MACHAZINE

Wiskunde Informatica Studievereniging 'Christiaan Huygens'

25 Years

MEMBERS IN THE SPOTLIGHT

Starting Associations

A STUDENT'S EXPERIENCE:

Software Project

FROM MINOR TO INTERNSHIP

Finance Track

MATHEMATICS

Discovery or Invention?

CONTAINING:

Current Affairs | Association | Computer Science | Mathematics | Extracurricular

Your student time is the time to try out as much as you can. In this period of your life you will get plenty of opportunities to find new hobbies, build connections and develop new skills. For example, you can join a student association, be a member of a committee, participate in a student project or start your own project. Doing these activities shapes you. You discover what you find interesting to do and what you are good at. You make new connections that help you in the future. You do things you probably will not try anymore once you have a job and a civilian life. For me, I am glad with all extracurricular experiences I have done so far: the MaCHazine committee, joining a student dance team and establishing my own student association. I am mainly glad that I actively participated at CH. The study association brings a lot of opportunities to develop yourself and build connections. This edition covers some of them. We will talk about the committee kick-off, where all committees of CH competed against each other in an online escape room. Spoiler: the MaCHazine knows how to dress up. Furthermore, CH organizes activities to delve deeper into mathematics and computer science. In this issue we talk about the Delft Algorithm Programming Contest and the online symposium about data analytics. But also outside of CH students can develop themselves in many different ways. In this issue we have two CH members that establis-hed their own student association in Delft!

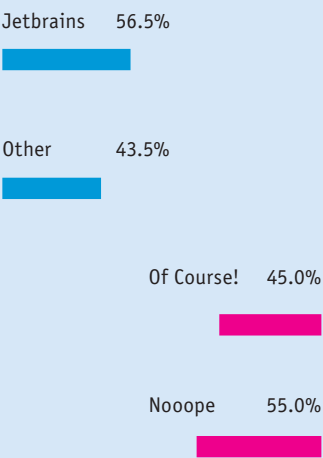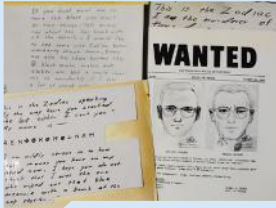I hope that, even in these hard times, you are getting the most out of your student time. And when you look back, I hope you can say that you experienced and learned a lot.

Yours truly,

Maxime Hoekstra
CHief editor

Instagram Poll Results - @wisvch

Jetbrains   56.5%

Other   43.5%

Of Course!   45.0%

Nooope   55.0%

Current Affairs

Association

Computer Science

Mathematics

Extracurricular

From the Board

Author: Bastiaan Bakker, Chairman

When you are reading this, the second quarter, and therefore the first semester of the academic year, has already gone by. During this second quarter, I have become more and more comfortable in my role as Chairman of our association. During the first quarter I was mostly experiencing what it is like to do a board year at CH and a lot of problems and challenges have come my way. In the second quarter, I had more experience with how to handle these problems and challenges and I found my preferred way of coping with these. In short, in only one semester, I may have learned more about myself than I learned in my last year.

This year is of course a very special year, also for our fantastic association. This year it has, in my opinion, shown that our study association is even more important than we thought before. Now we are seeing signs of students feeling lonely or stressed, and a hunger for social interaction with other students. Fortunately I have the privilege this year to work together with six other amazing people daily. I am very grateful for this.

As a chairman, it is amazing and inspiring to see that all the committees of the association are working extra hard to make the best of this year. It is amazing to see how the Business Tour committee has come up with a corona proof Business Tour or how the Area50Lan committee is planning different scenarios for how this event could take place. Together we can still organize most of the amazing events we organize every year.

Just as these committees do this year, in a CH board year you also throw yourself in the deep end. You start your board year not really knowing how everything will go. From the first moment you are caught by the current of the waves and now it has already brought me into the beginning of the second semester. Along the way you learn and experience so much, that there is almost no time to sit still and realize all the things you have learned. This is what I love the most about being a CH board member.

As a chairman you also have a lot of time to pick up different action points and projects during the year. This year, I am working on a lot of things. Two of these "random" projects are sustainability and mental health. I think it is time that also we, the study associations of TU Delft, start implementing sustainability into our associations and teach the members about it. Next to sustainability, I also believe that the mental health of our students should be an important action point for every study association in Delft. Of course, this also holds for CH board members. Therefore I am working together with multiple study associations to look for solutions to make it easier for students to talk about their mental health and try to come up with a way study associations can help their students with this. If you have any ideas or comments on these topics, I would love to hear from you!

As a board member, you work with six other board members. From what I expected in the beginning of the year, I would have never thought that you learn so much only from working with people who have different ways of working themselves. Some people in our board are much more direct than others and some are way more laidback. Everyone has different personalities and you work together with six of these at the same time. This can be very exhausting, but also very energy giving. Although you sometimes clash with someone else, I did not expect that you would fall in love so quickly with them. As a chairman, you are sort of the manager, and you have to cooperate with all these different personalities. To help me manage this, I plan a walk during the day with every board member once per two weeks. This gives me the chance to get some fresh air during the day,and to get to know my fellow board members better.

I hope that the first semester of this academic year has brought you joy 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 when it is allowed again! We really want to talk to you guys again in person. See you at our upcoming events!

With love and the best wishes,
Bastiaan Bakker
Chairman W.I.S.V. 'Christiaan Huygens'

Current Affairs
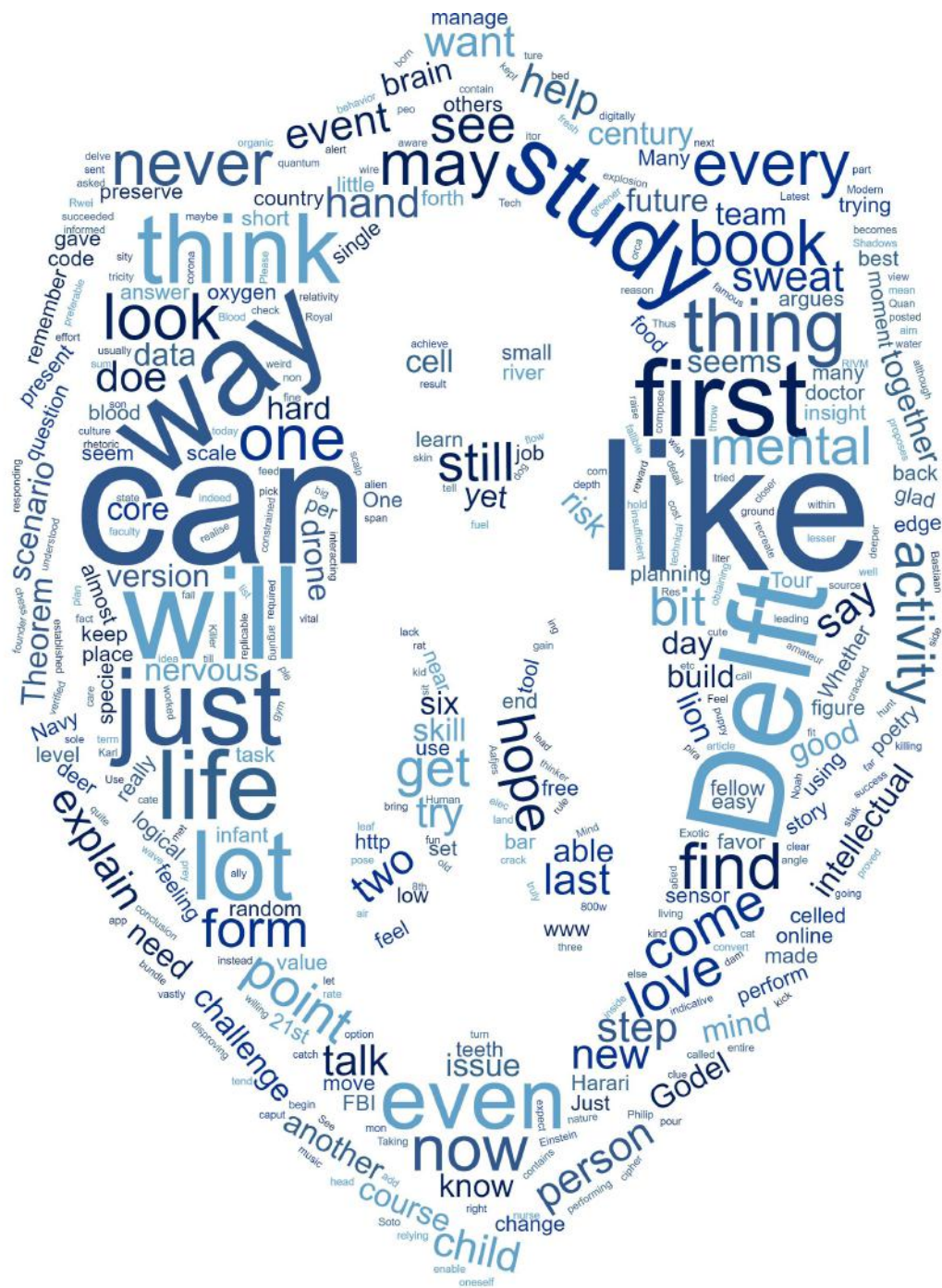
Science Trends:
The Science of Consciousness

Author: Akash Singh, MSc Student Computer Science

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

Once, there lived a child, curious, confused. One day, he learned in biology class that the cells in our body are continually being replaced. This means that the cells you were born with are no longer a part of your body. And yet here you are, the same person as ever. Another book taught him that our brain keeps changing as we go through life. Our habits, memories, likes, dislikes. Everything is subject to change. And this change is a physical rewiring of the neuronal connections inside our brains. The kid started wondering – is there anything that has been constant throughout his life? He could think of just one thing which had always stayed with him, unblemished – his ability to experience the world. His awareness, or as science people like to call it, his *consciousness*.

In his second book, Homo Deus, Yuval Noah Harari raises an important point about the development of machine intelligence in the 21st century – the decoupling of *intelligence* from *consciousness* [4]. Ever since the development of large scale collaborative activities such as economics and science, humans were the only valid intellectual contributors to these pursuits. Machines could take care of physical jobs for us, such as printing books, but the mental directive of *what* to print on that book was the sole property of humans. With the development of modern algorithms, this is changing. Algorithms can now write poetry, play chess, predict protein folding, and even compose music. In the last 5 years, almost every scientific discipline seems to be following a similar route, training a machine-learning algorithm on data to answer some important domain questions. And yet, we unanimously seem to agree that these algorithms do not understand what they are doing the way we humans do. A poetry writing algorithm simply adds the most probable word in a sequence given the words already present in that sequence. Whether this sequence speaks of a lover's passion, a mother's love, or a musician's intensity makes no difference to the algorithm. The algorithm itself will not be moved to tears.

This is what Harari meant by the decoupling – while *intelligence*, a skill we tangibly value in the world, is being developed so rapidly by algorithms, *consciousness* still remains an elusive concept no one, not even a scientist, is able to fully explain. And yet our consciousness is the only thing we all can trust to exist at the core of our beings. Few scientists like noble laureate Roger Penrose have ventured forth and proposed a profound relation

between consciousness and general human intelligence, something a computational device (like a computer) can never replicate, even *in principle*. Given the serious challenge posed by algorithms to our claim of intellectual superiority in recent years, this proposal deserves at-least an honest assessment.

Before we think about the possibility of consciousness in algorithms, let us try and understand the origin of consciousness in life. Evolutionary biology attempts to trace the lineage of intelligence and consciousness back to the first single-celled organisms. Any form of life will need to address the basic need to adapt its behavior to its environment to some degree, in order to obtain food, avoid predators, and procreate. Primitive life-forms such as prokaryotes (single-celled organisms) respond to external stimuli in a *hard-coded* manner. Protozoa have been observed to move away from danger and towards food, despite them lacking any evidence of a nervous system. For several billion years, life-forms without any nervous system did just fine. Hydra and Jellyfish developed the beta version of a nervous system for the first time – a concentrated bundle of neurons which specialized in responding to external stimuli.
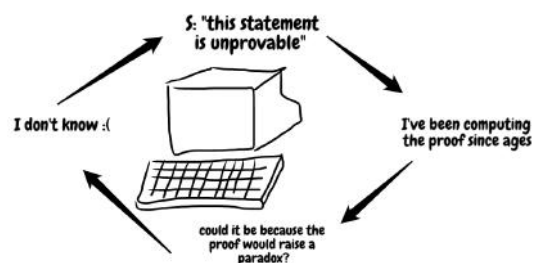
Figure 1: An algorithm's approach to Godel's Incompleteness Theorem

A further point down this road is the ability to store *internal representations* of external stimuli for future reference, commonly known as memory [2]. Sophisticated organisms like mammals exhibit the ability to remember important aspects of a past experience and also recombine such memories internally in novel ways to predict the outcome of different actions, thus choosing the most appropriate action in a situation. For example a lion might remember a deer drinking from a river and use it to assign a higher likelihood of finding deer near a different river, thus deciding to stalk that area for prey. This behavior is a fundamental building block of human intelligence. However, why did evolution invent consciousness? This is an unsettled debate as of now – some think it is just an evolutionary side-product while others find some intrinsic value in it. Since every evolutionary invention is random, it is the utility of an evolutionary feature which determines its importance.

Does consciousness provide us with a competitive edge? Leading neuroscientist Karl Friston argues that self-awareness enables an organism, for instance a child, to identify other organisms like itself (other children) and distinguish them from the environment (home or school) and organisms unlike itself (the family dog or cat). Why is this helpful? One answer could be that it enables social interactions.

A feature among life-forms which seems to go hand-in-hand with intelligence is social activity with members of the same species. Mammals considered to be intelligent are also found to be social, be it dolphins, elephants, lions, or humans. Many mammals evolve from social interaction to social cooperation – lions, hyenas, and orcas tend to hunt in teams, thus increasing their success rates. Of course, humans take social cooperation to another level with tools like religion, culture, and story-telling, all tools to enable large-scale social cooperation. Latest neuroscience research reveals that human minds are extremely good at inferring and imitating the emotional state of another human just by interacting with them; an ability we usually know as *empathy* [5]. Although current research is only indicative and not conclusive, it seems that consciousness does seem to provide an evolutionary advantage in terms of social cooperation.

Mathematician-physicist Roger Penrose thinks consciousness is not just an evolutionary feature, but a *non-computable phenomenon*. To be clear, consciousness is not the same as mental computations – much of the cerebellum, the computational powerhouse of our brain, is beyond our awareness [1]. Whenever you are employing a skill which comes like second nature to you, like brushing your teeth, you are relying on your cerebellum to perform all the relevant computations (the angle of your toothbrush, the pressure against your teeth and so on). We are never aware of these computations but can still perform the task by just willing so. Penrose proposes that although abilities like performing physical tasks, speaking a language, thinking and planning one's actions et cetera may be all computational procedures and hence replicable by computers, the ability to experience these abilities, i.e., consciousness is not. He presents a creative mathematical proof of this proposition using a famous mathematical theorem, Godel's *Incompleteness Theorem*, for this proof [1].

A simplified version of this theorem says the following statement can never be proved:

"This statement is unprovable."

If it was possible to prove this statement, it would falsify the statement itself because it says it is not provable, thus disproving it. Thus, it cannot be possible to prove this statement. However, this is a logical conclusion which cannot be presented as a proof of the unprovability of S. Penrose argues that while we humans can easily see this contradiction with our intuition (figure 2), algorithms cannot and hence if an algorithm was asked to prove the statement, it would attempt to do so without objecting that the proof is logically not possible (figure 2). You may argue that we can always tell the algorithm to check for such logical contradictions first before attempting the proof but then we are just providing another set of rules to the algorithm using our own mathematical insight. The core insight that a statement cannot be provable and unprovable at the same time is still something alien for the algorithm (I have presented an extremely simplified version of the core argument, presented in depth in the book *Shadows of the Mind* by Roger Penrose). After thus arguing that awareness/consciousness is something beyond computation, Penrose goes on to explain how the edge of scientific understanding, including general relativity and quantum phenomenon, are insufficient to explain consciousness. As a result, this article leaves the explanation of consciousness incomplete at this point and moves forth with consideration of what consequences does obtaining a scientific theory of consciousness bring.
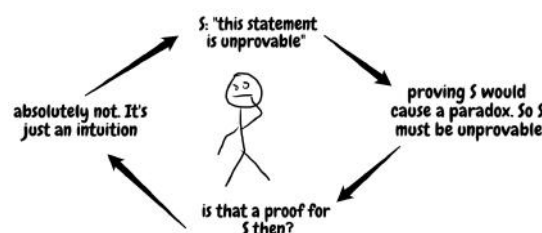

Figure 2: Human intuition's approach to Godel's Incompleteness Theorem

Many leading thinkers predict an *intelligence explosion* in the near future when machines gain the same faculties of intelligence as a human child (known as *artificial general intelligence*) and then go on to achieve *superintelligence* in a short span of time [3]. This leads to an important question – will the machines be motivated to preserve human interests in that scenario? Are we, as humans, motivated to preserve the interests of lesser intelligent species, like rats, currently? This rhetoric sets the ground for the argument that artificial intelligence poses an existential risk to humans. If we realize that our ability to experience is not just an aesthetic feature but a fundamental source of intuition, we may be able to develop artificial intelligence as an extension of our intelligence instead of a replacement.

Modern science currently lacks a fundamental theory of consciousness but we have convincing reasons to look for one. If it turns out that all human intellect and consciousness is in fact just a computation and hence can be replicated by algorithms, then we may develop human-like algorithms but vastly smarter than even Einstein and Newton. Would these algorithms want to keep us around then? Maybe they would think humans are adorable, the way we think puppies are. On the other hand, if we manage to develop a theory of consciousness and find it to indeed be beyond computation (as understood today), it may become possible to digitally recreate it. Exotic scenarios like uploading oneself into a computer and living for centuries becomes a possibility, the human experience will no longer need to be constrained within a fallible organic body. Computers will then be an intellectual extension of the human mind (the way machines are now an extension of the human body), and the existential AI risk might become just a cute story from the 21st century.

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4. Harari, Yuval Noah. Homo Deus: A Brief History of Tomorrow. Vintage, 2017.
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TU Delft News

Author: Srinath Jayaraman, Student Computer Science

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 TU Delft? This article will list the most important events of the recent months.

Guatemala gets ventilators

The Central American country of Guatemala has the lowest number of hospital beds per capita in the region and only 56 mechanically intrusive ventilators in the entire country. So to help, the founder of a nonprofit organization called Respira Guatemala (https://www.respira-guatemala.com/) is working with Project Inspiration of TU Delft to manufacture around 100 ventilators by the end of 2020, with 160 more in the pipeline for the first 5 months of 2021. The design is an upgrade of a mechanical ventilator that was used till the 1980's. According to their website, "Project Inspiration is an initiative of the Delft University of Technology in the Netherlands. The aim of the project is to develop a low-cost, easy to manufacture and easy operable mechanical ventilator that can be rapidly build, anywhere in the world." Quan and Project Inspiration hope to have more than 300 ventilators ready in the next few months.

Dutch favor vaccination certificates

According to a study of 1,640 Dutch people conducted by researchers from TU Delft, Erasmus University Rotterdam, RIVM, Maastricht University, and Roskilde University, around 73% of people approve of a vaccination certificate that would allow them to access public places (gyms, restaurants, bars, theaters, etc.). The study says that people view this as a form of reward for socially good behavior, much preferable to punishment. It is also viewed as a way to keep the economy going while also ensuring that those who are at risk are kept isolated as much as possible. Additionally, 50% of the respondents oppose mandatory vaccination while 28% are in favor of it.

Figure courtesy: https://www.tudelft.nl/

Blood oxygenation sensor for premature infants

One of the most important vital statistics that doctors monitor in a premature infant is the blood oxygenation level, i.e. how much oxygen the blood contains. Although there are machines in use for it already, they are quite large and clunky. They also have a lot of wires, in which the infant can get entangled. Additionally, these machines also sometimes damage the skin of the infant while they are being removed, so there are a lots of issues with the current system. Working in tandem with Northwestern University and the Lurie Children's Hospital of Chicago, TU Delft researchers have developed a small and bendable sensor that can be attached to a baby's scalp. It transmits data to an app that can be monitored by doctors and nurses and alerts them in case of potential intervention being required. It was tested on baby Philip, son of Dr. Rwei who conducted the research and whose baby is featured in the actual publication!

Figure courtesy: Dr. Alina Rwei

Maritime hydrogen drone

Researchers at TU Delft have worked with the Royal Netherlands Navy and the Dutch Coast Guard to develop a new maritime drone that is capable of efficient horizontal flight, while also being able to take-off and land vertically, an important advantage over existing drones. The drone is equipped with a composite cylinder of 6.8 liters, containing hydrogen at 300 bar. The cylinder feeds hydrogen at low pressure to the 800w fuel cell that converts it to electricity. The only emissions are oxygen and water vapor, thus making it a much greener option to the ones currently available.

Figure courtesy: Royal Netherlands Navy

References

[Project Inspiration, 2020] https://www.projectinspiration.nl/

[Premature babies, 2020] https://www.tudelft.nl/en/2020/tnw/delft-researchers-develop-blood-oxygenation-sensor-for-premature-babies/

[Hydrogen drone, 2020] https://www.tudelft.nl/en/2020/tu-delft/tu-delft-maritime-hydrogen-drone-flies-longer-and-greener/

The Sweat of an Integral

Author: Doris Aafjes, Mathematics Student

Doris Aafjes is a bachelor student Applied Mathematics at TU Delft and an active member of W.I.S.V. 'Christiaan Huygens'. Each quarter she writes a column about anything that's on her mind.

The sweat of an integral

"I hope you are having lots of fun in trying to catch me" was the first sentence of a 51-year-old message that was decoded last week. This decrypted message was once made by the "Zodiac Killer". In 1969 he murdered 5 people and sent several letters to the newspaper, including a '340 cipher'. This is a message of 340 different characters. In the following decades many authorities and researchers tried to crack the code, but never succeeded. Until last week, when the FBI informed that a team of three amateur codebreakers cracked the code. After the FBI verified the decryption, the codebreakers posted a video on YouTube with their solution.

In the video they showed, step by step, how they found the solution. It seemed like a lot of effort. Watching this gave me the same feeling as my studies in Applied Mathematics does. And not because those annoying integrals are killing me sometimes too.. It was because of the transformation from not understanding anything at all, to suddenly understanding every little bit of it. Maybe it's recognizable for you or maybe it's not. However, I want to explain this to you in detail: At first you see a math problem in your book. You look at it and you think: well that's a weird thing right there. Taking a closer look and you are getting a bit confused. The sweat on your head is starting to pour down a bit. Then things are getting a bit out of hand and the sweat suddenly begins to flow. You are starting to have no clue how to solve it. You look a little longer and now we are in the finale phase: you cannot even imagine how a person in the world could EVER solve this?! You are soaking wet with sweat and at that moment you are sure about it: this math problem CANNOT be solved! After this, it suddenly all goes very fast. You find a theorem that fits your problem. You follow the theorem
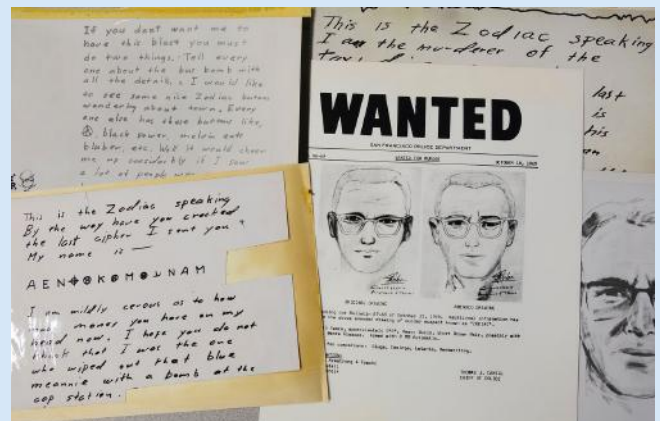
step by step, and at once the problem is solved! It all makes sense now and you feel like you are the smartest person in the world. This process immediately made me understand the drive and motivation of those codebreakers. And then, for them, it is not even the solution of an integral, but a message from a serial killer! They must feel like superheroes.

Watching this video also gave me a bit of the creeps. Imagine trying to decode a message and suddenly see words such as "gas chamber" or "slaves". Luckily those kinds of words don't appear when solving my math sum. Just as it does not take me 51 years to solve it, imagine how sweaty I would then be..

Association

Advanced Analytics:
Diving Deep into Your Data

Author: Daniël van Gelder, Chairman Symposium Committee

On the 19th of November the biennial symposium of our study association took place. The theme this year revolved all around data analytics. We took a deep dive into all there is to know about data analytics and what the societal consequences are of the more and more controversial applications of data analytics techniques. This year, as we all know, everything is different. This was also the case for the symposium, which would normally take place as a full day event at an external conference location. However, even though this year's format was different than usual, we were still able to organize a very successful and interesting online event!

Cruising to November 19th

Our preparations for the event started as early as November last year. First item on the agenda was to divide our roles and that makes for a good opportunity to introduce my awesome fellow committee members: we have Wouter as our secretary, Vera as our treasurer (now QQ), Lieke handling promotional affairs, Jasper and Kawin in charge of speaker affairs and finally Arian as QQ (now treasurer)! While back then the event still seemed very far away, we expected that there would still be a

huge number of preparations to make. So, we started getting busy right away. It may seem that the first actions like choosing a theme, color and event location would be relatively easy. But these turned out to be extremely hard and they would also have a huge impact on the rest of the preparations for the symposium! Luckily, since we quickly got to know each other well and everyone was determined to make this year's symposium the best so far, we were able to decide on most of these difficult choices quickly.

The topic of data analytics is ever more relevant. Our everyday lives are affected by data analytics more than we are probably aware of. In addition, lots of state-of-the-art research is about finding even more sophisticated methods for analyzing data and performing intelligent decision making based on these analyses. On the other hand, we see many examples of "data analytics gone wrong", almost on a regular basis. So, for us it seemed important to also highlight the impact of Data Analytics on a societal level.

The tsunami called COVID-19

At first, when the corona pandemic arrived and waved through the Netherlands, we were not sure how this would affect our symposium. Back in March, the symposium was still more than half a year away so it could be that we did not need to take extra precautions if everything would go well. No one knew back then how long the pandemic would last. Nevertheless, we did not want to take any chances and started looking at options to organize the event in an alternative form. This meant a lot of extra effort on our part due to the large number of uncertain factors: should it be a physical social distancing event? Or online? What if a speaker would be in quarantine during the event? Can we still offer lunch to the participants?

This meant that we effectively had to organize multiple symposia, one for each of the possible scenarios. As summer came along and the uncertainties remained, we eventually decided to take the plunge and go for an online event. This turned out to be a sensible decision seeing the rise of the second wave shortly after summer. Luckily, since we were prepared for this scenario, we would not have to change our planning that much. In addition, the preferred location of the event, DOB Academy, was able to function as a streaming location as well so that we would not have to worry about the technical aspects. There was one extra upside to the whole situation: since we were now hosting an online event, this meant that we could allow more people to participate. There would be no limit on the number of participants with an event in this form.

Troubled waters: a lesson in crisis management

The preparations were going smoothly in the final months leading up to the big day. We had a chair of the day, all our speakers, a sponsor and a location to stream the event from. Then, at the beginning of the week of the symposium, we received an email from one of our guest speakers. Due to serious personal circumstances, he could no longer participate as a speaker. This meant that we needed to find a new guest ASAP. We were extremely lucky and grateful to find Cynthia Liem, who was a member of our Board of Advice, willing to prepare a talk in such a short time. This meant that we would not have to change up our program and could still provide all the talks as we intended to.

With this small crisis averted, a new crisis arose. Our sponsor, PwC, notified us a few days before the symposium that due to some unexpected internal circumstances they would not be able to host the case study we planned before the event. This was a huge bummer for us, but especially for the participants that enrolled for this case study.

These issues taught us that no matter how well you prepare for something, some things just happen that you need to deal with it. In that moment, you just have to be flexible and make the best of it!

The event and its guests: taking the deep dive

And then it was the 19th itself, which is a good moment to take you through our program and tell you something about our guests.

Our chair of the day was Eva de Valk, a tech journalist for NRC, who knows all about the ins and outs of Silicon Valley. Having lived there herself, she knows all about the current challenges that Big Tech faces nowadays and thus made for an excellent host to guide us through the evening.

The first speaker on the program was Cynthia Liem, Assistant Professor at TU Delft in Multimedia Computing. Most of the CS students will know her from her various teaching activities. However, many students are probably not aware of her musical expertise! She has a MMus (Master of Music) in classical piano performance. In her talk, she discussed validity in data science: Are we measuring and predicting what we intend to? She connected this to multimedia data and classical music.

The next speaker was Dimitris Rizopoulos, professor of biostatistics at the Erasmus MC in Rotterdam. He is using advanced statistical methods to solve real-life challenges that patients face. In his talk, he discussed how he constructed a joint model for time-to-event and longitudinal data to personalize biopsy schedules for patients with prostate cancer. His optimized schedule is able to achieve the same results while reducing the negative consequences of treatment for patients. This technical talk provided a wonderful insight into the practical applications of advanced data analytics that have an actual impact on human lives.

Our final talk was by Jeroen van den Hoven, professor of Ethics and Technology at TU Delft. He spends a lot of time working with policy makers to create ethical frameworks for innovation. In his talk, he talked about incorporating values into the design of technology. This process is called Design by Values. His talk was an excellent basis for the panel discussion that followed.

The final part of the program, the panel discussion, consisted of four members and was led by our chair of the day: Eva de Valk. We had the following guests: Vincent Warmerdam, research advocate at Rasa and previous senior data person at GoDataDriven, Wouter Welling, coordinating policy officer digital identity at the Ministry of the Interior and Kingdom Relations, Ronald Prins, co-founder of Fox-IT and associate member at the Dutch Safety Board, and finally Jeroen van den Hoven, one of our previous speakers. In this panel discussion, we incorporated varying viewpoints on critical data analytics issues like discrimination, responsibility in automated decision making and social bubbles. Our four guests each offered different aspects, since they come from varying backgrounds. It was a lively discussion to watch and some very interesting points were raised.

Overall, the event was a great success! All our guests contributed greatly to make this an exciting and interesting symposium. The program explored all the ins and outs of data analytics and I believe that all our participants learned a lot more about this interesting topic. Despite the setbacks that were encountered throughout the whole year of organizing this event, I am very proud of what we as a committee achieved!

Starting Your Own Association

Authors: Maxime Hoekstra, co-founder D.S.D.A. Dynamic and Jasper Rou, co-founder DSAV'40

What to do when there is no student association for your interests? You create one your own! Two members of W.I.S.V. 'Christiaan Huygens' took the shot. The student culture in Delft has now extended with an association for dance and one for athletics.

Jasper Rou - DSAV'40

Almost two years ago, a dark era in the history of Delft in which there was no student athletics, ended with the rise of DSAV`40. In this article I would like to tell you a little more about my experience with the process of its foundation.

In the summer of 2017, I moved to Delft to study a double bachelor of Applied Mathematics and Applied Physics. By that time, I had been doing athletics for ten years and I would love to continue with it. During the OWee I found out that there was no student athletics association in Delft. I considered to join some other student association, but nothing made me as enthusiastic

as athletics and two bachelors seemed quite difficult, so I decided not to join those associations. This probably also caused me to join the activities of CH and become an active member here later. The week after the OWee I tried a training at the civilian athletics association AV`40. I did not like it very much as it was still summer holiday and the few students that were a member there, were not in Delft yet. I decided to join anyway, and this turned out to be one of the best decisions I ever made.

In my first year, I met a few students and I started to like it there, but felt more connected with the association in my parents' hometown (I am still a member there). I participated in

the Dutch student championships, but I didn't know about the student athletics associations from other cities that organized it. After a year, three other students that were a member at AV`40 and I decided to investigate if we could perhaps do something for students. A couple of months later, on February 25, we started with the first training especially for students that were already a member of AV`40 on Mondays 18:00. As the most experienced athlete of the four of us, I became the trainer. Furthermore, we started to promote ourselves with posters, flyers and our phenomenal Instagram which, within a year, had more followers than all other student athletics associations. It was a big success and in May we started with a second training on Wednesday.

Besides potential new members, there were many other parties to contact. For instance, of course, the TU Delft. When we contacted the OWee board we sadly were too late for the Binas, but luckily we were allowed to participate in the Sports market at X, which resulted in many new members. Additionally, we found a very enthusiastic sponsor who was also willing to make all our beautiful association clothing. Furthermore, we approached the other student athletics associations I mentioned earlier. Our big entrance on the Dutch student athletics podium was the Dutch Student Championship Teams in September 2019. There we became aspirant member of the Dutch student athletics association, which after a year became a true membership.

There were two personal highlights the following year. Firstly, The Board weekend with all other boards of the student athletics associations in the middle of nowhere, somewhere on the Veluwe. Secondly, the Beermile which we organized past October with much more participants than we had hoped for, and where I achieved a proud third place myself. There were many more highlights the past year and I had so much fun that I decided to do this again another year. I now have three new board members by my side, and I am very excited to see what cool things we can achieve this year.

Maxime Hoekstra - D.S.D.A. Dynamic

In June 2020, I received an interesting WhatsApp message in a group chat for ballet. It came from two students who wanted to start a dance association in Delft and were looking for other students to help establish this. I was immediately excited, since I sincerely missed an association for dance in Delft and I knew I was not the only one. Therefore I contacted these students and from that moment my journey of establishing a new student dance association started. It was more or less the start of COVID-19, little did we know that this issue would last so long...

First, let me tell you why we found it absolutely necessary for this association to enter the market of student associations in Delft. Once you have fallen in love with dance, you will never fall out of love with it. Once a dancer, always a dancer. Hence when you start your studies in Delft, there are a few options to continue dancing: stay at your old dance school and don't meet new students, sign up at a dance school in Delft where there are also not necessarily other students, or enter one of the two student associations for partner dance like Latin and ballroom (also fun!). However, when you are into ballet, hip hop, jazz, modern and other (single) dance styles and, additionally, wish

to meet other students to share your love for dance with, go to events with and have drinks with, Delft has nothing to offer. That is why we truly believe that this is an association a lot of students have been waiting for (including myself). And that is also why we just keep on going, even though things aren't easy because of the pandemic.

Personally I decided to join the founding board not only because I wanted this association to be established, but also because it is a very educational experience. I chose to be the treasurer because I did not have experience with that yet; I am already chairman of the MaCHazine committee and I have been secretary before. Setting up this association can be compared to having a startup, and I am learning a lot about promotion strategies, responding to demand and closing deals with external orga-nizations for dance spaces, for instance. This experience will definitely contribute to my future.

Once our fabulous website and Instagram had been launched and after a lot of word of mouth promoting, we had our first event planned: a hip hop workshop for beginners. At that time it was possible to let this event take place physically. We are very happy with the many people that signed up for the workshop and the positive reactions we received afterwards. Despite the COVID-19 measures taken, which included that everyone had to wear a face

mask and had to dance on stickers placed 1.5m distance apart, the participants were extremely enthusiastic and were looking forward for more workshops. We then wanted to organize more workshops like this, but then even stricter COVID-19 measures for the country came into effect. From there we have shifted to solely online events until physical sports lessons and get togethers are allowed again. We are happy to see that the online dance workshops also work out and can be sociable. We even hosted an online Just Dance Game Night which was a lot of fun.

Despite the limitations as a consequence of corona, the associa-tion is doing well and we gained a lot of members and followers in only a few months. Since these are probably the hardest times for D.S.D.A. Dynamic, I believe its success can only go up! I keep believing in this association and I look forward to meet our members at lots of our physical events. I am excited to see what the future of D.S.D.A. Dynamic holds!

Committee Kick-Off

Author: Jort Houben, Editorial Staff MaCHazine

The committee kick-off is an event organised by Christiaan Huygens in which all of its committees come together and undergo some social activity. Its purpose is to increase the connections, cohesion and friendships between these committees (and have an excuse to party). Customarily, all committees design their own outfit and wear this to the kick-off. Last year, all committees went pooling and had a diner afterwards in "Gasterij 't Karrewiel". Unfortunately, due to the corona pandemic, this year's kick-off could not take place physically. Hence, the event took place online instead.

The main outline consisted of two parts. First, all committees separately played an escape room made by the Christiaan Huygens board. Afterwards, everybody came together in the Christiaan Huygens Discord server. Meanwhile, there were two competitions being held: the fastest committee to complete the escape room and the committee with the best outfits. Obviously, it is much more preferable to judge outfits in real life. However, we refused to let this part of the competition be cancelled by the corona pandemic, so we all dressed up anyway!

Before the kick-off even started, I had some technical issues. There were some communication problems between the kitchen (a.k.a. my mom) and me, which caused our dinner to be slightly

later than expected, which in turn almost caused me to be late at the event! I was still finishing my pizza when the Zoom call started. I don't think anyone noticed, though.

Due to some cancellations of our team members, the MaCHazine committee played these competitions with significantly fewer members. It took us quite a bit of time to complete the escape room. In this part of the competition, we had to track down someone who committed a murder. We were shown several videos in which details of the story were revealed. It felt like watching a crime movie. We were granted three mathematics and computer science related puzzles to solve, each of which gave hints to the next puzzle.

Obviously, because of the lack of our team members (and certainly not the lack of our skills as competent mathematicians and computer scientists), we lost the escape room competition. However, we did win the prize for the best outfits! We came up with these outfits during a quick meeting in the very afternoon on the day the kick-off was being held. In all honesty, I never thought we would stand a chance. Turns out that other committees are even worse at designing outfits than we are! After a little bit of discussion, we decided to dress up like you would expect from such a committee: old-school journalists. That is, wearing a nice hat with a "press" sign attached to it, having an old camera, holding a microphone, and even wearing sunglasses.

When we caught the murderer and finally finished the escape room (after several hints from the board), most committees were already hanging out in Discord. Immediately upon joining the channel in Discord where all committees would meet up, we heard much laughter. There was an insane amount of people already present. In fact, there was so much laughter that we had a hard time stating our presence. So we went back to our Zoom call and chit-chatted in there for a short while before attempting to rejoin. When we got back in Discord, the winners of the escape room and the outfit contest were announced. As the winning picture for the outfit contest was shared, we were so glad to see that it was our picture!

In short, even though the committee kick-off could not be held in real life this year, it was still very enjoyable! 🛡️

The MaCHazine committee with their reporter outfits (I'm the weird guy with the camera)

Computer Science

Delft Algorithm Programming Contest

Authors: Merel Steenbergen, Participant, Raoul Bruens, Organizer

This quarter the Delft Algorithm Programming Contest (DAPC) took place. During this contest, participants had to solve several problems by developing their own algorithms. We asked a participant and one of the organizers to share their experience of the event.

Merel Steenbergen - Participant

"Let's participate in the Delft Algorithm Programming Contest!" It started with a suggestion on a Saturday night, the week before the contest took place. Just three people living in the same building. Suddenly, we were a team.

In the morning of the 14th of November, on the third floor of a student building, our team of three students were eagerly awaiting for the Delft Algorithm Programming Contest to start. We had everything we needed to spend the day solving puzzles and programming algorithms: coffee, chargers and some snacks. We were ready.

We were not expecting to win, but that doesn't mean we didn't try. Our plan was to divide the problems we had to solve over the team members. We're all good at different things, so we all read the problems and claimed a few to solve. Then, the programming started. It was pretty quiet for some time. The only sound that could be heard was the clicking of the keys of our keyboards. Until one of us called: "I think I got it!" We all stopped programming and all watched while we handed in the first algorithm. "CORRECT!" The screen read. We cheered and continued with extra motivation.

Even though the next algorithms wouldn't always be correct on the first try (or even on the last), we didn't give up. It was fun to program these things. Towards the end we started working together more and clicking of keys was no longer the only sound that could be heard on the third floor of our building. We all had an algorithm that we couldn't seem to get right, no matter what we tried. So we passed those around for other team members to fix. Sometimes that worked and we got an extra "CORRECT" in the leaderboard. But still, sadly, we didn't climb up to the top. We got close though; at one point we were in the 8th place! But then we encountered some problems we just couldn't seem to fix. Frustrated, but determined, we soldiered on.

We discussed possible fixes to the problems we didn't solve yet. Our productivity had been sky-high during the first hour, but then suddenly dropped. All of us got stuck on an algorithm. Time for coffee. The coffee break helped us to get back on track a bit, but didn't solve our problems. We ended up on the 38th place. While we had hoped for something better and were still frustrated that three or four of our algorithms were almost correct, it was now time to relax. Programming algorithms for an entire day is tough, it takes up a lot of energy. However, we needed to unleash for a second after working so hard.

We decided to order food and have some drinks. We discussed the algorithms a little more, now also chatting with other teams, since the competition had ended anyway. It comforted us that we weren't the only ones to get stuck on certain problems. We played some board games and just chilled for the evening. I think we deserved it.

While we didn't win, it was still very fun to participate in the Delft Algorithm Programming Contest. I like solving puzzles, so this was a nice way to spend my Saturday. Especially since I'm now doing my minor and am not programming at all, I had missed it. The DAPC provided me with a fun way to brush up my algorithmic thinking and programming skills. It was very nice to do the thing I love once again.

Joep and Cas, thanks for the coffee, drinks and the fun day. I had a lot of fun and I'll see you next year!

Raoul Bruens - Organizer

What is the most ideal way of loading a set of delivery trucks? What is the most optimal way to build a power grid such that the construction cost is the lowest? These are the types of problems that students try to solve during the Delft Algorithm Programming Contest (DAPC). This annual event is a preliminary contest for the international Benelux round, where students can qualify for the preliminary of the World Finals! Students partake in this programming contest in groups of three, in which they get five hours to solve around ten coding challenges. The organization is done by the CHipCie committee, who are a team of talented and enthusiastic people that love getting students into the programming contest community. Not only are you improving on your coding skills, but companies are also very present at these events since they are usually looking for potential employees that can sort out any of their (coding) problems. Hence, they love showering the contestants with sponsored goodies and sweets.

This year, the organization of the event was completely different than in other years. Usually, a team has access to one and one computer only, making the whole coding process itself a strategic optimization problem between typing, debugging and compiling. This year, because of COVID-19, teams were allowed to use their own setup at home, with at most three machines per team. This made the logistics a lot different; instead of having to rent out Drebbelweg and making sure we had a local network of contest

machines running, we had to set up an event stream and a cloud infrastructure to support running the problems tests (since one would want the same resources accessible to all test cases to ensure consistent test results). This was, of course, something the CHipCie never had done before. Luckily, with some help coordination among other preliminary sites, the CHipCie was able to pull this off and ended up having one of the largest DAPCs ever. This was not only because it was online: as other preliminary sites were unable to organize a local contest, we allowed them to join ours. In this way, the CHipCie also supported other universities (e.g. University of Amsterdam, Leiden University, Utrecht University, Groningen University, and even Université de Mons

and Louvain, both from Belgium!) who were unable to organize anything this year. In the end, around 90 teams attended the DAPC! This was definitely an online success!

At the time of writing this, the CHipCie is taking a lot of steps towards their next big event. This year, they have the honour of organizing the BAPC too. After seeing how well the DAPC went, I have no doubt that the BAPC will be a booming success too!

Do you also want to attend a programming contest? Around May, there will be the annual Freshmen Programming Contest, where you can compete as a spectator or you can attend as a programmer. Are you more interested in joining the CHipCie? We are always looking for enthusiastic people! Send an e-mail to chipcie@ch.tudelft.nl to get into contact with us. Looking forward to hearing from you!

Software Project

Author: Kasper Wolsink, BSc Student Computer Science

During the fourth quarter of the second year of the computer science bachelor, you have the software project. This is a big project where you will use your skills for the first time in a real-world situation. The project is the only thing you will do in quarter four and hence it is also worth 15 EC. I completed the software project last year and I am writing this to share my experience.

Getting into the software project

Before you can participate in the software project, you need to have completed a set of courses, otherwise you cannot enter. I don't remember all of the courses, but I do remember that I had to resit ADS (Algorithms and Data Structures), and pass SEM (Software Engineering Methods) the first try because the resit wouldn't be taken into account. Naturally, this led to some stress as failing either of those courses would postpone the entire software project to the next year. However, I did pass both of them (or else I wouldn't be writing this article) and with that I completed all prerequisites to partake in the software project. Exciting stuff!

The next thing you need to do is find a group of people you are going to work with (five people for my year), a company/institution that will provide you with the problem, and a mentor from the TU Delft. There are lots of projects to choose from; from major banking firms that want a new online payment method to small startups looking for some innovative students that can help their business grow. For me it was very exciting to see all these possibilities. It really shows that the stuff you have learned the past two years are really useful and that many corporations and institutions seek people like you.

I formed my group, picked a project and got assigned a mentor, everything was set for the project to really get started!

Getting ready to code! But first...

It was the first week of the software project and we were about to have our first meeting with the client (the company/institution providing the problem) and our mentor. This was an important meeting, as we only had gotten a brief overview of what the problem actually consisted of; no in-depth stuff at all. So, the first meeting was about finding out what exactly the client wanted from us and figuring out how we were going to do it. I remember during the SEM course that the teacher said that the client often does not know exactly what they want, and that it is a tough job figuring out what exactly that is. I also remember thinking that this was over-exaggerated. It couldn't be so hard, right? Well, I was wrong, to put it lightly. It took over two whole weeks to find out what exactly we were supposed to code and how we were going to do it. Even after these two weeks there were many unanswered questions about the specific requirements, of which we would only find out the answer in the very last weeks of the project. Requirement engineering is a hard task and you should certainly not underestimate it like I did. It was a fun process though, as it is probably the most creative part of the project. Your craziest ideas can become a reality!... If the client approves it, of course.

Chasing the deadlines

We knew now what we were going to make and how we were going to make it. Now comes the most complicated part: actually making it. There was an extra challenge: we were going to develop our application in Python and use the Django framework, neither of which I was familiar with. This might have been a big problem, however, Stack Overflow exists. That might have been a solution. The first few weeks we were primarily getting used to all the new programming languages we were using and developing our team chemistry. Working together on a big problem is great but you might have to get used to the workflow of your teammates. Luckily, this only took a few days in our case. Learning Python

and Django however, took nearly the entire project. Therefore, in order to make the first few deadlines, it is extremely important that you work together with your teammates properly, as you all really rely on each other (and on Stack Overflow). This is one of those skills that the university will never be able to teach you during lectures. The only way to really learn it is by actually experiencing it in a real-world. Another thing that only happens in the real world is clients that change their minds about certain features last minute. This happened often during the demos we gave every two weeks. We had a Zoom meeting with the client and our mentor, and we showed the latest version of the application. The client pointed out what they liked and what they disliked, then the mentor would ask some general questions and would monitor if the progress we made was following the schedule. After the meetings, we would go back to the drawing board and chase the next demo deadline.

The last few weeks

At this point, 80% of our "must have" features were implemented, and we were fully familiar with the tools we were using. The meetings were way more efficient compared to the first few weeks and we were actually able to understand the Python code we were writing. The client was happy, and the mentor approved of our workflow. There was only one more challenge ahead: the final deadline.

Stress is a wonderful thing that allows the human to do double the amount of work in half the amount of time. This proved to be really useful in the last few weeks as there were a lot of tasks left to do. First of all, all the "must have" requirements had to be implemented. Second - and I haven't spoken about this part yet - there is a massive report you have to hand in at the end of the project which consists of all your research, methodology and your eventual results. Finally, you have to actually present your final application to independent graders that have never heard of your application before. Remember the first two weeks of the project where you had to find out what the project was actually all about? You now have to condense this information in a 30-minute presentation. This all was very challenging, but there is one solution to super challenging problems: Stack Overfl- no just kidding: teamwork!

We somehow did the unimaginable and finished all the final tasks in time. We made the deadline and handed in the project. We got a very nice grade and the client thanked us for our work in the final meeting we had. All the hard work was worth it in the end.

To summarize

In this article I didn't really talk about the super technical parts of the project. The reason for this is because this is different for every project. The thing each project shares though, is that it is a real-world problem you will have to solve in a team effort. You will learn how to do so during the project and that is a very useful skill to have. Honestly, the project was the most fun I have had in the computer science course yet, and I wish all the current 2nd year students the best of luck with theirs!

Case notes: The AkCie

On day 357 of my time undercover in The Society, the trust I have built with Member X finally paid off. After months of superficial talks and pleasantries, I was invited to my first event. It was organized by the AkCie, the first subgroup in The Society I had discovered.

It seems this group is responsible for organizing mixers for teachers to meet students, and a festive event for the national 'Sinterklaas' holiday.

My presence at this event went unnoticed by most Members, until one of them struck up a conversation that led to an invitation to my next event: a barbecue. The search continues...

SUSPECTED "AkCie" MEMBERS:

Alexander van der Sluys
Luuk van der Laas
Isabelle Elias
Els Brouwer
Carinten Donker
Sabina Gradinariu
Jorn Dijk
Karel Cimbergh
Helena Ligtenberg
Ella de Vries
Phealana Fiamingo
Tinko Vialard

25th of February

Case notes: The CHoCo

Day 401 was the day for the CHoCo, another committee that organizes events for The Society. The goal of the event was to give the parents of Members some insight into the secret workings of The Society. Without showing too much, of course...

SUSPECTED "CHoCo" MEMBERS:

Radu Mihalachiuta
Charlotte Kauppinen
Bradley van Hooff
Daniel Wolff
Madelief de Ruiter
Winstijn Smit
Mirke Pietersma
Luuk Wubben
Tiinur Oberhuber
Chris Preda
Andreea-Luminita Mocanu

Behind the scenes of a private "AkCie" seemingly named "PrAkCie".

5th of February

Case notes: The SjaarCie

Following up on the invitation I recei[ved]
AkCie event, on day 381 I walked out[...]
full of Members barbecuing. This eve[...]
organized by a subgroup: the Sjaar[Cie]

I overheard two Members proudly d[...]
their misbehaviour at a previous [...]
event: a wild party. Something [...]
and 'barfen'. Note to self: must i[...]
meaning of this further.

SUSPECTED "SjaarCie"

Djura Beenen
Guus Dolder
Vincent van Vliet
Rinze Hallema
Merel van Santen
Aleksandra Andrasz
Vinh Ngu[...]

11th of Mar[ch]

DAILY N[EWS]

Wednesday, 6 March 1957

[DETE]CTIVE MISSING IN A[...]

BY MONSIEUR LE NOIR

On the 5th of March, Detective Hammer was abducted by a still unidentified perpetrator wearing a black ski mask. The detective was giving a press conference on new discoveries in his investigation into the Society of the Owl, the true name of which is still unknown. The shocking event took place in front of no less than 130 witness-

es, a bold move from a fearless abductor.

Although the motive of the abductor is still unknown, evidence suggests they were part of a highly organised group. Besides the detective himself, his notes for the press conference were also taken, seemingly on purpose. This suggests the content of the presentation was cause for the abduction,

[BI]NARY PUZZLE

[A bi]nary puzzle is an n × n binary array such that there are no three [consecutiv]e ones and also no three consecutive zeros in each row and each [column, the] number of ones and zeros must be equal in each row and in each [column,] every two rows and every two columns must be distinct.

[...] according to the rules and string the colored blocks behind each other [...] a three-letter puzzle word (so not a number).
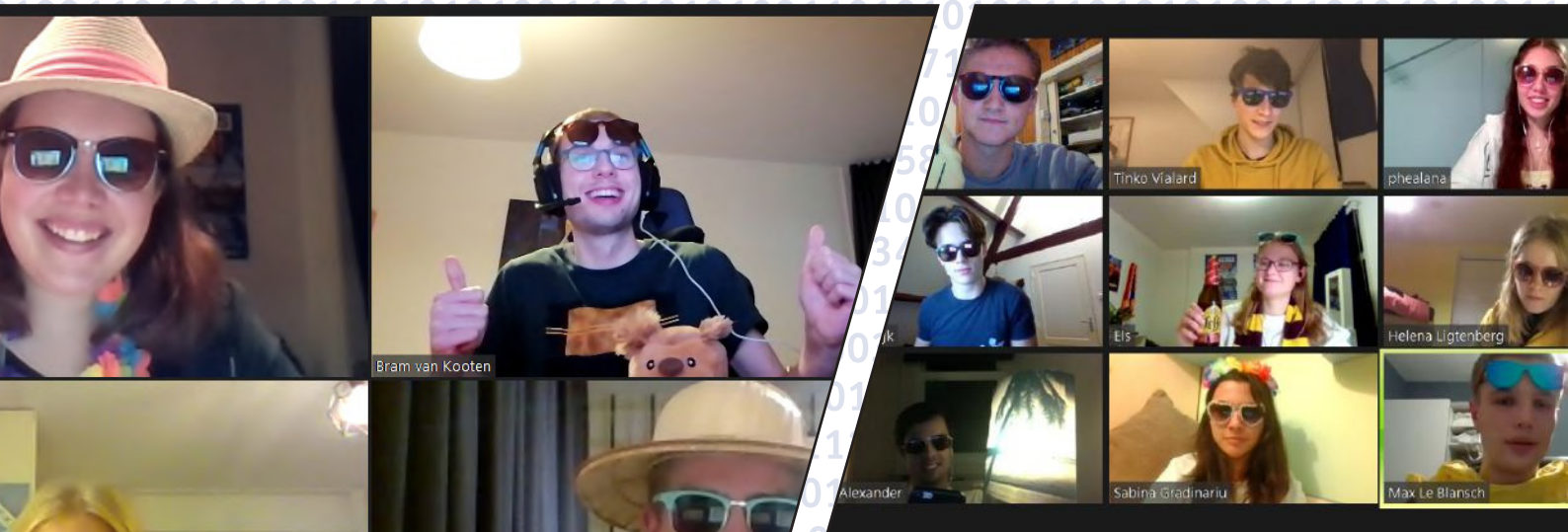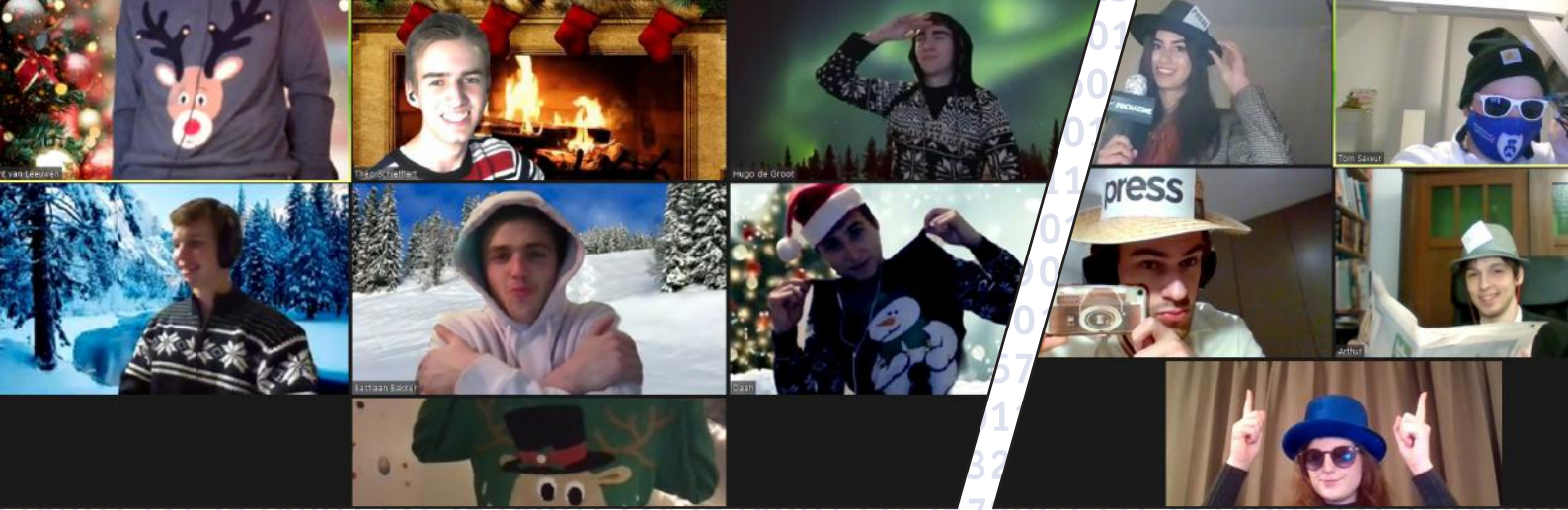
Optimal Drop Times Using Machine Learning
The Trade-off Between Efficiency and Being on Time

Author: Tom Steenbergen, Data Scientist at Picnic

Picnic delivers groceries to thousands of customers every day. In order to do so both efficiently and effectively, Picnic's distribution system needs to be as smooth as possible. One part of this system is the vehicle routing model, that determines which routes are optimal given the customers and their placed orders, amongst other factors. An important input into this model is the drop time: how much time we expect a delivery to take for a given customer (in the vehicle routing literature better known as the service completion time). This blog post covers why drop times are so important and how we, the Data Science team within Picnic, developed a model to better predict this amount of time.

Time is of the essence
Customers value the convenience of having their groceries delivered to their kitchen. To make the experience even more convenient, Picnic communicates a short time window on the day of the delivery in which the deliverer, or runner, will be at the customer's door. This time window is only 20 minutes long and it falls within the one-hour time slot the customer chose when placing the order. In order to make sure that we can make the customer happy by delivering his/her groceries within those 20 minutes, Picnic's distribution system needs to plan enough time so the runner can easily arrive at the customer on time.

As Picnic is growing rapidly, the number of customers that would like to have their groceries delivered by us keeps increasing. Therefore, it is key for the business to be able to deliver efficiently. In other words, there are two contrasting objectives here. On one hand, we want to have a high on-time percentage, which requires us to plan enough time for each and every customer. On
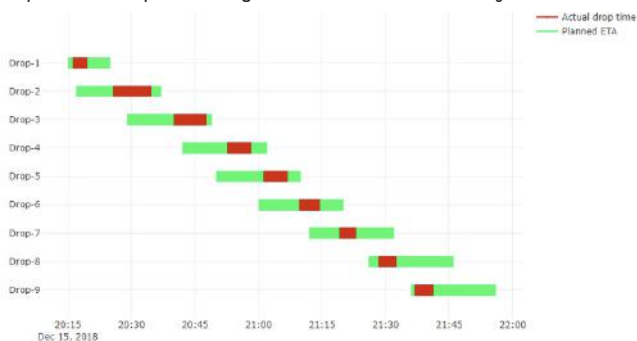

Gantt chart of a delivery trip

the other hand, we want to increase efficiency and serve as many customers as possible within the duration of a single delivery trip made by a runner.

In order to make sure that we can increase efficiency while maintaining the same on-time percentage, we need to have a better estimate of how much time is 'enough' to deliver a given order. Visually, this means that we would like the red bars (the actual drop times) in the chart above to start right in the middle of the green bars (the planned 20-minute windows). If we plan too much time, the red bars move to the left side of the green bar. In severe cases, this would mean a runner would even have to wait before he/she can deliver as the planned time window hasn't started yet. This is of course very inefficient and is something we would like to avoid. If we plan too little time, the red bars move to the right side of the green bars, causing each subsequent drop to be later. This could potentially cause orders to be delivered later than the planned time window, which deteriorates the customer's experience.

In short, when our drop time estimate is rather inaccurate, we need to plan a lot more redundant time on top of our estimate as a safety buffer to maintain a high on-time percentage. When this estimate becomes more accurate, we can reduce this safety buffer, increasing the distribution system's efficiency, without risking many late deliveries.

The road to success
We started off with some exploratory data analysis and looked for factors that affect the duration of a delivery. These factors can be roughly grouped into four areas: 1) customer, 2) order, 3) region, and 4) runner. A broad range of features was explored, from historical average drop time of a customer and the total weight of the delivery, to weather forecasts and address density. Naturally, a large and heavy order consisting of multiple bags of groceries takes a lot longer to deliver than an order containing only a couple of articles. There were also features that we would like to have, but we could not construct with the data that we have. For example, we would like to know on which floor the customer lives, as that could impact the drop time a lot. As you can imagine, delivering to a customer on the top floor of a four-story apartment building takes a lot longer than delivering to a customer with a front door on street level. For these kinds of features that we do not have, we constructed proxy variables. In this example, we used address density and the historical drop time of the customer.

Furthermore, we also had to make sure we chose a sensible loss function. Even though we have a great data warehouse that captures data from various back-end systems and third parties, sometimes the data received can still contain anomalous records. For example weird timestamps cause the recorded drop time of a delivery to be different from reality. In this case, we could luckily identify most of the anomalous entries and filter them out with some business rules. Additionally, we chose to use a loss function that handles outliers differently than the regular mean squared error loss function used for regression problems. The loss function we used was the Huber loss, a combination of the squared loss and the absolute loss. This function, like the mean squared error, penalizes large errors more severely than small errors. However, when errors exceed some threshold defined by a parameter p, (indicated by the dotted lines in the picture below) the Huber loss uses a linear loss to avoid putting too much weight on these potentially anomalous errors.
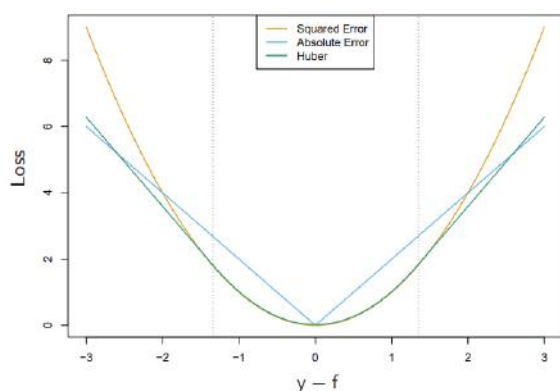
*Comparison of squared, absolute, and Huber loss*

Armed with an initial set of features and a sensible loss function, we started comparing various algorithms. As explained in this (https://blog.picnic.nl/the-art-and-science-of-data-science-80e215f92a99) other blog post our team made, we prefer simple over complex. Therefore, we looked at simple models first and compared that to the drop time calculation that was in place at that time. A simple linear regression model already turned out to be a lot more accurate than what was in use at the time. Comparing against this baseline model, we iteratively evaluated various other features and models.

Time for a test drive

After evaluating a number of options, we ended up with a multilayer perceptron (MLP). This model yielded the highest performance, and with all the well-developed deep learning frameworks that are available nowadays, it resulted in code that was hardly more complex. Compared to the current situation, the MLP model reduced the error by approximately 30% when evaluating historical test data. The data included all of Picnic's

hubs (site from which Picnic delivers to one or more cities) in the Netherlands. When these results translate to practice as well, it would mean that we could greatly cut down on the safety buffer.

In order to test how the new model would perform in reality, we decided to do a quick pilot in one of Picnic's hubs. For a period of one week, we planned all deliveries using drop times calculated by the MLP model. After this week we found that efficiency, measured in the number of deliveries per trip, increased for this particular hub by roughly 20%. The on-time performance only decreased by approximately 2 percentage points. A small decrease, but using a goodness-of-fit test found to be statistically significant. The decrease can be owed to unexpected events during the trip, such as roadblocks or traffic jams. When you don't have enough safety buffer on top of your drop time estimate, these unexpected events cause some orders to be delivered late. Overall, the test was a huge success and we made plans to roll out the model throughout the Netherlands.
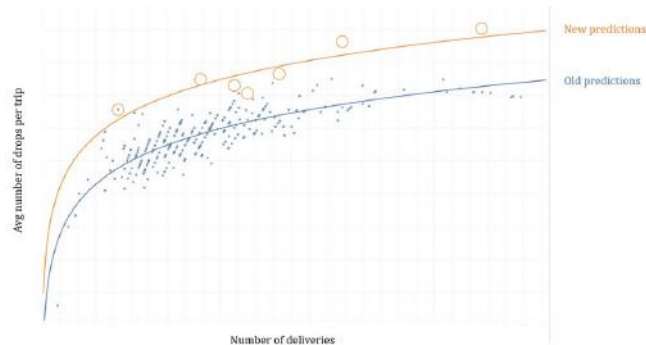
Efficiency of the new model during the pilot, compared to the old drop time predictions

We started off with a couple of hubs and gradually rolled out to more and more cities. Instead of immediately starting with the new model's predictions, we added a safety buffer on top of the MLP's predictions because of the decrease in on-time performance we noticed during the pilot. We then steadily decreased this safety buffer over the weeks following the roll-out so we would increase the efficiency of the system, while keeping a close eye on the on-time performance. This set-up gave us the tools to play around with the trade-off between efficiency and on-time performance for each individual hub. Fast-forward a couple of months and we now have the new model running in production for each hub in both the Netherlands and Germany.
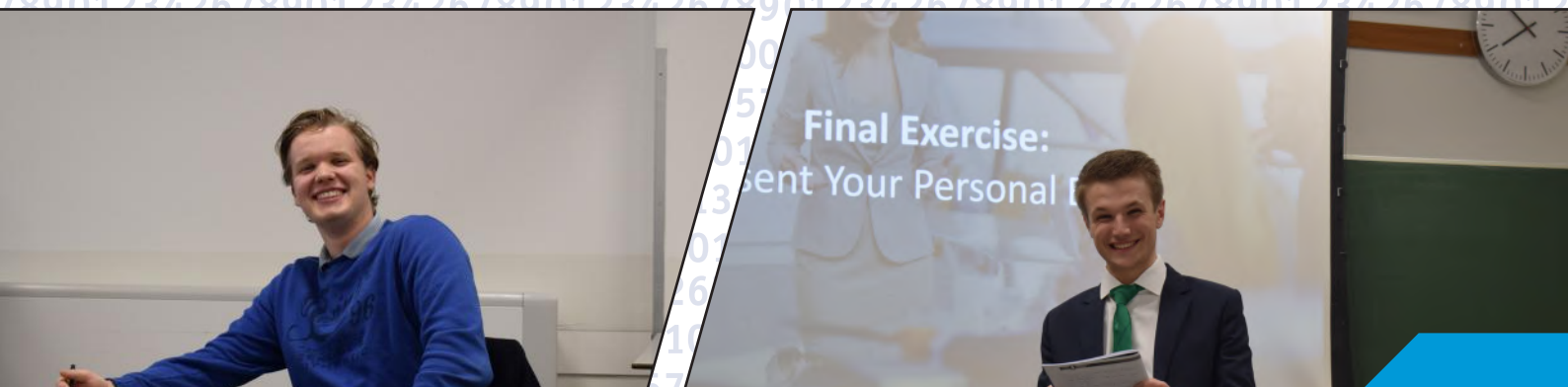
In for a challenge?

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Mathematics

Finance Track: From Minor to Internship

Authors: Marc Droog, MSc Student Computer Science, Tom Heijnders, MSc Student Applied Mathematics, Jorino van Rhijn, PhD Student Mathematics

The finance track is a large path within Applied Mathematics at TU Delft. In this article, two people will tell about their experiences in the two parts of the track, the minor and the master. Furthermore, a PhD student will tell about his experience interning in finance.

Marc Droog - Finance minor

I have always been interested in the world of finance. Therefore this minor was a great fit for me. It combines courses which focus on different aspects of finance. Next to a fair bit of mathematics, the minor focusses on general market principles, financial products and finally on assessing and controlling risk. These different aspects combined provide a great introduction into the field of finance.

Most of the attention goes towards options, which is a financial product available on almost every stock market. In short, an option is a financial product which depends on a stock; it gives the owner an option to either sell or buy the underlying stock for a certain price. When the holder of an option has the option to buy a stock for a certain price, a so called 'call option', it would be beneficial for the holder if the price of the underlying stock raises. That is because the owner can buy the stock for the price determined in the option and sell it for more on the stock market. On the other hand, when the option holder holds a put option, which gives the holder the right to sell the stock for a certain price, it would be beneficial for the holder if the price of the underlying stock drops. Due to these principles, calculating the price of an option can be mathematically complex.

In the minor, students learn how this can be done mathematically and by using MATLAB. In the minor there is also attention for the current state of the financial market: issues in real markets are discussed and a few lecturers invite interesting guests or companies which operate in different financial fields. Personally, I really enjoyed the minor and learned a lot. I especially enjoyed the guest lectures and companies. I would recommend this minor to everyone who is interested in the world of finance!

Tom Heijnders - Finance track master

After I finished my bachelor thesis, which you can read about in the previous Machazine, it was time for me to start a master. My interest has always been in the financial world, so I first looked into the master Quantitative Finance of the econometrics department of the Erasmus University in Rotterdam. After some thinking I decided to take another route. I was too attached to Delft and did not want to study at another university. Also, the transition would have cost me an extra year. I also discovered that a certain master in Delft would give me the same options for jobs in the financal world. This was the master Applied Mathematics and in particular the finance track.

Besides the finance track you can also follow different tracks such as optimization and stochastics. My decision was quickly made for the finance track. In the first semester, the master consists mostly out of common core courses. With the finance track you have to follow Martingales and Brownian Motions and Scientific Computing. You can then choose from Discrete Optimization and Statistical Inference. The courses that specifically belong to the finance track will take place in the second semester, which I am looking forward to! For now these courses have my full attention and I even got my first points for Game Theory. In this course you will learn the specifics of this field and analyze a lot of fun games. Among the courses in the first semester we have standard courses: Ethics and Scientific Writing. In these courses you will learn what you expect from their titles. I have already got my points for Scientific Writing by writing a literature review about option pricing. This quarter I follow Ethics where we have to participate in debates and also write a paper about a subject interesting enough for ethics.

To this point the master is fun and doable. But the hardest parts still have to come. During the end of January there will be exams for three of my courses. I am already looking forward to the holiday in February.

Jorino van Rhijn - Internship in finance

As part of my bachelor in Applied Physics, I minored in Finance at EEMCS, which turned out to be a great choice. I enjoyed it to such an extent that I switched from physics to mathematics and pursued the Financial Engineering master specialisation. I was intrigued by how the rise of technology had completely changed the way in which the stock market works within a few decades. It went from a group of (mostly) men shouting orders in a pit to a complex and data-driven system in which applied mathematicians and computer scientists thrive. Quantitative finance covers a large range of key fields at once: probability theory, game theory, numerical mathematics and modern machine learning techniques. This makes the toolset that you acquire very powerful.

After completing a tough six-month bridging programme that forced me to take Mathematical Structures and Real Analysis simultaneously, I was allowed entrance to the Applied Mathematics master programme. I took additional electives involving machine learning and neural networks and enjoyed an intermezzo as board member of the VSSD for a year. In October this year, I graduated after defending my thesis on the approximation of asset price models with neural networks.

In this piece, I would like to focus on a more practical experience I obtained during my master programme: for several months, I worked as an intern in the Corporate Finance department of a Dutch bank. Corporate Finance is related to the course Principles of Asset Trading from the minor Finance. I was part of the Mergers and Acquisitions (M&A) team, which acts as the financial advisor to medium and large businesses as they are involved in a (potential) merger or acquisition. A company may have several reasons to merge with or acquire another company, for example if the combination benefits from economies of scale, or if it is considered strategic to expand the existing market share over competitors.

Much of the work of an intern involves the creation of documents that contain strategic and financial advice to a client and (potential) investors. For example, they may contain an overview of the company at hand, the key strategic considerations, finances, market trends and possible directions involving a merger or acquisition. The financial advisor could either advise a client which intends to divest part of its assets (sell-side), or one that intends to take over another business (buy-side). The decisions that follow by the client are usually of large strategic importance and could have major consequences for its future operations. The information presented must be extremely concise, free of any errors and convey a clear, unambiguous message to the intended reader.

M&A requires the ability to interpret, process and visualise large amounts of non-financial and financial data, as well as making logical inferences, personal communication skills, advanced typewriting and the ability to deliver high quality work under time pressure. It is the combination of these elements together that makes the work challenging. At the same time, everyone continuously collaborates in teams. This makes M&A a great learning environment, especially for TU Delft students, for whom the emphasis usually lies solely on quantitative reasoning. At the TU Delft – and especially at EEMCS – we are not used to dealing with ambiguous or sparse information. In a mathematical proof or piece of code, for example, it is usually evident why each step is present and each step can itself be explained. In the corporate world, however, ambiguity is everywhere: in general, it is not clear which possible strategy is the best among alternatives, or limited information may be available about a company or market trend. Still, a strategic decision has to be made. How do you form and convey a message that is unambiguous from ambiguous data? How do you present this in a way such that anyone will understand it without confusion? I think the ability to deal with such questions is an essential skill to have as an engineer, especially as it is usually not part of our education.

During the internship I learned the basics behind corporate governance, reading financial statements and how corporate professionals make investment decisions. It formed a hands-on crash course that greatly increased my general knowledge about the world. I would recommend anyone to gain experience in the corporate side of finance to boost both their professional and personal development.

Mathematics: A Discovery or an Invention? - A Short Essay

Author: Jort Houben, Editorial Staff MaChazine

Ever since mathematics originated, there has been a philosophical debate about its nature: is mathematics discovered or invented? I gave this query some thought, and I will propose my philosophy in this essay.

Mathematics as a discovery

In a very pragmatic sense, mathematics "works". It allows Shazam to recognize your favorite songs, your mobile phone to work, and it puts people on the moon. It would be improbable that mathematics is strictly an invention, for otherwise all technology based upon it would not function. The fact that mathematics works implies that mathematical laws underlie reality, and when mathematicians are doing their research, they are discovering truths that are already present.

Plato

The Greek philosopher Plato had a conception of reality which is perfectly applicable to this idea. Plato thought of the world as an imperfect reflection of an invisible perfect world beyond our conception, in which "perfect ideas" live. For example, there is the perfect idea of the number 2. An object in the world could be said to have a length of 2 meters. However, this length is never exactly 2 meters; it is always slightly longer or shorter. The probability of an object having such a length is infinitely small, and therefore it never occurs. Even though objects of exactly 2 meters do not exist in this world, people can comprehend the "perfect" concept of the number 2. This perspective on metaphysics, literally coined Platonism, would confirm the notion of the inherent presence of mathematics in the universe.

Mathematics as an invention

Humans made up mathematics in their minds. People used nothing other than their own thought and logical reasoning to construct mathematics. This would imply that mathematics is a human construct: a human invention which is not inherently present in the universe, but fortunately happens to coincide with it. Moreover, there are fields in mathematics which do not apply to the physical world at all. There are formulas for computing the volume of hyperspheres in any given dimension (side note: interestingly enough, the volume of a hypersphere increases until its maximum at the fifth dimension, whereafter it decreases forever); one could do geometry in planes that are curved in any way possible, etc. These seem to be tiny worlds of mathematics which exist on their own, independent and disconnected from reality.

Moreover, throughout the centuries mathematicians may have "fitted" mathematics such that it matches reality. Calculus is useful because many real-world problems turn out to be problems in which extrema or areas under curves must be determined. It could be that mathematics is invented to solve problems that emerge in the world, so that it seems like mathematics fits the universe perfectly, whereas it actually does not.

There are also arguments in favor of mathematics being an invention whose roots are grounded in mathematics itself: Gödel's incompleteness theorems. The Austrian logician, mathematician and philosopher Kurt Gödel did shocking discoveries in mathematics in the twentieth century, which (indirectly) attack the notion of mathematics as a discovery. Gödel developed and proved two theorems, known as Gödel's incompleteness theorems, which had huge implications and impact on not only mathematics, but on philosophical and scientific thought in general. The first incompleteness theorem asserts that any mathematical system is either incomplete or inconsistent; the second states that in any mathematical system that is consistent, its consistency cannot be proven.

Kurt Gödel

An incomplete system means that there are always axioms missing; an inconsistent system means that there are theorems within this system that contradict each other. This is a disaster for mathematics. There is no value in mathematical truth if truths can contradict each other, for it was always supposed that mathematics was consistent. The second option, incompleteness, is not as catastrophic, but it remains a big issue when a theorem can neither be proven nor disproven, since it was also always supposed that each conjecture was either provable or disprova-

ble. It might be that there may not be a proof for the Riemann hypothesis, and the many brilliant mathematicians who attempt to deliver a proof for this theorem may be working in vain.

Gödel's incompleteness theorems undermine the notion of mathematics as a discovery: if the underlying laws of reality cannot be proven to be true, or are inconsistent, then reality would potentially contradict itself. Obviously, this would be nonsense.

A remedy: reconciling both conceptions

Let us approach the question again from the bottom up; that is, the axioms. Axioms are mathematical truths that are assumed to be self-evident. Therefore, they are provided without proof. Typical axioms are "there exists an empty set" in set theory, or "the shortest path between two points on a flat plane is always a straight line" in geometry. Using axioms and definitions, conjectures can be proven (or disproven). Out of this procedure a set of truths and falsehoods emerges. The word "emerge" here is important: it implies that these truths and falsehoods are already present.

For instance, there are the so-called Peano axioms which define the natural numbers and their arithmetic. Thereafter, one can define what an even number is, and prove the theorem which asserts that the sum of two even numbers is even.

Consider the following assertion. Axioms and definitions are constructed; they are not inherently present in reality. However, theorems and falsehoods are already true and false respectively before they are proven. That is, the sum of two even numbers is already even; furthermore it has always been even, and will always be even regardless of whether it is proven.
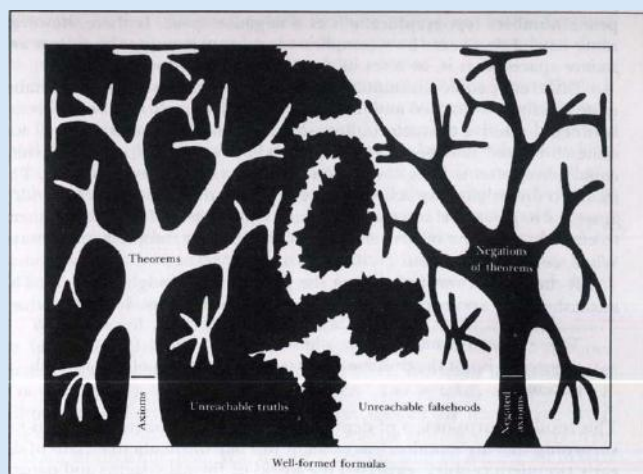
Diagram out of Gödel, Escher, Bach: an Eternal Golden Braid (D. Hofstadter). It illustrates axioms, its theorems and unreachable truths.

In other words, the axioms of mathematics are invented; but the truths and falsehoods which arise from these axioms are discovered. The seeds out of which mathematics grows are chosen, but the trunk, branches and leaves which grow out of these seeds are fixed from the very moment the seeds are planted.

Besides this notion, consider the following idea. Take again the natural numbers, and think about their nature. They are derived from (natural) amounts of objects: three sheep, one apple, five villages, etc. Natural numbers are thus abstracted from the real world. Now take the negative integers: these are an extension of the natural numbers to a non-existent domain, something absent in the real world (in our imagination, if you will). There are no negative amounts of sheep, nor are there negative quantities of apples or villages. People do understand the notion of negative quantities though, albeit their transcendent nature. Humans know exactly what they mean if one has a negative amount of money in their bank account.

Also consider the prime numbers, the "building blocks" of natural numbers. They are discovered; it is discovered that numbers exist which do not have any other factors than the number itself or one. Furthermore, the infinite amount of prime numbers is discovered (since it is a theorem), as well as the unique decomposition of a number into prime factors.

It is not straightforward to binarily decide whether mathematics is discovered or invented, as the question itself is not properly defined. It needs to be defined what is precisely meant by "mathematics" before the question can be answered. Parts of mathematics are discovered; other parts are invented. The only which certainly holds is the notion that definitions and axioms are invented, and the truth of conjectures are discovered.

Conclusion

To conclude, the central question on the nature of mathematics is too vague, for the devils are in the details. Mathematics is neither discovered nor invented in its entirety. The main conclusion of this essay is that the axioms, from which mathematics is built, are invented, and truths and falsehoods which arise from these axioms are discovered. Consequently, a part of mathematics is constructed and another part revealed; thereby generalization is discarded. Nuance is the key.

Feel free to challenge and criticize my ideas. I am highly interested in your thoughts. Please contact me if you have any.

You can contact me at jorthouben@gmail.com. 🛡

Automated Interpretation of Bank Payments Using Machine Learning Parameter Tuning

Rick van den Dobbelsteen is a Data Scientist at DSW and completed his MSc in Applied Mathematics at the TU Eindhoven.

Menno Turksma is a Financial Systems Developer at DSW and completed his MSc in Biomedical Sciences at the Rijksuniversiteit Groningen.

Evert ter Haar is a Senior Database Developer for SQL Server at DSW and has 41 years of experience with developing applications.

DSW

What does DSW, a Dutch health insurance company, have to do with Computer Science or Mathematics? It is probably not the first company that pops up when EEMCS students think about a future employer. However, about 200 out of 650 DSW employees work in IT/Data Engineering. Why? Because we know that digitalization and AI are very effective in reducing costs in the health insurance sector, thereby ensuring that a higher ratio can be spent on actual health care; we believe we can offer better service to our customers through the use of IT.

We touch many topics in ML, like NLP, CV and Graph theory. Starting from a potential business case from which we formulate related research questions. A few examples of our previous projects:

- Bipartite graph modelling to detect networks of fraudulent healthcare providers or to optimize company processes.
- Automated invoice processing from digital image to payment

Now we will focus on one of our current projects: AI matching of payments.

Currently, some of the bank statements needed to be manually checked due to missing information fields. This manual work can cause mistakes. For example, reminders to customers which already have paid their contribution and declarations. These issues are bad for the customer's satisfaction.

This is a typical problem which can be solved by a mathematical model built in an operational environment. We do not want the model slowing down other systems. The hardest part of this problem is not in the mathematical model, but how to use the model in practice and to make it understandable for the users.

Problem description

We receive daily statement files from the bank with payment information from different groups, like insured parties, intermediaries, bailiffs and healthcare providers. In 99% of the cases, the information can be linked to the correct group; only a small proportion of payments have to be matched on secondary characteristics.

To this end, a pre-selection is made in our system that reads the bank statements; it is determined for which group type the statement is intended, and an attempt is made to derive useful information from these secondary fields (a customer number or payment reference from the description).

Bank account screen where payment reference can be filled in

Subsequently, payments from insured parties are usually forwarded to the Debtor Administration Module (DAM). In DAM, the "matching of payments" starts, in which we try to find the right target group (customer) for the payment; if there is a payment reference, this is very simple; it becomes more complex when the primary features are missing. We aim to extract customer number, payment reference or IBAN from the description field and then match it. If this does not work, there will be a failure and an employee of credit management will manually match the payment. This manual action takes place for an average of 4500 payments per month. In the extreme case, no suitable relationship can be found and the payment is refunded.

Trusto: DSW's mascot

This can be done smarter. If matching on primary or secondary characteristics is impossible, DAM could utilize AI tooling to match the payment to the right customer. This can be interpreted by manually looking at the payment description and bank account information.

If the AI solution shows great confidence in a matching, it can return these results automatically. If the AI solution returns multiple potential customers matching the payment with similar confidence, the correct customer is picked manually. A selected range of potential matches allows for faster manual matching.

Initial matching

Starting with the bank payments that could not be matched by DAM, we determine all the customers that can somehow be linked to one of the terms contained in the description of the bank payment. That is where a SQL Server Stored Procedure comes into play. All the words in the description of the bank payment plus the bank account information are collected, cleaned and prepared for passing as an array to the Stored Procedure.

Cleaning methods remove the most commonly used typing mistakes, like split words which have alphanumeric and numeric characters and combine numeric words. They tremendously impact finding the correct customer later in the process.

Piet;Janssen/Voorbeeld-laan/17/ nr1234 567 89: NL91ABNA0417164300
→
[Piet, Janssen, Voorbeeldlaan, 1234, 567, 123456789,NL91ABNA0417164300]

Example of translation from payment description to array of cleaned words

A search is performed for each cleaned word from the array with words in the customer database. A customer is selected as a possible match if a word matches at least 1 out of 17 possible properties of the customer, like surname, address, town, account number and/or relation number.

Not all possible matches are found through a straight equality search, rather by making use of Full-Text Search. This feature is language aware (Dutch in our case), case- and accent-insensitive.

Matching with machine learning

The next step is to determine which of the found customers is the correct match. We tackle this problem by calculating a matching score for each of the found customers. The higher the score, the higher the possibility of a correct match.

For each of the found customers, we can look at the 17 properties of the customer and check if there is a match for the specific property and the cleaned words.

To determine if this is the case, we will retrieve the following information of this property:

• Length of the word
• Occurrence in the Dutch language and healthcare jargon
• Number of spelling mistakes (levenshtein distance)

Next step is to combine all the information. To determine the best combination we consider weight and bias parameters. By combining all results of all properties that match with one of the bank payments words, you get the score of one match.

We determine optimized parameter settings by using SMAC (sequential model-based algorithm configuration), to get the best parameter settings. We use SMAC, because this model is

$$a = (Word\,length)^{weight_a} + Bias_a$$
$$b = (Word\,occurrence\,Dutch)^{weight_b} + Bias_b$$
$$c = (Word\,occurrence\,Care\,Jargon)^{weight_c} + Bias_c$$
$$d = (spelling\,mistakes)^{weight_d} + Bias_d$$

$$score\,(match) = \sum_{matched\,words} (a+b+c+d)/ (total\,possible\,score\,of\,customer^{weight_e})$$

Pseudo-code of the score of one match

specialized in finding the correct algorithm configuration and proven to give better results than other sequential model-based optimizations within a small time period. Furthermore, this model has a built-in function in Python.

Lots of data is needed to train this model. To train this model we used old payment information and the original manual matched customers. Plenty of data of this kind is available, but unfortunately not all manual matched information is usable and therefore requires a check.

Results

With a small training set, ~1000 bank payments, the results of the test sets are already good. More than 90% of the bank payments were correctly transferred to the right customer when minimizing the F1_score. However, we require a low false positive rate in order to reduce the number of wrong matches. As matching to the wrong person can cause reminders to the right customer, which is bad for the customer's satisfaction.

Therefore we have to be on the left side of the ROC curve, to be sure that the false positive rate is low. This also means that the percentage of automatic matched bank payments is lower.

The first results show that 50% of the manual matched bank payments can be directly matched to the right customers and less than 0.1% of the bank payments go to the wrong customer. Furthermore, for another 35% of the manual matched bank payments we can provide the top 5 customers that might match to the bank payments, which then can be easily and fast checked by an DSW employee.

This already means a big improvement, because before all these bank payments needed to be checked manually. Therefore more than 60% of the manual work is reduced with this solution and these bank payments are checked faster. This shows that applied mathematics, combined with computer science, can help DSW become faster and more accurate in matching payments.

Has this applied research sparked your interest, and would you like to work for an organization that keeps exploring new techniques, you can contact HR at ictwerving@dsw.nl or take a look at ictbijDSW.nl .

[1]   Hutter, Frank, Holger H. Hoos, and Kevin Leyton-Brown. "Sequential model-based optimization for general algorithm configuration." International conference on learning and intelligent optimization. Springer, Berlin, Heidelberg, 2011.

Epidemic Model for the Infectious Disease Cholera

Author: Eva van Tegelen, MSc Student Applied Mathematics

Cholera is a bacterial disease that still impacts more than a million people worldwide each year. To be able to control such an infectious disease, it is important to understand how the disease spreads. During my bachelor thesis I developed spatial compartmental epidemic models that can be used to study the spread of cholera.

Introduction

Cholera is an infectious disease caused by the bacterium *Vibrio cholerae*. Although there are more than two hundred different types of *V. cholerae*, there are two that can cause the disease in humans[1]. For most people a cholera infection is mild or without symptoms. However, approximately 10% of infected will suffer more severe symptoms such as watery diarrhea, vomiting and leg cramps. Humans can get infected by drinking infected water or eating food with the bacteria in it, but also by direct contact with infected feces. The source of infection of most epidemics is contamination of water or food by the feces of an infected individual.

In some regions cholera remains a serious threat to public health. An estimation of the number of cases in the world is roughly 1.3 to 4.0 million a year [2]. Of all reported cases of cholera 54% occurred in Africa. A supply of safe water and sanitation is important to control the further spread of the disease.

To be able to control infectious diseases, such as cholera, it is critical to understand the transmission patterns of these diseases. Mathematical epidemiology is an important tool to study the spread, but also to simulate the outcome of possible measures against an infectious disease. Compartmental models make the mathematical modelling simpler. The basic principle of compartmental modelling is the division of the population into multiple compartments, such as susceptibles and infected. The interaction between the different groups is then simulated using differential equations.

Since cholera is a disease where its primary source of infections is indirect contact, the disease is very interesting to study using mathematical compartmental models. As the interactions between the different compartments such as the infected and susceptibles do not happen directly, adjustments have to be made to the basic compartmental model. To consider different measures against the infectious disease cholera, it is very useful to know how the infections will spread spatially. The main objective of my research is therefore to find and study a spatial compartmental model specific for the infectious disease cholera.

The model

In my research I studied an epidemic compartmental cholera model, the SIRB model. The assumption made in the SIRB model is that a population can be divided into three groups: susceptibles, infectious and recovered. These groups are then influenced by an additional bacterial group. The susceptible part of the population consists of people that are still able to get the disease. When these people become infected they move to the infected group. From the infected it is possible to move to the recovered. It will be assumed that the recovered consist of people that have had the disease and that they are not able to get the disease again. As mentioned before, cholera is a bacterial disease that not only spreads from human to human, but can also spread via contact with infected water. This is simulated by the presence of the bacterial group. This group is not part of the population, but influences the dynamics between the other groups (indicated by the striped arrows in the figure). The interactions between the four groups can also be seen in Figure 1.
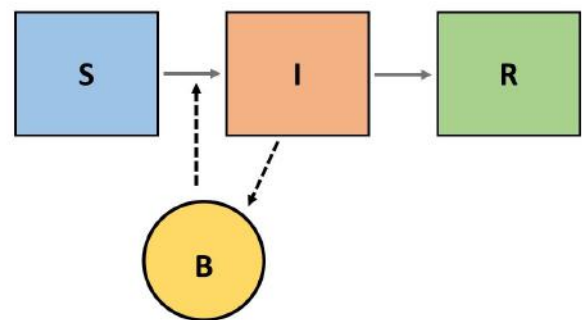

Figure 1: Visualisation of the SIRB model

These interactions can be translated into a system of four differential equations:

$$\frac{dS}{dt} = -\frac{\beta_h IS}{N} - \mu S + \Gamma N - \beta_e \lambda(B)S, \tag{1}$$

$$\frac{dI}{dt} = \frac{\beta_h IS}{N} - \gamma I - \mu I + \beta_e \lambda(B)S, \tag{2}$$

$$\frac{dR}{dt} = \gamma I - \mu R, \tag{3}$$

$$\frac{dB}{dt} = \epsilon I + (g_b - l_b)B. \tag{4}$$

Here S are the susceptibles, I the infected, R the recovered and B the bacterial group. The total population is indicated by $N = S + I + R$ and is in this case constant. Within each group we have mortality and birth. The parameter μ is the mortality rate and Γ is the birth rate within a population. We also have growth and death within the bacterial population. These rates are given by g_b and l_b respectively.

The parameter β_h is referred to as the transmission number. It de-

pends on the number of contacts per individual per time unit and the probability of disease transmission between an infected and a susceptible. The people that get the infection are added to the group of the infected and taken out of the susceptibles. The parameter β_e is the rate of exposure to the (contaminated) water. It shows how often susceptibles get in contact with the cholera infected water. The term $\lambda(B)$ is the probability of someone being infected by the water and logically depends on the bacteria concentration B in the water. From the infected compartment people that recover will cross to the recovered group R. The parameter γ is referred to as the recovery rate. The recovery rate indicates how fast people recover from the disease. This system of differential equations can be translated into different spatial models that illustrate how cholera spreads.

Spatial SIRB patches model

The first spatial extension of the model was created by considering different patches. For the patches model we assume that a population is divided over n patches. Furthermore, it is assumed that each patch has its own water reservoir where the bacterial concentration is denoted by B_p. The population size inside a patch can change due to mortality and birth, but also due to travel. The difference in population size inside a patch p due to travel to and from other patches denoted by N_p' is given by:

$$N_p' = \sum_{q=1}^{n} (m_{pq} N_q - m_{qp} N_p), \qquad (5)$$

where m_{pq} denotes the travel/migration rate from patch q to patch p. If we combine the migration term determined above with the single compartmental SIRB model the following system is obtained for each of the patches $p = 1, ..., n$:

$$\frac{dS_p}{dt} = -\frac{\beta_{hp} I_p S_p}{N_p} - \mu_p S_p + \Gamma_p N_p - \beta_{ep} \lambda(B_p) S_p$$
$$+ \sum_{q=1}^{n} (m_{pq} S_q - m_{qp} S_p),$$
$$\frac{dI_p}{dt} = \frac{\beta_{hp} I_p S_p}{N_p} - \gamma_p I_p - \mu_p I_p + \beta_{ep} \lambda(B_p) S_p$$
$$+ \sum_{q=1}^{n} (m_{pq} I_q - m_{qp} I_p),$$
$$\frac{dR_p}{dt} = \gamma_p I_p - \mu_p R_p + \sum_{q=1}^{n} (m_{pq} R_q - m_{qp} R_p),$$
$$\frac{dB_p}{dt} = \epsilon_p I_p + (g_{bp} - l_{bp}) B_p,$$

where the parameters β_{hp}, β_{ep}, μ_p, Γ_p, γ_p, ϵ_p, g_{bp} and l_{bp} are the same as described previously, but can now be patch dependent. By implementing these patches we can determine how cholera spreads between the patches and how this spread might be prevented. In Figure 2 the number of infected people is shown at the different patches. The darker the colour of the patch the more infected people that patch includes. The initial infection is in the middle patch and examining the figures it can be seen that the infections spread outwards due to migration.
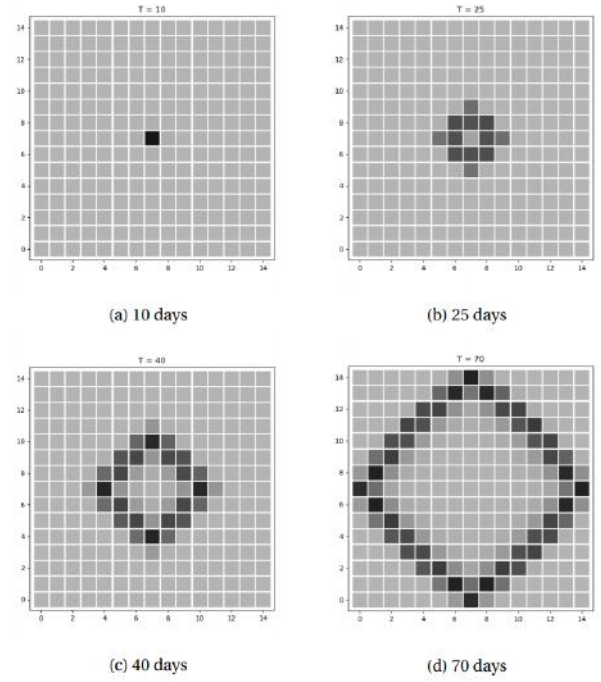

Figure 2: Number of infected people at multiple time instances for the SIRB patches model for $m_{pq} = 0.001$
.

Since the conditions can be chosen different at each of the patches, this spatial model is convenient when considering measures that might prevent the spread of the disease. Two possible measures have been considered: medicine and quarantine. By implementing a quarantine for patches when they reach a certain amount of infected, the outward spread of cholera is slowed down. The total number of infections in the population is not lower, but the total number of people that is sick at any given time is. Since creating a medicine takes time, it is not available immediately. When it does become available the number of infected people inside the population will decrease. The patches model showed that a combination of these two measures was most effective in keeping the total number of infections as low as possible. By slowing down further spread of the disease using quarantine, less patches have been infected by the time a medicine is developed.

Spatial SIRB diffusion model

The second spatial model for cholera that has been implemented, is based on diffusion of the population. When assuming that the population is constant, the spatial system for the diffusion model can be stated as:

$$\frac{dS}{dt} = -\frac{\beta_h I S}{N} - \mu S + \Gamma N - \beta_e \lambda(B) S + D_1 \nabla^2 S, \qquad (6)$$
$$\frac{dI}{dt} = \frac{\beta_h I S}{N} - \gamma I - \mu I + \beta_e \lambda(B) S + D_2 \nabla^2 I, \qquad (7)$$
$$\frac{dB}{dt} = \epsilon I + (g_b - l_b) B + D_3 \nabla^2 B, \qquad (8)$$

where ∇^2 is the two dimensional Laplacian operator and D_1, D_2 and D_3 are the diffusion coefficients. The model has been implemented

using a finite difference scheme, assuming Neumann boundary conditions. In Figure 3 the spread is presented for diffusion constants $D_1 = D_2 = D_3 = 0.01$. It can be seen that the outward spread of the disease is similar to that of the spatial patches model. However, the second model is less flexible when implementing different measures, because the conditions cannot be taken patch dependent.
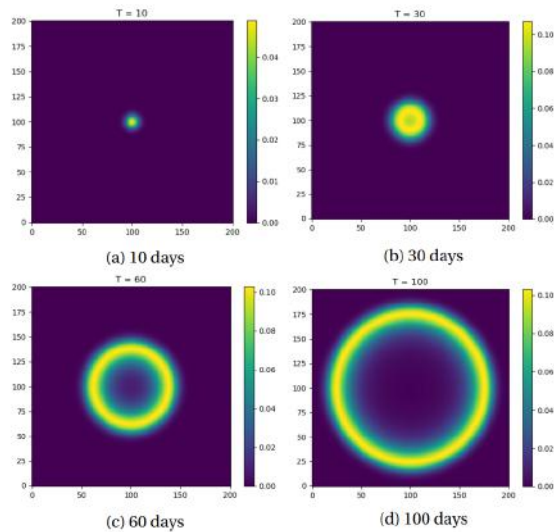

Figure 3: Portion of infected people at multiple time instances for the SIRB model using diffusion $D_1, D_2, D_3 = 0.01$

Conclusion

The spatial extensions of the SIRB model for cholera show similar spread of the disease. The patches model turned out to be very flexible and can be used to study different measures. The diffusion model is a little less flexible, but does give general information about pattern formation of the disease. The results from my bachelor thesis can be used as building blocks for further research into compartmental models that simulate the spatial dynamics of cholera. If you are interested in reading more, my thesis can be found in the TU Delft repository [3].

References

[1]   RIVM, *Cholera*, 2018. https://www.rivm.nl/cholera

[2]   WHO, *Cholera*, 2019. https://www.who.int/news-room/fact-sheets/detail/cholera

[3]   Eva van Tegelen, *Mathematical spatial compartmental epidemic models for the infectious disease cholera*, 2020.

Extracurricular

Solutions To Last Issue's Puzzles

Author: Annerieke Ohm, Editorial Staff MaCHazine

Computer Science puzzle

We can start by counting the number of ways to spell CAT I SAW. These will all start at the C at the center and be contained in one of the four triangles formed by the diamond's diagonals. The number of ways to spell CAT I SAW in the triangle can be found by the standard application of dynamic programming. These numbers can be computed by diagonals parallel to the triangle's hypotenuse by adding up the adjacent numbers to the left and below the letter in question. These numbers form Pascal's triangle. The sum of these numbers on the diamonds border is equal to 2^6.

Multiplying by 4 for all triangles and subtracting 4 to compensate for double counting gives that there are $4 \cdot 2^6 - 4$ ways to spell CAT I SAW in the diamond. So the number of ways to spell WAS IT A CAT I SAW is given by the formula $(4 \cdot 2^6 - 4)^2 = 63504$ [1].

$$
\begin{aligned}
&W_1 \\
&A_1 W_6 \\
&S_1 A_5 W_{15} \\
&I_1 S_4 A_{10} W_{20} \\
&T_1 I_3 S_6 A_{10} W_{15} \\
&A_1 T_2 I_3 S_4 A_5 W_6 \\
&C_1 A_1 T_1 I_1 S_1 A_1 W_1
\end{aligned}
$$

Mathematics puzzles
Problem 1

Suppose a company has n employees. For a day i each employee has a $\frac{1}{365}$ chance to be born that day, so there is a $\frac{364}{365}$ chance for each employee that he/she was not born on day i. Assuming that the birthdays of different employees are independent, we get

$$
P(\text{Day } i \text{ has no birthdays}) = \left(\frac{364}{365}\right)^n. \tag{1}
$$

We want to maximize the number of expected person workdays, which is

$$
E(\text{Person workdays}) = n \cdot \sum_{i=1}^{365} P(\text{Day } i \text{ has no birthdays}). \tag{2}
$$

Substituting Equation (1) in Equation (2) gives

$$
E(\text{Pers workdays}) = n \cdot \sum_{i=1}^{365} \left(\frac{364}{365}\right)^n \tag{3}
$$

$$
= n \cdot 365 \cdot \left(\frac{364}{365}\right)^n. \tag{4}
$$

To maximize this we will use that $\ln(x)$ is a monotonically increasing function, so we can equivalently maximize the natural logarithm of Equation (4). Using that the logarithm of a product is the same as the sum of the logarithms, we have

$$
\max(E(\text{Pers workdays})) = \max\left(\ln(n) + \ln(365) + \ln\left(\left(\frac{364}{365}\right)^n\right)\right)
$$
$$
= \max\left(\ln(n) + \ln(365) + n \cdot \ln\left(\frac{364}{365}\right)\right).
$$

Taking the first derivative with respect to n and setting it equal to 0 gives

$$
\frac{1}{n} + \ln\left(\frac{364}{365}\right) = 0, \tag{5}
$$

which gives

$$
n = \frac{-1}{\ln\left(\frac{364}{365}\right)} \approx 364.5. \tag{6}
$$

Checking with the second derivative, we see that this is indeed a maximum. Since we only consider a nonnegative integer amount of persons, we have to compare the values of the cases $n = 364$ and $n = 365$ in Equation (4). We will now show that these two values turn out to be equal.

$$
364 \cdot 365 \cdot \left(\frac{364}{365}\right)^{364} = 364 \cdot 365 \cdot \frac{365}{365} \cdot \left(\frac{364}{365}\right)^{364} \tag{7}
$$

$$
= 365 \cdot 365 \cdot \frac{364}{365} \cdot \left(\frac{364}{365}\right)^{364} \tag{8}
$$

$$
= 365 \cdot 365 \cdot \left(\frac{364}{365}\right)^{365} \tag{9}
$$

So the company should hire either 364 or 365 workers to maximize their expected person workdays [2].

Problem 2

This problem could be solved using algebra, but also using simple deduction. We know 1 chicken weighs the same as 1 cat and 1 owl and 2 chickens weigh the same as 3 turtles, so 3 turtles weigh the same as 2 cats and 2 owls. Adding 3 owls to both sides we get that 2 cats and 5 owls weigh the same as 3 turtles and 3 owls. Now using that we know that 1 owl and 1 turtle weigh the same as 1 cat, we get that 2 cats and 5 owls weigh the same as 3 cats. Now remove 2 cats from each side and we get that 1 cat weighs the same as 5 owls [3].

References

[1] Anany Levitin and Maria Levitin, *ALGORITHMIC PUZZLES*, p. 170-171, 2011

[2] https://www.youtube.com/watch?v=YhkvOwGmgg4

[3] https://www.youtube.com/watch?v=yiU4vUeWEYM

Puzzles

Author: Annerieke Ohm, Editorial Staff MaChazine

Every issue, the Machazine contains a Computer Science Puzzle and a Mathematics puzzle. The answers can be found on the next page.

Computer Science - Coins on a star

The goal of this puzzle is to place the largest possible number of coins at the points of the eight-pointed star depicted in Figure 1. The coins should be placed one after another, with the following two rules:

1. A coin needs to be placed first on an unoccupied point and then moved along a line to another unoccupied point.
2. Once a coin has been positioned in this manner, it cannot be moved again.

For example, we can start by placing the first coin on point 6 and then moving it along the line to point 1, we will denote this as $6 \rightarrow 1$. The coin will then have to remain at point 1. We could continue with the following sequence of moves: $7 \rightarrow 2$, $8 \rightarrow 3$, $7 \rightarrow 4$, $8 \rightarrow 5$. This places 5 coins. What is the maximum amount of coins we can place? And how can we place them [1]?
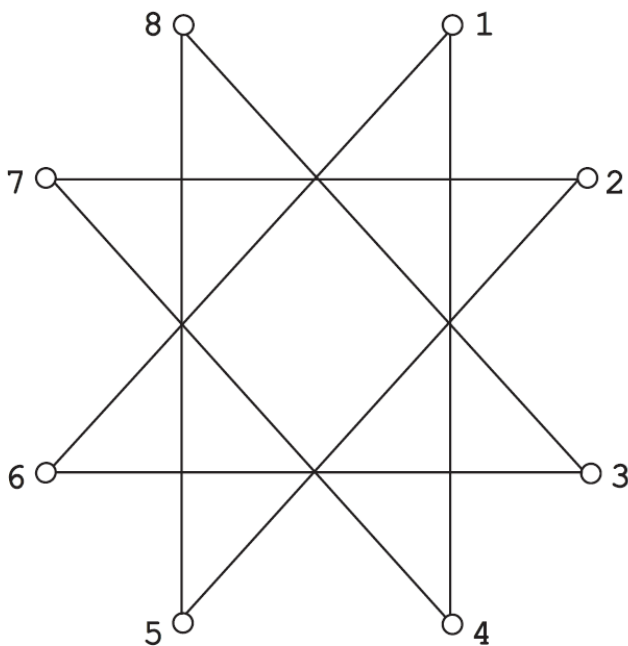
Figure 1

Mathematics - Three runners puzzle

Suppose three runners X, Y and Z run a 1000 meters race. They all run with a different uniform speed.

If X races Y, X gives Y a head-start of 50 meters, so they finish at the same time.
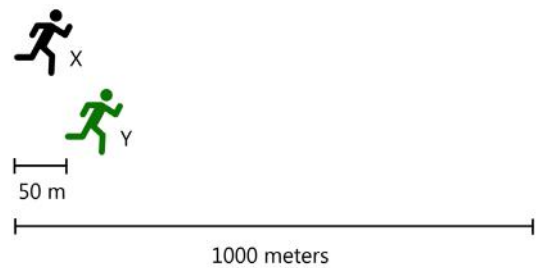
If X races Z, X gives Z a head-start of 69 meters, so they finish at the same time.
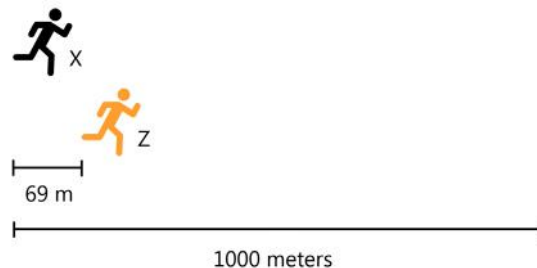
Suppose Y races Z. How much of a head-start should Y give to Z so they finish at the same time [2]?
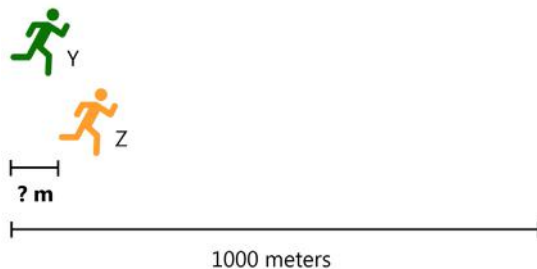
Solutions - Computer Science

The largest number of coins that can be placed is seven. Without loss of generality, we can start by placing the first coin on point 6 and then moving it to point 1 ($6 \rightarrow 1$). This will make the lines connecting point 1 with points 4 and 6 unusable for another coin placement. We should try placing each coin in a manner that minimizes the number of unusable lines and therefore maximizes the number of usable lines for the coins still to be placed. This implies that for each coin after the first one, we should try placing it on an unoccupied point of an unusable line by moving it there along a usable line. One way to do this is to always move the next coin so that it ends up at the point from which the previous coin has been placed. For example, seven coins can be placed by the following sequence of moves:

$$6 \rightarrow 1, \ 3 \rightarrow 6, \ 8 \rightarrow 3, \ 5 \rightarrow 8, \ 2 \rightarrow 5, \ 7 \rightarrow 2, \ 4 \rightarrow 7.$$

After placing seven coins there will be no unoccupied point from which an eighth coin could be moved, so placing eight coins is not possible. Therefore, the maximum number of coins that can be placed is seven [1].

Solutions - Mathematics

Many people might think the following: X gives Y a head-start of 50 meters and Z a head-start of 69 meters.
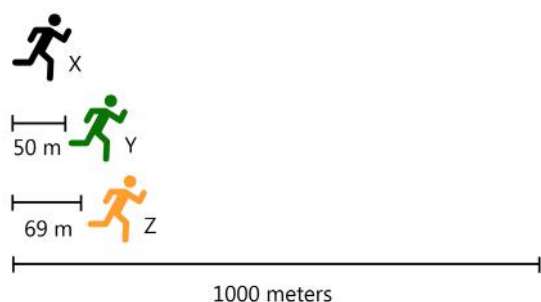
The difference is then 19 meters, so Y should give Z a head-start of 19 meters. Unfortunately, this is not correct. (Though it is close!).
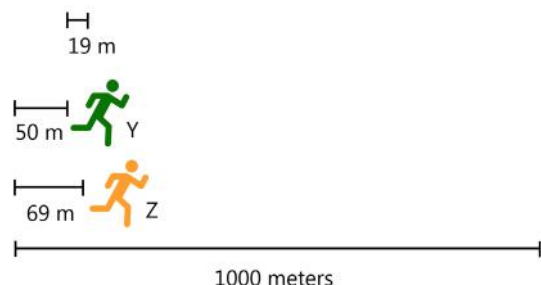
The problem is that in this situation Y is only running 950m and we need Y to run 1000 meters.

We will use the following formula:

$$distance = rate \cdot time \tag{1}$$

We know that X runs 1000 meters in the same time that Y runs 950 meters. If we denote time by t, the speed of X by x and the speed of Y by y, we get the following two equations:

$$1000 = xt \tag{2}$$
$$950 = yt. \tag{3}$$

Solving both equations for t gives:

$$\frac{1000}{x} = t = \frac{950}{y} \tag{4}$$

Solving this equation for y gives:

$$y = \frac{950}{1000}x \tag{5}$$
$$= 0.95x. \tag{6}$$

In the same way we get that

$$z = \frac{931}{1000}x \tag{7}$$
$$= 0.931x. \tag{8}$$

Where z denotes the speed of Z. We now have the following two equations to work with:

$$y = 0.95x \tag{9}$$
$$z = 0.931x. \tag{10}$$

We are interested in the ratio between z and y, so we will divide equation 10 by equation 9 to get:

$$\frac{z}{y} = \frac{0.931x}{0.95x}. \tag{11}$$

Canceling like terms gives:

$$\frac{z}{y} = \frac{0.931}{0.95} \tag{12}$$
$$= 0.98. \tag{13}$$

This can be written in the following way:

$$\frac{z}{y} = \frac{98}{100} \tag{14}$$
$$= \frac{980}{1000} \tag{15}$$

We can rewrite this to get the following:

$$\frac{y}{1000} = \frac{z}{980} \tag{16}$$

So Y runs 1000 meters in the same time Z runs 980 meters. Thus Y should give Z a head-start of 20 meters [2].

References

[1] Anany Levitin and Maria Levitin, *ALGORITHMIC PUZZLES,* p. 40, p. 107-108, 2011

[2] https://www.youtube.com/watch?v=C6emQS14Tbk

Who of the Board Do You Secretly Have a Crush On?

Enough talk about mathematics and computer science. We have to settle something serious. We all secretly admire them, but which member of the board do you have the biggest crush on? Using this highly advanced flow chart, you can finally get an answer!
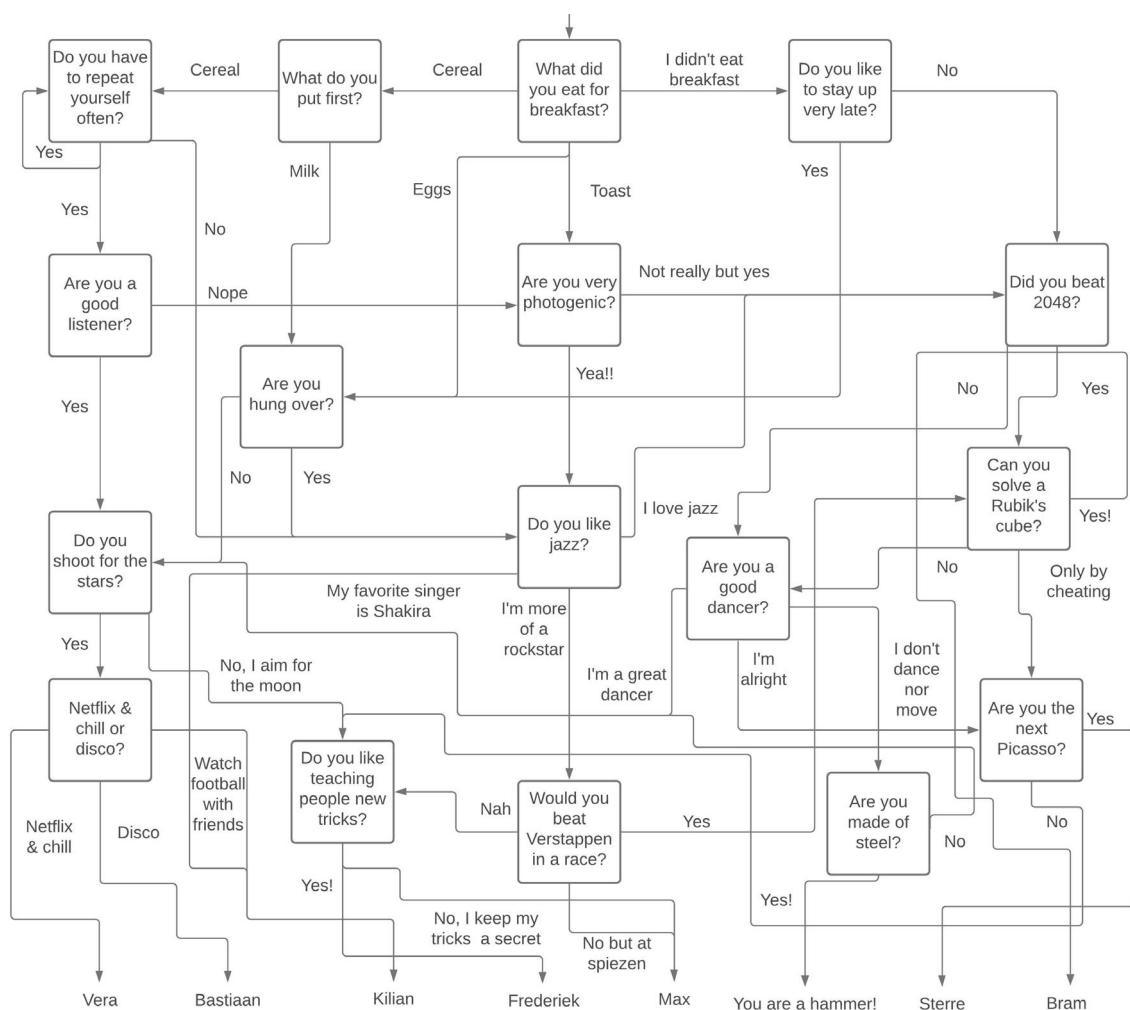
| Vera | Bastiaan | Kilian | Frederiek | Max | Hammer | Sterre | Bram |

Memes
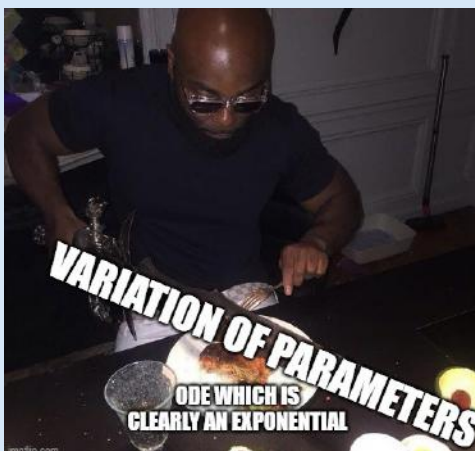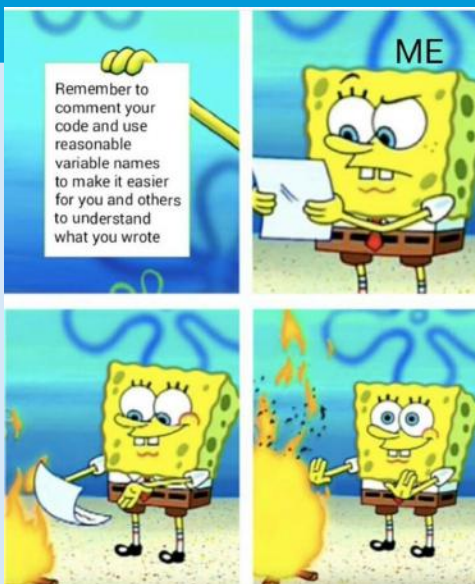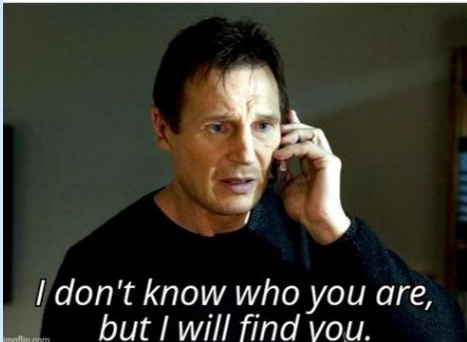
MARTINGALES BE LIKE:

$$E(corona\ measures_{January}|situation_{December}) = corona\ measures_{December}$$
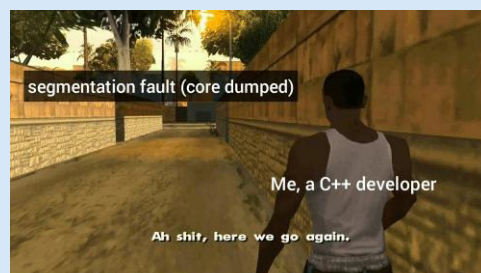
Too many times

Want a meme featured in an upcoming issue? Send it to machazine@ch.tudelft.nl!

AreaFiftyLAN
In February, more than 200 gamers will spend the weekend having a blast playing games together. All students will join from home to play their favourite games with their friends. There will be official tournaments where you can win amazing prizes. You can also team up and have fun with more casual games or organize your own tournament. Find out all about it on **wisv.ch/lan**!

DIES
Every year, W.I.S.V. 'Christiaan Huygens' celebrates its birthday with a week full of activities. This fun-filled week is organised by a second-year committee: the DIES. This week usually includes activities like lectures, dinners and parties, so this year, the committee will have to be creative. Keep an eye on the CH calendar to see what activities they have come up with!

Student Panels
In the student panels, we talk about each course in the bachelor as well as discuss the quarter as a whole. All the feedback we receive from these student panels will be communicated to the teaching staff and to the Director of Studies afterwards. The Student Panels will take place online via wisv.ch/crw (for Applied Mathematics) and wisv.ch/cri (for Computer Science).

February	
9	**Lunch Lecture: a.s.r.**
11	**ComMA (Master) Activity**
16	**Lunch Lecture: OGD**
17	**Online Algorhythm Party**
22	**Student Panel CSE: Year 2 Regular**
23	**Lunch Lecture: NetCompany /**
	MatCH Casino Night
24	**General Assembly 4 / Student Panel AM: Year 2**
25	**CHoCo Freshmen Dinner /**
	Student Panel CSE: Year 1
26-28	**AreaFiftyLAN**

March	
2	**Lunch Lecture: TBA Group**
4	**Student Panel AM: Year 1 / CSE: Year 3**
5	**Student Panel AM: Year 3 / CSE: Year 2 Variant**
6	Birthday W.I.S.V. 'Christiaan Huygens'
15	**Business Tour Week**
16	**Business Tour Week /**
	Lunch Lecture: Computer Science
17	**Business Tour Week /**
	AkCie Pubquiz: Team up with your teachers
18	**Business Tour Week**
22	**DIES Week**
23	**DIES Week**
24	**DIES Week**
25	**DIES Week**
30	**Lunch Lecture: Applied Mathematics**
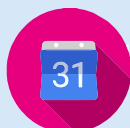
Want to stay updated on our events? Add the CH calendar to your own with our step-by-step guide on **wisv.ch/calendar.**
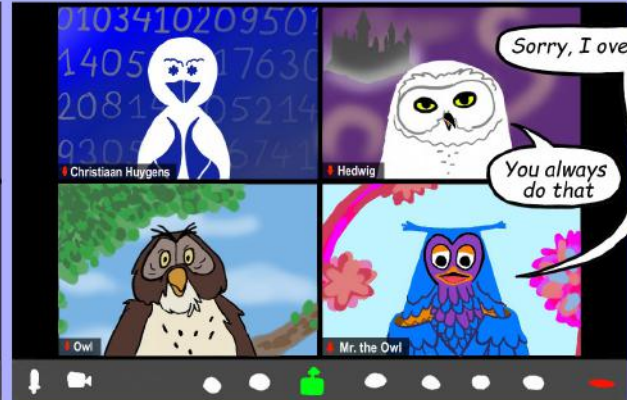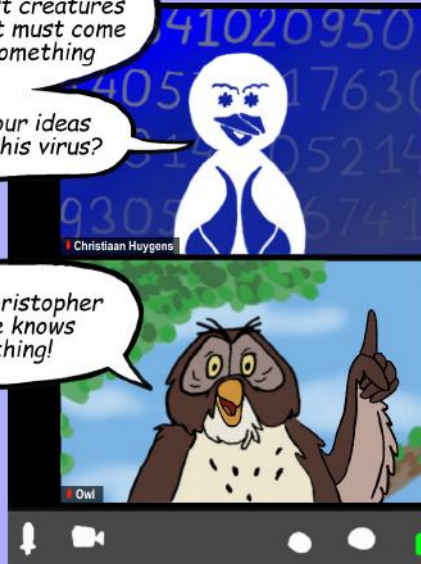
Made by: Maxime Hoekstra, Editorial Staff MaCHazine