

Scheduling of environmental monitoring in a biopharmaceutical facility

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Abstract

Pharmaceutical products must be free of contaminants that are not part of the product's intended composition. For vaccines, the possibility of injecting even minimum amounts of unwanted virus, mycoplasma or bacteria is unacceptable. Quality is built into a product produced by aseptic manufacture when sound process, equipment and facility design is employed to minimise or eliminate potential contamination hazards. Modern design approaches include systematic evaluation of potential process vulnerabilities and awareness of how daily dynamic operational factors can interact. A carefully planned and executed *environmental monitoring* (EM) program provides increased assurance of sterility for aseptically produced products. Environmental monitoring of cleanrooms is done at rest and in operation. At-rest monitoring is done when the no manufacturing activities are conducted and no personnel are in the cleanroom, while in-operation testing is done when normal activities are conducted. A complete EM testing regime comprises viable and non-viable testing. Viable testing is when micro-organisms are monitored for both personnel and the production facility. Non-viable testing, on the other hand, is for particles present in the cleanroom environment. Scheduling of these tests is challenging, particularly when production activities are executed. These challenges mostly stem from the fact that some production personnel involved in core activities also need to execute environmental monitoring and the fact that most often a limited number of test equipment is available and is shared across the facility. Most of the operations occur simultaneously which puts a further strain on resources. Careful planning and coordination need to be exercised for smoother EM runs. Environmental monitoring of a newly established vaccine manufacturing will be used as a case study for assessing quantitative management tools in order to improve EM scheduling and resource planning.

The sensitivity of a unit trust fund in a volatile market: Adjusting for changes

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Abstract

Financial markets are rife with uncertainty. Successful asset management requires experienced and intuitive decision making in order to optimise portfolio return and associated risk, given the market uncertainty. There are many approaches to portfolio optimisation. This study focusses on the maintenance of portfolio objectives during periods of economic uncertainty and macro-economic shocks which may not have been hedged in the initial compilation of the portfolio. A unit trust is used to provide a portfolio structure with mandate constraints. The asset classes considered in the unit trust are bonds, currency and equity. An event study is used to detect the effects of macroeconomic shocks on the South African markets over a given period and, more specifically, the effects on interest, inflation and exchange rates. A *Bayesian vector autoregressive* (BVAR) analysis is performed to examine these effects. The results may be used to forecast the outcome of similar events in the future. Based on the predicted outcome and given a similar shock to the market, a fund manager may be prompted to adjust the weightings of the different asset classes in order to maintain portfolio objectives. Single-period Markowitz optimisation is used to re-balance the portfolio.

The Shoprite Storage Volume Problem for fresh produce

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Abstract

The goal in this paper is to optimise the Shoprite Group's cold storage management setup for fresh fruit and vegetables. Each retail outlet has a cold storage room consisting of two different temperature regulated areas separated by an adjustable strip curtain, maintained at 5°C and 15°C, respectively. All the fresh fruit and vegetables are stored in these areas according to their storage temperature requirements. The position of the strip curtain adjusts to accommodate changes in demand and seasonal availability of fresh produce in each storage temperature category. The frequency of adjustment has to be minimised so as to obtain an easily implementable schedule of curtain adjustments. The delivery volume of fresh produce in each storage temperature category dictates the cold storage volume required for each day. The problem is deterministic in the sense that each fresh produce delivery schedule is determined beforehand by market researchers based on the demand for fresh produce at similar outlets during previous years. These delivery volumes are added together to obtain a *compact[†] storage volume* (CSV), measured in crates. The Group requires decision support in determining a suitable discrete number of strip curtain placement settings with time periods of validity assigned to each of these settings.

The methodological approach adopted in this project is to use a k -means clustering algorithm for determining the optimal number of settings for the strip curtain whilst minimising the CSV required for the specific setting. The goal is to design a decision support tool for the Shoprite Group in Microsoft Excel. The input parameters of this tool are store location, store brand (Checkers, Checkers Hyper, *etc.*), expected annual sales and sales participation of the fresh produce. The output values produced by the tool are the required CSV and the corresponding strip curtain adjustment dates and placement settings.

[†]Not taking into account isles for forklifts or crate stacking height restrictions.

The Size-mix Problem for seasonal products

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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.

This presentation will be a case study of *PEP Stores Ltd* (PEP) with the focus on the quantities of each size that should be ordered to minimize the occurrence of stock outs as well as leftover stock at the end of the season.

The first challenge is to filter historical data effectively. Product and size substitutions should be taken into account if stock-outs occur, as well as the fact that no two seasonal styles offered in different years, nor the sales thereof, will be exactly the same. The presentation focuses on ways to stay clear of creating self-fulfilling prophecies with the stock that is sent to a branch. Relevant information on how this problem is solved in the literature will also be presented.

A soft computing framework for modelling transmission dynamics of HIV/AIDS under combined use of male and female condoms in heterosexual populations

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Abstract

Globally, the pandemic of HIV/AIDS has continued to constitute serious health and socio-economic challenges for more than two decades, especially in sub-Saharan Africa. A permanent cure for this disease is still at an uncertain stage and the issue of abstinence and faithfulness to sexual partners — being the most reliable method of eradication — have been surrounded by serious questions of practicability.

In this presentation, we investigate the application of a soft computing framework in modelling the transmission dynamics of HIV/AIDS under the combined use of male and female condoms in heterosexual populations. This was achieved by using the intrinsic capabilities of soft computing in creating hybrid systems that are based on the integration of constituent technologies, namely fuzzy logic, neural networks, evolutionary computation and probabilities reasoning. The study revealed that it is sufficient to target condom efforts at male and female infected sub-populations in order to archive HIV/AIDS eradication in heterosexual populations.

Solving the Diet Problem using expert system technology and mathematical programming techniques

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Abstract

The classic Diet Problem entails finding a diet for an individual that provides all the nutrients important to a healthy body, at the lowest possible cost. This problem was extended to also accommodate the food preferences of individual users in the South African environment. The problem was solved by combining cost constraints and food preferences in a two-step linear programming solution approach using expert system technology to gain information on the user for use when formulating the problem. A combination of linear programming techniques is used to provide an eating plan for a typical female South African teenager.

A spatio-temporal model for the control of Eldana saccharina Walker

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Abstract

The control of *Eldana saccharina* Walker (Lepidoptera: Pyralidae) in sugarcane fields in KwaZulu-Natal remains a serious problem, and a means of effectively managing the pest is the subject of a number of intensive research programmes at the South African Sugarcane Research Institute. One of the methods of control currently being investigated as part of an area-wide integrated pest management programme, is the *sterile insect technique*. In order to aid current research efforts, a spatio-temporal model of *E.saccharina* population growth and dispersal has been formulated. The model describes the pest's population growth and dispersal under the influence of partially sterile insects released in a temporally variable and spatially heterogeneous environment. The model consists of a discretized reaction-diffusion system with variable diffusion coefficients, subject to strictly positive initial data and Neumann boundary conditions on a bounded spatial domain.

The primary objective was to establish a model which may be used within the area-wide integrated pest management programme for *E.saccharina* to investigate the efficiency of different sterile moth release strategies in various scenarios. The model, as well as some numerical results obtained, will be presented.

A stochastic simulation model of a continuous value chain operation with feedback streams and optimisation

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Abstract

Sasol, an integrated energy and chemicals company based in South Africa, leads the world in the production of liquid fuels from natural gas and coal. By-products of the *coal-to-liquid* (CTL) process is converted into polymers via a monomer value chain. The CTL plant runs independently from the value chain, resulting in significant feed stream variations which must be accommodated. The profitability of the whole value chain can be increased by a combination of improved availability and increased capacity of combinations of value chain components. A stochastic simulation model is used to determine the best solution from a number of solutions. The whole value chain is modelled as a continuous process. The presentation focuses on the challenges faced while building the model, such as recycle streams and optimal stream allocation with the current modelling methodology. A solution is then discussed, while simultaneously demonstrating the ability of the simulation method.

Studies in heuristics for the Annual Crop Planning Problem

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Abstract

Increases in the costs associated with agricultural production and the limited availability of resources have amplified the need for optimised solutions to the problem of crop planning. The increased costs have imparted negatively on both the cost of production as well as the sales prices of finished products to consumers, with significant effects on the socio-economic livelihoods of people around the world. This has increased the burden of poverty, malnutrition, diseases and other social problems in many countries. The limited availability of land, irrigation water and other resources in crop planning therefore demand optimal solutions, with the purpose of maintaining desirable levels of profitable output without straining available resources and still meeting the demands of consumers. The current situation is such that crop producers are required to generate more output per area of crops cultivated within the ambit of the available resources. This presents a significant challenge both for farmers and researchers in the field of mathematical and computing science.

To determine good solutions to crop planning problems, this study dwells on a fairly new but important area of crop planning known as *Annual Crop Planning* (ACP). ACP is essentially a crop planning problem at the level of an irrigation scheme. Two new mathematical models are presented for the ACP problem in this study in the contexts of both new and existing irrigation schemes. To determine solutions for the case studies presented, both local search and swarm intelligence metaheuristic algorithms were investigated, with three new local search algorithms having been introduced. These algorithms are called the Best Performance Algorithm, the Iterative Best Performance Algorithm and the Largest Absolute Difference Algorithm.

We present results showing the viability, effectiveness and efficiency of the incorporation of metaheuristic techniques into a decision support system that will help determine solutions to crop planning problems.

A study of cell depletion in the developmental approach for the Uncapacitated Examination Timetabling Problem

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Abstract

Quite often it becomes useful to turn to nature for inspiration to solve real world problems, including combinatorial optimisation problems. Examples of these types of problems include educational timetabling. The *developmental approach* (DA) is one of many biologically inspired methods successfully applied to the field of examination timetabling. Organisms are developed in nature through the many processes described in cell biology. The DA closely mimics some of these processes in order to develop an organism which then represents the examination timetable. These processes are cell division, cell creation, cell interaction and cell migration. We introduce a new process called *cell depletion*. A case is made for the inclusion of a cell depletion operator in the DA. The performance of this revised version (abbreviated as DAD) is compared to other versions of the DA and other biologically inspired methods in solving the twelve Carter Examination Timetabling Problems. The DAD generally performs better than the DA. Furthermore, its performance is comparative to that of methods producing the best results and other biologically inspired methods, outperforming the latter in some instances.

Sustainability: From theory to practice

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Abstract

Sustainability is most often 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 which 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 can 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. We first outline a high-level sustainability framework for the above programme, and then map out activities and definitions of victory proposed in terms of this framework.

The use of different clustering algorithms and distortion functions in semi-supervised segmentation

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Abstract

Methodologies used for model segmentation is typically based on either optimising the target variable separation (like decision trees) or maximising independent variable dissimilarity (like clustering). We explore and compare methodologies which balance both the use of the target variable as well as the distribution of the independent variables during segmentation. Because of its simplicity, k -means clustering is a very popular clustering technique and it can also be used in an unsupervised model segmentation framework. We show how adjusting this technique for semi-supervised segmentation influences segment selection and indicate some weaknesses of the methodology. In addition, the use of more complex density clustering methodologies, such as Wong's method, is explored and the effect of using different distortion functions on segmentation, such as chi square (as used in decision trees) and information value loss, is illustrated. Finally, model accuracy results of different segmentation techniques on industry data are provided using variations of the k -means and density approaches. Suggestions are made for the implementation of semi-supervised segmentation in practical applications.

The use of machine learning techniques to optimize admission requirements at a higher educational institution

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Abstract

Education is commonly seen as an escape from poverty and a critical path to securing a better standard of living. This is especially relevant in the South African context. The need is so great that we have, in one instance, witnessed people trampled to death at the gates of a higher education institution whilst attempting to register for this opportunity. The root cause of this great need is limited capacity and a demand which outstrips supply. It is therefore imperative for tertiary educational institutions to optimally select candidates who will successfully graduate.

At the *Nelson Mandela Metropolitan University* (NMMU) School of ICT the current selection mechanism is a points system derived from the candidate's matric results. If this score exceeds a certain threshold, set per individual qualification, the student is accepted into the program. Unfortunately this points system is not without error and the NMMU School of ICT still experiences a high drop-out and failure rate. This is especially prevalent amongst first and second year students. The throughput ratio, which is a comparison of the number of registered first year students versus those who graduate, is thus lower than desired.

We examine whether machine learning techniques, commonly used in artificial intelligence applications, can act as a more optimal predictor of success for applicants. The research uses student application and graduation data over a period of several years for the NMMU School of ICT and performs decision tree induction on these data. We consider decision tree induction in isolation as well as combining it with threshold bands in the current points system. We present a comparative analysis of the current point system versus decision tree induction as opposed to a combined approach of the point system and decision tree induction to predict eventual student success based on application data.

Using stochastic simulation to assess operability and availability of a unique new chemical plant

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Abstract

Sasol is constructing the world's first commercial ethylene tetramerisation unit. Beneficial operation of the plant will be reached late in 2013. Being a new technology, questions regarding the sizing of the plant equipment, availability, operations and associated risks were raised. Simulation was identified as the best risk mitigation tool to provide answers to these questions. Behaviour of this complex integrated system was investigated and variance-based sensitivities were determined.

A weapon assignment subsystem for real-time decision support in a ground-based air defence environment

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Abstract

In a ground-based air defence environment, human operators are typically responsible for defending ground assets against enemy aircraft entering the defended airspace. The problem of defending these assets is twofold, namely to evaluate the perceived level of threat that enemy aircraft pose to defended assets and to prioritise them accordingly, and secondly to assign available ground-based weapon systems to engage those aircraft classified as threats, a problem commonly known in the literature as the Weapon Assignment Problem. A computerised threat evaluation and weapon assignment decision support system may typically be employed to provide real-time decision support to operators who have to solve both these problems under severely stressful conditions and in a very short time span.

The aim in this presentation is to put forward the design of a weapon assignment subsystem which is meant to form part of a larger threat evaluation and weapon assignment system. This includes a description of the various substructures contained in such a system, with a focus on the weapon assignment model component which is used to propose the assignments of weapon systems to threats. A simulated, but realistic, ground-based air defence environment scenario is used to illustrate the working of such a system.

What your parents never told you about genetic algorithms and genetic programs

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Abstract

Genetic algorithms and genetic programs have proved themselves worthy competitors in the metaheuristic space although the subtle differences between the techniques and when they should be applied is often unclear. This presentation serves to dispel the mysticism around these techniques and give examples of dreadful and successful implementations as well as key features which lead to their failure or success.

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The Operations Research Society of South Africa gratefully acknowledges the support and sponsorship provided by the following organisations:

- *FICO*, for its substantial partial sponsorship of the conference.
- *Wolfram Mathematica*, for sponsoring the student competition prizes.
- *Blue Stallion Technologies*, for facilitating the student competition prizes.

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The conference organisers would like to thank the following organisations and individuals for services provided:

- The Meetings & Events Manager, Nirene Fortuin, and her entire team at the *Protea Hotel Technopark*, for catering and making their facilities available to ORSSA.
- *Lusan Premium Wines*, for the wine tasting presented at the conference venue on behalf of seven Stellenbosch wine estates.
- *Décor 4 U*, for providing the conference banquet décor.
- *Globok Branding Specialists* for providing custom-made conference bags and gifts.
- *Sun Media*, for printing the conference programme.

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