vsnu
vereniging van universiteiten
association of universities
THE NETHERLANDS

Digital Society Research Agenda

Leading the way through cooperation
in a Digital Society

Foreword

Leadership through cooperation
A research agenda for the Digital Society, formulated by the joint Dutch universities in accordance with the Dutch National Research Agenda.

This presentation of our new ambition marks an opportunity to briefly reflect on the past. In the case of the digital society, this past is quite recent. Just think back: new buildings didn't simply appear on a computer screen: they had to be painstakingly drawn by architects on huge sheets of paper. And while the Netherlands led the world in developing an impressive new navigation system, the self-driving car was still a distant notion.

So just how much have things changed? If we extrapolate the speed of these developments into the future, it becomes clear that digital technology is set to continue its rapid rise. The world is now digitally intertwined, and the Netherlands is proud to call itself home to the world's largest internet exchange (AMS IX). An example closer to home: just think of cars that won't require a driving licence. These cars, much like the latest buildings, will be designed in an entirely digital environment and sustainably manufactured using 3D printers. In future, all visits to our General Practitioner may even be digital as a chip remotely transmits our physical condition.

I can personally envisage a future in which all students have access to tailored education from global top researchers and even Nobel laureates. The transformation towards a digital world is in full swing, and continues to pick up pace. Naturally, this development is also having a major impact on science, the economy and broader society. Digitalisation is everywhere, and the Dutch scientific community aims to solidify its leading role in this area moving forward.

The document in front of you is the Digital Society Research Agenda. This elaboration of the VSNU proposition from 2016 represents a unique collaboration between the Dutch universities. Some 100 scientists of across all universities have contributed to shaping the programme lines described in the agenda here presented. The 'Digitalisation in academic education' agenda was presented during the opening of the academic year last September in conjunction with this research agenda.

The Digital Society Research Agenda aims to secure the Netherlands a leading international position in the field of human-centred information technology. In our view, the seven research programme lines incorporated in this agenda offer enormous opportunities with the potential for global impact. These themes range from democratic decision-making and eHealth to cyber security and responsible algorithm design. The Digital Society is a cross-cutting programme through nearly all of the routes of the Dutch National Research Agenda (NWA). In this effort, the fourteen collaborating Dutch universities are actively taking the lead on this subject.

In order to secure a leading global position, the Netherlands will have to develop new insights and solutions to digital issues through pioneering research and experimentation. This will attract national and international talent, investment, technology development, enterprise and collaboration. Research will thus contribute to broader society at a social, technological, and economic level.

I believe we can only lead by bundling our strengths in the area of digital technology development and reflection on those developments. This applies to the various disciplines, to the collaborating universities and to the cooperation with other knowledge institutions, societal partners including the technology community and the business community, and government parties. As we take this first step, the Dutch universities will actively invest in collaborations with each other, our partners and broader society as we move to further this research agenda. We call on our partners to join us in this important and exciting development.

Finally, let me take this opportunity to thank all researchers of the fourteen universities involved for their efforts in preparing this agenda, in particular the seven coordinating authors of the programme lines. I wish them every success in further developing the programme lines and look forward to the first results of this cooperation. These results can contribute to a digital future that improves on our current world.

Pieter Duisenberg,
President of the VSNU

On behalf of the Digital Society task force (Emile Aarts, Karen Maex, Jan Mengelers and Karel Luyben) and the Executive Boards of the Dutch universities

Introduction

Ambition & programme lines

'In ten years' time, the Netherlands will have become a leader in the field of digitisation in society.' This ambition was voiced by the fourteen Dutch research universities during the opening of the academic year in September 2016. Ambitions are obviously well and good, but the question remains: what now? How do we work towards achieving this goal?

The Netherlands is well advanced with pioneering digital innovations and has built up strong expertise on information technology and on creativity. That affords a breeding ground for new solutions and for the exploration of societal implications. Moreover, the Netherlands is often an innovator and pioneer in social policy and regulation. Attention for societal challenges, agile regulation and policy making as well as courage to policy innovation make the Netherlands an ideal breeding ground for pioneering solutions.

In September 2017, the universities published their elaborated plans for future-proofing education in a digital society. This accompanying research agenda elaborates the seven programme lines underlying universities' joint efforts towards their common goal in the years to come. The programme themes serve to bundle research activities and ensure a clearly-defined joint profile.

The seven programme lines in brief:

1. Citizenship & Democracy: how to reinvent trust, dialogue and decision-making
2. Responsible Data Science: how to enable full and responsible use of big data
3. Health & Well-Being: how to let technology generate longer, healthier lives
4. Learning & Education: how to enable people to participate meaningfully in all stages of life
5. Work & Organisations: how to prepare companies and workers for a new economy
6. Digital Cities & Communities: how to build smart, enjoyable cities and hinterlands
7. Safety & Security: how to protect data, people and freedoms

We set out how each programme line aligns with the Dutch National Research Agenda, Top Sectors and European and other international research programmes. We also set out long-term goals and short-term milestones, and discuss the relevant resources and methods for each programme.

Through these programmes, the universities are actively investing in and supporting innovative research, as part of a collaboration with other knowledge organisations and various technology, business and government parties. In ten years' time, this will enable the Netherlands as a global pioneer in human-centred information technology.

Taking on the digital challenge & key concepts

Digitalisation is without a doubt one of the biggest challenges of our time. The examples of technological innovations mentioned in the Foreword emphasise how wide-ranging and profound their impact on society is. This process is propelled by

digitisation, and related rapid technological disruptions, and affects all aspects of society. In our shared response to the challenges and opportunities of digitalisation we therefore firmly place the human centre stage.

Human-centred information technologies have vast implications on how we structure our society and our democratic values and systems. Moreover, these need to be regulated through democratic decision□making. Vital research on how digitalisation relates to citizenship and democracy constitutes the opening programme line.

Instrumental in shaping a better digital society for all involves a deep understanding of the technological drivers of digitalisation. Essential research on this is captured in the second programme line, designed to further frameworks and approaches for responsible data science.

Furthermore, digitalisation affects the key pillars of our societies: notably health, learning, work and cities. Crucial research into how new technologies can enhance these essential societal sectors is reflected in programme lines three to six. Finally, a digital society requires robust protection of data, people and human values. This domain is reflected in the closing programme line.

What connects these programme lines is the development of knowledge and understanding of the issues and technologies, in which interdisciplinary perceptions and methods become the norm instead of the exception. A convergence of the social and technological worlds needs to be matched by a similar convergence in academic disciplines.

As such, we have to create conditions, principles and technology to take on this digital challenge and ensure it will be beneficial for society. The collaborative advancement of responsible and secure science technology is pivotal to ensure that the human remains centre stage in a digital society. These conditions, principles and technological developments are essential for the Digital Society Research Agenda and apply to all seven programme lines. All programme lines are interconnected.

The following concepts are vital to understand the societal challenges and opportunities of digitalisation. Moreover, they provide building blocks for academics, government, private sector and other partners to move towards a better future. Digitalisation is not an autonomous process, and these key concepts help us shape and navigate these rapid developments.

SHARED society

For a digital society to remain open and democratic, the SHARED principles apply to human-centric information technology. From sustainable to diverse, they form the building blocks for a better world to live in.

S	Sustainable	Citizen engagement needs to be invited and organised in a way that it will last longer than just the launch of a project, or the development of a programme.
H	Harmonious	Citizen engagement needs to be organised in ways that are inclusive and do not contradict existing legislation, social policy and/or standard norms of good citizenship and civil behaviour.
A	Affective	Citizen engagement needs to include acknowledgement of and respect for different emotional investments and concerns that people will have with respect to technology and data.
R	Relevant	Citizen engagement need to engage those people who are directly affected by and involved with the relevant aspects and activities.
E	Empowering	Citizen engagement needs to be aimed at providing people with a better understanding what is going on, the intellectual and practical tools to form an opinion and assessment of it, and where possible, access to the technical tools to participate in it.
D	Diverse	Citizen engagement needs to acknowledge and accommodate the various dimensions of diversity, including gender, ethnicity, class, disability, sexuality, religion.

ROBUST systems

Rapid digitalisation also furthers the need for ROBUST systems, that are beneficial to as well as protect society from threats and harm.

R	Resilient	Changes due to accidental or malevolent damages can be absorbed without collapsing the system.
O	Open	Software and hardware (and science done with it) are open for inspection, improvement, and to learn from.
B	Beneficial	Society, economy and science benefit from the functionalities provided by the system.
U	User-oriented	Humans-in-the-loop are explicitly taken into account, following a process of co-creating affective solutions.
S	Secure	Systems are designed to keep intruders out, to avoid abuse, and to do no harm to its users.
T	Trustworthy	Systems are build such that they are available when needed and operate correctly and safely according to intended design.

FAIR data

In order to make use of integrated data sets, we have to continuously validate their accuracy, their reliability, and their veracity with new forms of big data analytics. It is therefore important that relevant data is findable, accessible, interoperable and re-usable (FAIR).

F	Findable	Easy to find by both humans and computer systems and based on mandatory description of the metadata that allow the discovery of interesting datasets.
A	Accessible	Stored for long term such that they can be easily accessed and/or downloaded with well-defined license and access conditions.
I	Interoperable	Ready to be combined with other datasets by humans as well as computer systems.
R	Re-usable	Ready to be used for future research and to be processed further using computational methods.

FACT data science & algorithms

Closely related to FAIR data is the societal necessity for FACT data science. Only if big data applications and algorithms take important human values into account, they can contribute to a better society for all.

F	Fair	Unfair conclusions are avoided even if they are correctly computed from available data and models.
A	Accurate	Computed answers are given with a guaranteed level of accuracy as so to avoid misleading conclusions.
C	Confidential	Results are achieved in a safe and controlled manner without revealing secret (private, company) information.
T	Transparent	Computed answers can be understood and clarified such that they become undisputable and hence trustworthy.

Digital Society Programme Line:

Citizenship & Democracy (1)

How to reinvent trust, dialogue and decision-making?

Coordinating Author: **Franciska de Jong**

Digital media have profoundly changed the way citizens inform themselves and participate in democratic debate. New ways of filtering, aggregating, and distributing information, new players and platforms, and changing news consumption have created opportunities and challenges. The digital turn can reduce social exclusion and advance social cohesion, active participation and the formation of national, cultural, and religious identities. At the same time, digitalisation has increased the risk of misinformation and polarisation, and challenges fundamental societal values such as diversity, inclusion, and privacy. The global scope of digital communication questions the effectiveness of national and international systems of governance. This programme line is crucial in identifying and better understanding the challenges for democracy, improving decision-making and realising the opportunities for digital citizenship. In so doing, this programme can make an important contribution to reinvigorating institutions that are vital for democratic participation, economic prosperity and the rule of law.

Academic and societal challenges for Citizenship & Democracy

The strength of societies is to a large extent determined by the quality of the formal and informal frameworks for interaction between citizens, and between citizens and institutions. This decentralised media ecology of networked communication can both foster and constrain democracy and public decision-making. With the increasing impact of digital platforms and technologies for societal interaction, a thorough understanding of the risks and chances inherent to the digital society is needed.

This requires a multi-disciplinary research agenda that can engage representatives of various fields of science to jointly answer questions such as: What is the role of digital, social and virtual media and communication in citizenship and democratic processes? How can technology help citizens in their interaction with representative democratic bodies? How can digital and social media, virtual environments and games better inform and motivate people? How can digital access to cultural heritage data support (collective) identity formation and the diversity of societal groups? How can societal diversity be supported along a wide range of dimensions, including culture, education and language? How can digital literacy be stimulated to overcome the digital divide? How are ownership and control of personal data organised? How to design workflows to ensure that humans and machines contribute in a balanced way to data-driven decision-making? How do we safeguard and advance fundamental values, such as inclusivity, diversity, autonomy, privacy and democratic participation?

Role of data science for Citizenship & Democracy

Availability and contributions to FAIR data (findable, accessible, interoperable and re-usable) will be very helpful for this programme. Even more crucial is the recent attention for FACT principles in data science (fair, accurate, confidential and

transparent). Trust in information flows and room for human intervention are key for citizens to be able to navigate the digital society and to be prepared to accept (big) decisions suggested by (big) data analysis.
In particular initiatives under the following headers are crucial for making the digital society a place that people can meaningfully participate in: responsible data science (see programme line 2), explainable artificial intelligence, transparent communication ecologies, interpretable data models, value-sensitive design, transparency and algorithmic oversight. The promises of these paradigms are still to be delivered. In the long run they will help citizens (including professionals and researchers) to assess and influence the design and outcomes of data-driven processes.

Relation of Citizenship & Democracy to NWA, Top Sectors and EU initiatives

The programme line 'Citizenship & Democracy' links with initiatives such as:

1. NWA-route 'Veerkrachtige samenleving'
2. NWA-route 'Levend Verleden'
3. NWA-Startimpuls 'Verantwoorde Waardecreatie met Big Data'
4. NWA-Startimpuls 'Jongeren in een veerkrachtige samenleving'
5. Top Sector programmes 'Creative Industries' and 'Commit2Data'
6. Horizon 2020 'Societal Challenge 6: Inclusive, innovative and reflective societies'

Long-term goals and short-term milestones of Citizenship & Democracy

The **main aim** of the programme 'Citizenship & Democracy is to optimise informed democratic citizenship in the digital society by developing, evaluating and integrating responsible digital solutions that can be tuned to individual and societal needs within the social, cultural, legal and ethical frameworks that guarantee fundamental human rights, including the rights to privacy, data protection, freedom of expression and non-discrimination.

To this end digital methods and applications should be responsive to the needs and expectations of the digital society and their design should take into account questions such as: How can we integrate the human factor into automated decision-taking? How can we optimise transparency about data collection, analysis, and use? How can information provision be transparent, accurate, and reliable in order to enable citizen participation in public debate and politics? And what is the role of the law and ethics to steer social processes and to safeguard core values such as personal autonomy, freedom of expression, equality, the rule of law (fairness)?

Several Dutch universities, research institutes and research teams are engaged in research agendas and or development programmes that strongly overlap with what could be core activities for the programme line 'Citizenship & Democracy'. These agendas and programmes bring together a variety of disciplines, including political communication, political science, law, communication science, political philosophy, media studies and digital humanities. This programme should extrapolate from smaller research initiatives into a bigger programme, where computer scientists, social scientists and humanities scholars collaborate to understand the impact of digitalisation on the democratic process, develop algorithms that can analyse the complexity of human communication and meaning-making on the scale of big data and the web, foster critical digital literacy, and provide transparency regarding the quality and perspectives in online data.

Short-term milestones to reach these long-term goals include:
1. Understanding of how digital technologies can contribute to a reliable, multiform, more diverse, inclusive and sustainable media landscape.
2. Understanding the contribution of digitisation to democratic processes, identity formation and citizenship, and the potential for making private and social processes richer, faster, more effective, better connected and more empowering.
3. Development of solutions and training methods for improving the digital literacy of citizens and scholars.
4. Specification of the implications of responsible data science for the use of (big) data in public decision-making.

Means and methods of Citizenship & Democracy

The following means are necessary to reach these goals:
1. **Train new generations** of researchers in the social sciences and humanities in digital research methodology, and in particular on validation methods.
2. **Train new generations of data scientists** and software engineers to be able to incorporate insights from the humanities and the social sciences in the design and application of new tools and systems.
3. Continued **attention and support** for research into digital citizenship and democracy.
4. Support for a **platform of multidisciplinary networks** of researchers and representatives of public bodies to stimulate the exchange of information, insights and best practices.
5. A **model for cross-fertilisation and crossovers** between (overlapping) programme lines.

Digital Society Programme Line:

Responsible Data Science (2)

How to enable full and responsible use of big data?

Coordinating Author: **Frank van Harmelen**

Responsible Data Science is an essential foundation for all programme lines of the Digital Society Research Agenda. Using data in reliable and responsible ways will be an integral part of any research programme. It limits the potential for misuse of personal data and the risk of undermining public trust. FAIR and FACT are the key principles for all the techniques, methods and tools that will be developed. They should be applied universally.

Academic and societal challenges for Responsible Data Science

Data science has emerged as a new scientific discipline providing techniques, methods, and tools to gain value and insights from new and existing data sets. Data abundance combined with powerful data science techniques has the potential to improve our lives. It enables new, efficient services and products of better quality. In fact, data science already fuels many of today's scientific discoveries. Think of the health sector with its use of statistics, data mining, machine learning, databases, and visualisation.

The importance of data science is widely acknowledged, but there are also great concerns about the use of data. Increasingly, customers, patients, citizens and other stakeholders are concerned about irresponsible data use. For example, automated data-driven decisions may be unfair or non-transparent. And confidential data may be shared unintentionally or abused by third parties. Moreover each step in the 'data science pipeline' from raw data to conclusions may create inaccuracies.

Rather than avoiding the use of data altogether, we strongly believe that data science techniques, infrastructures and approaches can be made **responsible by design in accordance with the FACT and FAIR principles** as explained in the introduction. That will be the most important challenge for this programme.

The deep, societal and academic challenge that Responsible Data Science faces, is not only to achieve these goals separately. It's also about, and that's much harder, how to address the inherent tension that exists between these goals. How do we achieve findability while not damaging confidentiality? How do we maintain transparency through long chains of data reuse? How do we guarantee accuracy across interoperable but heterogeneous data? In order to help shape a sustainable data-driven society, it is essential to obtain joint algorithmic and societal insights in these complex trade-offs.

Role of data science for Responsible Data Science

The omnipresence of data makes society increasingly dependent on data science. A digital society that complies with our shared democratic values is the kind of digital society we should aim for. But despite its great potential, there are many concerns on irresponsible data use. The motivation for the new EU data directive notes that 'consumers are increasingly concerned about privacy, loss of trust translates

into lost opportunities and revenues for companies, and recent high profile data breaches have pushed consumers to escape from service providers that did not adequately protect personal data'.

Data science provides unprecedented possibilities and can be disruptive in both positive and negative ways. Unfair or biased conclusions, disclosure of private information, and non-transparent data use, may inhibit future data science applications. Some have compared the current situation with the 'wild west': data science methods are rolled out first, questions about potentially undesirable consequence are asked later. Responsible Data Science turns this around. It is aimed at generating scientific breakthroughs by making data science **responsible by design.** Responsible Data Science develops techniques, tools, and approaches to ensure fairness, accuracy, confidentiality, and transparency.

Relation of Responsible Data Science to NWA, Top Sectors and EU initiatives

Internationally: The diffusion and the public endorsement of data FAIRness has been rapid. In 2015 at their summit in Japan, the European Council and the G7 adopted the reusability of research data as a priority, thus providing fertile ground for uptake of the FAIR principles. In 2016, the European Commission with Big Data to Knowledge (BD2K), Science Europe, and the G20 in the 2016 Hangzhou summit all endorsed data FAIRness. The FAIR principles are now the basis for the European Open Science Cloud (EOSC), and publication of FAIR-compliant research data is now mandatory across the Horizon2020 programme.

A 2016 report by the Obama administration on big data emphasises the importance of 'justice, fairness and accountability' as crucial for the social benefit of machine learning and data analytics. A similar report from the UK parliament around the same time also emphasises the need for transparency. Angela Merkel, the German Chancellor, echoed that call shortly afterwards when she asked for 'more transparency and also more attention for the effects of data analytics'. In terms of international policy making, a sustained effort in creating responsible data science algorithms will help maintain basic European principles in an increasingly data-driven society.

Scientifically, the importance of Responsible Data Science has been recognised internationally through, for example, the International Data Responsibility Group and their annual IDRG conference since 2015, the series of 'FAT' meetings (FAT = Fair, Accountable, Transparent) since 2014 and the first FAT conference planned for 2018.

Nationally: The Netherlands is widely seen as a guiding country by many others because of its leading role in the formulation of the FAIR-principles, and in the design of the European Open Science Cloud. The GoFair initiative is an excellent example of early adoption of FAIR in the life science and healthcare. More broadly, the Netherlands has a long tradition of multidisciplinary work and its innovation network. Especially its collaborations between academia and industry, it has received worldwide recognition. All those initiatives are essential ingredients of a successful agenda in responsible data science.

NWA: Of the more than 11,700 questions that were collected for the NWA from Dutch citizens in 2015, some 2500 (more than 20%) were related to data science and big data. Many of these questions expressed concerns with respect to irresponsible uses of data: questions related to balancing privacy and information

sharing, to digital security, to data in government, to the effects of digitisation on society, etc. A substantial number (about 25% of the 'data science' questions) related to (a lack of) fairness, accuracy, confidentiality, and transparency. The questions illustrate the tension between the need to exploit data (for example to improve efficiency or quality of services) and the possible negative side effects of this (for example privacy issues, and biased/inaccurate decisions). Consequently, the FACT-principles have been used as the basis for the 'Startimpuls' of the 'Big Data'-route in the NWA.

Long-term goals and short-term milestones of Responsible Data Science

Algorithmically, responsible data science principles and practices may be harder to realise than 'just any' data science principles and practices. These difficulties are further compounded by the inherent conflicts between some principles. The challenge is significant. But if we want to create a digital society that is both innovative and fair it should be addressed head on. This, then, is the long-term goal of the program: to advance the development of an innovative and fair digital society in which algorithms help create new opportunities in a responsible manner.

The digital society has ethical and social implications for the way people are seen and treated by the state and by the private sector. The power of data to sort, categorise and intervene must be explicitly connected to a social justice agenda, and a notion of 'data justice' must be developed. In a similar way, the economic notion of 'ownership' requires re-examination in the light of the valuable data-trails produced by every citizen. In the social sphere, our society has seen a dramatic shift in the past decade in its perception of privacy, leading the founder of Facebook to proclaim that 'privacy is no longer a social norm'. A foundational approach to Responsible Data Science must also address these philosophical and ethical aspects head-on.

To reach these long-term goals, we list examples of shorter-term milestones on which substantial progress can be made in a four year timeframe, and for which top-level expertise is available in the Dutch data science community:

1. Fairness: **computational methods** for fair data mining, and methods that detect and avoid unfairness resulting from selecting, combining and reusing data.
2. Accuracy: **statistical methods** to quantify (in)accuracy in complex models, and statistical methods that are robust against bias in both data selection ('selection bias') and result reporting ('p-value hacking').
3. Confidentiality: **computational methods for privacy preserving machine learning,** as well as mathematically sound and computationally feasible methods for multi-party and multi-purpose data encryption and data pseudonymisation.
4. Transparency: representing and **exploiting dynamically maintained data provenance,** methods for interpreting algorithmic decisions and communicating data comprehensibly; methods and tools for transparent and reproducible compliance checking (for example in health, finance, government and education).

The FACT-goals require progress on combining statistical and symbolic methods to describe data-sets, using FAIR-methods. In particular:

1. Findability: improved understanding of the trade-offs between **centralised and distributed data-access.**
2. Accessibility: **computerised negotiations** about protocols and licensing.
3. Interoperability: advances in data-interoperability **at all levels,** both syntactic, semantic and pragmatic.
4. Re-usability: **explicit descriptions and dynamic recording** of data provenance and processing pipelines.

Means and methods Responsible Data Science

The following three actions are crucial to reach the abovementioned goals:

1. Deepen the **foundations of data science:** artificial intelligence, computer science, mathematics, statistics.
2. Initiate ambitious **data science training programmes** in all academic disciplines to attract, educate, and foster a diverse and human-centred data science talent pool.
3. Create an **innovation ecosystem** in which risk taking and leaping into the unknown is a part of innovation, with suitable regulatory sandboxes in which research institutes, governmental organisations, corporations, and entrepreneurs are able to experiment with new, ethical and sustainable data science principles and innovations.

Digital Society Programme Line:
Health & Well-Being (3)

How to let technology generate longer, healthier lives

Coordinating Author: **Andrea Evers**

Digital technology can help to promote healthier lifestyles, create healthier environments, optimise detection, diagnosis and treatment of disease and well-being of patients, and advance the quality and efficiency of care, both at home and in institutions. The programme line aims to develop, evaluate and implement integrated and personalised digital healthcare solutions, while understanding the societal challenges raised by the digitalisation of healthcare, with the main goal to improve health and decrease the cost to society.

Academic and societal challenges for Health & Well-Being

Digital solutions are one of the key factors for an optimised organisation of healthcare, especially in a world with an ageing population and more people living with chronic somatic conditions. Already, digital solutions are increasingly used for the prevention and personalised treatments of chronic somatic and mental conditions. And healthcare is increasingly supported by cost-effective digital eHealth applications such as apps, serious games, virtual reality, wearables, and remote patient monitoring or e-coaching. Besides that, digital health applications are also a powerful instrument to empower humans. They can contribute to shared decision-making, since individual citizens have increasingly ownership and understanding of their health-related data. In addition, big data solutions can give more detailed insights into the molecular and psychosocial nature of health and disease. With those insights we can optimise personalised medicine. To realise these promises requires engaging with the technological and scientific challenges involved in the digitalisation of health and biomedical research; and, at the same time, the societal challenges that the digitalisation of health itself raises for patients, health professionals and other stakeholders.

The Netherlands is one of the key players in the development and implementation of digital health applications and solutions to improve the health and well-being of its citizens. Data-intensive research that draws on new sources of data and powerful computational methods can provide more detailed insights into the molecular and psychosocial nature of health and disease, offering new opportunities for personalised medicine. However, there is insufficiently knowledge how eHealth applications are optimally used and accepted by citizens and society. For example, how will seriously ill and vulnerable people cope in this high-technology environment and how can we ensure that citizens are confident that their privacy is safeguarded when health-related data flows between patients/citizens, medical practitioners and researchers? In addition, the available data and digital applications are not structurally connected, evaluated and implemented. Therefore integrated digital tools for prevention and personalised medicine are needed as well as knowledge about their optimal use and implementation for citizens and society. With those integrated tools we can improve health and well-being, decrease the burden of health care costs to society and foster solutions for the great health challenges during the next decades.

Role of data science for Health & Well-Being
Digital solutions are considered to be one of the key factors for the future healthcare challenges, such as a growing aging population, increase of chronic conditions and intensive health care use. Integration of data from different sources (e.g. hospital, patients own data, insurance) makes it possible to develop more personalised forms of medicine, healthcare and prevention, based on the genetic and psychosocial background and adapt to individual needs and preferences and monitoring of real-world data.

The development and deployment of digital solutions are increasingly dependent on the availability of personal standardised data sets. If citizens can manage their own health-related data, they will be better able to prevent or to self-manage illnesses. In addition, self-learning systems can be provided that are increasingly personalised to the individual characteristics of citizens and deliver insights into how health care can be delivered optimally.

The impact of digital health applications in today's data-driven era depends on their successful implementation in health care systems. Thereby we have to account for legal, governance and citizens perspectives. This requires an optimal understanding of how eHealth applications are used, both by patients and care providers, and how this can be integrated into the institutional structure and practices of national health care systems.

Relation of Health & Well-Being to NWA, Top Sectors and EU initiatives
The programme line 'Health & Well-Being' connects to several routes of the NWA. Particularly the routes, 'Personalised medicine', 'Health care research, prevention and treatment', 'Regenerative medicine', 'Neurolab', and 'Sport and exercise'. Furthermore, the routes 'Big Data', 'Sustainable production of healthy and safe food' and 'Resilient Societies' have evident points of interest.

The programme line 'Health & Well-Being' is directly connected to the Top Sector programme 'Life Science and Health', and 'Creative Industry' and the current Horizon 2020 agenda of the European Union. The expectation is that both 'health' and 'big data' will also be key components of the EU FP9.

This programme line also connects with the recently started KNAW vision HealthRI, that lays down the infrastructural needs for connecting data from research institutes, health care providers and individual citizens with the aim of developing novel personalised health care solutions. A flagship project in this context is the ongoing Personal Health Train project coordinated by the Dutch Techcentre for the Life Sciences (DTL). In that project, citizens can control their personal health data. They are in full control of sharing the data with health care providers or researchers of choice. The interoperable (FAIR) health related data can be exploited for optimizing prevention and treatment.

Long-term goals and short-term milestones of Health & Well-Being
The main aim of the programme 'Health & Well-Being' is to optimise health for humans by developing, evaluating, and implementing integrated digital healthcare solutions (prevention, assessment and treatments) that are guided by patient-centred and publicly legitimate values and that can be personalised to the individual and societal needs through the human life span. Integrated digital tools for prevention and personalised medicine will make it possible to improve health and well-being, and decrease the burden of health care cost to society.

To reach these aims, we need to turn heterogeneous data from various sources into personalised health advices for every individual. The main challenges are to develop prediction models for improving individual health and preventing disease, taking into account global, societal, and personalised characteristics of a constantly changing environment. This will be established by assessing the human and societal challenges that determine the use of health technologies as well as exploring large data sets and then tuning the resulting general models to individuals by utilizing individual-specific data in real time. At the same time, we need to understand the social, political and economic factors that shape the ways in which citizens, policy makers and other stakeholders adapt and use new digital developments.

Short-term milestones to reach these long-term goals include:

1. **Preparing citizens and health care providers for the use of digital health care solutions and understanding how digital health is experienced by users.**
   We will focus on the development of self-help tools and education to facilitate the continuous use and adjustments to the newest technologies. This requires that we need to have an optimal understanding how e-applications are used, by citizens, patients and providers of care, and how this use can be integrated into the institutional structure of the health care system.

2. **Increased interoperability of health data from different sources throughout the Netherlands.**
   Integration (joint use) of data from different sources (e.g. hospital, patients own data, insurance) makes it possible to develop more personalised forms of medicine, healthcare and prevention, based on genetic background and adapt to individual needs and preferences and monitoring of real-world data. Healthcare data can be combined with data from other sources, including citizen reported outcomes which can be mined for patterns, used for machine learning, and deployed to develop predictive models to aid decision making.

3. **Availability of health data of citizens in collaborative, privacy-friendly data storage projects.**
   The key concept is to bring methods to the data rather than bringing data to the methods. That gives controlled access to heterogeneous data sources, while ensuring maximum privacy protection and maximum engagement of individual patients and citizens (the Personal Health Train concept). This real world data can be used to prove the value of new diagnostic and therapeutic initiatives by measuring outcomes that matter to patients and society.

4. **Nationwide implementation of innovative evidence-based digital health applications.**
   These applications (e.g. monitoring, sensors, wearables, e-coaching) take into account legal, governance and citizens perspectives. This requires a focus not only on the possible benefits of the digital solutions, but also on possible barriers. For example, how to increase adherence to eHealth interventions, reluctance to participate in remote patient monitoring, anxiety-inducing effects of wearables and devices, or applicability of digital solutions for vulnerable groups.

5. **Governance and regulation of health data and digital health.**
   Digital health is an expanding ecosystem that includes data and stakeholders from outside of the traditional healthcare domain. New regulation and governance solutions will be needed to ensure this expansion is line with publicly legitimate and democratic values. Furthermore, governance models need to be developed for healthcare research and provision that increasingly involves private actors.

Means and methods of Health & Well-Being

The following means and methods are necessary to reach these goals:

1. Interdisciplinary assessment of the **individual and societal challenges** that shape the use of health technologies as well as the needs and requests of the citizens and society, to understand how e-applications are used and are optimally integrated in a constantly changing societal environment.

2. Advancements of **big data solutions** for the data infrastructure of digital health applications in the care process, education, prevention and research (e.g. connectivity of various digital health applications, such as games, virtual reality, sensors).

3. Health data owned by patients that are stored organised and supported by collaborative **data storage projects** and infrastructure.

4. Further development, evaluation and implementation of **innovative eHealth applications** for humans during the whole life span.

5. Development of **data science research** in responsible (big) health data methods and techniques.

Digital Society Programme Line:

Learning & Education (4)

How to enable people to participate meaningfully in all stages of life?

Coordinating Author: **Harold Bekkering**

Continuing technological change will both enable and require new types of learning not just during childhood but throughout people's lives. More than ever, people of all ages should be enabled to continuously update their skills to engage with the environment and the rest of the world. Formal and informal learning processes should be personalised and made more effective.

Academic and societal challenges for Learning & Education

In our modern society everything is being personalised from marketing campaigns, customised product delivery, and since the start of this century also education. The personalisation of education has had impact on a wide range of educational topics ranging from differentiation in the classroom to the design of intelligent tutoring systems. Also in society, digital information is present in every daily activity and in many professional skills. Being up-to date in knowledge and skills thus critically depend on digital tools demanding for life-long learning. Those digital tools enable personalised content delivery and for example personalised assessment related to the knowledge level of the student or worker. Supported by cost-effective **digital applications** such as serious games, virtual reality experiences, wearables, remote student monitoring or e-coaching it makes **Education and skill training** more efficient. Learning analytics is also a powerful tool to acquire insights in the level of performance. The biggest academic challenge in the field of digital education is to build applications that help to personalise learning such that we understand how individuals process information, how knowledge in a certain area is stored, and how the learner adapts current knowledge in an optimal manner. Next to the enhancement of cognitive insights, digital education should also help to motivate learning and increase social interaction.

These rapid developments also call for a focus on digital literacy of learners which is essential to make sense of an increasing digital and datafied society. Such a literacy is crucial for educating critical, informed citizens able to make sense of the complex digital world they live in. Research on the implementation of computational skills in curricula at all levels is therefore highly desirable.

The Netherlands is a key player in the development and implementation of digital education and professional skill learning. A recent initiative aims to accelerate the implementation of knowledge in higher education, but includes society at large. We have many innovative research centres in the fields of education, psychology, neurosciences and digital communication. However, scientific investigations, available data and digital applications are not structurally connected, evaluated and implemented to foster learning for all of us. Therefore, science-driven digital tools for personalised and naturalistic learning are needed to change the game of self enhancement in our society.

Role of data science for Learning & Education

Digital solutions are important for personalising education. Education can profit tremendously from personal, neurocognitive and behavioural insights on cognitive

and motivational concepts. Serious gaming, whenever you want, will likely take over traditional school-based learning for areas like reading, mathematics, history, biology etc. An optimal digital infrastructure at schools and at homes is a prerequisite to do so. Needless to say, that all principles of FAIR are need to be implemented in an optima forma.

We want to build models that offer the most optimal learning route for each individual at all ages. This requires that we need to know how e-applications are used, both by learners and customers, and how this can be integrated into the institutional structure of our educational system.

Relation of Learning & Education to NWA, Top Sectors and EU initiatives

The programme line 'Learning & Education' connects to some routes of the NWA. In particular to Theme 1 (with 'Vital Youth, 'NeuroLab') and to Theme 2 ('Understanding Digital Society'). There are additional connections to the Top Sector Creative Industry that contributes to serious gaming, but also to a more modern and creative way of personalised learning. In the European context, the programme line is directly connected to the Horizon 2020 agenda in many ways, i.e., Future and Emerging Technologies (FET), European Research Infrastructures (including e-Infrastructures) and Information and Communication Technologies (ICT). The expectation is that both 'education' and 'big data' will also be key components of the upcoming FP9 programme of the EU. Furthermore, there is a direct link between this programme line and the VSNU agenda 'Digitalisation in academic education'.

Long-term goals and short-term milestones of Learning & Education

The **main aim** of the **programme line** is to optimise learning. We will do that by developing, evaluating, and implementing integrated digital solutions through, for example, serious gaming and measuring bodily states via wearables in and outside the classroom. Thus learning of novel knowledge and professional skills can be personalised to individual and societal needs.

More short-term milestones include:

1. **Development of** science-based digital learning solutions, and smart-systems at schools and work environments.
2. **Implementing digital learning solutions and wearables** in knowledge and skill training in the Netherlands.
3. **Responsible data science** in all methods and techniques.

Means and methods of Learning & Education

The following developments are significant to reach the abovementioned goals:

1. The development of general (instruction technology) and content specific (of all domains and skills desired) learning tools to enable personalised **educational applications** based on solid academic knowledge.
2. **Advancement of** educational-fitted **wearables** to measure human activities during learning.
3. Support for **big data solutions** for the data infrastructure of digital educational applications.
4. Development of **digital literacy** programmes, to ensure citizens have the capacity and skills to critically navigate a digital media landscape.

Digital Society Programme Line:

Work & Organisations (5)

How to prepare companies and workers for a new economy?

Coordinating Author: **Marleen Huysman**

Digital technology disrupts markets for products, services and jobs. Artificial intelligence, robotics, digital platforms, and other smart technologies can revolutionise major industries, including logistics, retail and white-collar professions. They impact human skills and work/life interaction and enable micro-jobs, new forms of distributed organising, and new forms of collaboration between people and technology. We need new strategies to develop human-centred solutions that prevent social inequalities and societal exclusion.

Academic and societal challenges for Work & Organisations

Due to digitalisation, work and organisations as we know them will change. We already observe pervasive consequences of digital technologies, ranging from the rise of platform businesses like Uber to mass redundancies of workers in factories. We should not only focus on market forces or technological infrastructures. We need a human-centric view to understand how organisations design, develop and introduce digital technologies and how digital technology changes work and organisations.

Landslide changes are happening at work and in organisations in all kinds of sectors. Technologies are for example: algorithms and human intelligence, robots at the workplace, personal digital devices and online platforms, smart technologies and innovation. Below we elaborate a bit on those technologies.

Algorithms are perhaps the most striking examples of digital technologies. Those technologies will become smarter, and at some point maybe even smarter than humans because of the availability of more and more data, combined with the growing ability to store data and the development of sophisticated algorithms. An important question is: what are the ethical and societal implications of automated decision making in various sectors? Those sectors are for example: health, banking (fintech), creative industry, high tech and manufacturing, energy, government, science and education and professional services. Algorithms at work are associated with profound consequences ranging from deskilling and upskilling professionals, rationalising authority structures and human resource management practices, to power tensions in labour relations and managing by algorithms. Due to their hidden, proprietary and dynamic nature, they challenge research on 'digital work'.

Robots at the workplace, including bots, drones and automatic cars, rapidly permeate organisations. Care robots are increasingly seen as a solution to improving quality of life in health care. The DaVinci Robot is rapidly changing the practice of surgery. Robotisation may have implications for deskilling, but detailed studies of organisational change after the introduction of robots also point to reskilling and unforeseen upskilling. It thus should be a topic for research whether indeed robots take over the roles and functions of humans, or whether its consequences are more complex and unforeseen.

Personal digital devices and online (social media and sourcing) platforms proliferate in our lives and result in an ubiquitous workplace and an 'always on'-mindset. It shows that digitalisation has already started to fundamentally change contemporary working conditions. Important questions are: how does the working place of the future look like? How do people cope with transparency and connectivity? What skills will it require, professionally but also in terms of the ability to safeguard a healthy work-life balance? These issues are also closely linked to the Health & Well-Being and Learning & Education programmes.

Many of us use social media while criticising their privacy-invading tendencies. We enjoy the gig economy for its low-cost services while disliking its destabilisation of workers' rights. We perpetuate the quantification of academic life while criticizing it. It is to social scientists to understand this 'eyes wide shut' behaviour including its consequences and potentials to alter it.

Digitalisation also gives rise to an increased flexible workforce including opportunities to connect unknown crowds, flex-workers, digital nomads and micro-jobbers. This creates challenges for organisations on topics as knowledge fragmentation, quality loss and reduced learning capabilities. Digitalisation also reshuffles the information (and power) balance among employees and employers. On the one hand employees increase their expertise while on the other hand over-reliance on algorithms may eventually lead to losing crucial knowledge. As such, there is a direct link to the need for attention to learning and education in a digital economy and society.

Smart technologies and innovation, such as the Internet of Things, have a number of characteristics that differentiate them from other types of technological innovation, and significantly alter standard ways of developing technologies. For one, smart technologies consist of a physical layer, a content layer, a network layer and a service layer. Smart textiles for example, may involve contributions from sensor technology, fashion design, telecommunications, biometrical data analysis, and healthcare. Convergent, smart digital technologies are generative and reprogrammable. They can be connected to other devices and apps and generate big data that can be used to improve business processes and develop new products and services. Due to the above characteristics, smart digital technologies depend on ecosystems that bring together a group of interconnected and interdependent actors that create and appropriate new value. While there is some agreement that the development of digital technologies calls for a radical different way of organising and managing innovation, in-depth interdisciplinary research is needed to understand how these new products and services successfully come about and how they affect or alter society.

The above is just a selection of digital technologies. The impact of digitalisation at work and organisations will be far-reaching and requires rethinking of many dimensions of our societal arrangements, and of our role, as humans in society. For instance: what does 'work and leisure' mean in such a highly digitised economy? What are the implications for our legal system? What are the actual consequences of democratised access to digital technologies and expertise? How can organisational processes and practices be reconfigured to develop, implement and work with these new technologies? What are the consequences of introducing and collaborating with robotisation, of artificial intelligence for work, of organisation and society? How can we anticipate on the changing needs for organisations, labour markets and education? For that reason, this programme line calls for interdisciplinary and engaged academics.

Role of data science for Work & Organisations

Data science creates new solutions in fields such as artificial intelligence (emulating the human brain), human resource analytics (e.g. to predict employee performance) blockchain (enabling digital trust), and the Internet of Things (pervasive sensing, communication, computing, and actuation infrastructure). Applying data science to organisations is also associated with unforeseen and profound shifts that go beyond mere performance improvements. Biases may creep into algorithms when these are present in the data that are used to develop algorithms. It is therefore important that the principles of SHARED are taken into account, while applying the principles of FAIR and FACT as explicated earlier in this agenda. For example, over-reliance on the algorithms may eventually lead to losing crucial knowledge necessary for professional decision making. Among social scientists, there is also a growing realisation that analytics no longer merely represent the world, but also produce it. And given their growing interdependence, the ability to control any given technology is increasingly limited. Stock market flash crashes for instance, induced by algorithmic trading, are highly visible examples of such algorithmic phenomena. Have the things we have made, become out-of-control or can this be regained through digital literacy and responsible data-related frameworks such as SHARED?

Relation of Work & Organisations to NWA, Top Sectors and EU initiatives

The programme line 'Work & Organisations' connects to several routes of the NWA. For example to 'Smart Industry', 'Circular economy', 'Creating value through responsible access to and use of big data', 'Measuring and detecting: anything, anytime, anywhere'. The impact of data science and digitalisation will also be seen in the production of food (NWA route 'Sustainable production of safe and healthy food'), energy sector (NWA route 'Energy transition'), transportation ('Logistics and transport in an energetic, innovative and sustainable society'), and the way we organise our society (NWA routes 'Towards resilient societies' and 'Sustainable development goals for inclusive global development').

The programme line 'Work & Organisations' is connected to the Top Sector programme 'HTSM' and 'Creative Industries' as well as the agendas of 'Human Capital' and 'Dutch Digital Delta'. Various Horizon 2020 working programmes connect with the programme line.

Long-term goals and short-term milestones of Work & Organisations

The long-term goal is to help the Netherlands develop into a human-centric socially responsible digital economy. In order to reach this, a well-funded, productive and high quality research community is needed. The research community collaborates closely with organisations. We will set the Netherlands at the centre stage of interdisciplinary research on human-centric digital innovation related to work and organisation. Part of this long-term goal is to collaborate with the programme line 'Learning & Education' to prepare new generations for the changing conditions in labour markets. Also on the long-term agenda is a need to **reform research** to enable interdisciplinary top-level research on digital work and organisations in close collaboration with industry. Closing the gap between academics and practitioners will help to explore and assess **new work and organisational models** that take into account the transformative nature of digital technologies, including new and innovative forms of norms and ethical rules of conduct, legal protection of labour, distribution of responsibility, accountability and other human values.

To achieve these goals, important **short-term milestones include:**

1. **Finding coalition**s among knowledge institutions, private partners, governments and citizens, for example to develop an assessment framework for social consequences of digital technologies at work. Several Dutch research teams are already engaged in research that contributes to the Work & Organisations programme line, but more is needed.
2. Furthering recognition that **technological developments and social aspects** go hand in hand. As a country we strive for a leading position in digital technology (e.g. smart industry) with a human-centric perspective.

Means and methods of Work & Organisations

1. **Adjust curriculum** of social and technical studies to incorporate human-centric digitalisation.
2. Programs for research on digital work and organisations including increased international and interdisciplinary **collaboration programmes.**
3. **Critically assess digitalisation** and signal conflict and problems with automated decision making and governance of algorithms, as well as incorporation of societal norms and values, such as inclusiveness, non-discrimination and privacy.
4. Offering **hands-on 'sand-box' experimenting** in digital technology labs.
5. **Strengthening collaboration** between organisations and research, for example through field labs.
6. Include the programme line 'Work & Organisations' as the **social chapter of the HTSM roadmap.**

Digital Society Programme Line:

Digital Cities & Communities (6)

How to build smart, enjoyable cities and hinterlands?

Coordinating Author: **Liesbet van Zoonen**

Digital technologies can help to create infrastructures that efficiently and flexibly manage urbanisation, population growth, mobility, effects of climate change and transition to greater sustainability. Digital technologies also enable citizens to share new practices and create new communities. Moreover, digital technologies deliver massive amounts of data from which a wide variety of stakeholders can optimise their services and collaborations. The resulting 'smart cities' will provide their citizens safety and liveability, and interact optimally with surrounding rural communities, provided they are co-created by all stakeholders with the public interest in mind.

Academic and societal challenges for Digital Cities & Communities

What is the public value of digitisation and datafication for urban and regional challenges? This question pertains to the most pressing issues of today. It includes, but is not limited to, urbanisation, social inequality and exclusion, poverty, inclusive and sustainable growth, climate change and community building.

People experience these issues directly and personally in their neighbourhood, region or city. Many current trials explore how digitisation and datafication can contribute to public goals and values in these contexts. Examples are sensor and data driven mobility solutions, integrated and circular energy systems or personalised health and social care provisions. There are also cultural experiments with, for instance, urban lightscapes, virtual reality and digital art. Digitalisation and datafication result in cities, communities and their inhabitants being continuously measured. That raises urgent challenges with respect to the governance of data flows, and the privacy and engagement of citizens. These challenges cannot be solved by one single urban actor but require the collaboration of governmental, corporate and civic actors who will have both common and opposing interests.

As such collaboration is never smooth or painless, the overall question for this programme line is: which forms of useful, feasible and responsible multi-stakeholder collaborations and data science can be developed and engaged for the public challenges that smart cities and communities face?

This question needs input from various disciplines, such as urban and rural studies, social geography, history (for the understanding of local logics), sociology, cultural studies and psychology (for the understanding of citizens, their contexts and attachments), political science, public administration and law (for the understanding of governance and privacy), design, human-computer interaction and data science (for understanding the interaction between human beings, technology and tools).

Role of data science for Digital Cities & Communities

Cities and communities are pervaded by several 'layers' of data. Data comes from registrations and statistics, measurement and sensor tools, social and digital

media, oral and written testimonies, city archives and so on. This data differs in size and kind, in frequency and longevity, in accessibility and quality. The new forms of digitally generated data and the opportunity to link data require new forms of analysis offered by data science and enabling, among other things, the processing of enormous, diverse and unstructured data sets and the real-time visual presentations of urban and regional processes.

Relation of Digital Cities & Communities to NWA, Top Sectors and EU initiatives

With respect to the NWA, the programme line 'Digital Cities & Communities' connects to the route Smart and Liveable Cities and its five game changers ('Safe Big Data Cities', 'Smart polderen', 'Citizen Empowerment', 'Urban Technologies', 'Resilience'). Furthermore, there are connections with 'Resilient Societies', the 'Big Data'-route, 'Circular Economy' and 'Energy Transition'.

The Top Sector programme 'Creative Industries' forms a key connection for the programme line. Creative industries are important regenerators of local economies. Their focus on creativity and innovation positions them directly with data and design solutions.

In the European context, this programme line is articulated directly with The European Partnership on Smart Cities and Communities launched in 2013. The agenda of this partnership is to bring "together cities, industry and citizens to improve urban life through more sustainable integrated solutions. This includes applied innovation, better planning, a more participatory approach, higher energy efficiency, better transport solutions, intelligent use of Information and Communication Technologies (ICT), etc". While this programme has been up and running for a while, the expectation is that 'city' and 'big data' will be key components of the upcoming FP9 program. In addition, the Joint Programme Initiative Urban Europe is directly relevant for the programme line.

Long-term goals and short-term milestones of Digital Cities & Communities

The long-term goal is to have a well-funded lively, productive and high quality research community that collaborates closely with its immediate set of civic and city stakeholders.

The goals for this programme line in more detail are:

1. To **further develop,** test and exploit digital and data technologies for the public needs of cities and communities.
2. To **explore and assess new governance models** for the public application of digital technologies and data flows in cities and communities.
3. To **engage city and community stakeholders** in all their diversity and contradictions in these processes.

To achieve these goals, knowledge institutions, private partners, governments and citizens need to collaborate. Together they identify public challenges and they can co-create the research and development agenda. This so-called 'quadruple helix' involves differences and contradictions in purpose, interests, funding and knowledge. For example, citizens and local governments lag behind in data awareness and data literacy. And private partners may be hard pressed to focus on public goals rather than on commercial goals.

The short-term milestones can be achieved by supporting current coalitions in this field, and by exploring the feasibility of others.

Means and methods of Digital Cities & Communities
The current state of digitisation and datafication with its quick successions of innovations, practices and coalitions requires flexible and rapid support, funding and collaborative structures, with room to experiment and fail. This is thoroughly at odds with current academic and university procedures and requires some additional thought about new processes.

Specifically required are:
1. Support for **urban data sharing facilities** and data science expertise.
2. Structural **collaboration with telecom operators** and data brokers.
3. Agile **support for multidisciplinary networks** and intersectoral teams including but not limited to existing national research and innovation agendas, as developed, respectively, by the NWA and the Top Sector Creative Industries.
4. **Legal, ethical and privacy taskforce,** that further develops SHARED digital and data principles for cities and communities.

Digital Society Programme Line:
Safety & Security (7)

How to protect data, people and freedoms?

Coordinating Author: **Inald Lagendijk**

Digital technology provides opportunities and challenges for human and data safety. War, peacekeeping and law enforcement will increasingly involve all sorts of data connections. Government surveillance should reduce threats while preserving privacy and other civil liberties. Public and private organisations that store personal data require better protection against data intrusions. Vital institutions' data require more robust shielding from saboteurs. Reliable, secure, data transfer and storage processes are urgently needed.

Academic and societal challenges for Safety & Security

In the digital era we are facing fast changing safety and security challenges that we cannot afford to ignore. After all, to be fully embraced by citizens, government and companies, their services need to be trustworthy. Trust, in the sense that they function correctly and reliably. And trust, in the sense that they are safe to use and will not (be abused to) cause harm to us physically or in any other way. Unfortunately, we see an increasing number of incidents, ranging from attacks with ransomware and malware to theft and abuse of personal data, from cyber-attacks by home appliances to accidents due to incorrect functioning of autonomous systems such as self-driving cars, robots and drones. Even though safety and security hardly ever sells, they are utterly missed when things go wrong. While at the same time, society must accept that 100% safety and security is unattainable.

Building trust and enforcing legal standards of safety in today's digital society is an even greater challenge than in the old days. When dealing with individuals and organisations via the internet and e-mail, how do we know we can trust them? How can we trust what they offer, what they say? How can we trust that they do not abuse digital (personal) information? How do we even know that trust is at stake? How do we know that new digital products will not harm us? Especially if they become increasingly intelligent and may act on norms and values that are not ours? Or that they know how to deal with situations not covered by training data or scenarios during product design? Which legal rules are appropriate to enforce the standards of trust while at the same time facilitating innovations of digital business models at large?

The pervasive nature of information technology and the complicated interaction patterns of digital infrastructures, services and data make it difficult – if not impossible – to use only traditional approaches such as sector regulation, tort law, delineation of responsibilities, certification, and legislation of each and every (version of) a digital service or product. We will need to push for alternatives that anticipate future digital developments that fit into a global market economy. Therefore, major academic and societal challenges in creating a safe and secure society include:

1. **Raising awareness with citizens, government and companies.** These, and other, stakeholders all deserve to be included in realising an economic and ethical value-centric society. This also includes, for instance,

education, socio-economic factors of security, governance, and digital identity. At the same time, value created for one might be loss for another. We will find a delicate balance between interests when realising the potential of a (economic and ethical) value-centric society.

2. **Instilling duty of care with those that design, produce and use digital infrastructures, services and data.**
   This includes an adaption or creation of legal rules and standards in the area of tort law and regulations. And it comprises, for instance, impact assessments, privacy protection, security-by-design, creating a digital trust infrastructure, and setting appropriate incentives for the human factor.
3. **Improving operational readiness, resilience and recovery after digital safety and security incidents.** This includes, for instance, intelligence, effective law enforcement arrangements, situational awareness, monitoring and control of digital infrastructures, and fallback options for infrastructures.

The Netherlands is one of the key players in selected fields of safety and security in digital society. Strong links exist with data science research groups. The yearly Security One Conference attracts nearly thousand participants from government, companies, and academia. However, the academic momentum and collaboration between technical and non-technical disciplines is currently insufficient to sustain the key position. Without reinforcement, the Netherlands will not be able to address the safety and security challenges we are facing in the digital society.

Role of data science for Safety & Security

Digital infrastructures, including physical or social sensors, collect digital data about many different aspects of our life, health, environment and society. Digital services analyse and integrate myriads of data as so to support us, for instance, in understanding or making decisions. Data science thrives with increasing volumes of data. But at the same time, more data collected, means that we become more vulnerable if no measures are taken to protect ourselves from the above risks. Often we do not even know what data is collected, how it is used, and who the legal owner of the derived results is. That causes issues on copyright, patent and privacy. Data science is not by definition 'good technology'. We do not want data science to be the means for bringing about the dystopias of Orwell's '1984' or Kafka's 'The Trial'.

Data science will continue to develop, but its power needs to be cared for, directed, regulated, and potentially harnessed. We must be able to 'follow the data' and the decision making building upon those data, or at least trust that sufficient transparency exists such that this can be done if needed. And we need to accelerate developing safety and security measures to avoid that eventually data science is seen as a threat to society, while it is the means for the Netherlands to defend its superior welfare position in the world. Progressing digitalisation and the use of data science will produce winners and losers in society. New jobs and business models will be created while others will disappear. A proper safety and security education in the light of pervasive use of data science is the best protective measure against social erosion. This ties in with the necessity for increasing digital literacy, as explained in programme line 'Learning & Education'.

From that background, important steps to take, are the shift towards value-centric data science, where 'value' implies both the economic and legal-ethical dimension. Hence, all application domains that use data science are of interest here. Systems that are built using data and data science methods need to become resilient to failures and abuse, need to be open for inspection beneficial and user-oriented, and

secure and trustworthy (ROBUST principle). The same yields for the institutions, legal rules and regulations into which data become embedded.

Relation of Safety & Security to NWA, Top Sectors and EU initiatives

With respect to the NWA, there is no specific route on safety and security. However, all the routes emphasise taking a socially responsible approach to achieving the opportunities that they propose. They are referring to the social, legal and ethical consequences of research, for example privacy and security sensitivities, acceptance by society, and governance. The topic of safety and security is pervasive in several routes dealing with digitisation. In the route 'Creating value through responsible access to and use of big data' the topic of FACT data science is central. Strong relations exist with the routes 'Smart industry', 'Personalised medicine', 'Measuring and detecting: anything, anytime, anywhere', 'Energy transition', and 'Smart, liveable cities'.

Considering the Top Sectors, Safety & Security connects most strongly to the agenda of the societal challenges (MU) 'Secure Society', and to the key enabling technologies 'ICT' and 'Advanced fabrication systems and processes'. In this context focal points are cyber security, robotics and blockchain. Education, privacy of citizens and combating cyber-espionage are important in the government's 'Digital Agenda 2016-2017'. The programme line also connects to the national cyber security research agenda, to the HTSM roadmap 'Security', and the 'Smart industry action agenda'.

In the European context, the programme connects directly to the digital security chapter of the H2020 work programme 'Secure societies: Protecting freedom and security of Europe and its citizens'. The EU cyber security strategy includes a partnership with the European Cyber Security Organisation (ECSO), covering application areas such as ICT infrastructures, smart grids, transportation, smart cities, smart industry, healthcare, finance and insurance, and public administration and government.

Long-term goals and short-term milestones of Safety & Security

The long-term goal of the programme line is to foster the development of a trustworthy digital society by protecting from threats caused by misuse, abuse, ignorance, accidents, or faulty design of digital infrastructures, services, products and data. This requires accelerating research efforts in different safety and security-related disciplines, covering at least computer science, industrial design, information and technology law, intellectual property right law, privacy law, ethics, digital economy (management and economics) as well as collaborative research with application domains that increasingly depend on digital services. Furthermore, the Dutch digital society does not exist in isolation. We are a small country, strongly influenced by products and services from abroad. Hence our research efforts should be focused on how we wish and can react to international offerings and developments, thereby protecting the head position of the Netherlands in global competition. Hence we should focus the research contributions on those challenges for which we can make a difference at the international level and gain a prime mover advantage.

To reach these long-term goals, the short-term milestones include:

1. **The establishment of new models for data ownership.**
   The models factor in FAIR-principles (findable, accessible, interoperable, reusable) but use also new perspectives on balance-of-power in ownership and right-to-use of (personal) data (intellectual property rights).
2. **A shift of the utility-focus only of data science towards a value-centric perspective.**
   The FACT-principles (fair, accurate, confidential, transparent) will have a much higher priority than they currently have.
3. **Establishment of the principle of duty-of-care for all digital products and services.**
   This includes the development of legal and governance frameworks and technological solutions for implementing this duty, thus contributing to ROBUST systems.
4. **Development of an adequate digital identity infrastructure.**
   To help establishing trustworthy interactions between citizens, government and companies worldwide.
5. **Modernisation and scaling-up of training and education in digital safety and security.**
   Not only for specialists, but also for government, industry and the population at large as to increase awareness.

Means and methods of Safety & Security

The following means and methods are necessary to reach these goals:

1. **Enlargement of the staff at universities (and universities of applied sciences)** in all disciplines related to digital safety and security so as to be able to modernise and scale-up training and education.
2. **Strengthen scientific research** in collaboration with data scientists and social scientists in the area of FAIR data, FACT data science and ROBUST systems.
3. **Focusing on new and existing public-private collaboration agendas** of the related Top Sector/societal challenge 'Secure society' and the 'National cyber security research agenda'.
4. Advancement of **safety and security components** within **application-oriented programmes,** for example in collaboration with UMCs (health), cities (smart cities), and government (digital identity).

A final thought

On 25 May 1961, John F. Kennedy, then-president of the United States, held his famous 'Man on the moon' speech to US Congress members. Crucially, the speech sets out concrete actions rather than merely painting distant horizons. Kennedy also used his address to ask for money. A lot of money. He tells the Congress members he is aware of the sacrifices ahead and asks them to think carefully before making a decision.

In 2016, the Dutch universities expressed their ambition to lead the world in social digitisation within ten years. The Netherlands is a compact, highly developed, well-organised country with excellent physical and digital infrastructures. Our universities conduct high-level scientific research across the full spectrum of disciplines. Furthermore, our researchers are highly experienced in crossing the boundaries between disciplines and institutions. This unique combination of qualities offers the Netherlands a unique opportunity. We can lead the world in creating effective interfaces between digital technology and people and their societies.

This kind of leadership position not only benefits the quality of Dutch society, it also creates huge economic opportunities. It will greatly boost our international profile and competitive position, just as our system of dikes and polders made the Netherlands a world leader in the field of water management.

The Dutch scientific community can draw inspiration from Kennedy's ambition to put a man on the moon. In one key difference, the Dutch universities have yet to bring up the issue of investments. After all, this is the responsibility of government, not of the universities.

We all know how Kennedy's efforts unfolded. US Congress granted approval, and NASA launched various ambitious programmes. On 20 July 1969, the historic day finally arrived as Neil Armstrong became first to set foot on the moon. One small step for a man, one giant leap for mankind.

Annex 1: Overview of the university representatives involved in the Digital Society

Researcher	University	Research topic
Prof. dr. Joost Kok	Leiden University	Data science; Fundamental Computer Science
Prof. dr. Andrea Evers	Leiden University	Health and wellbeing; Healthcare Psychology
Prof. dr. Bernard Steunenberg	Leiden University	Digital politics law and governance; Public administration
Dr. Marise Kasteleijn	Leiden University	E-health
Prof. dr. Hilde De Weerdt	Leiden University	Chinese History
Prof. dr. Marcus Specht	Open University	Advanced Learning Technologies
Prof. dr. Marco van Eekelen	Open University	Software Technology
Prof. dr. Wouter Stol	Open University	Police Studies
Prof. dr. ir. Remko Helms	Open University	Information science
Prof. dr. Harold Bekkering	Radboud University	Behaviour & Education; Donders Institute for Brain; Cognition and Behaviour
Prof. dr. Bart Jacobs	Radboud University	Software Security and Correctness; Quantum Computing
Prof. dr. Guillén Fernández	Radboud University	Cognitive Neuroscience; Brain Research
Prof. dr. Ronald Stolk	University of Groningen	Big data; Clinical Epidemiology
Prof. dr. ir. Jacquelien Scherpen	University of Groningen	Smart Industry; Reduction methods for nonlinear control systems
Prof. dr. Marcel Broersma	University of Groningen	Journalism; Journalistic forms and styles; Relationship between press and politics
Prof. dr. Bayu Jayawardhana	University of Groningen	Mechatronics and Control of Nonlinear Systems
Prof. dr. ir. Dick den Hertog	Tilburg University	Data Driven Value Creation; Business Analytics ; Operations Research
Prof. dr. Johan Denollet	Tilburg University	Health and Wellbeing; Medical and Clinical Psychology
Dr. Marie Postma	Tilburg University	Cognitive Science
Prof. dr. Ton Wilthagen	Tilburg University	Empowering the Resilient Society and Labour Law
Prof. dr. Frank Hendriks	Tilburg University	Design and quality of democratic governance
Prof. dr. Jeroen van den Hoven	Delft University of Technology	Ethics and Technology
Prof. dr. ir. Inald Lagendijk	Delft University of Technology	Multimedia Signal Processing
Prof. dr. ir. Martijn Wisse	Delft University of Technology	Robotics
Prof. dr. Elisa Giaccardi	Delft University of Technology	Interactive Media Design
Prof. dr. ir. Wil van de Aalst	Eindhoven University of Technology	Data Science

Researcher	University	Research topic
Prof. ir. Ton Koonen	Eindhoven University of Technology	Computer systems; Architectures; Networks; Telecommunication engineering; Optical communication; Optical fibre to/in the Home, Broadband communication networks; Fibre to the home
Prof. dr. ir. Maarten Steinbuch	Eindhoven University of Technology	High Tech Systems and Materials
Prof. dr. Bettina Speckmann	Eindhoven University of Technology	Algorithms & visualizations
Prof. dr. Rudolf Müller	Maastricht University	Digital Smart Services and Blockchain; Operations research; Quantitative Economics
Dr. Tamar Sharon	Maastricht University	Philosophy of technology
Prof. dr. Sally Wyatt	Maastricht University	Impact of Digital Technologies on Society; Digital cultures in development
Prof. dr. Ron Heeren	Maastricht University	Big Data for Health and Wellbeing
Prof. dr. ir. Boudewijn Haverkort	University of Twente	Design and Analysis of Communication Systems
Prof. dr. Dirk Heylen	University of Twente	Socially Intelligent Computing; Human media interaction
Prof. dr. ir. Maarten van Steen	University of Twente	Distributed Computing
Dr. Annalisa Pelizza	University of Twente	Governance of and by Technologies; Politics of Information Infrastructures and online communities; Quali Quantitative Methods; Media Art, Users and Urban Spaces
Prof. dr. Claes de Vreese	University of Amsterdam	Politics and communications
Prof. dr. Julia Noordegraaf	University of Amsterdam	Data Science; Media studies; Digital Heritage
Prof. dr. Maarten de Rijke	University of Amsterdam	Data Science; Information retrieval
Prof. dr. Natali Helberger	University of Amsterdam	Data Science; Information Law
Prof. dr. ir. Arnold Bregt	Wageningen University	Geographical information systems; Land use planning; Soil sciences; Geodesy; Geomatics; Spatial data; Spatial models

Researcher	University	Research topic
Prof. dr. Jacqueline Bloemhof	Wageningen University	Social Sciences
Prof. dr. ir. Dick de Ridder	Wageningen University	Bioinformatics; Plants/animals
Dr. Ingrid Boas	Wageningen University	Environmentally-induced migration; Climate security; Urban resilience
Prof. dr. Heleen Riper	Free University Amsterdam	e-Mental Health Clinical Psychology
Prof. dr. Frank van Harmelen	Free University Amsterdam	Data Science
Prof. dr. Piek Vossen	Free University Amsterdam	Linguistic Engineering
Dr. Ivar Vermeulen	Free University Amsterdam	Communication Science
Prof. dr. Marleen Huysman	Free University Amsterdam	Knowledge & Organisation
Prof. dr. Remco Veltkamp	Utrecht University	Game Research
Prof. dr. Peter van der Heijden	Utrecht University	Categorical data analysis; Multivariate statisticsm; Official statistics
Prof. dr. Franciska de Jong	Utrecht University	eResearch for the Humanities
Dr. Zerrin Yumak	Utrecht University	Information and computing science; Interactionn Technology; Multimedia
Prof. dr. Liesbet van Zoonen	Erasmus University Rotterdam	Sociology
Prof. dr. Jan Hazelzet	Erasmus University Rotterdam	Healthcare Quality & Outcome
Prof. dr. Klaus Heine	Erasmus University Rotterdam	Law and economics
Dr. Fadi Hirzalla	Erasmus University Rotterdam	The function of the internet in political and cultural citizenship

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