NHL STENDEN
university of applied sciences

Big Image Data and Artificial Intelligence

Abridged version of inaugural speech delivered on 22 March 2018

Dr. Ioannis Katramados

"AI is one of the most important things that humanity is working on.

It's more profound than electricity or fire."

Sundar Pichai, Google CEO

Colophon

© Dr. Ioannis Katramados, Data Science.
NHL Stenden University of Applied Sciences, Leeuwarden 2018.
All rights reserved. Nothing from this publication may be duplicated or published by means of photocopy, microfilm, or by any other means, without written consent of NHL Stenden University of Applied Sciences.

Author: Dr. Ioannis Katramados
Print run: 250
Design: NHL Stenden University of Applied Sciences

© Photography: Henri Vos, iStock.

Disclaimer: The author has made every effort to track down and mention all sources and copyright owners.

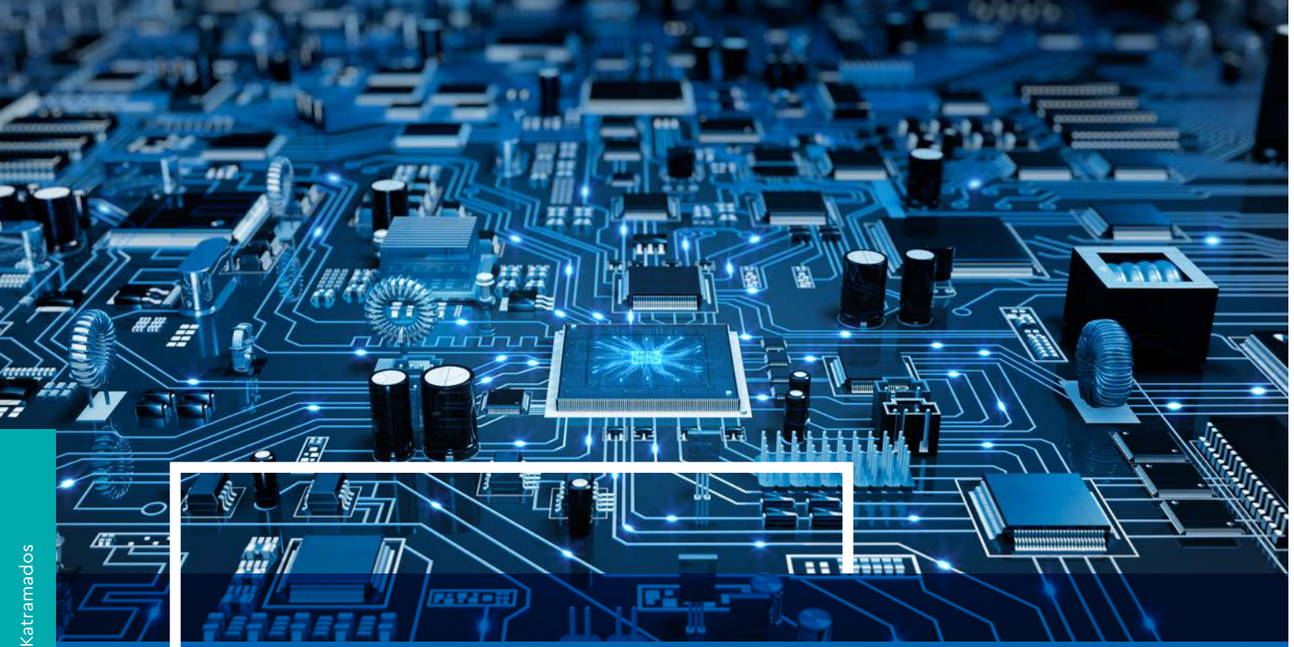
44 pages
ISBN/EAN: 978-94-91790-15-7

Professorship Data Science

Big Image Data and Artificial Intelligence

Dr. Ioannis Katramados

Abridged version of inaugural speech delivered on 22 March 2018



"Some people call this artificial intelligence, but the reality is this technology will enhance us. So instead of artificial intelligence, I think we'll augment our intelligence."

Ginni Rometty

Table of contents

"Learning from data is virtually universally useful. Master it and you'll be welcomed nearly everywhere!"

John Elder, Elder Research

1. Introduction

The field of data science and artificial intelligence (AI) is growing at an unprecedented rate. Manual tasks that for thousands of years could only be performed by humans are increasingly being taken over by intelligent machines. But, more importantly, tasks that could never be performed manually by humans, such as analysing big data, can now be automated while generating valuable knowledge for humankind.

The growth of data science and AI has not been accidental. This revolution has been fuelled by high-speed internet connections that link every corner of the world and make knowledge widely accessible. Researchers around the world can now collaborate with no physical limitations, and open-access publications are being produced more quickly than ever. Teraflops of computing power that used to only be available to a few giant corporations are now in the hands of everyone for an affordable price. What was science fiction a few years ago is now reality.

Education must adapt to this new reality. The current generation of students is expected to be competitive on a global scale. Preparing them for this task requires continuous learning and access to state-of-the-art course material and computing facilities. The new Professorship of Data Science – in collaboration with the Professorship of Computer Vision – aims to become a centre of expertise for data science and AI by connecting education to smart industries and start-ups.

One of the main challenges in creating an educational programme around data science and AI is choosing a focus area. The field is vast, so adopting an all-inclusive approach is not feasible. A breakdown of big data outlines some major research lines around fields like:

- image data (Lecun, Bengio, and Hinton 2015)
- text data (Ngiam et al. 2011)
- speech data (Deng et al. 2013)
- social data (Perozzi, Al-Rfou, and Skiena 2014)
- financial data (Ding et al. 2015)
- insurance data (Wang and Xu 2018)
- biological data (Alipanahi et al. 2015)
- medical data (Litjens et al. 2017)

Given NHL Stenden's history with computer vision, the new professorship aims to focus on analysing big image data. Other areas will not be excluded, since most applications require multiple sources of information to produce accurate results. However, big image data –including aerial image analysis, hyperspectral imaging and 3D imaging – will be the common factor.

"If the whole world wants to go left and you feel like going right, go right. You don't have to follow. You don't have to make a big deal about which way you're going. Just go."

Yanni (composer)

2. About the professor

Ioannis Katramados was born in Lesvos, Greece in 1981. A computer programmer since childhood, his dream was to work in the field of artificial intelligence. At the age of 18 he moved to the United Kingdom, where he earned a Bachelor's degree in Computer Systems Engineering (2003), followed by a Master's degree in Information Systems Engineering (2004).

During his studies, he was an intern at TRW Automotive, a company that designs active safety systems for cars. Many of these systems are built around cameras, which is how Ioannis got interested in computer vision and big image data. In 2004, Ioannis became a permanent employee of TRW Automotive, where he designed image analysis algorithms for camera-equipped vehicles and robots.

In 2008, a challenging defence project meant that he had to spend more time in academia, which led to his PhD degree in Real-Time Computer Vision (2013). Ioannis moved to the Netherlands in 2012, initially for one year.

While completing his PhD thesis, he started COSMONiO, a company that designs AI vision systems. The company quickly grew from a single-person company in Leeuwarden to an international R&D group of experts that were tackling some of the world's most challenging problems in radiology, biology, security and other sectors.

By 2016, the field of data science and AI was growing at an unprecedented rate, at which point it became clear that anything a company could achieve by itself would be a drop in the ocean. Any meaningful impact could only be achieved through broad collaborations of education and industry with the involvement of young engineers and entrepreneurs. This realisation made Ioannis turn towards education and mentorship of AI start-ups.

In December 2016, he joined NHL Stenden as a part-time Professor (lector) of Data Science. Applied education seemed more appropriate, since data science and AI is more about solving real-world problems than developing theoretical solutions. The foundations had already been laid at NHL Stenden by Jaap van de Loosdrecht, professor of Computer Vision, and Hans Drijfhout, then director of the Engineering Institute (Instituut Techniek). The Centre of Expertise in Computer Vision was already known throughout the Netherlands for its high-quality research but, as image data grew, data science was becoming an essential part of its activities. So, it made sense for Jaap and Ioannis to join forces in a new Centre of Expertise in Computer Vision and Data Science.

"The goal is to turn data into information, and information into insight."

Carly Fiorina, former CEO, Hewlett-Packard Co

3. Data science

Data science refers to the automated extraction of information from data and the conversion of this information into knowledge. It is revolutionary because it allows for the development of artificially intelligent machines that can learn to perform complex tasks that could previously only be performed by humans. Moreover, when data science methods are applied to big data, they allow experts to make sense of massive amounts of information and extract knowledge from it.

The potential use of data science methods has not gone unnoticed by industry, where there is an ongoing significant transformation from developing highly complex control software to utilising intelligent algorithms that learn from examples by using techniques such as deep learning. Early concepts demonstrate that such systems significantly outperform most existing solutions.

The DIKW pyramid: Data, Information, Knowledge, Wisdom. Data science mostly focuses on the first three. [Source: Cleveland, Harlan (December 1982). "Information as a Resource". The Futurist: 34–39; image from Wikipedia]

The impact of data science has exponentially increased the demand for more data scientists, leading to a significant shortage of experts in this field. Therefore, it is a logical next step for educational institutes to focus on training the next generation of data scientists and applying data science to a wide range of sectors, such as:

- Smart factories
- Robotics
- Water technology
- Agriculture
- Health
- Life sciences
- Security
- Defence
- Transport

Most of these sectors play a significant role in the economy of the northern Netherlands, so it is important for the Professor of Data Science to develop a curriculum and perform research that addresses industrial demands.

"Intelligence is the art of good guesswork."

H. B. Barlow, The Oxford Companion to the Mind

4. Mission, vision and objectives

4.1 Mission

The Professorship in Data Science has the following mission:

Educate the data scientists of the future in close collaboration with industry, while being a leader in applied research.

4.2 Vision

The vision for the Professorship in Data Science is to:

Perform cutting-edge research within the Centre of Expertise for Computer Vision and Data Science and provide up-to-date curriculum and commercial courses.

This vision is supported by the following principles:

- Data science is increasingly becoming one of the fastest growing areas in computing.
- Data science and big data are attracting a lot of attention worldwide, yet few universities of applied sciences are offering degrees to educate the image data scientists of the future.
- The academic level and skills of graduates from universities of applied sciences are expected to be sufficient for a large proportion of data science jobs that do not require specialist knowledge (PhD).
- Data science is expected to have a significant impact on certain sectors – such as Agriculture, Health, Life Sciences and Water Technology – that play a leading role in the economy of the northern Netherlands.
- The demand for data scientists is now greater than the supply. A new generation of data scientists is expected to be highly employable.
- There is an ongoing shift from traditional software to intelligent software based on data science techniques. As a result, the Professorship of Data Science is expected to attract a significant amount of industrial research projects in this direction.

4.3 Objectives

The mission and vision above are translated into the following objectives:

- Work with partners to initiate, support and implement applied research in the field of data science and support domains with a strong focus on innovation.
- Develop a Computer Vision & Data Science minor and continuously update the curriculum to meet the demands and expectations of the industry. It is also the joint ambition of the Professorships in Computer Vision and Data Science to develop a university of applied sciences Master's degree course in Computer Vision and Data Science.
- Collaborate with other departments at NHL Stenden to develop innovative cross-sector solutions.
- Engage with different colleges, universities, research institutes, government organisations and businesses.
- Play an active role in publicising NHL Stenden's research at both a national and international level through presentations, publications and consultancy.
- Establish a network of professionals with an active interest in data science, especially when this is also linked to computer vision.

"All data has its beauty, but not everyone sees it."

Damian Mingle

5. Identity, developments and trends

The identity of the Professorship in Data Science and the main developments and trends in this field are presented using a SWOT analysis.

SWOT analysis

SWOT	
Strengths	■ The professorship aims to become financially independent by seeking funding through industrial projects. ■ The curriculum will be designed to address industrial demands, so NHL Stenden students will be more likely to find employment. ■ The Professorship in Data Science will work closely with the Professorship in Computer Vision, so it will be built on strong foundations.
Weaknesses	■ Curriculum may be less generic since it is driven by market demand. ■ The focus will initially only be on imaging data.
Opportunities	■ NHL Stenden will get the opportunity to work on a wide range of data science projects with companies from the nine top sectors in the Netherlands.
Threats	■ The data science field is highly diverse and competitive at an international level, so strong focus is required to succeed.

5.1 Identity

The Professorship in Data Science aims to establish itself as a leading education and research centre that is specialised in the area of imaging data. Its finances will be based on industrial research projects that will be performed in close collaboration with the Professorship in Computer Vision. The advantage of this collaborative approach is that the data science group will be based on an already successful platform. In addition, the Professorship in Computer Vision will be able to maintain its strong position by using the latest advances in intelligent software and techniques, such as deep learning. The close relationship with industry will ensure that the curriculum is continuously updated to meet the highest standards and will ensure that our graduates are employable.

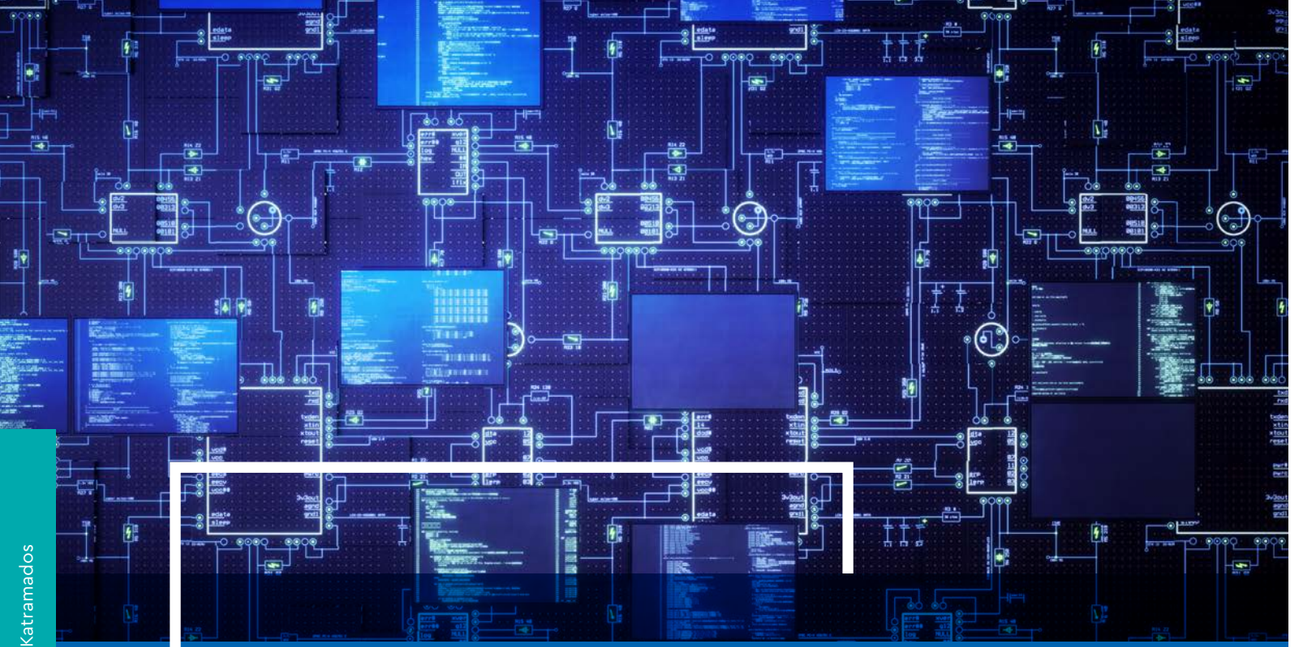
5.2 Developments and trends in data science

Here are some recent developments in the field of data science:

- Over the past few years, the performance of graphical processing units (GPUs) has increased exponentially while their cost has decreased significantly. Data science techniques that used to require very expensive supercomputers can now be implemented on embedded platforms. This is an important change that reshapes the field of computing.
- Advances in deep neural network techniques (also known as deep learning) have been able to solve many important big data problems.
- Traditional software algorithms are being replaced by intelligent algorithms that learn to perform pattern recognition from examples. Computer vision is one area where data science is having a considerable impact.
- More embedded platforms and mobile devices are now capable of running intelligent software, while hardware manufacturers are heavily investing in designing new types of computer processors.

Here are some recent trends in the field of data science:

- Self-learning systems are being taught to perform multiple tasks.
- Automatic analysis of big data is being performed with minimal human intervention.
- Intelligent algorithms are solving complex pattern recognition tasks that previously could only be performed by humans.
- Systems are being developed that learn from humans and improve their performance over their lifetimes.
- The cost of supercomputing hardware is decreasing dramatically.



"The best solutions to scientific problems are simple and elegant."

Jeff Hawkins, "On Intelligence"

6. Research

The Professorship in Data Science will focus on the following research topics:

1. Data science techniques for solving big data problems in the field of digital imaging (including 2D, 3D and hyperspectral).
2. Self-learning systems that require minimal human intervention.
3. Advanced visualisation methods for understanding the decision-making processes of intelligent systems. Collaboration with virtual & augmented reality experts.

6.1 Problem statement

Data scientists often develop complex systems which process information that only experts can understand. For example, only medical experts can accurately spot the difference between malign and benign tumours in certain types of cancer. As a result, the role of the data scientist should often be limited to developing the right tools that enable experts from each field to train intelligent systems by themselves. Currently available data science tools do not allow this.

Moreover, experts should be able to visualise the decision-making process of an intelligent system to gain confidence that it has learnt the correct concepts. At the moment, most intelligent systems operate as black boxes, so they are excluded from some important industrial sectors where transparency is essential.

6.2 Proposed research

A research group will be built to develop a data science platform that enables experts from different industries to train intelligent systems. For example, medical experts could train an intelligent platform to perform lung cancer detection on medical images, while water-quality experts could train the same platform to perform bacteria detection on petri dishes. If successful, this generic approach could revolutionise the field of data science by allowing different industries to deploy high-end intelligent technologies into their factories and products.

Research will also be performed in collaboration with virtual & augmented reality experts to develop tools that allow visualisation of the decision-making process of each intelligent system. Finally, the proposed research is expected to create new opportunities for collaboration with professorships such as Serious Gaming and Water Technology, since all these sectors face big data challenges that cannot be solved using traditional methodologies.

This research plan will be implemented through a number of industrial feasibility studies where the Professor in Data Science will help industrial experts solve specific data science problems. Subsequently, the research team will identify the similarities between different projects and evolve its generic platform to enable wider use across different industrial sectors.

"A teacher should learn all the time; a teacher should share all the time. Education is a big challenge now – if we do not change the way we teach, 30 years later we will be in trouble."

Jack Ma, founder of Alibaba

7. Teaching

For many years, generating educational material for a new subject has been based around textbooks that the teaching staff turns into a set of course notes and assignments. Although this approach has worked well for a long time, it is becoming less relevant in an accelerating world where technological advancements and fast internet access have introduced novel ways of learning. The impact of this revolution is especially felt in the field of data science and AI.

So where does someone start when he or she is asked to teach data science? Creating high-quality educational material for such a modern and continuously-evolving subject is challenging. New approaches and methodologies are emerging on a weekly basis, meaning that each semester a significant part of the course material is already outdated. For this reason, international corporations and large universities have invested in developing massive open online courses (MOOCs) that are dynamically adjusted over time (Santur, Karakose, and Akin 2016). This guarantees that students around the world will receive peer-reviewed course material and assignments that meet a minimum global standard. This is a ground-breaking approach that will increasingly have an impact on universities of applied sciences.

In teaching data science and AI, NHL Stenden was the first university of applied sciences in the Netherlands to join the educational programmes of Google, NVIDIA and Amazon. In September 2017, students were taught subjects such as deep learning using course notes from leading institutes such as New York University. Google engineers shared their knowledge through MOOCs and asked students around the world to solve real-world problems as assignments.

But there was a problem: each assignment required at least 2-3 weeks of computational time, even on our most powerful computer. Initially, we solved this problem by purchasing Deep Frisian, a supercomputer by NVIDIA that could solve the same problems within 1-2 hours using the latest

GPU technology. However, an oversubscribed course in September 2017 led us to realise that even Deep Frisian was not powerful enough to run the assignments of 24 students.

So how do you solve big data problems without cutting-edge computing facilities? Fortunately, Google, NVIDIA and Amazon addressed this issue by making their supercomputing facilities available to students for free via remote access. NVIDIA provided interactive notebooks that students could use to read theory and run experiments on state-of-the-art servers. Google Cloud provided virtual machines with four GPUs per student, meaning that each machine had power comparable to Deep Frisian. The estimated investment that NHL Stenden would have needed to purchase similar equipment was more than €1 million. As a result, there is no doubt that the future of education is tightly linked to international collaborations of this type.

But why are large corporations willing to invest in free student training? What is their motivation? The answer can be found by looking at the worldwide demand for data scientists (Davenport and Patil 2012). Despite the increase in data science and AI degree programmes, there is a significant shortage of data scientists. Furthermore, the salaries of PhD graduates in the United States have skyrocketed to a level similar to that of professional athletes. Large corporations such as Google, Microsoft, Facebook, Baidu and IBM are absorbing a significant portion of the available talent, leaving other companies to compete for the rest. The only way forward seems to be having each company contribute to increasing the talent pool, which is indirectly achieved through these "free" educational programmes. At the same time, software companies aim to increase the user base of their data science and AI tools, so an educational programme also acts as an effective marketing tool.

If a PhD is required to get a high-paying job in the field of data science and AI, is there a future for students of applied sciences? During the 2018 World Economic Forum, Sundar Pichai, CEO of Google, stated that: 'AI is probably the most important thing humanity has ever worked on. I think of it as something more profound than electricity or fire' (Petroff 2018). But, like electricity, AI took several years to evolve from an advanced research topic to a daily commodity. If Pichai is right, we are educating some of the most valuable assets of our future society.

"By far, the greatest danger of Artificial Intelligence is that people conclude too early that they understand it."

Eliezer Yudkowsky

8. Ethics

Data science and artificial intelligence are arguably the most powerful tools humanity has ever created. Intelligent machines promise to revolutionise every industry. From medical image analysis to space exploration, this technology will redefine what human kind is capable of. However, as with every great tool, its ethical use is essential.

What if data science and AI are used against humanity? This is one of the biggest concerns of our era. The same systems that demonstrate superhuman performance in detecting cancer and discovering new medicines can also be used to cause harm. In 2017, several leading figures wrote an open letter to the United Nations:

Open letter to the United Nations:

As companies building the technologies in Artificial Intelligence and Robotics that may be repurposed to develop autonomous weapons, we feel especially responsible in raising this alarm. We warmly welcome the decision of the UN's Conference of the Convention on Certain Conventional Weapons (CCW) to establish a Group of Governmental Experts (GGE) on Lethal Autonomous Weapon Systems. Many of our researchers and engineers are eager to offer technical advice to your deliberations.

We commend the appointment of Ambassador Amandeep Singh Gill of India as chair of the GGE. We entreat the High Contracting Parties participating in the GGE to work hard at finding means to prevent an arms race in these weapons, to

protect civilians from their misuse, and to avoid the destabilizing effects of these technologies.
We regret that the GGE's first meeting, which was due to start today (August 21, 2017), has been cancelled due to a small number of states failing to pay their financial contributions to the UN. We urge the High Contracting Parties therefore to double their efforts at the first meeting of the GGE now planned for November.

Lethal autonomous weapons threaten to become the third revolution in warfare. Once developed, they will permit armed conflict to be fought at a scale greater than ever, and at timescales faster than humans can comprehend. These can be weapons of terror, weapons that despots and terrorists use against innocent populations, and weapons hacked to behave in undesirable ways. We do not have long to act. Once this Pandora's box is opened, it will be hard to close. We therefore implore the High Contracting Parties to find a way to protect us all from these dangers. (Gibbs 2017; Musk 2017).

Although, this letter does not express my own opinion on this matter, it raises concerns about the ethical use of cutting-edge technologies.
Do we need to define a code of conduct for data science and AI engineers? Do we need new laws to regulate this fast-evolving technology? Will strict regulation have a negative effect on academic research? All these questions will become the centre of numerous debates in the coming years. However, from an educational perspective, we have a responsibility to make students aware of both the strengths and dangers of data science and AI.

"You don't need to know a lot of things, but you need to find the people who are smarter than you are. My job is to make sure smart people are working together."

Jack Ma, founder of Alibaba

9. Centre of Expertise for Computer Vision and Data Science

The new professorship is part of the Centre of Expertise for Computer Vision and Data Science. Initially founded in 1996, it has a state-of-the-art lab with one of the widest collections of visible-light and hyperspectral cameras in the Netherlands.

As a certified drone operator, the centre performs applied research in aerial imaging techniques, while addressing challenges such as plant disease detection and windmill blade inspection. Solving complex image analysis problems often requires immense computing power; thus, the addition of the Deep Frisian supercomputer has paved the way for answering an even wider range of questions for smart industries in the northern Netherlands.

The Centre of Expertise, originally started by Professor Jaap van de Loosdrecht, owes its existence to market demand for feasibility studies around applying computer vision, data science and AI in different industrial sectors. With two professors, two researchers and four project engineers, its team combines a broad set of skills in designing, implementing and deploying intelligent software for a wide range of hardware platforms.

Each semester, students get an opportunity to work on real customer projects, while gaining valuable experience for their future as employees. More than 500 students have completed their internship or graduation project within our lab, including students from France, Spain, Mexico, Belgium, Finland and China.

The ambition of the centre of expertise is to become a leader in applied data science and AI research in the north of the Netherlands. Combining groundbreaking hyperspectral imaging hardware with intelligent software has the potential to solve a huge array of problems in smart industry and agriculture amongst other sectors. By enabling wide collaborations between academic and industrial partners the centre of expertise in computer vision and data science aims to play a decisive role in developing the technologies of the future.

"Entrepreurship is all about getting knocked down and getting back up over and over again, healing your wounds until you win. Can you take the punches and keep going with determination and passion until you get it right? Or will you let them get to you and kill your dream? It's not easy and definitely not for the faint-hearted... Especially at times when nobody believes in your dream but you."

Pavlina Papalouka

10. IncubAI: Incubator for Artificial Intelligence

In educating students, a university is preparing the employees of the future, as well as new entrepreneurs. Like many subjects, entrepreneurship is better learnt through practice and hands-on experience. Business incubators are an essential part of this process. Anyone with a bright idea can join a business incubator to grow within a more supportive environment. However, in reality, the number of start-ups that survive for more than three years is low (Bandera and Thomas 2017). Although numerous factors contribute to failure, there are some clear obstacles that must be removed.

First, the majority of incubators and accelerators are hosting a very diverse set of companies that often have little in common. Low-tech and high-tech start-ups are asked to co-exist and evolve together. Although there are no hard rules about the best approach, it is fair to assume that a cluster of high-tech start-ups is more likely to succeed than a cluster of unrelated companies. Of course, a collaborative spirit is necessary so that individual entrepreneurs can openly share their successes and failures while helping each other.

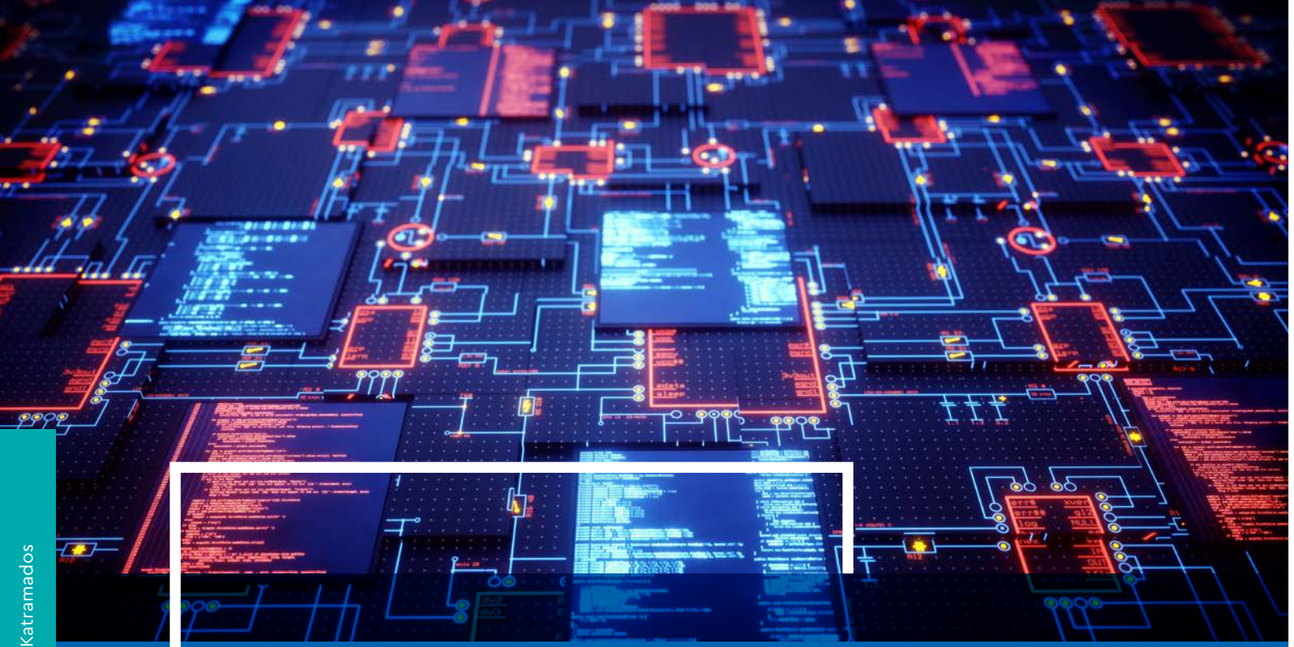
High-tech start-ups thrive on innovation, which is the heart of their existence. Being innovative requires focus and dedication. However, this "romantic" view is often spoiled by endless bureaucratic and administrative burdens that are imposed on business starters. From dealing with tax authorities to signing off on timesheets and other paperwork, a starter has to spend a significant amount of time on non-productive work. Even receiving a small subsidy from the government can often be a painstaking process that increases the administrative requirements of a small company.

What if start-ups could focus more on true innovation with minimal distractions? An incubator can help by introducing a "bureaucracy layer". The idea is that any non-innovative activity can be taken over by the central incubator administration that serves all its start-ups.

Another problem is that many entrepreneurs lack essential skills in non-technical areas such as marketing. Again, the incubator can assist its members by providing training and support where needed. Likewise, it is expected that certain non-technical start-ups will need access to data science and AI know-how. In this case, the incubator can turn into a networking facility, where technical start-ups and educational institutes can collaborate to develop a new product or service. In doing so, they can also jointly apply for investment or subsidies using the in-house advisors.

Ioannis Katramados and Lennard Drogendijk founded IncubAI in late 2017.

Stichting Incubator Artificial Intelligence (or IncubAI) is an initiative led by Dr Ioannis Katramados and Lennard Drogendijk. Positioned at the heart of the NHL Stenden campus, it aims to become the link between start-ups and education by supporting high-pace innovation. The ambition is that prototypes of new systems can be developed within a few weeks or months, depending on their complexity. This is an important consideration, since being first to market is of the utmost importance in the fast-moving world of AI.



"Thankfulness is the beginning of gratitude. Gratitude is the completion of thankfulness. Thankfulness may consist merely of words. Gratitude is shown in acts."

Henri Frederic Amiel

Acknowledgements

During my lifelong trip from Greece to the UK and Netherlands, there have been many people who supported, advised, encouraged and corrected me along the route. I would not be writing this book without their help.

Firstly, I would like to thank my parents and grandparents for being there for me along the way. My uncle Michalis for helping me make my first steps in the world of computers. My wife Varvara, who encouraged and supported my dreams over the past 10 years. My beautiful daughters Elli & Tina for making me smile when things were not turning out as I expected. My colleague Jaap van de Loosdrecht for trusting me to lead the data science research at NHL Stenden. By sharing his experience and wisdom he helped me avoid many pitfalls. Hans Drijfhout and Jan van Iersel for supporting my vision for the professorship of data science. Djoke Bijlsma and Meintsje de Vries for helping me through my first steps at NHL Stenden. Lennard Drogendijk for being a great business mentor. Without his help COSMONiO would not be in existence today and I would not be in Leeuwarden. Alastair Buchanan who has been instrumental in making COSMONiO grow. Peter van Ooijen and Anniek Visser for helping COSMONiO grow in the medical sector. Klaas Zijlstra and Corinne Capelle for turning my ideas into projects. Steve Crumpler, Rob Miller and everyone at TRW Automotive for teaching me everything I know about engineering. My PhD supervisor, Toby Breckon, for helping me complete my degree when I was about to drop out. Last but not least, I would like to thank Oliver Hamilton, Laurens Hogeweg and the entire COSMONiO team for believing in my dreams and making them come true.

Margaret Hamilton was the lead software engineer for Project Apollo (1961–1972).

In this photo, she is standing in front of the printouts of the programming code for the Apollo guidance system, a lot of which she wrote and oversaw.

She was 31 when the Apollo 11 lunar module landed on the moon, running her code.

Literature

Alipanahi, Babak, Andrew Delong, Matthew T. Weirauch, and Brendan J. Frey. 2015. "Predicting the Sequence Specificities of DNA- and RNA-Binding Proteins by Deep Learning." Nature Biotechnology 33(8):831–38.

Bandera, Cesar and Ellen Thomas. 2017. "Startup Incubators and the Role of Social Capital." Pp. 142–47 in 2017 IEEE Technology and Engineering Management Society Conference, TEMSCON 2017. IEEE.

Davenport, Thomas H. and D. J. Patil. 2012. "Data Scientist: The Sexiest Job of the 21st Century: Meet the People Who Can Coax Treasure out of Messy, Unstructured Data." Harvard Business Review 90(October):70–77.

Deng, Li et al. 2013. "Recent Advances in Deep Learning for Speech Research at Microsoft." Pp. 8604–8 in ICASSP, IEEE International Conference on Acoustics, Speech and Signal Processing - Proceedings. IEEE.

Ding, Xiao, Yue Zhang, Ting Liu, and Junwen Duan. 2015. "Deep Learning for Event-Driven Stock Prediction." (Ijcai):2327–33.

Gibbs, Samuel. 2017. "Elon Musk Leads 116 Experts Calling for Outright Ban of Killer Robots | Technology | The Guardian." The Guardian. Retrieved January 28, 2018 (https://www.theguardian.com/technology/2017/aug/20/elon-musk-killer-robots-experts-outright-ban-lethal-autonomous-weapons-war).

Lecun, Yann, Yoshua Bengio, and Geoffrey Hinton. 2015. "Deep Learning." Nature 521(7553):436–44.

Litjens, Geert et al. 2017. "A Survey on Deep Learning in Medical Image Analysis." Medical Image Analysis 42:60–88.

Musk, Elon et al. 2017. "An Open Letter to the United Nations Convention on Certain Conventional Weapons."

Ngiam, Jiquan et al. 2011. "Multimodal Deep Learning." Proceedings of the 28th International Conference on Machine Learning (ICML) 689–96.

Perozzi, Bryan, Rami Al-Rfou, and Steven Skiena. 2014. "DeepWalk: Online Learning of Social Representations." Proceedings of the 20th ACM SIGKDD International Conference on Knowledge Discovery and Data Mining - KDD '14 701–10.

Petroff, Alanna. 2018. "Google CEO Sundar Pichai: Artificial Intelligence More 'Profound than Electricity or Fire' - Jan. 24, 2018." CNN. Retrieved January 28, 2018 (http://money.cnn.com/2018/01/24/technology/sundar-pichai-google-ai-artificial-intelligence/index.html).

Santur, Yunus, Mehmet Karakose, and Erhan Akin. 2016. "Improving of Personal Educational Content Using Big Data Approach for Mooc in Higher Education." Pp. 1–4 in 2016 15th International Conference on Information Technology Based Higher Education and Training (ITHET). IEEE.

Wang, Yibo and Wei Xu. 2018. "Leveraging Deep Learning with LDA-Based Text Analytics to Detect Automobile Insurance Fraud." Decision Support Systems 105:87–95.

NHL STENDEN
university of
applied sciences

nhlstenden.com

The field of Data Science and Artificial Intelligence is expanding at an unprecedented rate, with Big Image Data being one of the driving forces. Extracting information from images and converting this information to knowledge has the potential to solve a huge array of problems in science and engineering. From diagnosing medical conditions to driving vehicles autonomously, approaches such as Deep Learning are redefining what technology is capable of. Experts are talking about a new industrial revolution where self-learning systems often exceed human performance, but also raise questions about the implications of such a disruptive technology to society. The new professorship focuses on the challenges and opportunities that Data Science presents to business, research and education.