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WHAT'S INSIDE

FROM THE PRESIDENT

The Uniqueness of IFORS

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As I write this, I have just begun my second year as President of IFORS. I have been president of a number of organizations in my life, most notably (apart from my high school chess club) INFORMS, the 13,000-member US operations research society. I have also been on the governing board or advisory board of a large number of organizations in operational research and computer science, including the Association for Constraint Programming, the open-source software COIN-OR initiative, and many others.

As I reflect on my first year, it is clear that IFORS is an organization like no other with which I have been involved. Here are a few of the most distinctive features:

IFORS only has 52 members. IFORS membership is composed of national OR societies. They, in turn, range in size from the previously mentioned INFORMS down to societies with perhaps 25 individual members. This strongly affects the services we offer. One question that is constantly on my mind is how we can best support our member societies. We have begun offering get-togethers at all the major meetings so that presidents and other representatives of national societies can exchange ideas and discuss issues they face. But we can do much more to support the member societies.

IFORS worries as much about non-members as members. IFORS, and particularly its Developing Countries Committee, spends a lot of time working with groups and individuals in areas where national societies are either absent or at their very early formative stages. IFORS as an organization sees its role as developing them so that they can eventually become members and, more importantly, so that they can bring operational research to areas that badly need the insights that our field provides. Whether the country without an IFORS membership is as large as Russia, a country where our European regional grouping EURO has taken the lead, or as small as Colombia, being supported by the Latin American grouping ALIO, IFORS spends a lot of time helping non-member societies become members.

IFORS volunteers are incredibly loyal. Whether it is interacting with past Presidents or current committee chairs, I have had tremendous support from those who have been part of IFORS for decades. It is not every organization where a former President will take it on herself to edit the Newsletter and

> "As I reflect on my first year, it is clear that IFORS is an organization like no other with which I have been involved."

website (as Elise del Rosario does), or former Vice Presidents continue by chairing committees for Publications (Graham Rand) and Developing Countries (Sue Merchant). This sort of institutional memory is invaluable, particularly for an organization that changes its Administrative Committee almost completely every three years.

As we think about what makes IFORS unique, it is important to think about how this uniqueness can permeate all of our activities. We don't want our Triennial conference to be just another OR conference: we want it to be an IFORS conference! Our journals are not just other OR journals: they need to have an IFORS feel. I believe that is going to be the challenge over the next two years of my Presidency. How can we make all of what we do align with the important goals of IFORS? Foremost of those goals is given by our constitution: "to develop operational research as a unified science and to advance it in all the nations of the world." A worthy goal indeed.

EDITORIAL

All Leaps, No Bounds for IFORS 2017

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As July 16 nears, frenzied activity is palpable, with IFORS pulling out all the stops. Program Chair Grazia Esperanza has not ceased spending nights and days working with the program committee members, stream organizers and session chairs to attract abstracts, which, by the way, has reached the 1,807 mark! Now comes the hard work of organizing them into sessions. From the Local Organizing Chair's desk, Irene Abi Zeid has not tired of ensuring perfect activities and facilities while reminding the community to register, book flights and reserve accommodations, and that we'd be in good company with the Quebec City Summer Music Festival 2017 happening at around the same time!

This big conference is preceded by an intimate one, which gathers a small group of Operations Researchers working in the area of development. The timing is an acknowledgement of IFORS' long-standing commitment to the International Conference on OR for Development (ICORD). On its 25th year, ICORD has had a lot of success in getting together the experienced and young workers in this area as they learn from each other. ICORD 2016 was held in Mexico, where an interesting proposal was put forward on how OR can help achieve the Sustainable Development Goals. A part of the lecture is presented in this issue.

Another one of the well-known IFORS programs is the IFORS Distinguished Lecture IDL) and the IFORS Tutorial Lecture (ITL). In our Tutorial section, we feature the paper delivered by our lecturer during the regional ALIO meeting last October. Indeed, development of theory on which we base our applications is what makes OR as rigorous as it is useful. The potential of OR for forest management, how OR can address health care challenges of an elderly population, and how OR made a restricted budget work more for police are tackled in the Book Review, Feature, and OR Impact sections, respectively.

IFORS is one with the international community in extending best wishes on the occasion of the anniversary of the OR Society of Japan, its 60th, which we will find out from the OR Society in Focus article, is a very significant year in the Japanese culture. IFORS mourns the loss of its Past President Brian Haley, who, as you would read in his Obituary, has seen OR tools and techniques grow by leaps and bounds.

When were you last in an IFORS meeting? Be surprised at the giant strides in the discipline since then, and while you're at it, maybe enjoy some festival music. See you at IFORS 2017!

Tackling the Global Healthcare Service Dilemma

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Healthcare quality is a key driver of innovation, development, and competitiveness. Healthcare quality and its relevant businesses, particularly from managerial and technological perspectives, are a key source of business innovation, improvements, and vitality in the social ecosystem. However, current healthcare quality performance is inadequate in both developed and developing countries. The implementation of meaningful advances in society through healthcare quality innovation will need a number of initiatives, including facilitating a new healthcare quality paradigm in the healthcare setting, synthesizing knowledge on ways to prevent social vulnerability, a commitment to the efficient practice of innovation, and methods to promote access to resources (Aaron and Ginsburg, 2009; Kim et al., 2016).

In order to achieve healthcare quality innovation, the significance of healthcare policies that may have an impact on industrial map changes in upcoming decades must be considered. This includes the perspective of healthcare policy-makers and decision-makers who recognize incentives and settlement of healthcare policy in the long term. On the other hand, healthcare consumers who, while both end users and beneficiaries of healthcare providers and pharmaceuticals, do not have a leading position in the third-party payer system that is multi-dimensional combinations of coinsurance, copayments, deductibles, and limits (Fried, 2012; Vita et al., 1998).

Societal aging, due to rising life expectancies and declining birth rates, has caused a key social change in many countries, leading to such social problems as a shrinking productive labor force, increasing healthcare costs for the elderly, and worsening of public finance. Societal aging has led to a fast increase in the demand for health promotion and enhanced healthcare services such as long-term care.

Without disruptive change, many people may not be able to afford healthcare. To address these problems, healthcare decision-makers and policy-makers in many countries have begun to focus on the innovation of IoT (Internet of Things)-based healthcare. For example, IoT-based healthcare technologies can be applied for certain diseases – equipping patients with (remote) sensors, wearables, monitors and other necessary devices to observe their health at home or a place, hopefully allowing them to reside within their own places or homes for longer, thus avoiding costly long-term care as well as reducing the demand for unintended hospital admissions or general practitioner (family doctor) visits. Such new healthcare technologies require big data and analytics collaboration, and other intelligent systems such as M2M(machine to machine interfaces), M2P(machine to people interfaces) and P2P(people to people interfaces) in healthcare systems.

It is expected that ubiquitous healthcare (u-healthcare) services will provide individualized and customized mobile healthcare services via wireless networks. Such a hospital-based u-healthcare requires technology that enables the right delivery of healthcare services regardless of time and place as well as healthcare service technology that enable the management of each user's requirements. With such technologies, users can receive reliable quality and information of healthcare service from their physicians or designated hospitals (Barbash and Glied, 2010; Jang et al., 2016).

IFORS Administrative Committee Welcomes New VP representing APORS

"David" Chang Won Lee replaces Ilias Mamat as IFORS VP for APORS effective February, 2017. A professor of Operations and Service Management area and Healthcare MBA program of Hanyang University, Seoul, Korea, and Director of the Center for Tech Entrepreneurial Studies, David currently serves as KORMS VP for international activities as well as VP of the Asia-Pacific regional grouping, APORS.

Disruptive innovation in healthcare sector is expected to result in u-healthcare, care that is available anytime and anywhere, such as self-care, mobile care, and home care. It will require a major change in the hospital service environment.

**This article is mainly from Jang, Kim & Lee (2016) "Effect of u-healthcare service quality on usage intention in a healthcare service," and Kim, Gaukler, & Lee (2016) "Improving healthcare quality: A technological and managerial innovation perspective."*

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** Full references are available upon a request.*

Brian (right) shown with Arne Jensen at the 1957 Oxford Conference.

OBITUARY

K. Brian Haley (1933-2016)

IFORS President (1992-94)

By Graham Rand g.rand@lancaster.ac.uk

The death of Brian Haley on Christmas Day at the age of 83, soon after a diagnosis of liver cancer, brought to an end nearly 60 years of substantial involvement with IFORS. During the first international conference held in Oxford, UK in September 1957, Brian's paper co-authored with John Stringer was presented, following that given by George Dantzig. Exalted company indeed!

Dealing with the application of linear programming to a large-scale transportation problem - of coal from pits to electricity generating power stations - the paper discusses solving transportation problems of size 32x130 by hand, and also presents a photograph of an analogue computer consisting of pulleys and strings to solve 4x3 problems. The authors point out that the application of this analogue is subject to difficulties with friction and extension of the string, and say that "a second machine is being constructed which incorporates a low-friction polythene (Fluon) as bearings and pulleys, and braided Terelyne for the strings, which are kept taut by graduated spring-loaded reels". In the published discussion, George Dantzig remarks that "analogue machines were useful for the solution of special types of linear programming problems, but that for more general types, digital computers probably would be required, from the point of view of both speed and accuracy." How perceptive! In the photograph of participants of the conference Brian is standing next to another future IFORS President, Arne Jensen (President, 1971-73). In 1957 he was clean shaven. His well-known beard began on holiday in 1966 when he forgot his razor.

The Oxford conference led to the creation of IFORS on 1st January 1959. The next conference, held in Aix-en-Provence in September 1960, was designated as the second IFORS Conference. During the conference the first general meeting of IFORS was held, at which a proposal from ORSA (OR Society of America) that IFORS sponsor a new abstracting journal (International Abstracts in Operations Research) was discussed and later approved by ballot. The journal required contributing editors from each member society: Brian was the first UK

editor. Later, he edited the proceedings of the seventh and eighth conferences, held in Tokyo and Kyoto, Japan (1975) and Toronto, Canada (1978). He then became successively Vice-President (1983-85), Chairman of the Publications Committee and, from 1992-1994, President.

For many years, Brian took pride in having attended every IFORS conference, usually accompanied by his wife Diana. At the fifteenth conference, held in Beijing, China (1999) IFORS' 40th anniversary was celebrated. It had been planned that Brian and Hugh Miser, who had also attended every IFORS Conference, would make contributions. In the event Brian was unable to travel, and Hugh Miser had sadly died two months earlier. But Brian did attend further IFORS conferences, with Diana, as was the case in 2008 for the conference in South Africa. Diana died in March last year and, no longer having to worry about caring for her, Brian had intended to attend the conference this year in Quebec, accompanied by his son, but sadly that plan was not able to be realised.

Brian, born in Smethwick, near Birmingham, England, in 1933 started at the University of Birmingham in 1950 to study mathematics. On graduating in 1953, he became a research assistant at the University's Department of Engineering Production. His doctorate in 1956 was on industrial applications of linear programming and his subsequent work always involved OR applied to real problems. In 1957, he joined the National Coal Board's Operational Research Group. He returned to the University of Birmingham in 1959, to become the UK's first designated lecturer in operational research in the Department of Engineering Production. In 1968, he became Professor of Operational Research, retiring in 1999.

Brian was a major figure in the Operational Research Society, being Editor of the Journal of the Operational Research Society from 1971-1980 and President of the Society in 1982-1983, as well as being on Council and many committees. Following his retirement from academic life, Brian continued to be involved in the Society's affairs, most notably as Chair of the Publications Committee, a position he held for a period of 11 years. During his time as Chair, the journals in the Society's portfolio flourished, and Brian oversaw the development of a variety of initiatives, including the birth of the Journal of Simulation.

Brian married Diana in 1960. They had one son, Alan, and two granddaughters. Brian was a keen sportsman, playing squash, badminton, rugby, as a prop, and latterly archery and a game called pickleball, and sailing. He followed cricket closely. He was very involved in church life; as treasurer, deacon and occasional lay preacher. Another major activity for nearly 40 years was as a governor of Bromsgrove School, for whom he created an L.P. model to evaluate alternative fee-structures.

It is clear that Brian made an enormous contribution to OR, both in the UK, and worldwide. Only one other person has been president of both the OR Society and of IFORS.

He was highly respected and made many friends in the OR community. They will miss him greatly. His death leaves the world of OR poorer.

Brian (second from left) during his last IFORS Conference in 2008, poses with other IFORS Past Presidents.

IFORS International Federation of Operational Research Societies

EWG ORD OPERATIONS RESEARCH FOR DEVELOPMENT

CIRRELT

ICORD 2017

OR: IMPACTING DEVELOPMENT

July 13 and 14, 2017

Salle Power Corporation du Canada (3452)Carré des affaires FSA ULaval-Banque Nationale
1030, avenue du Séminaire Université Laval, Québec, Canada

http://www.ifors.org/icord2017

Background

The International Conference on OR for Development (ICORD) aims to bring together researchers from around the world to present and discuss models and methods to overcome issues faced by developing countries. It aims to improve the links among researchers with the view to improving each other's effectiveness at bringing about meaningful changes towards development.

Eleven ICORDs have taken place since 1992 in countries across Asia, South America, Africa and Europe (http://ifors.org/icord-history/) with the latest one held in México City in 2016. In 2017, the ICORD will be held immediately prior to the IFORS Triennial conference in Quebec. In the past seven years as in this year, the EURO Working Group on OR for Development (EWG ORD) has been a co-organizer of the ICORD.

Call for Participants

Operations Researchers who have done work in the area of OR for Development are invited to participate. Participants must submit a full paper or extended abstracts of their work which has used Operations Research to help decision-making processes in such areas, but not limited to: sustainability, healthcare, energy, mobility, education, natural resource management, public policy and infrastructure. Purely technical papers, or those that have no relevance in the developmental context, will not be accepted, and papers should clearly describe the relevance of the research to development

The feedback received at ICORD is an opportunity for authors to improve the quality of the paper in a short time.

Extended abstracts (no less than 1,500 words) will be accepted, though full papers (needed for a meaningful review) are preferred.

Submit your full papers or extended abstracts not less than 1,500 words to: icord@ifors.org

Those who have participated in previous ICORDs and who have brought their work forward are encouraged to attend to report on developments on their previously presented work. They will also be given priority for the limited slots for delegates who are not presenting papers.

Papers submitted for IFORS Prize for OR in Development are invited. Competition finalists will find it beneficial to present their work in this forum and gather feedback prior to the Triennial Conference Competition.

Conference Format

The conference will be limited to a small number of participants who will each present their paper to others in their group and will benefit from a critique of their work by the other participants and invited experts. All participants will be given all the papers of accepted participants in advance, which will give them time to study the other papers in detail.

Ample time will be given for a discussion of each of the papers presented. There will also be plenary session/s for invited speakers and participants will be given the opportunity to attend a workshop on techniques especially relevant to developing countries.

Important Dates

Deadline for paper submissions: March 30, 2017
Notification of Acceptance: April 15, 2017
Deadline for early registration: April 20, 2017

Fees

Regular Registration Fee: USD 200
Early registration fee (on or before Apr 20): USD 150

Registration fee is inclusive of materials, snacks and lunches for the two days.

Accommodation

Standard University room accommodation starts @ $60/day.
For more information, please visit http://ifors.org/icord2017/accommodation/

Support for Participants

A limited number of slots for accommodation and registration support will be available, and will depend on the quality of material submitted. Updates on the Invited Speakers will be posted in the website in the next few weeks.

For inquiries, please contact any of the following organizing committee members:
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OR and the World's Sustainable Development Goals

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This article discusses some of the points raised by the author during his talk delivered at the ICORD 2016 in Mexico City. The talk cites MDGs and SDGs and how OR could contribute to these goals.

Despite the long involvement of the World Bank in studying and proposing theories of development[1], the outcome at the end of the twentieth century was one of skepticism and disagreement. In contrast, the Human Development Index (HDI) gained acceptance. Thus the signing of the Millennium Development Goals, MDGs[2] by all countries was an enormous success based on an approach more in the spirit of the HDI than in the theories put forward by the World Bank. The idea was to reach an agreement about goals but not about how to achieve them.

MDGs comprise the first version of the Institutional Framework for Development (IFD). The second version expanded the scope of the goals and was renamed as the Sustainable Development Goals, SDGs[3], For example, MDG 1 deals with extreme poverty while SDG 1 includes all kinds of poverty and is supplemented with SDG 10 on inequality. The agreements are binding for the countries as well as for the agencies of the United Nations System. Thus, in the IFD, every agency is linked with its counterpart in each country. For example, the World Health Organization and the ministry of health of a country are supposed to collaborate to fight malaria (SDG 3.3) or child mortality (SDG 3.2) or HIV (SDG 3.3).

The eight MDGs were focused mainly to relieve the burden of poverty in its several dimensions: Hunger, poor health and poor education; but also tried to improve the situation of women and ensure environmental sustainability. The program ended in 2015 with mixed results but with an overall positive outcome.

A new set of goals, the SDGs, was set up and 2030 was defined as the new horizon. With 17 goals, SDGs are more ambitious. For example, one of the targets of Goal 1 is to eradicate all types of poverty by 2030. The new goals include not only the fight against poverty but also the decreasing inequality (goal 10) along with a much firmer stand on environmental sustainability. In summary, the challenge that humanity, as represented by the General Assembly of the United Nations, has picked up is a big one. The acceptance of such big a task by the countries can only be explained by the sense of urgency to remedy the world situation that prevails among many conscious people.

How can operations researchers, specifically those in the area of OR for Development, get involved in this extraordinary project?

The general structure, IFD, is already set up, and has, as its subsystems, the organizations that are in charge of each goal in the SDGs. The challenge is to detail the system at a lower level with all its interactions and find out which goals are complementary and which ones compete with each other. Consider, for example Goal 1: No Poverty. The struggle to diminish poverty in the last 15 years was perturbed by the financial and economic crisis of 2008. Thus, a good policy to diminish poverty has to be complemented with strategies that procure economic stability. This was recognized in target 10.5: "Improve the regulation and monitoring of global financial markets and institutions and strengthen the implementation of such regulations". Goal 10 is devoted to reduce inequality.

At a lower level, management problems abound. For example, goal 11 deals with the management of cities to make them "safe, resilient and sustainable". In particular, target 11.2 deals with transportation in the cities and target 11.6 includes waste management. These two targets could benefit greatly from the models that the OR community has developed or is developing.

At the operational level, there is certainly room for the use of OR tools. However, in order to support the SDGs, the models have to include environmental and social objectives in addition to the economic one. This is a difficult task since, for many years, the main objective of companies has been the maximization of profit. However, models that include a longer planning horizon can prove that in the long run, incorporating social and environmental objectives pay off.

Other examples at the operational level follow:

• Target 3.2 aims to end preventable deaths of newborns and children less than 5 years of age by 2030. There have been attempts to use modifications of the diet problem of Linear Programming to design minimum-cost porridge mixes for undernourished children, without much success. More realistic models can help children to survive.

2015 **UN Millennium Development Goals**

• Target 3.8 "Achieve universal health coverage, including financial risk protection, access to quality essential healthcare services and access to safe, effective, quality and affordable essential medicines and vaccines for all". Here the main objective is social. A plausible application of OR is to improve the cold chain in the transportation of vaccines in developing and less developed countries.

• Humanity is in the transition from using fossil fuels to clean energy. One challenge in this process is the management of power grids as a growing number of households generate electricity from solar energy, that is partially fed into the grid. This modifies greatly the economic dispatch process, which has been modeled as an optimization problem by the OR professionals. This is central to Goal 7: "Ensure access to affordable, reliable, sustainable and modern energy for all".

• SDG 16 is about Governance. Without governance there is no hope for the success of the SDGs. In particular, target 16.5 refers to corruption. While a large bibliography on the economics of corruption exists, literature on an OR approach (apart from a game theoretical perspective by an economist) is scarce. A good challenge for the community is to fight corruption with models.

• SDG 17 is about financing development. In 2015, development assistance from member countries of the Development Assistance Committee of OECD totaled $131.6 billion. Therefore, any OR project that could enhance the efficiency of the assistance will mean significant savings.

Readers are invited to email the author on their thoughts on this issue.

1 https://openknowledge.worldbank.org/handle/10986/2586
*2 Millenium Development Goals, MDGs, (*http://www.un.org/millenniumgoals/*)*
*3 Sustainable Development Goals SDGs (*https://sustainabledevelopment.un.org/sdg2*)*

OR IMPACT

Optimising Efficiency in the UK's National Police Air Service

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Introduction

Many of the UK's 43 Police Forces across the country had their own air support services (e.g. helicopters) until 2012, when financial cuts forced Police chiefs to rethink how air support could be provided more efficiently. This same year, the National Police Air Service (NPAS) was formed to provide a national airborne response capability with borderless tasking, with the aim of delivering a cost effective service that yields actual savings. West Yorkshire Police (WYP) volunteered to act as the lead Force for the development and delivery of NPAS.

After achieving initial savings of 23%, NPAS was interested in using quantitative methods to identify how further savings can be achieved while still delivering the level of service required. This article explains how simulation modelling helped this effort.

The Need for Modelling

In early 2014, WYP worked alongside the Home Office to produce a spreadsheet model looking at the potential location of bases, with a focus on the benefit covered within a certain response time. This benefit was based on social economic analysis on the cost of crimes or the cost of not providing support. However, this model did not look at the level of service provided. NPAS thus commissioned WYP in September 2014 to provide independent analysis and an evidence based view on a new operating structure testing the indicative performance and viability of alternative base

numbers and locations. The analysis also had to appeal to the diverse members of the National Strategic Board covering the operational and financial risk, and to take a logical approach to avoid any emotional bias in the decision-making process.

The Model

A model was built as a discrete event simulation in Witness to look at the operational ability of NPAS responding to calls for support. This included modelling:

• All 23 bases and 24 helicopters in England and Wales, and the new concept of operating fixed wing aircraft in NPAS. These were modelled as the resource.
• Over 300 operating areas for 43 Forces, where areas are the local authorities or police districts within a Force. These were modelled as the activities.
• Different types of support e.g. searching for a suspect or pursuit of a vehicle. These were modelled as the entities.
• Characteristics for these calls for support where the priority and duration changes for each type of support

The process of an aircraft responding to a task starts with generating and allocating a task to an operating area within a Force, then identifying which type of support is required along with the duration and priority of the task. This stage of the model is based on various distributions for: demand by hour of day, day of week and week of year indicating when support is requested; demand profiles at Force level, operating area level and for type of task; and a standard profile for the duration and priority of the specific task. The task is then allocated to the operating area which prompts the model to find the nearest aircraft that can respond. This takes into account: whether it is currently responding to a task and when it will be free to respond; the remaining operating time of the aircraft based on the fuel, including how long it would take to respond to the task and return to the base to refuel. Once the nearest available aircraft is found, it attends to and completes the task. An outline of this process is in Figure 1.

The model provides a visual representation of the service, showing a map of the bases, tasks, and aircraft responding to tasks. There is also an information feed of when tasks are generated.

Data

A range of data was collected for the simulation model including NPAS data for the received calls for support from Forces, for tasks and flights completed by each aircraft, and non-NPAS air support unit data for tasks and flights completed. Without this support from other Forces, the model would not have been able to provide a national picture. The data was analysed to produce distributions that were used in the model. Any details on aircraft specifications, operational ability and shift patterns were provided by NPAS.

Inputs

The three categories of inputs used in the model are data, engagement and experiments. Data includes inputs gathered by analysing data, such as: profiles for the demand covering the different characteristics and types of support requested; when and where support was requested; chance of a task being abandoned because of poor weather (an important element NPAS wanted captured). Engagement refer to inputs that required engaging with NPAS and specialists e.g. pilots on such information as base operating hours, the number of hours a pilot can fly in a shift and the maintenance schedules for each type of aircraft. The last set of inputs are those that are mostly used in the experiments and include the number of bases and their locations, and the type of aircraft located at each base.

Outputs

The outputs collected from the model and saved in Excel were categorised by aircraft, Force, time period and base, including details on hours flown, response time, number of calls for support and number of tasks completed.

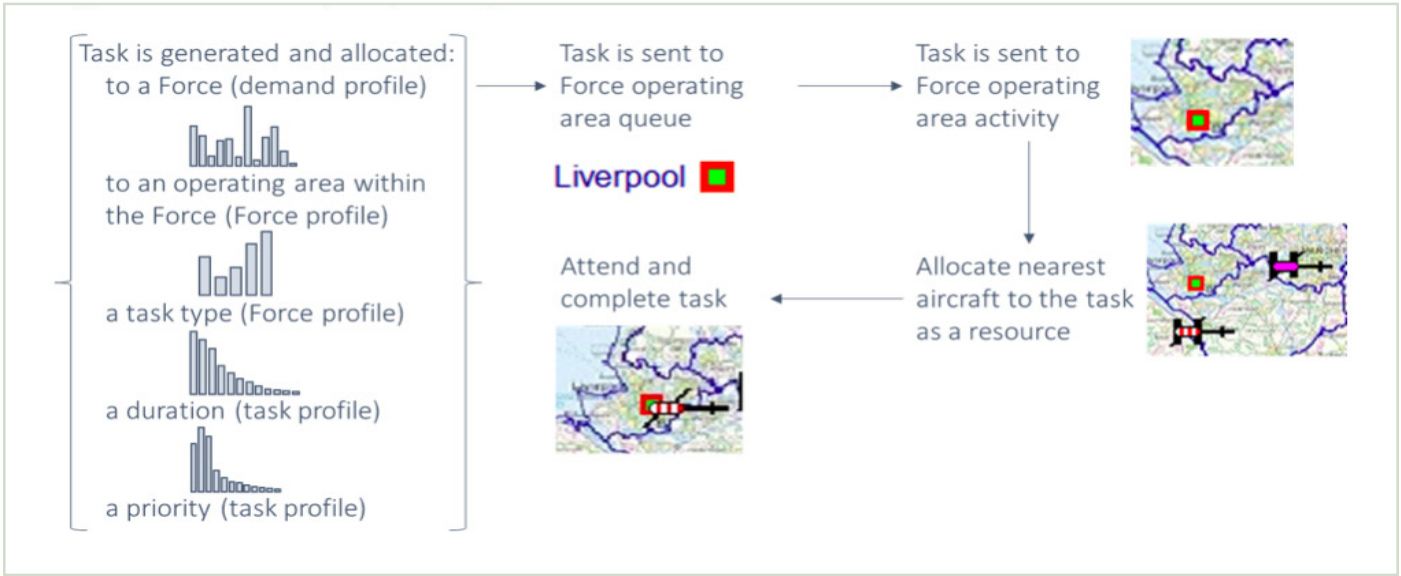


Figure 1: Process of responding to a task in the model

Assumptions

As the process of providing air support is complex with various factors affecting the response such as weather, maintenance, the aircraft being interrupted to attend to another task, available fuel, some assumptions and simplifications had to be made. These simplifications underestimate the performance that could actually be achieved. The key assumptions and simplifications included: aircraft only land at their allocated bases and refuel each time they land; only a single aircraft responds to a task; no overtime is included in the model; once an aircraft has been allocated to a task it can not be interrupted to respond to another; shifts are modified to allow for a 30 minute aircraft check at the start of each day; fixed wing aircraft return to a central 'operating point' between tasks (in reality, they operate where necessary).

Validation and Verification

To validate and verify the simulation model, the outputs from the model were compared with both the inputs and the original data. There was also consultation with experts within NPAS to check that the aircraft in the model were behaving realistically, for example, where an aircraft would travel to. For modelling the fixed wing aircraft, there were various discussions with fixed wing pilots to check how these aircraft would be used and how the model could capture this. Since fixed wing aircraft were a new feature for NPAS, behaviour of these aircraft could not have been obtained with the use of historical data.

How The Model Has Been Used

In December 2014, the model was introduced to the National Strategic Board to engage the stakeholders and to build acceptance and buy-in before any results were presented. This involved running through the details of the model and a video of the model running so they could see aircraft responding to tasks. The December minutes for the National Strategic Board state 'It was agreed by the Board that this was an excellent piece of work and it was confirmed that the modelling would be flexible enough for other emergency services to use.'

A range of options, saving between 7% and 28%, were presented to the Board in January 2015 with the anticipation of further budget cuts in the 2015 Spending Review. These options included changing the:

- Number of bases and locations
- Mix of fleet of fixed wing and helicopters including the number of resilience aircraft
- Type of aircraft at each base
- Locations of fixed wing patrol areas
- Base operating hours
- Distribution for the priority of the call for support

Details of selected bases were removed from the options to avoid any emotional bias caused by stakeholders having to make a decision on the future of their local base. The Board members considered the indicative service level and the cost of each option to select one for further development.

This developed option was presented to the Board in February 2015 where the Board agreed upon a new 15 base operating model with a fleet of 19 helicopters and 4 fixed wing aircraft with each base operating 24/7. This option achieved an approximate saving of 14% of the current budget, in addition to the 23% originally saved from nationalising police air support.

A series of road shows held across the country opened the model to further scrutiny and challenge and facilitated greater acceptance of the model. NPAS has also requested further variations to the model to assess the effect on performance of different conditions.

How The Model Has Made An Impact

The simulation model has secured diverse stakeholder buy in, enabling agreement across the National Strategic Board on which level of service and financial savings are suitable for both operational and financial perspectives. It has also provided 'what-if' analysis of other options and has informed a review of the NPAS funding formula.

The work has also prompted the National Strategic Board to consider a new fleet plan and estates plan; and the National Police Chiefs Council has adopted a new deployment model with 3 different priorities of calls.

The model has various possible future uses. With the range of inputs that can be modified, the model can be used to run additional options if further savings are required, and different support tasks that NPAS provide can be added along with requests for support from other organisations. There is also the possibility that the model could be used by other air support providers wishing to look at a national service.

Project Success Factors

The success of the project was potentially mainly due to the following factors:

- Engaging with diverse stakeholders and building acceptance and buy-in to the model through the use of the visual element in simulation modelling.
- Avoiding any local emotional bias from the decision-making process by removing the details of which bases were selected for each option.
- Providing an evidence based process which enabled agreement across diverse stakeholders covering both operational and financial perspectives.
- Building further acceptance into the model across individual Police Forces through the roadshows.

Comments from NPAS

Tyron Joyce, Chief Operating Officer for NPAS, said, ***"The early introduction of indicative mapping was essential in securing and maintaining the trust and confidence of all of our many stakeholders. As a direct result of this work we were able to***

develop the new operating model and base locations and latterly a completely new funding model. I have no hesitation in describing its use as essential during this process."

Acknowledgements
This work has also been published in the OR Society's Impact Magazine.

BOOK REVIEW

Root and Branch Approach to Forestry Management

Hans W. Ittmann, University of Johannesburg, hittmann01@gmail.com

Operations Research has been an important tool used in forestry, specifically, forest management planning. It has been successfully applied and used in management decision-making at the strategic, tactical, and operational levels.

Typically covering 20 or more years, long range or strategic planning focusses on what is wanted from the forest e.g., what species will give the highest yield and satisfying long-term demand without overharvesting. Tactical planning, covering 5 to 20 years, details out how strategic goals are to be achieved, considering such issues as: alternative forest plans including stand or compartment (blocks of trees) regimes, harvesting strategies, and since roads account for 30 to 40% of operating costs, construction of road access to areas to be harvested. Operational planning are execution plans that provide answers to such questions as: when to harvest a stand or compartment, amount to harvest, harvesting equipment to use, transport scheduling of logs to mills for sawing or for pulping. The plans are interlinked, given that the long rotation ages of timber (up to 35 years), require that short term gains do not sacrifice long term sustainability.

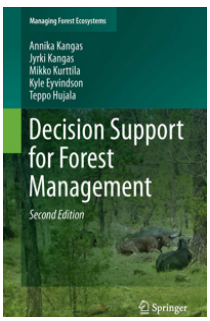
Already on its second edition, this book is based on the research, lectures and real-life experiences of authors who all originate from Finland. This edition puts greater emphasis on the practical aspects of multi-criteria decision-making in the forestry context as well as participatory planning situations and the tools used for this purpose. Advanced problem formulations are included with examples of more advanced optimization methods and methodologies to solve these.

The book is divided into five parts. Part One covers concepts and definitions. The focus here is on all aspects of operational. tactical and strategic planning, decision making phases, and such planning problems as compartment sizes to select for a profitable yield, or whether to plant trees on steep slopes. Forestry planning management is outlined while giving special emphasis to sustainability, a concept that is discussed in detail. The development of approaches for optimization and multi-criteria decisions used in forestry management and the need for participatory planning is dealt with as well.

In Parts Two and Three, discrete and continuous problems are introduced in a number of chapters. The theory behind these types of problems is explained in detail and solution methods are illustrated with examples. Examples used to illustrate the techniques gradually shift to forestry applications. In this part, different methods are used to address the same problem, or as the theory is enhanced, the enhancement is applied to the problem, a very useful aid to understanding the material.

In the first discrete problem chapter, focus is on single-criteria problems where the reader is shown how to measure utility and value, assess risk, and estimate the value function. This is followed by the chapter on multi-criteria problems. All aspects related to decision models, multi attribute utility functions and the Analytical Hierarchy Process (AHP) are discussed comprehensively.

This includes a range of techniques and utility functions such as SMART and TOPSIS, the AHP, the Analytical Network



Decision Support for Forest Management

2nd Edition

Decision Support for Forest Management 2nd Edition *by Annika Kangas, Mikko Kurttila, Teppo Hujala, Kyle Eyvindson and Jyrki Kangas, 2015, Springer-Verlag, Berlin, pp. 307, ISBN: 978-3-319-23521-9, EURO 149.99 (Hardcover).*

Process (ANP), Even Swaps and A'WOT (using the AHP with SWOT analysis) as applied through different examples. The whole range of uncertainty in multi-criteria decision making, fuzzy set theory, outranking methods such as PROMETHEE and ELECTRE, and probabilistic uncertainty using Stochastic Multi-criteria Acceptability Analysis (SMAA) are discussed. Techniques for addressing continuous problems include optimization (i.e. linear, goal, integer programming), heuristic optimization (covering various heuristic methods) and uncertainty in optimization (stochastic, robust and chance-constrained programming, stochastic portfolio modelling). Separate sections are devoted to forest planning with LPs, the general forest planning problem formulation, hierarchical forest planning and modelling, among others.

An interesting addition to the book deals with a phenomena that has become very common in forest management planning situations: how to deal with public participation and involve various stakeholders. "Public" includes the general public, stakeholders, decision makers and facilitators. Recognising that group decision making and participatory planning not only call for careful planning but also require facilitators who are able to cover all issues and all those affected, chapters are devoted to designing and facilitating (for different roles) a group decision process as well as measuring the success of sessions. To enable real participation of all involved, different voting methods and strategies are included in chapter ten. Covered are: social choice theory, positional voting schemes, pairwise voting, fuzzy voting and probability voting.

In chapter eleven, examples of participatory planning processes in the context of forest management planning are presented, ranging from managing the forest of a city park to preparing national forest programmes. Different decision support tools and methods are discussed to handle participatory planning processes. These include problem structuring methods (Strategic Options Development Analysis (SODA), Soft Systems Methodology (SSM) and Strategic Choice Approach (SCA) to elicit public preferences. For group decision making, Group Decision Support Systems (GDSS) tools for distributed group negotiations is discussed. Various examples to illustrate and explain the use of the methods and approaches as used in the forestry environment are scattered throughout the various chapters.

The penultimate chapter is devoted to behavioural aspects of planning, decision making and participation, including concepts as 'satisficing' or ´groupthink'. The authors make the point and endeavour to illustrate that while people without any aids do not necessarily maximise their utility, they might in fact make better decision when aided. It is also shown that decision support based on image theory (the way people perceive themselves) could provide a possible way of solving the challenge of combining behavioural and decision aid views.

Well managed forests are a renewable resource that, with minimal waste and energy use, produce essential raw material for a whole range of products. A shift from traditional multi-functional forest management focusing on for example, timber production and livestock grazing, to modern multi-functionality which deal with ecological aspects such as soil and water protection, as well as carbon sequestration, has been noticeable over the last years.

Making full use of technologies and new developments to deal with this shift is therefore one of the challenges faced by the forestry sector. This book presents the advances and progress in the use of OR in forestry management over the last forty to fifty years. The substantial growth in the range of techniques, methods and approaches extensively shown through examples in the book *Decision Support for Forest Management*, should put forest managers and decision makers well equipped to face this challenge.

OR SOCIETY IN FOCUS

ORSJ @60: Revisiting the Past, Redefining the Future

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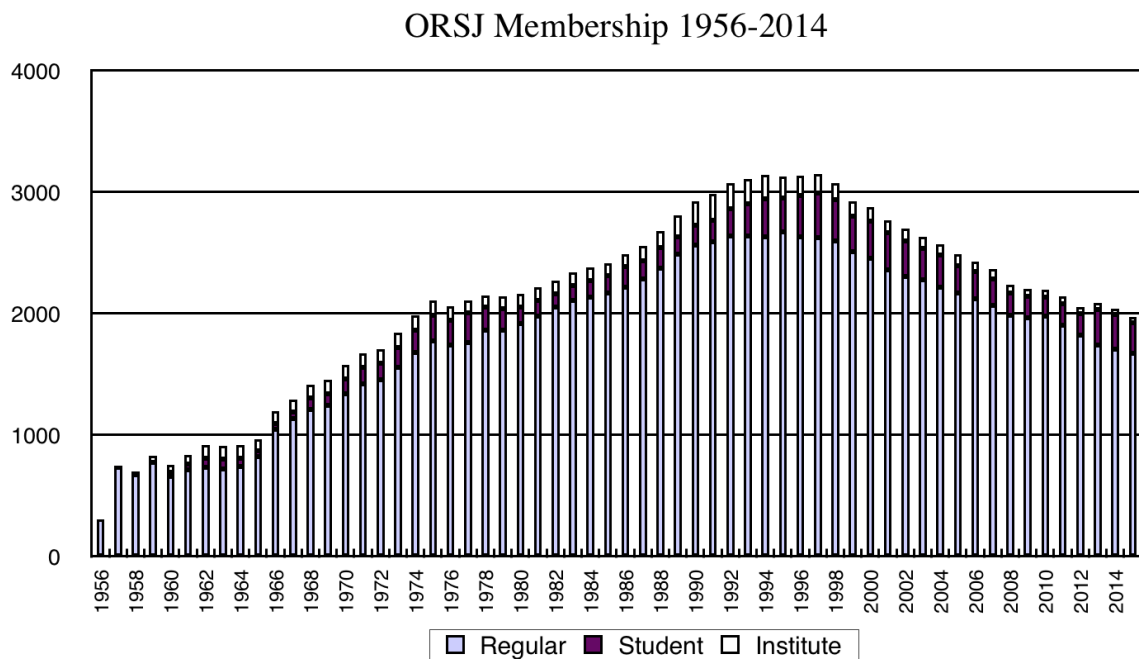
Tatsuo Oyama is the current President of the Operations Research Society of Japan (ORSJ), Past IFORS VP for APORS and currently Professor Emeritus, Board of Trustees of the National Graduate Institute for Policy Studies, Japan.

In Japan, a person's sixtieth birthday marks the calendar's return to the starting point, a kind of rebirth. The Japanese (or Chinese) zodiac spans a twelve-year period, and an animal is assigned to each year in the twelve-year cycle beginning with the rat, followed by the ox, tiger, rabbit, dragon, snake, horse, sheep, monkey, cock, dog and boar. Five times around this 12-year-cycle is the sixty-year period called *kanreki* in Japanese. For humans, this signifies that the clock has returned to 'zero.'



In this year of the cock, 2017, the ORSJ turns sixty and will be celebrating its *kanreki*. It is therefore fitting to look back at where it all began, the moment of its birth. The Operations Research Society of Japan (ORSJ) was established in 1957, four years after in the US, the Operations Research Society of America (ORSA) and The Institute of Management Science (TIMS) were founded. The first ORSJ meeting was held in 1955, and the first Japanese OR journal, *Keiei Kagaku* (Management Sciences) was published in 1956. In 1957, the first IFORS Conference was held in London.

The Union of Japanese Scientists and Engineers (JUSE), one of the leading consulting companies in Japan at that time, contributed greatly to the formation of ORSJ, with its organization of the first OR conference in 1955 and its publication of the *Keiei Kagaku* in 1956. As shown in Figure 1, the total membership of the ORSJ increased steadily from around 350 at the time of founding in 1957 to its peak of 2,638 in 1992-1993. During the period 1993-1997, the membership peak period of ORSJ, the total membership, including regular members, students and institutes, reached more than 3,100.

Since its 1997 peak, total membership has been decreasing steadily, a fate that most Japanese academic societies have been experiencing over the last 20 years or so. For some major academic societies in Japan, membership has decreased by some 50% of their peak number. Fortunately, this decrease for ORSJ was less. By 2005, the total membership of ORSJ was 2,570, including 85 institutional members, which kept ORSJ in a good financial standing.

ORSJ has kept a tradition of holding special celebrations every ten years of its foundation. It is worthwhile noting that the Japanese also have special names for 10-year anniversaries, following the custom of Chinese classical literature. On its 40th year in 1997, ORSJ held its anniversary conference in Tokyo jointly with APORS (Asia-Pacific Operational Research Societies), inviting some 10 young researchers from Asian countries to the APORS session. ORSJ also published a new revised edition of its Japanese OR Dictionary, containing around 500 entries. Copies were distributed in CD-ROM to all society members. Subsequently published was the New Frontier of Management Sciences, a 40th anniversary series of 15 books, including "Parallel Computation in the Mathematical Programming," "Combinatorial Optimization Focusing on the Meta Heuristics," "Queuing Algorithm," "Fuzzy OR," "Mathematical Modeling in Marketing," "Public Policy and OR" (written by the author), "Congestion and Queue," "Logistics Engineering," and "Production Scheduling and DEA."

In 2007, ORSJ held its 50th anniversary ceremonial conference, again in Tokyo, along with several other memorial events. These included a 50th anniversary ceremony at the National Graduate Institute for the Policy Studies, with guest speakers from INFORMS, Chinese, Korean, Philippine and Indian OR Societies, along with Japanese distinguished guests from the academe, industry, business, and public administration. The Conference invited 15 young OR researchers from the region. In addition, special issues of both Communications of the ORSJ and Journal of the ORSJ were published.

On this its sixtieth year, called *ji-jun* (*ji* means "ear" and *jun* has the connotation of "follow", "respect", or "obey") ORSJ listens to

the worthy advice of both older and younger people that the future may be happy, comfortable and prosperous. Through the efforts and advise of both the young and older people, ORSJ carried out 10 major events that form part of the 2017 60th anniversary, as follows:

(1) A series of publications entitled "optimization modeling."
(2) A special issue of ORSJ Communications.
(3) A special issue of the ORSJ Journal.
(4) The international conference, ICCOPT2016.
(5) The 60th Anniversary OR Conference in Okinawa (spring 2017).
(6) Support for young OR researchers to attend conferences.
(7) Dispatch of young OR researchers overseas.
(8) Publicity activities to enhance the image of OR.
(9) Preparation of visual content for ORSJ.
(10) Distribution of OR publications to high school students.

To carry out these activities, 17 million yen (US$ 17,000) had been budgeted. Events (1) and (4) are completed while (5) is scheduled for March 16-18, 2017, in Okinawa which will host its first ever ORSJ conference.

At its *kanreki*, ORSJ looks back to the moment of its birth so that it may be inspired to be more active, positive and progressive in spreading the spirit and the principles of OR to the general public and to society in general.

The theory and methodology that used to belong to OR, such as LP (linear programming), PERT (program evaluation review technique) and simulation are now well known and utilized by many researchers and practitioners in various fields. At the same time, many complex societal issues in areas such as energy, the environment, transportation, traffic, health care, medical policy, social welfare are public policy problems in urgent need of solution. Under the present circumstances, there is a need to develop: (i) new modeling or simulation techniques and (ii) new theory and methodologies for the solution of these serious societal problems.

By implementing the two major actions mentioned above, ORSJ can successfully turn full circle to its "golden age" of 1993-1997, disseminating OR theory and techniques to as many areas and fields as possible. Internally, this could start through closer communication among all the members of ORSJ, whereby each one – whether young or senior, academician or practitioner, listens more attentively to ideas and opinions of people from different areas and fields, even as they work together harmoniously. With these in place, a bright future awaits both ORSJ and the theory and practice of operations research.

CONFERENCES

Keeping Mathematics and OR Alive in Indonesia

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The *National Seminar on Mathematics and its Applications (SiManTap2016)* (http://ocs.usu.ac.id/simantap/2016) with the theme "Mathematics and Educational Mathematics are Keywords for Better Living" was held at the University of Sumatera Utara, Medan, Indonesia on November 28-29, 2016. A collaborative effort between the Indonesian Mathematical Society (IndoMS) - Aceh-North Sumatra Region, and other Indonesian universities, it aimed to provide a forum for researchers, lecturers, educators and students to exchange ideas, to communicate and discuss research findings and new advances in Mathematics. It further aimed to explore possible avenues to foster academic and student exchange, as well as

Baldemor (3rd from right) and Ramli (2nd from right) pose with the orgaizers and speakers.

scientific activities within the region. Topics discussed during the event included Mathematics and its applications and other related operations research topics. It was attended by 350 participants, of which 190 are paper presenters.

Highlights of the conference SiManTap2016 included the Plenary Talks of: Dian Armanto (KOPERTIS WIL – I) on *Mathematics For All and All For Mathematics*; Vincent Geiger (Australian Catholic University, Australia) on *Seeking Out and Taking Advantage and Opportunities for Mathematical Literacy Across the Curriculum*; Intan Detiena Muchtadi (Institut Teknologi Bandung, Indonesia) on *Implementation of Messaging and Pollard Rho Attack in Elliptic Curve Cryptography*; Ismail Bin Mohd (University Malaysia Perlis, Malaysia) on *Mathematical Concept of Wakap*; Mardiningsih (Universitas Sumatera Utara, Indonesia) on *A Solution Method of Mathematical Model for Combinatoric Polynomial*; and Intan Syahrini (Universitas Syiah Kuala, Indonesia) on *Integer Programming Model for Production and Distribution Planning Problem of Fish Processed Product with Multiple Plants*.

Participants gave glowing feedback on the seminar preparations, plenary lectures and paper presentations. The learning experience and meeting other research enthusiasts from different parts of the region and from all over the world were the most cited conference benefits

The first SiManTap seminar was organized in 2010 by the University of Sumatera Utara of Medan, Indonesia. Succeeding annual SiManTap seminars were sponsored by institutions of higher learning with *IndoMS*. It is worthwhile noting that the core team of SiManTap2016 consists of the main organizers of the *InteriOR (International Conference on Operational Research)*, a biennial event, located in Medan. With connections to EURO and IFORS and to their renowned *EURO* and *IFORS* Conference series, InteriOR has served as the conduit of international OR in Indonesia.

OR and Computing Meet in Texas

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Andrew Schaefer emphasises a point on Markov Decision Processes in Healthcare on the last day of the conference.

The INFORMS Computing Society (ICS) held its bi-annual conference in Austin, TX on January 15-17, 2017. The theme of this 15th conference was Healthcare Analytics. Of approximately 200 abstracts received, 175 were included in the program. The conference attracted slightly over 200 researchers from the US and around the world.

ICS addresses the interface of operations research and computing, two areas that have been tightly linked since their earliest days. Recognizing that the practice of OR depends heavily on the availability of software and systems capable of solving industrial-scale problems, ICS focuses on algorithms and software for modeling, optimization, and simulation, as well as the effect on OR of leading edge computing. Topics presented during this conference included learning methods in healthcare, stochastic models in healthcare, resource allocation for epidemics, radiation therapy treatment planning, and models for disease screening and treatment.

The conference also highlighted five plenary and tutorial speakers, namely: Martin Wainwright on *Statistics Meets Optimization: Some New Phenomena at the Interface*; Shane Henderson on *Citibike: Continuous, Discrete, and Simulation Optimization*; Dimitri Bertsekas on *Proximal and Temporal Difference Methods: A Bridge between Numerical Convex Analysis and Approximate Dynamic Programming*; Cole Smith on *Next-generation Network Interdiction Algorithms*; and Andrew Schaefer on *Markov Decision Processes in Healthcare*.

A session was organized to discuss new developments for the INFORMS Journal on Computing (IJOC), which was particularly useful for researchers intending to publish or have published in the Journal. The Conference Program is available at http://easychair.org/smart-program/ICS2017/index.html.

TUTORIAL

Chance constrained optimization

Tutorial Lecture delivered by author during the CLAIO 2016 meeting held in Santiago, Chile.

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Laboratoire de Recherche en Informatique (LRI) at the Université Paris Sud.

We consider the following stochastic linear optimization problem:

$$\min \sum_{j=1}^{n} c_j x_j \quad \text{subject to} \quad \sum_{j=1}^{n} \xi_{kj} x_j \leq b_k,\ k = 1, \ldots, m,\ x \in X, \tag{1}$$

where $X \subset \mathbb{R}^n$ is a deterministic closed convex set, c_j, ξ_{ij} and b_i are random parameters. Without loss of generality, we assume that the vectors $c \in \mathbb{R}^n, b \in \mathbb{R}^m$ are deterministic vectors, and $\Xi = (\xi_1, \ldots, \xi_m)^T \in \mathbb{R}^{m \times n}$ is a random matrix. Chance constrained optimization can be used to solve problems involving chance constraints, i.e., constraints with a finite probability $p \in [0; 1]$ of being violated. We assume that Ξ is a random matrix with a known distribution. The linear chance-constrained problem with random matrix can be stated as follows:

$$\min \sum_{j=1}^{n} c_j x_j \quad \text{subject to} \quad \mathbb{P}\{\sum_{j=1}^{n} \xi_{kj} x_j \leq b_k,\ k = 1, \ldots, m\} \geq p,\ x \in X. \tag{2}$$

The chance constraints of problem (2) are called joint chance constraints while they are called individual chance constraint when there is a single constraint under the probability, i. e., $m = 1$. We call hereafter these two problems (JCC) and (ICC) respectively. Denote $X(p)$ the feasible set of (2), i.e.,

$$X(p) := \{x \in X \mid \mathbb{P}\{\sum_{j=1}^{n} \xi_{kj} x_j \leq b_k,\ k = 1, \ldots, m\} \geq p\}.$$

A key point for solving chance constraints problems is to find convex equivalent or approximate formulations of $X(p)$ suitable for both theoretical and numerical purposes.

Chance constrained optimization dates back to the fifties when a problem involving chance constraints was formulated by Charnes et al. [1958]. Since these pioneering results, it was recognized that these problems are hard to solve both from theoretical and computational points of view. van de Panne and Popp [1963] proposed a solution method for problem (2) with one single normally distributed constraint. In parallel, Kataoka [1963] studied a problem with normally distributed ICC with random right-hand side. It is well known that convexity issue is a hard topic when considering chance constrained problems which often lead to a nonconvex feasibility set. To overcome this issue, Miller and Wagner [1965] studied an (ICC) model with independent random right-hand side where the probability distribution has some specific properties. Jagannathan [1974] extended this result to the dependent case, and considered the case of random constraint matrix with normally distributed independent rows. The major contribution is due to Prékopa [1971] who introduces the notion of logarithmically concave probability measure. The reader is referred to Prékopa [1995, 2003], Chapter 5 in Ruszczyński and Shapiro [2003], Henrion [2007] and Chapter 4 of Shapiro et al. [2009] for an exhaustive study concerning convexity theory in chance constrained optimization.

We consider a special class of problems (2) where $\Xi_k, k = 1, \ldots, m$ are multivariate normally distributed independent row vectors with known mean vector $\mu_k = (\mu_{k1}, \ldots, \mu_{kn})$ and covariance matrix Σ_k. We can derive a deterministic reformulation of problem (2) as follows:

Let $\xi_k(x) := \frac{\xi_k^T x - \mu_k^T x}{\sqrt{x^T \Sigma_k x}}$ and $g_k(x) := \frac{b_k - \mu_k^T x}{\sqrt{x^T \Sigma_k x}}$. In this case, the chance constraints in problem (2) can be written as $\mathbb{P}\{g_k(x) \geq \xi_k(x),\ k = 1, \ldots, m\}$ where $\xi_k(x) \sim N(0; 1)$. If $k = 1$, then the (ICC) feasibility set can be written as

$$X_1(p) = \left\{ x \in X \mid {\mu_1}^T x + F^{-1}(p)\sqrt{x^T \Sigma_1 x} \leq b_1 \right\}$$

where F is the cumulative density function of the normal distribution. Notice that the constraint of $X_1(p)$ is called Second Order Cone Programming constraint (SOCP for short). In this case $X_1(p)$ is a convex set, and the related chance constrained problem can be solved efficiently using interior point methods. It is well known that (JCC) model is more robust than (ICC) one, and therefore more interesting to model the risk in a chance constrained formulation, see for instance Cheng and Lisser [2012] and Liu et al. [2016] for a comparative study. However, solving (JCC) problems is more complicated than (ICC) as the corresponding problem is generally not convex. Cheng and Lisser [2012] proposed tight relaxations for solving (JCC) by introducing auxiliary variables y_k when the matrix vectors are independent and normally distributed. In this case, the feasibility set can be reformulated as follows:

$$X_2(p) = \left\{ x \in X \mid \exists y_k \geq 0,\ \sum_{k=1}^{m} y_k = 1 : {\mu_k}^T x + F^{-1}\left(p^{y_k}\right)\sqrt{x^T \Sigma_k x} \leq b_k,\ k = 1, \ldots, m \right\}$$

We can see that $X_2(p)$ is a bi-convex problem and its constraints are not SOCP. However, it and can be reformulated using piecewise linear/tangent approximations, see Cheng and Lisser [2012] for more details.

When the Ξ matrix vectors are dependent, the notion of copula can be used to capture their dependency structure. We refer to the book of Nelsen [2006] for a complete introduction to the theory of copula. Cheng et al. [2014] derived a deterministic reformulation of problem (2) using Archimedean copulas. In this case, $X(p)$ can be written as:

$$X_3(p) = \left\{ x \in X \mid \exists y_k \geq 0,\ \sum_{k=1}^{m} y_k = 1 : {\mu_k}^T x + F^{-1}\left(\psi^{-1}(y_k \psi(p))\right)\sqrt{x^T \Sigma_k x} \leq b_k,\ k = 1, \ldots, m \right\}$$

where ψ is the generator of an Archimedean copula describing the dependence properties of the rows of the matrix Ξ. We can notice that $X_3(p)$ is also a bi-convex problem which can also be reformulated using piecewise linear/tangent approximations, see Cheng et al. [2014] for more details. It is easy to see that $X_2(p)$ and $X_3(p)$ have almost a similar structure in terms of the constraints which are not SOCP. The aforementioned reformulations allow to transform them into SOCP like problems, and hence to solve the corresponding relaxations efficiently.

Chance constrained optimization has been widely used successfully for solving industrial problems with uncertain parameters, e.g., Andrieu et al. [2010] studied a model for dynamic (JCC) applied to a water reservoir management. van Ackooij et al. [2014] considered (JCC) for hydro reservoir management. Water quality management problems were considered by Takyi and Lence [1999]. Several papers were dedicated to risk measures, amongst all Ruszczyński and Shapiro [2006] and Shapiro [2008]. Recently, Singh et al. [2016] studied chance constraints in stochastic game theory.

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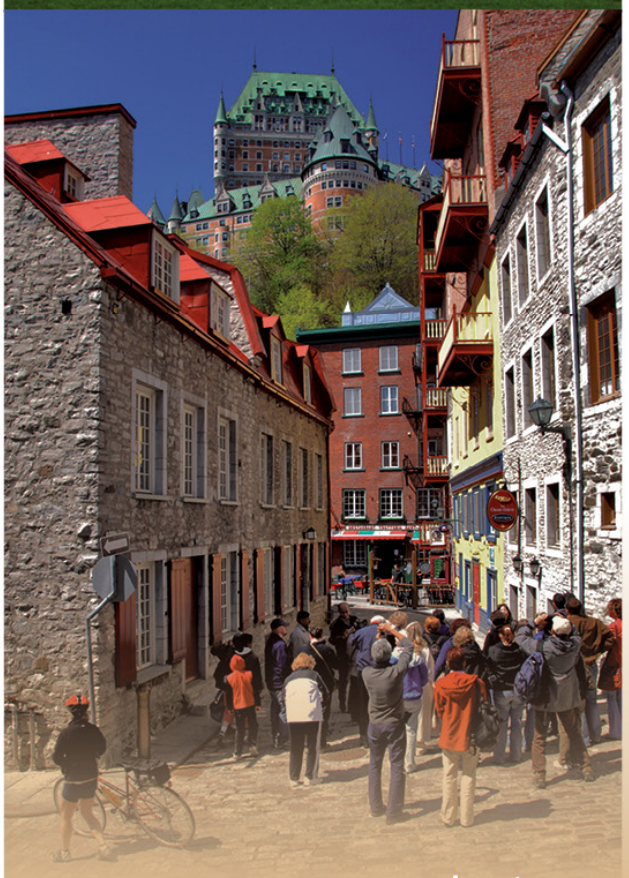

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