MACHAZINE

Volume 22 - Issue 1 November 2017 Wiskunde Informatica **Studievereniging**



Christiaan Huygens'

BUSINESS TOUR 2018

Register now!

FRESHMEN WEEKEND REVISITED BY

a Mentor & Freshmen

STONE COAL

English

HISTORICAL PERSON

René Descartes

CONTAINING: CURRENT AFFAIRS | ASSOCIATION | COMPUTER SCIENCE | MATHEMATICS | MISCELLANEOUS

Wiskunde Informatica Studievereniging



Career College 2nd Quarter

Save the dates: 23rd of November 7th of December 11th of January





MACHAZINE is a publication of W.I.S.V. 'Christiaan Huygens'

Chief Editor

Arthur Breurkes, Rebecca Glans

Editorial staff Marjolein Bouwmeester, Marc Corstanje, Jamy Mahebier, Angelica Babel

Art Directors

Floris Verburg, Dieuwer Hondelink

Contact address

Mekelweg 4, 2628 CD Delft E: machazine@ch.tudelft.nl

T: 015-2782532

Concept and design G₂O Kesteren

Publisher

GildePrint drukkerijen

Cover

Capitol Building's reflection on water surface October 1st, 2017 by Kendall Hoopes.

Cooperating on this issue:

Angelica Babel, Daphne van Tetering, Fred Vermolen, Felienne Hermans, Romi Kharisnawan, Felix van Doorn, Dieuwer Hondelink, Geert-Jan Houben, Sophie Walboomers, Daphne van Dorst, Sara op den Orth, Simone Vis, Anne-Fleur Janssen, Paul Verkooijen, Yanna van der Vlugt, Jasper Abbink, Floris Doolaard, Michel Dekking, Joris Bierkens, Mirrelijn van Nee, Marjolein Bouwmeester, Rebecca Glans, Sven van Hal, Arthur Mooiman, Jochem Lugtenburg

Terms and Conditions

The MaCHazine-committee and the Board are responsible for the content within this MaCHazine, in such terms that the opinion of a writer is not (necessarily) a reflection of the opinion of the committee or association. All rights reserved. No part of this publication may be reproduced, stored in a (retrieval) system or transmitted in any form or any means, electronic, mechanical, photocopying, recording, scanning or otherwise, without the prior written permission of the committee or association.

Advertiser index

Technolution	2
Deltares	16-17
ProDrive	Back Cover

Angelica Babel

Summer is almost over. In the Netherlands, summer only exists a couple of weeks. The sun shines really hard on us, but when you get used to it, it disappears. The sun is gone and has made place for something else, rain. After the summer, fall starts. The time when leaves fall off trees, the time when we have to choose whether to ride a bike or take the bus. What I like the most about fall is sitting at home, looking out of the window and drinking a cup of hot tea. Oh yes, summer is over.

But when summer is over, a new academic year starts. This time it is the academic year of 2017-2018. First year students are arriving, both bachelor and master students. They walk these halls almost with a small road map in their hand. I remember when I first came here; good for me I made some friends who kind of knew where to go. This year, I will start my master



Applied Mathematics together with the master Science Communication. 'Science Communication? How and Why?'. Well, I really liked my

minor Communication Design for Innovation, so why not start the master? With this choice, I have to work a bit harder than before, but I really like this challenge. The new students this year will also have some challenges. At first every student always has the intension to go to every lecture or prepare every lecture. The difference between school and university is large. So everyone has to work a little bit harder than before, but this is also fun, because you can make new friends along the way.

When the summer is over and the academic year starts, also a new board will start. Next to a new board, also some people will leave our committee. Daphne and Irene will be part of the board, so they will leave. Because of this Floris and Marjolein will also help the first quarter and we are very happy with their help! Marc will stay and become our new QQ'er for the year. In a couple of weeks, new members will become a part of our family, which results in fun times!

Unfortunately, EEMCS will no longer be EEMCS. Every new student will start in EEMCS as we know it now, but we will move to another building eventually. Now, they look at this building and see the beauty it has. The height of the building, the red side and the 100 windows it has. Unfortunately, the new students will not have the time to get used to this building. EEMCS will no longer exist. The faculty, or more specific the people and the programmes, will move into another building. We, EEMCS, will not be the tallest faculty of them all, but we will move to a smaller building.

Looking at EEMCS now, I think of all the fun things that happened. Starting my bachelor mathematics, making new friends, being part of the study association. Leaving this behind is not that difficult, i.e., I will not cry, but it is sad to leave, because the building is beautiful and there are so many memories here.

Nevertheless, we already said goodbye to board 60 and said hello to board 61. Saying goodbye is also a good thing. It means saying hello to something new. As I look out my window and see the sun going down and see the moon, I think it's time to tie an end to it all. If you have any questions or suggestions for MaCHazine, I encourage you to send a mail to machazine@ch.tudelft.nl. We're always glad to receive input of our readers. I will no longer keep you from reading the rest of this issue, enjoy!

Editorial





IAVA PUZZLERS eclipse AspectJ

ERVARING

OPDOEN

Refactoring

KENNIS

INZETTEN

sion Patterns

WICKET IN ACTION

Waarom wachten tot je bent afgestudeerd? Ervaar al tijdens je studie het gevoel van werken in een dieptechnologische omgeving - tijdens een stage! Werken met vakgenoten waar je jouw technische kennis nu al kan inzetten. Bij Technolution krijg je die kans. Jouw werkplek staat zelfs al klaar.



DIRECT

STARTEN

VAKGENOTEN

>dieptechnologisch

Table of Contents











Current Affairs

From the board	4
Can we model a possible 'clash of the civilizations' in the NLs?	6
Stone coal English	8
Perks of being an international student at Delf University of Technology	9
Faculty Student Council	10
Delft University of Technology news	11
New director of Education	12

Association

Freshmen weekend by freshmen	14
Freshmen weekend by a mentor	15
Hydrological modelling with big data	16
MaPhyA	18
CoH alumni barbecue	19
Business Tour 2018	20

Computer Science

Popularity-based detection of Domain Generation Algorithms	22
BEPSys 2.0: Getting the bachelor system back on track	24

Mathematics

How to find your integer sequence	28
MCMC: Universal tool for sampling from probability distributions	30
Power estimation in wheelchair basketball	32
Leveling the number of required beds in a hospital	34

Miscellaneous

Historical person: René Descartes	
Science trends	39
Minors	40
Mathematical puzzle	42
Computer Science puzzle	43



From the board

Each academic year, lots of new freshmen start their time at university, where they get to experience all the perks of being a student. For others, the new academic year means that the holidays are over and that it's time to get serious again and maybe even obtain that Bachelor's or Master's degree they've been working so hard for. For me, the start of a new academic year meant the start of my year as Secretary of the Board of

W.I.S.V. 'Christiaan Huvgens'.

around the EEMCS faculty.

Since then, almost seven weeks have passed. During this time, I have started to get the hang of it. I remember my first day, full of energy I arrived at our association, only to find that the previous Board had hidden my phone (and what's a secretary without a phone) and my computer. Fortunately, I wasn't the only one who had lost their stuff, most of us couldn't find their phone or their computer. We spent the whole day searching for them and luckily found them, for instance, at the Academic Counselor and the Dean. One advantage of

In the month before that, we had already done a lot of preparations. For example, we figured out what new things we want to bring to CH during our Board year, such as awareness of sustainability, a freshmen dinner, a book counter and much more! And we also learned how to run an association like CH and how to guide committees to their goals. To get to know all the new students coming to study Applied Mathematics or Computer Science and Engineering, we went on Freshmen Weekend with 2950 enthusiastic freshmen, 5040 mentees and almost 30 members of the WIEWIE and the Wocky! That made sure the weekend would be unforgettable! The freshmen got a chance to meet CH and also their study mates for the first time. But, there were more firsts that weekend:

this treasure hunt was that we got to know a lot of people during this journey.

getting turned upside down while sleeping, blind soccer, drinking beer with a banana in your mouth and dancing till the sun comes up! I'm sure everyone had a lot of fun, we sure did!

Of course, I'm not running our association all by myself. I am one of the seven people of the Board and while writing this, everyone is working very hard to get all their tasks for this week done. It's a Wednesday afternoon, which means that we all want to go and have a drink in the /Pub later, but not before we've finished our tasks for the day. Next to me is Ricardo, our Treasurer, who's working very hard to make sure CH is financially healthy. To my left are Irene and Willemijn, who are preparing our presentations for the General Assembly. Behind me are Francis and Marc, who are responsible for all Education Affairs. These affairs are one of the reasons CH was founded and therefore we dedicate a lot of time to evaluate and monitor the education given at our faculty. Last but not least, Niek is on the phone helping a company in enrolling themselves for 'De Delftse Bedrijvendagen'.

Since the start of the academic year, a lot has happened. The first T.U.E.S.Day lecture given by Adyen was a big success. On 19 September we hosted the Freshmen Weekend Reunion, where everyone enjoyed a couple of beers while watching the Freshmen Weekend after movie. On the 22nd of September the ChipCie organized the Delft Algorithm Programming Contest and on the 16th th of September we had our first members' lunch! Since Career College is back again this year, we had a workshop in Networking and a start-up event where Somnox, FeedbackFruits and pop-up escape told about their experiences when they founded their companies while still studying. It was a very interesting night, if you weren't there; we hope to see you next time!

Current Affairs





Can we model a possible 'clash of civilisations' in the NLs?

Fred Vermolen

Nowadays, when you read the newspapers, you will see quite a score of topics about refugees and immigrants. Some politicians predict the 'clash of civilizations' within a couple of decades. Will there be a 'clash of civilizations'? Further, can we estimate when this 'clash of civilizations' will take place (if it takes place at all)?

It is believed that the first Dutch residents were Celts, which were later succeeded by the Romans. The Roman occupation brought Germanic tribes to the Netherlands, who originally came from the south of Germany. In fact the Germanics dominated the Celts and that is how the Netherlands got a Germanic language. Hence the present Germanic population can be considered as not being the original residents of the Netherlands. Later on, more immigration (and emigration) took place from surrounding countries. Of course the Vikings raided the Netherlands (predominantly it was the Danish who invaded the Netherlands), and some of the Vikings left their genes in the Netherlands, not in a subtle way. the Netherlands also used to be part of the Habsburg Empire in Europe. In this sense, the present European Union is just a repetition of history. Later on we became a part of the Spanish Empire. The Spanish king Philips II started to raise taxes and he did not tolerate Dutch people to become part of the Lutheran movement that was going on in the North of Europe. The Dutch started to revolt and after eighty years, the Dutch deliberated themselves from the Spanish Empire under the command of Willem van Oranje. Willem van Oranje is a relative of present day King Willem-Alexander. In many of the history books, it has not been reported that many soldiers who fought for Spain remained in the Netherlands. Later on, many Hugenots, who were French and Walonian protestants, migrated to the Netherlands, because the Netherlands were one of the first countries in the world that enjoyed freedom of religion. This freedom of religion is a fantastic thing. Later on, more immigrants moved to the Netherlands from the neighbouring countries, with large numbers from Belgium and Germany during world war I. Of course, I should not forget the Jews from Eastern and Southern Europe (Spain and Portugal) who came here, in particular because of the inquisition. All these immigrants assimilated smoothly. Of course, some tensions always existed. Unfortunately, there was a significant number of Dutch people who betrayed Jewish families to the Nazis during the second world war.

The first humans on this planet did not live in the Netherlands. Hence, throughout its history, the Netherlands experienced several waves of immigration from other European countries and later from its former colonies. Later on, immigration proceeded from Northern Africa and Turkey because there was a need for low-paid labourers and presently there is considerable immigration and emigration between the Netherlands and other EU-countries. Recently, a lot of tensions broke out in the Arab world (for instance I.S. in Syria and Iraq), which instigated the influx of Arab and African immigrants to the Western Europe. We should consider ourselves fortunate, since we are living in a free and safe country with good facilities for education and health. Even the Dutch beers are not so bad (okay, do not compare our beers to the German and Belgian ones). Immigration has brought and still brings new ideas, science and skilled people to the Netherlands. Nevertheless some people think that this immigration should be inhibited, whereas others think that the ageing society of the Netherlands needs the influx of (young) people.

But the question remains, will we experience a possible 'clash of civilizations'? Well, I looked up some numbers from *CBS*: We have a population of about 17 million people. Around 4 million of them have an international background. Further, in 2016, about 172 000, 148 000, 140 000, 227 000 people, respectively, were born, died, emigrated and immigrated out of / into the Netherlands. This gives a positive balance to population growth. Approximately 30 000 people of foreign origin emigrate out of the Netherlands. We use the following simple differential equations-based model for the various groups (N= ethnically Dutch (indigenous people), A = immigrants without legal status, M = immigrants with legal status or with Dutch nationality):

$$\frac{dN}{dt} = \alpha_N N \left(1 - \frac{N+A+M}{L}\right) - \epsilon_N N,$$

$$\frac{dA}{dt} = w + \alpha_A A \left(1 - \frac{N+A+M}{L}\right) - \mu A(t-\tau) - \epsilon_A A,$$

$$\frac{dM}{dt} = \alpha_M M \left(1 - \frac{N+A+M}{L}\right) + \mu A(t-\tau) - \epsilon_M M,$$
(1)

subject to initial conditions. The α -terms stand for birth and death where the total population can only be sustained if it does not exceed L (we took L = 34 million out of the blue). Further emigration has been taken into account by the ϵ -terms, and the fraction of immigrants that obtain a legal status was incorporated via the delay (τ -) term with the μ -factor. The Dutch need a long period to decide about assigning a legal status: we used $\tau = 5$ years.

The order of magnitude of the coefficients can be estimated using the information from *CBS*. It is to be expected that these numbers will change over the years, but for simplicity we take them constant. The results using this simple model are displayed in Figure 1, using the assumption that all the parameters in the model stay constant in time. The graphs will be explained shortly in the text that follows.

From the website of *Rijksbegroting*, it can be found that the Netherlands spent about 253 billion euros over 2016. Further, the cost per capita were 18 643 euros per citizen and about 23 000 euros per asylum seeker (Geert Wilders speaks of 36 000 euros per asylum seeker). The evolution of the total expenses as well as the population of the Netherlands over the next 100 years (I did not correct for inflation!) is given in Figure 1.

It can be seen that the numbers for people with Dutch ethnicity decline as a result of emigration and because of small birth rates. In the computations, I guessed that the birth rate of international people was twice as large as the value of indigenous people. In Figure 1, it can also be seen that after ≈ 54 years the number of indigenous people (N) starts to be lower than the number of international people (A + M), that is N(t) < A(t) + M(t) for t > 54 years.

Can we take these simulations seriously? We realise that all models are wrong, but some of them are useful. Models are just (simplified) descriptions of

reality. I think that the model has some predictive power in the coming years. But making predictions over centuries (like I did!), is dangerous, because we do not know what will happen, and how the coefficients have to be adjusted. In the second figure, it can be seen that time at which the international people outnumber the ethnically Dutch people occurs increases with the maximum sustainable population, when the population size is not too large.

This might suggest that Geert Wilders and Thierry Baudet should aim at abolishing our high-technological lifestyle to decrease the carrying capacity (maximum sustainable population) so that the 'clash of civilizations' can be postponed. In fact, this is more-or-less what they want according to their policy programmes. Despite the cost going up (because the number of people increases), we should aim at providing good opportunities for education to everyone in the Netherlands (regardless background), and try to make products from the Netherlands interesting from a quality point of view so that our turnover will also be high. We should try to keep our GNP high by allowing as many people to work as possible, then we can become a strong country with many good new ideas.

Using a Bayesian parameter variation approach, we can get the histogram in Figure 1, which shows the statistical distribution of the time at which the international people outnumber the indigenous people. This Monte Carlo simulation ($n_s=10^4$ gave converge) gave a probability of about one out of three that the international people outnumber the indigenous people within the next 50 years. Further, it is easy to simulate different scenarios regarding policy. Hence, if you define the time θ as the minimal time at which N(t) <A(t) + M(t) for $t > \theta$ as the time at which the Dutch society will experience a 'clash of civilizations', then it is to be expected that within several decades the majority of the Dutch will have a foreign origin. This should not be a problem! As long as our society helps the newcomers integrate in terms of language, work and education. In the past decades little emphasis was laid upon integration. Often the immigrants don't cause the problems, but our policy-makers do. If you want to model assimilation, then a loss term on M, which is balanced in N should be added. This will change some of the conclusions quantitatively, though probably not qualitatively.

Sorry for all my useless information; Thanks, Berna Torun, your input was useful; Time for English (EU or non-EU?) alcohol; Skål!!







Figure 1: (1) The number of residents split in various groups. (2) The time of 'clash of civilizations' as a function of the carrying capacity for various relative immigration influx rates. (3) Histogram of the time of 'clash of civilisation' from a Bayesian parameter variation.



Stone coal English

Felienne Hermans

Since this month we are in the wonderful situation that all Computer

Science courses, also in the Bachelor program, have to be taught in

English. We are ahead of the curve here, in the Netherlands about 20%

of BSc programs is in English¹. Not everyone likes this, there is even

a petition by "Beter Onderwijs Nederland" that wants to go to court

against this movement², saying it destroys higher education³.

And why does EEMCS want this? According to our strategic plan, the reasons are:

1. Preparing our Bachelor students better for the English taught Master and the global workplace;

2. Facilitating more bilateral exchange during the Bachelor phase, increasing the opportunities to gain international experience during the minor phase for our bachelor students;

3. Increasing the international exposure (internationalization at home) of our Bachelor students, by enabling more foreign Bachelor exchange students to follow courses at EEMCS;

4. Attracting more international Bachelor students once complete Bachelor programmes are offered in English.

Let's pick these apart. The logic of reason 1 seems a bit backwards. It is like we changed the MSc program to English, but students are struggling, so let's start earlier so they will struggle earlier...? Reason 2 is a bit weird, if students want to study abroad for a minor, they can do so too when our program is still in Dutch. I guess they mean that we could also host international minor students, but that, with reasons 3 and 4, seems to come down to attracting more students (3,4). Okay, fair enough, we need to make money, but currently, our lecture halls are almost exploding as we speak. Our program grew from about 150 to over 400 students already, with only a few non-Dutch speakers in the first year now.

The plan does not mention any downsides, which at first sight is understandable since this feels like a clear win. There is this secret assumption underneath it: all Dutch people speak English well enough, whether or not this is true (spoiler alert: it is not).

I too used to be in favor of teaching in English, it feels like progress, like new and modern. Those old fashioned people who did not want to change to English were just blocking the natural progression of things, and also they must have been protesting just because their English is bad. However, my opinion changed when I spent three months in Cambridge last summer. Suddenly, I was forced to speak and think in English all day. My own Bachelor's and Master's programs in Eindhoven were in Dutch (although we have some courses where instructors did not speak enough Dutch so they used English) and my PhD supervisor and me both spoke Dutch, so I have never needed to communicate in English all the time. Sure, some courses I taught were in English, and 2 of my 4 PhD students do not speak Dutch, but it was a mix and often, when in absolute need of the perfect word, I would use a Dutch one and explain after. This allowed the students to learn a few words in Dutch.

In the UK however, I had to speak and listen to English all day, and I must say, it was exhausting. I could not think and express myself as fluently and precise as I can in Dutch. I felt myself spending energy looking for the right words, needing to focus deep to understand my colleagues (more so even because a lot of other people in Cambridge are not native speakers, and my boss came from Scotland, so I had listen to very different forms and accents of English) rather than on what they were trying to convey. I felt and feel that I am not as smart in English as I am in Dutch. I just cannot be, it is not my native language.

Of course I can be good enough, technically I am, I am certified C2 so qualified to teach in English. Surely I can give talks and lectures and arguably my English is better than that of some of our country's politicians and radio hosts that are not ashamed to speak English in public. But my job is not just delivering speeches; my job is to listen to students, to understand the nuance in their words and to respond with the same nuance. To understand when they are confused, happy, engaged or distracted.

Every ounce of energy I spend on speaking English, reaching for words, carefully formulating is not spent on teaching. And also, every ounce of energy the students spent on speaking English, reaching for words, communicating in a language that is not their own is not spent on learning, or rather it is, but not on learning computer science. English is a valuable skill, and it is important that our students are prepared for an international world, but there is no way on earth that this measure is not lowering the quality of the program, simply because the energy needs to be spent on improving our English.

Students deserve to be taught by the best teachers we have. And Dutch Felienne will always be the better teacher compared to English Felienne.

References:

- https://nos.nl/op3/artikel/2182626-engels-in-het-hoger-onderwijs-moet-niet-vanzelfsprekendzijn.html
- [2] https://www.beteronderwijsnederland.nl/nieuws/2017/06/rechtszaak/
- [3] https://www.volkskrant.nl/opinie/opinie-engels-als-voertaal-vernielt-het-hoger-onder wijs~a4503046/



Perks of being an international student at Delft University of Technology

Romi Kharisnawan

Short story about me: I am a 2nd year computer science student from

Indonesia who had no experience living abroad for a long time. Yes, that

is definitely a challenge in which I want to grow myself, both in hard and

soft skill.

Time flew really quickly. It's been a year since I put my feet on the land of windmill, The Netherlands. There were a lot of struggles, but more excitements for sure! Flashing back to a year ago when I entered the highest building of the TU Delft, I sat in classroom Ampere, finishing all mandatory courses, working in four different projects in parallel, having some sleepless nights, adjusting life in a four-seasons country. It sounds so surreal for me. Am I the only one who feels stuying abroad is so hard?

"Is it only me?" is a repeated question that I asked myself, especially when I was faced with challenges that shook my confidence. I believe that will also be the questions that pop up in the heads of some students. That's why I would like to share a glimpse of my story during my year as an international student at the TU Delft.

Learn the hard way

I had a computer science background in my bachelor which I finished four years ago. I worked for about three years, which made my brain a bit in rusty to study again. In my country, it's a common thing: working directly after graduation and not thinking about getting a master degree at first. Maybe it is caused by the joy of earning money for the first time.

This makes the transition to start a master become quite difficult. All theoretical background about statistic and programming almost evaporated from my head, since I only used specific skill sets in work. On the other hand, most of the students in my class were just graduated from a bachelor with their fresh-from-the-oven mind. Also, learning in an international environment is totally different. As a nonnative English speaker, I found understanding and expressing ideas in a different language was my biggest challenge.

No way back, that's the words I kept in mind which helped me survive. The only way to survive is to dive deep into the study and share knowledge and struggles with friends.

Keep your friends close and your enemies closer

Don't forget to make good friends. As an international student, blending in an international group is more a necessity than an option. Some people are comfortable with a group of friends from the same country, including me, but I realized it won't make you grow. You need to take the opportunity to get to know people from various backgrounds. For me, the main key is to find the right balance of interaction. I remember during IR class, the professor didn't want groups of only one nationality, which made some of students move out from their comfort zone.

There are lot of ways to meet new friends. One activity I have never regret is to join COMMA in Christiaan Huygens. It was not only to make new friends but also to channel my interest to organize events. Also, I became good friends with some people that I met during the Introduction Program, which was called "Scandinavian and The World", and not to forget to mention all my Indonesian friends, especially my ex-housemates.

Having said that, this is also the way to overcome my biggest enemy, which is fear of leaving my comfort zone and shouting my opinion out loud. That's why I always try to keep this enemy close to me, to challenge myself to grow and expand my horizon of view.

Keep yourself challenged

Another way to go out from my comfort zone is to challenge myself, like joining competitions. I was a person who was afraid to join any kind of hackathon because of the thought not being good enough. Then I broke the boundary by joining my first ever hackathon in Amsterdam. I also had summer school in Philips Lighting recently which pushed me to improve my skills. I was put in a group of four people from different fields of study: business, design, computer science, and embedded system. This program gave me other extra experiences; not only as first time working in Netherlands, but also becoming full-stack software developer.

"Is it only me?"

Most probably no, it's not only you. Everyone has their own struggles or dreams. You may find other friends who experience the same question, like "is it only me that hasn't understood this subject?" or "is it only me that can't cycle in the middle of heavy rain to catch the exam?" or "is it only me that wants to join the Honors Programme?". You should share it with friends to release your stress and stories. I always remember the quote "what doesn't kill you makes you stronger" and I believe this is also a perk of being an international student.

Finally, two years of study is relatively short, so enjoy every moment as much as you can!

9

Faculty Student Council

Felix van Doorn

This September the new EEMCS Faculty Student Council (FSC) took office. To those readers who have not been at our faculty for that long, let me briefly explain to you what the FSC does. The FSC is the official representative body of students at the EEMCS faculty. This council is therefore not only comprised of students in the Applied Mathematics or Computer Science programs, but also of Electrical Engineering and Sustainable Energy Technology students. The FSC is open to both BSc and MSc students. In total twelve students are elected by their fellow students to advise the faculty board and promote the interests of students. Apart from working together with just the faculty board, we also have close ties with the FSCs of other faculties and the Central Student Council.

At the time of writing the new FSC is busy outlining the most pressing issues at the faculty. Obviously, we are looking for ways to deal with growing student numbers, moving out of the EEMCS high rise, education evaluation and inter-

nationalization. This year there will also be a revision of faculty regulations, which takes a painstaking amount of time and effort for all involved parties. Rewriting an article of just a few lines is bound to take up a few days of your time.

I suppose by this time plenty of you will think to yourself, "Why would you sign up for a year like that, that sounds terrible!" Well, dear reader, I obviously have a very elaborate answer for that. Getting to deal with legal, financial and operational issues greatly complements your technical know-how from your coursework. The great deal responsibilities and duties thrusting your way once you've been elected, also offer a great deal of opportunities for personal development.

Representing you!

"Duties, responsibilities, I thought the board just ran the show?", you might ask. Hah, now I've tricked you into a history lesson! Student representation, both on faculty as on central level, is something very special within the Dutch academic community. It finds its origins in the first "Maagdenhuisbezetting" (by now there have been quite a few of them), where students at the University of Amsterdam occupied the office of the university board to grant students more influence on university policy. Their demands were not only honored by the university, parliament even passed legislation to ensure adequate student representation at every academic institution in the country. The ultimate goal was to radically transform the way in which universities were run in this country. This would ultimately result in universities being run by the students and teachers. Although there were still professionals in charge, like faculty deans and the board of executives, it was decided that policy related to certain subjects required explicit approval from student representatives before universities can implement these policies. Failure to do so could even result in a fully-fledged lawsuit, although this very rarely happens. The cooperation between the faculty and the FSC EEMCS is fortunately very good. As you might infer from this, being part of the FSC is a challenging, but also a very rewarding experience. The opportunity to really help improve the way in which the faculty is run is definitely worth all the work you will put into it.

You can always contact us

Whenever you have a complaint about something at the faculty, please come to us so that we can try to solve it. Either send us an email or approach us personally. We also organize coffee moments every quarter. Here you can come for a cup of coffee or tea and talk to us. Alternatively, you can go directly to the dean. Although the dean is usually very busy, he does plan open office hours every now and then. These are meant to give students the opportunity of talking to the dean directly about issues they are facing. It makes his job a whole lot easier if he better understands what students want and need at the moment, so we advise you to keep an eye out for these office hours.

We're all looking forward to the challenges the year will bring us and to promote the interests of our peers to the best of our abilities. After all, being elected by your peers does bring just that little extra bit of pressure to get things done this year. We would like to thank you for your support and wish you a great academic year!

Delft University of Technology news

Dieuwer Hondelink

The Delft University of Technology is the biggest and oldest Dutch publicly available technical university, established by King Willem II on January 8th, 1842. But what is currently happening in and around the TU Delft? This article will list the most important events of the recent months.



Human Power Team wins cycle race

With a stunning speed of 121.5 km/h, cyclist Aniek Rooderkerk broke the Dutch speed record for women. With this achievement, she won the World Human-Powered Speed Challenge in the Nevada desert, held on the 16th of September. In this competition for the most innovative cycles and riders from all over the world, Rooderkerken was riding the VeloX7: the latest model of aerodynamic cycles designed by the Human Power Team, a group of students from TU Delft and VU Amsterdam. Rooderkerken had already unofficially broken the previous Dutch record, 114 km/h, four times. However, these results were ruled invalid because of strong winds.

Vice President Education & Operations steps down.

Anka Mulder, Vice President Education & Operation (VPEO), will be stepping down on 1 January 2018. After starting at the TU Delft as VPEO on 1 April 2013 she will now continue her career as President of Saxion University of Applied Sciences. Mulder has made great contributions to putting TU Delft on the map internationally in the field of education. She has led the establishment of institutional accreditation, with TU Delft just having been awarded a renewed accreditation.

TU Delft opens teaching innovation lab

On the 27th of September, the TU Delft Teaching Lab was opened. This place was specially designed for new developments in teaching. Lecturers can come here to experiment with their teaching, share experiences and methods with colleagues and work together. Lecturers can also consult with colleagues who have more experience in teaching-innovation support.

First new watch regulator since 1675

A joint effort of LVMN Watch Division, TU Delft and TU Delft spin off Flexous has led to a completely new watch regulator. Modern mechanical watches are still operating on the 'balance and hairspring' principle. This is a timekeeping device invented by the Dutch scientist Christiaan Huygens in 1675. The LVMN Watch Division, TU Delft and Flexous joined forces to create a completely new regulator technology. Guy Sémon, CEO of the R&D Science Institute of the LVMH group says: "This is the first time since Christiaan Huygens invented the pendulum clock that there is a new technology in regulators. The new regulator has no hairspring, no balance wheel and doesn't need oil, because it has no friction. Accurate to one second in 24 hours, it generates the most accurate mechanical watch ever". A regulator traditionally has multiple parts and is composed of multiple layers. The newly developed 'monolithic' regulator, however, is made in a single layer and out of one piece, so it doesn't require any assembly.



References:
[1] https://www.tudelft.nl/en/current/latest-news/

New director of education

Geert-Jan Houben

When Rebecca asked me to contribute a small article for MaCHazine, she told me I could write about anything. At the same time, she suggested I could write about becoming Director of Education, about my research, or about my courses. I will say something about all of these suggestions.

I will start with my role as Director of Education, since that was the

trigger for Rebecca and her fellow committee members to ask me.

I am proud and happy to serve as Director of Education. In a faculty like EEMCS, education is an important part of our work. In fact, our education and the programs we offer define who we are as EEMCS.

Within EEMCS, we have a set of study programs at various levels, and in each of these programs, many of EEMCS's staff members are engaged. This does not include only the teaching staff, but also all others that support the teachers in the smooth organization of the education. A large number of people share the responsibility for all this education, most notably our Directors of Studies: they are in the end formally responsible for particular study programs. The Directors of Studies take care of the day-to-day running of the programs. As well, together with the departments they ensure that strategic developments lead to continuous and great success. Since, there are many connections in our faculty between what happens in each of these programs, especially regarding the more strategic developments, we have a team in which the Directors of Studies together take care of all EEMCS education. The Director of Education chairs and leads that team.

It is particularly exciting in that role to look at ways to innovate our education. Of course, the subjects we teach involve many technological developments: it means we continuously look at how we keep our research and education in these subjects at the current state of the art. In addition, we also see that we innovate in the way we teach: the use of online education is becoming quickly a valuable asset in our portfolio of educational offerings. With the whole team and teaching staff, we develop best practices of how online education can help students and teachers even more.

By mentioning online education, I can also jump to my own research and education. As a professor of Web Information Systems (WIS) within computer science, I am working with a group of colleagues in the area of web-based systems. With a background in databases, we started studying what distinguishes web-based systems from traditional information systems and what is different in making this kind of systems. Then, two elements emerge: scale and semantics. It is obvious that web-based systems typically are systems that store and process data at large scale, so some of us concentrate on the architecture of web-based systems and their large-scale data processing. The other feature is that web-based systems are typically facing an audience of users that is unknown, unseen and undefined (compared to the more traditional system engineering): it implies there is uncertainty about whether the users and the system actually use the same semantics (meaning) for the data. Therefore, one very important piece of functionality in a web-based system is its capability to do user modeling: modeling who the users are, in order to adapt the processing and delivery of data to what fits the users and their interpretation. As researchers, we have been involved in research into user modeling for some time now and with great success in several domains.

We have for example been involved in research into the analysis of social web data, in order to extract additional insight about a system's users: if you know more about the users (than what your own internal logs tell you), then you can better serve those users. This theory and technology we have been applying and experimenting with in domains such as smart cities (to analyze pedestrian traffic or large-scale manifestations, e.g. in Amsterdam), in large-scale multi-national companies (to analyze collaboration and knowledge sharing, e.g. in IBM) or in large online courses (to analyze learning behavior, e.g. in edX MOOCs).

In all these cases, the common recipe was to take data and process it at scale in order to obtain the desired insights. To do this, we employ techniques from databases, data science, information retrieval, human computing, or human-computer interfaces for example. As scientists, we can therefore contribute in these technology-oriented areas as well, often with fellow scientists from other scientific disciplines, in a set of application domains.

With our web data research, we are also strongly present in Delft Data Science (DDS), our university's program for big data and data science.

In particular, we contribute a lot to DDS's research line on social data science, where together with other groups we concentrate on all aspects of data science on data that is human-generated: if data science is already about the complexity of processing and analyzing big data at scale, it is twice as hard (and twice as much fun) when there is also complexity in interpreting the data due to the involvement of humans in the creation and interpretation of the data.

We also contribute to DDS's research line on big data engineering, where combined software and data architectures are studied for the large-scale processing of data.

With our passion for databases, data science, information retrieval, human computing, and human-computer interfaces come also our own courses in the computer and data science programs. In one of my own courses, the one on web science & engineering, with much pleasure I consider with students the state of the art of research in understanding the web and data on the web, and in creating systems that leverage that understanding. For me, this connection between science and engineering is really important and great fun: both in research and in education.

Therefore, it is a pleasure to see how in EEMCS, we together are passionate about the science and engineering of perhaps the most important cluster of technology that makes the world tick. (3)





Association





Freshmen weekend by freshmen

Sophie Walboomers, Daphne van Dorst, Sara op den Orth

As insecure, unknowing freshmen, we, along with 300 others, enrolled for a weekend which would be forever in our memories as purely epic: full of integration games, awesome morning gymnastics, white shirts, very wise lessons, lots of bananas and beers and sometimes a little bit of a

headache.

The weekend mainly consisted of a sequence of fantastic integration games. There was the WIEWIE WIE is WIE game with lots of questions, which is perfect if you wish to know whether your fellow students prefer to lie on top or below. We also got the opportunity to hit other freshmen with leeks if they did not know each other's names quickly enough. Furthermore, there was something with a lot of spins and some occasional beers, a game that not everyone was equally good at. For mathematicians and computer scientists, this might not be enough to break the ice and therefore there were plenty of useful opening sentences in our booklet, which we called our "soul" throughout the weekend.

And then there were the late hours, when we exchanged our flattery white shirts for regular outfits. After the bar opened too late, we got plenty of opportunities to show our dancing and singing skills while enjoying a drink. At this moment, the hunting season for the FilmCrew was started and their mission was to capture everyone at his or her best moments. Not really beneficial for the integration between males and females by the way, as mainly the kissing was eternalized. The icing on the cake was the midnight-snack at 4 o clock for the real diehards, where many mouths have been burnt.

Also in this weekend, there was no lack of sports. In the mornings, we were dragged out of bed with a bit of a hangover for a refreshing round of morning gymnastics. If this was not really your thing, the WIEWIE would reward you with their water guns. After this, the sports day was organized. Whether you are a fan of football, handball, hockey, twister, jeux-de-alles, getting soaking wet on a belly slide track or slipping in a slippery trail, there was something for everyone. All of these physical activities were a success, but the unanimous favourite remains the beer relay race.

Besides being sportive, the freshmen weekend was informative as well. For example, we got a tour through EEMCS. We also learned that we have to make it clear to our fellow students in Delft that Computer Science and Mathematics are the best studies. Then there was the fox hunt, perfect to get to know all the committees of CH, or if you needed an opportunity to see your bed once more. After the fox hunt, there was a brilliant evening where the Board and a couple of committees showed themselves once more. Here, it became clear who is the fastest beer drinker, the best actor and the best singer. Now we also know who looks best in a dress.

Next to all this information, we also took a few wise lessons home which should help us during the start of our studies. We learned how to obtain free lollies with a beer, that you are fine living without your soul, that bananas and beers are not the best combination, that the WIEWIE is always right and that the FilmCrew sees (almost) everything. By the way, watch out what you tell the FaCie. Just run away from these pink sweaters.



After forming the groups for the introduction week, the weekend was basically finished. A group of friends, unforgettable memories, a huge lack of sleep and a backpack full of wise lessons richer, we sat in the bus back to Delft, on our way to the OWee. It was not clear yet how we were going to survive this week, but we definitely had an amazing weekend. This is thanks to the Wocky!, who would never let us starve, the FilmCrew, who captured our most beautiful moments, the FaCie, who gathered the best stories about us, the awesome WIEWIE, who organized it all and the fantastic Board.

Freshmen weekend by a mentor

Simone Vis

We started our studies of Applied Mathematics and Computer Science at TU Delft a year ago. We participated in the Owee to get to know the city of Delft and what Delft had to offer us as a student. This year, we were mentors ourselves and accompanied a group of first-year students of our studies.

The summer before you start university, you usually have the option to go to an introduction week of your own university. The introduction week of TU Delft is called the Owee. The Owee is intended for prospective students to get to know the new city where they are going to study. You will discover Delft in a group of about ten fellow students of your own study. Two mentors, who are often older students of the study, will guide you throughout the week. Your mentors will guide you through Delft, the sports associations and the student associations. In short, they show you all you need to know when studying in Delft.

The Owee started on Sunday afternoon after freshman weekend. You could pick up your bracelet for your participation in the Owee at the TU Delft aula. Afterwards, there was a big barbecue with a parade of all student and sport associations of Delft which you can join during your time when you're studying in Delft. In the evening, there was a big party on the market in the city center with very nice artists. The whole market square was filled with students who



were enjoying the good performances.

Monday morning was the official start of the Owee in the aula. In previous years, this is a very hyped thing, because here you need to sing the songs you learned on freshman weekend. It's like a contest against the other stud associations from the TU Delft. This year it was not as spectacular as previous years, because there were not a lot of students that attended the early shift. But after that, there was the Rabobank Delft city break-in. We did go to the Prinsenhof museum but, because of the nice weather, we decided to chill in

a park. After that, there was the information market where everyone did go separate ways. We thought it was very important that everyone, especially here, do what they want, because only then you will get a good overview of the student and sport associations that you can join as a student in Delft.

In the evening, we went to a student association to have dinner and after that, we went to the Bolk to drink cocktails with other members of Christiaan Huygens. After that, we were been partying at various student associations until the early hours

On Tuesday morning, getting up was heavy! But once we had the group together, we went to see some different student associations. Some student associations have very nice old momentary properties. We just relaxed during the day. On that evening, we chilled on the Oude Delft with some beers, a guitar and crazy conversations and games. Afterwards, we went to the sports party which was very busy. After a few hours, we decided to go back to Delft city centre to catch some other parties and it became very late again.

Wednesday is kind of the last real day of the Owee, but it is one of the best days. At the beginning of the day you could walk around the sports market at Sports and Culture and try out all kinds of sports. It was very good weather, about 25 degrees and sunny. After the sport activities, the beer cantus started. Everyone was dancing on tables with beer in their hands and singing along with the good songs (or trying it). The beer flew around our ears, it's literally like you're under a beer shower! But it's again one of the best moments of the Owee. Once the beer cantus ended, we went to Christiaan Huygens to eat pizza. At night, we went into Delft to party again at the different student associations and some of us went to the open air cinema on the roof of the university library.

We personally thought being mentors is very much fun, but also very different from being a first year student. As a mentor, you have already experienced the Owee, so you know what is coming. You also know Delft a lot better and you maybe also live in Delft. Our group was very close and we did most of the things with the whole group (apart from breakfast). For us as mentors it was very nice to see that everyone liked each other and that they became one big group of friends. Being a mentor also makes you responsible for making sure that everyone gets a good overview of the student associations and other things that you can do. That is in our opinion a very hard thing to do, because there are a lot of things you can do in Delft and everyone has different interests. Making a compromise to get everyone to the same party in the evening is very hard, so you need to make sure that everyone does what they want and not that they feel obligated to go with the group. We had a great time being mentors during the Owee this summer. Unfortunately, our studies have started again, but in less than a year we can enjoy the Owee again!



Hydrological Modelling with Big Data

Hydrological models are essential tools when dealing with flood risk, water scarcity and pollution. In times of crisis, the models must be available on call. A sufficient level of detail and accuracy is required to assess the situation, predict the near future and simulate potential countermeasures. Furthermore, the simulation results need to be intuitive for decision makers and stakeholders.

At Deltares, multidisciplinary teams are working on solutions for vulnerable delta areas. Our software engineers develop the software that warns people for floods and droughts. We provide civil engineers with the tools for water management and flood protection. Our research themes are closely linked to the major societal issues of the 21st century, such as adaptation to climate change, management of water resources, rapid urbanisation, the production of sustainable energy and ecosystem restoration.



New scientific and technological developments are shaping the future of hydrological modelling at Deltares.

1. Take a 3D point cloud and add some water

The world is being digitised at a rapid pace. Three-dimensional point clouds are digital geometric structures that can be used as the basis of a water model. Point cloud visualisations of the current situation can be made quickly. You can show simulated water levels in the point cloud, for instance to demonstrate the impact of a flood. The 3D visualisation makes the situation recognisable for citizens and mayors.

2. River networks from satellite data

Satellite images can be used to map the water systems of a region from above. Clever algorithms determine the position of rivers and the size of reservoirs, thus providing in the basis of a hydrological model. Ideally, a modeller needs no more than three clicks to model the hydrology of a catchment.

Satellite images provide a high resolution picture of the impact of human activities. Arrange these images in sequence and you see the changes taking place like in a film. Large-scale infrastructure projects such as the construction of water reservoirs and land reclamation are easy to follow from space. The Aqua Monitor is a new web app that allows you to observe how water systems change over time. (http://aqua-monitor.appspot.com/)



3. Big data and high performance computing

As the level of detail of simulation models grows, the required computational power increases as well. We are working towards direct access to cloud computing services from our simulation software. Copying terabytes of data is not always the most efficient way to work. One of the trends is to do the computations where the data is, for instance on earth observation platform such as Google Earth Engine.

4. Digital pioneers discover new data sources

In former times, the modeller received the data from the client. Nowadays, modellers are using a multitude of data sources. Crowd sourced data from OpenStreetMap (land use) and Twitter (messages about floods) can have added value in data-scarce environments.

Extracting information from those data sources requires skill and creativity from a modeller. For example, as individual tweets can be inaccurate, a method was developed that uses the 'wisdom of the crowd' to derive a map with the most likely flooded areas. The flood maps can be of great value during disasters, because they can be produced very fast.

5. From global to local

Water related crises can happen anywhere around the globe. To understand the situation quickly, Deltares uses one of the global water models. At Deltares, we now have a number of global models, such as a Delft3D Flexible Mesh model that spans all the seas and oceans, and groundwater models for all continents on earth. Flexible computational grids make it possible to refine a local grid. The global models can be accessed in our iD-Lab, an interactive data research laboratory. One of the challenges is to zoom in on a particular catchment or coast, by making refinements of the model and adding local information.



6. Serious Gaming meets Numerical Simulation

The latest trend is the fusion of several types of software. For a long time, serious gaming, numerical simulation and decision support systems were separate applications. Now we have brought them together, with very promising results: water models can be operated interactively from a game engine.

Tailor made software solutions are getting easier to develop. The same numerical simulation models can be embedded in products that serve different purposes, from quick scans to early warning systems to interactive decision support systems.

7. Mapping water systems with drones

Rivers and drainage channels must be kept in shape to discharge the water when it rains. The natural growth of vegetation tends to clog the water system and without proper maintenance, farmland and cities will suffer from inundations. Drones and autonomous boats can map larger areas in more detail than an inspector can do.

Drones equipped with full spectrum cameras and smart algorithms can find the bottlenecks in rivers and channels with a surgical precision. Artificial intelligence can support water managers in taking quick and efficient measures to solve potential threats, by focused maintenance of watercourses.



Conclusion

Hydrological modelling is evolving very fast these days. Automatic model building is within reach and even in remote areas, modelling becomes feasible. Big data allows for sophisticated models that run on high performance computers. Thanks to the fusion of serious gaming with numerical simulation, models are no longer the exclusive domain of experts. Future innovations can be achieved when data scientists, hydrologists and software engineers work together closely.



Anne-Fleur Janssen

One of the less well known committees of our association is the MaPhyA. The MaPhyA is a committee, that organizes activities especially for the double degree students, the so called 'dubbels'. Hence, the name of the committee Ma(thematics and)Phy(sics)A. Now it is possible for you to wonder; "What does the A stand for?". To be honest, we are still not sure and have lots of discussions about it. It might stand for Activities,

Association or something completely different, but who will tell?

The year started with tackling the most important issues. During the meetings we talked about the color of the clothing, who gets which function and even a brand new logo was designed! Back then, our goal was to introduce a new song for all the dubbels on the melody of "Ik zag twee beren..". Unfortunately, our commissioner, who was in charge of this song, changed course and moved back, so that at the end of the year the song was still unknown. This year however, the song was introduced to the new dubbels. So if you happen to see dubbels, which is rare since they are always running between lectures or practical's, ask them to sing it for you. And if you are lucky, they will sing it for you.

Activities

On a cold Thursday evening in the beginning of January the first activity took place; the Double Degree Dinner (D3). More than sixty fellow dubbels came to eat pizza. This activity has been a tradition for a while now and we see why. The D3 is the perfect opportunity to catch up with your friends after the oh so needed winter holiday. It was an evening with a lot of laughter, beer and free fizzy drinks (we are still sorry about that!).

After the first event, it was time to think about a new activity. After long hours of thinking it was clear that we wanted to stay close to our roots. Namely, the mafia. What game is better to play than a murdering game also known as "MaPhyA-praktijken". The aim for this game was to "kill" a fellow dubbel. One could kill one another by bringing him with a specific object to a place in Delft or on the campus. Just like that, a murder was committed with a towel in the faculty of Industrial Design. If you were murdered, you had to give your card, that contained all the details of the murder, to your murderer. The dubbel who committed the most crimes won different kinds of, what else could it be? Double beer.

The murdering game was not the only activity where it got nasty. This time the physicists were at odds with the mathematicians and informaticians in one of my favourite activities of the year; the interfaculty pub quiz. The pub quiz was organised in cooperation with the activity committees of both VvTP (AC) and CH (Actie). The aim of the quiz was to determine which study association has smarter students; VvTP or CH. Willemijn, our lovely president of Board 61 and double degree student, and Lauren, a physics student, acted as the quizmasters. The competition was high until the very last moment. Team CH was taking the lead with just a few points. However, the physicists took the victory in the last round. It turns out that CH is not the best at guessing different old(er) songs.



Recently the last activity was held; Fresher's Introduction Activity. In the beginning, there were not many dubbels. However, in the last two years, this course exploded and around fifty new students started each year. Unfortunately, these new students did not all go to the same fresher's weekend, since they went with VvTP or CH, or did not go at all. Thus those fifty students did not know each other, both the boards and both the faculties that well at the start of the year. We, the MaPhyA, came up with a fresher's activity, so that these 'problems' could be solved. Last June we began organising a tour along the board rooms, where they could play a game of twister or chess, and both of the pubs, /pub and TPKV, in which they could get a drink and get to know the other committees a little bit better. After the tour, we wanted to host a BBQ to thank everyone for their work and welcome the new dubbels.

This activity was a huge success. Unfortunately, the weather threw a spanner in the works and we had to cancel the BBQ and we decided to go for the 'classic' pizza with drinks at VVtP. Here we could enjoy playing games of snooker/pool and foosball. Later that evening, we decided to go to the /pub for last drinks as the end of a great year!



CoH Alumni Barbecue

Paul Verkooijen

Hi, we are a committee for Mathematics and Computer Science (and Engineering) alumni of the TU Delft: 'Constantijn Huygens'. While most Alumni (should) know of our existence, a lot of MSc and BSc students haven't heard of us. Therefore, a small introduction in the first edition of this year's MaChazine is in place.

What do we do?

Every year we organize several events for alumni and graduates. Everyone who finished their Bachelors, Computer Science and Engineering or Mathematics, is welcome at our events.

Two of our events return annually, the others differ each year. Our returning events are the CoH Barbeque and the New Year drinks.

At the end of September each year the CoH BBQ takes place. We will have a look at the previous edition in just a moment. The next event will be the New Year drinks and over the year we will probably visit several places for an event. For example, last year we had a presentation about IT in a digital era presented by Digital McKinsey. Afterwards the attendees had the opportunity to share a drink with McKinsey employees. It wasn't just interesting for older Alumni, our younger Alumni had a great opportunity to network and meet new people.

For our members who don't live in the small city of Delft anymore, our events might be interesting as well. The McKinsey lecture for example, took place in Amsterdam. One of our other events took place nearby Delft, in Zoetermeer. The coming years we are planning to have gatherings throughout the Netherlands, so all of our Alumni have the opportunity to visit our events.

While the first part of this page is only meant as a small introduction, a little bit of promotion for our events is permitted too. Every event is free for our visitors, even if you are doing your masters. The drinks are a great opportunity to meet new people, just for fun or for networking. We would gladly see all of our Alumni back at the next event, which will be announced soon on coh.ewi. tudelft.nl!

The previous CoH BBQ

As every year on the last Friday before the start of the Academic Year, a barbecue takes place for the alumni of W.I.S.V. 'Christiaan Huygens'. The weather didn't go easy on us, the last few years. However, this year, finally, the sun was shining! It was almost warm enough to take off our coats. Where last year the barbecues were almost blown away by the wind, this year there was a little breeze which made the temperature perfect. This year was different in a lot of manners. As mentioned, the weather was great, but also the meat was different. This year we got the meat from our good friend Leo. Most of the students will know him for his excellent sandwiches, this quality butcher also provided delightful meat for the barbecue.

This year we had some interesting guests, just like every year. A few months



before the barbecue we were contacted by the president of the Study Visit committee of more than thirty years ago! We were contacted to find almost twenty 'Christaan Huygens' members who went on the Study Visit of 1985, so we could invite them for a reunion during the barbecue. Not all of them could attend, but the few who did really enjoyed the small reunion the barbecue became.

If you are thinking of the good times you had with some committee (members) or a study trip you had several years ago, feel free to contact us! We will gladly help you find old, or even lost, friends for a reunion during one of our events. This year was the first time we reunited old friends and it was well received!

Upcoming events

If you are interested in any of our events, visit our website or email us at coh@ch.tudelft.nl to contact us. If we can help you out with any questions or request, we would gladly do so! Reunions, attending events, changing your address to still receive the MaCHazine, anything is possible. We hope to see you at our next event: the annual New Year drinks!



Business Tour 2018

Yanna van der Vlugt

From the 19th to the 25th of March 2018, thirty Applied Mathematics and Computer Science & Engineering students of W.I.S.V. 'Christiaan Huygens' will embark on the Business Tour: a week-long trip around nine companies in the Netherlands, ending with a weekend abroad. The purpose of this trip is to inspire students to investigate career opportunities by introducing them to interesting businesses. Did you miss the interest

lunch? Read on for a recap!

A week filled with inhouse days

The Business Tour is a unique opportunity for students and companies to get in touch. Students can meet companies for possible internships, thesis assignments or future careers. This will be achieved through two company visits per day, where the group will visit a company for a morning or afternoon to participate in an inhouse day. An inhouse day involves activities ranging from cases to workshops, tours or presentations. Afterwards, we will enjoy a lunch or dinner hosted by the company in order to get to know the employees in a more informal manner.

The companies are specifically selected for diversity and to be interesting to both mathematics and computer science students. Specifically, we plan on visiting Adyen, Bol.com, Deloitte, Deltares, Fox-IT, ING, KPN, Optiver and Shell. Here, we will be exploring themes such as artificial intelligence, cyber security, blockchain, big data, optimization, mathematical modelling, finance and consultancy.

Ending the week in Stockholm, Sweden

Of course, when exploring our future, we shouldn't limit ourselves to only one country. That's why, to finish off the week, we will be visiting Stockholm to explore opportunities in the field of mathematics and computer science there. Today, Stockholm boasts the second most billion-dollar tech startups per capita in the world, second only after Silicon Valley. One of the suburbs of Stockholm, Kista, has recently started profiling itself as Kista Science City, and is now the largest ICT cluster in Europe. It will be a fun and exciting end to the week!

Register now!

The registration for the Business Tour is open till the 26th of November. In order to register you must be a member of W.I.S.V. 'Christiaan Huygens', and:

- A third year bachelor student with at least 90 ECTs, or
- A fourth year (or higher) bachelor student with at least 135 ECTs, or
- A masters student of Applied Mathematics, Computer Science, Computer Engineering or Embedded Systems

Only Computer Science and Engineering, and Mathematics bachelor students can register. As only thirty students can participate, selection of the participants will be done on basis of their CV and a motivational letter.

The Business Tour takes place once every three years, so this is a unique opportunity to explore future career paths with your fellow students! Interested? Check out our website, *businesstour.ch.tudelft.nl*, where you can also find reports about the previous Business Tours. Moreover, feel free to approach one of us with any questions or email us at *bt-extern@ch.tudelft.nl*.



Computer Science





Popularity-based detection of Domain Generation Algorithms

Jasper Abbink

During my thesis, I worked on a new mechanism to detect so called domain generation algorithms (DGAs) in large networks (e.g. the TU Delft network). By the MaCHazine committee, I was asked to write a short summary of what I did during this final step in my education at the TU Delft.

Cyber crime is an ever growing problem in recent years. It has been estimated that in 2013 alone cyber crime cost United States companies and private parties \$100 billion and estimations for 2019 predict that this will rise to over \$2 trillion world wide. These numbers include everything from targeted attacks on companies and governments to large scale broad attacks on personal computing devices, including average desktop computers and laptops, but also routers and Internet-connected "smart" devices (Internet of Things (IoT); e.g. fridges, watches, washing machines). Nowadays, these personal desk- and laptop computers are often targeted to be infected with software that includes the host in a botnet, a network of computers, also called bots, executing tasks as controlled by a central authority. Examples of botnets running on lower level devices are known as well and will probably be used more often in the future. Well known examples of traditional personal computer botnets include Conficker, ZeuS and Torpig. At their peak, these botnets had tens of millions of individual computers infected and were mainly responsible for sending spam messages.

Evolution in Botnet Control

To receive their task, botnets connect to a command and control server (C&C). A basic problem in the deployment of botnets that malware authors (botmasters) face is that they need to find a way so that the distributed clients can find and connect to the C&C server, and although the address is known to anyone in possession of the malware, the channel should not be easily disrupted by network owners or law enforcement. This is for example the case with the most simple way of linking clients to the C&C server by means of a static and hard-coded IP address, which could trivially be blacklisted in firewalls or taken out of circulation by a hosting provider on request from the authorities.

In order to be able to dynamically update the location of the C&C infrastructure, botmasters came up with multiple approaches to dynamically locate the command and control server. The most commonly used techniques observed in practice are:

Use a publicly available website to distribute information about commands to be executed, for example post instructions to a Twitter account.
 Create a distributed network with no clear central authority, comparable to the infrastructure used by BitTorrent.

3. Generate randomized domain names in a regular interval, hence changing the C&C server on a regular basis.

This article will only focus on this third approach. Although a domain can also be seized by law enforcement, the process takes significantly longer, as it may require cross-border actions. The domains at which the C&C server is contacted are computed using a domain-generation algorithm (DGA) based on the current time or some other information publicly available across all hosts, each only valid for a short amount of time. In addition to the short validity, DGAs frequently generate also hundreds of candidate domains per time interval. Infected hosts look up all candidate values to find the domain that was actually registered by the botnet owner, which from a defense perspective makes this mechanism very difficult and costly to suppress, as registering, seizing or sink holing thousands of domain names per day is often too administratively complex, costly or not scalable.

Current DGAs generate domain names by concatenating random letters and morphemes. This has the clear advantage that the resulting domain names are with very high likelihood available, but has the drawback that they leave in the network a characteristic trace of a series of unsuccessful look ups (NXDomains) for domain names, each with a high entropy name such as yfewtvnpdk.info or rwyoehbkhdhb.info that is unlikely requested by normal users. A variation to this from literature, applies this same technique of generating domain names, to generating user names on websites that allow publishing arbitrary data (e.g. twitter.com and github.com). In practice, malware employing this technique has not been observed, yet.

Current detection mechanisms

Domains generated by a DGA currently work by concatenating random characters, therefore domains generated by a DGA have a distinct look compared to domains used by legitimate services. Examples of domains generated by a DGA are hrgcmmihpxth.in, cbkmotlvy.yt and ecsiequ.pm. Approaches have been made to detect botnets by analyzing statistical features of domain names (e.g. domain name length, used top level domain and entropy of the string). While these systems are specifically designed to detect currently known botnets employing DGAs, the assumption is, that they do not perform necessarily (well) for botnets generating domain names that are pronounceable or are created with the help of a (English) dictionary. Other attempts do not make these assumptions, but rely on a fixed periodicity in botnet communication instead. This fixed periodicity can be circumvented by a botmaster randomizing the timing parameters of all bots in such a way that no fixed periodicity can be determined. Research into IRC botnets has already shown that botmasters try to communicate the least amount possible and that botmasters help each other to defeat new detection mechanisms. Therefore my assumption while starting the work on my thesis was, that if a DGA were designed that reduces the obvious linguistic red flags by concatenating valid English words in a non-fixed (time wise) manner.

Proposed alternative method of detection

The key differentiating part of the algorithm presented in my thesis is that no assumptions on the structure and mechanics of the domain name candidates used within the DGA are made. However, implicitly it is assumed that domain





Figure 1: Amount of times a domain was accessed on a daily basis for google.com (top) and facebook.com (bottom). Weekends are indicated by vertical lines.

names used for botnets are only used for a short period of time, as long-term malicious domain names would otherwise be trivially filtered by a defender. As the adversary will avoid this situation, DGA-based DNS traffic will be transient. Therefore, the idea is to calculate the popularity of domain names and detect sudden increases and decreases of traffic over multiple days. This allows for a very simplistic, yet efficient method in detecting DGA anomalies. Examples of legitimate popularities can be seen in figure 1. Shown are the popularities of the domain names google.com and facebook.com on the TU Delft network for two weeks in January of this year. Even though the absolute popularity greatly differs, the same pattern can be seen in both plots. Contrary to this, the popularity of a domain belonging to a small DGA can be observed in figure 2.

Related host detection

After this filtering step, the harder problem can be approached: matching domains of the same DGA together in order to find the entire set of infected hosts



Figure 2: Amount of times a DGA domain was accessed on a daily basis. Weekends are indicated by vertical lines.



Figure 3: Method used to find IP addresses I' broadly related to a domain D. In this figure, D is indicated in blue, D' in red and blue. The elements of set I are colored orange, I' yellow and orange.

contacting these domains. To do this, the list of domain names is filtered to only include those that are only requested on one to three consecutive days and not before or after that. From these remaining domains, all IP addresses that requested similar domains are looked up. The rationale behind this approach is to not miss any domains contacted by a DGA contacting domains in a locally random order which might not get contacted by all infected hosts. If this would not be done, these domains would still get recognized as malicious, but cannot be clustered together as belonging to the same botnet afterwards. A drawback of this method is that unrelated domains can easily be involved into a cluster consisting of DGA domains.

In practice, the list of related hosts is found in the following way: Given a domain D:

- 1. Find all IP addresses I that requested a domain D
- 2. Find all domains D' requested by all IP addresses in I
- 3. Find all IP addresses I' that requested domains in D'

A visual representation of this process is given in figure 3. After this process, the algorithm has a list of domain names with corresponding sets of hosts. Another description of this process can be described as having a bipartite graph, with one set of vertices representing all suspicious domain names, and another disjunct set of vertices representing the hosts requesting these domain names. Then, retrieving the set of broadly related hosts I' for any suspicious domain D can be interpreted as traversing the graph in a breadth-first manner starting with a single suspicious domain from D and going to a depth of three, halting in the set representing the hosts, this process is stopped and all marked vertices define the set I'. All vertices are unmarked again, and the process repeats for the next suspicious domain.

After traversing through this graph once for each domain name, the resulting sets can be searched in order to match similar sets together. Unfortunately, this requires a lot more explaining than I am able to fit in this short article. Therefore, if you are interested in reading more about this, you can find a short version of my thesis in the proceedings of the 12th International Conference on Availability, Reliability and Security [1].

References

 Jasper Abbink and Christian Doerr. Popularity-based Detection of Domain Generation Algorithms. In Proceedings of the 12th International Conference on Availability, Reliability and Security - ARES '17, pages 1–8, New York, New York, USA, 2017. ACM Press.



BEPSys 2.0: Getting the bachelor project system back on track

Floris Doolaard

In the very last quarter of the three year degree programme, the Computer Science and Engineering Bachelor is concluded with one final project: the Bachelor Project. In this project bachelor students team up and solve a real world problem provided by a 'real world' client, such as a company or a research group within the TU Delft. This problem ranges from designing theoretical algorithms for planning and scheduling to developing new software that automatically mines bitcoins or serves you tea whenever you desire some.

In the 2016-2017 academic year, one of the available projects was BEPSys 2.0, provided by Otto Visser on behalf of the education innovation project at the TU Delft. This project was chosen to be the bachelor project for students David Alderliesten, Floris Doolaard, Jesse Tilro, and Niels Warnars. The supervisor for the project was Alessandro Bozzon, the final assessor was Huijuan Wang.

BEPSys: Out with the Old?

The BEPSys system provides a central location for all Computer Science bachelor projects to be administered. Research groups and external companies (non-TU companies) can provide their projects, and after coordinator approval, students can select them when they take the course (the Bachelor Project). The previous version has been utilized for a few years, but began to show issues both in implementation (the system was not secure, initial experiments allowed us to hijack user accounts and escalate account privileges) and logistics (e.g. the course demands new variables such as different starting dates due to student expansion). Thus, due to the large amount of changes and a lack of safety in today's web environment, the system required a major update.



Figure 1: BEPSys allows TU Delft staff, students and external company representatives to coordinate their efforts.

The team decided to create a new system: BEPSys 2.0. This system had to be the spiritual successor and feature support for increased safety, the new TU single sign-on environment, and support a change in logistics and course setup. Students had to be able to select courses and timelines to see projects, and companies needed to be able to offer multiple projects and maintain their projects. All of this came alongside requests from the teaching staff for better administrative support and convenience features.

Research

There was a clear and strong focus on the implementation for the project, mainly invoking the skills we had obtained in the field of software engineering. This was due to the fact that there were many demands for new features of the system. This posed a minor challenge for us to select suitable research methods and topics to incorporate into the process. A large part of the research we ultimately conducted was the requirements elicitation, which we performed through a series of informal interviews with a diverse collection of stakeholders: the administrator, the study counselor, external company representatives, coordinators, coaches and students. Afterwards we aggregated these requirements and administered them through issue tracking software. In addition we put effort into designing and documenting the system, using various forms of modelling that are specifically relevant in the field of web engineering and data modelling (e.g. an entity relationship model, business process model and notation and mockups of the user interface).

Not only technical aspects were researched, but also the social aspects of the product had to be addressed. Group formation was the main topic in this area. According to research, creating random groups introduces slackers into the team, people who will do less than the average of the team. Thus, it was decided to create a group formation functionality. One idea was to provide a form to every individual student in which they are prompted for personal preferences (e.g. desired projects), and subsequently match students based on this information. However, this was too time consuming to implement. Letting people create their own groups and choosing their own projects seemed to suite the most. This meant we had to implement functionality for inviting other group members and coaches. When a group has been formed a First Come First Serve approach will be used for the final admission of a group to a project. Finally we worked on selecting suitable technologies for the implementation, along with justifying their employment.

BEPSys: In with the New!

The new version of BEPSys was developed in a Ruby on Rails language / framework combination. The Bootstrap 3 layout framework was used for building the web interface. The Rails framework implements the Model View Controller design pattern, which allows to conveniently separate the concerns of the data entities, the user interface and their interconnection over distinct components, which is particularly useful for web information systems. When a request is made to the web server, this is first handled by the router component of the framework. The router will map the path in the URL to the controller action responsible for handling the request. We tried to construct the routes and controller actions such that they adhere to the REST architectural style. The following table shows an example of routes leading to a certain action in the controller.

HTTP Verb	Path	Controller#Action	Used for
GET	/photos	photos#index.	display a list of all photos
GET	/photos/new	photos#new	return an HTML form for creating a new photo
POST	/photos	photos#create	create a new photo
GET	/photos/:id	worka@actoring	display a specific photo
GET	/photos/.id/edit	photos#edit	return an HTML form for editing a photo
PATCH/PUT	/photos/.id	photos#update	update a specific photo
DELETE	/photos/:id	photos#destroy	delete a specific photo

Figure 2: Routes which transform a server request to a specific controller action.

The controller will then request data from Models depending on which controller action was selected. These Models represent entities that are persisted in the database. Finally, the controller will render a view with the necessary data from Models and send it back in response to the original request. A positive aspect regarding Rails is that models can still be accessed from within the views, such that not all data necessarily have to be injected via the controller.



Figure 3: The Request-Response Cycle Source: https://www.codecademy.com/articles/request-response-cycle-dynamic

Many of the functionalities were efficiently implemented by using extensions for the Rails framework in the form of Ruby gems, which are maintained by the open-source community. These gems ranged from providing technicalities like abstractions for implementing a certain design pattern, to components for building the web interface. For example, user authentication was handled by a well-developed plugin, Devise, which provided bcrypt support and ensured encryption standards were met. This meant that the team did not have to develop a security implementation themselves, which could introduce additional bugs or vulnerabilities.

Features: Fresh Paint, Recycled Cogs

After a development timeline of 10 weeks, a new version of BEPSys was completed. This new version provides many new features which were implemented according to the requirements of the stakeholders. If a feature existed in the old system, it has remained the same or has been enhanced in this new version.

As mentioned, group formation is an important part of the system. In the old system it was often the case that unwanted people joined in on projects, which meant it was hard to form a real group. However, it is now possible for students to create their own groups and remove members if needed. To meet the requirement of finding a group there is also a 'Looking for group' section, both for students and for coaches. The first groups that have a certain number of members will be eligible to join a project and after approval of coordinator and client they can start working on the project.



Figure 4: Screenshot of the view listing the groups for a project

Students will need approval in order to join the Bachelor Project. Previously the study counsellor had a lot of work dealing with all the paperwork involved with the approval process. To make the process of enrolling for a course (edition) more convenient for both students and staff, it was digitized and integrated with the system. Along with this, import and export functionalities have been introduced allowing OSIRIS grading and entrance lists to be utilized and instantly imported into BEPSys. The old system accommodated for only one course or course edition. It is now possible to create multiple courses and course editions in BEPSys, which gives the opportunity to set course variables such as the number of people that can join a group. This feature also allows the system to scale to other faculties as each course can be used in parallel.

Release the Beast

The new implementation of BEPSys is being released this year, and the departments are currently working on setting it up. The first batch of students using it will be this year's third year computer science students. Plans for future development indicate that this platform may be expanded as a thesis selection tool for Masters across the TU Delft.

More Information

For additional and more detailed information, the entire technical report can be found at the TU Delft's official repository: https://repository.tudelft.nl/islandora/object/uuid:6f06fe0a-c9a7-4c5a-8bba-3d8de901be8a. If you have any further questions, feel free to send a message to one of the team members using their TU Delft e-mail address.



















Mathematics





You stumble on a sequence of integers, e.g., 1, 6, 21, 107. What is the next term? Where does this sequence come from? Usually there is more

than one answer to these questions. We tell you here the best way to

find these answers.

We enter the sequence 1, 6, 21, 107 into OEIS, which is short for the 'On-Line Encyclopedia of Integer Sequences'. The result is that we learn that 1, 6, 21, 107 is uniquely attached to the Busy Beaver problem—and the next term is not known.

OEIS started as a sequence database begun by Neil J. A. Sloane in early 1964 at AT&T. A book appeared in 1973 ("A Handbook of Integer Sequences", Academic Press, NY). The book contains 2372 sequences. In 1996 the On Line Encyclopedia of Integer Sequences® (OEIS®) appeared on the Internet.

How does it work?

1) Go to the OEIS website: oeis.org

- 2) Type in your sequence
- 3) Wait

THE ON-LINE ENCYCLOPEDIA OF INTEGER SEQUENCES® Bonded in 1943 (5 N 1.4. Show

The On-Line Encyclopedia of Integer Sequences® (OEIS®)

These sequence, well as supervisedent EXAMINATION CONT FORMER AND ADDRESS AN

ICS

ple, if you submit the sequence 1,1,2,3,5,8,13,20, you find 11 answers from Round(226*phi^n) to Dying Rabbits. If you want to reduce the number of answers you will have to find the next terms of the sequence, and submit the longer sequence.

The sequences are identified by the letter A, followed by a six digit number. You can register, and submit a sequence yourself. It would be nice to hit sequence number A300000.

Here is some history: A100000: submitted by Dirk Huylebrouck, Nov 07 2004; A200000: submitted by Jon Wild, Nov 20 2011; A292420: submitted by Michael Somos, Sep 16 2017.

Not only integers....

Suppose you do a numerical experiment with outcome a number in seven decimals: r = 1.5707963. You have reason to believe that this is not any number. Here OEIS can be useful for you: turn x into an integer sequence! We do a search for 1,5,7,0,7,9,6,3.

The output from OEIS:

Displaying 1-3 of 3 results found. page 1

A019669 Decimal expansion of Pi/2.

1, 5, 7, 0, 7, 9, 6, 3, 2, 6, 7, 9, 4, 8, 9, 6, 6, 1, 9, 2, 3, 1, .. N.B. The OEIS search engine will convert numbers containing decimal points into digit sequences automatically, so you can type 1.5707963 directly.

Example: Ternary Thue-Morse

An interesting way to generate sequences is by substitution. There are hundreds of such sequences in OEIS. Here is an example. Take an alphabet of three letters $\{a, b, c\}$. A substitution replaces letters by words, for example: $a \rightarrow abc, b \rightarrow ac, c \rightarrow b.$

Starting with a we obtain longer and longer words by iterating the substitution:

 $a \rightarrow abc \rightarrow abcacb \rightarrow abcacbabcbac \rightarrow \dots$

Where is the integer sequence? Replacing a by 0, b by 1 and c by 2, we obtain the infinite sequence

 $x = 0, 1, 2, 0, 2, 1, 0, 1, 2, 1, 0, 2, \dots$

In OEIS:

A036580

Ternary Thue-Morse sequence: closed under a->abc, b->ac, c->b

0, 1, 2, 0, 2, 1, 0, 1, 2, 1, 0, 2, 0, 1, 2, 0, 2, 1, 0, 2, 0,... There is something arbitrary about the alphabet $\{0, 1, 2\}$, and also about the choice of the letters in the substitution. If we exchange 0 and 1, we get an infinite sequence 1,0,2,1,2,0,1,... which is essentially the same. Neil Sloane has personally added all 12 versions of the ternary Thue-Morse sequence to OEIS, exhausting all 3! permutations of the letters of the two alphabets 0,1,2and 1,2,3.

Will OEIS explode?

Here is a sequence on an alphabet of six letters:

 $x = 1, 4, 2, 1, 6, 3, 5, 4, 2, 3, 5, 6, 1, 4, 2, 1, \dots$

It is generated by the (square of the) substitution on six letters given by

 $1\rightarrow 23,\ 2\rightarrow 14,\ 3\rightarrow 21,\ 4\rightarrow 56,\ 5\rightarrow 63,\ 6\rightarrow 54.$

It is a (mildly) interesting sequence, see [1].

Is somebody going to put all 6!=720 versions, times two = 1440, into OEIS?! Here is a proposal (cf. [3]) to dispose of this problem:

For any 'symbolic' sequence on c symbols take the alphabet $\{1, 2, \ldots, c\}$, and put the *lexicographically smallest* sequence into OEIS.

I proposed this in August 2016 to Neil Sloane in an email. His reaction was "Nice idea!", but as yet it has not been implemented....

Sturmian sequences

A Sturmian sequence is a sort of opposite of a random sequence (after the periodic sequences): for every natural number n it contains only n+1 different subsequences of length n. Taking n = 1 we see that it must be a sequence on an alphabet of two letters, say, $\{a, b\}$.

EXAMPLE: The "Fibonacci word" x = a, b, a, a, b, a, b, a, a, b, a, a, b, a, ... which is generated by the Fibonacci substitution $a \rightarrow ab, b \rightarrow a$.

QUESTION: Are there more Sturmian sequences generated by substitutions?

Take the two substitutions (the second is the 0-1-version of the Fibonacci substitution) $% \label{eq:constraint}$

$$\varphi_0: \ \begin{cases} 0 \to 0 \\ 1 \to 01 \end{cases} \qquad \varphi_1: \ \begin{cases} 0 \to 01 \\ 1 \to 0 \end{cases}.$$

You can compose substitutions, just like functions. For example: $\varphi_0\varphi_1(0) = \varphi_0(01) = 001, \ \varphi_0\varphi_1(1) = \varphi_0(0) = 0, \text{ giving}$

$$\varphi_0\varphi_1: \begin{cases} 0 \to 001 \\ 1 \to 0 \end{cases}, \text{ which generates } x = 0, 0, 1, 0, 0, 1, 0, 0, 0, 1, 0, \dots \end{cases}$$

FACT: Any composition of these two substitutions (excluding the powers of φ_0) generates a Sturmian sequence (see Chapter 2 of [6]).

Form a tree of substitutions by putting $\varphi_{i_n}\cdots \varphi_{i_1}$ at node $\underline{i}=i_1\ldots i_n$:



QUESTION: Are substitutions at different nodes always different? Fancier: do the two substitutions generate a free semigroup?

A tree is not a sequence...but we might look at all the nodes at a fixed level, say level 3. A substitution is not an integer...but we might add the lengths of the two words $\varphi(0)$ and $\varphi(1)$ (fancier: we can take the L₁-norm of the incidence matrix of the substitution φ). For the first 4 nodes at level 3 we then obtain the sequence 5,7,7,8.

OEIS: Search: seq: 5,7,7,8

Displaying 1-10 of 261 results found.

That is too many results. So we go to level 4 of the tree! Easy computations give

$$0^{\phi_0\phi_0\phi_0\phi_0} = \{1 \to 00001, \phi_0\phi_0\phi_0\phi_1 = \{1 \to 0101010, enclosed \}$$

You may check that the sum of the lengths of the substitutions at the first 8 nodes 0000 till 0111 at level 4 are: 6, 9, 10, 11, 9, 12, 11, 13.

This time we only find four results in OEIS, one of them looking particularly interesting:

A086593 Bisection of A086592, denominators of

the left-hand half of Kepler's tree of fractions.

Here bisection means that you only take the odd numbered terms, i.e., A086593(n) = A086592(2n-1).

Kepler's tree of fractions

What is Kepler's tree of fractions? It is again a binary tree with at every node a fraction p/q, where p and q are positive integers. A node has two childern labeled with fractions as follows:



The first three levels of the tree- starting with 1/2 in the root:



Note how you can read off the denominators of the odd nodes at level four: $6 = 1 + 5, 9 = 4 + 5, 10 = 3 + 7, 11 = 4 + 7, \ldots$

Below you see the page with Kepler's tree from his book "Harmonices mundi". For a translation see [2].

prà pro numeratore, &	unitasinfrà pro deno	imi.	1	CAP. IL.
natore : deinde uterqu	numerus feorlim pon	ine	25	7
fuprà, & fumma utriul	quutrinquinfrà : ut ex	iona 👘	55	4.10
qualibet fractione due	oriantur rami . co	ulq	2 21	All Vantage
oom ex tumma flat nu	merus muex nguræn	ide-	+ 4	70
rocentratins,		G	5	9
Hasfeltiones	chorder (entern	aria 1		the state
and and in the index into	enorma reptem	mucha he	Barne	7 Californ
funt Harmonie non m	aiores una Disnaton.	no. i li	Condi L Inno	nerg horse
ftea caulas & fectionum	fingularum, & unive	ria.	Burn 16	7 intents,
rum Numeri, non line la	bore expenitillimis (ico-	5 Charles	A.
metriz fontibus erui.	Legat curiotus led	tor,	5 3 1	200
qua de his fechionibe un	te annos ze. fcripfi m	My_	1	1
fterio Colmographico,	Capite XII, & perpen	dat, I	55 .	100
quomodorucrim ilio lo	co hallocinatus luper	Call- 3 14	mi ST T	2/1
infectiouum & Harme	smarum (perperain r	INCO.		-

One can prove that all fractions on Kepler's tree have relatively prime denominators and numerators, and that any such fraction in the interval (0,1) occurs uniquely on the tree. This appeared to be very useful in analysing the tree of Sturmian substitutions. In particular this can provide the answers to the two questions on the left—see [4].

Challenge

There are thousands of conjectures in OEIS. Show that the two sequences A171588 Fixed point of the morphism 0->001, 1->0. Pell word.

and

A289001 Fixed point of the mapping 00->0010, 01->001, 10->010, starting with 00.

are the same sequence (conjectured by Richard Mathar, July 07 2017).

N.B. Here 'morphism' is a synonym for 'substitution', and the mapping in A289001 works by cutting a word into words of length 2, and then replacing each of these according to the given 2-block substitution—ignoring the last letter if a word has odd length.

References

- E.M.Coven, F.M.Dekking, and M.S.Keane, Topological conjugacy of constant length substitution dynamical systems, Indagationes Mathematicae 28 (2017) 91-107.
- [2] Johannes Kepler with E.J.Aiton, A.M.Duncan, and J.V.Field, trans., The Harmony of the World (Philadelphia, Pennsylvania: American Philosophical Society, 1997).
- [3] F. Michel Dekking, Morphisms, symbolic sequences, and their standard forms, Journal of Integer Sequences 19 (2016), Article 16.1.1, 1-8.
- [4] F. Michel Dekking, Substitution invariant Sturmian words and binary trees, preprint (2017), arXiv:1705.08607.
- [5] Johannes Kepler, "Harmonices mundi", Book III, 1619.
- [6] M. Lothaire, Algebraic combinatorics of words, Cambridge University Press, Online publication date: April 2013 Print publication year: 2002.



Joris Bierkens

Performing numerical computations with random variables is not as

straightforward as you might think. But, Markov chains come to our

rescue.

In various scientific areas such as statistical physics, statistics, machine learning and data science, it is often necessary to compute an expectation, which is essentially the same as computing an integral. For example, suppose we have a system of particles with random positions $\boldsymbol{X} = (X^1, \ldots, X^n) \in \mathbb{R}^n$, where n is large. Let's call π the probability density function of \boldsymbol{X} and suppose we wish to compute $\mathbb{E}_{\pi} f(\boldsymbol{X})$ for some function $f : \mathbb{R}^n \to \mathbb{R}$ that we care about. Then

$$\mathbb{E}_{\pi}f(\boldsymbol{X}) = \int_{\mathbb{R}^n} f(\boldsymbol{x})\pi(\boldsymbol{x}) \, d\boldsymbol{x}.$$

Computing such an integral even approximately on a computer is very costly: it typically scales exponentially in the dimension n. This is not too difficult to see, because we would use some n-dimensional discrete grid of values of f(x) and $\pi(x)$, and if we take k grid points in every dimension, there will be k^n grid points to process. Even for moderately sized systems (take k = 10, n = 120), such a computation is impossible on a computer: indeed, if every atom in the universe were a supercomputer it would take longer than the age of the universe to perform this computation.

There is however, a wonderfully simple alternative. Instead of discretising the integral, we simply draw random independent samples X_1, \ldots, X_k from π . We can then use the law of large numbers,

$$\lim_{k \to \infty} \frac{1}{k} \sum_{i=1}^{k} f(\boldsymbol{X}_i) = \mathbb{E}_{\pi} f(\boldsymbol{X}),$$
(1)

which says that if we use sufficiently many samples, the average becomes an arbitrarily good approximation of the expectation we wish to compute.

Problem solved! Or not? One of the crucial remaining problems is that it is not so clear how to draw a sample from π . Let me explain how this can be done, in principle, in one dimension. If we know the cumulative distribution function Π of π , and we can generate a uniform random variable U in the interval (0, 1), then $\Pi^{-1}(U)$ has density π (to show this is an exercise; look up the definition of the cumulative distribution function if you forgot!). So if we have access to Π^{-1} then we are done once we can generate random variables $U_i \sim \text{Uniform}(0, 1)^1$: we define $X_i = \Pi^{-1}(U_i)$ and there we have our samples. This is nice, but in multiple dimensions this trick does not work anymore. What can we do? Now things become really interesting. We design a Markov chain which has π as its stationary density. If you don't know, a Markov chain is a random process, with values $oldsymbol{X}_0, oldsymbol{X}_1, oldsymbol{X}_2, \dots$, which makes random transitions. The next transition is chosen randomly conditional only on the current position of the chain. If our current state is x_i , our next state Yhas distribution p(x, dy), where p is called a *Markov transition kernel*. Then, what does it mean that π is stationary? Well, if the starting value X_0 of our Markov chain has distribution π , we want that the distribution at any future time, say of $oldsymbol{X}_i$ for $i\in\mathbb{N}$, is still $\pi.$ One of the wonderful properties of Markov chains is that if π is stationary² the probability distribution of $oldsymbol{X}_i$ converges to π , regardless of the initial value $oldsymbol{X}_0$. Even then it is remarkable that we can now use the values $(\pmb{X}_1, \pmb{X}_2, \dots)$ of the Markov chain in (1). Why is this remarkable? Well, the $oldsymbol{X}_i$ are not independent, and furthermore if we start from some arbitrary initial value X_0 , the X_i are not exactly distributed as π . But still it can be proven that (1) is true!³

If you followed the story thus far, hopefully you agree that we have transformed the problem of computing $\mathbb{E}_{\pi} f(\mathbf{X})$ to the problem of designing an ergodic Markov chain with stationary distribution π . It is not clear that we can design such a Markov chain. But let me reassure you. This is almost always possible, and usually in many, many ways. The big breakthrough in this field came in 1953, when N. Metropolis and his co-authors published the following simple trick [2]. First take a Markov chain in \mathbb{R}^n , with transition kernel $q(\mathbf{x}, d\mathbf{y})$ having a continuous density, i.e. $q(\mathbf{x}, d\mathbf{y}) = q(\mathbf{x}, \mathbf{y})d\mathbf{y}$. Let us assume for simplicity that q is symmetric in \mathbf{x} and \mathbf{y} , so that $q(\mathbf{x}, \mathbf{y}) = q(\mathbf{y}, \mathbf{x})$. For example, we take a Gaussian density centered at \mathbf{x} ,

$$q(\boldsymbol{x}, \boldsymbol{y}) = \frac{1}{\sqrt{2\pi\rho^2}} \exp\left(-\frac{1}{2\rho^2} |\boldsymbol{x} - \boldsymbol{y}|^2\right).$$
(2)

Starting from a point X_0 , we randomly *propose* a new point Y according to the distribution q. Now we are randomly going to *accept* Y as our new position X_1 with probability

$$\alpha(\boldsymbol{X}_0, \boldsymbol{Y}) = \min\left(1, \frac{\pi(\boldsymbol{Y})}{\pi(\boldsymbol{X}_0)}\right).$$

If we do not accept Y, then we assign the old position, so $X_1 := X_0$. This funny game in fact defines a Markov chain, since conditional on X_0 we have some probability distribution on where we go next. And if you look at the acceptance probability, it makes sense. If our random variable Y increases the value of π , then we will always accept Y, so we are inclined to move to regions of high probability π . However, if the proposal Y decreases the value of π , we might still accept Y. It can be shown that the resulting Markov chain indeed has π as stationary distribution.

¹Since a computer is a deterministic machine, this is strictly speaking somewhat problematic, but at least we can generate *pseudo-random numbers* which have all the essential properties of uniform random variables.

²Under some mild conditions that I won't go in to.

 $^{^3\}mathrm{Again},$ under some reasonable conditions, which we call $\mathit{ergodicity}$ of the Markov chain.

The discovery of this algorithm, which is called the *Metropolis(-Hastings) algorithm* initiated a complete research area called *Markov Chain Monte Carlo* (*MCMC*). You may think that we are done now that we have this algorithm, but to this day there are important problems remaining. One of these is that the quality of the approximation (1) crucially depends on the type of proposal q we are making. For example, if q proposes very small steps, then we are quite likely to accept our proposals as long as π is continuous (why?), but the resulting values X_1, X_2, \ldots will be highly correlated, with the effect that the convergence in (1) is slow. On the other hand, if q proposes very big steps, then we may well reject most of the proposals because the acceptance probability becomes too small. Again the convergence in (1) will be slow. We want to propose moves that have the optimal size: It has been shown theoretically that in this case an average acceptance probability of 0.234 is ideal! See Figure 1 for an example.



Figure 1: The Metropolis algorithm applied to a standard normal 2D Gaussian density, with a Gaussian proposal given by (2). The figures on the left are plots of the trajectory of the Markov chain along with a contour plot of the density. On the right you find plots of the averages $\frac{1}{k} \sum_{i=1}^{k} f(\mathbf{X}_i)$ as a function of k, where $f(\mathbf{x}) = \|\mathbf{x}\|^2$ as an example. In the top row, the step size $\rho = 0.05$ (too fine, slow exploration), the second row has $\rho = 10$ (too coarse, few

accepted moves), and the third row has $\rho = 2.5$ (close to optimal). Convince yourself that in the bottom row the averages converge to the correct value.

This is just an example of the type of questions you run into. As I wrote, there are many ways to design Markov chains which have the correct stationary distribution, and we wish to find the best one: i.e. the one which has the fastest convergence in (1). In my own research I am using a recently discovered type of Markov processes: so called *piecewise deterministic Markov processes* [1]. These travel for a random amount of time in a fixed direction, until changing direction, see Figure 2 for an example. If you are interested in this, don't hesitate to come and talk to me! If you want to read more, I propose for starters you look at [3].



Figure 2: An example of a piecewise deterministic Markov process is the Zig-Zag process which moves in directions within the discrete set $\{-1,+1\}^n$, where n is the dimension.

References

- J. Bierkens, P. Fearnhead, and G. O. Roberts. The Zig-Zag Process and Super-Efficient Sampling for Bayesian Analysis of Big Data. arXiv preprint arXiv: 1607.03188, 2016.
- [2] N. Metropolis, A. W. Rosenbluth, M. N. Rosenbluth, A. H. Teller, and E. Teller. Equation of State Calculations by Fast Computing Machines. *The Journal of Chemical Physics*, 21(6):1087, 1953.
- [3] G. O. Roberts and J. Rosenthal. General state space Markov chains and MCMC algorithms. Probability Surveys, 1:20-71, 2004.

Mathematics



Power estimation in wheelchair basketball

Mirrelijn van Nee

Winning in sport events is difficult without the right training and equipment. Professional athletes often have a whole team of experts consulting them on optimising different aspects to achieve the best results. This professional approach is emerging in wheelchair sports such as wheelchair basketball. Small sensors can nowadays be used to gather a lot of data about the movements of the wheelchair with the athlete. You can imagine that it might be useful to know the top and average speed or acceleration, how many times someone rotates left or right, how much energy each match costs and many other things. For my graduation project I developed a model to extract the power from the data.

If you still remember some basic physics from highschool, you might remember that the power can be defined as a flow of energy. With Newton's laws, it isn't too hard to derive the so-called *power balance equation* for a simple representation of the power in wheelchair basketball:

$$P_{ext} = (F_{roll} + F_{air} + m \cdot a) \cdot v, \tag{1}$$

where P_{ext} is the external power, F_{roll} the rolling resistance on the wheels, F_{air} the air resistance, m the mass, a the acceleration and v the velocity of the athlete with wheelchair. We use the parameters τ and K to model the rolling and air resistance: τ is equal to the rolling resistance F_{roll} on both wheels and the air resistance is given by $F_{air}=Kv^2$.

Whereas we can derive the velocity and acceleration from the data of the sensors, we will have to estimate the resistance forces before we can compute the power. How can we do that? Well, we can use *coasting periods* (dutch: uitrolperioden): if someone coasts, he is not pushing or moving in his wheelchair so the external power is 0. So a basic, general algorithm would consist of the following steps:

Algorithm 1 General algorithm for estimating external power

Input: Velocity, acceleration, other model parameters.

Output: External power

- 1: Determine coasting periods.
- 2: Estimate (parameters in) resistance forces based on coasting points or periods.
- 3: Calculate external power at all times with Equation (1).

This naturally leads us to the following questions: how do we determine the coasting periods? And if we know those periods, how exactly do we estimate parameters for the rolling resistance and air resistance?

One of the things I tried and what I will explain here in more detail, was to fit a so-called *Hidden Markov Model* to answer both questions at the same time.



Figure 1: Graphical representation of HMM, [1]

Hidden Markov Models

Hidden Markov Models (HMMs) and variations of them are widely used in several research areas and applications, for example in speech recognition and econometrics, DNA sequencing and tracking. HMMs consist of an unobserved, or *hidden*, Markov process, denoted by $\{X_k\}_{k\geq 0}$ and a sequence of observed variables, denoted by $\{Y_k\}_{k\geq 0}$. The Markov process variables X_k are referred to as *states*. Since the states are hidden, the HMMs are a form of *missing data models*.

HMMs can be graphically represented, giving a quick overview of dependence structures. Figure 1 shows such a representation: the state X_{k+1} depends on the previous state X_k and the observed variable Y_k depends on the state X_k at time t_k .

A formal definition of a basic HMM is as follows:

Definition 1. A Hidden Markov Model is a bivariate discrete time process $\{X_k, Y_k\}_{k\geq 0}$, where $\{X_k\}_{k\geq 0}$ is a Markov chain and, conditional on $\{X_k\}_{k\geq 0}$, $\{Y_k\}_{k\geq 0}$ is a sequence of independent random variables such that the conditional distribution of Y_k only depends on X_k .

The model gets a bit more complicated if we add directed arrows between the observed variables as well, as shown in Figure 2. This type of model is known as a *switching* HMM, with formal definition:

Definition 2. A switching HMM is a bivariate discrete time process $\{X_k, Y_k\}_{k \ge 0}$, where $\{X_k\}_{k \ge 0}$ is a Markov chain and $\{Y_k\}_{k \ge 0}$ is a sequence of random variables such that the conditional distribution of Y_k only depends on X_k and Y_{k-1} .

HMM applied to our data

With that bit of theory in the back of our mind, we can construct an HMM for the sensor data. Remember, before we can estimate the external power, we need to estimate coasting periods and resistance parameters. Given the *state* (x_k) coasting/not coasting, we can say something about how the *observed* speed (v_k) will change. If someone is not coasting, (s)he is either accelerating, braking, rotating, or (s)he might be standing still. Let's assume that if someone is not coasting, then the speed will change randomly.

However, if someone *is* coasting, the speed at some time t_k will not change randomly but it will decrease by some rate (acceleration a_k) depending on the resistance forces, with possibly still some measurement noise.





Figure 2: Graphical representation of switching HMM, [1]

Transforming this idea into formulas leads to the following model for our data:

$$\begin{split} &\{x_k\}_{k\geq 0} \text{ is a Markov process,} \\ &v_k | v_{k-1}, x_k \sim N(\bar{\mu}_{x_k}, \sigma_{x_k}), \\ &\bar{\mu}_{x_k} = \begin{cases} v_{k-1} & \text{if } x_k = 1, \\ v_{k-1} - \frac{\bigtriangleup t}{m} \left(\tau + K v_{k-1}^2\right) & \text{if } x_k = 2, \end{cases} \end{split}$$

where the state variable $x_k = 1$ for not-coasting, $x_k = 2$ for coasting, v_k is normally distributed with some standard deviation σ_{x_k} dependent on the state x_k and mean $\bar{\mu}_{x_k}$. For not-coasting periods $(x_k = 1)$, the mean is the previous speed v_{k-1} , representing a random walk. For coasting periods $(x_k = 2)$, the mean is the previous speed plus the time step Δt times the acceleration $a_k = -\frac{\tau + K v_{k-1}^2}{m}$, representing a random walk with drift.

I used a Bayesian approach to derive estimates for the parameters. In Bayesian statistics, you don't see a model parameter as a deterministic fixed value, but rather as another random variable that has some probability distribution. *A priori* (so before we've used any data), we assume that the model parameters follow some distribution, the prior distribution. We impose the following prior distributions on the model parameters:

$$(q_{i1}, q_{i2}) \stackrel{i.i.d.}{\sim} Dir(\delta_1, \delta_2), \ i = 1, 2,$$

$$\tau \sim U(\alpha_{\tau}, \beta_{\tau}),$$

$$K \sim U(\alpha_K, \beta_K),$$

$$\sigma_i^2 \stackrel{i.i.d.}{\sim} IG(\kappa, \gamma), \ i = 1, 2,$$
(3)

with Dir the Dirichlet, U the Uniform and IG the Inverse Gamma distributions.

Once we have data, we infer parameter estimates on the *posterior* distribution (P(parameters|data)). We cannot derive the posterior distribution analytically, but we can use a *Gibbs sampler* to approximate it. I won't go into further detail here, but I can really recommend the master course Statistical Inference if you'd like to know more about Bayesian statistics.

Some results

With estimates for the model parameters τ and K from the Gibbs sample, and the observed data v and a, we can fill in Equation (1) to derive an estimate for the power. Furthermore, we can use credible sets of the Gibbs sample to compute the uncertainty in the power estimate propagated from the uncertainty in the parameter estimates.

Figure 3 shows the power measured with a smartwheel and the estimated power (red) with uncertainty intervals too narrow to be clearly visible on this scale. The peaks corresponding to pushes are clearly visible. There is some difference in fluctuation of the power and the negative peak just before a push, which can be explained by a slight difference in the power that is measured and that is estimated: the smartwheel registers power only when force is exerted on the



Figure 3: Blue: measured power. Red: estimated power



Figure 4: Segmented speed in circuit data. Blue: not coasting $(x_k = 1)$. Red: coasting $(x_k = 2)$

handrims of the wheels, but the estimated power is modeled differently via the speed and acceleration. Moreover, upper body movements are not measured with the smartwheel, but do influence the external power.

Figure 4 gives an example of how the model segments the speed data in coasting (red) and not-coasting periods (blue). This example shows that the fairly naive Hidden Markov Model –using just two states and random walk with drift to model the speed– is already able to identify the two coasting periods around t = 468 and t = 474. However, it also incorrectly identifies some other periods as coasting periods, biasing the parameter estimates.

The model can be extended to improve the coasting period identification and parameter estimation and with that, improve the power estimation. But for now, the first steps have been taken.

References

 C. Cappé, E. Moulines, and T. Rydén, Inference in hidden markov models (Springer Science & Business Media, 2005).



Levelling the number of required beds in a hospital

Angelica Babel

Last academic year, I ended my bachelor Mathematics with my 'BEP':

bachelor end project. This project is the last thing you do as a bachelor

student and requires all the information you learned throughout the

years. My project was all about the number of required beds at the

holding and recovery department.

1 Introduction

Due to the decreasing number of nurses and the increased workload, it is important to develop methods to reduce this workload and make the lives of the remaining nurses better. When we look at the hospital and we want to reduce the workload there, we need to know what influences this workload. The workload increases when patients arrive or stay at a department at the same time. In other words, when the number of required beds is high. The number of required beds is equal to the number of patients who are at a department at the same time. When the number of required beds is high, the workload is high. When the number of required beds is lower. So, we need to develop methods, such that the number of required beds is lower. We develop methods in which we create a new order of surgeries. A hospital can give a schedule and we can calculate the number of required beds. This new order of surgeries will have a lower number of required beds.

2 Recovery and holding departments

The holding and recovery departments are the departments where the patients stay right before or right after the surgery. In Table 1, the time table for a patient is shown.





3 Number of required beds

There are a couple of things that influence the number of required beds. Firstly, the number of patients who arrive at the holding department is important. When a lot of patients arrive at the same time, the number of required beds at that moment will be high. So, we want to take this into consideration when creating a new order of surgeries. We do this by spreading the start and end times over the day.

Secondly, the length of stay (LOS) of a patient is important. A patient stays a certain amount of time at the holding or recovery department, which depends on the surgery type. Each patient has a certain surgery type, for example a patient gets an surgery for his/her kidney, then this patient has a certain LOS. This LOS is not equal to the LOS for a heart surgery of course, because each surgery has a certain preparation time for example.

LOS depends also on the patient itself, so when patient 1 and patient 2 have the same surgery, their LOS can be different. So, we can not use one specific LOS for each surgery type and need to use something else. We assume that the LOS is stochastic, i.e., we use a distribution which describes the probability a patient leaves the holding or recovery department at a certain time in the time horizon.

4 Calculating the number of required beds

In order to calculate the number of required beds at the holding and recovery department, we need the LOS distributions. The probability that patient $i \in I$, stays m minutes at the holding department has to be determined. Historical data given by a hospital can provide this distribution.

We denote the probability that patient i, whose surgery will be performed in OR k, needs between [n, n + m) minutes of preparation as p_n^i , where m is the length of each interval and n the time. With this, we can determine the probability that patient i occupies one bed at the holding department. We denote this probability as $g_n^{ik}(1)$ which is given by,

$$g_n^{ik}(1) = \sum_{j=n}^{M_i - m} p_j^i.$$
 (1)

where M_i equals the maximum length of stay at the holding department. There is also the possibility that a patient i occupies 0 beds. Because a patient can only occupy one bed or zero beds, $g_n^{ik}(0)$ equals $1 - g_n^{ik}(1)$. The probability that patient i, whose surgery will be performed in OR k, occupies zero beds is given by

$$g_n^{ik}(0) = 1 - \sum_{j=n}^{M_i - m} p_j^i$$
⁽²⁾

We have to shift the distribution in such a way that the probability is in the right order. We want the probability that patient i occupies one or zero beds between [n, n+m) on a specific time t before surgery. This is done by shifting the distribution:

$$\overline{G}_{t}^{ik}(x) = g_{s_{i}-t}^{ik}(x) \quad t \le s_{i}$$
(3)

where s_i is the start time of the surgery performed on patient *i*. The approach introduced by Vanberkel et al. [Vanberkel1] calculated the number of required beds on a daily basis for a cyclic schedule. We only consider the bed occupancy distribution for one day which is given per time period.

Next, the combined probabilities of all the patients in OR k is obtained by taking discrete convolutions. This is the probability distribution of the bed occupancy at each moment t over the whole day resulting from OR $k \in K$ and is given by G_t^k :

$$G_t^k(x) = \overline{G}_t^{1k}(x) * \overline{G}_t^{2k}(x) * \overline{G}_t^{3k}(x) * \dots * \overline{G}_t^{|I_k|k}(x)$$
(4)

Because we took the discrete convolutions over all the patients in OR k, the variable x can take up to the number of patients $|I_k|$. The only thing left to do is to combine all ORs. This is done by taking the discrete convolutions of all the $G_t^k(x)$ for all $k \in K$. The obtained distribution is given by,

$$\mathscr{G}_t(x) = G_t^1(x) * G_t^2(x) * G_t^3(x) * \dots * G_t^R(x)$$
(5)

The previous function gives us the probability that there are x beds occupied on time t, but we need the number of required beds. We want a sufficient number of beds available at the holding department. A sufficient number of beds at the department means that there should be at least x beds available at time t. We want the number of required beds at the holding department to be higher than a given probability. This is the probability that there is a sufficient number of beds available at the holding department. We denode this probability as $\frac{p}{100}$. The p can be for example 95%, which means, there is a 95% chance that there will be a sufficient number of beds available. We determine the number x as followed:

$$y = \max_{t \in T_h} \min \left\{ x \left| \sum_{y=0}^x \mathscr{G}_t(y) \ge \frac{p}{100} \right\} \quad \forall t \in T_h \right\}$$
 (6)

After calculating the number of required beds at the holding, the same is done for the recovery department.

5 Changing the surgery schedule

In my thesis, I created two types of schedules. In the first schedules, the start and end times of the surgeries are spread. For the other schedules, the order of the surgeries is obtained by solving an ILP. This ILP minimises the number of required beds at the holding and recovery department using the stochastic LOS.

6 Spreading start and end times

As told before, if a lot of patients arrive at the same time, the number of required beds at that moment will be high. We want to lower the number of required beds, so we try to spread the start and end times. This spreading is done using so called Break-In-Moments. A Break-In-Moment (BIM) is the moment when a surgery starts or ends. In a paper written by Van Essen et al. [Essen1], they determined a couple of solution methods in spreading the start and end times of surgeries over the day. The method uses the interval between two consecutive BIMs and makes sure this interval is equal over the day. Such an interval is called a Break-In-Interval (BII). Spreading the BIMs equally over the day equals spreading the start and end times over the day. The spreading of BIMs does not guarantee the numbers of required beds being levelled, but it may help. There has not been a method presented before, in which the BIMs are spread over the day combined with the LOS. In this thesis, we only use the methods from Van Essen et al. [Essen1], to see if the result helps levelling the number of required beds over the day.

6.0.1 Fixed Goal Values

The 'Fixed Goal Values' is an algorithm that uses a given goal λ to approximate the new BII. This λ is the length of each BII if the start and end times over all the ORs are equally distributed, i.e.,

$$\lambda = \frac{e-s}{1+W-R}.$$
(7)

Here, e-s equals the length of the occupied interval, e the end time of the occupied interval, s the start time of the occupied interval, W the number of surgeries over the whole day and R the number of ORs used over the day.

The algorithm calculates in every step for each patient i in OR k, the end time e_i if it is placed in the schedule, i.e., $e_i = B_k + d_i$, with B_k the end time of the previous surgery in OR k. In the first step, it will calculate the end time if the surgery starts at the beginning of the day, at $B_k = s_k$. Then, the algorithm finds the end time e_i of surgery i that approximates the start time of the occupied interval $s + \lambda$ the best. The start time of OR k will be updated: $B_k = e_i$. In the next steps the end times of each surgery i will be calculated again and the surgery i with the end time e_i that approximates $s + 2\lambda$ the best, will be placed next in the schedule.

We also checked another method, in which λ changes every step. This method is called 'Flexible Goal Values'. The steps are similar to Fixed Goal Values.

7 ILP

ILP is the abbreviation for Integer Linear Program. Simply said, we can formulate a mathematical problem in an objective function with restrictions and variables. These variables are either one or zero and determine the solution. When solving an ILP, the variables are found in which the restrictions are met.

The objective function in my case was to minimise the number of required beds at the holding and recovery department. Because the number of required beds at holding is different from the number of required beds at recovery, we need to do something different. We used a weighted sum method. The objective function was:

$$\min F = q_1 \gamma^1 + q_2 \gamma^2 \tag{8}$$

, in which q_1 and q_2 are both bigger than zero and smaller than one and add up to one. γ^1 and γ^2 are simplified versions of the number of required beds. We needed to come up with good values for q_1 and q_2 . When we choose q_1 and q_2 equal to 0.5, we put more focus at the recovery department, because the number of required beds there is higher than at the holding department. So the new values should put equal focus on both departments. These values are created by making use of the number of required beds at both departments.

8 Results

The solution methods were implemented in MATLAB and were used to create new schedules. These schedules were made by spreading the start and end times or minimising the number of required beds at the holding and recovery departments.

We saw that the spreading of the start and end times does not reduce the number of required beds and that the LOS is the most important. The number of required beds can be lowered making use of the ILP, but finding a solution takes a lot of time.

Overall, this thesis showed that the number of required beds at the holding and recovery department can be reduced. Although the ILP did not provide many solution, the provided solutions did reduce the number of required beds at the departments. This thesis also showed that the number of required beds at the holding and recovery department does not depend on the start and end times of the surgeries. With this, a hospital has the knowledge that the number of required beds can be reduced.

35



Miscellaneous





Historical person: René Descartes

Marjolein Bouwmeester

The first days of academic year 2017-2018 have already been spent in the lecture rooms, with way more to come. I guess one of the fullest lecture rooms for Mathematics is the lecture room where Real Analysis is given. One of the Mathematical legacies on this topic is René Descartes. So let's

talk about him this issue.

René Descartes (March 1596 – February 1650) was a French man with many talents. Next to a mathematician, he was a philosopher and a scientist. It could be possible that his name rings a bell, but I suppose that is because of his contribution to the philosophy. "The father of modern western philosophy" is what he is being called, as a response to his writings, which are studied closely to this day. But also his fingerprint on mathematics is still visible. The Cartesian coordinate system was named after him. And next to a father in the philosophical field, he is also called the father of analytical geometry. Analytical geometry is the bridge between algebra and geometry, used in the discovery of infinitesimal calculus and analysis. And that makes him a perfect person for this issue's Historical Person piece.

A bit about his background. Descartes was born in La Haye en Touraine in France. When he was only one year old, his mother died after trying to give birth to a brother or sister. His father was a member of the Parliament of Brittany at Rennes. Because of the busy life of his father, René lived with his grandmother and great-uncle. In 1607, which was late because of his fragile health, he entered the Jesuit Collège Royal Henry-Le-Grand. Here he was first introduced to mathematics and physics, including Galileo's work. After his graduation in 1614, he studied at the University of Poitiers for two years, in accordance with his father's wishes for him to become a lawyer.

But being a lawyer was not something René himself wanted. He had an ambition to become a professional military officer, so he joined a mercenary in 1618. He joined the Protestant Dutch States Army in Breda under the command of Maurice of Nassau, and undertook a formal study of military engineering, as established by Simon Stevin. Descartes, therefore, received much encouragement in Breda to advance his knowledge of mathematics. He also became acquainted with Isaac Beeckman in this way. Together with Isaac he worked on several writings, such as free fall, catenary, conic section and fluid statics. They both believed that it was necessary to link mathematics and physics.

Next to physics, he also linked mathematics to philosophy. It is said that Descartes shut himself in a room and worked on his three visions. He believed that a divine spirit revealed a new philosophy to him. When he came out of that room, he had formulated analytical geometry and the idea of applying the mathematical method to philosophy. He made a conclusion at that moment: his pursuit of science would prove to be his pursuit of true wisdom and a central part of his life's work. He also saw very clearly that all truths were linked with one another. This made him think that finding a fundamental truth and proceeding with logic would open the way to all science. From this vision came his famous saying: "I think, therefore I am."

As already mentioned, his mathematical legacy is the development of Cartesian or analytic geometry. He "invented the convention of representing unknowns in equations by x, y and z, and knowns by a, b and c". He also "pioneered the standard notation" that uses superscripts to show the powers of exponents. He was the first to assign a fundamental place for algebra in our system in knowledge. For this he would be using it as a method to automate or mechanize reasoning, particularly about abstract, unknown quantities. Geometry has previously been viewed as a more fundamental form of mathematics by European mathematicians, serving as the foundation of algebra. Equations of a degree higher than the third were regarded as unreal, because a three-dimensional form, such as a cube, occupied the largest dimension of reality at that time. Descartes professed that the abstract quantity a^2 could represent length as well as an area. This was in opposition to the teachings of mathematicians, such as Vieta, who argued that it could represent only an area. Although Descartes did not continue with this subject, he preceded Leibniz in envisioning a more general science of algebra.

Descartes' work provided the basis for the calculus developed by Newton and Leibniz, who applied infinitesimal calculus to the tangent line problem, thus permitting the evolution of that branch of modern mathematics. His rule of signs is also a commonly used method to determine the number of positive and negative roots of a polynomial.

In short, Descartes is one of the important contributors of the existence of what we know call R, the real numbers. Think of him every now and then, while studying Real Analysis.

Science trends

Rebecca Glans

On this page you will find some brief info on recent scientific

breakthroughs or interesting news. Whether they're big or small, if we

think they might interest you, we will mention them here! Do you miss

a certain trend or want to inform your fellow readers of an interesting

innovation? Feel free to contact us.

Being social becoming less complicated!

In the Frontiers' journal dedicated to "Robotics and AI" a study was published about using Google Glass to assist children in social interactions. Their target audience being children with autism spectrum disorder (ASD). Children with ASD are often very keen users of technological devices, especially those designed to help them in any way. The app is called Holli and can be used with wearables. Holli listens to the conversations taking place and then prompts the user with an appropriate reply. In contrast with existing technology, the user doesn't have to interact with the software and can focus on his/ her conversation. Professor Kushki explains: "The interesting thing about our new technology is that we are not trying to replace human-to-human interactions; instead, we use this app to coach children who are communicating with people in real-world situations (...) The children can now practice skills and techniques learned (at therapy sessions) more easily. So far, the children that have used Holli are very pleased with how the app works. Researchers hope to have customization options for users in the future, to make the experience even better. [1]

Copy-Paste just got a lot easier

MIT's Computer Science and Artificial Intelligence Laboratory (CSAIL) has developed CodeCarbonCopy (CCC). This system can transplant code from one program to another. Research scientist Stelios Sidiroglou-Douskos explains: "It's another step toward automating the human away from the development cycle. Our view is that perhaps we have written most of the software that we'll ever need - now we just need to re-use it". CCC first checks how the donor and recipient program handle the same input (file). This way it can find which variables in both programs have the same function, but (probably) a different name. Along with variables CCC could not find matches for in the recipient, these are presented to the user. Often when a match can't be found, it means some variables which play a role in the donor program aren't relevant in the recipient. The user can flag these variables and CCC will not transplant any operations using them. Next to code structure, data representation can also differ between the donor and recipient program. CCC tries to find systematic relationships between how both programs store their data. If found it generates the appropriate translation. [2]



Figure 1 Representation of the 15 pentagonal tiles [4]

Scientists like art, too

For many centuries man has been interested in the mathematical problem to tile a plane with a single pattern, or shape in this case. To tile a plane is to use a single shape to cover a plane (surface) without gaps or overlap. There already exist many solutions for tiling a plane with for instance triangles, rectangles and hexagons. The search for these solutions was initiated by Karl Reinhardt in 1918 during his thesis. From 1918 to 2015 a total of 15 different pentagons were discovered that could tile a plane. It was uncertain if there were other appropriate forms of pentagons, until last month. Michaël Rao, a researcher at the Laboratoire d'informatique du parallélisme, showed that the 15 found pentagons are the only ones able to tile a plane! Using software, he found 371 potential pentagon families. Testing all these families narrowed it down to 19. 15 pentagons were already known and the remaining were particular cases of the already known pentagons. [4]

References:

 Google Glass app helps autistic children with social interactions. (2017, September 14). Retrieved October 2, 2017, from \url{https://www.sciencedaily.com/releases/2017/09/170914152254.htm}
 Ben G. Kinsella, Stephanie Chow and Azadeh Kushki (2017, July 12). Evaluating the Usability of a Wearable Social Skills Training Technology for Children with Autism Spectrum Disorder. Retrieved October 2, 2017, from https://www.frontiersin.org/articles/10.3389/frobt.2017.00031/full
 Automatic code reuse: System automatically modifies code for transfer to other programs. (2017, September 20). Retrieved October 2, 2017, from https://www.sciencedaily.com/releases/2017/09/170920144651.htm

[4] (2017, September 29). There are only 15 possible pentagonal tiles, research proves. Retrieved October 3, 2017 from https://phys.org/news/2017-09-pentagonal-tiles.html

39



Technology-based Entrepreneurship

Sven van Hal

Last year, it was (finally) the moment I got to do my minor. To be honest, I was looking forward to it for a while : studying something totally different than computer science. The availability of minors for students of computer science is quite limited, but luckily I found Technology-based Entrepreneurship: the ideal opportunity to grow as an entrepreneur

and to gain great knowledge in that area.

The minor consists of several modules which you then apply in a central course on a tangible business idea, which you need to come up with yourself. In preparation, you first attend a few courses in Industrial Design and Systems Engineering, Policy Analysis and Management. These subjects are mainly about product development- how do you transition an idea to an actual product- and the essence of entrepreneurship- what makes you an entrepreneur. Additionally, you attend courses like Finance for Entrepreneurs and Business Marketing, to be able to analyse markets and bring your product to the people.

The first (quite woolly) course focused on yourself and your personal values. Motivation, so the things you do which you like, is namely the most important incentive for an entrepreneur. After that, we could start brainstorming. Coming up with a viable idea for a product is a lot more complicated than you might think. Many ideas seem like a great idea at first, but then it turns out there isn't any market for it or you do not have the right expertise to realize it.

The final product of my group is the automatic razor cleanser "Shave & Save". Eventually, amongst others, there has been done a market research for this product, multiple multiannual plans and budgets have been drafted and even an attempt has been made to persuade investors to join this project. Therefore, the minor really is comprehensive.

Looking back at this minor, I mainly learned a lot in the area of finance and financial planning. It has become clear why certain companies against all odds managed to be profitable (or vice versa) and what aspects are involved in the realization of an idea for a product. However, the minor is not a silver bullet which can transform every single idea to a success: this is something that comes from within.



Computer Science Minor

Arthur Mooiman

My name is Arthur Mooiman, I'm a third-year student in Applied

Mathematics (AM). In order to improve my knowledge in programming, I

chose to do a 'free minor' at Computer Science (CS). The dean of CS and

I managed to find 6 subjects that were given over a course of 3 quarters,

because that was best for me.

The first three courses I took were Software Engineering Methods, Computational Intelligence and Signal Processing. As an AM student, I was thrown in at the deep end right away. Over the first two weeks, I had to create a game; the little knowledge of programming I had made it hard to do this. Luckily, we had to work in groups, so I wasn't in this alone. Additionally, while studying concepts of Artificial Intelligence, I made my own AI which had to walk through a maze to find the shortest path.



Additionally, I took the subjects Image Processing, Algorithm Design and Complexity Theory. In Algorithm Design, they teach you many algorithms which I had seen in AM already. However, the level of difficulty increases rapidly if you have to program these algorithms. Plus, it has to have a fast runtime too! I managed to succeed with a little help from some CS students. The subject Image Processing allowed me to create my own license plate recognition program, which had to find the license plate and write down the numbers. Lastly, the hardest subject of my minor: Complexity Theory. This course focuses on thoroughly analyzing the complexity of problems and whether a problem is solvable within my lifetime when I'd start now. I recognized some concepts of this course from the AM course Optimization.

The minor was a completely different challenge than mathematics, which really appealed to me. I definitely recommend this minor to people whom are interested in programming.



Communication design for innovation

Electrical Engineering

Jochem Lugtenburg

Angelica Babel

In the first semester of last year I did a minor called 'Communication Design for Innovation' at the faculty of TNW (I also didn't know there's a communication part in the building). It gave the students the possibility

to try something else; something new on the communication side of

innovation.

The whole group was split in smaller groups of 4 or 5 people and the smaller groups had to solve a so-called 'ill-wicked, ill-defined problem' within a real company. I had to solve a 'wicked problem' within the Province of Noord-Brabant. We made a communication strategy on 'how to involve the citizens of Noord-Brabant in a decision-making process about the environment'. We learned a lot of theories on how individuals make decisions, how they act and how they are motivated to do certain actions. The way companies work, how they make a strategy and how they maintain their competitive advantage were also dealt with, and it gave us a closer look on how we can solve our problem.

We also had masterclasses in which different organizations within the communication division came to teach us about (for example) the way we should act when we meet new people. This taught us that a firm handgrip means the individual is dominant and if an individual touched your elbow when shaking a hand, it means they want to be the upper hand in a discussion.

Overall, the minor was very educating and I met a lot of people whom I can call 'my friends'. This minor gave me another way of thinking, and maybe (if I don't change my decision) you will see me as a communication expert in a firm in ten years.

My name is Jochem and I'm currently in my third year of the Computer Science Bachelor. A big part of the third year is the minor. After a long search, looking for a minor with a connection to the Computer Science program, the perfect minor appeared: Electrical Engineering for Autonomous Exploration Robots.

The minor has a broad range of courses for someone unfamiliar with Electrical Engineering. Courses range from basic knowledge about circuits (Circuit Analysis, Electronic Circuits) to applications of this knowledge (Telecommunication Techniques, Electronic Power Conversion). During these courses, you are introduced to sometimes familiar concepts like transistors, but also completely new topics like the "magical" Nullor: an ideal component providing infinite gain.

In the second quarter of the minor, you team up with three or four other students to build a "Mars Rover". This mars rover is basically a white dish on wheels with an FPGA chip on top. While the visuals did not match NASA's Curiosity by far, building a rover with only one sensor was already very challenging. The design of the rover consists of two parts; programming an FPGA chip and designing circuits to handle the rovers solar power supply. Both parts were far more challenging than expected and force a software engineer to think different. After ten weeks, we were very happy to have a robot that behaved like we wanted it to.

The minor also opened new possibilities for my existing programming knowledge; using a Raspberry Pi, I can now use software to control a circuit I've designed and built myself. It also enables me to communicate with Electrical Engineers, which might be a useful skill in my future career.

Overall it was a hard, but rewarding semester which I would definitely recommend to anyone looking for a minor close to the hardware.





Mathematical Puzzle

Optimize your wife!

You have a very active love life. You estimate you will have a maximum of 100 girlfriends. Out of these 100 you will choose one to marry. Then of course, you want the one that is the most amazing match with you. That sounds great, but there is one problem. You can't "try" them all, before you can choose one. After you break up with a girlfriend, she will be gone and she will never return. So you have to make up with a plan. You decide to use the following technique.

First you try a couple (n-1) girlfriends. After that, you marry the first girlfriend who is better than all the previous.

Of course you want to choose so that the chance that you get the very best is maximal. As you may have guessed the question now is, what to choose for n?

A free ticket to the movies!

There is a long queue standing in front of the cinema. All people are waiting to buy a ticket.

As a joke, and to satisfy all the waiting people a little, the manager comes out, and says: "When it's your turn to buy a ticket, and your birthday is on the same day as one of the people that already has a ticket, then your ticket is free."

Sounds good, but the manager only does this for the first person who is lucky; only one free ticket.

You want to get that ticket! In the case you could choose your place in the queue. Where would you prefer to stand?

Getting home early

After work and taking the train, you arrive at the station at 5 'o clock every day. Your friend picks you up there and you drive home together. But today, you're an hour earlier at the station. The sun is shining, so you decide to walk home. You walk exactly the route you use to drive with your friend. You meet your friend on the way and you drive the last part together. You won some time! You're home, had some exercise and you're 10 minutes earlier than you use to arrive at your house. You can assume your friend drives with a constant speed and would be at the station at 5 'o clock sharp, like any other day.

How long did you walk?



Miscellan

Computer Science Puzzle

Below is a class that models the life of a house pet. The main method creates a Pet instance representing a dog named Fido and lets it run. Although most dogs run in the backyard, this one runs in the background. What does the program print? And if it doesn't print, why is that? The answer to this puzzle will be published in the next MaChazine!

References

[1] J. Bloch, N. Gafter (2005). Java Puzzlers. Indiana, USA: Pearson Education.

```
public class Pet {
    public final String name;
    public final String food;
    public final String sound;
    public Pet(String name, String food, String sound) {
        this.name = name;
        this.food = food;
        this.sound = sound;
    }
    public void eat() {
        System.out.println(name + ": Mmmmm, "+ food);
    }
    public void play() {
        System.out.println(name + ": " + sound + " " + sound);
    }
    public void sleep() {
        System.out.println(name + ": Zzzzzzz...");
    }
    Public void live() {
        new Thread() {
             public void run() {
                 while (true) {
                      eat();
                      play();
                      sleep();
                 }
             }
        }.start();
    }
    public static void main(String[] args) {
         new Pet("Fido", "beef", "Woof").live();
    }
}
```

Miscellaneous

Business Tour 2018 Register now!

Wiskunde Informatica J**dievereniging**

Join us for inhouse days at 9 companies in the Netherlands and a weekend abroad in Stockholm! Find out more and register for the Business Tour before 26th November at businesstour.ch.tudelft.nl

ocation: The Netherlands and Stockho

Calendar



ADSL

The annual Teach-Student Lounge (Adolescenten Docenten Studenten Lounge) will take place this month. The AkCie will organize a drink in the /Pub that is perfect for integrating with your teachers. Getting to know them better is not only beneficial for yourself, but also for your wallet, as their drinks are free!



Christmas Holidays

At the end of December, the christmas holidays will finally begin! We wish you a merry christmas and a happy new year and hope to see you again at CH in 2018!



Career College

Are you a mathematician or computer scientist, but one with no idea what to do? Career College might be the outcome for you. Three times each quarter, there is a lecture, workshop or something ecompletely different to help you orient on your career opportunities

November

- 13 Committee Kick-off
- 14 T.U.E.S.Day Lecture
- tba WiFest, MaPhyA pre-activity
- 21 T.U.E.S.Day Lecture Deltares
- 22 WiFest
- 23 Career College 2.1: Entrepeneruship Workshop
- 28 T.U.E.S.Day Education Lecture
- 28 Birthday Prof. dr. dr.h.c. L.J.M. Rothkrantz
- 29 ADSL

December

- 6 Members lunch (Sinterklaas)
- 7 Career College 2.2
- 19 T.U.E.S.Day Lecture
- 23 Christmas Holidays!

Januari

9	T.U.E.S.Day Lecture
10	Double Degree Dinner
11	Career College 2.3
16	T.U.E.S.Day Education Lecture
16	MatCH activity
18	Company Dinner
23	T.U.E.S.Day Lecture
29	Start of exams

Proactive and responsible? Get the job!



Prove your talent at Prodrive Technologies

Proactivity and responsibility is the core of dedicated teams. We give our young teams the freedom to achieve success and the responsibility of the entire project. We support the growth of your potential with our knowledge base, our company culture and facilities.

Apply now at prodrive-technologies.com/careers

Unlimited opportunities for talents with a passion for technology

Software engineering Embedded / Application / Web / Robotics & automation / GUI / Back-end / Mobile Apps / Data Science / Embedded Linux / Functional Programming Mechanical engineering Thermodynamics / Constructional engineering / Material science / Dynamics & control / Opto-mechanics / Manufacturing engineering Electrical engineering Signal processing / Electronics / Electromagnetics / Telecommunications / Embedded systems / Power electronics / Motion control Manufacturing Process development / Automated electronics & mechanics manufacturing / Lights-out factory / Logistics Human resources, sales and support Corporate law / Purchasing / Supply chain / Office management / Business development / Sales / Account management

We offer Parttime - Fulltime - Internship - Bachelor end project - Graduation - Traineeship



Global presence The Netherlands | USA | Germany China | Israel

prodrive-technologies.com jobs@prodrive-technologies.com