orbit

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On optimal proportional representation • Digitalisation of Integrated Logistics Chain in Roll-on/Roll-off Shipping • Solving a Rubik's cube in fewest possible moves • Science Junkies & Junk Science (...)

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Editor

Dear Reader,

It has been some rough months since the lockdown due to the Corona virus and I hope that this edition of ORBit finds all members of DORS in good health and spirit.

New experiences with online meetings, online teaching, and home schooling surely were not easy to go through, so I hope that this edition of ORBit relaxes a bit your mind and gives some nice memories of, e.g., the DORS company visit provided by Alexander Krogsgaard, and some fruit for thoughts on how to distribute mandates in parliament with respect to votes given to parties in democratic elections presented by Kaj Holmberg. Moreover, a lot of things have happend also at SOAF. Information about these are provided by the new president of SOAF, Mattias Grönkvist including an article about the SOAF annual meeting.
Insights into maritime shipping provided by Beizhen Jia. The ECOPRODIGI project deals with the digitization for RoRo-shipping enabling an integrated supply chain which becomes more and more important in the light of information handling and management.
Who has not played with the Rubik's cube at a certain point in lifetime and, maybe, got mad with solving it (as, e.g., me)? Jonas Ehlers Nilsson shows how operations research can support us in solving it.
Last, but not least, Michael Patriksson let us participate in some reflections on the ways how scientific work has changed with digitization and reminds us that "the old ways" had their merits.

Together with the manifest of Nelson Maculan that reminds us that our work with operations research methods matter, I wish you all a good reading!

Best, Julia Pahl (Editor)

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Svenska operationsanalysföreningen

Även i dessa speciella tider är det vissa saker som trots allt inte förändras. En sådan sak är att SOAF lite då och då byter ordförande, och nu har det blivit dags för mig, Mattias Grönkvist, att ta över SOAFs ordförandeklubba. Jag arbetar till vardags med tillämpad operationsanalys inom flygindustrin på Boeing i Göteborg (tidigare Jeppesen, och innan det Carmen Systems), och jag har tidigare varit vice ordförande och även Orbit-ansvarig inom SOAF. Som vi alla har märkt genomlever vi just nu en unik tid, där världen i skrivande stund står inför en hälsokris vars omfattning vi aldrig har upplevt i modern tid och som vi ännu inte vet hur den kommer att sluta. Vissa av oss drabbas direkt genom faktisk virussmitta, medan flertalet förhoppningsvis mest drabbas av förändringar i arbetsförhållanden. Min egen bransch, flygindustrin, står inför en närmast existentiell kris där dramatiska åtgärder kommer att krävas för att undvika, eller iallafall minimera effekterna av, en massiv kris.

En liten ljusglimt i mörkret för oss som operationsanalytiker är att det i denna kris kommer att krävas nya lösningar för planering och schemaläggning av såväl krisande kommersiella verksamheter som sjukvård, så förhoppningsvis kan våra expertkunskaper inom dessa områden komma till användning under de kommande veckorna och månaderna! Förhoppningsvis kan en kombination av forskningsinsatser inom olika områden som medicin, artificiell intelligens, logistik och operationsanalys ta oss igenom den här krisen och ge oss en ljusnande framtid.

Jag skulle vilja avsluta med att tacka SOAFs avgående ordförande Elina Rönnberg, som har gjort storartade insatser under sina år som ordförande, inte minst genom flera lyckosamma konferenser och nya aktiviteter för doktorander! Tack Elina, och lycka till med dina nya uppdrag!

Ta hand om er, och låt oss hjälpas åt att tillsammans ta oss igenom denna prövande tid!

Mattias Grönkvist, Ordförande, SOAF

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Aktuellt om SOAF

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By Alexander Krogsgaard

DORS Company Visit

Back in October 2019 DORS teamed up with Trapeze and Qampo to hold the annual company visit. This turned out to be quite a success, as Trapeze and Qampo had done an excellent job of promoting the event. With more than 50 attendees, this was probably one of the largest company visits DORS have held.

Figure 1: Anders Kühnaue, chairman of Region Midtjylland, presenting the political aspects of public transport

The topic of the company visit was public transport and how operations research and decision science can support this area. After everyone had grabbed a cup of coffee, the political aspects of public transport was introduced by Anders Kühnaue who is the chairman of Region Midtjylland.

Both Trapeze and Qampo work extensively within the field of public transport, and in incorporating Operations Research into it in various ways.

Trapeze works with delivering intelligent software solutions in all aspects of the public transport sector. From tendering of traffic contracts, to planning school and on-demand transport, all the way to the dispatching of busses and taxis.

Qampo is a decision science and mathematical consultancy company that has helped many customers including Trapeze and other actors in the public transport sector. They use all the tools in the operations research toolkit including mathematical modelling, machine learning and artificial intelligence.

With the stage set around public transport, Jørgen Haahr from Qampo began the presentations by telling us about his research on train delays using artificial intelligence. Jørgen and his co-researchers from the Technical University of Denmark with this research in fact won the INFORMS Rail Problem Competition, by being able to predict train delays in the Dutch train system by up to 20 minutes.

Following up was Jørgens colleague Shyam Sundar who gave a presentation on his research on holistic bus planning, combining the bus routing and the driver scheduling problem into one. Shyam also found that in a time of electrical vehicles being more and more in demand, his work could help bus companies and municipalities decide on a strategy for acquiring electrical busses and incorporate them into their schedules and operations.

Figure 2: Ali Khatam presenting the four experts that gave the talks of the day

Thirdly, Christian Erikstrup from Trapeze presented their work on optimizing flexible transport services. The idea of flexible transport services is to have more of a demand driven taxi-like transport system, rather than regular fixed bus schedules.

Figure 3 : All of the talks engaged the audience and gave way for discussions and questions

Fixed routing and schedules for busses is ideal in densely populated cities with high demand. However these fixed schedules fall short in more rural areas, where there is not enough demand to justify hourly services. For flexible transport services to work well it is important to plan and optimize the routing dynamically as demand changes continually over time, based on customer requests.

The final talk was held by Kasper Sørensen, also from Trapeze. Compared to the other talks Kasper presented another perspective revolving around the usability and UX of decision support tools, rather than mathematical modeling and optimization. Personally I find that this topic is often overlooked within Operations Research. Oftentimes however, usability is a crucial part of promoting decision science and letting end users interact with the complicated optimization algorithms created by experts.

After these four exciting and inspiring talks, the evening was rounded out with some beers, soda, pizza and a lot of networking. As always many were eager to follow up and discuss the various topics presented. Especially the political aspects of how Operations Research plays a part in the future of public transport, was of great interest to many. Time flew with these interesting discussions, until it was time for me to head the long way back home from Aarhus to Copenhagen. With public transport - of course.

Alexander Krogsgaard is a board member of DORS and works as a Optimization Specialist in Portchain. He has a MSc degree in Transportation and Logistics from DTU, with a focus on Operations Research and Business Logistics.

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By Kaj Holmberg

On optimal proportional representation

Abstract

In a democratic proportional election system, it is vital that the mandates in the parliament are allocated as proportionally as possible to the number of votes the parties got in the election. We formulate an optimization model for allocation of seats in a parliament so as to minimize the disproportionality. By applying separable programming techniques, we obtain an easily solvable problem, and present a method for solving it optimally. We get the solution with minimal disproportionality, even in the presence of a parliament threshold. We apply the approach to real life data from the last three elections in Sweden, and show that the result is better, i.e. more proportional, than what was obtained with the modified Sainte-Laguë method, which is presently used.

1. Introduction

Have you ever thought about what happens at an election? More precisely after all the votes are cast and before the result is announced. They count the votes, see how many votes each party got, and then the result is ready, right? Wrong, it is not that easy. There is some Integer Programming needed here. In the election 2018 in Sweden, there was 6,476,725 valid votes but only 349 seats in the parliament. That in average gives 18,557 votes for one mandate. One vote in average means 0.0000538 mandates. If we divide the number of votes each party got with the total number of votes, we get the perfect proportions, "the will of the people", and of course the proportions in the parliament should be equal to those numbers. But it might not be possible because of the integrality of the mandates.

Consider an election with n parties. Each voter votes for one party, and the mandates in the parliament should be allocated proportionally to the votes. Let p denote the total number of votes and m the total number of mandates in the parliament. We can calculate $d=m/p$ (the number of mandates per vote) and $1/d$ (the number of votes per mandate). Let r_j specify how many votes party j received in the election (so $p=\sum_j r_j$). What needs to be decided is x_j, the number of mandates party j will obtain.

A solution with perfect proportionality would be $x_j=dr_j$ for all j. Then the proportions of the mandates would coincide exactly with the proportions of the votes. However, dr are seldom integral. Then we need to find an integer solution x that lies "as close as possible" to dr. We need a measure to compare the solutions with, and must find the solution that minimizes the "disproportionality". This gives an optimization problem, a nonlinear integer programming problem. But surely it has been solved? Isn't that done after every election? And has been done for many years? No, unfortunately not. But it can be done, and I will show you how.

All (democratic) countries have their own procedures for mandate allocation. I have not found two that are identical. A common feature is that they are all basically very old, more than 100 years old. There has been adjustments, modifications and changes of parameters, but the basic old methods are still used. If you read Swedish, I recommend the very extensive work [4], which covers most mathematical aspects of proportional election systems, and has a very comprehensive reference list.

In Sweden today, the mandates are distributed according to the modified Sainte-Laguë method (in Swedish: "den jämkade uddatalsmetoden"). I will here propose a method that gives better solutions, in the sense of least square distance. A main aspect here is that the knowledge of integer optimization has advanced a bit the last 100 years. So maybe it is time to update the old procedures. By the way, I'm not saying that all the old methods are bad, most of the are actually rather good. But why settle with "rather good" when you can get the best?

This article is a much shortened (and somewhat popularized) version of the paper [3]. It is mainly aimed at Swedish circumstances, but will hopefully be of interest in other countries with similar systems. In this paper we ignore constituencies, i.e. see all of the country as one constituency. The question about constituencies is treated in [3], where also more references can be found.

2. OPTIMIZATION

2.1 Measures

Which measure should we use when deciding which integer solution *x* lies "closest" to *dr*? In [2], [1] and [5] several such measures are compared. One measure is the Loosemore-Hanby index, [6], where the target function is $f(x) = \sum_{j=1}^{n} |x_j - dr_j|$ (We will use the notation LH-index). Another measure, in [2] called the Least Square index, but later called the Gallagher index, is √*(v/2)* where $v = \sum_{j=1}^{n} (x_j - dr_j)^2$ (We will use the notation G-index.) In a third measure, the Sainte-Laguë index, the terms are weighted with the proportion of votes, $f(x) = \sum_{j=1}^{n} (x_j - dr_j)^2 / r_j$ (We will use the notation SL- index.) One could also use any *p*-norm, even the max-norm.

We could use any measure with the following properties:

1. If *dr* is integer, the solution *x=dr* should give perfect proportionality, i.e. index value zero.

2. The function should be separable in *j*. Moving a mandate between two parties should not affect a third party.

3. The function should be convex. Increasing the deviation from dr_j should always give a marginal increase of the cost.

Which measure is best? Here different opinions are given in the literature. Let us now give our reasoning.

4. We prefer a strictly convex function, since it has better controllability. A function where many different solutions have the same value is not good. This is satisfied by all measures except the LH-index and the max-norm. Our computational tests with the LH-index will illustrate this.

5. A certain deviation should have the same measure regardless if it is a vote for a small party or a large party. This is satisfied by all measures except the SL-index, for which a certain deviation for a smaller party gives a larger measure than for a larger party. The system should be designed to treat all votes equally.

When it comes to forming government, several parties usually need to collaborate. If a small and a large party are collaborating and we only consider the sum of their mandates, one mandate more or less for the large party has the same effect as one mandate more or less for the small party, and should therefore have the same measure.

Our conclusion is therefore that the G-index is the most relevant measure of the deviations. An added plus is the well-known interpretation as a distance, which one often has in mind when saying the something should be "close" to something. The LH- and SL-indices have certain disadvantages that don't make them our first choice. However, any of these measures can actually be used in our model and in our method. An important aspect of this paper is that it gives a framework for finding optimal proportional representations, for any separable, convex function.

2.2 An optimization model

The integer solution that lies as close as possible to perfect proportionality in a least square meaning is the solution of the following optimization problem.

$$
\begin{aligned}
&\text{(P1)} \qquad \min \quad f(x) = \sum_{j=1}^{n} (x_j - dr_j)^2 \\
&\qquad\qquad \text{s.t.} \quad \sum_{j=1}^{n} x_j = m \qquad (1) \\
&\qquad\qquad\qquad x_j \geq 0, \text{integer} \qquad j = 1, \dots, n
\end{aligned}
$$

One could also use any of the other measures in the objective function.

2.3 A threshold

Often there is an explicit parliament threshold, i.e. a lower proportional limit, *l*, for a party to get any mandates at all. If a party gets less than *lp* votes, the party gets no mandates. In Sweden, *l=0.04*, i.e. if a party gets less than 4% of the votes, the party gets no mandates. Convergence proofs for older methods generally do not include thresholds.

It is clear that $x_j=dr_j$ is the optimal solution of the continuous relaxation of P1, if there is no lower threshold. With the help of the KKT conditions, one can show the following for the optimal continuous solution with a threshold. (For details, see [3].) Let $J = \{j : r_j \geq lp\}$ i.e. J is the set of parties that do not fall below the threshold. We then get x_j=0 for $j \notin J$, and $x_j = dr_j + \delta$ for $j \in J$ i.e. all values for the remaining variables will be increased by the same amount, *δ*, so that the sum becomes equal to *m*.

Doing the same using the SL-index yields $x_j = \delta dr_j$, i.e. all values for the remaining variables will be multiplied by the same amount, σ, so that the sum becomes equal to *m*.

We note the significant difference that using the G-index, there is a common additive adjustment of the values, while using the SL-index there is a common multiplicative adjustment. In other words, the G-index leads to changes in absolute values while the SL-index leads to changes in relative values.

3. THE PRESENT METHOD IN SWEDEN

In Sweden, the mandates are distributed according to "the adjusted odd number method" (my own translation of the Swedish name "jämkade uddatalsmetoden"), presented in Algorithm 1. It is specified in legal text, namely chapter 14, paragraph 3, in Sweden's election law. It can also be called the modified Sainte-Laguë method or the modified Webster/Sainte-Laguë method. The (unmodified) Sainte-Laguë method was proposed 1910 by Sainte-Laguë. In 1832 Webster proposed a method that yields the same result, although it was described differently.

The method has also been used in Denmark, Norway, Bosnia-Herzegovina, Iraq, Kosovo, Latvia, New Zealand and Nepal. It can be described as follows.

One works with values, v_j, for each party, and allocates mandates one at a time to the party that has the highest value. Then one divides the party's value with the next odd number, and repeats this. The values are initially set equal to *r*, the number of votes the party got.

The adjustment/modification is to divide the initial values of *v* by a certain coefficient. In the election in Sweden 2018, the coefficient was 1.2, but before that 1.4. The effect of the adjustment is that the first mandate for each party is somewhat delayed, so it gives a disadvantage for smaller parties.

Algorithm 1 The adjusted odd number method

1: Set $\hat{m} = 0$, $s_j = 0$ for all j, and calculate $v_j = r_j/1.2$ for all j.
2: **while** $\hat{m} < m$ **do**
3: Find $t = \arg\max_{j \in J} v_j$.
4: Set $s_t = s_t + 1$, and $\hat{m} = \hat{m} + 1$.
5: Calculate $v_t = r_t/(2s_t + 1)$.

Empirically, this method appears to give quite good proportionality. One can show that it minimizes the Sainte-Laguë index. However, the proof of this does not include the adjusted factor 1.2, or a threshold.

In another method, called d'Hondt's method, step 4 is replaced by $v_t = r_t/(s_t+1)$, i.e. division is made with the next integer, not the next odd integer. In Sweden this method is used in elections conducted by a city council, municipal council or municipal board of directors. The method is said to favor large parties.

A technique occasionally used to avoid the disadvantages for smaller parties is electoral cooperation, where two different parties sum up their votes and are counted as one. Obviously this may make it possible to avoid the threshold, and also to avoid effects of the initial factor 1.2. Furthermore, it changes the sizes of parties, so that a small party becomes (a part of) a large party. This has effect on the SL-index, since a large and a small party are treated differently. For the G-index, there is no such difference.

4. SOLVING THE INTEGER PROBLEM

Let us now address the integer problem P1, and let us (as a notational simplification) assume that there are no parties with less than *lp* votes. The objective function is convex and additively separable in *j*, so we can introduce a piecewise linearization of the non-linear objective function $f_j(x) = (x_j - dr_j)^2$. Since the variables must take integer values, this linearization becomes exact if it has the correct values in all integer points. In Figure 1 we show the piecewise linearization.

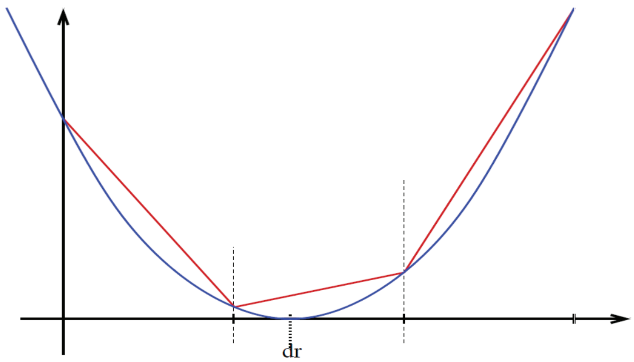

Figure 1: Piecewise linearization of the objective function of P1-G

We can calculate coefficients representing the slope of the objective function between two adjacent integer points by the following expression, for each *j* and $k = 1, \ldots, m$.

$$c_{jk} = f_j(k) - f_j(k-1) = 2(k - dr_j) - 1$$

Now we replace x_j by $\sum_k x_{jk}$, where the binary variable x_{jk} is the part of x_j that lies in the interval *[k-1,k]*. We get a linear integer optimization problem, which gives the same optimal solution as P1 (with $x_j = \sum_k x_{jk}$). The number of variables is mn. The extreme points of the feasible set of the LP-relaxation are integer, so we can drop the integrality requirements, and solve the following LP-problem.

$$\text{(P2)} \qquad \min \quad f(x) = \sum_{j=1}^{n}\sum_{k=1}^{m} c_{jk}x_{jk}$$

$$\text{s.t.} \qquad \sum_{j=1}^{n}\sum_{k=1}^{m} x_{jk} = m \qquad (2)$$

$$0 \le x_{jk} \le 1, \qquad j = 1, \dots, n, \;\; k = 1, \dots, m$$

In [3] we derive the following method, given in Algorithm 2, based on a well known greedy algorithm that optimally solves continuous knapsack problems. A lower threshold *l* is simply taken care of by not allowing any mandates to parties with less votes than this, $j \notin J$. This method gives the optimal solution, i.e. the feasible solution with the minimal disproportionality, in P2 and P1.

Algorithm 2 Exact mandate allocation

Set $\hat{m} = 0$, $s_j = 0$ for all j, and calculate $v_j = 1 - 2dr_j$ for all $j \in J$.
while $\hat{m} < m$ **do**
    Find $t = \arg\min_{j \in J} v_j$.
    Set $s_t = s_t + 1$, and $\hat{m} = \hat{m} + 1$.
    Calculate $v_t = 2(s_t - dr_t) + 1$.

In each iteration, one new mandate is handed out, and the question is which party shall get it. For each party we calculate the change in disproportionality (the cost function) if it was given the mandate. As long as x_j is less than dr_j, this cost is actually a gain, i.e. a negative coefficient, and in each iteration the mandate is given to the party that gives the maximal decrease of the disproportionality.

In [3] we verify that the solution obtained by the algorithm is optimal, with the help of LP-duality. This proof holds for any *c* that is convex in *k* (i.e. for any of the previously discussed measures), and a threshold is included in the proof.

Traditional methods for allocating mandates can be classified as "largest average methods" ("divisor methods") or "largest remainder methods", where the Sainte-Laguë method and d'Hondt's method are divisor methods. In for example [4], many properties of these classes of methods are given. An example of a largest remainder method is Hamilton's or Hare's method (1860). The initial allocation of mandates is simply $s_j = |dr_j|$ (i.e. the continuous solution rounded down) and then the additional mandates are allocated one by one to the party with largest fraction, $s_j - |dr_j|$, until *m* mandates have been allocated. If there is no threshold, Algorithm 2 can be shown to give the same solution as Hamilton's method. However, if there is a threshold, our method and Hamilton's method may give different solutions, and our computational tests reveal big such differences.

An advantage of this approach is that we can easily change the objective function. We can use the G-index, as we have done, or the SL-index, or even the LH-index, as objective function. The effect is only that the coefficients *c* and values *v* are calculated differently. If we believe that several of the measures have merit, we can actually combine them.

A (mostly theoretical) question is what to do if the minimizer in an iteration is not unique. If two parties get exactly the same number of votes, there is no way to distinguish between them. In that case they should preferably get the same number of mandates. If that is not possible, there is no other option but to use a random allocation of the final mandate.

However, it is possible that the minimal value v_j in an iteration is not unique, even though the number of votes are different. In the method presently used in Sweden, it is stated that randomness should be used in each case the choice is not unique. We here suggest another possibility, with a better mathematical motivation.

In [3] we show how a type of lexicographic ordering is obtained by using the G-index plus ε times the SL-index. The value of ε does not matter, and the method is as follows. Use Algorithm 2 as long as the minimizer is unique. If the minimizer is not unique, give the mandate to the party that has the highest number of votes (of those that gave the minimal v_j). This gives the optimal solution to the problem with the G-index plus ε times the SL-index as objective function.

Giving the mandate to the party with highest number of votes is a natural thing to do. This idea (but together with another basic algorithm) has been used in Norway, Belgium and Luxembourg, according to [4]. Here, however, we have a good mathematical motivation for doing this.

5. COMPUTATIONAL RESULTS

5.1 Implementation

The algorithms are implemented in Python. We have implemented our method, Algorithm 2, denoted by KH (for lack of a better name), the modified Sainte-Laguë method, Algorithm 1, denoted by mSL, (used for example in Sweden and Norway), d'Hondt's method, denoted by dHo, (used for example in Finland, Belgium, Iceland, Israel, Netherlands, Spain and Austria), Hamilton's method, denoted by Ha (used for example in Italy, Greece, Latvia, Denmark, Bulgaria and Cyprus), and Droop's method without rounding, denoted by

Dr, which is similar to Hamilton's method, but with *d=(m+1)/p* instead of *m/p*, (used for example in Slovakia). The code can be obtained by contacting the author at kaj.holmberg@liu.se.

5.2 Small real life instances

In [1] numerical examples from two Hungarian cities are described. In the first *r=[397,394,285,224,209,172,136]* and *m=7*. Here KH, mSL, Ha and Dr all give the solution *[2, 1, 1, 1, 1, 1, 0]* with G-index 0.687, while dHo gives a worse solution. In the paper [1] the Sainte-Laguë method is said to give the solution of one mandate to each party, which is said to be a better solution (i.e. less least squares disproportionality). However, when we test that solution, we get G-index 0.691, which is worse than the above. On the other hand, the SL-index is lower for that solution than for our solution.

Results for the second instance are reported in Table 1. (The SL-index is multiplied with 100 to improve readability.) Here we find that KH and Ha give the best solutions (least G-index, 0.523), while the other methods give worse (G- index 0.794). An interesting fact here is that mSL gives a worse SL-index than KH, which might seem contradictory. It turns out that in this case it is the modification of the SL-method that is bad. Without the modification, (m)SL gives the same solution as KH.

	r_j	dr_j	KH	mSL	dHo	Ha	Dr
A	2371	5.18	5	6	6	5	6
B	1274	2.78	3	3	3	3	3
C	245	0.53	1	0	0	1	0
D	230	0.50	0	0	0	0	0
G			0.52	0.79	0.79	0.52	0.79
SL			0.20	0.26	0.26	0.20	0.26
LH			0.68	1.04	1.04	0.68	1.04

Table 1: Mandates for the second Hungarian instance.

5.3 Sweden

In our main computational tests we have used the data from the three last elections in Sweden, see Tables 2, 3 and 4 for the number of votes and mandates, and Table 5 for the disproportionality indices. The data is retrieved directly from the Election Authority's website ("Valmyndigheten" in Swedish) for the whole nation. In these runs we use *l=0.04* and *m=349*, as is the case in reality. The last row, named "Others" is the sum of all minor parties.

The results from Algorithm 1 are not identical to the final real life allocations, due to some deficiencies in the allocation of compensatory mandates. Our main goal is to compare the algorithms, but we also give the actual mandate allocation in the last column, under Res.

Party	r_j	dr_j	KH	mSL	dHo	Ha	Dr	Res
M	1791766	104.91	106	106	107	107	107	107
C	390804	22.88	23	23	23	23	23	23
FP	420524	24.62	25	25	25	25	25	24
KD	33369	19.54	20	20	19	20	20	19
S	1827497	107.00	108	109	109	108	108	112
V	334053	19.56	20	20	20	20	20	19
MP	437435	25.61	26	26	26	26	26	25
SD	339610	19.88	21	20	20	20	20	20
Others	85023	4.98	0	0	0	0	0	

Table 2: Votes and mandates for the 2010 election in Sweden.

Party	r_j	dr_j	KH	mSL	dHo	Ha	Dr	Res
M	1453517	81.40	83	85	85	93	92	84
C	380937	21.33	23	22	22	22	22	22
FP	337773	18.92	21	20	19	19	19	19
KD	284806	15.95	18	17	16	16	16	16
S	1932711	108.24	110	112	114	109	109	113
V	356331	19.96	22	21	21	20	21	21
MP	429275	24.04	26	25	25	25	25	25
SD	801178	44.87	46	47	47	45	45	49
FI	194719	10.90	0	0	0	0	0	0
Others	60326	3.38	0	0	0	0	0	0

Table 3: Votes and mandates for the 2014 election in Sweden.

Party	r_j	dr_j	KH	mSL	dHo	Ha	Dr	Res
M	1284698	69.22	70	70	71	70	70	70
C	557500	30.04	31	31	30	31	31	31
L	355546	19.16	20	20	19	20	20	20
KD	409478	22.06	23	22	22	23	23	22
S	1830386	98.63	99	100	101	99	99	100
V	518454	27.94	28	28	28	28	28	28
MP	285899	15.40	16	16	15	16	16	16
SD	1135627	61.19	62	62	63	62	62	62
FI	29665	1.60	0	0	0	0	0	0
Others	69472	3.74	0	0	0	0	0	0

Table 4: Votes and mandates for the 2018 election in Sweden.

In all these elections, KH gives the lowest G-index. For 2010 and 2014 all other methods are worse, and for 2018, Ha and Dr are equally good. Our method is better than mSL (which is used in practice) in all cases. When it comes to the SL-index, mSL and KH give very similar results for 2010 and 2018, while for 2014 mSL yields a lower SL-index. We conclude that based on least square distance, KH would have given a more proportional mandate allocation in all the elections.

For 2018 the solution of mSL and the actual allocation are identical. For 2014, the actual result is slightly worse, and for 2010, there is a large difference, as KH gives G-index 3.802 and mSL 3.916, while the actual result gives 5.267. There were articles in newspapers claiming that the election result was flawed, and we can only agree.

The issue about political blocks is discussed much in Sweden. Traditionally there has been a left block, LB, of S and V, where MP in later years has been included. The traditional right block, RB, has been M, KD, L and C. Where to put SD has been unclear. For 2018 mSL gives the left block one more mandate than the right block, which is equal to the actual result. However, KH would give the right block one more mandate than the left block.

The point here is not to dwell on Swedish party politics, but to show that even the small differences between mSL and KH might make a important difference for the government. Our conclusion is that it is not sufficient to allocate mandates in a “rather good” way. If it is possible to do it the best way (which it is), one should do that.

5.4 The EU-election 2019

In the election for the parliament of EU, the different countries use their own systems. When the election took place 2019, Sweden had 20 seats. All the methods KH, mSL, dHo, Ha and Dr give the same result, which also was the result that was decided. However, when the United Kingdom left the EU, Sweden got one more seat. It was decided to give this mandate to MP.

Index	KH	mSL	dHo	Ha	Dr	Res
G	3.802	3.916	4.118	3.928	3.928	5.267
SL	0.298	0.296	0.298	0.296	0.296	0.311
LH	4.978	4.978	5.517	4.978	4.978	7.313
G	8.848	9.128	9.576	11.549	11.083	9.466
SL	0.860	0.835	0.838	0.896	0.884	0.844
LH	14.284	14.284	14.284	14.284	14.284	14.284
G	3.226	3.292	3.794	3.226	3.226	3.292
SL	0.296	0.295	0.297	0.296	0.296	0.295
LH	5.342	5.407	6.012	5.342	5.342	5.407

Table 5: Indices for the elections 2010, 2014 and 2018 in Sweden.

There was an article in Svenska Dagbladet 2020-02-16 claiming that this was a result of a “manipulated system”, and that the mandate should have gone to V. The article argues that the Swedish election system should be changed in order for the Swedish population not to loose confidence in the system.

Running the code with $m = 21$ gives the following results. dr increases for all parties, for V from 1.36 to 1.43 and for MP from 2.30 to 2.42. We also find that mSL indeed gives the additional mandate to MP, while KH gives the additional mandate to V. Using the SL-metric it seems that 2.42 is closer to 3 than 1.43 is to 2, while using an ordinary distance, as KH does, it is of course the other way around. We must agree with the newspaper article. Why settle for a solution with G-index 0.711, when there is one with G-index 0.705?

6. CONCLUSION

We propose a new method for allocating mandates after an election. Tests show that our new method often produces solutions with better proportionality than the one presently used, measure by least square distance. The method correctly solves a relevant optimization problem, can optimally handle a parliament threshold, and allows different objective functions. Previously different measures required different methods, and for many variations of the methods, it is unclear which optimization problem the method actually solves, if any.

A final question for the future: Does the paragraphs in the election law have to include a detailed algorithm? Or could it refer to the optimal solution of a well specified optimization problem? If the answer to the first question is yes, we can abandone all hope of optimal solutions for more complicated problems, such as constituencies with lower bounds. It can be solved as a rather easy LP-problem, but not by a greedy type of algorithm. I can’t see the Swedish election law describing the simplex method.

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By Mattias Grönkvist

SOAF årsmöte

Den 26 februari höll Svenska Operationsanalysföreningen sitt årsmöte med tillhörande OA-föredrag på Institutionen för Matematiska Vetenskaper vid Chalmers Tekniska Högskola i Göteborg. Årsmötesdagen inleddes med lunch på Chalmers Kårhus, och därefter hälsade Elina Rönnberg, avgående SOAF-ordförande, deltagarna välkomna till mötet. Därefter följde tre intressanta tekniska föredrag, och först ut var Karin Thörnblad från GKN Aerospace Engine Systems med presentationen Flexible Job Shop Scheduling – from research to industrialization. Karin beskrev modeller för schemaläggning av verkstäder, och talade med stor insikt om de utmaningar som ofta möter industriella OA-tillämpningar, såsom kamp för budget, internpolitik och ägarbyten.

Därefter var det dags för ytterligare en presentation med industriell bakgrund, som skulle ha getts av Maria Taljegård från avdelningen för Energiteknik vid Institutionen för Rymd-, geo- och miljövetenskap vid Chalmers Tekniska Högskola. Tyvärr blev Maria kallad till Bryssel för ett projektmöte med kort varsel, och hennes föredrag, med titeln Modeling of Electric Vehicles in Electrical Systems, presenterades istället av Caroline Granfeldt från Institutionen för Matematiska Vetenskaper vid Chalmers. Caroline berättade om den intressanta tillämpning där elektriska fordon kan användas som energikällor för att planera ett optimalt energisystem. I den optimeringsmodell som presenterades tog man hänsyn till individuella krav på batterinivåer för att kunna använda fordonen vid de tidpunkter de behövs för transport, samtidigt som man kan använda deras batteri för att bidra med energi vid andra tidpunkter!

Sist ut av de tekniska föredragen var Professor Mikael Patriksson från Institutionen för Matematiska Vetenskaper vid Chalmers med sitt föredrag Science junkies & junk science, Reflections from a very distant past –30 years of research and teaching. Professor Patriksson bidrog med en uppskattad personlig reflektion på vedermödorna med att publicera, läsa och granska akademisk litteratur.

Figure 1: Årets exjobbspristagare Linnea Ingmar och exjobbspriskommitténs ordförande Per Enqvist.

Efter de tekniska föredragen var det i vanlig ordning dags att dela ut SOAFs exjobbspris. Ordföranden för SOAFs exjobbskommitté Per Enqvist meddelade att årets exjobbspris tilldelas Linnea Ingmar, för hennes uppsats Modelling diversity of solutions. Examensarbetet har utförts vid Uppsala Universitet i samarbete med Monash University i Melbourne, Australien. Examinator var Mats Daniels och handledare var Maria Garcia de la Banda, Peter J. Stuckey och Guido Tack vid Monash University. Exjobbskommitténs motivation till priset var

Linnea har utvecklat ett system för att ta fram flera heterogena lösningar inom MiniZinc som är ett modelleringsspråk för kombinatoriska problem. Det är en komplex och krävande frågeställning med stora praktiska tillämpningar, och hon har behövt ta sig igenom många teoretiska och praktiska utmaningar. Linnea har också tillämpat detta på fallstudier inom vattenbehandlingsanläggningar och formgivning av kemiska fabriker.

Grattis Linnea!

Efter prisutdelningen var det dags för årsmötesförhandlingar. Då den stadgeenliga mötesordföranden, valberedningens ordförande Anders Petersson, inte kunde delta vid årsmötet var det istället biträdande professor Ann-Brith Strömberg som agerade mötesordförande. I vanlig ordning gavs en verksamhetsberättelse och en ekonomisk redogörelse, den här gången av avgående SOAF-ordförande Elina Rönnberg. En delvis ny styrelse valdes in med före detta vice ordförande Mattias Grönkvist i spetsen som ny ordförande. Vi välkomnar de nya styrelseledamöterna Henrik Svärd, Nils-Hassan Quttineh och Jonas Ekblom, samtidigt som vi tackar de avgående ledamöterna Elina Rönnberg, Jonas Westin och Krisjanis Steins för deras strålande insats!

Avslutningsvis vill vi tacka Chalmers, våra presentatörer och den lokala koordinatorn Sunney Fotedar för ett väl genomfört årsmötesprogram!

Mattias Grönkvist is the president of the Swedish Operations Research Association (SOAF). He is an expert in aviation operations research, and has many years of experience developing world-leading crew and aircraft scheduling optimizers. Mattias works at Boeing Global Services in Gothenburg, Sweden.

Her kunne din artikel have været!

Send dit bidrag til orbit@dorsnet.dk

By Beizhen Jia

Digitalisation of Integrated Logistics Chain in Roll-on/Roll-off Shipping

Introduction

In Europe, Roll-on/Roll-off (RoRo) shipping provides door-to-door transport solutions to manufacturers of consumer and industrial goods. For shipping companies to remain competitive, it is critical to provide a satisfactory service level to their customers and optimize operational efficiency through a digitalized and integrated logistics chain. Sounds like a good idea - like all the other hyped words and smashy sentences, no? So how can we get life into it?

ECOPRODIGI, an EU Interreg Baltic Sea Region flagship project is tackling this problem in collaboration with industrial partners, specifically DFDS in the case described in the following [1].

Founded in 1866, DFDS has become one of Europe's largest shipping companies operating one of the largest networks of roll-on/roll-off passenger (RoPax) and ferry routes in and around Europe including their own terminals in key locations. All routes operate on fixed schedules and are strategically located to provide freight services to forwarders, haulers and manufacturers of heavy goods.

The scope of ECOPRODIGI is in line with DFDS's determination to map the end-to-end cargo stowage process in the logistics chain which includes the following sub processes in sequence of occurence:

1. Booking of cargo units
2. Gate-in of units in port
3. Positioning of units in terminal
4. Planning of stowage positioning onboard of vessel
5. Load planning/dispatching of tugs
6. Loading and lashing (if required) of cargo units
7. Planning of vessel departure, operations and arrival
8. Discharge planning/dispatching of tugs
9. Unlashing (if required) and discharging of cargo units
10. Positioning of units in terminal
11. Pick up of trailers
12. Gate-out of terminal

In the beginning of the project, meetings and workshops were organised among the different parties. The project team mapped processes, collected and analysed several sets of operational data from sample routes, terminals, and ships, such as, booking data as well as terminal and vessel operations data. Based on analysis of the current state, the project team drafted a vision for the year 2025 (Figure 1), which depicts how DFDS can operate a more eco-efficient logistics chain in the future by digitalising some of the above mentioned sub processes and integrating them through system integration and data sharing standards.

Systems integration and data sharing across applications in the logistics chain are critical prerequisites. This includes, for example, deploying identical data platforms and sharing data formats across applications for bookings, terminal operations, stowage planning and stability calculations, voyage data and performance monitoring. Good data quality is the basis for good decision support models and business intelligent analysis.

Stowage as a core sub process in the logistics chain contains a complex task that requires data from the various sources – booking data, terminal management data, cargo information, customer requirements, loading and unloading planning, ship stability and fuel consumption, etc. A well performing algorithm for stowage planning not only saves time for the work force but also allows better decision support including optimization.

OR and Data Science in Play

Operations research and data science are powerful tools to enhance performance of processes and can be applied in various areas. For that reason, the focus of the project is on those areas where they can be most beneficial, specifically for stowage optimization, dual cycling, and cargo arrival time estimation.

Stowage optimization has been well researched for container shipping. However, this is not the case in RoRo shipping. Considering the size of the ship and the amount of cargo to be planned, the possible combinations of cargo and slots just explodes, let alone considerations of stability constraints and/or optimal trim fuel consumption. It is almost impossible for a human to find an optimal stowage plan manually using spreadsheets. This is where operations research comes in to help stowage planners to make better decisions with special attention to balance ships with cargo weight instead of excess ballast water thus providing feasible stability requirements.

Dual cycling is a term used for loading and unloading of cargo operations in a simultaneous manner (see Figure 2) that helps to reduce the port stay as one of the primary goals. Traditional loading and unloading entails simply emptying all cargo in one step and then filling up the ship with new cargo afterwards. Inspired by dual cycling operations in the container shipping sector, the project investigates the potentials of formulating and solving the RoRo Dual Cycling Problem (RRDCP): Given a setting for a Ro-Ro ship including a set of cargo onboard to be discharged, a set of cargo at the yard to be loaded to certain positions onboard, and precedence constraints among

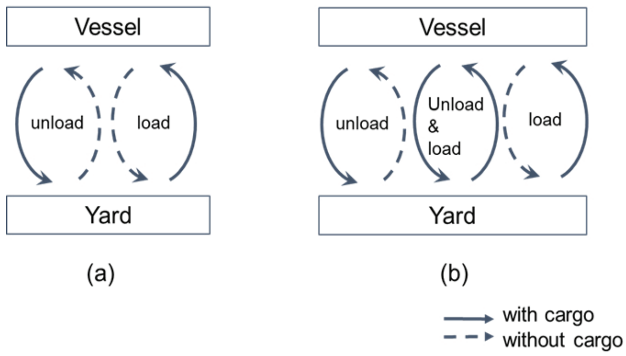

Figure 2: Dual cycling illustration

positions onboard, the objective is to minimize the total makespan of loading and unloading operations thus how much time

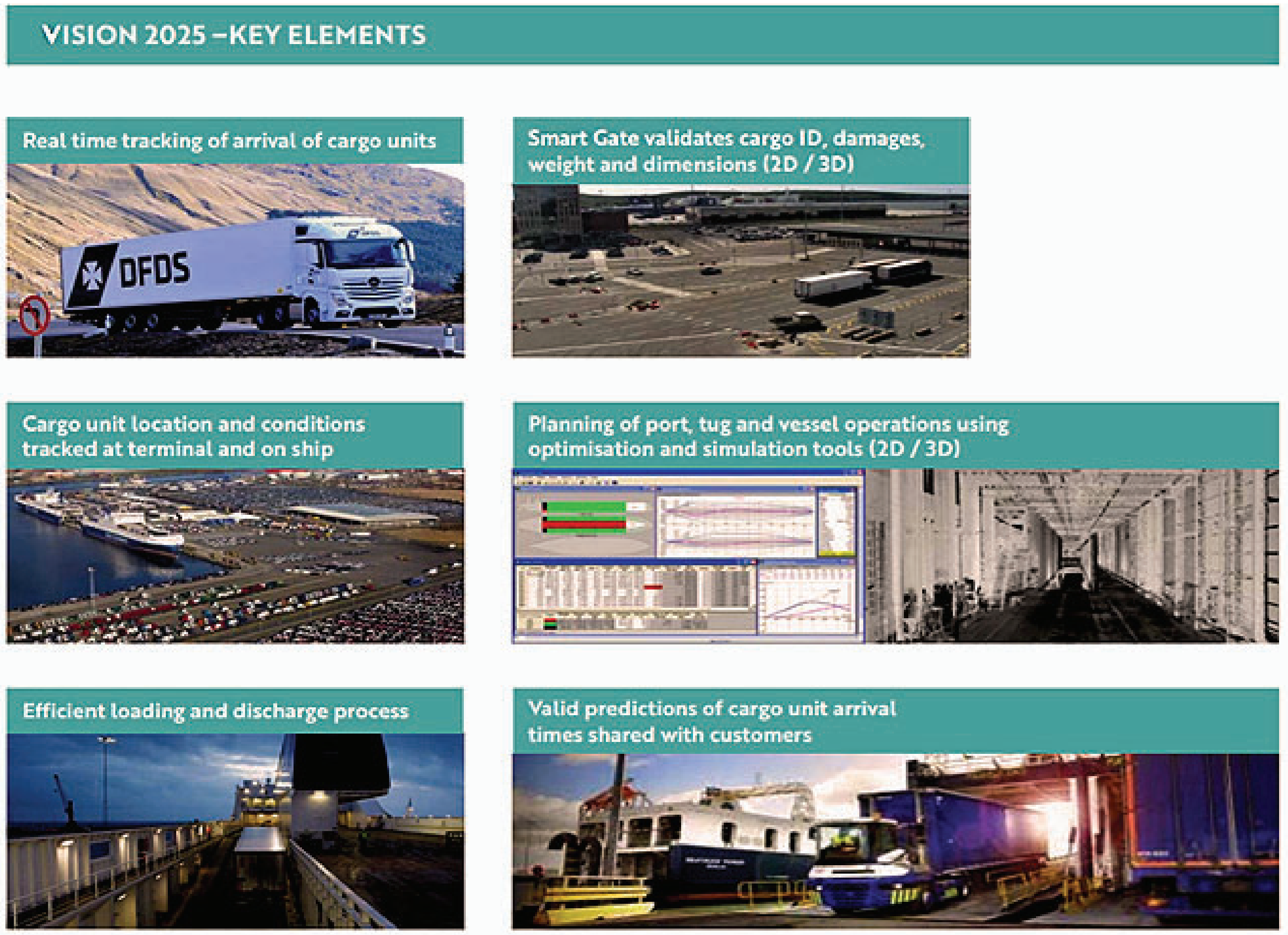

Figure 1: Vision 2025 for the end-to-end stowage process

of a vessel's port stay can be reduced by using dual cycling strategy.

The RRDCP has been firstly examined with respect to its complexity by reformulating it as an m-parallel identical machine scheduling problem for unit time jobs with arbitrary precedence constraints [3]. A MIP formulation of the problem is presented and two different strategies proposed including a greedy algorithm as a warm start to the MIP model. The result shows that the total makespan can be reduced significantly using dual cycling strategy compared to the traditional one.

Besides Operations Research methods, data science and simple statistical models are also applied in some sub processes to achieve better performance, e.g., estimating cargo arrival time. A simple framework for estimating cargo arrival times for customers has been developed based on data of loading sequence and time stamps of cargo units from previous port of departure, available tugs at arrival ports and other factor. Customers are enabled to better plan their logistics chain. Being able to provide this information to customers is an enormous competitive advantage for the company. At the same time, it reduces terminal congestions and truck-related CO_2 emission. More details about the model can be found in [2].

There are various challenges especially when it comes to the implementation of mathematical models in the industry. However, it is a step forward to combine human decision making and the support of digitalisation and optimization tools.

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By Jonas Ehlers Nilsson

Solving a Rubik's cube in fewest possible moves

The Rubik's cube was invented in 1974 by Hungarian sculptor and professor of architecture Ernő Rubik[1]. The original 3x3x3 Rubik's cube consist of six faces that each consist of 9 tiles. Each face can be turned 360 degrees clockwise or anticlockwise.

Figure 1: The original 3x3x3 Rubik's cube

The original 3x3x3 Rubik's cube has 43 252 003 274 489 856 000 possible combinations (43 quintillion)[2]

Ever since the Rubik's cube was introduced to the public, mathematicians have been searching for the cube's god number. The god number is the upper limit for moves needed to solve any given combination for a cube. In 2010 the god number was proven to be exactly 20 by Tomas Rokicki, Herbert Kociemba, Morley Davidson, and John Dethridge[3] [4]

In this article I will propose a model describing a way to find the fewest moves needed to solve any given combination for a cube.

Model introduction

A Rubik's cube can be considered as a collection of tiles and locations. Each tile has an origin location. The tiles can be moved from one location to another by a set of mappings. The cube is said to be solved if all tiles are located at their origin location. The figure below shows a simplified Rubik's cube consisting of 4 tiles and 4 locations.

A mapping can consist of one or more moves. For the simplified Rubik's cube we can define the following six mappings, that map a tile from its current location to a target location:

[Tile 1, Location 1]	[Tile 2, Location 2]
[Tile 3, Location 3]	[Tile 4, Location 4]

Figure 2: 2x2 Simplified Rubik's cube in solved state

- M1 swaps the tile on location 1 with the tile on location 2, while the tiles on location 3 and location 4 remain unchanged.

- M2 swaps the tile on location 3 with the tile on location 4, while the tiles on location 1 and location 2 remain unchanged.

Mapping	M1	M2	M3	M4	M5	M6
Current: Location 1	Location 2	Location 1	Location 3	Location 1	Location 2	Location 3
Current: Location 2	Location 1	Location 2	Location 2	Location 4	Location 4	Location 1
Current: Location 3	Location 3	Location 4	Location 1	Location 3	Location 1	Location 4
Current: Location 4	Location 4	Location 3	Location 4	Location 2	Location 3	Location 2

Table 1: A table showing six mappings for the 2x2 simplified Rubik's cube

- M3 swaps the tile on location 1 with the tile on location 3, while the tiles on location 2 and location 4 remain unchanged.

1 https://en.wikipedia.org/wiki/Rubik%27s_Cube
2 https://www.therubikzone.com/number-of-combinations/
3 http://www.cube20.org/
4 https://www.youtube.com/watch?v=yF2J39Xny4Q

- M4 swaps the tile on location 2 with the tile on location 4, while the tiles on location 1 and location 3 remain unchanged.
- M5 rotates the cube clockwise.
- M6 rotates the cube anticlockwise.

Appling mappings M1, M3, M6, M1 in order, to the solved simplified cube will result in the following combination:

[Tile 1, Location 1]	[Tile 2, Location 2]
[Tile 3, Location 3]	[Tile 4, Location 4]

Figure 3: 2x2 Simplified Rubik's cube in a scrambled state

Solving the cube in the fewest moves possible is equivalent to finding the shortest ordered list of mappings that will return all tiles to their origin location. For the above combination the solution is M6 followed by M2.

Mathematical model

Solve a Rubik's cube in the fewest moves possible.

Sets

- T is the set of all tiles on a Rubik's cube.
- L is the set of all locations on a Rubik's cube.
- M is the set of mappings that can be performed on a Rubik's cube. A mapping transforms the cube from one state into another.
- I is a set of iterations described as discrete time. In other words I is the ordered set $\{0, 1, \ldots, Last\}$, where $Last \in N^+$ is the upper limit of iterations needed to solve a Rubik's cube i.e. God's number.

Variables

- x_{tli} is a binary variable: 1 if tile $t \in T$ is located at location $l \in L$ at iteration $i \in I$, 0 otherwise.
- y_{mi} is a binary variable: 1 if mapping $m \in M$ is used at iteration $i \in I$, 0 otherwise.

Constants

- C_m is vector of positive integers describing how many moves mapping $m \in M$ consist of.
- $A_{ll'm}$ is a binary matrix: 1 if location $l \in L$ is mapped to location $l' \in L$ by mapping $m \in M$, 0 otherwise.
- S_{tl} is a binary matrix: 1 if tile $t \in T$ is located at location $l \in L$ in the first iteration, 0 otherwise.
- E_{tl} is a binary matrix: 1 if tile $t \in T$ is located at location $l \in L$ in the last iteration, 0 otherwise.

Constraints

A tile must be in exactly one location in each iteration:

$$\sum_{l \in L} x_{tli} = 1 \;\forall\; i \in I \quad t \in T$$

A location must be occupied by a tile in any given iteration:

$$\sum_{t \in T} x_{tli} = 1 \;\forall\; i \in I \quad l \in L$$

A tile must be on its start location in the first iteration:

$$x_{tl0} = S_{tl} \;\forall\; t \in T \; l \in L$$

A tile must be on its end location in the last iteration:

$$x_{tlLast} = E_{tl} \;\forall\; t \in T \; l \in L$$

A tile on location l in an iteration can only be on location l' in the next iteration if the applied mapping for the iteration allows the transformation:

$$x_{tli} - x_{tl'i+1} \leq 1 - \sum_{m \in M} A_{ll'm} * y_{mi} \;\forall\; t \in T \; l, l' \in L \;\; i \in I \mid i \neq Last$$

This constraints work by forcing $x_{tl'i+1}=1$, if $x_{tli}=1$ and the mapping being applied maps a tile from l to l', while leaving all other $x_{tli+1} \mid l \neq l'$ unbounded.

To make sure the above constraint works a mapping must be applied in each iteration (The last iteration can be omitted):

$$\sum_{m \in M} y_{mi} = 1 \;\forall\; i \in I \mid i \neq Last$$

Because a mapping is needed in every iteration a mapping corresponding to not making a move is needed. This mapping will be referred to as the unit mapping or M0.

Objective

Finally, the objective can be defined as minimizing the cost of applying a mapping in each iteration:

$$minimize\ z = \sum_{m \in M} \sum_{i \in I} C_m * y_{mi}$$

The cost of the unit mapping is 0.

Solving the 3x3x3 Rubik's cube

The 3x3x3 Rubik's cube has 54 tiles, but the centre tiles cannot move relative to each other so they can be ignored, leaving 48 tiles. There are as many locations as there are tiles.

Each of the cube's six faces can be turned 90 degrees clockwise, 90 degrees anticlockwise and 180 degrees, giving 18 mappings. Adding the unit mapping gives 19 mappings in total.

The maximum number of iterations needed is the god number, which is 20 for the 3x3x3 Rubik's cube. This yields 46.460 binary variables and 2.107.795 constraints.

I have implemented the model in C# using the free library Google OR-tools[5]. Solving the smaller cubes can be done in reasonable time but solving the 3x3x3 Rubik's cube with more than 5 iterations allowed, takes more than an hour. This does not look promising for solving every Rubik's cube in fewest possible moves in a reasonable time.

The transformation constraints seem to be the culprit constituting more than 99% of the 2.107.795 constraints. If anyone have an idea on how to improve the model feel free to contact me at jonas.ehlers.nilsson@gmail.com.

5 https://developers.google.com/optimization

Cube type	Tiles	Locations	Mappings	Iterations	Variables	Constraints
2x2	4	4	7	20	460	1.427
3x3	9	9	15	20	1.920	14.392
2x2x2	16	16	19	20	5.500	78.995
3x3x3	48	48	19	20	46.460	2.107.795

Table 2: A table with model sizes for different Rubik's cubes

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By Michael Patriksson

Science Junkies & Junk Science – Random Reflections from a Distant Past – well, 30 Years or so

1. Purposes and aims

Figure 1: A bust representing Dr. Sofia Kovalevskaja - the first female mathematics professor in Sweden.

The purposes and aims of this article are to discuss twists and turns that I have experienced – or measured – as a researcher: I fairly recently passed my 30th postgraduate anniversary! One striking characterization is that cross-fertilization is wonderfully prosperous among subjects – team members work with several scientists outside of Math and also outside of Chalmers. But there is also theft (to be demonstrated) and pseudo-science [examples: Life – "Misleader of the year" in 2016 (homeotherapy), flat/young Earth, ...]. Academia also grows too fast for its own good: we have re-discoveries; we also have shallow work in fraudulent journals, accepting anything within 48 hours, if you just pay. Evaluators of science more often put quantity before quality – quantity can be measured; quality is harder to assess, and evaluators have less stamina.

2. Ch-Ch-Ch-Ch-Changes

I began my postgraduate studies in the Summer of 1988, dedicating a lot of time trying to find suitable articles from which to form a survey for my first article. In 1988 one would typically search in the Science Citation Index for the presence of key words or phrases, as well as synonyms, in the right journals, in a suitable range of volumes. In 1988 a search in the Science Citation Index required booking a librarian at Stockholm University at Frescati, who then forwarded it to a database in Italy – costing at least 1,000 SEK per hour. A first print-out in the math library provided the journal, the paper title, and key words; marking the interesting ones and forwarding them to the librarian, you could receive a print-out of a selection of abstracts. Those that looked interesting were then looked up on the library shelves, and the Science Citation Index books helped you find papers that cited those, whence a citation search could be performed, forward and backward in time. Now the vast volume of papers requires an even more focused approach when searching. (That initial thinking about search terms was very handy!) It is impossible to integrate and relate everything nowadays – editors don't like very long lists of references; survey papers are needed, but few are good at writing them, and journals hesitate, since surveys are long, even though they might render several more citations than a standard journal paper. At Linköping University, the optimization group circulated copies of the contents lists of new journal issues in our field – it was quite helpful!

In a poll performed a few years ago at Chalmers/math, many staff members stated that they no longer visit the mathematics library at all … but then one will not be able to find something interesting by chance!

3. In 1988 (LaTeX came later) a secretary typed the manuscript from your written notes, using a special typewriter with math symbols. You communicated with the publisher by snail mail (letters!). Scientists (the "referees") near your field received the manuscript from the journal's editorial office; they provided criticism/corrections/suggestions; a new iteration ensued. If accepted, you received the article in your mail slot at work, set in the journal style, for correction using special symbols, and to be returned within 48 hours. The resulting paper would appear when the designated issue had been printed and distributed to the scientific libraries. Now, authors typeset the papers, based on LaTeX

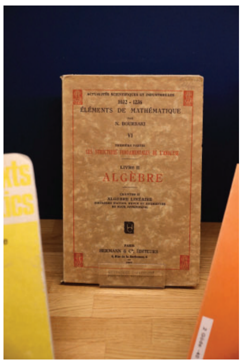

Figure 2: A representative mathematics book at the math library on display.

templates; the accepted paper can be read online well before the printed issue arrives (if at all!). Scientific production is vast – David Hilbert (1862–1943) is said to be the last to know all then contemporary math (>75 years ago).

Personally, I have performed 300+ refereeing assignments for journals and conference proceedings volumes, and 70 reviews for Mathematical Reviews.

4. A few years ago, I studied whether there might be a positive correlation between the “relative size” of some of the parts of an article, and the ensuing citations later on. I used the perhaps most general journal in the field of operations research – indeed, the journal Operations Research – and took two volumes 25 years apart (1981 and 2006), attempting to see what type of material in a journal renders a higher citation rate. The verdict is that it is beneficial to have a long survey, much theory, and a long reference list, while the issue of modeling is less attractive.

5. In 1996 in the optimization group we had a new division leader – Subhash Narula. While he did not stay very long, he had a long-lasting influence of some of us, in particular thanks to a discussion Subhash lead with me and my closest ally in the group – Dr. Torbjörn Larsson. Subben’s checklist is composed by eight items, which are mandatory to be discussed in every article: Relevance, Background, Motivation, Remedy, Hypothesis, Method(ology), Realization, and Analysis. Feel free to check your own articles and see whether they comply – you can find the article in the journal Computers & Operations Research.

6. In 2014 I was a member of a thesis committee at Lund University. When I first browsed the thesis, I quickly found that the subject was identical to one of mine at the time, namely the analysis and computation of optimal resource allocations. While my focus was computations, in the field of logistics, his was focused on economics, and based on characterizations; my problem was differentiable and strictly convex, while his was convex and potentially non-differentiable. I hired a librarian at Chalmers, to see if there were any citations in common, but the simple graphical tool from Scopus found no connection. This might be one instance where AI could be used – to search for more complex citation patterns.

7. Things that concern me nowadays are plenty: one is that young researchers at research forums like ResearchGate are phishing for answers, instead of asking their advisors. Another short-cut is the utilization of metaheuristics, when there often are clearly better alternatives within mathematical optimization.

8. I will finish with some lessons for the future scientists:

- Be conscientious – relate to and cite past efforts – form a sustainable synthesis of prior knowledge, i.e., write a good survey.
- Be meticulous with theory and experimentation; don’t skip details; also illustrate cases that may not be favourable; do not jump to conclusions; do not trust simple performance profiles.
- Be inquisitive – read and report more than you think you need to, broader as well as deeper; feed your head!
- Be generous – in your articles, do provide potential avenues for continued studies; you will be more rewarded than robbed of your ideas.
- Write what you like (within reason!) – and make sure that you like what you write; then the readers might also like it.
- Listen to Albert Einstein: “If you can’t explain it simply, then you don’t understand it well enough.” It’s an antidote to the classic mistake: “If it was hard to prove it, or write it, then it’s OK for it to be hard to read.”
- Cite others fairly – in proportion to their achievements, impact and lasting value – citing others does not diminish what you do; if you don’t cite well, then you break the chain of connections to the past.
- Assess your own work as you would assess others’ – if you dare! 🙂 Don’t cheat or be sloppy – your good conscience should guide you.

Good luck!

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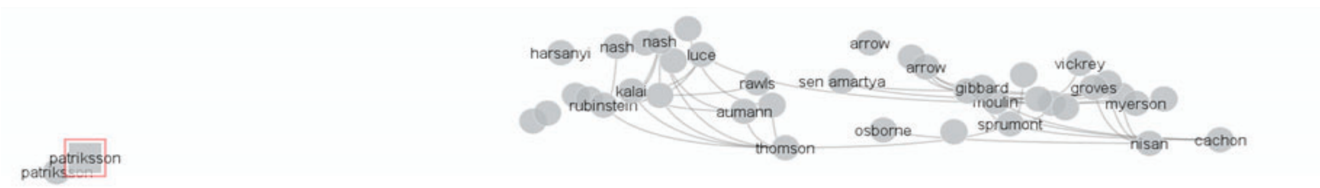


Figure 3: Same math, but citations-wise no connection between the two islands.

By Nelson Maculan

Manifesto

Since the 1940s, Science of Logistics has been always a cornerstone of Operational Research.

Since November 2019, our planet has been hit by the new coronavirus (COVID-19). This seriously challenges our societies, economies, healthcare systems, education and several other services and infrastructures, all around the globe. The uncertainty that has been introduced by this hit, has caused serious confusion and indecision in different parts of our societies and has affected our lifestyle.

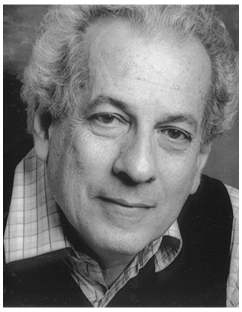
Most authorities (states, regions, cities, etc.) have opted for and instructed various forms of lockdown and restrictions, promoting social distancing, remote working, shutting down non-essential services and several others, aiming at controlling the spread of the virus and managing the capacity of health care systems.

The imbalanced spatial distribution of various facilities, in many districts and neighborhoods, has caused access problem for citizens. Some citizens have walking distance access to facilities in order to fulfil their primary needs while for others, the use of public transport (which is also used for home-to-work commute of workers in essential service sectors) remains inevitable. The latter being a challenge to the precautionary measures of social distancing, thus increasing the risk of spread.

We are talking about facilities associated with health, food, policing, energy, telecommunications, garbage collections, equipment, and so on. While under these circumstances, demand for some non-essential services has drastically dropped down, there is a need to identify new policies aiming at introducing an adequate level of access to the essential services and facilities. This is particularly the case in those less developed suburbs and neighborhoods wherein new facilities shall be launched.

Sure enough, there are and will be serious social and societal problems, where Operational Research could act by presenting decision scenarios. Given the growth in the number of positive cases of COVID-19, decisions need to be made quickly, avoiding further casualties.

This is the time for all Operational Research societies and those interested in emergency logistics to approach and place themselves at the disposal of the mayors of their cities, governors of their regions and the top representative of their countries. It is our obligation to be at the forefront in the fight against this pandemic.



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