MACHAZINE

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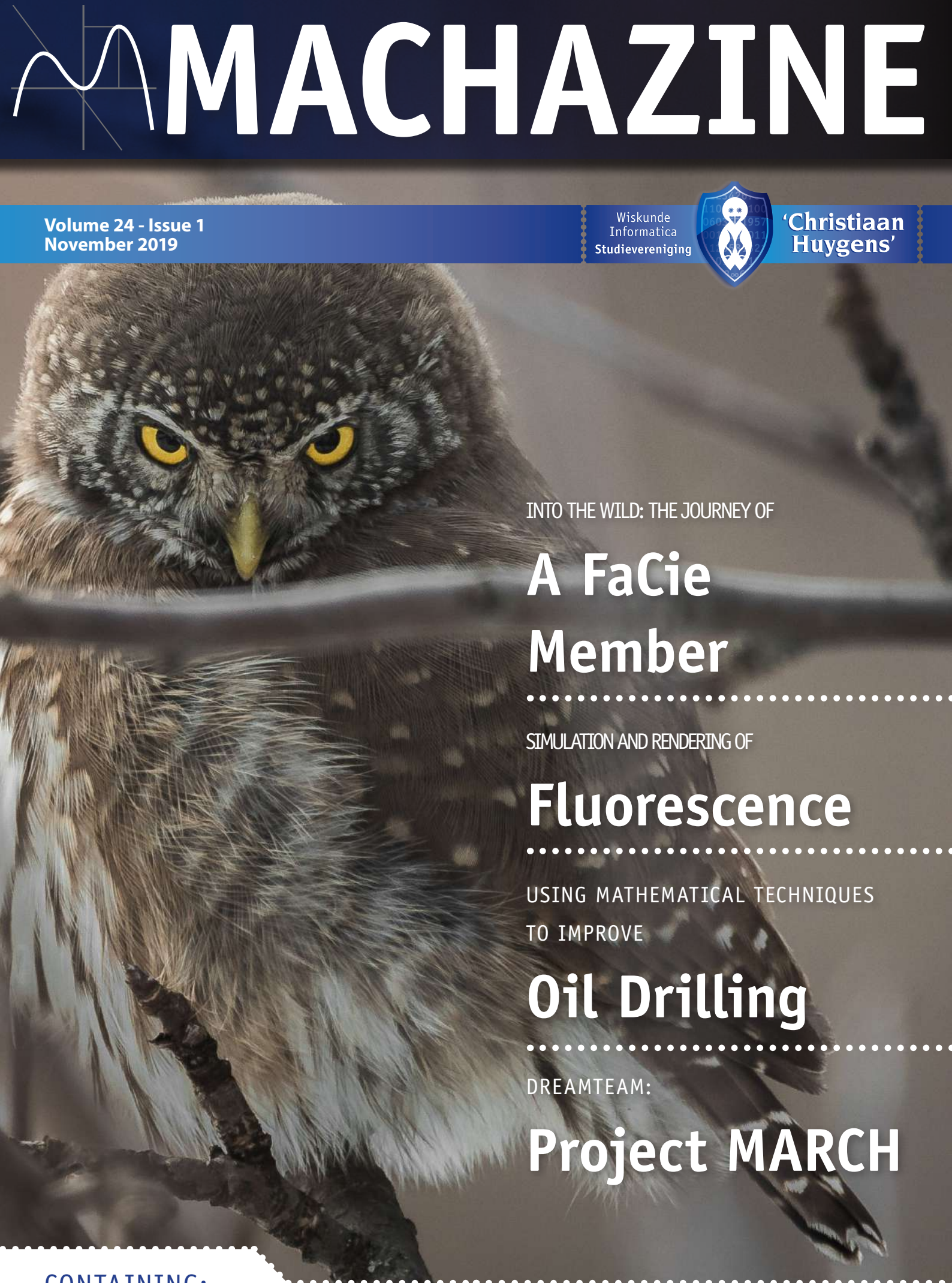
Wiskunde Informatica Studievereniging 'Christiaan Huygens'



INTO THE WILD: THE JOURNEY OF

A FaCie Member

SIMULATION AND RENDERING OF

Fluorescence

USING MATHEMATICAL TECHNIQUES TO IMPROVE

Oil Drilling

DREAMTEAM:

Project MARCH

CONTAINING:

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Editorial

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

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Advertiser index

As a committee, we are always working on improving the MaCHazine. One of the ideas was to change the editorial, because we heard from some of the readers that they want to know more about the people behind this beautiful MaCHazine. Therefore, since it's the start of the year, we decided to all answer the question:

How was your holiday?

Eva: "After working for a couple of weeks, I attended the National Cyber Security Summer School, which was really interesting. Djoshua wrote an article about it, so if you want to know more about it, turn over to page 22. In the last week of the holiday, I went to Terschelling. There, I joined an awesome canoe trip where we saw a lot of seals, who came really close!"

Marjolein: "This summer I went on a few trips. I spent a week in the Czech Republic, in which I visited Prague and spend a few days near a lake, where it was very sunny. About 2 weeks later I went to Brussels for a weekend. The last week of the holiday, I spent in Croatia, where lying at the beach was the main activity. Overall, I had a very relaxing and fun holiday."

Daniël: "I had an amazing summer, it was a well-deserved change of pace after the final stressful weeks of my 'BEP'. I spent the first few weeks travelling with fellow students from the Honours Programme through South Korea. We saw amazing stuff and visited lots of great companies and places. I also went to Germany for a more relaxed vacation before getting ready to start studying again!"

Kilian: "My summer started with studying in EEMCS for my resit. But once I nailed my resit, I had an amazing holiday in Barcelona with two friends. When I got home, I attended the Freshman weekend and the OWee as a mentor. In between this all, I worked quite a lot in my hometown The Hague."

Maxime: "This summer I had an amazing time in Florida. We rented a car and went to the most beautiful beaches where I surfed a little, but we also went to the theme park Universal Studios for two days and we swam with dolphins! The place I liked the most was Miami Beach. This is really a place to party and to relax on the most beautiful beach."

Louise: "After two relaxing weeks in Mallorca, I joined my 'club' on a week long trip to Alicante. I then headed back to the Netherlands for a two week journey through the North of Holland with my mom. Here we visited the places where she grew up, our old summer home and we even had time to visit some old friends."

Boaz: "I spent the first half of my summer in Japan and South Korea, on the CH Study Visit that I helped to organize. With a group of 30 students and 2 professors, we visited various companies and universities and experienced the unique culture of the two countries. After this unforgettable trip, the rest of my holidays were spent preparing for my board year!"

Tom: "My summer was spent arranging everything for my minor in Sweden. I had to find a place to stay, making sure I got all my grants as well as finding a way of fitting 6 months of clothes into my suitcase. The last weeks of my summer holiday I spent in Sweden, moving into my new room and having all kinds of activities to meet other international students, like a trip to the biggest student owned wood fire sauna."

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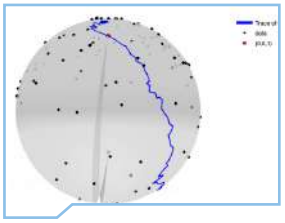

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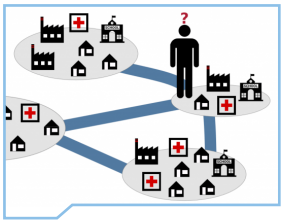

Miscellaneous

MAGNAZINE

From the Board

Marleen Hielkema, Chairman

When you are reading this, we have already passed a complete quarter of the new academic year. To me, this past quarter seemed like a very short one since a lot of new things have happened. For a lot of you it just meant that you got your study rhythm back after an amazing holiday, but for a certain group (the freshmen) it meant meeting a lot of new people and finding the way in EEMCS. We, the board, can relate to the freshmen a lot since the positions that we are fulfilling are completely new to us. For me, the past few weeks have been centered around being the Chairman of W.I.S.V. 'Christiaan Huygens'.

When we just started fulfilling our new positions, we had no idea what we had to do or what we were doing. We were just very busy working off our to do list, which grew harder than it got tagged. But every event that we organized, every lunch we fixed, it worked out very well and it got easier for us to organize when more events passed. It is amazing to see that so many people come to our events and have fun with each other, and with us. There are a few events that stood out the previous weeks. One of them is of course the Freshmen Weekend. We got the chance to meet 250 freshmen that joined us on the weekend. We partied together, played games together and everyone got to observe that all the board members are exceptionally good dancers. Everyone knew that this weekend had to be relived, that's why the /Pub was fully packed during the Freshmen Kick-Off drinks to watch the aftermovie!

For most of you, the year had just begun during that weekend. But me and my board members have spent a big part of the summer to prepare for this year. We learned a lot from the previous board on how to fulfill our positions, but we also made a plan on how we want to contribute to our association. This plan contains improvements concerning the quality of education but also how we can involve our new students to our association more effectively. I encourage you to all follow us on Instagram (@wisvch) and on Facebook (/wisvch) to stay updated on our events and receive fun pictures from the board in the association room!

Luckily, I am not running CH on my own this coming year. Together with six amazing people we are working to create an amazing study year for all of you. We all have our own specialties, which makes a great team. From my spot on CH, I am privileged to always be able to look at Tim, our secretary. He will most likely pick up the phone if you ever call CH, how lucky are you! On the left of Tim is Arian, our treasurer. He maintains the financial health of the association. Arian loves to spend some money, so this position is perfect for him. Next to me sits Louise. She is in charge of the Mathematical Education Affairs. Behind me, Raoul is placed. He is in charge of the Computer Science Education Affairs. Raoul and Louise work a lot together to improve and maintain the quality of education of Applied Mathematics and Computer Science. So if you have any complaints, tips or just want to tell an AM or CS joke, feel free to contact them! When the three of us are at CH together, Ariana Grande will most likely be playing, so make sure to witness the sing-a-long. On the same side as Raoul, on the far right of him, Boaz is sitting. He is in charge of Public Relation Affairs, dedicating half of his time to the contact of our association with the outside world. The other half of his time he spends organizing the biggest technological career event of the Benelux: 'De Delftse Bedrijvendagen' or DDB for short. Boaz is the best in making horrible word jokes, come by and ask for one! Last but not least, Diederik is sitting in between Boaz and Raoul. Diederik keeps in touch with our alumni and organizes our helpful Career Colleges. He also installed a pull up bar at CH, so make sure to come by to try it out with him! And then there is me, the Chairman. I keep myself busy keeping contact with special members, the TU and making sure the year planning is consistent.

I hope that the start of this academic year has exceeded your expectations, and that the people you met will take you to all of our activities the coming years. Please never hesitate to come by for a free cup of coffee, a pen or a notebook! We really enjoy having a chat with you all.

See you at CH and our upcoming events!

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Current Affairs

TU Delft News

Daniël van Gelder, Editorial Staff MaCHazine

The Delft University of Technology is the biggest and oldest public technical university in the Netherlands, 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.

National Climate Strike

On Friday 27th of September, students from all over the world gathered for an international climate strike in order to draw attention to the rising problems that are a consequence of climate change. The goal of these protests is to demand that governments take more ambitious measures to counter climate change. While it is hard for scientists to take an active stance in the polarized debate, in order to not compromise their objectivity, they could count on the TU Delft for support if they were to take the day of in order to join the strike. In the end, thousands of people gathered in The Hague for the strike and millions across the globe.

Scientists UAntwerp, UHasselt and TU Delft discover "electrified" bacteria

Cable bacteria are organisms that consist of thousands of cells and are up to a centimeter in length! Scientists have long suspected that these organisms conduct electricity and that they could be useful in replacing conventional biological methods of conducting electricity. Researchers from UAntwerp, UHasselt and TU Delft have now finally confirmed that long held belief and have made astonishing discoveries about the conductive properties of these cable bacteria. It seems that the conductive properties are much better than initially expected while the scale at which it occurs is tremendously small (cables are 50 times thinner than a human hair). While we can't expect our electricity grid to be powered by bacteria anytime soon, the researchers will devote more research to find out what is causing these organisms to be able to conduct electricity so well. The conductive fibers of these bacteria provide opportunities to be used in medical implants and could be used to reduce the problem of electronic waste by providing an eco-friendly alternative.

Study Grant for Students to be Possibly Reconsidered by Dutch Government

The Dutch Labor Party (PvdA) has recently withdrawn its support for the study loan system that exists in the Netherlands. That is, a system where students borrow money in order to finance their study at a favorable interest rate. However, this system has only been in place since 2015. Before that time, students would get a grant from the government that wasn't a loan but a gift. The introduction of this study loan system has had a profound impact on students' finances as the average study debt has risen to about 21.000 euro. Therefore, this measure has unsurprisingly been very unpopular among students. It seems, according to the PvdA, that the introduction of the study loan system had created a barrier for low-income families to support their children to pursue a higher education degree. With the withdrawal of support by the PvdA there might be hope for the return of a study grant system for future students. However, it is certain that these changes will not happen soon as we will need to wait at least until the next general elections in 2021 before any concrete measures can be taken.

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[1] https://www.nos.nl
[2] https://www.tudelft.nl
[3] https://www.delta.tudelft.nl

Current Affairs

The Conference Enumath 2019: The Organization

Fred Vermolen, Department Numerical Analysis

In the period of September 30 - October 4, the Enumath 2019 conference took place in Egmond aan Zee. The conference attracted 449 numerical mathematicians from all over the world. In this text, I will say something about this big event.

In May 2017, I received a message from Professor Barbara Wohlmuth, who is the president of the Board of Enumath with the question whether I would like to organize the next event in The Netherlands. I felt very honored, but at the same time, I realized that this was a large responsibility. The Enumath conference series are known as a major event in Numerical Mathematics, and these conferences have a very good reputation. Hence organizing this event is a big responsibility. To warm up, I was in the scientific committee of the previous event Enumath 2017, which took place in Voss, near Bergen in Norway. We had a great time in Voss, which is located amidst the mountains and not far away from the famous Sognefjord. We had splendid mathematical discussions and a magnificent sunny hike to a water fall. The weather was great with lots of sunshine and temperatures ranging between 20–25 degrees centigrade.

First of all, a local organizing team had to be installed. Kees Vuik helped me to form a local committee, which consisted of core members of DCSE (TU Delft Center for Computational Science and Engineering). Subsequently, we contacted Gemma van der Windt and Marion van den Boer-Roggen for practical issues. Gemma and Marion have done a very fine job! The first job was to present an apriori budget, including the conference fee, hotel fees, etc. We quickly agreed upon the conference hotel Zuiderduin in Egmond aan Zee as the venue. My personal preference was to have the event in Delft, but since the lectures would already start and since we do not have such a conference venue in Delft, we were to organize the event elsewhere. The location is great, it is in the middle of the dunes and it is very close to the beach. During the closing remarks of Enumath 2017 in Voss, I showed the location and expressed the wish to have the same weather we had in Norway. The conference weather in the Netherland became windy, rainy and with temperatures ranging between 10-15 degrees...

After the conference in Norway, the work accumulated. First, the venue was booked, sponsors were sought, an international scientific committee was composed. When I was invited to other universities, I advertised for Enumath. One of the Board members, Pekka Neittäänmäki from Jyväskylä invited me for a short stay in Finland, from which a paper and a new research direction resulted for both myself and the Finns. Pekka introduced me all the time as 'conference organizer' and even invited my entire family to come back and stay in his summer house in Finland. Organizing the conference, also entailed accepting or rejecting incoming minisymposia and abstracts for contributions. Of course, this was done by the whole team, but we had to do it and on my behalf letters of acceptance or rejection were sent. I have a lot of friends in the community, but now the number of enemies also started to increase...

After a while, the accepted contributions had to be scheduled: a program was to be composed. This meant ordering talks by topic and relevance. I composed the program in a day, in which I disconnected myself from the entire world. The result was approved by the fellow committee members and published on the website as a preliminary program. Many emails came in, where delegates were requesting their talk to be shifted. I tried as much as possible, but to a bounded extent, to respect these requests. It is pretty much like working with students: maintaining deadlines, handling requests, and sometimes disappointing people and making people happy. Next to this, chairmen had to be appointed for the various symposia and keynote lectures. Eventually the schedule got definite.

Then the conference started. During the opening ceremony speech I mentioned some historical facts about the conference series, some facts about the Netherlands, and about the Delft University of Technology. The keynotes went fine, the symposia went fine. I even started enjoying the conference myself, which is not that common for a main organizer. We had an ice-breaking party, with high quantities of good quality alcohol and snacks. The next day, there was a bowling contest (I was second in my group (due to the poor level of the other participants)). We organized a social program and a banquet in Haarlem. We are looking back at a great event. We thank our sponsors (The Dutch Burns Foundation, NDNS+, 4TU-AMI, DCSE, TUD).

Well, I have bored you enough. This alcoholic needs alcohol. Skål!

"Here, I work on what interests me"

TNO

Anneke Schwedersky, Laura Veerman and Rolf van Wegberg make up half of a TNO team of six involved in cybercrime research. They are passionate about their job because of its societal relevance: they aim to make the Netherlands a more secure digital society.

Rolf van Wegberg: "We are based at the TNO department 'Networked Organisations', working together with national security organisations in the Netherlands - the police, the judiciary, the Royal Marechaussee, the National Coordinator for Security and Counterterrorism and so on. Our aim is to strengthen the capabilities of the criminal justice apparatus, particularly through increasing the knowledge and skills of individual organisations and ensuring that they share these among themselves. The department looks at both physical and digital threats. Our cybercrime team focuses on the digital aspects, with topics ranging from DDoS attacks to phishing and malware. Over the past year, we have invested a great deal of time and energy into researching marketplaces on the dark web."

Anneke Schwedersky: "We are not solely technology focused. Yes, we collect large-scale datasets and analyse them for patterns and trends, but that's just where we start. We look for meaningful metrics by making sense of these patterns and trends. Hence, a technical problem becomes a social-technical project."

Laura Veerman: "It's a mix of quantitative and qualitative research. For example, I've studied the types of vendors on dark markets. Do they comply to the rules of the underground marketplace and what can the police learn from this?"

Rolf: "We also investigate the effects of specific interventions by the police. What's the effect on the criminal community, for instance, if they infiltrate markets and try to break the confidence in vendors on these markets?"

OPEN TO IDEAS

Laura: "I'm in the third year of the criminology bachelor program at the Vrije Universiteit. Last year, I finished an internship at the Ministry of Justice and Security, where they told me that TNO was looking for people. Before I knew it, I was working here 16 hours a week next to my study program! It turned out that TNO was open to my ideas: the research idea became my bachelor thesis."

Anneke: "I also studied criminology, but at Leiden University and with terrorism as the subject of my bachelor thesis. Through a side job, I ended up in the world of IT and simultaneously began my master in Forensic Criminology. My master thesis concerned a comparative study into malware on servers, research which I carried out at TNO. I worked in IT after my master degree, but about a year later I returned to TNO so that I could specialize myself futher. Now, I'm a researcher and consultant in the field of cybercrime, counterterrorism and extremism. TNO's primary objective is to create new insights and technologies making the Netherlands safer and more secure, not to make a profit. This allows me to fully focus on the content. Here, I work on what interests me."

Rolf: "It sounds monotone, but I'm also a criminologist. I was a lecturer and researcher at Leiden University for two years, where I graduated in 2011. Initially, I focused on financial and economic crime, but the research increasingly took a turn into the digital domain. That's what made me transfer to TNO. At the moment, I work at TNO for half of the week. The other half I spend at Delft University of Technology, where I am working on my dissertation on cybercriminal business models and the question of how the police, in particular, can disrupt these models."

TEAM SPORT

Rolf: "It doesn't actually matter what your background is. At TNO, it's all about your motivation and your interests. I think it's great that TNO offers opportunities to students like Laura. You have to jump through a couple of hoops first, of course, but when it's done, you are part of the team. And that's the way it should be: this is a team sport. Collaboration in this field is the only way to obtain meaningful information."

Anneke: "It's more than IT. You need knowledge of other areas, such as criminology, economics and sociology. That's why this work is truly a team sport and why there are few others who do what we do."

Rolf: "TNO is a special organisation with a reputation when it comes to independent research. Hold up a TNO report in parliament and no one will question it. How does TNO maintain that position? By hiring the right people, it's as simple as that."

Laura: "When thinking about TNO as an employer, the first thing I think about is flexibility."

Anneke: “Exactly. In what you do, how you do it and when you do it. And if you have a good idea, most of the time you get the freedom to develop it further.”

Laura: “I can decide my working hours for myself. That’s what makes it so easy to combine working at TNO and my study program.”

AS LONG AS IT DOESN’T FEEL LIKE WORK

Rolf: “My ideal working day is a day with no appointments, a few new datasets and then getting to do what we’re good at: tinkering. But appointments are a part of the job of course. Monday is our ‘appointment day’. One day a week, that’s what makes it so useful in planning and coordinating the rest of the week.”

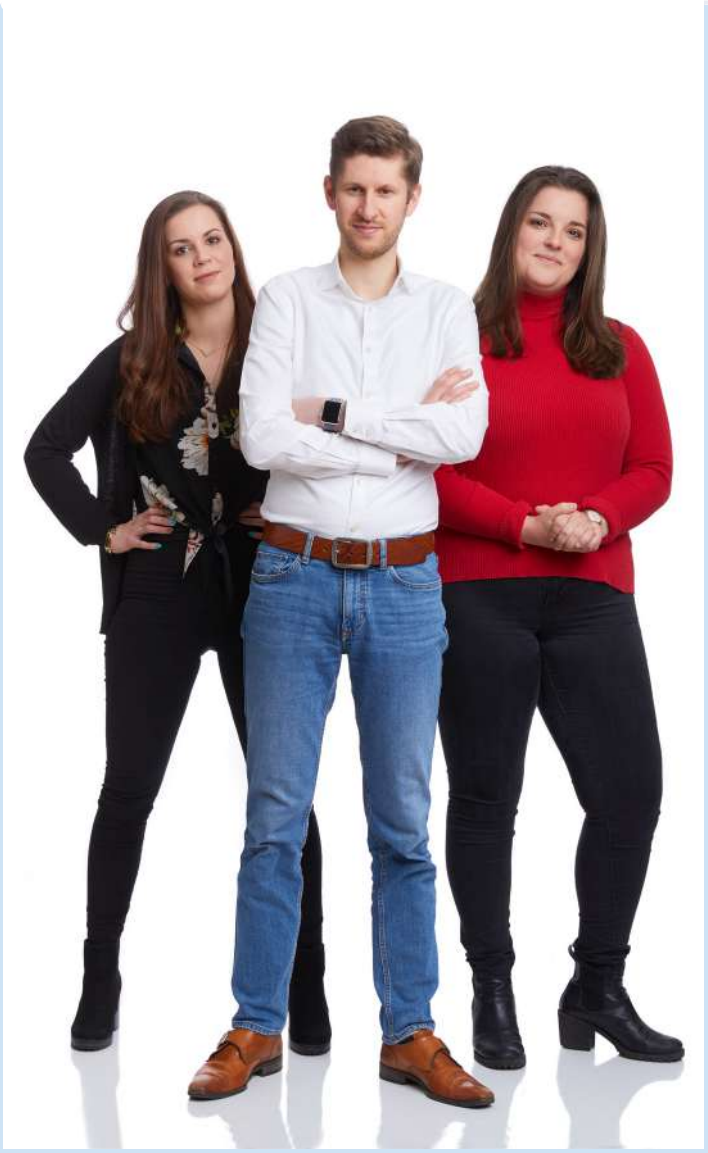
Anneke: “I love the days we spend with partners in our projects. When you spend a day at the Ministry of Defence, the people around you feel like colleagues. These different working environments also keep things interesting for me.”

Laura: “I get a lot of energy from sparring sessions, in which we determine our direction. What will our role be, how are we going to organise this?

Anneke: “The future? That all depends on what comes my way. For the time being, I want to continue doing this work. That’s logical as I’m investing in it now, and you don’t want to throw it all away after just a couple of years.”

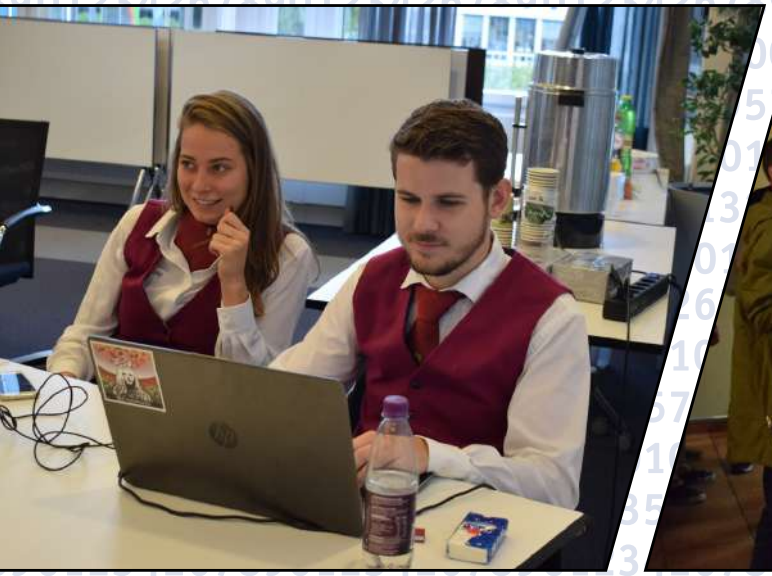
Laura: “I would very much like to continue doing this work during my master programme. A thesis is concrete and sharply defined, whereas here I’m working on a much broader scale.”

Rolf: “As long as most of it doesn’t feel like work, I’ll keep doing it. That’s why I like it when an organisation enables people to grow and develop as a specialist. We don’t all have to become managers.”



Advertorial


Agenda




LOVE

Association


Technolution


Technolution

Into the Wild: A FaCie member's journey

Lynn de Lange and Mirte van Loenen, Chairman and Treasurer of FaCie committee

The FaCie is a first-year committee consisting of 5 freshmen and 2 QQers. We create a booklet that involves the brand-new freshmen who went to the Freshmen Weekend or to the Freshmen Day and we try to give all of them their own part.

The best way to start your student life is by attending the Freshmen Weekend! Here you will meet all your new friends and party all weekend long. But after a weekend of partying, remembering everyone can be a challenge. Also, many many years later when you want to look back at your crazy student years it is so nice to see where it all started. The FaCie makes sure this is all possible by making a booklet containing photos and stories about all the freshmen from the Freshmen Weekend and the Freshmen Day. Embarrassing stories, funny quotes and beautiful photos are all contained in this booklet, but don't be fooled, this booklet does not make itself.

The story of a FaCie member started this year with an unexpected invitation from one of the QQers to join this committee. A surprise to most of us, surely, but a welcome one. Soon the first meeting was planned where you meet everyone for the first time and you realize who you'll be doomed to work with for the next few weeks. Shortly after, we planned a brainstorm session for the theme of this year's FaCie.

The theme is the most important thing. Your outfits, the logo and the booklet depend on the theme you pick, so you don't want to make the wrong choice. A few ideas came up but eventually we ended up with Safari, so we could name our committee: SaFaCie.

But one does not simply create a FaCie booklet. Working with our design environment, InDesign, proved to be quite a challenge, especially since it's only usable at the TU Delft computers at CH. But after some practice and thinking, there was a nice design and good ideas on how to finish the booklet successfully. Some time during this process we met up with some previous FaCie members to reunite during dinner and learn about what they did in their years. All the while, the weekend gets closer and closer and before you know it you're standing near the entrance of EEMCS, in your outfit and with a little notepad in your hand to write down all you can find out about the approximately 250 freshmen. It sounds like an impossible task but you'll figure it out. Almost all of them are new and they know each other as little as you know them. What worked for most of us, was to ask a ridiculous question to break the ice and see what kind of person they were, or just join any random conversation. People don't seem to mind that as much as you'd expect. Of course, being FaCie helps.

Our other duties include taking pictures, taking surveys and of course have a great performance during the 'bonte avond'. The best way to show safari in an exciting way was of course to use 'Freek Vonk' in all of this and luckily it worked out pretty great. We got so many compliments and we still talk about the performance regularly.

After the weekend (and after the resits for most of us), it's all about writing pieces about each freshman. It takes a while but it's nice to imagine all of them, reading whatever you wrote specially for them. Unfortunately, there were still quite a few freshmen that none of us spoke to during the weekend, but thank the universe for the FaCie surveys. All needs to be done before the deadline the printer set for us, so the booklets can be delivered to us before the Freshmen Reunion, where we reunite with each other; the other committees, mentors and freshmen. Here all of us watch the aftermovie made by the FilmCrew and everyone can buy the FaCie booklet for just €1,-. Now our last task is to write a personal piece from each of us in the booklet of all freshmen, so they remember who made this amazing booklet which they can enjoy for years.

Now our story has come to an end, writing the last piece in the MaCHazine, but hopefully about whoever may continue our tasks next year. Good luck to you.

The FaCie

Lynn, Jules, Mirte, Nick, Jaron, Tom en Jari

Study Visit: New Horizons

Boaz van der Vlugt, Acquisition Study Visit Committee

This summer, 30 students and 2 professors from Applied Mathematics, Computer Science and Embedded Systems embarked on the W.I.S.V. 'Christiaan Huygens' Study Visit 2019, a unique three-week journey through Japan and South Korea to explore companies, universities and new cultures.

For me, however, the journey started a year and a half ago. Every three years, our study association organizes a three-week trip to a destination outside Europe. Past destinations have included Brazil, China and the United States. The aim of these study visits is to visit universities and companies in different countries, as well as to experience cultures outside of the Netherlands. Such a journey requires intense preparation, which is why more than a year prior to leaving for Japan, the Study Visit 2019 Committee had their first meeting. I was lucky enough to be a part of this committee. Together with 6 fellow CH members – Dion van Lange, Bastiaan Bakker, Maaike Mol, Thomas van der Pas, Marijn Roelvink and Annemieke Brouwer (who kept an eye of us on behalf of the board) – I spent many hours each week working towards making this trip an amazing experience.

Our first important task was, of course, choosing a destination. With a whole world of options in front of us, it was difficult to narrow our list down to one place. We ended up selecting Japan and South Korea as our destination due to the vast array of technological companies, the highly ranked universities and – most importantly – the unique culture. The months that followed were spent researching the countries, looking up accommodations, sorting out travel schedules and contacting various organizations. In September 2018, we hosted an information lunch where we presented the destination and a basic outline of the programme. Over 100 students attended, whilst we only had 23 places that we needed to fill. After reading countless CVs and motivation letters, we selected the 23 most suitable participants for the study visit. Little did we know how close we would end up being with this group.

In the months leading up to the study visit, a preliminary program took place in the Netherlands. With the selected participants, we visited various companies (such as Deloitte, Flow Traders, Deltares and MIcompany), and attended several workshops and lectures in Delft. The aim of this programme was to expand the students' knowledge of the job market in the Netherlands, and to show the students where they could potentially end up in their career. The activities also provided a great bonding opportunity for the group; many company visits included working on a so-called 'case', a small project/exercise to give an example of what the employees at the company work on every day. Working on these cases together was a nice way to get to know each other before we departed on a three-week journey through Asia.

On July 10th 2019, the big day had finally arrived: the first day of the study visit. After meeting early in the morning at Delft station, we travelled to Schiphol as a group. The security and check-in went smoothly, and in no time we were on our way to Tokyo Narita airport. Thanks to the wide selection of movies on board of the plane, the 11 hour flight flew by (pun intended) and at 8:00 AM local time – which felt like 1:00 AM to us – we landed safely in Japan. After some chaos at the train ticket office (which was mostly caused by our lack of understanding of the Japanese language), we managed to get on the right train towards the city. We dropped off our luggage at the hotel and went straight to our first activity: the Mori Digital Art Museum! This museum contained various light shows and beautiful projections, some of which were even interactive. Even with our heavy jetlag, it was a very cool experience. At the end of the day, however, everyone was tired from the intense travelling, so after a quick taste of the local food we headed back to the hostel for some well-deserved sleep.

The next week was spent in Tokyo, visiting every interesting place that we could find on Google. Never before had I been in a city with such a variety of districts. My personal favorite was Akihabara, a large area that was seemingly made up of only arcades and anime stores. Even though I am personally not a huge fan of anime, it was interesting to see how present it is in the Japanese culture. We also spent one of the days climbing a mountain (Mount Takao), and of course multiple nights were spent with the whole group singing our hearts out in the famous Japanese karaoke bars. Aside from touristic attractions, we also visited several companies and universities, such as NII (the National Institute of Informatics), Preferred Networks, OLM (Oriental Light Magic – the animation studio that created Pokémon!), Rakuten and Tokyo Tech. The people here gave interesting talks explaining exactly what they do, and how they apply mathematics and computer science in their work.

On our last day in Tokyo, after a visit to Huawei in the morning, we took the Shinkansen bullet train to our next city. At a speed of 300 kilometers per hour, we travelled through Japan for a couple of hours until we reached Kyoto. We only spent one full day here, on which we visited Kyoto University in the morning and walked a 'temple route' in the afternoon, a several-hour walk past various beautiful temples. The most notable stop was the Kinkaku-Ji, a beatiful golden temple in the middle of a small lake.

Sadly, after nine nights our time in Japan had come to an end. A six-hour boat trip brought us to our next country: South Korea! After arriving at the port in Busan, we took the train to Daejeon where we would stay for three nights. The difference between the two countries was immediately noticeable; whilst Japan was very neat and traditional, South Korea gave off a much more modern impression. Our days in Daejeon were spent mostly exploring the city and eating at 'Korean BBQ' restaurants, where meat was prepared on the table in front of you. We also paid visits to KAIST (Korea Advanced Institute of Science and Technology) and ETRI (Electronics and Telecommunications Research Institute), where we were shown demonstrations of various technologies.

The last stop of the study visit, and perhaps my personal favorite, was Seoul. On the day we arrived, we visited the Dutch Embassy where we were given a 2-hour crash course on South Korean history and customs. The next week was spent visiting Samsung, Seoul University and Naver (the South Korean version of Google), as well as exploring the nightlife of Seoul and visiting various palaces and museums. We also were lucky enough to spend a day visiting the DMZ (Demilitarized Zone), the area around the border between North and South Korea, which was very interesting.

On July 30th, it was sadly time to take the plane back to the Netherlands. The three weeks had flown by, but I look back on them fondly. I can confidently say that this trip was the most unique experience of my life so far; it was amazing to be able to observe such different cultures than what I am used to, and to do so with such a large group of fellow students made it extra special. It was also very rewarding to see how more than a year's worth of preparations amounted to such an extraordinary journey, and I'm very grateful to my fellow committee members for helping to make the Study Visit 2019 a great success.

Wiskunde Informatica Studievereniging 'Christiaan Huygens'

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Computer Science

Volume 24 • Issue 1 • November 2019

Creating a Fast and Concurrent Decision Engine using Actors

Mark Acda, Toon de Boer and Thomas Bos, Students Computer Science

In current businesses, there are a lot of problems that needs to be decided. The decision-making is automated to increase the efficiency, but bigger companies need to take more and more decisions. To keep up with the increasing amount of decisions, they also need to be made faster. The problem of the existing software for decision-making is that they are not scalable. They do not use concurrency in order to increase performance. During our Bachelor End Project at Finaps B.V. we tried to address this issue.

What is a decision engine?

Decision engines are software which calculate the output of a Decision Requirements Diagram (DRD) on a given input. A DRD is a collection of decision tables which take inputs and then determine, via a set of rules, their output. Furthermore, the output of one decision table can be the input of other decision tables. For an example of a DRD and a decision table you can take a look at Figure 1 and 2.

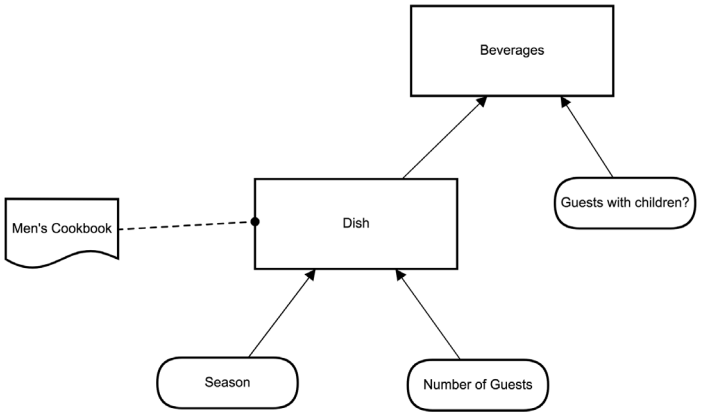

Figure 1: A DRD of two tables and three input variables. The 'Dish' table takes the season and the number of guests as input and outputs a Dish. The 'Beverages' table then takes that dish, and whether there are guests with children, and determines the corresponding beverage. [2]

Dish

dish

View DRD

U	Input		Output	
	Season	How many guests	Dish	Annotation
	string	integer	string	
1	"Fall"	<= 8	"Spareribs"	-
2	"Winter"	<= 8	"Roastbeef"	-
3	"Spring"	<= 4	"Dry Aged Gourmet Steak"	-
4	"Spring"	[5..8]	"Steak"	Save money
5	"Fall","Winter","Spring"	> 8	"Stew"	Less effort
6	"Summer"	-	"Light Salad and a nice Steak"	Hey, why not?
+	-	-	-	-

Figure 2: The 'Dish' table, which takes the season and the amount of guests as input and outputs a dish. [2]

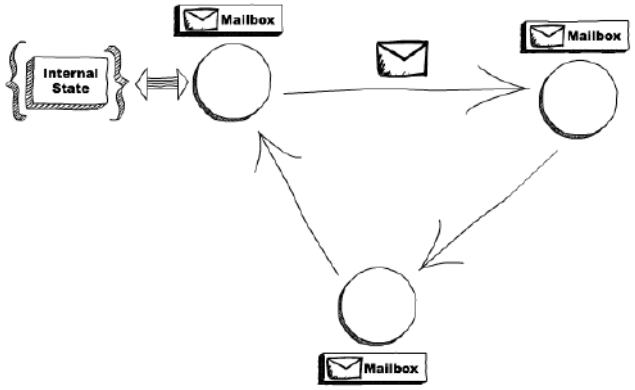

Figure 3: The Actor Model with 3 actors. [3]

Improving on existing software

The specific goal of the project was to improve upon the existing software which deals with DRDs and more specifically, the Camunda[2] decision engine. A big advantage during the project was that the Camunda software is open source so we could easily see what the problems were in their solution and in what way we could improve it. The biggest issue we came across is the fact that their solution used no concurrency at all, so all results of decision tables within the DRD were calculated sequentially within one single for loop.

The concurrency model we were going to use, which was part of the project specification, was to use the Akka implementation of the actor model. The actor model is a conceptual model to deal with concurrent computation. Every actor is isolated, so multiple actors can act at the same time. Actors can send messages between each other and every actor has a 'mailbox' where it stores messages when it is processing another message as is shown in Figure 3. The actor model also provides fault tolerance, as the crashing of one actor does not mean that the whole system fails. Actors in the system can act upon the failure of other actors [4].

The Akka library is a toolkit for building highly concurrent, distributed, and resilient message-driven applications for Java and Scala and is an implementation of the actor model on the Java Virutal Machine (JVM) [5]. Akka, which implements the actor model in the form of a hierarchy, allowed us to use actors and concurrency without diving deep into the underlying implementation of the framework.

Our implementation of the actor model

The way we used the actor model can be seen in Figure 4. The root actor is the Master actor which receives an instruction to calculate the result of a DRD on an input. It then sends the DRD to the left side of the tree to parse the DRD into an decision tree to allow for faster computation. This happens only once per DRD as the result is cached. The decision tree is then sent back to the master who then sends it together with the input data to the Solve Supervisor actor, which forwards it to a Tree Solver actor, which takes individual decision tables from the decision tree and lets Element Solver actors solve individual

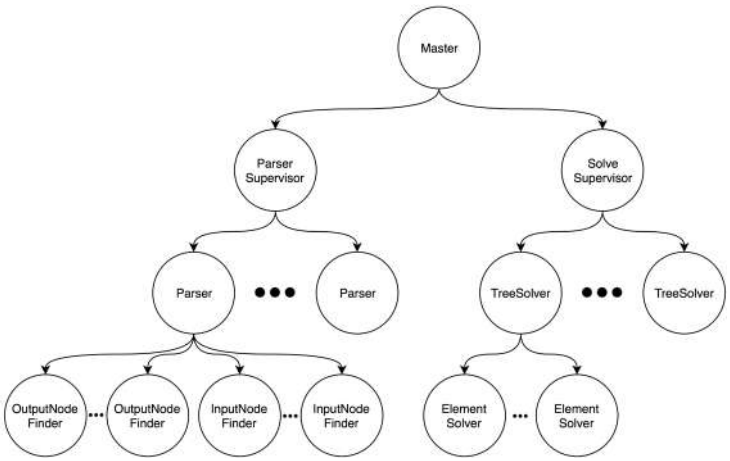

Figure 4: The actor hierarchy.

decision tables on input. Because the amount of actors at different layers can be customized, potential bottlenecks in the system can be resolved by either increasing or decreasing the amount of actors. For example, if we have five Parser actors and five TreeSolver actors and only one Parser actor is working, while all five TreeSolver actors are working, we can decrease the amount of Parser actors and increase the amount of TreeSolver actors.

Results

In order to evaluate the performance of our implementation we created a benchmark which creates *very* large DRDs and compared the performance of our software and Camunda's implementation on DRDs of different sizes. One of the results is shown in Figure 5. This shows a relation between the number of rules in a DRD and the run time of Camunda's and our program. The line of Camunda stops at a certain point, and is extrapolated. That is because it just took too much time to complete the benchmark. What our program did in 20 seconds was expected to take over 5 hours by Camunda.

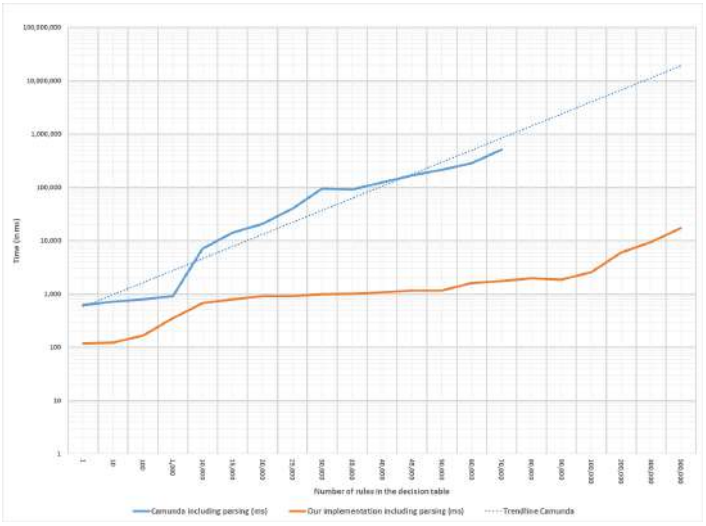

Figure 5: Run time of our program compared to Camunda's program. The x-axis contains the number of rules in the .dmn file used by both programs.

Conclusion

The main goal of our program was to create a fast and concurrent decision engine, which was very scalable and performs very well on a very high load. Our program runs concurrent due to the usage of Akka. The performance drops only slightly when the load increases. Compared to existing solution, our program is thousands of times faster at high load. Therefore we can conclude that the goal was reached.

For more explanations on how we reached our final goal and some additional results, we would like to refer you to our thesis [1].

Final remarks

We want to thank everyone at Finaps for all their support with Andrew in particular, and also Casper Poulsen who helped us with feedback during the project. Nice to say is that with the results of our program we exceeded our expectations, but especially those of the colleagues at Finaps. They will continue working on what we created, and will eventually make it open source.

To do our BEP at an external company was a very nice experience. Not only because of the financial compensation or the free lunch every day (yes, apparently there does exist a free lunch in computer science), but also because you learn a lot from working with people around you that have years of experience. They immediately helped us with any problems, gave us valuable feedback, and made us perform as good as we could. Therefore we recommend other students that want to do their BEP externally to really go for it. Just ask companies where you are interested in if they have a project for you, because if they don't, they will make one for you. And we hope that in the end, you will have just as much fun as we had.

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HARVEST

The talent incubator for software engineers

Building the tech leaders of tomorrow from the graduates of today

Een incubator is een broedplaats of couveuse en is sinds het digitale tijdperk een overdrachtelijke term voor high-tech en software omgevingen waar bedrijven, projecten en talenten zich ontwikkelen. De Software Talent Incubator van Harvest is opgezet met als doel het professioneel en gestructureerd aantrekken, ontwikkelen en behouden van talent. Wij helpen afgestudeerd software talent en organisaties om dit doel te bereiken. Het resultaat? Business Impact.

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Wat kun je verwachten van The software Talent Incubator?

Samen met jou gaan wij op zoek naar een innovatief project en organisatie die bij jou past. Hierin sta jij centraal en met minder nemen wij dan ook geen genoegen. Binnen het programma van één jaar krijg je Masterclasses aangeboden op The Best Practices in ons vakgebied door de absolute experts. Uiteraard ga je ook certificering behalen maar dat doen we in overleg.

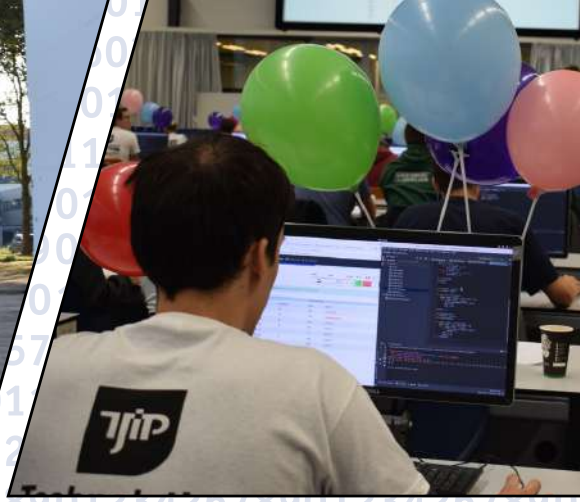
Naast uitdagende werkzaamheden aan mooie projecten werk je -samen met onze coach- continu aan jouw persoonlijke en professionele ontwikkeling. Je krijgt inzicht in je eigen talenten en hoe je deze het beste kunt inzetten. Kortom, hard werken in combinatie met veel gezelligheid en plezier! Na het Harvest jaar is het de bedoeling dat je in vaste dienst treedt bij een van onze klanten waar je een glansrijke carrière kan voortzetten als toekomstig technisch leider!

HARVEST







5 Days To Explore The Cyber Security Field

Djoshua Moonen, Student Computer Science

Last August, the fourth edition of the National Cyber Security Summer School was organized. Djohsua, a Computer Science student here at TU Delft, was one of the participants this year and tells about his experience.

What is the NCS3?

The National Cyber Security Summer School (NCS3) is a course in cyber security aimed at students interested in the field. By introducing the technical and non-technical aspects without requiring any previous experience or skills, it shows participants the different angles that the field has to offer. Overall the course presented and explored different career options in the public, private or academic sector of cyber security.

When was it?

In 2019 the NCS3 was held over a five-day period starting on the 19th and ending on the 23rd of August. Every day the venue was held in a new location in the Netherlands and focused each day on one of the concepts of cyber security. With the venues being in The Hague, Rotterdam, Delft, Enschede and Amsterdam, the program aims to show the participants some of the most important players in the national cyber security world, whilst still keeping the combined travel time over the week to a reasonable amount.

What was your reason for participating in the NCS3?

The main reason for me to take part in the NCS3 was to inform me on which master to pursue. I am interested in a career in cyber security, but figuring out if this field suits me, has been a challenge. Whilst discussing this with a cyber security professor at the TU Delft - who coincidentally gave a lecture in the NCS3 - he told me that the best way to figure this out is by doing extracurricular activities related to the field. Following his advice, I found the NCS3.

What is the Cyber Security Council Challenge?

The Cyber Security Council (CSR) Challenge was an assignment the participants worked on during the summer school. Participants were placed in groups of 8, assigned a mentor as well as a critical sector, which is a sector critical to the functioning of a nation. Each group had to analyze how an emerging technology (AI, Drones, Wearables, etc.) would impact the critical sector along with the cyber security risks this would bring. Throughout the summer school, time was allocated to work on the challenge, for which a report was required and a presentation was to be given. A jury comprised of experts in the field would judge the results of all the groups, where the winning group would get the opportunity to present their work to and meet the Cyber Security Council.

What did the program look like?

On the first day the NCS3 was located at the Ministry of Justice and Security in The Hague and was focused on introducing digital security. This meant after a group photo was made and an opening speech was given, we attended lectures that introduced aspects of digital security. Lectures were given on the role of the National Cyber Security Center, high-tech crime and the investigative process, GSM and GPRS interception, the infrastructure of the internet and cyber security strategies. Together these five lectures gave the participants a better insight on technical and non-technical aspects of digital security. This day, just like most of the days, the summer program ended with a complimentary diner. Within walking distance from The Hague central station we spend the evening at Hudson for a splendid three-course meal accompanied with drinks. This evening was special, because besides talking to friends made during the day or mentors working in the industry, we also had the opportunity to socialize with alumni from the summer school. After a day of learning and an evening of socializing, everyone went to get some rest in preparation for the next day.

On the second day all the participants gathered at CGI in Rotterdam to learn more about critical infrastructure and cyber threats. After being welcomed by the cyber security practice lead of CGI, we attended lectures on today's central theme. The lectures were about critical infrastructure protection, security in a changing (smart) grid, war-fighting in the 21st century and on how information technology can fail operational technology. Furthermore, we attended a hacking lab session. Here we were tasked to log in to websites specifically designed for this challenge by abusing designer mistakes. Due to many participants not coming from a technical background, it was an entry-level capture the flag (CTF) challenge, nonetheless it was fun to do and I managed to learn something new by completing it. The day concluded with us having diner and drinks. This time it was located at Shabu Shabu. I spend this evening talking to participants who originated from other countries and learned about differences in culture and traditions.

The third day was organized in the Westcord Hotel, nearby Fox-IT in Delft. Here, we would get a deeper understanding of data and privacy. We attended lectures on the influence that cyber security has on telecommunication companies, cryptography, quantum computing and the reality of cyber security breaches. This day was special in the way that we had a session on crisis simulation. This crisis simulation was an exercise where participants were divided into groups and tasked to handle the crisis at hand. Each participant, representing a board member of a company, was given information their role has access to. The task at hand was to analyze the situation within a limited amount of time and 'handle' it. This was to be done by preparing and giving a statement to either the press or the stakeholders of the company. Overall this day gave insight on the practical and theoretical aspects of data and privacy. At the end of the third day we attended a networking event. This gave us, the participants, to opportunity to talk to our lecturers in an informal setting. Whether one wanted to discuss the lecture material further, ask about what it was like to work for a certain company or what the aspects of their jobs were that they liked the most; this was to place to learn more about it. Like the name suggests, it was a place to network with people active in the cyber security field.

On the fourth day of the summer school we traveled all the way to the other side of the country, to Enschede. This could be done on your own, or by using the bus provided by the NCS3. Once arrived at the venue, we spent the day on cyber security innovation. Lectures were given on query execution over encrypted databases, securing the internet of things, AI, hospitals and cyber-attacks and on building cyber norms. To close the day, we went over to restaurant Hanninkshof where a barbeque was arranged for us. The evening consisted of talking with participants and lecturers, after which the bus that we arrived with, brought us back to The Hague.

On the last day, the NCS3 was located at Deloitte in Amsterdam. This day focused on finishing and presenting the work done on the CSR Challenge and therefore there were no lectures. The groups worked on their respective reports and presentation slides until the moment the groups were to present their work. When it was time to present our results the participants, mentors and the jury gathered together and the presentations began. Each group presented their work after which the jury would engage in a questions and answers session. After listening to the innovative solutions provided by all the different groups, the jury went and discussed who won the competition and in turn would be presenting their work to the CSR. After the winning groups was announced, the NCS3 concluded with a speech and farewell drinks where participants received a badge and certificate for participating.

What did you take away from NCS3?

There are multiple things I gained from the NCS3. Firstly, I gained knowledge on many topics within the field of cyber security. This is knowledge that I will be able to use in computer science in general. Secondly, I managed to meet like-minded people from different disciplines. These are people I can turn to when I am in need of a different perspective. Lastly, I was able to gain a better understanding on what the field of cyber security has to offer. This will aid me in choosing my master as well as my career path. Overall, the NCS3 has been a rewarding experience, not only on the intellectual but also on the social level.

Simulation and rendering of fluorescence

Vera Hoveling and Marijn Roelvink, Honours Students Computer Science

What do blood, tonic water and bank notes have in common? They all glow when UV light shines on them: they are fluorescent. We present the Daisyriot renderer, a program to generate images with realistic lighting that includes the exotic property of fluorescent materials. So we can now render realistic images of the aforementioned three under black light!

The DaisyRiot renderer was developed as part of our honours project in the Computer Science bachelor. All source code is released online: github.com/asylunatic/DaisyRiot.

Core concepts

At the heart of the renderer there are three core concepts: Fluorescence, spectral rendering and radiosity.

Fluorescence

Fluorescence is the emission of light by a substance that has absorbed light or other electromagnetic radiation. Generally, the emitted light has a longer wavelength (lower energy) than the absorbed radiation. In other words: fluorescent materials can bend light from one wavelength to another. Glassner [1] developed a mathematical model for fluorescence in 1995. To the best of our knowledge, this model has not been combined with radiosity rendering before.

Spectral rendering

In spectral rendering, a scene's light transport is modeled after individual or small bands of wavelengths. This is in contrast to, for example, the RGB color model, in which color measurement relies on a system of only three values. Simulation of the light spectrum enables a more physically accurate simulation of the scene. To display any image to screen, the spectral color space must be converted to screen color space (sRGB).

Radiosity rendering

Radiosity is a global illumination algorithm based on thermodynamics: it models how energy moves through a space. In radiosity, all surfaces in the space are subdivided into small 'patches'. Any two patches I and J have a view factor $F_{I\to J}$ that describes how much energy is reflected off of patch I to J. It is modeled by the following integral:

$$F_{I\to J} = \frac{1}{A_I}\int_{A_I}\int_{A_J}\frac{\cos\theta_I\cos\theta_J}{\pi s^2}dA_I dA_J \tag{1}$$

In which A is the surface of the patch, θ the angle of the line between the patches and the surface normal and s the distance between the patches. The radiosity of a patch is the energy per unit area leaving the patch surface per discrete time interval and is the combination of emitted and reflected energy. The radiosity of a patch I is formalized as:

$$B_I = E_I + \sum_{J=1}^{n} F_{J\to I}B_J\rho_I \tag{2}$$

in which B is the radiosity, E the emissiveness and ρ the reflectiveness of the surface. This radiosity equation can also be represented as a linear system of equations:

$$B = E + \rho KB \tag{3}$$

where K is a square matrix of view factors. Solving this system yields the radiosity of each patch.

Combining radiosity with spectral rendering and fluorescence

To explain how we combined radiosity with spectral rendering and fluorescence, we will first describe our approach to radiosity and then our method to facilitate spectral rendering and fluorescence.

Approach to radiosity

The integral that describes the view factor in Equation 1 can only be directly computed for trivial cases. We therefore approximate it with a Riemann sum: to obtain the differential areas of any patches I and J, both I and J are subdivided first. The integrands between all of the subdivided patches are calculated and weighted by the area of I. An additional check for obscurity is performed: if I and J can only partially see each other, their respective view factors are multiplied by the fraction of visibility to one another. For each patch, the view factors to all other patches are stored as a row in a matrix. This radiosity matrix describes the flow of energy through the scene:

$$\begin{bmatrix} 0 & F_{0\to1} & F_{0\to2} \\ F_{1\to0} & 0 & F_{1\to2} \\ F_{2\to0} & F_{2\to1} & 0 \end{bmatrix}$$

To solve the linear system, and thus to obtain the radiosity values for each patch, we have chosen the progressive approach: we iteratively calculate an approximate solution, based each time on the previous approximation [2]. Every iteration corresponds to a light bounce in the scene. To do so, we formulate the radiosity in the scene as

$$B = E + \sum \rho KB \tag{4}$$

in which B, E and ρ are vectors containing the radiosity values, emission and reflectiveness, respectively, of the surface for each patch. K represents the radiosity matrix. With each pass, the system converges towards the solution, this convergence is ensured by the property of diagonal dominance in the radiosity matrix. The convergence of the calculations and the iterations of light bounces in the scene are illustrated in Figure 1.

Spectral rendering & fluorescence in radiosity

To facilitate spectral rendering in radiosity, wavelengths are sampled discretely [3]. The larger the number of sampled wavelengths, the closer the approximation. When we assume that all wavelengths are decoupled, the solution for the radiosity at wavelength λ would be independent of the solution at some other $\grave{\lambda}$. So to find the radiosity values, we would solve a set of linear equations for each individual λ.

Figure 1: The first three light bounces in a scene (from left to right)

However, fluorescence breaks the assumption of decoupled wavelengths (wavelengths can influence each other). To facilitate this, each material is modeled with a parameter. M is an $m \times m$ matrix for m number of samples, which represents the transfer of energy from one wavelength to another [4]. For a non-fluorescent material, this matrix has non-zero values only on the diagonal. For fluorescent materials, M is a triangular matrix, as the radiated energy is lower than the absorbed energy. We adjust the solution to the linear equations to take fluorescence into account:

$$B = E + \rho \sum K\grave{M}B \tag{5}$$

in which B is an $n \times m$ matrix for n number of patches and m number of wavelength samples, E is an $n \times m$ matrix containing the emissive values, ρ an $n \times m$ matrix with the reflectivity of each sampled wavelength per patch, K is the $n \times n$ radiosity matrix, and $\grave{M}$ a 3D matrix of dimensions $m \times n \times m$, containing the matrix M for each patch. Take note that for each sampled wavelength, the dimension m is incremented, so with more samples comes a higher computational cost [5].
For simplification, we have chosen to ignore time dependence between frames, as fluorescent materials cease to glow nearly immediately when the radiation source stops.

Rendering to screen

To display the scene on screen, it is first traced with primary rays from a given camera and view direction. For each pixel, a patch index and barycentric coordinates are obtained. The pixels' color values are interpolated between the adjecent patches. To render the image to screen, the spectral color model is converted to CIE XYZ color space [6] and consequently to RGB.

Results

The most important part of course! Figures 2, 3, 4, 5 and 6 demonstrate some typical features of the renderer:

Wavelength sampling

As mentioned earlier, there is a tradeoff between the number of sampled wavelengths and the computational costs. To determine which wavelengths we should sample, we started with a suggestion by Meyer [3], that a set of just four samples can in most cases provide a good balance: 456.4, 490.9, 557.7, and 631.4 nm. Unfortunately, we found that these did not work very well for our case. Eventually, we found good results when sampling wavelengths between 350 and 650 nm with uniform intervals of 50 nm (7 samples in total), as seen in Figure 2.

Colored light sources

Figures 3 and 4 demonstrate the application of colored light sources in the renderer. In Figure 3, a model is lit from two sides, allowing the shadow on the right to contain more red, and the shadow on the left to contain more blue. Figure 4 illustrates a pink and a green light source, which are both partially obscured by a structure, allowing for colorful light patterns on the walls.

Fluorescence

As illustrated in Figure 5 and 6, the emissiveness of the fluorescent materials differs from any other emissive surface, as the light is only emitted from where it can see the blacklight. It is literally a reflection of invisible light: only the reflection is visible. Observe the faint violet tint of the black light sources: The black light was sampled with an emissive peak at 350 nm, well outside of the visible range, however we also sampled a smaller peak at 400 nm, as is often found in the spectra of black light sources: their dark blue filters often leak a bit around 400nm, causing the violet glow.

Typical artifacts

Most notable artifacts in the images are visible edges of patches when the scene is not sufficiently subdivided. Objects can also appear as slightly floating when the scene is not sufficiently subdivided, as one can observe in Figure 2. Adaptive subdivision [7] should be an appropriate solution to this.

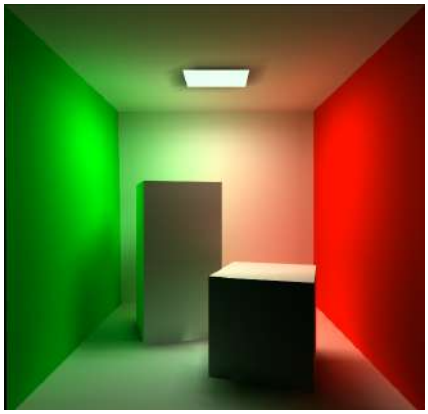


Figure 2: Spectral rendering of the Cornell box with wavelengths sampled in 50 nm intervals between 350 and 650 nm.

Figure 3: Scene with red and blue light sources.

Future work

Although our honours project is finished, we still have plenty of ideas on how the DaisyRiot renderer could be improved. We briefly suggest three areas for future work that we consider particularly exciting.

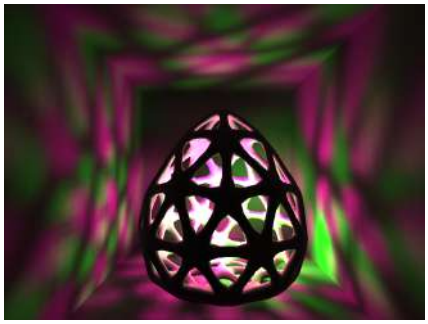


Figure 4: Scene with partially occluded pink and green lights.

Figure 5: Black light interpretation of the Cornell box with a black light and blue and pink fluorescent cubes.

Interactive materials editor

The spectral values for the materials are sampled from RGB values, which provides a convenient way to define materials: materials can be inspected visually in an editor such as Blender, and then read from a materials file. However, it would be a great addition to have an interactive materials editor within the renderer itself. In the editor, the materials could be previewed and the scene updated (relatively) quickly, providing an efficient workflow for artists. The manipulation of materials could be done by allowing manual adjustments to the curves that represent the reflective and emissive spectra of a material. The fluorescent color could be edited in a similar fashion. Alternatively, the fluorescent properties could also be edited with more detail for how and which wavelengths bend to what frequency, even enabling materials that might not be fully physically correct, but perhaps visually interesting.

Additional spectral light sources

The only light sources currently emitting UV light in the renderer are blacklight sources. Of course these are not the only sources of UV light in the real world. Adding sources for, for example, sunlight would be a major addition to the program, as fluorescence also happens in daylight, which makes the color of a neon shirt pop so bright.

Simulation of X-ray fluorescence

Having set up a framework for spectral rendering with fluorescence, it would probably be possible to visualize wavelengths outside of the visible spectrum and enable simulations of phenomena such as X-ray fluorescence. X-ray fluorescence is the emission of fluorescent X-rays from a material after being exposed to high-energy X-rays or gamma rays [8].

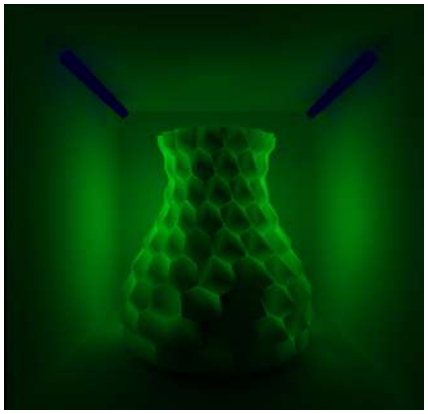


Figure 6: Black light scene with a green fluorescent object lit by two black light tubes.

Conclusion

We have given an overview of the DaisyRiot renderer, which combines radiosity with spectral rendering and novelly supports fluorescent materials.

Our approach to radiosity uses a Riemann sum approximation to calculate the view factors, which we store in a matrix that represents the flow of energy through the scene. We chose an iterative approach to solving the radiosity equation and then modeled the solution to the equation for all wavelengths as a set of matrix operations that takes fluorescence into account.

The results show that we found a good set of sampling wavelengths at 7 uniformly spaced intervals. We also see that fluorescent materials are emissive in a unique way and so bring the possibility for a new range of images. Typical artifacts appear when the mesh is not sufficiently subdivided, for which a solution exists.

We hope to have enabled new visualisation by supporting a new kind of material in radiosity: bank notes and tonic water under blacklight are definitely possible now! This can perhaps even be made easier in the future with the road map we've laid out for the editing of materials and light sources.

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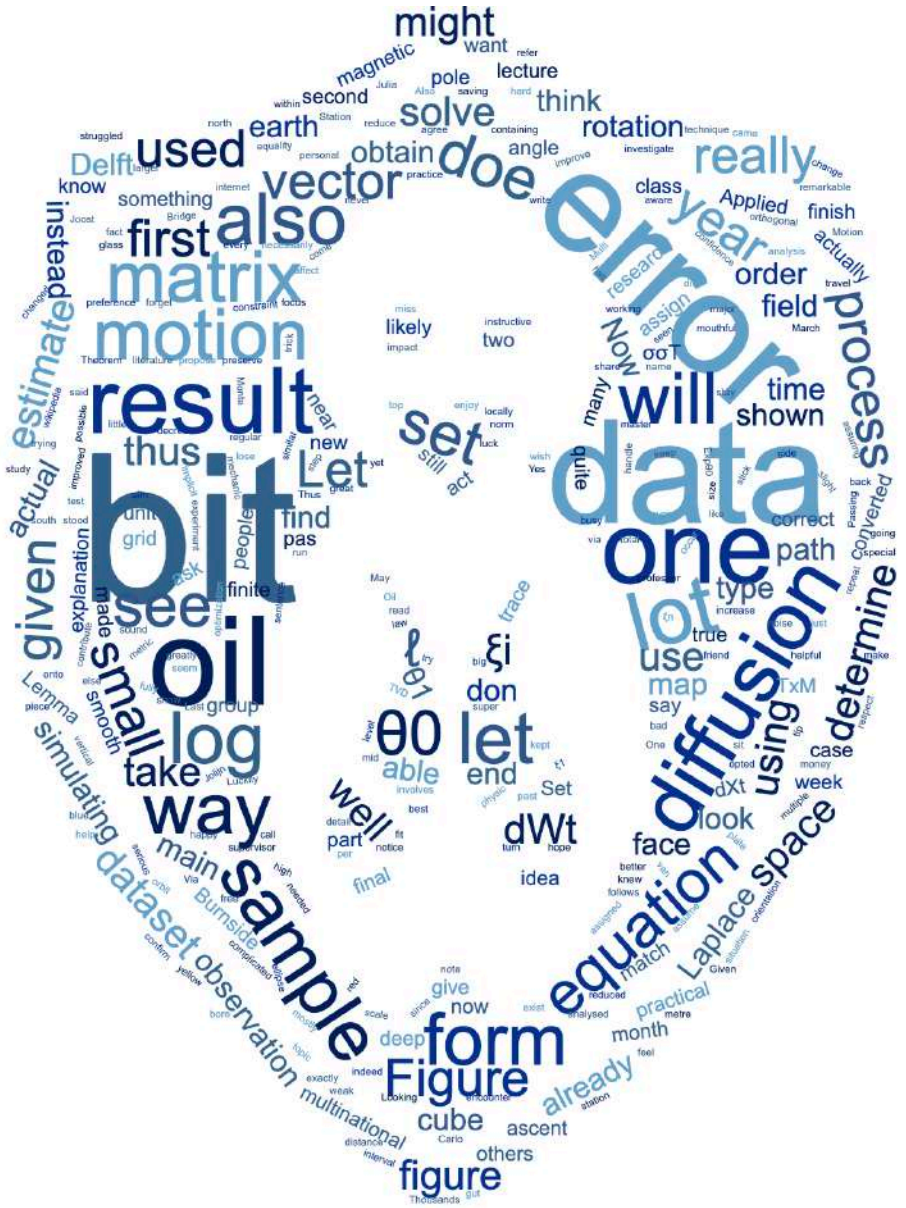
Mathematics



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Likelihood-based Inference on Nonlinear Spaces

Marc Corstanje, Master of Science

In many statistical applications, we encounter data in high dimensional spaces with some constraints on them. One can think of the example of a set of locations on the earth. Since these spaces are not linear, the sample mean generally does not exist. In this article, we propose a method to perform likelihood-based inference on the center of a dataset that takes its values in a Riemannian manifold by modeling the data as observations of independent Brownian motions.

A Mathematical Model

Let $(\mathcal{M}, g)$ be a Riemannian manifold [1] of dimension d and let $(X_t)_t$ be a Brownian motion on $\mathcal{M}$ starting at $\theta \in \mathcal{M}$. Given $T > 0$, we consider a dataset $\xi_1, \ldots, \xi_n$ of independent observations of X_T and aim to do likelihood-based inference on θ.

Brownian Motion on $\mathcal{M}$

There are multiple ways to characterize Brownian motion on a Riemannian manifold (see [**1**]). In this article, we will introduce a characterization inspired by [**2**]. Throughout this article, we consider the class of regular submanifolds, which is a subset of the class of all Riemannian manifolds containing sets of the form

$$\mathcal{M} = \left\{ \begin{pmatrix} y \\ F(y) \end{pmatrix} : y \in \mathbb{R}^d \right\} \subseteq \mathbb{R}^N, \tag{1}$$

where $F : \mathbb{R}^d \to \mathbb{R}^{N-d}$ is a smooth function. Note that by the implicit function theorem, any level set $f^{-1}(\{0\})$ for a smooth function $f : \mathbb{R}^N \to \mathbb{R}^{N-d}$ is locally of this form.

It is important to notice that $\mathcal{M}$ is a subset of $\mathbb{R}^N$ and that a tangent space $T_x\mathcal{M}$ to $\mathcal{M}$ at $x \in \mathcal{M}$ is a vector space of dimension d embedded in $\mathbb{R}^N$. We can thus let $P(x)$ denote the orthogonal projection matrix of $\mathbb{R}^N$ onto $T_x\mathcal{M}$. In [**1**], we show that

$$P(x) = \begin{pmatrix} I \\ J(y) \end{pmatrix} g(y)^{-1} \begin{pmatrix} I & J(y)^T \end{pmatrix}$$

where J denotes the Jacobian matrix of F and g a Riemannian metric on $\mathbb{R}^d$ that preserves the norms of the tangent vectors to $\mathcal{M}$ in $\mathbb{R}^N$.

Theorem 1. *Let $W = (W_t)_t$ be a standard Brownian motion in $\mathbb{R}^N$ and let $X = (X_t)_t$ be the solution to the Stratonovich stochastic differential equation given by*

$$\mathrm{d}X_t = P(X_t) \circ \mathrm{d}W_t, \qquad X_0 \in \mathcal{M} \tag{2}$$

Then the first d components of X form a diffusion process in $\mathbb{R}^d$ with infinitesimal generator $\frac{1}{2}\Delta$, where Δ denotes the Laplace-Beltrami operator

$$\Delta f = \frac{1}{\sqrt{|g|}} \partial_j \left(\sqrt{|g|} g^{ij} \partial_i f \right)$$

[1] For background reading on Riemannian geometry, we refer to [**1**] and [**3**].

A well-known result form stochastic calculus is that Brownian motion is generated by the Laplace operator and thus theorem 1 gives us a characterization of Brownian motion on $\mathcal{M}$ through solutions to equation (2), as a solution to this equation is generated by the Laplace-Beltrami operator on the Riemannian manifold $(\mathbb{R}^d, g)$.

Approximation of the likelihood for θ

Let $(X_t)_t$ be Brownian motion on $\mathcal{M}$ starting at θ and let p denote the transition density of $(X_t)_t$, i.e. $\mathbb{P}(X_t \in \mathrm{d}y \mid X_s = x) = p(s, x; t, y)\,\mathrm{d}y$. The likelihood for θ is given by

$$L(\theta \mid \xi) = \prod_{i=1}^{n} p(0, \theta; T, \xi_i) \tag{3}$$

Since p is intractable, we will approximate it using diffusion bridges between θ and the data points. This method is based on the simulation method proposed in [**4**], which we will now briefly introduce. Let X be a diffusion governed by

$$\mathrm{d}X_t = b(t, X_t)\,\mathrm{d}t + \sigma(t, X_t)\,\mathrm{d}W_t, \qquad X_0 = \theta \tag{4}$$

where $b : [0, \infty) \times \mathbb{R}^d \to \mathbb{R}^d$ and $\sigma : [0, \infty) \times \mathbb{R}^d \to \mathbb{R}^{d \times d'}$. Under weak conditions (see e.g. [**1**] and [**4**]), the conditioned process $X^* = (X \mid X_T = v)$ is governed by the SDE given by

$$\mathrm{d}X_t^* = b^*(t, X_t^*)\,\mathrm{d}t + \sigma(t, X_t^*)\,\mathrm{d}W_t \tag{5}$$

where

$$b^*(t, x) = b(t, x) + \left(\sigma\sigma^T\right)(t, x)\,\nabla_x \log p(t, x; T, v)$$

Since p is still intractable, we simulate diffusion bridges via guided proposals governed by the SDE

$$\mathrm{d}X_t^\circ = b^*(t, X_t^\circ)\,\mathrm{d}t + \sigma(t, X_t^\circ)\,\mathrm{d}W_t \tag{6}$$

where

$$b^\circ(t, x) = b(t, x) + \left(\sigma\sigma^T\right)(t, x)\,\nabla_x \log \tilde{p}(t, x; T, v)$$

where $\tilde{p}$ is a transition density of a process of which we know it. In [**4**], it is shown that, under a few conditions regarding the behavior of X°, the laws $\mathbb{P}_T^*$ and $\mathbb{P}_T^\circ$ of X^* and X° respectively are equivalent and that we have a continuous function ψ known in closed form such that

$$\frac{\mathrm{d}\mathbb{P}_T^*}{\mathrm{d}\mathbb{P}_T^\circ}(X^\circ) = \frac{\tilde{p}(0, \theta; T, v)}{p(0, \theta; T, v)} \psi(T, X^\circ) \tag{7}$$

Now note that if we integrate both sides with respect to the measure $\mathbb{P}_T^\circ$, we obtain the following equality

$$1 = \frac{\tilde{p}(0, \theta; T, v)}{p(0, \theta; T, v)} \int \psi(T, X^\circ)\,\mathrm{d}\mathbb{P}_T^\circ(X^\circ)$$

The integral can be interpreted as an expectation and can thus be approximated by simulating several diffusion bridges and taking an average. For computational convenience, we stick to 1 diffusion bridge. If we simulate

guided proposals for diffusion bridges $X^\circ_{(1)}, \ldots, X^\circ_{(n)}$ between a given θ and each of the data points ξ_i, we find an approximation of the log-likelihood at θ given by

$$\begin{aligned} \ell(\theta \mid \xi, X^\circ) &= \sum_{i=1}^{n} \log p(0, \theta; T, \xi_i) \\ &\approx \sum_{i=1}^{n} \left[\log \tilde{p}(0, \theta; T, \xi_i) + \psi\left(T, X^\circ_{(i)}\right) \right] \end{aligned} \tag{8}$$

Numerical results on the unit sphere

For numerical experiments, we simulated 100 data points on the sphere by simulating paths of the diffusion seen in equation (2) starting at $\theta = (0, 0, 1)$ and saving its value at $T = \frac{1}{2}$. Via simulations using the Bridge.jl package in Julia, we can obtain approximations of ℓ on a grid of points on the sphere

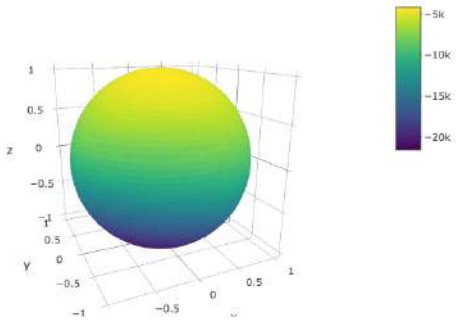

Figure 1: The results of equation (8) on a grid of points on the unit sphere

Figure 1 looks as one would expect. The true parameter used for simulating the data was $(0, 0, 1)$ and we clearly see that the likelihood is large near the north pole and small near the south pole.

Drawing samples from the likelihood

By slightly adapting the Metropolis-Hastings algorithm for Markov chain Monte Carlo methods, we can also simultaneously update the guided proposals and draw samples from the likelihood for θ, as is demonstrated in figure 2.

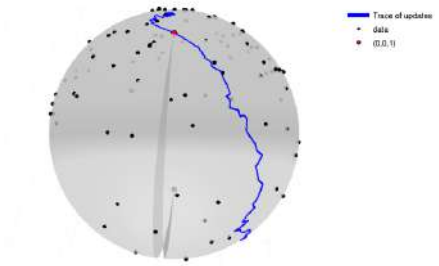

Figure 2: 1000 iterations of an adapted Metropolis-Hastings algorithm for drawing samples of the approximated log-likelihood from equation (8).

Figure 2 was made by starting at a random point on the sphere and proposing a new point from a uniform distribution. Acceptance or rejection of this new point was determined by ℓ. Within about 20 iterations, the Markov chain draws samples from the likelihood. Note that these samples are not precisely at $(0, 0, 1)$. It is likely that this is caused by the small sample size and the randomness in the stochastic approximation for the likelihood.

Maximum likelihood estimates

In order to find a maximum likelihood estimate for θ, one can apply a gradient ascent algorithm. The idea behind such an algorithm is to take steps in the direction of the gradient of ℓ, as this is a vector that points to the maximum. In order to stay on the manifold, we use the exponential map when known in closed form and thus apply algorithm 1.

Input: Start with random point θ_0 on $\mathcal{M}$.
Set $\theta_1 = \mathrm{Exp}_{\theta_0}\left(hP(\theta_0)\nabla\ell(\theta_0)\right)$;
if $\|\theta_0 - \theta_1\| < \varepsilon$ **then**
  Stop
else
  Set $\theta_0 = \theta_1$ and repeat
end

Algorithm 1: Algorithm for finding a maximum likelihood estimate using stochastic gradient ascent in combination with the exponential map.

Not that we apply the projection matrix to obtain a tangent vector to θ_0 before being able to apply the exponential map. A trace of the updates of a run of this algorithm on the sphere can be found in figure 3.

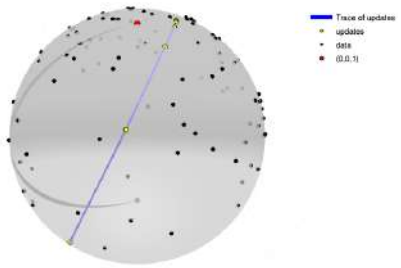

Figure 3: A trace of the updates when applying algorithm 1 to a simulated dataset on the sphere

Convergence is typically observed within 30 to 50 iterations.

Concluding Remarks

In this article, we demonstrated a method for approximating the log-likelihood for θ that seemed to perform as one could expect on the sphere. The slight deviation from the true center is likely to be caused by a small dataset and the randomness in the stochastic approximation. For more reading on this topic and for a more extensive explanation on the backgroud theory and the statistical methods, feel free to take a look at [1].

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Improving oil drilling using mathematical techniques

Simone Vis, Student Applied Mathematics

At the end of your bachelor's degree in Applied Mathematics, everyone does a final bachelor project of around 10-12 weeks to finish his or her bachelor's degree and so did I.

This all started in March, when everyone had to indicate a preference for different bachelor projects. There were a lot of interesting problems in different fields such as analysis, optimization, numerical mathematics and probability. In my top 3, I opted for practical projects in which I could apply my mathematical knowledge to a problem in practice. Then I was assigned to an oil drilling project in the numerical mathematics department in collaboration with Shell. As a result, I had 2 supervisors for my bachelor project, one professor from the numerical mathematics department and a coordinator from Shell.

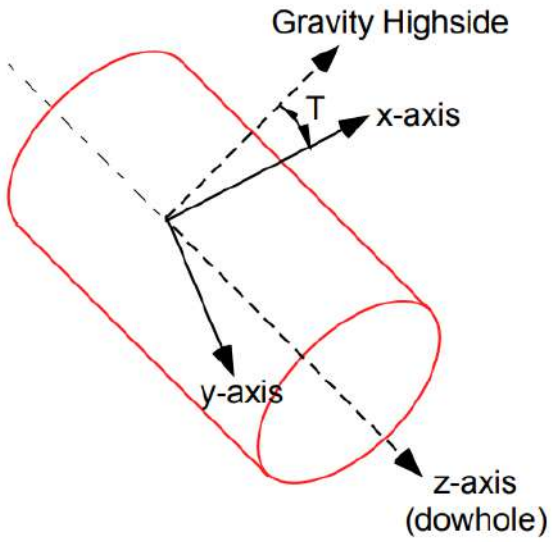
The project started with reading literature that kept me busy until mid-May. Oil drilling involves a lot of physics, mechanics but also a lot of complicated mathematics, so I had to read a lot in the first few weeks. Luckily my coordinator from Shell was very helpful and he was able to explain to me the practical problem and the mathematics used when oil drilling.

The problem I have been working on for 3 months is as follows. To explain it in one sentence: I have analyzed the position uncertainty of a drill bit during oil drilling using numerical methods. Yes, this is quite a mouthful, so I'll explain it in more detail.

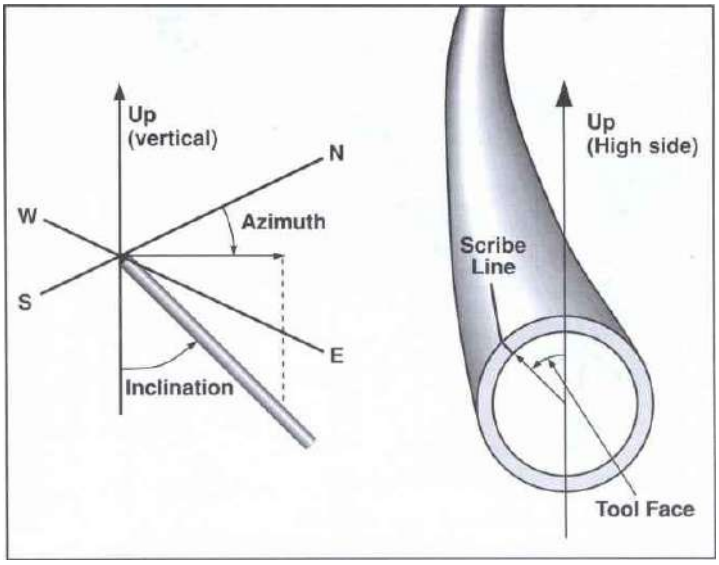
Shell is a multinational oil company with great interest in oil drilling. They use a drill bit to drill down through the ground to an oil well, sometimes up to 15 kilometers deep, in order to pump the oil up. However, the earth is not a glass plate so you cannot look down and see where the drill bit is located under the ground. Therefore, the drill bit has measuring equipment that determines indirectly the position of the drill bit under the ground. This measuring equipment measures the magnetic field of the earth. However, disturbances can occur, which we also call noise, resulting in the fact that the measurements are no longer correct and therefore the position of the drill bit does not match the measurements. As a result, the actual position of the drill bit does not match that of the measurement data, which can have serious consequences. To indicate some scale of the errors, one could think of a position error of, for example, 30 metres per kilometre. As a result, the drill bit can miss the oil well completely at kilometres deep, causing oil companies to lose a lot of money.

That is why oil companies are trying to determine the position uncertainty of the drill bit and, if possible, also to reduce it. By uncertainty we mean, for example, a 95% confidence interval. In my bachelor project, I examined two methods to determine that position uncertainty of the drill bit and compared these methods.

The drill bit can be modelled as a cylinder. However, in the well-bore industry, they use an orientation expressed in two angles, the azimuth and inclination angle, and the total vertical distance (TVD) instead of a x,y,z system. Therefore, coordinate transformations are needed. I used several matrices that converted the measurement data to another system of coordinates, but also to transform the data back.

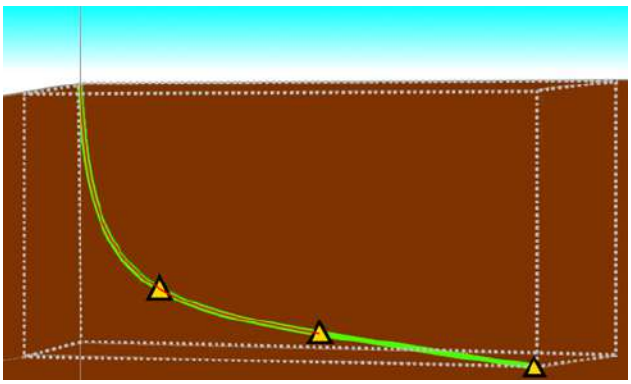


Mathematics



I modelled drilling trajectories to test the methods. In this model trajectory, I knew exactly the drill bit's position and could therefore determine the position uncertainty of the drill bit with the different methods.

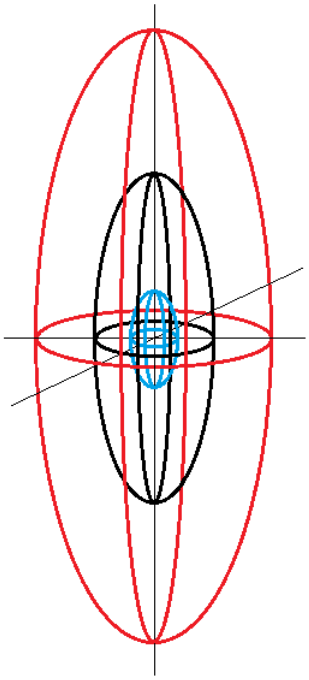
In such a model trajectory, I modelled a drill path with a number of measuring stations (see the yellow triangles in the figure), where the drill bit measures the magnetic field. These data are converted to directional vectors with transformation matrices. This data is then used to model a model trajectory with a final position of the drill bit, which was my main interest.



The first method I investigated was Multi-Station-Analysis, which has been the industry standard for quite some time now. This method tries to estimate the errors in the measurement data and then tries to correct these errors. This method then uses the improved measurement data to model a drilling path. As a result, the position uncertainty of the drill bit was indeed reduced compared to the situation if this method was not used.

The second method I looked at was the covariance method. This is a method that uses mostly linear algebra where matrices are multiplied to determine the errors in the measurement data. The position of the drill bit is then shown in the form of a covariance matrix.

Looking at the results of my research, I found that the position uncertainty can be modelled as an uncertainty ellipse around the actual end position of the drill bit. When comparing the methods, something important stood out. This was the choice of how to handle an error. You can assume that the errors are random in the drilling process and that the error in one part of the drill trajectory does not affect the error in another part of the drilling process, but you can also consider the errors as systematic or global, for example. When errors were considered random, the position uncertainty was much smaller and when errors were considered systematic, the position uncertainty was much larger. This is shown in the figure with the 3 ellipses around the actual position of the drill bit. The main conclusion from my research was that the choice of the type of error had a major impact on the position uncertainty. Thus, it is not necessarily correct to say that one method is better than the other but the choice of the type of error greatly increases or decreases the uncertainty. This was a remarkable observation for Shell, which they will investigate further.



I found my bachelor project a very instructive experience and a super interesting problem to focus on for 3 months. I learned a lot about oil drilling and how everyone can contribute something to a problem with different backgrounds. It was also a special experience to be able to work with a multinational company like Shell.

All in all, you can see how interesting projects are that you can do with just a bachelor degree in Applied Mathematics, let alone if you have a master degree.

Algebra 1

Jolijn van Delft, Student Applied Mathematics

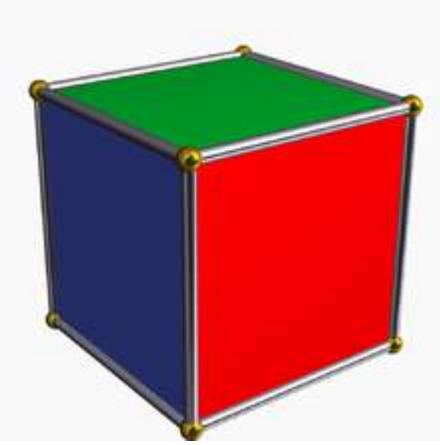
Hello everyone! My name is Jolijn van Delft and I'm a second year AM student. Last year, I followed the course Algebra 1. I've been asked to write a piece about the course and about my experiences concerning it. So whether you already passed the course or not, and whether you enjoyed it or not, keep reading if you're interested.

Multiple changes had been made in the year I followed Algebra. Most importantly, the course was taught in Delft for the first time instead of in Leiden. Although I never followed the course in Leiden, I think this has been a big improvement. I can imagine that, for the people that disliked the course, it takes way too much effort to travel all the way to Leiden to sit in a lecture hall you don't want to be in. Also, by taking the course to Delft, it's main language was changed to English. This turned Applied Mathematics into an official English-taught study.

As most of you already know, Algebra is no course like all others. It is very theoretical and does not really fit into the 'Applied' Mathematics we all specifically chose for. So what makes it so important then? According to Wikipedia, Algebra is the unifying thread of almost all of mathematics. Now my knowledge about mathematics in general is too small to really confirm this statement, but if you ask me in 10 years, I expect to say I fully agree.

The example below is one of the questions from the reader that might give you a little idea of the type of questions that is being asked throughout the course.

Suppose you have a cube and you want to color every face red, white, or blue. There are 3^6 ways to assign a color to each face. However, regard two colorings the same if they differ by a rotation of the cube. How many different colorings are there?



To solve this problem we use Burnside's Lemma. If G is a finite group that acts on a finite set X, Burnside's Lemma states that the number of orbits is equal to the average number of fixed points of elements $g \in G$. Now to solve this problem, we simply let X be the set of all 3^6 ways to assign a color to each face and we let G be the group that acts on X by rotations of the cube. We find that there are only 30 different colorings. This might seem as a difficult problem to solve, but it turns out the computations are actually straightforward. Having said that, I must admit there's still a die in my pencil case since I was really struggling to come up with the set X of rotations in the beginning. Anyways, don't hesitate to ask if you're interested in the way to solve the problem.

Let me finish by assuring you that passing the course is not impossible! Although Algebra is one of the most difficult courses of the first year, you will definitely pass if you work hard enough. I'm aware of the fact that might have sounded a bit too cliché, that's why I came up with other tips and tricks that will actually be useful.

1. Doubt everything that might have been straightforward in the past. Passing the course requires the development of a different way of thinking. Therefore, you should definitely not trust your gut instinct, but solely the mathematical proofs.

2. Go to the instructions (even rather than going to the lecture). It helps a lot to work on the course together instead of alone. Lectures can be really complex, but the exercises most of the time clarify a lot (small shoutout to Joost for all additional explanation too).

3. Google is your friend. Thousands of people have struggled with similar exercises as you will, and others are very happy to share their knowledge about Algebra on the internet.

To the ones that already passed the course, congratulations! I hope you enjoyed reading about my personal experiences. In case you did not pass yet, I wish you the best of luck. And don't forget to enjoy, because Algebra is really not as bad as it sounds ;).

Miscellaneous

Science Trends

Eva Slingerland, Editorial Staff MaCHazine

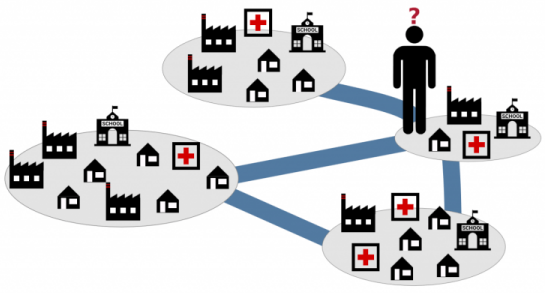
On this page, you will find some brief information on recent scientific breakthroughs or interesting news. Whether they are big or small, if we think they might interest you, we will mention them here! Do you miss a certain trend or want to inform your fellow readers of an interesting innovation? Feel free to contact us.

Using Math to Learn how Diseases Work[1]

Scientists at the University of California Los Angeles are investigating what changes in the brain cells can lead to diseases like epilepsy, Alzheimer's, Parkinson's and other neurodegenerative diseases. In order to do this, they use mathematical models to simulate sick brain cells. One of the involved researchers is Dr. Sharmila Venugopal, who used to be an electrical engineer but switched to neuroscience. She develops those models to see how the diseases alter the physiology of the brain. "Our brain is a very complex machine, and understanding its complexity requires many disciplines to come together, including mathematics and computer simulations. Math models are necessary because physiological variables are often experimentally intractable. Moreover, diseases are elusive, and models can help make important predictions to guide valuable new experiments," she notes. The models suggest ways to restore the normal activity patterns of the cells, which could help devise biomarkers and design effective interventional strategies.

Reconstructing Commuter Networks Using Machine Learning[2]

Humans are moving on a daily basis from one area to another. In order to explain the processes related to this behaviour, it is vital to understand human mobility: when do we move, why do we move, how do we move, etc. Improved models of the human mobility can help with urban building plans, they can support forecasting the spread of epidemics and they can prevent catastrophic events.



Recently, a group of researchers used classification and regression machine learning algorithms to quantify the flow of people and reconstruct the network topology of human mobility. Adapting to and learning from the data at each iteration, the algorithms improve the prediction ability of the model. The model that is used, which relies on a gradient-based algorithm, can thus predict the links of the commuter network with high accuracy. Using the Shapley Additive exPlanations (SHAP) values, the results of the model are interpreted in order to quantify the importance of each feature in the prediction task. Through this, the most important features, such as distance and unemployment rate, were identified to describe the phenomenon of human mobility.

The challenge of 3D printed guns[3]

When someone has been murdered by a gun, the forensic team will inspect the crime scene thoroughly. This is because a gun will leave significant markings on the bullet and the cartridge case. These so called ballistics can be used to identify with which gun the shots were fired. A 3D printed gun however, will not leave any of such prints. Right now, 3D printed guns are seen as more of a risk than a reality, since most commonly available 3D printer won't be able to print usable guns. However, in 2013 blueprints were released of the so-called Liberator handgun, which were downloaded over 100,000 times within days after the release. So, it seems like there is enough interest for 3D printed guns. As the technology is improving and the costs of 3D printers are decreasing, some experts are worryied about the effect it will have on forensic investigation. Therefore, researchers are already busy to figure out how to identify a 3D printed gun, since they leave no markings on the bullets and have no serial numbers, which is also why those guns are called ghost guns. Another danger is the possibility that such a plastic gun could be taken apart and destroyed by dissolving the different parts in solvents, so it is possible to let the gun disappear. Furthermore, the gun won't be detected by any of the current security measures like metal detectors. Therefore, a lot of new challenges arise with this innovation.

References

[1]https://sciencetrends.com/did-you-know-math-can-help-us-learn-how-diseases-work/

[2]https://sciencetrends.com/reconstructing-commuter-networks-using-machine-learning-and-urban-indicators/

[3]https://www.sciencenews.org/article/3d-printed-guns-plastic-ballistics-crime

Historical Figure: Edsger Dijkstra

Daniël van Gelder, Editorial staff MaCHazine

To almost every person who has ever written a computer program, this man's name will ring a bell. Edsger Wybe Dijkstra has been one of the most influential Computer Scientists of the last century, although he never approved of the term 'Computer Scientist'. According to him[1], the term Computer Science draws attention away from the abstract reasoning that is required to comprehend the complexity behind computing. As he puts it: "Computer Science is no more about computers than astronomy is about telescopes." [2] In this article, we will explore what his influence was on Computer Science as we know it today and how his views have shaped the discipline.

At the time that Dijkstra started working in academia, Computer Science was far from an established field within universities. Most Computer Science researchers had a background in Mathematics or Physics. In fact, Dijkstra was offered a job to became the Netherlands' first computer programmer in 1952[2]. His PhD thesis was devoted to describing an assembly language for the first commercial computer developed in the Netherlands, called the X1. So it is important to realize that this was a very exciting time for researchers as it was such a fresh field of research.

Contributions to Algorithm Design

Dijkstra is by far most well-known for his proposal of a Sing-Source Shortest Path (SSSP) algorithm, or 'Dijkstra's Algorithm' as we know it today. While it seems that such an important invention would have taken years to design, Dijkstra later recalled he thought of it over a cup of coffee while shopping with his fiancée and designed it within 20 minutes or so, without pen and paper[3]. Since most readers of this article will probably already be familiar with how the algorithm works, there is no need to outline the technical details of the algorithm. However, we will consider the impact it had. As Mikkel Thorup mentioned: "Since 1959, all theoretical developments in SSSP for general directed and undirected graphs have been based on Dijkstra's algorithm."[4] It is not very hard to imagine an application in which Dijkstra's algorithm offers a solution to a complex problem. Just consider how often you use Google Maps to find the (shortest) route to your destination.

However, Dijkstra's contributions to Algorithmics were not solely based on route finding. He proposed algorithms to parse mathematical expressions into a more 'computer-friendly' format like an Abstract Syntax Tree. This algorithm is called the shunting-yard algorithm. In addition, he was one of the first to identify the deadlock problem in concurrent programming and proposed several algorithms to tackle this problem. Furthermore, he proposed the semaphore mechanism for mutual exclusion of memory values, a very important mechanism that operating systems use to ensure the consistency of memory values. All these ideas are definitely worth taking a look at and have all found their way into our everyday computers.

Views on Computer Science

Since Computer Science was such a new discipline in academia, there were little standards involved with programming. Dijkstra was one of the first academics to advocate a way of 'structured programming', which was programming in a systematic way. This formed the basis of programming paradigms that we know today like Object-Oriented Programming. It also led to the foundation of a new discipline called Software Engineering (although Dijkstra disliked this term as much as he did Computer Science). While programming languages in the 60s were far less sophisticated than the programs that are known today, some initial efforts were made to create more structure in programs like: the definition of abstract data types, the proposal of software metrics and the introduction of the principle of Separation of Concerns.

Apart from an avid researcher, Dijkstra was an enthusiastic teacher. He believed that teaching was not only a required activity but also a serious research endeavor[2]. He spent time memorizing the names of his students, would never follow a textbook and often taught on his feet while lecturing. He was known for lacking social skills when interacting with his colleagues and his wit and directness. Unfortunately, Dijkstra died in 2002 after a long battle with cancer.

References

[1] Dijkstra, E. W. (1986). On a cultural gap. The Mathematical Intelligencer, 8(1), 48-52.

[2] Faulkner, Larry R.; Durbin, John R. (19 August 2013). In Memoriam: Edsger Wybe Dijkstra. The University of Texas at Austin.

[3] Misa, T. J., & Frana, P. L. (2010). An Interview With Edsger W. Dijkstra. Communications of the ACM, 53(8), 41-47.

[4] Thorup, M. (1999). Undirected single-source shortest paths with positive integer weights in linear time. Journal of the ACM (JACM), 46(3), 362-394.

Project MARCH

Stijn van Weegberg, Roel Vos and Rutger van Beek, Members of the Project MARCH team

Aspiring to give back mobility to people with a Spinal Cord Injury in order to increase the quality of life, that is what Project MARCH is about. In this D:DREAM team, initiated and carried out by students from nearly all faculties, a new team voluntarily commits to the development of a new and improved exoskeleton.

This mechanical suit, developed with the newest technologies and robotics, enables people with a Spinal Cord Injury to stand up and walk again, and - perhaps - do even more in the future. Every year the new team develops a new exoskeleton and builds on the knowledge of the previous years. Co-creation is central in this project. This is achieved by close cooperation with the health sector and our pilot. Our pilot is a person with a Spinal Cord Injury (paraplegia) that controls the exoskeleton. Co-creation is absolutely crucial in the development of the ultimate exoskeleton. The pilot and involved physiotherapists understand the needs like no others and has practical experience in what does and does not work. This approach results in an exoskeleton that is not just technically optimized, but also user-friendly for our pilot.

PROJECT MARCH

In most years, the team builds towards the ultimate test of the exoskeleton: the Cybathlon Experience in september. This year, however, this is not the case. Once every four years, the actual Cybathlon competition takes place, which is organized in May. In this race, pilots in exoskeletons of various international teams compete against each other. Within ten minutes they must successfully complete obstacles portraying everyday activities, like stairs, slopes or rough terrains. Currently, Project MARCH is the only student team in the Netherlands to develop an exoskeleton and participate in the Cybathlon.

The fact that the race of this year is relatively early has led the team to decide that instead of building a new exoskeleton this year, they will improve upon the existing MARCH IV exoskeleton. This will result in an optimized exoskeleton, with enough time for practicing all obstacles together with our pilot, resulting in the best possible chance to win the Cybathlon! A lot of the optimization can still be done in the software that runs the exoskeleton. That is why this year the team has a larger software development team with two new functions: Simulation Engineer and Data Analyst.

Application Applied Mathematics & Computer Science

The software in the exoskeleton is built on ROS (Robot Operating System). ROS is a communication framework for different types of hardware spread across the exoskeleton. ROS also provides tooling for controlling, visualizing and simulating the exoskeleton.

Rutger is an applied mathematics student, who is working as a data analyst at Project MARCH. Currently, there are already some sensors in the exoskeleton, such as temperature sensors, encoders which measure the joint angle, and current sensors. This year the team wants to add more sensors, like IMU's and pressure sensors in the foot soles. An Inertial Measurement Unit (IMU) measures linear and rotational acceleration in all dimensions. These sensors can be used to track movements of both the exoskeleton and the pilot. The pressure soles consist of a lot of different pressure sensors and a built-in IMU. The pressure sole data can be used to determine how the combined weight of the pilot and exoskeleton is distributed across both feet. The data of all these sensors can be combined to evaluate the gaits. The data can be compared to known mathematical models about human walking gaits to improve these gaits. In the future, the team wants to implement dynamic gaits based on data generated by the different sensors.

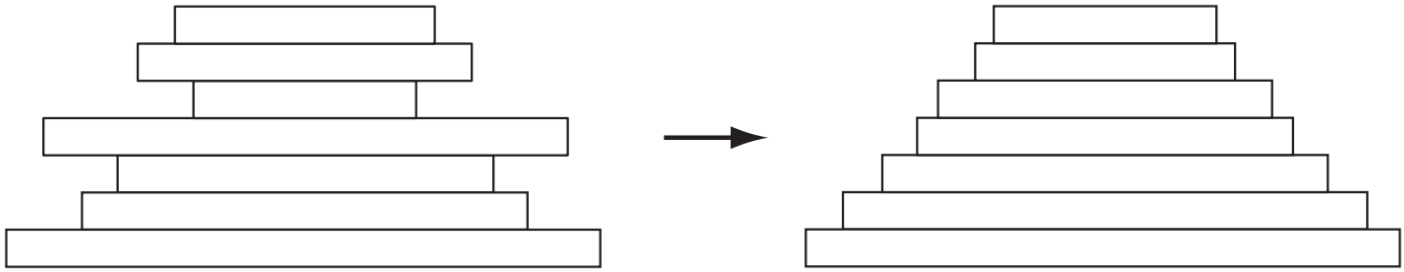
Roel is the simulation engineer of Project MARCH. With a background in applied mathematics and physics he will spend his year building a simulation of the exoskeleton. Once the simulation is completed, a large part of the testing can be done without the engineers having to leave the comfort of their desks. Currently, all that testing has to be done with the actual exoskeleton, which results in an overdemand of its usage. A good simulation can help resolve this issue and also make testing faster and safer, resulting in a lot of value for the team.

Computer Science Puzzle

Louise Leibbrandt, Editorial Staff MaCHazine

Pancake Sorting

There are n pancakes, all of different sizes, that are stacked on top of each other. You are allowed to slip a spatula under one of the pancakes and flip over the whole stack above the spatula. The objective is to arrange the pancakes according to their size with the biggest at the bottom. The image below shows an instance of the puzzle for n = 7. Design an algorithm for solving this puzzle and determine the number of flips made by the algorithm in the worst case.



Solution to last issues' computer science puzzle

Bakuro

	9 1001	6 0110		7 0111	1 0001	15 1111	
5 0101	1 0001	4 0100	7 0111 / 14 1110	2 0010	1 0001	4 0100	3 0011
15 1111	8 1000	2 0010	4 0100	1 0001	3 0011	2 0010	1 0001
		6 0110 / 13 1101	2 0010	4 0100	10 1010 / 15 1111	8 1000	2 0010
	12 1100 / 12 1100	4 0100	8 1000	3 0011 / 3 0011	2 0010	1 0001	
12 1100	4 0100	8 1000	10 1010	2 0010	8 1000	10 1010	
9 1001	8 1000	1 0001	7 0111	1 0001	4 0100	2 0010	
				9 1001	1 0001	8 1000	

Mathematics Puzzle

Kilian Buis, Editorial Staff MaCHazine

Problem 1

Solve the following binary puzzle. In a binary puzzle each box should contain either a zero or a one. More than two equal numbers immediately next to or below each are not allowed. Each row and each column should contain an equal number of 0s and 1s. Each row is unique and each column is unique. Thus, any row cannot be exactly equal to another row, and any column cannot be exactly equal to another column.

			0			1			0
		1		1				0	
	0						1	0	
	0								
				0					
		1							0
			1			0			
	0							0	
	0	0					0		0
			0			1		0	

Problem 2

Find a 10-digit number where the first digit is how many 0s are in the number, the second digit is how many 1s in the number etc. until the 10th digit which is how many 9s are in the number.

Solution to last issues' mathematics puzzle Problem 1

Note that we can write a general formula G_k for what piece Guest k will get. That is

$G_k = \frac{99}{100} \cdot \frac{98}{100} \cdot \ldots \cdot \frac{99-(k-2)}{100} \cdot \frac{k}{100} = \frac{99!}{(99-(k-1))!} \cdot \frac{k}{100^k} = \frac{99!}{(100-k)!} \cdot \frac{k}{100^k}$.

Now we need to see what happens with Guest k+1. Therefore we analyse the following fraction:

$\frac{G_{k+1}}{G_k} = \frac{99!}{(100-k-1)!} \cdot \frac{k+1}{100^{k+1}} \cdot \frac{(100-k)!}{99!} \cdot \frac{100^k}{k} = \frac{(100-k)(k+1)}{100k}$.

Note that if this fraction is greater than 1, then the pie slice increases in size. Therefore we need to take a look at the following inequality:

$$\frac{(100-k)(k+1)}{100k} > 1.$$

This inequality holds for k = 1, 2, ..., 9. So k = 10 is the first number for which this inequality does not hold. That means that the size of the pie increases to guest 10 and then decreases. Hence, guest 10 will get the largest piece of the pie.

Solution to last issues' mathematics puzzle Problem 2

Note that every parenthetical term is of the form:

$$\begin{aligned} x^4 + 324 &= x^4 + 4 \cdot 3^4 \\ &= (x^2 + 2 \cdot 3^2 - 2x \cdot 3)(x^2 + 2 \cdot 3^2 + 2x \cdot 3) \\ &= (x(x-6)+18) \cdot (x(x+6)+18) \end{aligned}$$

If we use this expression to evaluate the fraction we get

$$\frac{[(10(4)+18)(10(16)+18)][(22(16)+18)(22(28)+18)]\ldots[(58(52)+18)(58(64)+18)]}{[(4(-2)+18)(4(10)+18)][(16(10)+18)(16(22)+18)]\ldots[(52(46)+18)(52(58)+18)]},$$

which simplifies to be just

$$\frac{58(64)+18}{4(-2)+18} = \frac{3730}{10} = 373.$$

BUILD YOUR FUTURE

Application Trainings

11 - 13 February 2020

A good preparation is half the battle. At the application days recruiters from high ranked companies will provide trainings for job application. Refresh your LinkedIn profile picture with a photo taken by a professional photographer and get your resume checked by an expert.

Orientation Days

17 - 19 February 2020

Meet 150 national and international companies at the career fair. Companies, ranging from consultancy to engineering, come to the Aula. At the Orientation Days days you can orientate yourself by attending presentations or visiting info stands.

Coffee Dates

23 March - 3 April 2020

The Coffee Dates is an approachable event where you have the opportunity to get to know a company over some coffee. Companies select the students they want to get in touch with beforehand, based on your resume. The conversations will take 20 minutes and will take place at a Coffee bar located at Delft University of Technology.

In-house Days

28 April - 12 May 2020

In-house Days offer an opportunity to form a better, more complete idea of the companies you are interested in. Your resume will be forwarded to the companies of your choice. Based on the resumes the companies will select the participants.

HOW TO JOIN

You can sign up at the website ddb.tudelft.nl, starting on the 6th of January, till the 23rd of February, or on the 21st and the 22nd January at the desk in the Aula. Up until the 22nd of January subscription is available at a reduced price.

DE DELFTSE 2020 BEDRIJVENDAGEN
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ddb.tudelft.nl

Calendar

Winter Party

The Ski Trip Committee will be organising a winter-themed party at De Kurk in Delft to give everyone a taster of the CH Ski Trip taking place in February 2020! Buy your ticket now at wisv.ch/events!

Gala

After 3 years of waiting, the CH Gala will take place in December 2019! Prepare for a fantastic evening at the stunning Koetshuis in Rotterdam, complete with a fancy dinner, bands and DJs!

Christmas Dinner

Just like every year, CH will be organising a fancy Christmas dinner for all members at a restaurant in Delft! Aside from the delicious food, our chairwoman Marleen will tell a beautiful Christmas story!

November

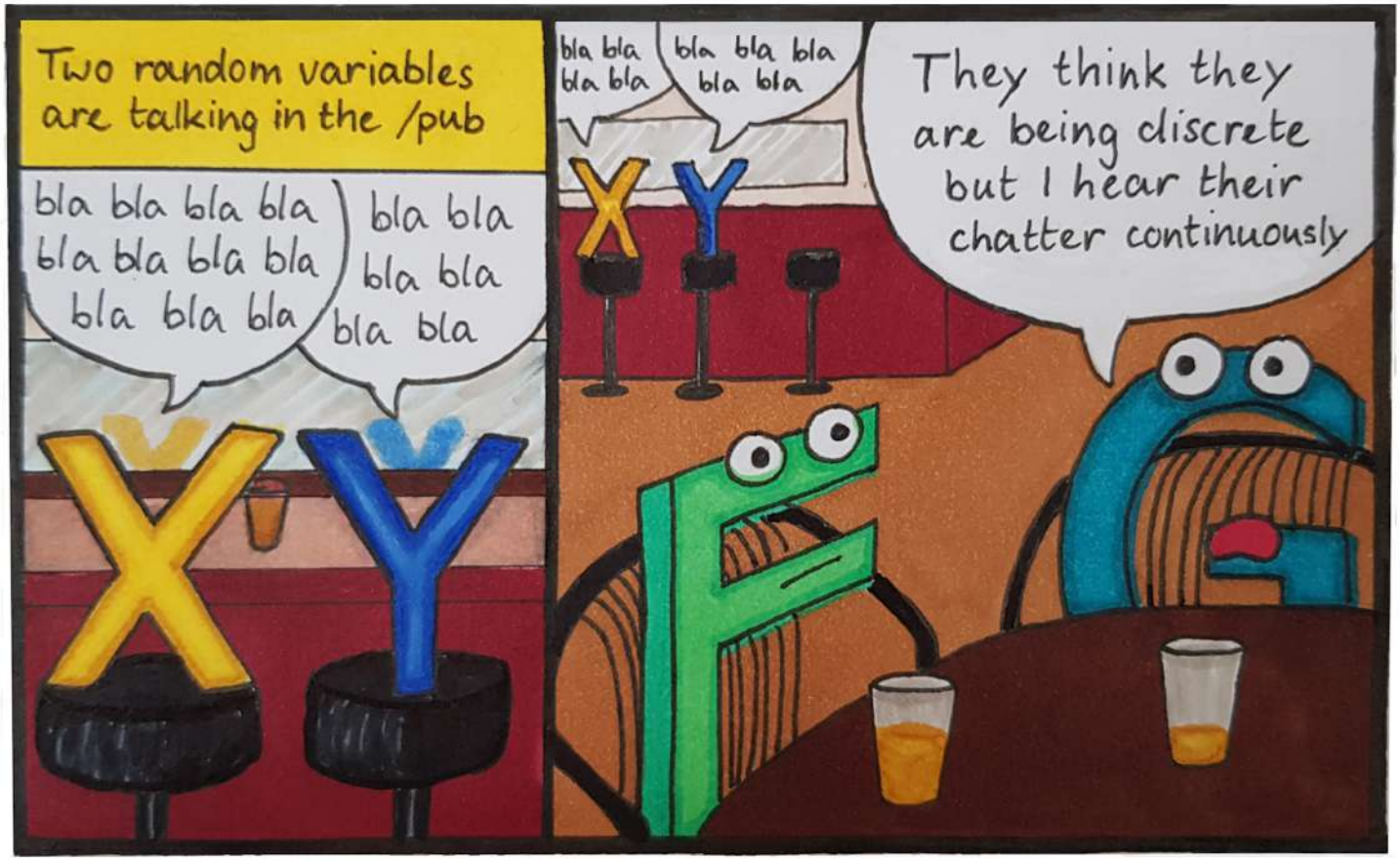
11	Committee Kick-Off
12	Drinks Lecture: Facebook
18	Career College: Pitch Training
19	Lunch Lecture: NAVARA
19	Pre-Gala Activitiy
20	Winter Party
26	Company Lecture
28	Board Information Lunch

December

3	General Lecture
4	Sinterklaas Lunch
13	Gala
16	Career College: Personal Branding
17	Lunch Lecture: Applied Mathematics
18	Christmas Dinner

January

7	Lunch Lecture: Computer Science
9	Freshmen Dinner
14	Lunch Lecture: TNO



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