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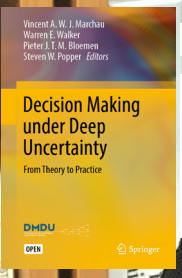

Learn more about Dr. Sheetal Silal and her field of interest

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ORSSA Newsletter

March 2020

THE PRESIDENT'S DESK

Gemma Dawson
gemmadawson@gmail.com

Over the past few weeks, we have watched as Covid-19 claimed inch after inch of the news, both paper and app. So, when the inevitable announcement of its arrival on our shores was made, unsurprisingly the panicked masses headed to their nearest store and started piling their baskets with as many bottles of hand sanitiser as they could carry. As they stood in line to pay for their new collection, they felt that they were doing something to protect themselves and their loved ones from this virus. The reality is that our best chance to slow the spread of Covid-19 is if everyone is washing their hands, so cleaning out the shop of soap and sanitiser only increases the possibility that the next hand you shake is not quite as disinfected as you may prefer.

Cooperation has been a critical element in ensuring life on this planet, from ants sharing the best routes to take to find food, to birds that alert others to the presence of a predator. Since just about the beginning of our time on Earth, humans have worked together, initially as a matter of improving the odds of survival and much later, writing Wikipedia articles. Multiple studies show that cooperation is typically human's intuitive impulse and that slower, more reflective decision-making processes are when our selfish instincts may start to take over.

One of the aspects which makes me proud of being a member of ORSSA, is the manner in which we conduct ourselves. I am of the opinion that we all have something new and exciting to learn from each member, whether they are the most junior or the most senior. This is what makes ORSSA such a remarkable community. Just as with any other community, we may not always agree on the manner in which to achieve our common goals, but we definitely do recognise that these goals are only achieved when everyone is working together. It is through cooperation that our community reached the landmark anniversary of fifty years, and only through continued cooperation can we expect ORSSA to reach its 100th anniversary.

It is a great honour to have been elected to step into the role of President of ORSSA and to lead our exceptional Executive Committee. I look forward to playing a role in steering the society through the challenges that lie ahead.

I wish you all a healthy 2020 and please remember, go with your first instinct and share your sanitiser!

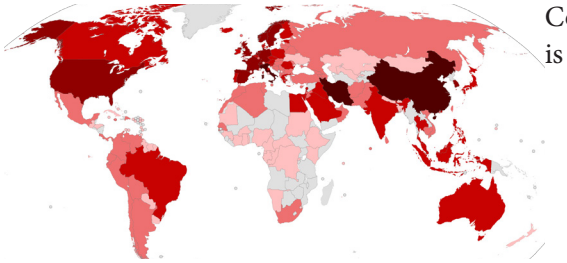
IFORS PRIZE FOR OR IN DEVELOPMENT

In the December 2019 edition you read all about Dr. Andries Heyns and what he is currently busy with. He mentioned that he published an article in the International Journal of Wildland Fire about the optimization of tower site locations for South African developed ForestWatch camera-based wildfire detection systems, and he has informed us that he has just completed his project on optimising camera surveillance for a rhino sanctuary.

You also read that Andries was at that stage working on his team's manuscript, which served as their entry for the second round of the IFORS prize for OR in development 2020. The competition is set in three stages. First, the team had to submit a summary, and an initial evaluation was carried out by an international panel of jury members. The second stage comprised of a full length (25 pages) manuscript of the research, where the panel selected the finalists. The finalists will present their work at the IFORS Triennial conference in Seoul on 21-26 June. After the conference the winners will be announced, based on all three stages.

Andries and his team were selected as one of six finalists for the IFORS prize for OR in Development. Congratulations to him and his team. We wish them success with the competition, and will keep an eye on the conference.

FEATURES



Covid-19 is currently on everyone's lips and part of our daily lives. There is already a lot of research done in the OR community on this outbreak.

"We developed a stochastic transmission model, parameterised to the COVID-19 outbreak."

"We estimated the basic reproduction number from the initial period of the outbreak using (SEIR) models."

"a simulation model was created using known parameters"

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FROM THE EDITOR

Annelie Wessels
annelie99@hotmail.com

Embarking on this new challenge of editing the ORSSA Newsletter, I found it appropriate to give this edition the theme of *New Challenges*. Not only are we entering a new year, but also a new decade. So many new challenges lie ahead of us, of ORSSA and this newsletter in particular. I am privileged to be at the head of this newsletter going into 2020, but I also want to thank everyone that contributed and helped with the publish of this edition. Hopefully the rest of my term as editor will also be filled with joy, support and challenges.

I am not new to the publishing of a newsletter, as I was sub-editor to my school newspaper a few years ago. At that stage (and for many years after that) we had the best newspaper in the country according to Media24. I hope to bring some of that experience to this newsletter, while still remembering the purpose of it: to report on news in the ORSSA family and to keep each other posted on what is happening in the society. I will also try to reach those who might not be so well informed about ORSSA.

My second goal for my term as editor, which goes hand in hand with the first, is to make sure that we as a society communicate our research to our fellow members, as well as with the public. To this purpose I will constantly ask members to write about their research in layman's terms. With this, I hope to reach more people and find appeal amongst the general public. Although we do great things in our research, we sometimes struggle to explain it to everyone else and thus the lack of interest (or rather lack of level of understanding) from the public.

Currently I find myself in the Netherlands, at Tilburg University, where I am busy with an exchange programme for six months. I therefor apologise if I do not meet anyone in person to discuss articles and ideas.

I, myself, have a tremendous amount of new challenges that occur in my life everyday at the moment - simple things, like catching the desired bus to a bus stop which I do not even know the name of, or buying something that I cannot read the label of, trying to communicate with other international students that can barely understand English or convincing people that it is not always a given for a bus or train to be exactly on time, clean and in a desirable condition. I sometimes find myself quite frustrated if my bus is one minute late and then laughingly have to remind myself that I have to return to our wonderful country in four months time.

I am very excited about what my term as Newsletter Editor might bring. Hopefully I will encounter a lot of the ORSSA community and learn more about everyone and what they keep themselves busy with. I am also currently under quarantine, so it was quite nice to have this newsletter to keep me busy with things outside of "the daily life in my room".

Groeten uit Nederland

Annelie

ORSSA REMEMBERS PROFESSOR PAUL S KRUGER

2 November 1944 - 11 December 2019

It is with great sadness that we announce that our beloved colleague, Professor Paul Stephanus Kruger, passed away on 11 December 2019.

Professor Kruger obtained a BSc (Eng) Industrial, MSc (Eng) Industrial, and DSc (Eng) Industrial from the University of Pretoria. He joined the University of Pretoria, in the Department of Mechanical and Industrial Engineering, in 1967 and served as a lecturer in the Department of Mechanical and Industrial Engineering from 1968 to 1970. In 1973 he was appointed as a senior lecturer in the Department of Management and Prof Kruger came back to the Department of Industrial and Systems Engineering in 1974 as a Senior Lecturer. He was appointed as an Associate Professor in 1981 and as a full Professor in 1986. He served as Head of Department of Industrial and Systems Engineering from 1989 to 1996. Although Prof Kruger retired in 2009, he had been kind to support the department until 2015.

He was a founding member of the SA Institute of Industrial Engineering (Council member, President and Honorary Fellow), and founding member of the Operations Research Society of South Africa (ORSSA).

Prof turned 75 on 2 November 2019. He attended the annual Project Evening of the Department of Industrial and Systems Engineering at the University of Pretoria and will be remembered fondly by colleagues and students alike.

Professor VSS Yadavalli remembers Professor Kruger (2 November 1944 - 11 December 2019), his time at the University of Pretoria and the many legacies he leaves behind.

There is an African saying that "You do not know the depth of a well until when it is dry". For as long as it serves us well, the water is taken for granted. We only know how much water it has provided us when it runs to the bottom. This may aptly describe the life of Prof Kruger. When he is around, it seems normal. You only miss him when he is not there.

> "He is a friend of the high and a pal of the low.

Prof Kruger is one lecturer that relates well with all and sundry. He is a friend of the high and a pal of the low. He talks freely with all, shares freely with all, and contributes freely to all. He has something to say when it comes to the technical, but also the humour to complement when the atmosphere needs to be relaxed. He has his own weight to bear in life and office, but still manages to say something to make someone smile.

He was an erudite and astute academic as well as an amiable and ebullient colleague. It should suffice for him to be a father to many, but he chose to be a friend to all. To him, all staff and students can fit the role of a colleague. You do not have to be grown to his stature in order to rub your shoulder with him. He never demands from you to know so much to be able to contribute an opinion to his discourse.

> "He was an erudite and astute academic as well as an amiable and ebullient colleague.

For the entire industrial engineering community, to which you have dedicated the cream of your life, it would always be difficult to say good bye, Prof Kruger. Even when it is on a short journey of time, it always is, but more so, when it is on a journey of eternity. We, however, take solace in the fact that your impressions would live on and be indelible. In the students you have trained, the staff members you took under your wing, the school you served with all your might, your "student children" for whom you made the difficult courses to seem as if they are playing. Whenever they apply the techniques you taught in their research and professional career, would remember you fondly with a smile, as they re-emboss your ink all over again.

COMMUNICATE YOUR SCIENCE COMPETITION

ORSSA launched its first Communicate Your Science competition during 2019. It was the brainchild of Linke Potgieter (as marketing manager of ORSSA), with the aim to showcase more of the research that operations researchers do in a three-minute video competition on YouTube to the general public, thereby contributing to raising awareness of operations research in South Africa. The competition was open to all postgraduate students and alumni who developed or applied operations research methodology in their research. There was R15 000 prize money up for grabs and the judging panel had three criteria categories, namely communication style, content and creativity and engagement. The idea was to explain the research to non-experts without using difficult technical terminology. Thank you to everyone who entered the competition, and also to the judges! A lot of hard work went into the making of the video's and the content received was of very high quality. Submissions for the 2020 Communicate Your Science competition will open during the second semester, and we encourage more operations researchers to take part in this effort of raising awareness of all the fascinating things we do!

Finalists

JUDGES' CHOICE	PUBLICS' CHOICE
1. DJ Human	1. Gunther Husselmann
2. Gunther Husselmann	2. Timothy Mountford

GUNTHER HUSSELMAN

1. How did you go about making your science communication video?

The idea was to keep people's attention from the start and not lose it and not use operational research jargon that would throw the layman off. Therefore the stop-motion drawing of the main concepts without many words emerged, as a picture says a thousand words. We also had to put everything into 3 minutes, which is quite short, but was a good challenge!

2. Was the effort worth the outcome?

It was indeed! Although giving some of my off days for the making of the video, the video crafting process was very fun for me, and I am very happy with the outcome.

3. How did your approach to your research change when making the video?

I realised that there are simpler and easier ways to communicate what I do without having to go into the details, and thinking and rethinking your topic, having some platform to showcase what you do, forces one to be creative in the communication of what you do, even when writing about one's work.

4. How did you experience the competition?

The competition aspect of it was quite exhilarating, more than what I anticipated and got my heart racing quite a bit, and probably took too much of my attention at times. Especially seeing the 'Likes' rise on the various videos. But all in all, the experience was very positive.

DJ HUMAN

1.How did you go about making your science communication video?

I wanted to follow the approaches of YouTube creators such as Wendover Productions or RealLifeLore, that used stock footage with voiceover and animation to communicate complex topics, but usually with a light and humorous twist. I've made videos before in a past life, so the rest fell into place pretty quickly.

2. Was the effort worth the outcome?

Considering the value of the prize compared to the time I put in, absolutely. And now my mom even has a better understanding of what my research was about.

3. How did you experience the competition?

Being a finalist was interesting, I found that a lot of the people I shared it with were unaware of the function to "Like" a YouTube video, they would often just like or react to the social media posts!

TIMOTHY MOUNTFORD

1. Why did you decide to enter for the competition?

I was told about the competition by my supervisor and thought it would be a good opportunity to be able to concisely show the research I'd been working on to a large group of people and spread some information about what can be done in the field, as I feel many people wouldn't have had a good idea of the type of work being done otherwise.

2. How did you experience the competition?

I found it to be entertaining to have an excuse to be able to show others the work I had been doing and why I felt it was interesting. The public voting was very competitive so it meant it was necessary to actually go out and put effort into spreading the word.

3. Was the effort worth the outcome?

I would say it was, not only because it was an exciting way to be able to describe my work with the possibility of financial incentive; but also because it meant I had an excuse to show my research to people of influence in my field as well as my friends and family.

Watch the top 5 video's on ORSSA's YouTube page by scanning this QR-code or following this link.

HAVE YOUR SAY

The ORSSA Newsletter is an excellent medium for showcasing one's work or interests to the Operations Research community, not only in South Africa, but around the world.

Contributions of any nature are welcomed. If you would like to submit material to the Newsletter, please send your article, review, photo or any other contribution to the editor at **annelie99@hotmail.com**.

We specifically welcome science communication articles for this new section.

DR. SHEETAL SILAL: CONQUERING DISEASES

Annelie Wessels
annelie99@hotmail.com

Dr. Sheetal Silal is currently a senior lecturer at the Department of Statistical Sciences at the University of Cape Town. She is also the founder and director of Modelling & Simulation Hub, Africa (MASHA) as well as an Honorary Visiting Research Fellow in Tropical Disease Modelling at the Nuffield Department of Medicine at the University of Oxford. She has published in the world's leading multidisciplinary science journal, Nature, and in June 2019 she presented a tutorial at the EURO 2019 30th European Conference on Operational Research in Dublin, Ireland.

Dr. Silal obtained her B.BusSci in Quantitative Finance & Statistics at UCT in 2006. She claims to have been quite bored with the field and found herself disinterested. Prof. Theo Stewart then suggested that she should take a few OR modules in her honours year. At that stage she did not know what OR was, but it ended up as the best career choice. She then did her MSc in Operations Research in 2009 and followed with a PhD in Mathematical Modelling of Infectious Disease in 2014.

With expertise such as mathematical disease modelling, evidence-based vaccination modelling, malaria and simulation, I asked her how she specifically found herself in the epidemiology side of OR. One of the things that she loves most about OR is the ability to use mathematics to solve problems. When she was looking for a topic for her masters' dissertation, her supervisor directed her to a paper where the authors used a differential equation model to simulate malaria. It was the first time that she came across models that could be used to answer policy questions and she claims to have been hooked ever since. She was fascinated by the idea that you could combine mathematics, biology, computer science and statistics to simulate disease behavior. Like most students, after spending a lot of time on a specific research area, one becomes quite tired of the topic, but for Dr. Silal it was not the case. Performing research where she could potentially make a difference in people's lives (en masse in many cases) kept her motivated and still continually interested in the field. She says she is still excited to take on new disease modelling projects, even 14 years later.

With quite a few students doing their research under her supervision, I asked Dr. Silal what she is typically looking out for in a good research project or thesis:

- The OR type of thinking.
- A well thought-out model that takes a systemic view of a problem.
- The use of mathematics in a novel way to solve a situation.
- She also values rich discussion and maturity in considering the complexity of the real world.

For young and upcoming academics and researchers she says "have ambition and pluck". "To be bold and to realise the important role that you can play in society, not only in teaching and developing our field, but also in applying our skills to aid decision-making in the public sector." She believes that academics need to play a greater role in engaged scholarship. "It is a daunting task to apply your skills in the real world, but with humility and scientific integrity, you will be able to offer responsible support to decision-makers."

> "academics need to play a greater role in engaged scholarship

For Dr. Silal 2020 is already jam-packed. She is currently busy with her Wellcome Trust Innovator's grant. She's already developing malaria epi-econ models for Papua New Guinea, Solomon Islands, Timor-Leste, Vanuatu, Brazil, Guyana, French Guiana, Suriname, South Africa and Zambia. She was also very honoured to be asked by the WHO to be a part of the modelling taskforce to join the conversation and research on the spread of the new Covid-2019.

She says her work is not really academical in nature, because the vast majority of the research that she does is for national governments around the world and large donor bodies such as the Global Fund to fight Aids, Tuberculosis and Malaria. However, if she was not doing disease modelling, she would probably have become a veterinarian or working in an animal sanctuary.

Dr. Silal believes Africa needs more disease modelers. In her travels throughout our continent, she has found that we have very talented mathematicians and students of mathematics. This talent

needs to be harnessed and channeled through funding and research projects to support our continent's governments to control the diseases that continue to devastate our people. It has been her long-held belief that Africans can solve Africa's problems.

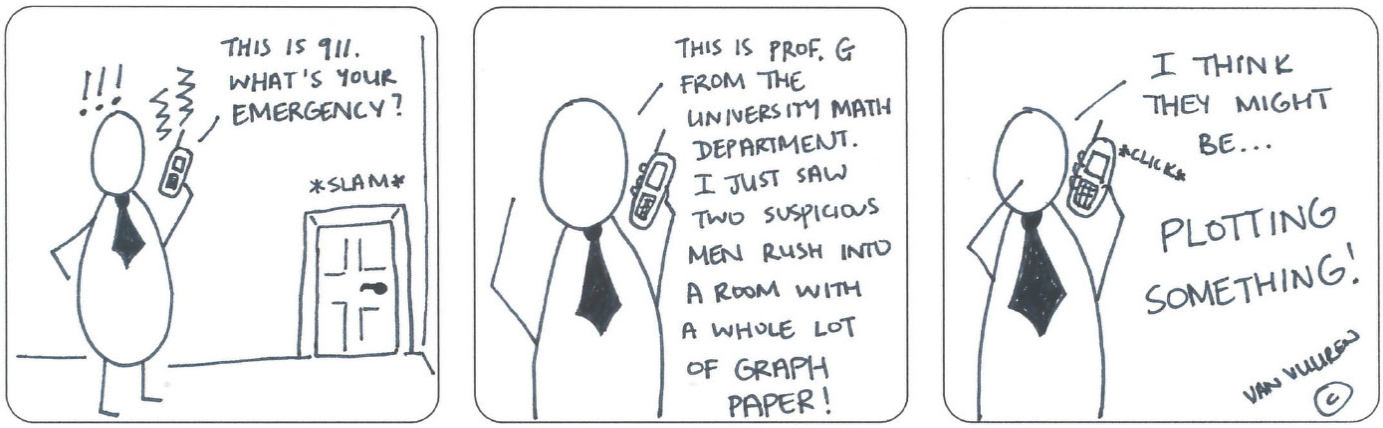
Sometimes she wishes that people could appreciate the systemic nature of most problems and that OR is well positioned to unravel the complexities of these systems, also that OR is not Statistics.

Dr. Silal has been researching disease modelling for more than ten years now and she is still inspired to remain in this field because of the difference it can make in people's lives. "Science is growing every day. Twenty years ago, this kind of modelling was practically impossible. But today, scientific and technological advancement has allowed mathematical modelling to become an invaluable tool in shaping health policy and saving lives. Once again, it's the impossible made possible, through science."

When not working, Dr. Silal is kept quite busy at home with her four dogs, seven cats and three ducks. She says when she is not covered in fur and feathers, she dances (Bharata Natyam), sings and plays the sitar. She also spends a lot of time cooking and baking and an equal amount of time eating.

In 20 years she sees herself surrounded by cats, dogs and hopefully cows, mentoring disease modelling projects. Although she says that we should probably have eliminated malaria by then, she is quite sure that diseases (both communicable and non-communicable) will still be posing a global threat. "There'll still be plenty of problems that need solving!"

Dr. Silal's New Challenges for 2020 is to achieve a balance by increasing the efficiency in her work which will allow for enough time to play sitar, exercise and sleep. New Challenges for her in the work environment will be to dedicate a few hours a week to learning something new.



DECISION MAKING UNDER DEEP UNCERTAINTY – FROM THEORY TO PRACTICE

Decision Making under Deep Uncertainty – From Theory to Practice by Vincent A. W. J. Marchau, Warren E. Walker, Pieter J. T. M. Bloemen and Steven W. Popper (Editors), 2019, Springer, pp. 405, ISBN 978-3-030-05251-5, ISBN 978-3-030-05252-2 (eBook), 49.99 Euro (Hardcover); the book is also an Open Access book available from https://doi.org/10.1007/978-3-030-05252-2 both as a pdf or as an epub book,.

Hans W. Ittmann
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Decision making for the future depends on anticipating change. Climate change and everything that goes with it is an excellent example of this. Today most people believe climate change is a reality but there is considerable uncertainty about aspects such as the magnitude of climate change, the speed of climate change, the implications for specific geographical areas and regions and then, most importantly, the policies that should be implemented to mitigate and/or hedge against the adverse consequences of climate change. This is an example characterized by "deep uncertainty". In a deep uncertainty situation, there is typically a lack of knowledge or disagreement about "(i) the external context of the system, (ii) how the system works and its boundaries, and/or (iii) the outcomes of interest from the system and/or their relative importance". Uncertainty may be defined simply as limited knowledge about future, past, or current events. Uncertainty refers to the gap between available knowledge and the knowledge decision makers would need in order to make the best policy choice.

According to the editors, Decision Making under Deep Uncertainty, provides a unified and comprehensive treatment of the approaches and tools for developing policies under deep uncertainty, and their application. It contains state of the art material, both in terms of the theory and practice, and of the approaches and tools that has been developed for assisting decision making under deep uncertainty. This volume was produced under the aegis of the Society for Decision Making under Deep Uncertainty and is available as an Open Access book. This indicates how important this society values the topic as well as their willingness to share it with the broadest possible decision maker and analyst communities.

There are four main parts in the book, each containing a few chapters. In Part I an outline is presented of each of the five main Decision Making under Deep Uncertainty (DMDU) approaches while Part II contains an application of each of the five approaches. Three implementations, where some of the DMDU approaches and tools used in real-world applications, are illustrated in Part III. In Part IV, one of the chapters is devoted to a taxonomy of DMDU approaches and tools and a second chapter provides a reflection on the connection between theory and applications of DMDU and how this contributes to the emerging needs of public policy decision making processes.

In the introductory chapter the entire spectrum of uncertainty is discussed. Donald Rumsfeld (Former US Secretary of State) with his famous quote acknowledges this:

"As we know, there are known knowns – these are things we know we know. We also know there are known unknowns – that is to say we know there are some things we do not know; but there are also unknown unknowns – the ones we don't know we don't know.… It is the latter category that tends to be the difficult one".

Uncertainty stretches from total certainty across a spectrum of uncertainty levels to total ignorance. There are four uncertainty levels discussed, namely: Level 1 – no absolute certainty; Level 2 – can describe inputs probabilistically; Level 3 - limited set of plausible futures; and Level 4 - the deepest level of recognized uncertainty. Given this a brief outline is presented of decision making under deep uncertainty. What is required is a paradigm that is not based on predictions of the future but that aims to prepare and adapt by monitoring how the future evolves and allowing adaptations over time as knowledge is gained.

The five different DMDU approaches are outlined in Part I. Each approach consists of the following elements and steps: frame the analysis; perform exploratory uncertainty analysis; choose initial actions and contingent actions; and iterate and re-examine. In each case the approach is discussed in detail and in some cases the approach is illustrated through an example. These five DMDU approaches are outlined in Chapters 2 to 6, respectively:

- Robust Decision Making (RDM): RDM is a set of concepts, processes, and enabling tools that use computation, not to make better predictions, but to yield better decisions under conditions of deep uncertainty. The example used to illustrate this approach is to determine the most robust combination of carbon prices and technology subsidies, to reduce climate-altering greenhouse gas emissions;
- Dynamic Adaptive Planning (DAP): DAP focuses on implementation of an initial plan prior to the resolution of all major uncertainties, with the plan being adapted over time based on new knowledge. DAP is a relative new approach, but an interesting illustration is provided where DAP was used for the long-term development and strategic planning of Schiphol airport in the Netherlands;
- Dynamic Adaptive Policy Pathways (DAPP): DAPP considers the timing of actions explicitly in its approach. It produces an overview of alternative routes into the future;
- Info-Gap Decision Theory (IG): An information gap is

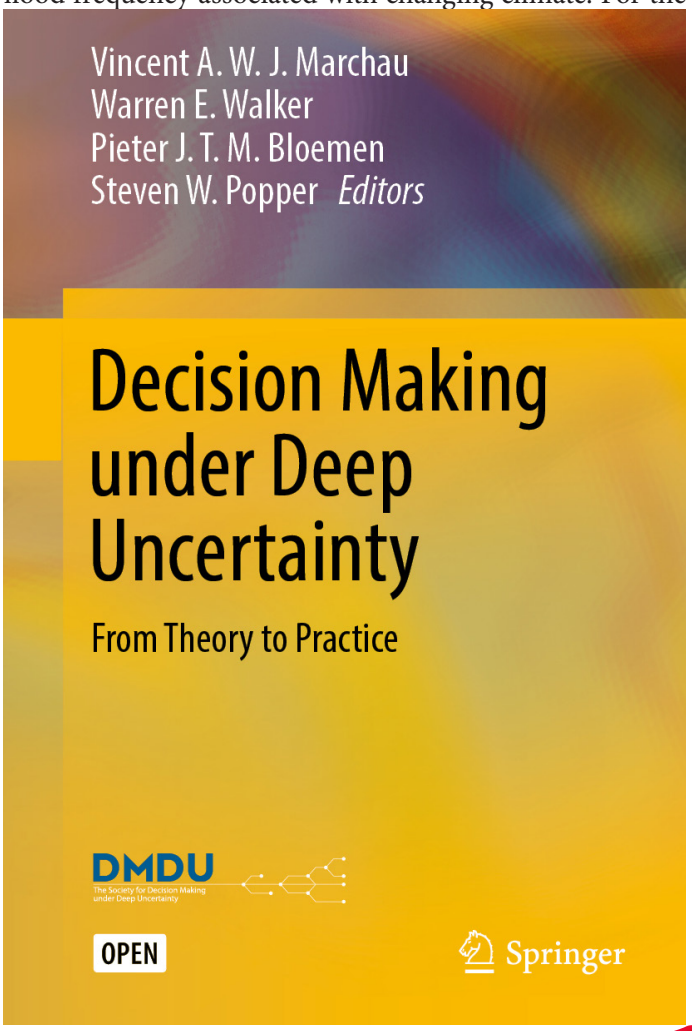
defined as the disparity between what is known and what needs to be known in order to make a reliable and responsible decision; and

• Engineering Options Analysis (EOA): EOA refers to the process of assigning economic value to technical flexibility.

These are all very new concepts for those not familiar with this field.

Applications for each of the approaches are covered in Chapters 7 to 11, while Chapters 12 to 14 each contain a detailed outline of an DMDU implementation process. The problem description of each applications is presented, and then the reader is taken step by step through the process of developing the application. In each application a different approach is used which is useful since it gives practical exposure to each approach. Anticipated future change, deep uncertainty and long-term decisions are common characteristics in these applications.

Two case studies demonstrate how RDM can help develop robust long-term strategies. In the first case study RDM was used for the 2012 Colorado River Basin Study—a landmark 50-year climate change adaptation study. The second case study outlines how RDM is used to define the key vulnerabilities of global climate policies and regimes for technology transfer. To develop and test the DAP approach the implementation of a type of innovative traffic safety technology in the Netherlands was used. Flood risk managers at a regional level in New Zealand applied the DAPP approach to managing deep uncertainty around flood frequency associated with changing climate. For the application in Chapter 10, the IG robustness approach is used to manage uncertainty in the early-stage design of a latch mechanism and how robustness functions may be exploited to support decision making. Chapter 11 illustrates the use and value of EOA using two case studies, namely, the Liquid Natural Gas case that involves the development of a liquid natural gas plant in Australia and the second one is the IJmuiden case as it relates to water management and flood control facilities in the Netherlands.



As this is a new field, generic rules are lacking how to implement the new approaches and tools into practice, however, lesson can be drawn from the ADM approach used in the Dutch Delta programme on flood risk management, freshwater availability, and spatial adaptation as outlined in Chapter 14.

In the development and description of the different applications and implementations, the focus and objective of the different DMDU approaches is to facilitate the development of policies that are robust and/or adaptive, meaning that they perform satisfactorily under a wide variety of futures and can be adapted over time to unforeseen future conditions.

There are several remaining challenges in the DMDU field listed, as well as future work, that require more attention and research. These are: (i) the improvement of the existing DMDU approaches; (ii) further guidance on when and how to apply a specific DMDU approach and the tools; (iii) broadening the scope of DMDU applications; and (iv) striving towards "monitor and adapt" as the more preferable strategy, as against "predict then act", for long-term decision making in the face of deep uncertainty. As in so many research areas there is still much to do and here it is no different!

> "a welcome addition to the ever-increasing body of knowledge

In conclusion Decision Making under Deep Uncertainty is a monumental piece of work and a welcome addition to the ever-increasing body of knowledge in this important emerging field. What is presented and covered in the book is refreshing but admittedly it requires focussed attention as it does not make for "bedtime" reading. Nevertheless, the various DMDU approaches, comprehensively outlined, represent an evolving capacity to deal with the challenge of the future, and all its associated uncertainties, by providing a technology of complexity, especially in the analysis of problems in public policy. This book presents major advances in tackling and addressing the "black swan" events, namely those problems, decision makers are faced with, that does not fit within the realm of regular expectations, with huge impact and that can only be explained retrospectively. The editors, authors and other contributors need to take a lot of credit for this comprehensive source of material contained in the book!

ORSSA Conference 2020

30 Aug - 2 Sept 2020

The 49th Annual Conference of the Operations Research Society of South Africa (ORSSA) will take place at Valley Lodge in Magaliesburg, South Africa and will be hosted by the Vaal Triangle Chapter.

The theme of this year's conference is *Analytics for sustainability*, and will provide delegates the opportunity to engage with academic presentations by experienced academics and industry leaders on, amongst other, the following topics:

- Energy
- Logistics
- Health care
- Finance

Visit the ORSSA Conference 2020 website at www.orssa2020.com

COMMUNICATE YOUR SCIENCE

Willem Moore
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Shared-resource school timetabling decision support

Education is arguably one of the most important aspects in the development of cognitive and social abilities of children throughout their growth towards adolescence. A further invaluable aspect of education, especially in the context of South Africa, is that it provides a platform for individual empowerment to transcend poverty and reap the benefits of the skilled working class. Unfortunately, the concept of universal education is still a distant dream in various parts of South Africa due to a widespread lack of educational resources, and teachers in particular. These shortcomings have made it increasingly important for organisations in the private sector to contribute towards high-quality education through the medium of independent schools.

In the management of such an independent school, the optimal utilisation of time and resources is imperative to the success of the initiative. A useful tool by which teacher utilisation may be improved is high-quality decision support in respect of school timetabling. School timetabling focuses on the assignment of teaching tasks, or the teaching of subjects to the smallest number of teachers in such a manner that all subjects are represented the required number of times during a timetable scheduling cycle, without violating physical constraints.

The field of research in educational timetabling is very popular in the operations research and industrial engineering literature, and a wide variety of studies have focused on the problem. The school timetabling problem (STP) has, however, induced a smaller field of research within the overarching realm of educational timetabling, which predominantly consists of university course timetabling and examination timetabling problems [1]. A possible explanation for this phenomenon is that the various studies addressing the STP have been undertaken in isolation from one another [3]. Furthermore, the shared resource school timetabling problem (SRSTP), differs from ordinary school timetabling in that schools adopt a shared-resource policy whereby teachers may be shared between schools in close proximity, with the goal of minimising the global number of teachers required by the combined schools under consideration.

Various methods for solving the STP have been proposed in the literature (see Pillay [2] for an excellent methodological, bibliographical and application survey). Some of the early research in the field focused on mimicking manual heuristics employed to solve the problem [4] and as the field of study progressed, various new algorithms have been proposed with certain solution methods being applied more frequently to solve instances of the STP than others. Examples of such methods include simulated annealing, evolutionary algorithms, constraint programming, tiling algorithms, bee algorithms, cyclic transfers, threshold accepting, a walk down jump up algorithm, Greedy Randomized Search Procedure (GRASP) and integer programming [2]. This list is by no means exhaustive, but provides some insight as to how many diverse algorithmic approaches have been adopted to solve instances of the STP in the literature.

During the author's final year project as part of the industrial engineering curriculum at Stellenbosch University, a mathematical model for the SRSTP was formulated and served as the basis for developing a decision support system (DSS) in respect of the minimum number of teachers required in a school system adopting a shared-resource policy. The model was formulated as an integer programming problem and was implemented in the CPLEX application programming interface (API) of the programming language Python. CPLEX is a powerful commercial solver from the IBM stable which employs the branch-and-cut algorithm to solve binary programming problems, such as the SRSTP.

The solution methodology described above was thereafter embedded in a user-friendly computerised DSS capable of assisting timetablers in their timetabling decisions. Within in the graphical user interface, the user is able to specify timetabling constraints such as the required frequency of a specific subject during a scheduling cycle, the maximum frequency of any specific subject per timetable day, the set of subjects that a specific teacher is able to teach and the length of the scheduling cycle in terms of the number of days and periods per day. Furthermore, the mathematical model was formulated in such a way so that if teachers are required to travel between schools, they should have at least one off period to account for travel time.

The DSS was validated by means of a case study involving two schools included in the Curro Holdings Limited group. The schools collectively employed sixty-three teachers, who were required to present one hundred and seventy-four subjects for the grade 10 to 12 year groups, also known as the Further Education and Training (FET) phase. These specific grades were considered due to the typical complex nature of timetables in these grades as a result of learners being afforded the opportunity to select their own combinations of subjects. The purpose of the case study was to recommend a set of timetables to the schools in question, which improves their teacher utilisation when compared to the status quo, by sharing teachers between schools.

Based on the model parameters presented to the DSS during the case study, an improvement of five teachers over the current sixty-three employed was achieved after approximately twelve hours of computational time. This

result, although significant, was compared with a system that does not implement teacher sharing and therefore the resulting improvement is measured from a relatively low base in terms of efficiency. Furthermore, as the size of the of the SRSTP instance increases, so too will the required computational time required of an exact method such as that proposed in the project, hence the use of a meataheuristic might be more practicable approach towards in finding high-quality solutions which are not necessarily optimal.

Nevertheless, the DSS shows potential as a valuable cost saving tool for Curro, should an automation of the school timetabling process be pursued. Furthermore, the proposed DSS has the potential to provide a dramatic reduction in the cradle-to-grave time of the entire timetabling process, can significantly simplify the once troublesome and time-consuming task of timetable construction at Curro and holds the potential of realising substantial cost saving for Curro in terms of teacher remuneration.

[1] Alvarez-Valdes R, Parreno F & Tamarit JM, 1961, A tabu search algorithm for assigning teacher courses, TOP, 10(2), pp. 239-259.

[2] Pillay N, 2014, A survey of school timetabling research, Annuals of Operations Research, 218(1), pp. 261-293.

[3] Santos HG, Uchoa E, Ochi LS & Maculan N, 2008, Strong bonds with cut and column generation for class-teacher timetabling, Proceedings of the 7th International Conference on the Practice of Theory and Automated Timetabling (PATAT), Montreal, pp. 1-13.

[4] Schaerf A, 1999, A survey of automated timetabling, Artificial Intelligence Review, 13(2), pp. 87-127.

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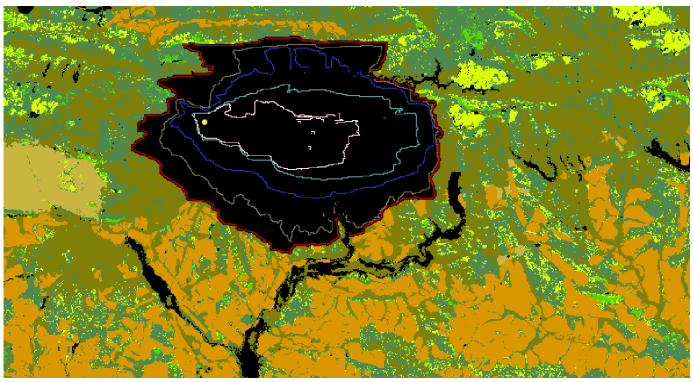
Modelling the spread of fire in conservation areas

Fire has always played a significant role in the development and evolution of diverse ecosystems all around the world. It has the exceptional natural power to transform environments in a harsh but often necessary way. Due to the potentially enormous environmental effects of fire on its surroundings, there has been a growing demand to understand the underlying characteristics of fire that influence its spread so that the behaviour of this volatile phenomenon can be predicted accurately in order to improve the effectiveness of firefighting and fire management.

The primary objective of the project was to propose a model capable of predicting the rate and extent of fire spread within a user-specified natural geographic area of heterogeneous vegetation. The proposed model aimed to predict how a fire is likely to spread under various environmental circumstances. The working of the model was based on a simulation approach within a cellular automata (CA) modelling paradigm. This meant that the specified geographic area was partitioned into a set of uniformly sized cells, with each cell taking on a set of burning characteristics based on the predominant type of vegetation found in the cell. The rate of fire spread within each cell could then be determined using basic underlying mathematical modelling relationships. Due to its extensive use in various well-establish fire spread simulators, the Rothermel rate of fire spread equation was used to calculate the rate at which a fire is likely to spread through each cell. By calculating this rate, it was then possible to determine the time at which the fire in a burning cell would spread towards and ignite its neighbouring unburned cells. Although the transition rule was simple in essence, iterating it over multiple time-steps allowed the complex nature of fire spread to be successfully modelled.



The model-predicted extent of fire spread at various points in time (the case study performed: Pink after 5000 iterations (15h 16min), turquoise after 10000 iterations (19h 27min), blue after 15000 iterations (35h 16min), brown after 19000 iterations (45h 47min) and red after 22500 iterations (55h 53min).

The model inputs in this project were related to the contents of biofuel parcels, the characteristics of the fuel bed through which the fire spreads, and the prevailing environmental conditions (terrain slope and meteorological conditions) over a stipulated time interval of simulation. The contents of the biofuel parcel and characteristics of the fuel bed found in each cell of the CA domain were provided to the model by allocating a fuel model to each cell that best describes the predominant type of vegetation found in those cells. Each fuel model consisted of a set of parameters that were required to calculate the expected rate of fire spread using the Rothermel equation. Thus, by allocating a fuel model to each cell, the rate of fire spread could be predicted for each cell in the CA domain under no-wind no-slope conditions. Incorporating the terrain slope and meteorological conditions over the time interval, therefore, meant that the no-wind no-slope rate of fire spread could be corrected based on the direction of the prevailing wind as well as the angle of the slope found between adjacent cells. The model was capable of performing a simulation where the strength and direction of the wind could be changed over time. Finally, an important aspect of the model was

that it incorporated an adaptive time step (instead of a fixed time step) for each iteration in order to facilitate the conservation of heat energy during the transition of a cell to the burning state. This led to larger computational requirements in the latter stages of a large simulation but is believed to have increased the accuracy of the fire spread prediction. The model's output was a time-stamped visual description of the expected extent of fire spread over the user-specified time interval, which thus allows a user to investigate the expected future spatio-temporal extent of a fire ignited at a known location under various conditions.

The final verification exercise in this project took the form of a validation case study in which the model was tested with respect to data pertaining to an actual fire which transpired in an area just outside the town of Riversdale in 2018. The general conditions under which this fire took place (wind conditions and the terrain slope) were used to simulate the prevailing conditions during the three-day fire. Data relating to the vegetation in the area was then provided and carefully transformed so that each cell in the CA domain could be allocated an appropriate fuel model, along with the associated fire spread parameters. These data served to identify the underlying factors utilised by the CA model of this project in order to predict the final extent of the fire in retrospect. This simulated extent was then compared with the spread of the real fire over the same time interval and it seemed to be in fairly good agreement with what transpired during the real event, especially in certain directions where the fire perimeter was predicted to spread over distances from the ignition point that were in agreement with the actual fire perimeter. This was a very promising sign for the model developed during this project and, although certain areas of improvement were identified during this process, the general behavior of the model seemed to be consistent with what occurs in the natural world.

NEW CHALLENGES FOR 2020

With the new year and new decade lying ahead of us, a few people shared their *new challenges* with us. Members responded with various types of challenges such as personal challenges, industry related challenges or academically related challenges, such as new courses that are presented in the OR field.

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The Department of Logistics at Stellenbosch University launched a new BCom focal area on Business Analytics (BA) this year. BA is the methodical exploration of an organization's data, with an emphasis on analysis. Successful business analytics depends on data quality, skilled analysts who understand the technologies and the business, and an organizational commitment to using data to gain insights that inform business decisions. Recommended parallel modules for BA are statistics, business management, economics, and logistics management.

The new BA focal area consists of four modules starting at second year level. Students are introduced to traditional Operations Research (OR) techniques, specifically optimization and modelling. Should they show a particular aptitude for the discipline, they then have the opportunity to choose more OR modules which can be taken in parallel to the remaining BA modules. The remaining three modules cover social network analytics, big data management, analysis, introduction to machine learning techniques, and visualization and reporting methods with a strong application focus in R.

BA replaces the Quantitative Management (QM) course that has been offered at the department since the early 2000's. Programme renewal is a challenging task but always worth the effort to keep up with the latest industry demands. The teaching corps presents both the old and new curricula to accommodate the cohort phasing out and the cohort phasing in. All the BA modules contain new content, so additional time is spent on finding the best prescribed textbooks, creating new class material, assessments, and liaising with industry to find moderators and case studies. In contrast to QM, all BA lectures are presented in computer labs and the additional strain on these resources make updates to the university timetable a complicated problem. The new Jan Mouton Learning Centre will provide much needed infrastructure and its opening is eagerly awaited.

The Department of Logistics is very excited to welcome students to these new modules. The cutting-edge techniques obtained here will truly prepare practitioners to provide insight from data to meet the demands of modern industry.

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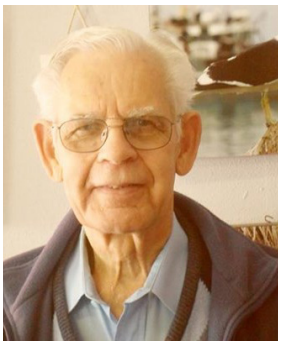
Studying part time is something that definitely sounds good in theory, but ends up being a nightmare in practice. I started working for FNB in 2015 after completing my honours degree in Operations Research at the University of Stellenbosch in 2014. I was always keen to pursue my master's degree and thought "how hard can it be?". The answer is: very.

It took me basically four years to get it done, which means four years of finding the energy after a full day at the office to work on a thesis, or else not work on it and feel guilty all the time. But I persevered and eventually received

my masters cum laude in 2019. And then I got bored, of course. Habits are hard to break, after all.

After five years at FNB I decided that my challenge for 2020 would be to take my career to the next level and properly step out of my comfort zone. I applied for, and after a gruelling interview process over several months, got the job as the first Customer Facing Data Scientist for DataRobot Inc in South Africa. I've developed a liking for the data science work, and I hope to see its place within Operations Research realised sooner rather than later.



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One of the areas in which I hope that OR will have a greater impact in the coming years, is decision making in the public sector. This could start at local and provincial levels and could eventually be extended to national level. Some of the problems in the public sector may be amenable to traditional OR approaches.

Other problems in the public sector in which OR could play a role are complex and involve communities and groups with needs and aspirations that differ widely and might even be conflicting. Changes in one area may have unexpected repercussions in other areas. OR has developed approaches such as soft OR and community OR, which should be valuable in defining the real problems that need to be solved and ways in which communities could become involved in the process of finding solutions. The multi-disciplinary nature of OR should also be advantageous in such circumstances. There is a wide variety of OR methods, including multi-criteria decision analysis and system dynamics, which could be utilised. Exciting opportunities for creative work would no doubt arise. Such tremendous advances have been made in computer-based applications of OR that the size of problems in the public sector need not necessarily be a deterrent. Some form of marketing by ORSSA and its chapters and members will be required to make decision makers in the public sector aware of the contributions that OR can make.

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As a previous student member of ORSSA, I have now taken the plunge into full-time working life. Like many of my fellow graduates, I have found the adjustment to full-time work quite jarring. Not that it has been bad, I am enjoying my job. There is just a lot of new faces, technologies, acronyms (!) and change. Nothing can quite prepare you for it, as I have told the multitudes of friends and family who have asked how my first job is going. I could hardly wish for a better opportunity than where I am right now - I did not even have to move out of my flat in Stellenbosch and I'm delighted with the company I am at. Yet, despite that all, the new structure and processes in my life have taken a few months to get used to.

I have also now come to terms with the fact that I am not, and may never be, an Operations Researcher by job title. Sure, I use a lot of machine learning and there is always algorithms and optimisation problems and data lurking around every corner, but I am now a Data Scientist. Or, more specifically, a Machine Learning Engineer. And I have noticed that most of my former classmates have now become the same. Perhaps being an Operations Researcher transcends beyond a particular title and into a way of thinking.

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The year 2020 marks the first intake of students for the two new postgraduate programmes with focus on data science hosted by Stellenbosch University's Department of Industrial Engineering, in association with the School for Data Science and Computational Thinking. The structured masters degree and the postgraduate diploma programmes each consists of eight modules, which are presented during block weeks. The masters students will, upon completion of the modules, undertake a final project applying the knowledge gained on a relevant industry-related problem. The selection of modules vary from Programming in R and Applied Machine Learning to Big Data Technologies and Deep Learning.

The programmes focus on enabling students to develop innovative optimisation and machine learning techniques to produce novel, efficient and robust data science technologies, for use in industrial engineering, engineering management and related applications. With the programmes allowing for fulltime and part-time options, it is structured in such a manner to serve people from industry, as well as recently graduated students.

Coordinating these programmes with the school's collective vision of becoming a world-class institution for data science and computational thinking in and for Africa, is a fairly daunting task. I am, however, very privileged to be part of a bigger team working towards this vision. Prof Andries Engelbrecht serves as the academic head to these programmes in his position as the new Voigt Chair in Data Science in the Department of Industrial Engineering. A team is always greater than its parts and we are fortunate to be working with an excellent group of core lecturers, which includes some familiar faces in the ORSSA family – Prof Jan van Vuuren, Thorsten Schmidt-Dumont, Jacques du Toit and Stephan Nel.

Great endeavours are bound to have some challenges that arise along the way. It is, however, with determination fuelled by a collective vision and the harnessing of team efforts that these challenges will be addressed, mitigated and ultimately embraced.