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VALUES, ETHICS AND INNOVATION

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INTRODUCTION

In this paper we discuss the social and ethical issues that arise as a result of digitization based on six dominant technologies:

- *Internet of Things*
- *Robotics*
- *Biometrics*
- *Persuasive technology*
- *Virtual & augmented reality and*
- *Digital platforms*

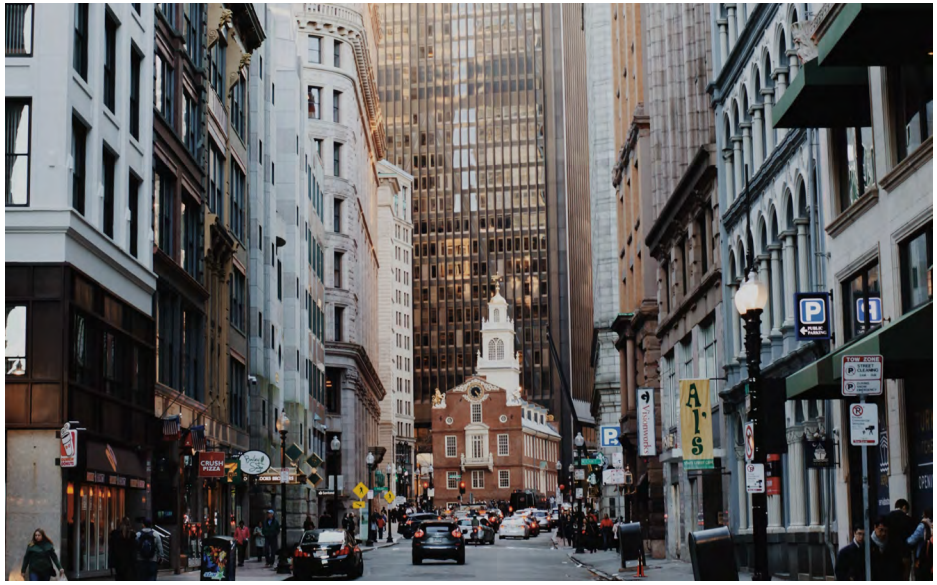
We highlight the many developments in the digitizing society that appear to be at odds with six recurring themes revealing from our analysis of the scientific literature on the dominant technologies: privacy, autonomy, security, human dignity, justice, and balance of power. This research shows that the new wave of digitization is putting pressure on these public values. In order to effectively shape the digital society in a socially and ethically responsible way, stakeholders need to have a clear understanding of what such issues might be. Supervision has been developed the most in the areas of privacy and data protection. For other ethical issues concerning digitization such as discrimination, autonomy, human dignity and unequal balance of power, the supervision is not as well organized.

VALUES, ETHICS AND INNOVATION

Technologies enable us to live longer, healthier, more fulfilling lives. Since the first Industrial Revolution in particular, the development, commercialization and diffusion of new technologies have vastly expanded opportunities for people around the world. They have also generated riches, both quantitative and qualitative, for industries and societies, increasing the real average global wage by at least 2900% since the 1700s. The technologies emerging today promise further value, both economic and social. For example, artificial intelligence alone could generate between $3 trillion and $5 trillion across nearly 20 industries, and blockchain could help revolutionize humanitarian relief.

Humankind, however, is only just beginning to realize how technologies of the Fourth Industrial Revolution are fundamentally challenging our ideas about the world and are able to bring about undesirable externalities. This goes beyond headline-grabbing concerns about robots taking jobs, cybersecurity disasters or existential threats from an artificial superintelligence. The fact is, technologies already widely deployed are slowly fracturing social cohesion, widening inequality and inexorably transforming everything, from global politics to personal identities. No one fully foresaw or intended these outcomes. However, they make it harder to deny that the influence of these technologies on society reflects how they were developed and deployed. The recent debate about data collection on social media that exploits people's vulnerabilities exemplifies how technologies embody the values and interests of their makers and how this can impact us in potentially harmful ways. As Marc Benioff, Chairman and Chief Executive Officer, Salesforce, USA, remarked at the World Economic Forum Annual Meeting 2018 last January, the task of regulation is to set true north. It is not just about what companies and governments create and do, it's about how they create and do it.

The moral role of technologies that concerns the values and ethics of technological development must be addressed at this critical moment in history, and industry is asking for guidance.
Rethinking the processes of technological development is needed, asking first what long-term future is wanted, and then how to orient technological development towards achieving it. Technologies cannot decide for people what constitutes the good life. The United Nations 2030 Agenda for Sustainable Development represents a step in this direction. It recognizes that technologies will play a role in whether the Sustainable Development Goals are reached, and establishes a multi stakeholder "Technology Facilitation Mechanism" to maximize the chances. The World Economic Forum is also pioneering a future oriented agenda – one that promotes responsible development and the adoption of new technologies, and drives a higher quality of life with greater public participation in how technologies are employed – by taking



seriously the roles of values and ethics in technological development. Leaders from multiple sectors must now come together to guide the development and deployment of new technologies that will further values, such as environmental stewardship, the common good and human dignity. To fight growing inequality and resulting populism, greater awareness of technologies' impact on human rights is required, as well as their more inclusive integration into societies and economies. This White Paper is part of the Forum project on Values, Ethics and Innovation. It expands on the call to action for values leadership in Shaping the Fourth Industrial Revolution (Klaus Schwab and Nicholas Davis, 2018). The first section of this paper argues that society and technology develop in tandem, with technologies shaping and embodying societal values, and calls for a human-centred approach to technological development. The second section identifies and describes the new tools, skills, partnerships and institutions required to achieve transformative innovation – namely, innovation that no longer widens the gap between the haves and have-nots, and that facilitates technological advance in line with social progress. All stakeholder groups stand to benefit from this approach. Governments can re-establish trust in their governance of technologies by better aligning them with societal values. Industry leaders can hope to develop new markets, attract new investment and create more positive engagement with customers. Civil society can claim a role in shaping the preservation of rights and freedoms through the design of societally aligned technologies. And citizens will have greater potential for self-realization.

Technologies continue to be seen as part of the solution to many complex global challenges in the 21st century. They are also capable of taking society forward in an inclusive, sustainable and positive way, if the right approach to their development is taken. This is a pressing issue after 30 years of stagnating wages, with 80% of the reduction in labour's share of national income attributed to technologies. Technological and economic progress can no longer be assumed to be aligned with social progress, and data from many European countries and the United States, in particular, suggest material conditions have improved much more than the quality of life. The human story over the next half century will turn largely on how well societies succeed in collectively defining their priorities, engaging essential questions about values and ethics, and aligning technological development accordingly.

TOWARDS A HUMAN-CENTRED APPROACH

How people think about technologies matters. This is not simply because technologies are the primary contributor to economic growth worldwide. It's because technologies shape people, and people shape technologies. This relationship not only impacts research agendas, it also impacts investment flows, business models and the content of education systems. The two most widely held views of technologies among current business leaders and senior policy makers fail to reflect the complexity of our relationship with these technologies. The first widespread perspective approaches technologies as mere tools that are intrinsically and unquestionably aligned with greater opportunity. The second prevalent view regards history as driven by technological progress, with people powerless to shape its direction: in this view, technologies are inevitable and out of human control.

Neither of these views, though pervasive, is ideal nor fully accurate. The lack of a more critical comprehension of technologies, and their moral role in society, reduces our ability to make informed decisions about the development and application of powerful new approaches, particularly with those technologies that blur the lines between human and technological capabilities, such as machine learning, biotechnologies, neuro-technologies, and virtual and augmented reality. A more balanced and empowering perspective recognize technologies as capabilities that interpret, transform and make meaning in the world around us. Rather than being simple objects or processes that are distinct from human beings, they are deeply socially constructed, culturally situated and reflective of societal values. They are how we engage with the world around us. They affect how people order their lives, interact with one another and see themselves. Far from an academic observation, this more nuanced view has practical importance for strategic needs as well as implications for

successful governance of technologies. This perspective opens up space for critical reflection on the question of how societies should govern technologies that pose ethical challenges and may have undesirable influences on societal priorities. It also provides ground for conversations about technology and values trade-offs and their impact on business and society. Moreover, this view allows for a better examination of technologies at different levels – from broad technical architecture to integrated personal applications. Most critically, it acknowledges that taking up these challenges involves decisions about values and uncertain outcomes. Part of the challenge is that the full impact of technologies is difficult to ascertain when they are still emerging. But when technologies are mature, embedded in social and economic infrastructure, those impacts are difficult to change. This is known as the Collingridge dilemma. The United States has tended to respond to this dilemma by prioritizing innovation as a core value, thus delaying regulation and focusing on products and outcomes. In Europe, a precautionary approach focused on process has prevailed. A classic example here is the different approaches to genetically modified foods. Policy development routes that focus on process rather than outcomes have their advantages. Reflective, deliberative and participatory approaches can more effectively embed values and ethics in technological development. The EU General Data Protection Regulation, a recent example of policy developed with ethical challenges in mind, requires organizations to consider privacy from the initial design stages through to the end of the product development process.

Focusing on processes as well as outcomes is increasingly needed as technologies such as artificial intelligence, geoengineering or gene editing have the potential to change the world profoundly and irrevocably. Waiting until they are fully developed and deployed to try to understand and shape their impact is simply not feasible. Institutions and organizations are currently underprepared to address the complex issues stemming from progress in these fields.

As mentioned previously, industry is asking for guidance here. Among global business leaders, even in the technology sector, the question is not whether there should be regulation, but rather what type of regulation and accountability are most appropriate. During his Senate Testimony in April 2018, Mark Zuckerberg stated that "the real question, as the internet becomes more important in people's lives, is what is the right regulation, not whether or not there should be regulation."
Industry leaders, as well as legislators and civil society leaders, are rapidly appreciating that technologies are having an effect on societal values in ways that can be negative. Making progress in governing technologies requires recognizing that technologies embody values. But it is not enough to simply acknowledge that the development and use of technology is inherently political, or that technologies come with built-in biases. As soft and hard forms of governance

are created through policies and laws, individuals and organizations working with new technologies 6 Values, Ethics and Innovation must engage actively and thoughtfully with the values they embody and influence. To do this effectively, a human-centered approach to technological development is called for that recognizes the tension between seeking efficiencies and realizing human values. A human-centered approach to technologies means never losing sight of one central question: How can technologies enable a meaningful future for humankind? Neither technologies nor markets can answer this question on their own. People cannot realistically support products and services that align with their values if access to them is too inconvenient or too expensive. Instead, guidelines and policies that fold societal values into technologies during their development must be established, so people are not incentivized to choose products that ultimately work against the common good. If this basic tension in technological development is ignored, the chances of unnecessary social discord will be increased, as will its uncomfortable political consequences. As philosopher of technology Peter-Paul Verbeek relates, "A real technocracy comes about when technologies implicitly answer the question of the good life for human beings." To build a just and equitable society that is more interconnected and more inclusive, the process must start with people – with their logic, ideals, experience, empathy and collaboration. Society – which is to say, all of us – must figure out how technology can empower, create meaningful opportunities, and enhance an individual's potential and agency. A human-centered approach cultivates contextual and

emotional intelligence to guide technological development based on values and ethics. It raises awareness of issues throughout the development process, supplies practical ways of addressing values-related and ethical challenges when they arise, and works to craft technologies towards positive ends for society. A human-centered approach means taking on a "co-development" mindset, paying attention to the process through which technologies and societies recursively influence and form each other. Taking on a human-centered approach involves adopting three complementary strategies: first, adopting a systems view of technologies; second, appreciating and shaping the moral role of technologies; and third, engaging with a wide variety of stakeholders.

ADOPTING A SYSTEMS VIEW OF TECHNOLOGIES

The concept of co-development can help frame how technologies and people act together to create new technologies. People develop technologies in environments that are simultaneously opened up and limited by how existing technologies have shaped societal, political and economic values. In turn, technologies now being developed will open up or limit the environment for creating future technologies by shaping society's vision, priorities, goals and objectives. Take the automobile, for example. At the turn of the 20th century, vehicles powered by steam, electric or internal combustion engines that could run on gasoline or biofuel all looked to be potential alternatives to horse-drawn vehicles. Gasoline-powered vehicles gradually reached socially transformative scale due to a wide system of aligned interests, visions, technological advances, investments, business models and political support. As this system became entrenched, it directed and constrained choices, incentivizing technologists to focus efforts on improving gasoline engines rather than on innovating in steam- or electric-powered transport. This "lock-in" has long-lasting effects, and constrains problem solving as systems develop.

The automobile opened and closed choices in other, broader ways. Widespread car ownership conferred greater personal autonomy, for example, but led to the design of cities that were challenging to navigate on foot, by bicycle or by public transport. It enabled suburban sprawl, with attractive individual places to live but ways of life that arguably eroded social cohesion. Moreover, this development contributed to deep economic dependence on oil and to pollution that has severe health and environmental consequences, including impacting climate change. None of these impacts were inevitable; they were mediated by collective choices, such as tax incentives and the relative priority placed on building roads or mass transit systems. Technologies impact entire systems – economic, social and political. They shape world views, and world views shape them as well. They are dreamed up and refined in laboratories and workshops by teams of people. Their development, just as anything else, is subject to social factors, such as tribalism, water-cooler politics and gender discrimination. A systemic view of how values and ethics become part of the technological development process is needed.

"We need a systemic perspective for thinking about where and how values and ethics can find their way into technologies and policy creation. Despite the tendency to think of technologies as objects or tools, they inevitably embody the values of their creators, whether of a small team of engineers hoping to solve a technical challenge, or of a large group of nations imagining a collective destiny. Looking at technologies from this perspective can help stakeholders shape the societal effects of technological development. In fact, well-informed leaders and creative executives already recognize the need for this and are discussing opportunities for cooperative and collaborative policy-making. Appreciating and shaping the moral role of technologies have a clear moral dimension – that is to say, a fundamental aspect that relates to values, ethics and norms. Technologies reflect the interests, behaviours and desires of their creators, and shape how the people using them can realize their potential, identities, relationships and goals. While all technologies have some impact in this regard, sometimes developers explicitly aim for a moral impact; examples include the contraceptive pill, which was intended to give women greater control over their bodies, and the Internet, which was developed with the intent of increasing accessibility as a goal. The Internet Engineering Task Force (IETF), one of the main standards organizations, states: The Internet isn't value-neutral, and neither is the IETF. We want the Internet to be useful for communities that share our commitment to openness and fairness. We embrace technical concepts such as decentralized control, edge user empowerment and sharing of resources, because those concepts resonate with the core values of the IETF community. These concepts have little to do with the technology that's possible, and much to do with the technology that we choose to create on policy, sustainability and social stability, are becoming mainstays of global multi-stakeholder conversations. Thanks to dedicated research over the last 30 years, more is understood about how and where values and ethics are relevant in the development process – from decisions about infrastructure development to organizational incentives to the imagination of schoolchildren."

APPRECIATING AND SHAPING THE MORAL ROLE OF TECHNOLOGIES

Technologies have a clear moral dimension – that is to say, a fundamental aspect that relates to values, ethics and norms. Technologies reflect the interests, behaviors and desires of their creators, and shape how the people using them can realize their potential, identities, relationships and goals.

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how and where values and ethics are relevant in the development process – from decisions about infrastructure development to organizational incentives to the imagination of schoolchildren. Economic Political, and Social Educational Curricula Economic Incentive Structures Decision making and Priority Setting Entrepreneurial Values Technical Architecture Fundraising and Investing Organizational Culture Operational Methodologies Product Design Societal Resistance human resources Values, Ethics and Innovation Broadly stated, the moral components of technologies, such as the internet, explicitly influence what they can be used for. More specifically, as argued by Corinne Cath and Luciano Floridi of the Oxford Internet Institute, the values undergirding the engineering decisions for the infrastructure and software running the internet are passed on through the functionality resulting from those decisions. How such decisions are reached impacts the capabilities of the internet far beyond the infrastructure and logical implementation layers. Ultimately, they influence the internet's economic and social layers

Ibo van de Poel, Professor of Ethics and Technology, point out that even when engineers focus narrowly on creating economic value, the products they develop often have fundamental societal impacts, such as increasing or decreasing opportunities for marginalized populations: "In this sense, engineering is an inherently morally motivated activity. Changing the world for the better is, however, no easy task and also not one that can be achieved on the basis of engineering knowledge alone. It also requires, among other things, ethical reflection and knowledge." In their book, Ethics, Technology, and Engineering: An Introduction, they outline the skills engineers need to develop moral sensibilities, moral analysis, moral creativity, moral judgement, moral decision-making and moral argumentation. Decisions they make can include or exclude potential users, based on factors such as disability, educational background, gender roles or financial means. Of course, engineers are not the only stakeholders responsible for how technologies are developed. They respond to decisions made by organizational leaders and policy-makers, and incentives created by potential customers. Unfortunately, many stakeholders are often left out of the discussion and the development process. Keeping with a human-centered approach, however, requires involving a wider set of perspectives and considering the outcomes for society – not only from the top down through regulation, but also from the bottom up through the attitudes, behaviors and actions of stakeholder groups.

ENGAGING WITH A WIDE VARIETY OF STAKEHOLDERS

Engaging a wide set of stakeholders who could be affected by technologies is more than a moral obligation; it is good business sense. Aligning systems and products with societal priorities, and anticipating and forestalling potential negative effects, can create reputational capital and lower the long-term costs of dealing with social resistance. Thinking about large stakeholder groups and their potential motivations for caring about values and ethics can shed light on where discussion is relevant:

Civic leaders and citizens are concerned with large, social aspirations, such as equality of opportunity, access to shared resources, transparency, procedural fairness and a range of rights and freedoms: values that culminate in a greater sense of well-being with a specific cultural context.

Consumers generally welcome opportunities to choose products aligned with their personal and community values and eschew technologies that are perceived to harm their interests. But if they can only influence the process of technological development through consumer choice, they may not have a meaningful choice.

Engineers are also citizens, and many are concerned about the impact of their work on society and the environment. Darshan Karwat's concept of engineering activism is one example. Supplying engineers with tools to address values and ethics gives them more agency than simply focusing on compliance issues or being constrained by economic incentives.

Executives, looking to create value for the organization and society, care deeply about purpose and know that meaningful work motivates employees, which is reflected by the success and continued relevance of True North: Discover Your Authentic Leadership by Bill George.
Boards are interested in values and ethics to develop trust within an organization and with partners, to build reputation and to create stable and supportive ecosystems and markets. With their guiding role, boards are aware of issues, a critical factor in propagating an organizational orientation based on values and ethics.

Policy-makers are obligated to enable fair and equitable marketplaces, involve citizens and create more deliberative and participative governance practices. They care about how values and ethics are incorporated into processes for technological development and outcomes for industry and society at large because societal well-being is their putative raison d'etre. Educators are motivated to improve future citizens and professionals through the study of values and ethics. They are attuned to the way values and ethics education can support intangible benefits for societies, such as concern for the common good, building trust and thoughtful deliberation.

Expecting that every stakeholder be informed about and involved in each step of developing and deploying technologies would obviously be unrealistic; so, too, would the expectation that every stakeholder will have intentions aligned with the common good or be a trained ethicist. As explored in the next section, tools and techniques can help stakeholders identify ethical issues, evaluate potential choices, express their preferences and have them taken into consideration. However, building the necessary skill sets will require new resources, curricula, programmes, training and disciplines.

THE NEED FOR NEW DISCIPLINES

Integrating a systems view of technological development with an understanding of the moral components of technologies and an inclusive process for stakeholder engagement takes this human-centered approach beyond any single discipline. New curricula and programs of study will have to be created and adopted for a world that requires more from advancing technologies as they envelop our environment and become integrated in our bodies. This new reality needs new disciplines and new structured approaches to values and ethics, especially in engineering and business studies.

Structured approaches to values and ethics, based on taking responsibility for other members of society, have long been embedded in older professions, such as medicine and law, and specifically in their training and education. Their socially situated contexts meant the decisions of their practitioners had long-lasting effects on the community. Engineering and business schools have only just begun to understand the socially situated contexts of technologies and organizations they help to create and maintain. Both disciplines need to embed a deep and nuanced practice of thinking beyond execution and towards social responsibility and outcomes. According to Rob Reich, professor of political science at Stanford University, the imperative for educational institutions is to focus on cross-disciplinary competence. He suggests that one approach could be having students focus on philosophy, politics and engineering, a new PPE curriculum, in order to begin training a new generation of professionals that will encounter this overlap in real world organizations. In the last 10 to 15 years, engineering and business schools have begun introducing mandatory ethics courses in their curricula. Front-running universities are pushing lessons from the social sciences into business and engineering disciplines through textbooks, such as Engineering Ethics; Ethics, Technology, and Engineering; and Philosophy of Technology: An Introduction for Technology and Business Students.
Programs in the Netherlands and Germany have been particularly successful in creating cross disciplinary theoretical and case-based research. Nonetheless,

ethics courses for engineering and business students often focus narrowly on issues of compliance and procedure rather than on a broader duty to think through the potential societal impact of one's work. Clear and consistent educational requirements have yet to emerge. Ultimately, lessons need to reach beyond the university to build individuals' skills, so they can influence technologies through their roles as users, consumers, citizens and investors.

ACHIEVING TRANSFORMATIVE INNOVATION

These are not theoretical issues. Engaging with values and ethics in technology is practical, accessible and essential at the beginning of the Fourth Industrial Revolution. Transformative innovation will enhance well-being for society as well as bring economic value to businesses, manifesting both tangible and intangible benefits. Leaders looking for transformative innovation can find it by shifting their perspective towards the human-centered approach outlined in the first section. Adopting this new perspective does more than clarify the role that technologies play in shaping society; it brings a more comprehensive way of increasing well-being. Three main sources of economic value are at stake, but they require a broader outlook that cultivates medium- and long-term benefits. The first major source of value will come from building trust through more attentive and inclusive processes of technological development that prioritize multi-stakeholder input. According to the Edelman Trust Barometer, industry leaders need to rebuild trust and facilitate transparency by safeguarding privacy, investing in jobs and focusing on consumer safety. Demonstrating commitment to the public by involving those affected by technologies and attempting to understand how business can further societal priorities are steps in this direction. The second source of value comes from widening the market by authentically raising well-being. Developing technologies aligned with societal values and the common good, and promoting greater inclusivity and accessibility, has the ability to affect and provide more people with a higher quality of life, creating a more robust and resilient marketplace.

And third, a larger market with increased trust between actors spells the creation of surplus value through higher quality of market participation and exchange. The lowering of transaction costs, the willingness to take risks, and the potential for the output of economies to be greater than the sum of their parts are all dependent on the fostering of an environment where values and ethics are incorporated in such a way that they blend into the background of technological development. To do this effectively, however, business leaders and policymakers must create and implement new ways of working collaboratively among employees and citizens, individuals and institutions. Transformative innovation requires new tools, new skills, new partnerships and new institutions that can mold technologies to serve a collective vision of the future.

NEW TOOLS

Soft governance tools may not be encoded in legislation, but they do have the ability to shape technological development. Standards, codes of conduct, oaths and company policies are all good starts, but consideration must go beyond simply adding a layer of aspiration. The following six imperatives identify what needs to be done as technologies are developed, and where businesses, governments and the public need the tools to do more.

1. Involve others – Participatory tools are needed to understand how a technology fits into stakeholders' lives, engages citizens in policy-making and incorporates external voices in critiques of the technological development process. From "guerrilla testing" to "journey mapping", the UK government has collated many such promising tools in its Open Policy Making toolkit.33

2. Surface assumptions – Individuals and social groups may not realize they work on different assumptions about societal values and ethical concerns, especially in environments lacking diversity in gender, background, regional experience or other factors. For example, decision-makers may wrongly assume that every city resident would welcome a network of sensors providing data about air quality, not considering that homeowners in poor areas might justifiably worry about a potential negative impact on their property values.

3. Determine consequences – Foresight tools, such as horizon scanning and scenario planning, can be extremely helpful in anticipating how a technology may influence individual behavior, how it fits into a population's "social and material arrangements", and what its "moral outcomes and consequences" may be.34 The UK Government Office for Science, for example, provides The Futures Toolkit for such foresight thinking.35

4. Align incentives – Stakeholders can explicitly align incentives at critical junctures by using more nuanced methodologies that accompany technologies as they are developed.36 While many process tools already exist, such as in responsible research and designing for values,37 they are often regarded as options and not as requirements.

5. Facilitate decisions – Tools are needed to evaluate risks and benefits to give leaders practical guidance, helping them to make decisions at inflection points of the technological development process.

6. Maintain flexibility – Technologies can meet resistance as they grow and evolve in unexpected ways. For example, how can companies and citizens constructively respond to the concern about addictive "slot-machine" principles in mobile applications?38 Leaders need tools that help in conversations with those affected and the ability to effectively address undesirable outcomes.

Design thinking, a growing trend, has an excellent set of tools that create flexibility in thought processes for developing new technologies, as well as for organizational needs. Tim Brown, Chief Executive Officer, IDEO, USA, characterizes design thinking as "a human-centered approach to innovation that draws from the designer's toolkit to integrate the needs of people, the possibilities of technology, and the requirements for business success".

Nesta, the United Kingdom's National Endowment for Science Technology and the Arts, has used design thinking to help policy-makers contextualize policy development around citizens and users. The same approach is applicable to technological development. Another example is the implementation of "The Signal Code", developed by the Harvard Humanitarian Initiative. The rights-based framework provides a clear way for governments, the private sector and civil society to think about what rights people have in humanitarian crises in relation to the ethical challenges created by information technologies and their capabilities.

To realize the potential economic value as well as the quality of life value – to push for truly transformational change – institutions and companies need to know which questions regarding values and ethics are worth asking, as well as how technologies are impacting citizens, consumers and communities. Developers and adopters of technology must answer questions such as: – Who are the stakeholders involved and what is at stake? – Whose values are driving this technology? – What values are involved with the technology at this point in its development? – How do those values align with societal priorities? – Which value sets are in conflict? – Which ethical issues need to be addressed that relate to the technology? – What is the best format for deliberation, exchange and action? – How is technological decision-making related to investment, social or regulatory pressures? – Which social groups might lose out from the effects of the technology? – What recourse is available to those affected adversely? These questions have not always been given the proper priority, but rethinking technological development and engaging in a human-centered approach will require rethinking current siloes practices.

Indeed, many existing tools can meet some of these challenges, at least in part. Transformative innovation, however, demands a systemic approach to make sense of the ethical landscape and to apply principles across the incentives, cultures, designs and constraints that result in a finished product. New, more inclusive methodologies – some in pilot schemes, others still as theoretical options – look at technological development from a broader view and address values and ethics issues throughout the process. To make full use of these tools, however, requires new skills.

NEW SKILLS

Much discussion already focuses on how the Fourth Industrial Revolution is creating the need for new workplace skills; automation replaces some jobs, significantly changes the nature of others and opens up new opportunities for people to create value. Investing in lifelong learning opportunities is a commonly promoted strategy to help labor markets adjust to this change. However, new skills that assess the values- and ethics-related issues of technologies are needed just as urgently. Critical-thinking and problem-solving skills are necessary but not sufficient. Collaborative thinking will be increasingly important, relying on broad technological competence which, in turn, implies more opportunities to experiment with new technologies. The complexity of converging technologies means that most are developed in multidisciplinary teams and working environments, requiring skill sets in science, humanities, business and the arts. Thus, collaboration skills and cognitive flexibility will be required on top of standard technical expertise. As mentioned in the previous section, skills that apply new tools and can facilitate their use within organizations will also be highly desirable. New skills are particularly required in crafting common understanding, resolving conflicts, mapping systems and overlaying them with ethical frameworks. For example, understanding when aggregate outcomes contradict the intentions behind individual actions is critical, as is being able to parse complex issues, such as the desirable and undesirable aspects of anonymity and encryption. When anticipating the future, policy-makers and educators must ask the right questions, beginning with: what values and ethics-related skills are needed now for dealing with technologies?; will these skills be needed in the future?; what value do they bring? The World Economic Forum's report, The Future of Jobs, identified the trends in skills changes most desired by 2020, and ranked the top 10.

In addition to technical and collaborative skills, stakeholders need new models for framing technologies; with these, they can challenge current structures so engrained that they go unnoticed – for example, the assumptions about artificial intelligence and robotics that initially considered automating human tasks rather than augmenting employees' skills and capabilities. Firms, governments and individuals stand to benefit from understanding how to act on and respond to issues involving values and ethics as they encounter ever more technological crises. In relation to employment, for example, it is not just the skills people have that are important – it is thinking about how these skills provide meaning, about

the intrinsic value of individuals, and about how reskilling protects and helps create a just transition for those affected by technological change. These skills can help everyone see where choices about technologies can lead to unwanted outcomes and thus help them to respond collectively. Moreover, cultivating new skills around values and ethics is essential for building a collective vision of the future, one that remains open to opportunity and retains space for self-realization. And, critically for an economic transformation, these skills can help to expand economic models beyond financial and growth metrics by "The complexity of converging technologies requires skill sets in science, humanities, business and the arts" Furthermore, developing values and ethics skill sets can help society anticipate threats, reveal conflicts between moral stances, build a collective vision, cultivate responsibility and accountability, and align business models with societal priorities. Making best use of these new skills, however, will depend on the quality of stakeholder partnerships.

NEW PARTNERSHIPS

Emerging technologies present business and government leaders with a challenge: creating, shaping and commercializing these technologies require groups of people with specialized education, vision and business acumen. Assessing their role in society demands the involvement of stakeholders who lack these specialized skills. Moreover, not all people whose inputs are needed are likely to be found in the same place at the same time. New models of collaboration that go beyond organizational boundaries create value in four main ways:

1. Understanding what other stakeholders think and how they act is necessary to develop technologies that support their values. The needs of customers, communities or members of product value chains cannot be understood sufficiently through secondary research. Traditional arm's-length approaches to consultation, based on surveys or requests for input, often fail to surface deep beliefs and cultural values critical to how a technology is perceived, used, experienced and reinvented. Partnering with a group of stakeholders around shared goals, risks and rewards is often the only way to truly appreciate what drives and challenges them.

2. Assessing and embedding positive values in the development of technology will require human resources that almost inevitably lie outside an organization. According to economist Friedrich Hayek, "the knowledge of the circumstances of which we make use never exists in concentrated or integrated form". Or, as Sun Microsystems founder, Bill Joy, stated, "No matter whom you are, most of the smartest people work for someone else." Companies cannot always solve problems by hiring smart people from elsewhere. They need to develop knowledge systems and partnerships that incentivize ongoing, strategic conversations with external experts who bring challenging perspectives and constructive feedback that can help improve products and services.

3. Partnering with external organizations can signal seriousness. Partnerships are not easy. They consume valuable management time and financial resources, making them a credible indicator of legitimacy for organizations investing in ethical approaches.

4. Working across organizational boundaries is the only way to achieve systemic change. This is particularly so in solving problems related to public goods or the commons. For visionary leaders, partnerships can transform entire industries. Successfully catalyzing new standards, spreading norms and contributing to public policy all require commitment to external engagement – often through institutional mechanisms.

NEW INSTITUTIONS

Institutions can spread new tools, skills and models of collaboration among stakeholders. This helps to turn zero sum games into cooperation that creates both tangible and intangible value for all through the alignment with societal values. Traditional institutions, however, are struggling to keep up with the complex, transformative and distributed nature of emerging technologies. Governing responsibly in response to the speed, scale, scope and impact of change will require disrupting institutions by changing their own incentives – or, in some instances, creating entirely new institutions.
As institutions evolve in the Fourth Industrial Revolution, they will have to assume four key responsibilities:

1. Protect and promote responsible innovation for a sustainable and inclusive future
2. Build clear and fair rules for competition and create incentives for players to perform in accordance with societal values
3. Safeguard and serve vulnerable and marginalized communities
4. Assess and manage systemic risks proactively that derive from the impact of technologies

Building these institutions, either de novo or from existing ones, will challenge governments and societies to work more closely together. This especially concerns technologies that could deploy government services or create perceived risks for portions of society. Participatory models that include citizens and social groups will be needed to ensure fair outcomes that optimize benefits across stakeholder domains. Constructive public deliberation will be no less important. Polarized discussion around technologies with no opportunity to resolve conflicting viewpoints could fester into political turmoil.

Inclusive governance, participatory processes and alternatives to cumbersome regulatory schemes can turn the corner towards more effective policy and public engagement. Traditional institutions, however, will have to change. Currently, they tend to act periodically, apply general principles to specific cases, focus on objectives and rules, monitor activities from a top-down perspective, and incentivize by enforcing penalties. Newly configured or engineered institutions must become more agile, inclusive and iterative – acting when needed, judging when to apply existing principles to new cases or adapt principles in light of new cases. They must focus on outcomes and impact, and incentivize through influence to create intrinsic motivation and empower organizations and individuals with responsibility and authority.

Institutions need to implement agile governance principles and engage stakeholders at each of the inflections points of the technological development cycle. Building the capacity of institutions to develop new regulation and governance, including creating new business models and incentives – from scoping and goal-setting to implementing, iterating, assessing and evaluating – is paramount. The willingness to experiment and try out diverse governance mechanisms is the key to success in a dynamic technological environment. The World Economic Forum is taking this approach as well. Applying agile governance principles and deliberation over values and ethics issues is being integrated into its System Initiatives and projects within the Centre for the Fourth Industrial Revolution Network. The Network's pilots offer the potential to further explore the development and application of values- and ethics-related skills, methods and tools. Work within the Network involves nascent and growing technologies, where many values and ethics components are often undefined and/or under-regulated, or not regulated at all. The Forum is committed to addressing values and ethics in a cross-cutting way at these early stages because it provides the greatest opportunity to profoundly influence the future.

The opportunities and threats created by emerging technologies require leaders across business, government and civil society to understand the importance of values and ethics in technological development. This means taking a conscious perspective of technological development that prioritizes the values of society and acting accordingly. Contrary to the common perceptions of the challenges of working with values and ethics, taking them on in the process of developing technologies is beneficial and, more importantly, practical, accessible and essential. The increasing attention given to how technologies can support, undermine, influence and contravene societal values is evidence of a shifting global consciousness towards a more constructive view of technology, its complexity and its impact on daily life. The saturation of urban, rural and orbital environments with technical infrastructure; the personal and professional needs for connectivity; the advancement of computational capabilities; the breakthroughs

of biotechnological manipulation; and the rapid scaling and dissemination of emerging technologies have all contributed to this shift.

Continuing to treat technologies as merely objects, industrial products or external forces prevents us from understanding how technologies impact the world around us – their cohesiveness, capabilities, models for employment, perspectives on what is meaningful, and ultimately what they value. We need to invest in a more grounded approach to technological development that doesn't lose sight of the true ends of technological progress – social progress and the well-being of humanity in terms of opportunities and self-realization – and comprehends the difference between material wealth and quality of life. This means investing in the tools and approaches that have just begun to be described in this paper.

In practice, rethinking technological development will require taking a human-centred approach – that recognizes how technologies and societies are co-produced – and prioritizing a future that involves all stakeholders, fostering the goal of greater social cohesion, trust and well-being. It will also mean developing and investing in new tools and skills, bringing together new curricula to shape future generations, and building new institutions and partnerships. This challenge is a systemic challenge, where progress made in values leadership can positively affect both technology leadership and governance leadership. In Shaping the Fourth Industrial Revolution, leaders are tasked with developing systems leadership through three components: technology leadership, governance leadership and values leadership. Taking on the imperative of working through values and ethics issues is one pillar in the move towards transformative innovation and responsible leadership in the Fourth Industrial Revolution.

THE ETHICS OF THE FOURTH INDUSTRIAL REVOLUTION

The Fourth Industrial Revolution, a wave of innovation enabled by the digital age, raises some profound ethical questions about the kind of world we want to live in. From artificial intelligence to virtual currencies, it's a complex and contentious trend. Below are articles that will help you get to grips with the ethical issues at hand.

Every day we see the emergence of new technologies. And every day we see a widening gap between progress and society's ability to cope with its consequences. Whether it is an impending shift in the nature of work as technology changes production systems, or the ethical implications of reengineering what it means to be human, the changes we see around us

threaten to overwhelm us if we cannot collaborate to understand and direct them.
Unprecedented and simultaneous advances in artificial intelligence (AI), robotics, the internet of things, autonomous vehicles, 3D printing, nanotechnology, biotechnology, materials science, energy storage, quantum computing and others are redefining industries, blurring traditional boundaries, and creating new opportunities. We have dubbed this the Fourth Industrial Revolution, and it is fundamentally changing the way we live, work and relate to one another.

This revolution is arriving on the back of a slew of transformative technologies. But it is much more than the sum of these technologies. The first industrial revolution came in on the back of a wave of innovation – the invention of the steam engine and the cotton mill, for instance – and represented a history-altering wave of systemic change such as urbanization, mass education and industrialization of agriculture. The second industrial revolution, with electrification and mass production, saw the advent of entirely new social models and ways of working, and the third industrial revolution – the digital revolution – provided the electronic and computing foundations for the radical shrinking of the world we have seen over the past five decades.

The same will be true this time – individual technologies will be influential, but the real change will be in the social and economic systems that shape our lives and how we live them.
The Fourth Industrial Revolution metaphor is most useful as a mental model to help business, government and society navigate the radical shifts that will occur as these technologies become embedded in our lives. We are encountering new business models as well as ethical, safety and social issues as emerging technologies come to life. But we have yet to collectively solve some of the most basic questions on critical issues such as the ownership of personal data, security of social infrastructure and systems, and the rights and responsibilities of the new leaders of our business landscape.

For a prosperous future, we must ask how all of us, and the technological systems we design and build, can serve the proper ends and not be confined to the means. Our efforts must focus on the impact of the Fourth Industrial Revolution on human beings, society and the environment, and not just focus on technological progress or economic productivity.
We see four principles which should guide our policy and practice as we progress further into this revolution.

Firstly, we must focus on systems rather than technologies, because the important considerations will be on the wide-reaching changes to business, society and politics rather than technologies for their own sake.

Secondly, we must empower our societies to master technologies and act to counter a fatalistic and deterministic view of progress. Otherwise, there is no room for optimism and positive transformation, and society's agency is nullified.

Thirdly, we need to prioritize futures by design rather than default. Collaboration between all stakeholders must play a central role in how we integrate these transformative technologies. Otherwise, our future will be delivered by default.

And lastly, we must focus on key values as a feature of new technologies, rather than as a bug. Technologies used in a way that increase disparity, poverty, discrimination and environmental damage work against the future we seek. For the investment in these technologies to be justifiable, they must bring us a better world, not one of increased insecurity and dislocation.

The social and economic challenges posed by the Fourth Industrial Revolution are too much for any stakeholder to tackle alone. Business has an enormous amount at stake, as creating the conditions for safe and socially prosperous technology development and deployment is critical. Active government engagement is crucial, but without engagement and collaboration with those leading the revolution, governance will always be a step behind.

And without an informed civil society understanding and engagement around the issues, we are likely to miss complex interactions on humanity, society and the environment.

The Fourth Industrial Revolution and the systemic changes it will usher in emphasize more than ever the critical need for collaborative engagement around increasingly complex and fast-moving issues. We need new ways of working together to tackle issues that arise faster than ever, provide clarity of operating environment for business, and provide society with confidence that it is moving forward into a technological future where the opportunities and benefits outweigh risks and unknowns. Leadership in these complex times requires nothing less than a wholesale shift of our mental models, a step change in collaborative engagement, and the ability to collectively envisage the futures that we want to create, and manage ourselves away from the dystopias which technological progress can conjure.

THE TOP TEN EMERGING TECHNOLOGIES

A diverse range of breakthrough technologies, including batteries capable of providing power to whole villages, "socially aware" artificial intelligence and new generation solar panels, could soon be playing a role in tackling the world's most pressing challenges, according to a list published today by the World Economic Forum.

"Technology has a critical role to play in addressing each of the major challenges the world faces, yet it also poses significant economic and social risks. As we enter the Fourth Industrial Revolution, it is vital that we develop shared norms and protocols to ensure that technology serves humanity and contributes to

a prosperous and sustainable future," said Jeremy Jurgens, Chief Information and Interaction Officer, Member of the Executive Committee, World Economic Forum.

The Top 10 Emerging Technologies 2016 list, compiled by the Forum's Meta-Council on Emerging Technologies and published in collaboration with Scientific American, highlights technological advances its members believe have the power to improve lives, transform industries and safeguard the planet. It also provides an opportunity to debate any human, societal, economic or environmental risks and concerns that the technologies may pose prior to widespread adoption.

"Horizon scanning for emerging technologies is crucial to staying abreast of developments that can radically transform our world, enabling timely expert analysis in preparation for these disruptors. The global community needs to come together and agree on common principles if our society is to reap the benefits and hedge the risks of these technologies," said Dr Bernard Meyerson, Chief Innovation Officer of IBM and Chair of the Meta-Council on Emerging Technologies.

One of the criteria used by council members during their deliberations was the likelihood that 2016 represents a tipping point in the deployment of each technology. Thus, the list includes some technologies that have been known for a number of years, but are only now reaching a level of maturity where their impact can be meaningfully felt.

The top 10 technologies to make this year's list are:

1. Nano-sensors and the Internet of Nano-things
With the Internet of Things expected to comprise 30 billion connected devices by 2020, one of the most exciting areas of focus today is now on Nano-sensors capable of circulating in the human body or being embedded in construction materials. Once connected, this Internet of Nano-things could have a huge impact on the future of medicine, architecture, agriculture and drug manufacture.

2. Next Generation Batteries
One of the greatest obstacles holding renewable energy back is matching supply with demand, but recent advances in energy storage using sodium, aluminum and zinc based batteries makes mini-grids feasible that can provide clean, reliable, round the clock energy sources to entire villages.

3. The Block chain
Much already has been made of the distributed electronic ledger behind the online currency Bitcoin. With related venture investment exceeding $1 billion in 2015 alone, the economic and social impact of block chain's potential to fundamentally change the way markets and governments work is only now emerging.

4. 2D Materials
Graphene may be the best-known, single-atom layer material, but it is by no means the only one. Plummeting production costs mean that such 2D materials are emerging in a wide range of applications, from air and water filters to new generations of wearables and batteries.

5. Autonomous Vehicles
Self-driving cars may not yet be fully legal in most geography, but their potential for saving lives, cutting pollution, boosting economies, and improving quality of life for the elderly and other segments of society has led to rapid deployment of key technology forerunners along the way to full autonomy.

6. Organs-on-chips
Miniature models of human organs – the size of a memory stick – could revolutionize medical research and drug discovery by allowing researchers to see biological mechanism behaviors in ways never before possible.

7. Perovskite Solar Cells
This new photovoltaic material offers three improvements over the classic silicon solar cell: it is easier to make, can be used virtually anywhere and, to date, keeps on generating power more efficiently.

8. Open AI Ecosystem
Shared advances in natural language processing and social awareness algorithms, coupled with an unprecedented availability of data, will soon allow smart digital assistants help with a vast range of tasks, from keeping track of one's finances and health to advising on wardrobe choice.

9. Optogenetics
The use of light and color to record the activity of neurons in the brain has been around for some time, but recent developments mean light can now be delivered deeper into brain tissue, something that could lead to better treatment for people with brain disorders.

10. Systems Metabolic Engineering
Advances in synthetic biology, systems biology and evolutionary engineering mean that the list of building block chemicals that can be manufactured better and more cheaply by using plants rather than fossil fuels is growing every year.

To compile this list, the World Economic Forum's Meta-Council on Emerging Technologies, a panel of global experts, drew on the collective expertise of the Forum's communities to identify the most important recent technological trends. By doing so, the Meta-Council aims to raise awareness of their potential and contribute to closing gaps in investment, regulation and public understanding that so often thwart progress.

THE 4 BIG ETHICAL QUESTIONS OF THE FOURTH INDUSTRIAL REVOLUTION

We live in an age of transformative scientific powers, capable of changing the very nature of the human species and radically remaking the planet itself.
Advances in information technologies and artificial intelligence are combining with advances in the biological sciences; including genetics, reproductive technologies, neuroscience, synthetic biology; as well as advances in the physical sciences to create breathtaking synergies – now recognized as the Fourth Industrial Revolution.
These new powers hold great promise for curing and preventing disease, improving agricultural output, and enhancing quality of life in many ways. However, no technology is neutral – and the powers of the Fourth Industrial Revolution certainly are not.

Since these technologies will ultimately decide so much of our future, it is deeply irresponsible not to consider together whether and how to deploy them. Thankfully there is growing global recognition of the need for governance. Whatever forms governance takes, and it will (and should) take many forms, we need to make sure that governing bodies and public discussion address four critical questions. The answers to these questions will require both scientific input and a willingness to discuss the ethical and social implications of the choices we face.

1. Should the technology be developed in the first place?
This question, for example, is now being asked with regard to a possible ban on autonomous lethal weapons, or militarized robots. To date, there is no record of a lethal autonomous weapon picking its own target and destroying it, without humans being involved in the decision-making. However, many experts see this prospect materializing in the near future, unless a worldwide ban is instituted soon.

Another example is geoengineering, which is the use of technology to alter planetary conditions, often to change the climate so as to reduce the earth's warming. This is a truly global issue that needs a collective approach, since one nation-state may make climate changes that are beneficial for itself, but detrimental to others. Furthermore, some of the strategies – for example, proposals to seed the stratosphere with nano-particles - carry unknown but potentially large risks for the planet as a whole. Science may or may not be able to quantify the risk, but even if we have risk estimates, discerning how much risk we should take, if any, is not something science alone can answer. Ultimately it is a moral assessment we need to make collectively.

2. If a technology is going to proceed, to what ends should it be deployed?
During the Fourth Industrial Revolution, there will be a wide variety of so-called

human enhancements on offer. Some will focus on eliminating diseases; others may extend human capacities we wish to promote or reduce, such as greater athletic ability, greater memory, or less aggressive behavior. Rather than making endorsements or prohibitions about enhancements in general, each type should be considered on a case-by-case basis in terms of how likely it is to advance, or diminish, human flourishing.

3. If the technology is to go forward, how should it proceed?
It matters how a technology is researched and how it enters the world. For example, The National Academy of Sciences, Engineering and Medicine in the United States recently issued a landmark report that takes a precautionary approach to the use of gene drives.

Gene drives are technologies, which in combination with CRISPR Cas9 gene editing, can exponentially increase the prevalence of specific genetic elements in a whole population of certain kinds of wild plants or animals. Right now, for example, gene drives are being considered as a way of controlling, or even eradicating, mosquitoes that are disease vectors for human illnesses, like malaria and Zika. The National Academies' report encourages the development of gene drive technology, but calls for carefully paced research, first in laboratory settings and small field studies, before engineered organisms are released into the wild.

4. Once norms have been set, how will the field be monitored to ensure adherence?
Right now, there are guidelines for many aspects of research and technology diffusion, but serious gaps in our ability to monitor adherence or hold bad actors accountable. For example, there are sound regulations for the management of some kinds of toxic chemicals, but extremely inadequate funds for regulatory staff to monitor and inspect chemical sites. Governance mechanisms for the 21st century will have to grapple with what areas need mandatory regulation and how to enforce them.

FACTS ALONE ARE INSUFFICIENT

The answers to these questions need to be informed by facts, but facts alone are insufficient. All four questions require a willingness to discuss the values we hold dear, even when values discussions may lead to controversy and conflict.
Safety is perhaps the least controversial value. Most of us around the globe believe that there is an obligation to reduce the likelihood that individuals will be harmed by new technologies. Indeed, the primary responsibility of most existing regulatory bodies is to promote safety.

But there are other very important values at stake, and they are often given short shrift. First, we should commit to equity – to doing all that is possible to ensure that all people, regardless of their economic means, will have access to technology's benefits. Otherwise, we run the risk of exacerbating what Hastings Center scholar Erik Parens has called "the already obscene gap between the haves and have nots."

Even harder to talk about are values that have to do with ways of being in the world, with how we humans relate to one another and to the natural environment.

For example, some people worry that human genetic engineering could transform parent-child bonds, encouraging "hyper-agency" on the part of parents who would focus more on designing babies to suit their needs than on nurturing children to become who they will be.
Values like stewardship and respect for the intrinsic worth of wilderness areas are often invisible in our discussions or falsely framed as in opposition to economic development. And underlying so many of these issues is the fundamental ethical question about how much we humans should intervene in changing the nature of our species, other species, and the environment. Is there a level of human intervention that crosses a boundary into hubris, or that erodes cherished virtues like living in harmony with nature, rather than in dominion over it?

In short, the Fourth Industrial Revolution has brought us enormous powers. Now we must use them wisely. Governance, which will take many forms, must involve the public as well as experts. And, whatever forms it takes, we should anticipate at least four critical questions that need to be answered, no matter the technology sector. In answering those questions, we will need deliberate, thoughtful conversations about values that are often hard to reconcile. This path will engender strong differences of opinion, but that is exactly why we must embrace the dialogue – and soon.

The past 30 years have seen incredible growth and innovation in the tech industry. We've gone from pocket calculators and PCs to pocket computers more powerful than the mammoth mainframe computers of the 1980s. The Atari 800XL computer I used in high school to develop games was powered by a microprocessor with 3,500 transistors – the one

running my iPhone today has 2 billion transistors. The cost of a gigabyte of storage was in the range of $100,000 and the size of a refrigerator. Today, it's basically free and size is measured in millimeters.
This is incredible progress, and today the pace of technology change is moving even faster. The entire planet of people and things is becoming connected. Five billion people have access to a mobile device, and more than 3 billion of the world's citizens can instantly connect with almost anyone around the world via the internet. In the next few years, 50 billion things – everything from light bulbs and refrigerators to roads and clothing – will be connected to the internet.

THE NEXT TECH REVOLUTION: AI

Every generation or so, a number of emerging technologies converge, and something revolutionary occurs. Over the past decade, a maturing internet, increasing bandwidth, compressing costs and Apple's now iconic iPhone paved the way for companies like Uber, Airbnb, YouTube, Facebook and Twitter to upend industries and redefine the mobile customer experience for billions of users. We are on the cusp of one of those disruptive shifts again. For the first time, artificial intelligence (AI) is moving into the mainstream, and thanks to the convergence of increasing computing power, big data and machine learning, it's reshaping the world we live in and our relationships with technology and each other.
Following Einstein's dictum – the definition of genius is taking the complex and making it simple – AI is about reducing complexity and embedding machine intelligence in many aspects of our lives. As it evolves, AI will become a defining technology of the 21st century, just as the microprocessor was in the 20th century.
As consumers we already experience AI as an integral part of our daily lives. Google uses machine learning to autocomplete search queries, predicting what you are looking for with great accuracy. Facebook news feeds and Amazon product recommendations are targeted just for you via machine learning algorithms. And self-driving cars apply various AI techniques to avoid collisions and traffic congestion. AI has become a worthy game player, teaching itself how to play the complex, ancient board game Go, and beating the best human player in the world.

Today, every company faces an intelligence imperative – to harness the power of AI and integrate it into its products and services. Every company wants to be as smart as Uber in using networks and data to deliver intelligent customer experiences and make smarter business decisions. The generations who have grown up digitally now expect companies to anticipate their needs and provide instant, even personalized responses at every touchpoint, across every device.

But AI has largely been out of reach for the majority of businesses due to the cost and complexity of delivering intelligence in apps. Most business decisions today are made based more on instinct than data – just a small percent of the business data available is used to inform decision making. In addition, infusing apps with AI has historically required highly skilled data scientists.

But over the next few years, AI in the cloud promises to democratize intelligence, potentially making every company and every employee smarter, faster and more productive. Machine learning algorithms can analyses billions of signals to determine which customers are most likely to purchase a particular product or automatically escalate and route customer service calls to the most appropriate agent. From online to in-store, the shopping experience is being transformed by AI. More than 90% of shopping is still done in brick-and-mortar stores today. But soon every customer who walks into a store will be able to interact with a chat bot knowing all of their shopping history, preferences and other relevant information to make recommendations, offer special discounts and handle customer service issues.

Advances in deep learning, a branch of AI modelled after the brain's neural network, will enable intelligent digital assistants to help plan vacations with the acumen of a human assistant, or determine sentiment for a particular brand by analyzing millions of signals from social networks and other data sources. In healthcare, deep learning algorithms can learn to identify types of cancer cells or intracranial abnormalities, providing doctors access to the most accurate diagnostic tool, from anywhere in the world in real time.

THE TRUST REVOLUTION

Deploying AI will require a kind of reboot in the way companies think about privacy and security. AI is fueled by data. The more the machine learns about you, the better it can predict your needs and act on your behalf. But as data becomes the currency of our digital lives, companies must ensure the privacy and security of customer information. And, there is no trust without transparency – companies must give customers clarity on how their personal data is used. It turns out that the capability of AI to detect and remedy security breaches plays a critical role in protecting user privacy and building trust.
AI is going to unleash a whole new level of productivity and augment our lives in many ways. As in past industrial revolutions, AI will also be a disruptive force, dislocating people from jobs and surfacing profound existential questions about the relationship between man and machine. It's inevitable that jobs will be impacted as AI automates a variety of tasks, but just as the internet did 20 years ago, the AI revolution will transform many

jobs as well as spawn new kinds of jobs that drive economic growth. As a society, we need to adapt to the changing nature of work by focusing on training people for the jobs of tomorrow and addressing growing economic inequality.

AI is still a very long way from surpassing human intelligence. It's taken 60 years from the time the term artificial intelligence was first introduced by John McCarthy at a conference at Dartmouth College for computers to detect cats in YouTube videos or tell you the best route and time required to arrive at the airport two hours before a flight.

But we can count on technological innovation to continue at an even more rapid pace than what we've seen with previous generations. AI will become like electrical current – invisible and augmenting almost every part of our lives. Thirty years from now we'll wonder how we ever got along without our telepathic digital assistants, just as we can't imagine life today without checking our smartphones a dozen times each hour.

So far, economies and businesses have benefited from cheaper and better imports and improvements in efficiencies in production. And growth has come from selling at a greater scale and has been achieved through volume.

Unfortunately, in the past 50 years, 60% of the earth's ecosystem has been depleted and natural-resource consumption is expected to rise by three to six times by 2050. The population is expected to reach over 9 billion people by 2050 and the global middle class is expected to triple by 2030. With this in mind, how long can we sustain this development model without further damaging the environment and aggravating existing inequalities?
The Fourth Industrial Revolution will provide some of the solutions, with a further increase in the efficiencies of the value chain through data analysis, robotics, sensors and 3D printing. We are already seeing the impact that this revolution is having on business and society.

Previously there was a greater incentive for companies to always produce more to decrease the cost of each product as quantity increased, but huge gaps between the forecasting decisions and the consumer demand create an estimated 30% waste in all manufactured goods. There is waste created at every step of the supply chain: the energy used to produce and ship the goods, the packaging and the waste of land in the landfill. 3D printing and today's hyper-connected consumers will help bridge this gap.

Avery Dennison, a packaging and labelling company, has come together with Evrything, a London-based internet-of-things start-up, to create over the next three years a web identity for over 10 billion pieces of apparel. This partnership will enable companies to track products for supply-chain purposes and decreasing waste. It will also empower customers to check the manufacturing history of these products and provide them with recycling options. The possibilities of recycled materials and high fashion were

highlighted by actress and campaigner Emma Watson through the Green Carpet Challenge. Every part of her gown had been made from recycled materials and organic cotton.

But these technological advances are only one part of the equation: the consumer will also need to reevaluate their lifestyle and their environmental, social and economic impact. They will need to assess how they choose and use products and services.

Even as consumers demand better accountability from companies, few change their own consumption patterns. This demand seldom translates into sustainable consumption. Most consumers are blocked by availability, affordability and their own skepticism. Transparency offered by technology and consistent and effective customer service can alter the public perception about green claims.

These barriers are slowly being broken down by companies incorporating data and analysis provided by this new industrial revolution. They are producing better products with maximum societal value and minimizing environmental cost. Nike is such a company, the Nike Flyknit Lunar 1+ design reduces waste by 80% compared to traditional Nike running footwear. Nike Free Flyknit has 35 fewer pieces to assemble than Nike's Air Pegasus+ 28 runner and that equates to a considerable reduction in terms of waste. Nike has perfectly combined the need of their customers with sustainability through innovation.

Companies are also marketing to influence and raise awareness, encouraging and enabling their consumers to choose and use their products more efficiently and sustainably. The World Economic Forum has created the Positive Change Effie Award which recognizes and rewards brands who emphasize sustainability in their marketing programs.

And the new generation's consumption patterns are also changing: millennial consumers are increasingly looking for products that make them look and feel good, and which are also good for the planet and society, according to the findings of the Forum's Engaging Tomorrow's Consumer project. The #WhoMadeMyClothes campaign is tied to the Rana Plaza factory collapse and calls for a renewed customer focus on supply-chain transparency and the millions of people who are a part of the industry's enormously complex value chain.
Governments and civil society will also need to engage and encourage the removal of "unsustainable" products and services from the marketplace. This editing process will be critical and will also be fueled by the new pace of change and disruptive companies. Counties like Taiwan are part of the booming upcycling of e-waste. Taiwan headquarters several major technology companies such as Asus, Acer and HTC, and produces more electronics per capita than any other country. Their commercial efforts (which returned over 2.2 billion dollars in 2012), combined with a government fund and increased consumer awareness, have helped clean up the country. It now has one of the highest household recycling rates in the world, at roughly 42%, up from 5% in 1998, according to Taiwan's Environmental Protection Administration.

The government also started the Taoyuan Environmental Science and Technology Park, an industrial complex that offers incentives for recyclers of glass, plastic and electronics, and also uses advanced technologies and invests in research and development to increase the island's reuse rates. The W Taipei has embraced this initiative and has turned the 300,000 plastic bottles created every year into coasters, games, key- and change-holders.

Organizations like Cradle to Cradle are helping companies manage resources, and address the impact at the local level. But companies, international organizations and governments still need to establish how they can work together to improve their water management. These disruptions will multiply as our existing expansionary development models clash with the natural limits of the planet.

To achieve a future where the consumer will be better equipped to lead a more sustainable lifestyle, based on informed purchase, businesses and governments need to come together. We must take the necessary action today and explore new models of consumption to ensure the needs of future generations and prevent the continued degradation of our environment.

INFORMATION AND COMMUNICATION TECHNOLOGY (ICT)

Information and Communication Technology (ICT) and digitization are ubiquitous in our society. ICT is also linked with other technologies, such as nanotechnology, biotechnology and neuro-technology. This so-called NBIC convergence has become increasingly visible since the late 1990s. Digitization penetrates every aspect of our lives: the technology nestles itself *in* us (for example, through brain implants), *between* us (through social media like Facebook), knows more and more *about* us (via big data and techniques such as emotion recognition), and is continually learning to behave more *like* us (robots and software exhibit intelligent behavior and can mimic emotions). Van Est referred to this as the intimate technological revolution. The digitization of society pushes the boundaries of our abilities and offers all sorts of opportunities, but also challenges our moral boundaries. In this paper we describe what social and ethical issues arise when society becomes digitized on the basis of six dominant technologies: Internet-of-Things, robotics, biometrics, persuasive technology, virtual & augmented reality, and digital platforms.

Internet-of-Things (IoT) and robotics mainly penetrate in our *material world* (e.g., the production process, public space, and our home). IoT is based on a worldwide network that integrates the physical world with the virtual world of the Internet. Through the emergence of IoT, we are on the brink of a new era in which objects and people in the material world can be monitored, and where objects and people can exchange information automatically. In this way, the alarm clock does not just wake up a person, but at the same time switches on the coffee machine for making fresh coffee with our breakfast; or the fridge tells us a product has passed its expiry date; or the lighting in the room adjusts itself to what is happening in a video game being played at that moment. Many technology companies predict that IoT will be omnipresent in our daily lives in the future. Many of the technologies we describe in this article are part of IoT: like the augmented-reality glasses which use the Internet to give users real-time additional information about their environment, or a biometric camera which can be linked to an online database to recognize faces. The development of IoT and robotics is strongly linked. Just like IoT devices, robots are mostly equipped with sensors to read their environment; they are increasingly connected to the cloud to share and analyse data, and on the basis of those analyses, carry out independent actions. Although some issues consequently overlap, robotics triggers its own set of specific ethical dilemmas.

Over the past 6 decades the *biological world* (e.g., the human body, the brain, and our behavior) has also been digitized by biometrics and persuasive technology. Biometric information enables the use of unique physical characteristics—such as a person's face, voice or fingerprint—for verification or identification purposes. An example of verification through biometrics is the electronic border control (e-gates) at airports. The traveler puts their passport on a reader, looks in the camera and the gate then opens or not. The identification system operates as follows: a digital image of the face stored in the passport is compared with the picture of the face taken when the traveler looked in the camera. If the biometric system—in this case a face recognition system—decides that the face stored in the passport is the same person as in the picture, the passport control system concludes they must be the rightful owner of the passport and opens the e-gate. After recognizing and analyzing human behavior, the next step is influencing that behavior. Persuasive technology is defined by Fogg as a technology that aims to encourage people to change their behavior. To achieve this, there should be the right motivation, the possibility to undertake action and a stimulus that induces certain behavior. Persuasive technology is, for example, used to persuade a driver to wear a seat belt. Security is the motivation here. By sounding a signal when drivers are not wearing a seat belt, they can be persuaded to actually fasten the belt.

The growing use of ICT also means digitizing the interaction between people, as well as between people and organizations by augmented & virtual reality and digital platforms. So digitization penetrates our *social-cultural world*: shopping, transactions, listening to music, contacting friends, taking action and finding a date are things we do increasingly online. The advent of social media and other online services in the late 1990s and at the turn of the century have had a huge impact on the way we communicate. Services have acquired an increasingly important role in our culture and for forming our identity. Our lives are, for example, interwoven with our smartphone, which forms the connection between the real and virtual world. Floridi refer to this as *onlife*: the distinction between offline and online life is now completely blurred; they have become one. Recent developments in virtual reality (VR) and augmented reality (AR) also contribute to this fusion. In AR, the real world is mixed with virtual information, animation or objects. In fact an additional digital layer of information is added to our reality, for example, via smart glasses such as Google Glass. With VR, the interaction takes place in a completely virtual, three-dimensional, interactive and computer-generated environment, in which users have an artificial experience. In the future, VR could play an important role in our social lives. It will vastly expand the social media opportunities: people will be able to spend not only time with friends online but also share all kinds of experiences and adventures. Digital platforms enable smart and efficient transactions. Through these digital platforms, radically new organizational forms began to appear after 2010. Examples are Airbnb and Uber that in a few years have become major economic players, drastically disrupting their respective branches. There are plenty of other initiatives particularly in relation to the sharing economy, i.e., the phenomenon that consumers let each other have their unused consumer goods, perhaps for a fee (Frenken and Schor). Another example of a digital platform is blockchain technology. This technology enables the development of so-called autonomous organizations—consisting entirely of bits and bytes. As the technology can automate a series of appointments and tasks, it can therefore take over the function of a certain organization.

Our description is not exhaustive but gives an idea of the various types of societal and ethical issues that arise as a result of digitization. At present, most of the public and political focus is on privacy issues (especially personal data protection) and digital security. The major challenges are the search for digital inviolability of the home and the protection of privacy with the emergence of IoT. We also see a growing focus on issues like justice and the balance of powers. Regarding the former, the focus is on big data, algorithmic profiling, the impact on the right to equal treatment, and presumption of innocence. The dominant position of large internet companies is becoming a hot topic of debate with regard to the balance of powers. Autonomy, human dignity and control of technology are still less popular topics in the public debate and are only being flagged up to a limited extent by social organizations and in policy-making and provision circles. Consequently, these are the areas where we identify blind spots in the governance

landscape. We are therefore conducting an ethical technological assessment from the perspective of digitization, and that digitization and the ensuing social and ethical issues will find their way to the social and political agenda.

Our analysis of the scientific literature on technologies revealed several recurring themes: privacy, security, autonomy, justice, human dignity, control of technology, and the balance of powers. We have applied these themes to structure our discussion in this paper. The various ethical and social issues manifest themselves per technology in different ways. Privacy, for example, takes on a whole different meaning in the context of IoT than in the context of biometrics. Not every theme is explored in depth for every development; we focus on the distinctive issues that a particular technology demonstrates within the overarching trend of digitization. Finally, our summary in the conclusion shows which ethical and social issues have explicitly put the new wave of digitization on the map. We briefly indicate how the issues in this paper relate to important values as laid down in international treaties.

The research to describe the ethical and societal issues raised by digitization was done by carrying out a literature review. The scientific literature, mainly, from 2010 was investigated for each area of technology, using search engines such as Google Scholar and Scirus as well as the PiCarta database. Combined with the term for the technology (or related terms and synonyms of this technological field), we entered the following search terms for each area of technology: ethics, ethical, moral, morality, normative, or normativity. Based on the finding publications, we describe the most urgent and problematic ethical and social issues per technology mentioned in the literature. In addition to scientific publications, the desk review included consulting all kinds of newspapers and news sites to illustrate certain issues based on compelling reports in the news.

PRIVACY AND DIGITAL HOME

Through IoT, more and more information about ourselves is being exchanged, without us really knowing or having control over it. Samsung's 46-page privacy policy that comes with its smart TV, tells you that Samsung registers where, when, how and what time you have your TV turned on. The TV also has a camera for face recognition and a microphone for speech recognition. Samsung's manual warns you to watch out what you say in the vicinity of the TV: "Please be aware that if your spoken words include personal or other sensitive information, that information will be among the data captured and transmitted to a third party." This led to quite a fuss. The example shows that permission is given unwittingly to use certain data, because people are not able to understand the entire manual or are suffering from so-called *consent fatigue* due to the large amount of permissions they have to grant about using data that devices capture (Pereira et al)

This raises the question of where the responsibility lies in this process: should the user be expected to sift through the conditions for each and every device? Or do the manufacturers of all these devices also bear some responsibility? Should they not ensure a certain reasonable expectation of privacy?

Because of IoT, we can in fact be followed everywhere, which can lead to huge transparency at the expense of our privacy. In most cases, the data collated by smart toothbrushes, thermostats, televisions, refrigerators and washing machines are the property of the manufacturer, not the user. The home, which we consider to be our private domain, is thus becoming transparent, because processes in the home can be monitored via the IoT devices inside our houses. The distinction between home and the outside world is blurring as the walls and curtains no longer protect the house against prying eyes. That is why Koops and Prinsen argue for protecting citizens against this digital spying and for providing citizens with digital privacy alongside physical privacy in the home. This should ensure protection against observation from outside with technical aids, so that citizens have a place where they can pre-eminently be themselves.

Pervasive monitoring

Just like the IoT, robots contribute to the increasing potential for collecting data in situations where formerly no (digital) data collection took place. Robot technologies can be deployed in a variety of ways to monitor certain situations, such as a patient's wellbeing, a car driver's state of mind or the safety situation on the street. As a direct result, robot technologies can invade our privacy in all sorts of ways. Robots and domotics, for example, can monitor people, record and pass on details of their physical condition, and even enable a care recipient to be watched 24 h a day. As this data provides a great deal of information on the care recipients' daily ups and downs, it thereby raises issues about their privacy. Care recipients will not appreciate, for example, that it is recorded when they are not yet dressed or about to have a bath. This issue is more complex when it comes to older people with dementia: to what extent can they show whether they are aware of the presence of a technology that captures their daily lives (Borenstein)?

Privacy enhancing versus losing control of sensitive information

In relation to privacy, biometric technology is a double-edged sword. It can be used to protect privacy, whereby only the minimum amount of information is required to determine whether someone is entitled, for example, to enter a building or to buy alcohol. On the other hand, because biometrics can identify sensitive information, controlling what happens with that information may be tricky, especially now that the technology has reached the stage of being applied in many more devices and situations.

In the above example of the e-gates, biometrics is implemented in such a way that privacy is guaranteed. The identity of the user is not released, only authentication takes place: is the face in front of the camera the same face as in the passport? Verification can also be done by comparing someone's biometric characteristic with the information already stored about that person. For example, if wine shops make use of a biometric fingerprint system to verify that someone is older than eighteen, all they need to know is that the information in the fingerprint belongs to someone over the age of eighteen. The name of the customer is not important. Thus biometrics can be a good way to prove legitimacy while maintaining privacy.
Other applications of biometrics are particularly aimed at identification and recognition .

For example, someone's facial profile is compared with a database to see if the scanned person appears in that database. The technique is applied in police investigations or for security cameras in public spaces. This use is regulated by law; importantly, such highly sensitive information must be stored safely and securely. The biometric data can namely contain information about the user's health and ethnicity. It could be undesirable that, for example, an insurance company or employer gets a hold of the information. This problem is aggravated by the fact that modern biometric identification methods can also find indications of a person's health risks. An iris scan can, for example, determine diabetes or high blood pressure. Irregularities in fingerprints may indicate leukaemia or breast cancer.
Recent years have seen huge advances in biometrics. The presence of large databases with photos, the accessibility of software, and the ubiquity of cameras in smartphones, ensure an uptake of facial recognition technology in an increasingly wider range of situations (Janssen et al.) Scientists showed that by using facial recognition technology and public data in Facebook profiles, they could identify a third of the students on a university campus (Acquisti et al). The fear is that accessible facial recognition technology could ultimately lead to a situation where it is no longer possible to walk down the street anonymously. The app FindFace, which was launched in Russia in 2016, allows users to compare a picture they have taken of someone on the street, with profile photos on Vkontakte—the Russian counterpart of Facebook—in order to discover someone's identity. "If you see someone you like, you can photograph them, find out their identity, and then send them a friend request," according to one of the app's creators (Walker).
The next generation of biometrics not only gives insight into "who you are" but also focuses on the question "how you feel" (Mordini et al.). Emotion recognition technology, for example, gives insight into people's state of mind, and can even be used to expose emotions that people try to hide, by examining people's unknowingly automatic non-verbal comments (Dwoskin and Rusli). This is an invasion of a new field of privacy, namely "mental privacy".

We are talking about people's right and ability to keep private what they think and feel. In addition to facial expressions, other forms of behaviour can be analysed. Certain ways of walking, grimaces and other facial expressions can reveal something about a person and their behaviour. The extent to which a person has control over whether they submit the above data seems to be limited, as the collection of this information can be done remotely and covertly, for example, by inserting facial recognition technology in mannequin without the knowledge of the person being observed (De Hert and Sprokkereef).

Little Brother and misuse of virtual avatars

A hotly debated development in AR is Google Glass. Launched in 2013, this portable computer designed in the shape of a pair of glasses, projects information onto a small display in front of you. In early 2015, Google stopped manufacturing Google Glass as a consumer product for the time being in order to focus on business applications. One of the reasons why the public launch of Google Glass floundered was because of so much public unrest concerning the possibility to film private conversations and social interactions (unsolicited) with the glasses. The development of AR is causing concerns about a so-called 'Little Brother' scenario: instead of a government spying on everyone, citizens and companies are the ones spying on each other continuously. Smart glasses or lenses are ideal for tracking people and spying on them without people being aware of it (Gese). Especially if such AR glasses or lenses are equipped with a face recognition app, the user gets real-time information about the person in front of them. The glasses thus enable the wearer to register all sorts of things without others seeing that registration is taking place. The fact that this is against the law will probably not hinder attackers, because it is almost impossible to trace them.

In addition, the smart glasses or lenses raise yet another issue: who owns the images that the glasses record? In other words: does the wearer of the smart glasses or lenses have exclusive rights to his/her own observations (Brinkman; Wolf et al.)? Google applied and obtained a patent for the technology that enables the company, by following eye movements, to see what the person wearing Google Glass is looking at. In this way the company not only has at its disposal the image that the wearer of glasses sees, but also obtains information on precisely when and what the wearer is looking at. Other companies that record images can make very good use of this data for profiling and thus incorporating it in their business model.

The issue with privacy in VR concerns the new ways of tracking people's behaviour in virtual spaces. Games manufacturers like Knack demonstrate, that from the way someone plays a game in the virtual world, we can learn a great deal about their personality, how they interact with others and how they solve problems (Peck). The more that social interaction shifts to social networks in VR—Face-

book's aim—the greater the impact on privacy. In addition, continuous monitoring can lead to social conformism, reduced authenticity and self-censorship (O'Brolchain).

Insight in all platform interactions

The issue of privacy also applies to digital platforms. The platform administrator can track all the transactions and interactions that take place within the platform and many of these transactions contain sensitive information. Platforms can easily track their users with simple tools. In particular the way Uber (employees) dealt with the privacy not only of their drivers but also of their customers, caused quite a stir (Rogers). It was reported that Uber used their so-called 'God View' real-time tracking system on customers as well as drivers. An Uber employee's blog post, which incidentally has been removed, bragged that, based on the data they collect, Uber can assess which of their customers has had a one-night-stand. They can draw this conclusion when two different customers are dropped in the evening at an address where neither of them lives, and are picked up in the morning and then each taken to their own address.After reaching a 20,000 dollar settlement with the department of justice in New York, Uber tightened up their privacy policy. 'God View' has since been anonymized and the number of employees that can access drivers' personal information has been reduced. In addition, the location data for the Uber drivers and customers is encrypted. This data can still, however, be viewed with a password known to Uber. Strict surveillance of privacy guidelines for platforms that have a tendency to evade regulations, seems badly needed. In this way, it can be clarified what data is collected, how it is collected and used, and whether it is resold (Scholz).

Autonomy and Technological paternalism

IoT does not just offer us comfort, but can also lean towards technological paternalism (Hilty). We speak of paternalism if someone professes to know better what is good for other people than these people themselves. With technological paternalism, the paternalism is 'delegated' to technology. A smart fridge is technologically capable of changing the order for your favourite cheese to a low-fat cheese because the biometric sensor has measured that the particular person's cholesterol levels are too high. The question is, however, whether the fridge and the biometric sensor should be allowed to make such a decision together. This kind of technological paternalism has serious ethical implications for IoT: the implicit enforcing or provoking of certain behaviour can endanger personal autonomy. What is more, IoT can thus be implemented as persuasive or even manipulative technology.

Control and manipulation through technology

The most prominent ethical issue that imposes itself on persuasive technology is that of human autonomy: to what extent may we influence people and when can we apply this technology? According to Smids, persuasive technology should comply with the requirement of voluntariness to guarantee autonomy. An action is only done voluntarily if the action is done intentionally (the one acting is 'in control') and is free from controlling influences. For example, if someone does not want to wear the seat belt and hears a constant beeping sound, they are being subjected to a controlling influence—in this case a kind of coercion. The driver can only stop the irritating sound by fastening the belt. Besides this coercion, there are examples of manipulation of controlling influences (such as withholding information or deception) and excessive stimuli (for example, a massive reward).

Ideally, persuasive technology aims to halt temptation, and have the user independently display the 'desired' behaviour. In that case, persuasive technology is training the user. The purpose of training someone is that they can function independently and no longer need guidance. Unlike training, manipulation aims to keep someone dependent. According to Spahn, persuasive technology should be training not manipulation, and eventually make itself superfluous. An important condition for this is that the user shares the same goal of the intended persuasion. If a user wants to drive more sustainably, she will warmly embrace any attempt to help her achieve her goal. If the user does not share this goal, then an additional motivation can provide a solution, in this example by pointing out that it is financially attractive to drive sustainably.

Technology that triggers behaviour in a more compelling way is, however, not necessarily undesirable. Firstly, people themselves can opt for compelling technologies. Some people are very pleased with the peeping sound that a car makes if it is too close to another vehicle or object, for example, when parallel parking, or with rest break software to prevent RSI with programmes that compel you to take a break. People decide for themselves, by not switching off these systems, to depend on this technology. Secondly, compelling technologies could be used if the individual's behaviour can lead to a collective risk. Some people advocate mandatory speed limiters in cars, which restrict individual freedom but reduce the collective risk of other road users.

As we have seen, persuasive technology can also feature in smart IoT environments. This means that influencing becomes part of the environment and in some instances occurs less consciously. This is the case when subtle feedback is given on ambient lighting (Maan et al.), whereby the 'nudging' takes place at a low cognitive level without the user being aware of it. Such forms of persuasion may constitute a threat to the individual's autonomy if behaviour is controlled without the individual knowing or being aware of it. Transparency and insight in the way persuasive technology is applied are therefore important factors for protecting autonomy.

Steering preferences

When a smart IoT environment anticipates our needs and wants, a choice is made about our supposed preferences—for ex-

ample, suggesting a selection of certain TV programmes—based on previously displayed behaviour. With that choice, the smart environment sorts our options and steers us in the direction of certain choices and behaviour. The way subtle changes in our behaviour can be accomplished through technology became apparent from the Facebook emotion experiment in 2014. By adapting the number of positive and negative messages in users' *newsfeeds*, they were able to influence users' state of mind without them being aware of this (Kramer et al.).
Hildebrandt puts forward that a future generation of technology could be so sophisticated in reading our preferences, that it detects preferred choices before we ourselves are even aware of them. She outlines the scenario of a smoker: someone profiled as almost wanting to stop the habit, but has not yet consciously made that decision; they are subsequently targeted via ads and news reports criticizing the negative effects of smoking, to steer them in a different direction. According to Hildebrandt, providing transparency in the profiles on which automatic decisions are based, is an essential condition to protect the autonomy of the individual.

'Man out-of-the-loop'
In robotics we see a shift "from *in*-the-loop to *on*-the-loop to *out*-of-the-loop" (Sharkey), which is also noticeable in IoT. In-the-loop means that the person is in control and human permission is required to have the system carry out an action. On-the-loop means that the person makes a decision based on information in the system. Out-of-the-loop refers to a situation of full automation, where the system makes a decision without human intervention. The shift from *in* to *on* and *out* of the loop has occurred due to the increasing amount of information from various sources/devices that has to be integrated and subsequently interpreted to come to a decision. Robots can do this far more efficiently and effectively than humans, for whom it is almost impossible. As a result, people in fact no longer make the decisions themselves but leave it to technology. Examples include knowledge systems that make medical diagnoses based on a large amount of information, military robots that take life or death decisions using information from various sources, and the driver support systems that decide what speed we should drive on a particular stretch of road. It raises the question of how these systems come to their decisions and if the competitor's software would make the same decision.

Due to the huge advances in artificial intelligence, robots are becoming more and more autonomous. The crucial question is: to what extent is it ethically acceptable to delegate the responsibility for moral decisions to robots? This is an ongoing debate in the field of military robots and self-driven cars. According to Arkin, the military robot will surpass humans when making moral decisions, because human soldiers undergo tremendous stress in the battlefield, and robots—free from stress—make fewer mistakes. The problem here is that robots cannot be called to account, and for many scholars, that is the reason why robots should never be allowed to make life and death decision.

The same problem occurs with self-driven cars. Traffic accidents are inevitable, also with a self-driven car, and so this car will experience situations that require a moral decision (Goodall). In such a situation, a human driver acts instinctively; It is impossible to expect him in half a second to make a well-considered choice between driving into a truck or mowing down a child on the pavement. For a self-driven car, however, half a second is more than long enough to asses various scenarios. Should the car choose the least injury to the occupants of that car or, for example, for the least total damage, thereby also taking other road users into account? The question we need to ask before this issue arises is: Do we leave this moral decision to the self-driven car, or do we determine beforehand what this car should decide in situations where it cannot avoid an accident?

Filtering and freedom of expression
Online platforms play an increasingly greater role in determining what information and what news people see. A well-known example is how different persons' Google search results vary because of a personalization algorithm that looks at things such as previous searches (Pariser). Algorithms used to be deterministic—the programmer determined beforehand an action for every situation—and it was possible for someone to figure out how the algorithm came to a decision. Through systems like artificial intelligence, algorithms do not follow a predetermined set of rules but make use of self-learning statistical techniques. As a result, the decisions that an algorithm makes are almost unfathomable and uncontrollable for humans (Pasquale; Scholz). To prevent manipulation, it is therefore crucial that we understand why such algorithms make certain choices, and how to implement transparency (Turilli and Floridi). Research by psychologist Robert Epstein showed that search results can greatly influence voters' preferences by changing the order of the results in a search engine, such as Google. According to Epstein, this represents a serious threat to democracy. This raises questions about the steering role of major platforms and also about freedom of expression. A recent example is when Facebook removed the iconic and harrowing 1972 World Press Photo of a girl fleeing from a napalm attack (the 'napalm girl' as the picture would later be called). Following widespread criticism, Facebook later reversed its censorship decision and reinstated the photo. Other platforms like Google and Twitter (not forgetting Facebook), have been criticized for facilitating the spreading of 'fake news'. This has led to a debate on the role and responsibilities of platforms in relation to freedom of speech and filtering information. In the aftermath of the 2016 US presidential elections, this debate triggered a great deal of controversy. The platforms are examining what action they can take against fake news.

Information security gets a physical dimension
Digitization also presents serious crime problems: the Internet or the devices connected to the Internet can themselves be the target of crime, as is the case with

hacking or DDoS (Distributed Denial of Service) attacks which paralyses websites or systems. Experience shows that virtually any digital system can be hacked. In 2012, for example, researchers at the University of Texas demonstrated to the US Department of Homeland Security how relatively simple it was to hack into and take over control of a military drone. To do this, they used the technique known as *spoofing*: obtaining unauthorized access to a device by forging the identity of the person controlling the device. There is indeed a fear of cyber-terrorism in policy circles.

Hackers can also gain access to sensitive information, and that information could end up in the hands of the wrong people. A hacked smart meter could give burglars insight in the exact times of the day or week when we turn the heating down and are—evidently—absent. Besides extracting information that is valuable to them from smart devices, criminals can take over the control of smart devices. This adds a physical dimension to the issue of security. A security researcher demonstrated how simple it is to hack the toy doll Cayla, and have it quote passages from the erotic novel *Fifty Shades of Grey* and from the fictional psychopath Hannibal Lecter in the book *The Silence of The Lambs*. The hacking of the doll is a relatively harmless example, but New Zealand hacker Barnaby Jack showed at a conference in 2011 that he could hack his friend's insulin pump. He could take complete control and was able to administer a fatal amount of insulin. Other hackers have also already pointed out that they could take control of a wireless pacemaker and have the device deliver a fatal shock (Greenberg and Zetter).

The issue of security is becoming even more complicated because of the fact that IoT devices are connected to each other. So, for example, successfully hacking a coffee machine can give you access to a car or open the front door. In addition, this type of security issue is new for many manufacturers of consumer electronics, which means it has not always been given much thought. As hacker Runa Sandvik neatly surmised, "When you put technology on items that haven't had it before, you run into security challenges you haven't thought about before" (Greenberg and Zetter).

Identity fraud

Identity fraud is a major social problem that will probably only increase in scope (Sandhya and Prasad). Identity fraud is the intentional obtaining, appropriating, owning or creating of false identifiers, thereby committing or intending to commit unlawful conduct. Advanced biometrics has to reduce identity fraud. Passports nowadays have a chip with a facial scan and digital fingerprints. In the United Kingdom they use iris scanning. Besides the frequently mentioned convenience for users, biometric recognition also has the advantage from a security point of view that the user must be physically present. This reduces the risk of fraud by means of falsification of documents, theft of cards and revealing of passwords.
However, biometric technology is not infallible (Heimo et al.): biometric systems

can be misled with falsified elements, for example, by means of spoofing: falsifying characteristics in order to assume a false identity temporarily. In this way German hackers showed that by using a couple of photos—such as those of a press conference—they could forge the German Minister of Defence's fingerprint (Hern). Another disadvantage is that in case of biometric identity theft, no other fingerprint or facial profile can be made, unlike being able to request a new password. Less sophisticated methods of detecting identity fraud also led to the first horrific scenarios with securing fingerprints. In a car equipped with a fingerprint reader, during a car theft, in order to disconnect the security, the owner's finger was cut off, so that the perpetrators were able to drive off in the car. Instead of consisting of mere information about persons, also a proactive understanding of biometrics is needed to consider the ways in which this 'informatization of the body' may eventually affect how people use their bodies and experience space and time (Hayles; Van der Ploeg).

Safety: psychological damage in virtual worlds (VR)

German philosophers Madary and Metzinger () focus on the risks of VR technologies that give users the feeling they are in a different body to their own and particularly in situations where users interact with other virtual or real people. In these situations, unethical behaviour occurs which has already led to controversy with computer games (Seddon). A well-known example is that someone reported that her avatar was apparently indecently assaulted in the computer game Second Life. According to Madary and Metzinger, the emotional involvement within a virtual environment in which we are *actually embodied* is much greater. That means that the psychological damage that someone incurs as a result of an indecent assault in virtual reality, will probably be much greater than previous cases in the game Second Life (see also Kizza). It is expected that in the near future, people will visit each other more often in virtual environments and that social networks such as Facebook will also support these possibilities.

Balance of power

IoT devices are often offered as part of or in combination with a software service. Thus the sale of a smart TV or smart refrigerator can include software support. The product's capabilities are for the most part embedded in the accompanying software. Thus the ability to have the refrigerator in the morning display the schedule for the following day, depends on the manufacturer's software support. The manufacturer can decide to stop offering support for older appliances, rendering them partially or entirely useless. The Electronic Frontier Foundation raised the alarm because consumers, having forked out hundreds of dollars for a smart home console with lifetime software support, were suddenly left with a worthless product because the support was removed after a competitor took over the company (Walsh).

When products become more dependent on software controlled by the manufac-

turer, this strengthens the manufacturers' control and how that can be utilized. In addition, there is a noticeable trend that the products themselves are being offered as services. This is called 'servitization': consumers no longer buy light bulbs but purchase light as a service, they do not purchase a washing machine but make use of washing services, etc. The manufacturer is responsible for the maintenance of the appliances, consumers only need to pay a periodic fee. Proponents advocate the convenience that such services provide, whereas opponents see consumers' control of their own environment dwindling; it is, for example, no longer possible to unscrew or adjust something yourself. The manufacturer retains ownership and can decide to change the product in some way whenever they like. A case in point is when Amazon decided to remove from customers' eReaders certain eBooks by George Orwell, notably the author of the work 1984, due to a conflict with the supplier about copyrights. Amazon was allowed to do this, because customers did not officially purchase the books, but had them on loan from Amazon (Stone).

Who sets the standards?

In relation to persuasive technology, a user is not able to engage in a discussion with the technology like they can with a human interlocutor. That makes for an asymmetrical relationship in this communication: the standard is set in the technology, and the user is unilaterally exposed to it. Spahn therefore argues that it is important that the user has as much influence as possible on how this standard is determined, and consciously agrees to applying persuasive technology. If a user decides to purchase a digital fitness coach, we can assume this is of her own accord. However, when persuasive technology is used in the context of a working environment or in insurance, this issue becomes more problematic (Timmer et al.). It raises the question of whether the employer or insurer should be allowed to determine the standards for an employee or client's behavioral change, or if this is an infringement of their personal autonomy. The Dutch data protection authorities recently ruled on the application of wearables by employers for gathering personal information, but there is still no ruling on whether employers may implement wearables for steering behavior.

Unfair competition and monopolisation

According to Scholz, certain platforms' success is not only due to the technological possibilities, but is to do with the company's concerned applying 'illegality as a method'. This leads to unfair competition between platforms and regular companies, because platforms do not (have to) stick to the rules or permits that apply to regular companies. Airbnb enables individuals to let rooms without a license, and does not have to fulfil the same safety and tax liability requirements as regular hotels. UberPop drivers do not have to keep to the driving and rest periods, nor comply with the same safety regulations as taxis, and they do not need to charge VAT. On the other hand, the average UberPop driver earns less than the minimum wage and most drivers see this as a part-time job.

Frenken et al. think that a tolerance policy is initially logical in order to give experiments space and to assess the effects. However, the authors advocate clear legislation as platforms like Airbnb and Uber are growing so quickly that they have a disruptive and unexpected impact on existing sectors and on society as a whole. Such platforms can be concentrations of power, with monopolies consequently yielding high profit margins. These monopolies can exist because the platforms typically benefit from network effects as we have seen with internet companies like Google (internet searching), Facebook (social networking) and WhatsApp (mobile messaging). Whatsapp, for example, only works if there is a large network of users. Once an app like this becomes the largest, competing with it is almost impossible because of what we call 'the winner takes all' (Kreijveld et al.). Kreijveld et al. state that it is relatively easy for platforms to expand their scope by integrating and adding new services (like Uber, that is now working on package delivery), which begs the question whether such platforms are not getting too big. One consequence is that users become dependent on such a platform, because it is a hassle to use a different platform where the network is too small and therefore not interesting. Accumulated data and connections within a platform as well as other services associated with the accumulated profile also make it difficult for a user to move to another service - the so-called '*lock-in* effect' (Parker and Van Alstyne).

Relations between private and public parties

The 'public space' on the Internet—consisting of things like social networks—is mostly in private hands. All the interactions that take place in that pseudo-public space are therefore the property of the platforms, and the information generated in this way can be used or resold as required. Also the conditions for interactions taking place, and what statement may or may not be desirable, can be changed by the platform administrator at will. There has been a lot of controversy about Facebook's decisions to remove certain statements from the platform. Critics argue that the current situation is leading to a form of *digital feudalism*, a situation in which people's ownership of themselves—their digital representation—is lost.

Governments are also gathering more and more data about citizens. Helbing et al. describe a future scenario of *big nudging*, with authorities using data to steer citizens' behavior. The most striking example is the Chinese Government: for each of its citizens it keeps a *citizen score*, which plays a role in determining whether someone is eligible for a loan, a visa or a job. Government data collection is causing increasing information asymmetry between citizens and governments, with citizens becoming more transparent and governments becoming less transparent for their citizens.

Dehumanization and unemployment

Although robotics can provide great support in health care, entertainment, the

police and the army, if the technology is not applied within certain framework conditions, it can undermine human dignity. We are talking about the risk of objectification or instrumentalization of people, in other words dehumanization.

The health care sector seems to be anxious about the implementation of robotics. The way robots are deployed seems the crucial fear. Coeckelberg argues that care robots should only be used for 'routine care tasks'. That means tasks for which no emotional, intimate, personal involvement is required. If robots are deployed to replace the caregiver, there is a risk that care is dehumanized (Sharkey). When robots take over tasks such as feeding and lifting, the care seekers can feel like objects. The ethical complaint about 'objectification' ties in with the idea that robots cannot provide care. The underlying argument is that robots are devices which are not able to replicate the empathic capacities and reciprocity of human care relationships. Human contact is usually found to be essential for providing good care. The patient's quality of life should therefore be the guiding principle for robotics in healthcare (Van Wynsberghe).

There is also a risk of dehumanization in other areas of care. Soldiers, who control armed robots remotely, are not present in the danger zone. In such a situation, the use of tele-guided robots creates an emotional, and therefore also moral, distance between the action and the ethical implications of that action. Proponents argue that this can reduce psychological suffering among soldiers and ensure decisions are more rational. Critics fear that the danger lurking in creating more distance between an action and its consequences is that controllers make important, sometimes life or death decisions, as if they are playing a video game. Tele-guided armed robots can heighten the risk of dehumanizing the enemy and desensitizing the controller (Royakkers and Van Est).
Another aspect that has led to a great deal of discussion in recent years is the potential impact of robotization on employment. Robots are not only capable of supporting human tasks, they can gradually replace more and more human tasks and therefore also jobs. Two opposing views dominate this discussion on the effect of automation: on the one hand robotization leads to economic growth, employment growth (new jobs are created) and an acceptable distribution of wealth; on the other hand, robotization leads to fewer jobs and consequently declining prosperity.

Instrumentalization and the standard user

Biometric systems can give both 'false negative' as well as 'false positive' results. You get a 'false negative' result when the identification device does not recognize an authorized person. This need not be a problem if they can immediately try again to identify themselves.

But something like this can also cause a great deal of inconvenience. For example, a motorist in the United States had his license taken away because the facial recognition system mistook him for another person. It took 10 days of bureaucratic wrangling before he could prove who he was and finally get back his license. This example shows that the use of biometric systems can lead to instrumentalization of the individual, thereby reducing the individual to a data point in a system. The user-friendliness of biometrics is great if the system works well for people. But for those who are incorrectly identified as suspicious by the system, it is often very difficult to rectify errors. In addition, it appears that biometrics cannot be used for everyone. Two percent of people's fingerprints cannot be 'read' because they are senior citizens or because of certain chemotherapy treatments (Renaud et al.).

This kind of problem occurs in many digital systems: they are designed on the basis of particular standard user characteristics, which means they are not always accessible to people who do not conform with these criteria, for example, because their name does not match the system, or they have changed gender.

Unlearn moral skills

One objection to persuasive technology is that users' actions have nothing more to do with ethics: they make no moral decisions but simply display controlled behavior (Spahn). A driver support system that constantly warns us if we are driving too fast can be very effective in terms of safety, but the risk is a certain reduction in standard awareness. Persuasive technology is potentially a powerful regulatory tool, but the moral issues call for further consideration of applying it as technical regulatory instrument. Critics paint a doom and gloom picture of persuasive technology creating a society whose citizens are controlled to behave according to the norm, without sensing that norm themselves. Internet critic Morozov therefore makes the case for technology that stimulates people's deliberative capacity (the ability to gather information and consult with other people and exchange arguments), and encourages reflection leading ultimately to behavioral change. A smart car prompts the user to drive more economically, but not to think about leaving the car in the garage for a day. In Morozov's opinion, persuasive technology should therefore encourage us to do the right things.

Desocialization and alienation

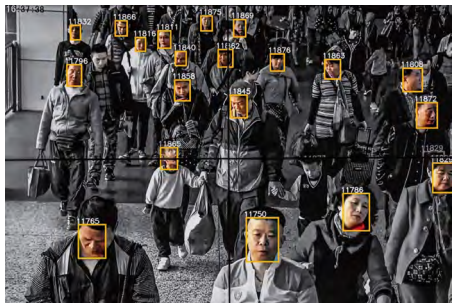
VR technology defies the usual distinction between virtual and real worlds. This arouses the fear that at a certain moment, people can no longer distinguish 'real' from 'fake'. Melson and others fear that the massive use of these technologies will replace our interaction with nature. As a result, we will also miss the healing and creative power of nature. Louv speaks of the *nature deficit disorder*. Madary and Metzinger even voice the danger that frequent VR users will regard the real world and their body as unreal, and that their sense of reality shifts exclusively to the virtual environment. They end up neglecting their actual physical and social environment.

As far as shifting social contacts to the virtual world is concerned, Turkle is afraid that people will lose their social competencies—like dealing with rejection and settling arguments—if we have pre-

dominantly virtual contacts in the future. Turkle's fear for this loss is based on her lengthy research into the influence of social media and mobile phones on communication between young people. Turkle argues that the younger generation is much less empathetic than its predecessors were, because intimacy can be avoided and therefore relationships through social media or VR are less binding. Dotson even envisages a future in which we have contact with virtual people. In his opinion, this will contribute to an undesirable shift in the collective view of 'authentic sociality'. A small group of Japanese men, nicknamed Otaku, already indicated that they prefer a virtual girlfriend to a real relationship: "With real girlfriends you have to consider marriage. So I think twice about going out with a 3D woman" (Rani). Another risk, according to O'Brolcháin et al., is that VR can be addictive, just as the virtual world has produced other addictions. Gambling and pornography are constantly available through the internet, thus allowing for new online forms of addiction.

Classification and the presumption of innocence

The application of biometrics can result in misclassification and stigmatization, by automatically putting someone in a certain category, such as a terrorist, criminal or unreliable individual. This can lead to a reversal of the presumption of innocence. Biometric systems can cause someone to be considered a criminal until evidence to the contrary is furnished. It is highly likely that this stigma will stick with such a person, for example, because the presumption is stored in a database (Sutrop and Laas-Mikko; Sutrop). This could be reinforced by facial recognition, which makes it easier to figure out a person's identity. Thus the stigmatization of a person can take place without that person knowing about it. In the name of national security, it is only a small step to *function creep* meaning technology will be used for a different purpose than originally intended (Tzanou).



Facial recognition (source twitter)

Exploitation and exclusion

Platforms ensure that users have a dual role: as producers and as consumers. In this context, they are called *prosumers*. The power of platforms is that they bring supply and demand together in an efficient way, and via smart assessment mechanisms, they create the confidence that enables transactions such as renting out an apartment to an unknown person. To be able to respond efficiently to the changing demand, platforms often have a flexible team of providers who are available on demand. For this reason we refer to an *on-demand economy* (Scholz). The fact that providers offer their services on call and are not employed on a permanent basis can put pressure on traditional mechanisms of employee protection, with the lurking risk of exploitation. We see that Uber drivers' working days are too long and they have little input if the company decides to adjust the fare rates (Rogers).

At the same time, platforms can decide unilaterally to deny a user access to the platform. For users who depend on access to the platform for their income, this can have far-reaching consequences. Current case histories moreover show that platforms have no qualms about excluding certain users. Uber drivers may not have a rating lower than 4.6 stars (4.8 stars is average). Otherwise they can be removed from the service. Rogers describes how the continuous review system means that providers must always be friendly and cheerful. In addition to their physical work, they are expected to perform certain 'emotional labour'. Regular taxi drivers are free to sit behind the wheel with a grumpy face, whereas for Uber drivers, that could mean losing their source of income.

Discrimination and unjust exclusion

Automated systems harbor a risk of wrong judgements. Several studies warn against wrongful exclusion and discrimination by automated systems (Zarksy; Podesta et al.; Citron and Pasquale). Profiling puts people in certain categories, each of which is handled differently. From a service point of view, this can offer convenience and customization. But if it causes certain (groups of) people to be structurally disadvantaged, that is problematic. It appeared that female jobseekers were shown advertisements for senior posts, served by Google, less frequently than men with a similar profile (Datta et al.). Even if no data about race or religion is used, other strongly correlating variables can still cause discrimination to occur (Hildebrandt).

A profile that sticks to someone on account of their behavioral history, can affect their options for the future. That can lead to a self-fulfilling prophecy: someone with a good credit score finds it easier to secure a loan and to work on their financial future, whereas someone who poses a higher risk and has to comply with stricter conditions is therefore more likely to land in trouble with repayments (Citron and Pasquale). The Dutch Data Protection Authority warns of 'digital predestination', the danger that people can no longer 'escape' from the digital profile established about them. When profiling and risk assessment methods are also deployed in the security domain, for example, to track down potential fraudsters or criminals, the presumption of innocence is put under pressure. Whereas data is normally only collected *after* people are suspected, big data enables data and risk profiles to be prepared before there is an actual suspicion.

INTERNATIONAL TREATIES AND FUNDAMENTAL RIGHTS.

In this paper, we have described the societal and ethical issues emerging with the digitization of society on the basis of six dominant developing technologies: IoT, robotics, biometrics, persuasive technology, platforms, and augmented & virtual reality. Table summarizes for each overarching theme the discussed societal and ethical issues evoked by these technologies. To underline the importance of these issues, we will briefly discuss the connection with important values set out in international treaties and fundamental rights.

Regulating big data and transparency of algorithms

The digitization of our material, biological and socio-cultural world leads to an ever-expanding digital world of data. In that digital world, the data which is processed and analysed forms the basis for people as well as automated systems to make decisions that subsequently have an impact on the physical world. For all kinds of essential services and products, we make increasingly more use of digital technologies and we are becoming increasingly more dependent on digital systems: in healthcare, banking, media, education or the justice system. The digitization of society is entering a new phase, and has blurred the distinction between online and offline: we are *onlife*. Developments in the field of big data, smart algorithms based on artificial intelligence are indispensable elements of the technologies discussed above. These developments, for example, play a role with IoT devices that send information to the cloud (big data) and are at the same time steered by data and algorithms from the cloud to perform a specific action in the physical world. Big data and algorithms help to make decisions in the public and private sectors, from detecting fraud or the likelihood of reoffending, to medical diagnoses. In some areas, smart algorithms and intelligent systems are already taking over decision-making from people, for example, with armed drones, or in smart cars. Technologies, embedded in advisory apps on our smartphone of in smart street lights, can be persuasive and may influence our behavior and autonomy in subtle ways.

Due to digitization, there is now a lively trade in information. 'Big data' is sometimes referred to as 'new gold'. Data is valuable because it enables better decisions, for example, about which consumers should be shown which ad or which people should be investigated as potential fraudsters. We have already discussed various issues regarding privacy, and big data presents a specific challenge in this respect due to the re-use and potential combinations of different data sources. Combining and reusing big data seems to be at odds with the principle of purpose limitation, which is one of the pillars of data protection legislation. Various authors argue that legislation and supervision in the big data era should focus more on companies' responsibilities (accountability) and how data is used (Podesta et al.; Cate et al.).

But opponents say that the principle of purpose limitation is an important mechanism to counteract unbridled collection and *data obesitas* (Hildebrandt).

In addition, a significant characteristic of big data is that it is not clear beforehand which insights can be captured from the data. Researchers showed that on the basis of Facebook 'likes', it was possible to identify someone's sexual preference, religious and political orientation, personal characteristics and use of addictive substances (Kosinski et al.). Authorities are also looking into big data's potential. One example is the Dutch anti-fraud system called System Risk Indication (SyRI) which encrypts, combines and analyses data about fines, debts, benefits, education and integration in a secure digital environment in order to search more effectively for people abusing benefits or surcharges. SyRI has been criticized by both the Data Protection Authority and the Senate because of the impact on privacy.

Data mining techniques (*data analytics*) and algorithms (combined with artificial intelligence, especially techniques such as *deep learning*) benefit immensely from the large amounts of data that have become available in recent years. The data forms coaching files for self-learning software: the more data the software gets, the smarter it becomes. Companies like Facebook and Google have facial recognition software that is improving quickly thanks to the many photos that users upload every day. Translation software is also improving because it can draw on a large number of officially translated documents from the United Nations and the European Commission (Mayer-Schonberger and Cukier). In recent years, the discussions on monitoring the underlying algorithms in automated systems have come from different angles. The German Government recently released a position paper stating that online platforms—such as Google and Facebook—should provide more information about how their algorithms work, for example, when filtering news or search results.

Public values

This study shows that the new wave of digitization is putting pressure on public values. ICT services and products are no longer gadgets: they are having a radical impact on our society. It is time to recognize the implications and to ensure that our public values and fundamental rights are safeguarded in the new digital era. The building blocks and the infrastructure for the new digital society are materializing now. The governance system to deal with the resulting social and ethical issues falls short in several dimensions, mainly because there is no clear understanding of the social and ethical issues implications of the digitization. Such an understanding is necessary so that these issues can be proactively addressed, that is, be anticipated, reflected upon, deliberated with the public and other stakeholders, and be responded to (Stahl et al.; see also; Kizza).

The supervision has been developed the most in the areas of privacy and data protection. For example, at European level, there has been an attempt to deal with big data issues by modifying the legislation. The new European Data Protection Regulation (EU 2016/679) building on the principles of the data protection directive (95/46/EC), adds a number of new obligations and responsibilities for data processors, and strengthens individual rights. This regulation shows that the topic of data is high on the agenda. However, there is also an ongoing debate about whether these legislative adjustments are adequate to deal with the inherent challenges of digitization. Particularly with regard to profiling, the legal framework only offers partial protection. For other ethical issues concerning digitization such as discrimination, autonomy, human dignity and unequal balance of power, the supervision is hardly organized.

The most telling examples are the European Data Protection Supervisor initiatives (EDPS), in particular to establish an ethics advisory group. Although social and ethical issues appear on the agenda, they are not being translated into policies that protect public values in practice. Supervisory bodies do not have enough insight in the emerging digitization issues. Likewise, civil society organizations and citizens are not sufficiently aware of the new digital developments, nor do they realize how they will be affected; the possibilities to defend themselves are too limited.

The need to focus on the effects of digitization is underlined by the fact that the central ethical themes relate to important values set down in international treaties and national constitutions. We can see issues such as privacy and justice reflected in the right to respect for private life, the right to equal treatment and the right to a fair trial. Human dignity and safety are mentioned in international treaties such as the Charter of Fundamental Rights of the European Union (EU Charter) and the Universal Declaration of Human Rights (UDHR). Values such as autonomy, equal power relationships and control over technology are not explicitly named in the treaties but can be seen as part of or following from these fundamental and human rights. Digitization affects important public values.

The main task ahead of us is to effectively safeguard these widely acknowledged public values in our new digital society's everyday practices. Unless government, industry, civil society and members of the public act now, there is a risk that while we are trying to get to grips with the new digital world, the frameworks to protect public values are meanwhile losing their relevance.

Digitization is changing all aspects of human life

The changes brought about by digitization can be compared with the ones that took place in Europe in Modernity with a peak in the industrial revolution in the 19th century. These changes concerned European self-understanding particularly with regard to the idea that not god but the human being was the center of reality. To be human means not to be god's creature but an autonomous being who understands himself—it was mostly himself and not herself—as a subject facing objects in the so-called outside world.

This subject/object dichotomy as developed by, for instance, René Descartes was the basis of the triumphal progress of modern science and technology. Modernity brought also up the paradox of decentering the human subject with regard to the universe (Copernican revolution), natural evolution (Darwin) and even to our own consciousness (Freud) while at the same time providing the basis for the conquest and exploitation of nature as well as for the domination of other nations politically, economically and culturally.

JANUS-FACED EUROPEAN MODERNITY

European Modernity, now spread over the world, is Janus-faced: It has brought positive changes in human life while at the same time these changes were and are concomitant with colonialism, imperialism, capitalism, slavery, fascism, world wars and climate change. The self-understanding of humans as autonomous beings implied a change in the moral ideas and ideals based on metaphysical and theological presuppositions inherited from Antiquity and Middle Ages as well as the reasons and procedures for their political legitimization. How is morality without religion possible? How can political power be justified if there is no king by the grace of god? What are the rules of legitimization and the limits of human action if there are no dogmatic prescriptions? Based on which procedures and by which institutions are legal rules to be justified, evaluated and implemented?

Digitization has breathtakingly evolved in the last twenty years implies no less a change in our self-understanding. But who is meant when we speak about "our" self-understanding? We are subjects embedded in a global network of networked objects. Being human means being-in-the-networked-world, most but not all of the time. The modern subject–object dichotomy as well as the dualism of autonomy versus heteronomy has changed. Networked things are not the same as the objects in the outside world imagined by Modernity, nor humans can be conceived of as purely as autonomous beings, something that was already questioned by the modern scientific and technological discoveries themselves. What makes the digital era unique is probably that although digitization is a project of Modernity it does not rely on the subject–object dichotomy in its original absolute form alone. Digitization changes the anthropological self-understanding of encapsulated worldless subjects facing objects in the so-called outside world.
Digital ethics undertakes a critical reflec-

tion about ourselves in a world shaped by digital technology. It was developed since the 1940s by pioneers like Norbert Wiener (1894–1964) and Joseph Weizenbaum (1923–2008). It was first called computer ethics and dealt mainly with professional issues of computer scientists although Wiener and Weizenbaum were well aware that the ethical issues about the impact of computer technology concerned society as a whole and not just a profession (Bynum). This became particularly clear when the concept of information society became popular in the 1980s. In 1997 UNESCO held the first International Congress on Ethical, Legal and Societal Aspects of Digital Information (INFOethics).

ITU (International Telecommunication Union) took care of the World Summit on the Information Society (WSIS) held 2003 in Geneva and 2005 in Tunisia. During the last fifteen years, professional societies dealing with ethical issues of IT were created such as INSEIT (International Society for Ethics and IT) or the International Center for Information Ethics (ICIE). Journals, academic courses, congresses and workshops flourished soon. The website of ICIE provides comprehensive information on publications, events and courses in the field.
The label Digital Ethics is recent. The Academy of Korean Studies in Seoul invited me to speak on this topic at the 2009 Global Forum on Civilization and Peace (Capurro).

The Center for Digital Ethics and Policy at the Loyola University Chicago published the proceedings of its first conference:

Source: Unsplash.com/Glen Carrie

"Digital Ethics. Research & Practice" in 2012. The Stuttgart Media University created in 2014 an Institute for Digital Ethics. In the meantime, ethical issues dealing with the impact of digitization on society are daily topic of newspapers and journals worldwide. This public debate mirrors the moral and legal changes in society. New customs (Latin: *mores*) arise. We should distinguish moral customs from the academic discipline dealing with them, namely ethics or moral philosophy.

According to the French philosopher Michel Foucault, ethics means the problematization of morality (Foucault). Digital Ethics is a special field of Information Ethics that embraces ethical issues of information and communication beyond the ones raised by digitalization. Digital Ethics is closely related to, for instance, Bioethics, Medical Ethics and Business Ethics.

Per definition ethics should help humans in their moral decisions
The kind of help ethical theories can provide is one of the analyzing and criticizing theoretical presuppositions as well possi-

bilities of action and their potential consequences for the actors and the world in which they live. The plethora of ethical theories in different cultures and epochs is witness of the complexity of the issues dealing with human action. They concern not just the responsibility of encapsulated worldless subjects as envisaged by the modern subject–object dichotomy, but their original social embeddedness sharing a common world. Ethical analyses aim at questioning theoretical and practical biases such as *prima facie* clear concepts and goals, hidden agendas, power structures and information myths as well as fostering intercultural dialog on basic human experiences and values.

It is not the aim of ethics to take away responsibility about the risks that any theoretical or practical option implies for ourselves, for others and for the world we share with others. This is particularly relevant in case the existential coordinates that rule human life are subject to change in such a way that they cannot provide any more the kind of protection a symbolic "immune system" (Sloterdijk) that morality and legal systems should provide.
We do not live in two separate worlds, namely the analog and the digital one. But it is no less true that being-in-the-networked-world has become a predominant feature of today's society. Moreover, sharing a common world implies in the meantime that not only humans but other living beings as well as natural and artificial things are more and more connected to the Internet. This creates dysfunctionalities, collapses and breakdowns. Symbolic systems that were designed to protect individuals and societies turn out to be insufficient or outdated. New questions arise about the criteria of good life. Digitization becomes symptomatic for societal transformation. This is the reason why research in information ethics is so crucial today. But thinking needs time.

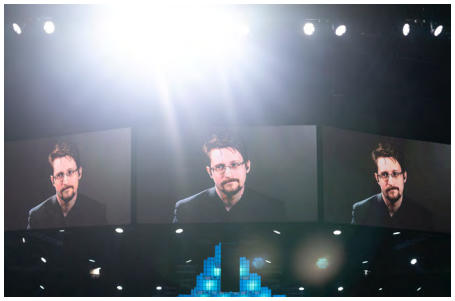
Knowledge is a key value in today's working environment
One reason why knowledge is a key value in today's working environment is that we do not live in a slave-based economy as in Antiquity or in modern colonial states although digital technology fosters new forms of oppression and exploitation. The French Revolution brought about the democratization of libraries owned by nobility and the Catholic Church.

With the Internet and the World Wide Web, digital libraries as well as digital encyclopedias like Wikipedia that we should better call *endictyopedias* (Greek *diktyon* = network) are set up (Capurro 2004). Since the 1970s with the production of computerized bibliographic databases, the importance of knowledge for public (research) policy was highlighted particularly by, for instance, the Weinberg Report "Science, Government, and Information" (Weinberg 1963). Alvin M. Weinberg (1915–2006) was the chairman of President Eisenhower's (and Kennedy's) Science Advisory Committee.

The use of digital technologies in industry as well as in society at large goes hand in hand with the development of bibliographic und full text databases,

search engines, social platforms, mobile technologies, the internet of things and robotics, to mention just a few areas. It is symptomatic for our era that what started as a tool, namely the development of search engines to deal with bibliographic data for scientific research and industry has now become a core of the digital era.

As with industrial society, new monopolies and power struggles arise between digital capitalism and the (new) working class. Millions and even billions of users worldwide give their data for free to a few global players and are happy to be addicts of their "free" services at least until they become aware that the digital capital owners use the personal data of their customers without their consent either for profit or under political pressure as disclosed by whistle blowers like Edward Snowden. In other words, class struggles in the 21st century are also between digital customers and data owners.



Source: unsplash.com/ Random Institute

We are facing different forms of class divide based on the exclusion from access to digital networks as well as on economic and educational differences within a society as well as between nations. The so-called digital divide is not just a technical but a complex local and global societal phenomenon for which key ethical questions concerning justice, freedom, peace, cooperation and identity have to be redefined. Modern concepts such as autonomy, democracy or the rule of law under the umbrella of the nation state are part of the problem when dealing with global issues such as climate change, digital economy or *cybertariats*, the digital version of former proletariats (Gopal). A new form of cosmopolitanism is underway that should embrace the well-offs and the *cybertariats*. Digital technologies might help overcoming social inequalities and forms of exclusion, but they might also aggravate these and other divides in society.

Digital natives become aware that digitization is not the only measure for good life

Uruguay, the small South American country, started in 2007, as the first country worldwide, an experiment called "Plan Ceibal." "Ceibo" is the name of a native tree as well as an acronym for "Conectividad de Informática Básica para el Aprendizaje en Línea" (Connectivity with Basic Informatics for Online Learning) (Plan Ceibal). According to this plan, the state would provide a laptop for every child going to public schools, following Nicholas Negroponte's idea One Laptop per Child presented at the World Economic Forum in 2005.

This was a good idea but ten years later the situation of public education in Uruguay is dramatic and can be compared, according to Jorge Grünberg, Rector of the ORT University in Montevideo, with the one in Tanzania (Grünberg). There are social and economic reasons for this. Middle-class children, living in better neighborhood, having access to books and whose parents have university education are in a much better position when they go to school that cannot be equated with technology alone.

What do digital natives need in order not to be dazzled by digitization? A globalized world is a world of translations. The knowledge of foreign languages enables us to take a distance of ourselves taking a distance from our cultural bias. In a broader sense, exercising translation can be learned from the history of science with regard to scientific revolutions as well as from the history of technology. Translations are exercises in creativity which is the engine of social change. They are also an ethical exercises dealing with challenging traditional customs, principles and values, i.e., the ethos that holds together a society. If we give time to the students for different kinds of translations particularly with regard to the difference between *onlife* and *offlife*, they will have the opportunity to take a critical view of digitization.

The drawback of too much surveillance

Privacy is neither a relic of bourgeois society as Marxists believe, nor is it a hopeless struggle against digital windmills in a restless information society as digital evangelists propagate. Thinking about the relation between the realm of the public and the private is no more and no less than thinking about freedom as the capacity to reveal and conceal who we are. The public–private relation has had different shapes in other epochs and societies (Capurro).

The idea that we could become completely transparent to ourselves as individuals or as society or that others could know everything about us or we about them is a myth. The question is about the reasons and the legitimization for such need. If I reveal something about myself in a specific context, this does not mean that I automatically agree that such data can be widespread to other contexts without my consent. This is the issue raised by Helen Nissenbaum in her influential book "Privacy in context. Technology, Policy and the Integrity of Social Life" (Nissenbaum 2010).

Privacy means then that the information flow does not continue only on the basis of customs and convention but also due to "key organizing principles of social life, including moral and political ones." (Nissenbaum 2010, 231) In a recent book by Finn Brunton and Helen Nissenbaum: "Obfuscation. A User's Guide for Privacy and Protest" (Brunton and Nissenbaum) the authors show which kinds of mechanism of obfuscation users can learn in order to protect themselves. This is a kind of guerrilla tactics to which I point ironically with the maxim "Never enter your real data" (Capurro). Whistle blowers are needed more than ever but also rules of fair play at national and international level. And we need institutions and forms of political debate dealing with ethical and legal issues of the information society (Capurro).

SYMPTOMS AND SOLUTIONS

Driverless cars are a symptom that something is going wrong locally and globally with our transportation system. It is not only the chaos in our roads and streets, particularly in megacities like New Delhi or Sao Paulo, but also the impact on climate change that raises the question about which kind of transportation is adequate in the 21st century from the perspective of digitization. This is not only a technological but also an ethical and legal challenge.

Norms and rules do not fall from heaven but are embedded in legal systems, cultural traditions and geographic conditions. It is possible to program traffic rules into a driverless car, but this does not mean that the car mutates into a being capable of reflecting critically, i.e., ethically on such rules taking action in a given situation. A code of morality or a legal code is not identical with moral philosophy or jurisprudence. When a driverless car follows a rule, this does not mean that the car is able to give reasons about its decision beyond the fact that such reason were given to it. It is not able to interpret the norms.

This is the reason why the use of the term autonomy with regard to driverless cars is problematic. Autonomy is a key term of moral philosophy particularly since Modernity. A driverless car is basically a heteronomous agent not only because it is not able to move by itself like a living being, although it is called "auto-mobile," but also because it is not able to give itself the norms according to which it should act and to take the responsibility for what it does or does not in a given situation. If something goes wrong, then manufacturers, programmers and buyers have to face the issue at stake at least as long as cars or other "autonomous" things do not mutate into philosophers with whom we could continue the talk we are having right now. It would be silly to do business as in a historic situation in which we face what we could call, following Thomas S. Kuhn's concept of "scientific revolution," a technical revolution (Kuhn). In this case, we are not facing the challenge of understanding an aporetic situation as a motivation for thinking and acting beyond a traditional way of thinking or producing. For a philosopher like Socrates, a productive dialog ends with an *aporia* that is supposed to wake up the reason and imagination to go beyond, in case one is able to accept that the way done so far does not take her further.

There are a lot of excellent managers and engineers in the automobile industry that are able to face the challenge of digitization also as an ethical challenge, i.e., as a challenge that gives rise to radical solutions beyond the narrow interests of profit making.

Globalization and digitization as a strategic goal

In his book "What is Globalization?" the German sociologist Ulrich Beck (1944–2015) uses the term "globalization" coined by the sociologist Roland Robertson (Beck). The risks of globalization come from the trap of globalism. Cultural diversity must be taken into account if manufacturers expect that people like their products and are ready to pay for them. The more a company becomes global, the more it must pay attention to locality. But this strategy can turn into a new kind of cultural and economic colonialism. Local users must be aware of this (Capurro). We should get rid of the ambitions and obsessions associated with digitization.

How the field will be monitored to ensure adherence

Right now, there are guidelines for many aspects of research and technology diffusion, but serious gaps in our ability to monitor adherence or hold bad actors accountable. For example, there are sound regulations for the management of some kinds of toxic chemicals, but extremely inadequate funds for regulatory staff to monitor and inspect chemical sites. Governance mechanisms for the 21st century will have to grapple with what areas need mandatory regulation and how to enforce them.

The answers to these questions need to be informed by facts, but facts alone are insufficient. All four questions require a willingness to discuss the values we hold dear, even when values discussions may lead to controversy and conflict.
Safety is perhaps the least controversial value. Most of us around the globe believe that there is an obligation to reduce the likelihood that individuals will be harmed by new technologies. Indeed, the primary responsibility of most existing regulatory bodies is to promote safety.

But there are other very important values at stake, and they are often given short shrift. First, we should commit to equity – to doing all that is possible to ensure that all people, regardless of their economic means, will have access to technology's benefits. Even harder to talk about are values that have to do with ways of being in the world, with how we humans relate to one another and to the natural environment.

We live in an age of transformative scientific powers, capable of changing the very nature of the human species and radically remaking the planet itself.
Advances in information technologies and artificial intelligence are combining with advances in the biological sciences; including genetics, reproductive technologies, neuroscience, synthetic biology; as well as advances in the physical sciences to create breathtaking synergies.

These new powers hold great promise for curing and preventing disease, improving agricultural output, and enhancing quality of life in many ways. However, no technology is neutral – and the powers of the Fourth Industrial Revolution certainly are not.
Since these technologies will ultimately decide so much of our future, it is deeply irresponsible not to consider together whether and how to deploy them. Thankfully there is growing global recognition of the need for governance.

In short, the Fourth Industrial Revolution has brought us enormous powers. Now we must use them wisely. Governance, which will take many forms, must involve the public as well as experts. And, whatever forms it takes, we should anticipate at least four critical questions that need to be answered, no matter the technology sector. In answering those questions, we will need deliberate, thoughtful conversations about values that are often hard to reconcile. This path will engender strong differences of opinion, but that is exactly why we must embrace the dialogue – and soon.

TO CONCLUDE

It now obvious that Industry 4.0 is a philosophical transformation of the society. This transformation is expected to lead to major changes in society, education, economy and trade, just like any other industrial revolutions. By keeping this in mind, this article provides some information about the ongoing debate around Industry 4.0 in both the scientific and the industrial communities. Practical contributions of the paper are twofold: First, given definition for Industry 4.0 helps clarify the basic concept among practitioners. Second, it can be used to support the implementation of six design principles of Industry 4.0 scenarios. It helps determine potential situations and will be a source of guideline during implementation.

Note that, although the component market is dominated by a few big players, there are thousands of production facilities all over the world ready to expand their manufacturing lines to either work along with the Industry 4.0 standards or to produce products to ease Industry 4.0 implementations.

There is no doubt about that these factories will continue to produce components in the future because of the spread of electronics in all areas human life through extensive "digitization" of everything possible.

The correct use of real-time information is expected to lead the next industrial revolution. High level of variability is the key to understanding what variability is, in order to reduce it and integrate it into production management tools, leading to high level of confidential information. Today we call for more focus on the basic understanding of production systems and the greater use of industrial data in research to find solutions for tomorrow's "intelligent Industry". Providing intelligence to industry is wide spread out from using support vector machine to energy entropy to utilizing risk-value graphs, from fuzzy risk manager to experimental design using fuzzy desirability function.

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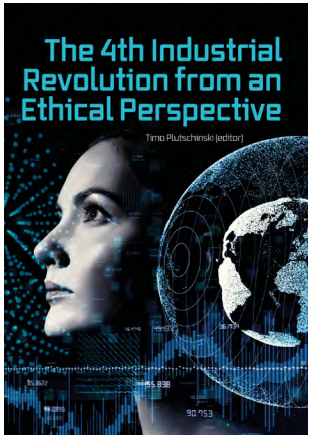

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As the Fourth Industrial Revolution ushers into a new era of artificial intelligence (AI) and virtual reality, how should we respond to the societal and ethical dilemmas associated with this new age of transformative scientific power? This research highlights the need for an ethical and globally shared view on how technology affects the economic, social, cultural and spiritual aspects of daily life. With thanks to the international team of experts this book is outlining consequences of the Fourth Industrial Revolution in a broad range for business and work life, for leadership, for media and communication, for churches and for personal and family life.

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