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Next exit: The future

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Next Exit: The Future
Reports from a Changing World

Ranga Yogeshwar

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Introduction

All that has been wilts and withers under the hot breath of the new age.
– Stefan Zweig

When I was a child I always wanted to catch a rainbow. I would stalk them furtively and run up towards them, but they were always quicker than I was, keeping their distance like a timorous animal. No matter how close I got, the rainbow was always just out of reach and never revealed its mysterious secret.

In many ways the future is similar to a rainbow. No matter how earnestly we grapple with it, no matter in how much detail we try to predict specific developments, we can never hold the future in our hands. As I grew up I learned that the rainbow is an optical phenomenon that cannot be touched. Sunlight is broken up into a spectrum of colours by millions of raindrops and reflected across the sky. The arch shape is formed from the fixed angle between the sun, the water droplet and the observer. This fixed angle is the reason why we can never catch the rainbow. It is also what makes the rainbow so unique, because it – *the* rainbow – doesn't exist. We all see our own rainbow in this optical interplay. When two people marvel at this natural phenomenon, they are both – strictly speaking – looking at two different things.

The future is also perceived just as differently from different viewpoints. While one individual may look to the future with great optimism, another may conjure fearful visions of a bleak dystopia. When asked whether the world will, on balance, be a better place in future, the overwhelming majority of people are convinced that things will deteriorate. In one international study, only four (!) per cent of respondents in Germany believed that life will improve in future.[2] Answers given by respondents in France, Denmark, the UK and the USA were similarly pessimistic.

But why this anxiety when we contemplate the future? Are we really heading towards an age of dissolution in which humans, by means of technological progress, do away with ourselves as an active factor of production? Will we be managed by machines one day? Is progress itself the problem? Will our future really be that bleak, or is this gloomy view simply the result of a limited perspective? When we look back on history, innovation has always initially been accompanied by a sense of disorientation. Scepticism and apprehension dominated following the introduction of both the railways and the automobile. The modern era too was characterised by deep social uncertainty. But with the advent of turbomodernity – our age – the bond linking past and future gives way completely. The future, according to Hans Ulrich Gumbrecht, Professor of Literature at Stanford University, is no longer seen 'as a horizon of open possibilities; the future has turned into a dimension that increasingly evades prediction and simultaneously as something threatening coming toward us'.[3]

In this book I describe how digitalisation is making the present provisional, into a discontinued model whose use-by date is almost upon us, because tomorrow we will be waking up in a brand new world. But what is it that is changing and what remains the same? In what direction is innovation taking us? What are the laws governing this transformation? What is our place in this future? Do we belong to a transitional generation lost in the shift from yesterday to the day after tomorrow?

These are not abstract theoretical questions. I will show you, using concrete examples, how algorithms not only change processes but also increasingly shape our behaviour. They have the power to rock society to its core and threaten our democratic way of life.

Almost all areas of our lives are subject to growing uncertainty. Even though most people in the west have a certain level of material comfort, vague anxiety about the future is prevalent. According to one study published in 2015, 'Fifty-seven per cent of respondents in Germany say that the speed at which new business ideas are developed, and product worlds change, is too rapid. People in other countries are also wary of the increasing speed at which the technological landscape is changing. Fifty-one per cent of opinion leaders from a total of 33,000 respondents in 27 countries also believe that change is happening too quickly.'[4] Today, the future itself is on trial it seems.

As a science journalist I have had a front seat view of this transformation for several years: from an artificial intelligence research laboratory in Sweden to the ruins of a nuclear power station in Japan, from a cloning laboratory in South Korea to a trip in a prototype driverless car in Hanover. I am often standing on the crest of this wave of progress and can see how innovations spread and find a foothold in our living environment. My perspective has been shaped by this immediacy and direct experience.

In the face of this anxiety and alarmism I believe it is high time we take a fresh look at our changing world. And that is exactly what I shall be doing in this book. Based on personal experience I look not only at the digital upheavals and changes in the media, but I also question the views we hold regarding an increasingly globalised world, scrutinise the new role of women, and consider the value of ancient cultural assets. In this diverse range of topics I notice some astonishing commonalities. There are striking parallels, for example, between the Silicon Valley boom and the development history of the vacuum pump.

In this world of upheaval there is no doubt that some developments are indeed worrying, and I address those in detail. There is an urgent need for a rethink in some areas, and a necessity to change the course on which we are headed. However, I believe that progress, when thought through properly, also brings with it valuable opportunities. For the first time in human history we can change the world in a direct way. While every generation that went before us had to exercise patience, often having to wait decades if not centuries for the next innovation in any particular field, we are endowed with a new freedom.

We will discover golden opportunities when we engage with innovation, if we can muster the courage to alter our perspective. There is good reason to be optimistic. We are becoming the designers of our world, and therein lies opportunity.

[…]

The digital revolution[10]

My father screaming, my mother crying, and I hear the distant voice of my grandmother coming from the telephone receiver through the static. 'Merry Christmas, my boy!' When I was a child, long-distance phone calls from Luxembourg to India were outrageously expensive. You had to book each call in advance and you would invariably be waiting for several hours before being given a noisy connection – but for a few precious minutes you had a direct line between continents. We would call

at Easter and Christmas, and at other times of the year we made do with letters that took weeks to reach their destination.

Now, in the digital world, we are always 'on', no matter on which continent we might be standing. I even had a reasonable mobile signal in the remote jungles of Vietnam recently, and nearly jumped out of my skin when a member of my team defiled the exoticism of the wilderness by conducting a telephone call.

Travel, media, politics, communication, shopping habits, bank transactions, production procedures and manufacturing techniques … wherever you go, processes are changing in fundamental ways. We are still only at the beginning of this digital revolution. No one can say where it will all lead because the future cannot be foretold – even expert predictions usually turn out to be off target. We look at the new with old eyes and fail to take into consideration that these developments will change us, our views and our image of ourselves.

Behavioural patterns, shopping routines, and search, interest and movement profiles are all being recorded – the rise of Big Data has well and truly begun. We obligingly feed the hungry data machine with our most intimate secrets. Eighty-four per cent of smartphone users say the first thing they do when they wake up is to check an app on their phone.[11] Fitness bands relay heart rates and the number of steps walked each day to the Cloud, and omnipresent voice recognition systems decipher our desires and record our habits. *Allow this app to access your location?* 2.5 billion gigabytes of data is accrued each day: payments, website visits, news headlines, orders, travel routes, music titles, search results, the list goes on.[12]

Most of this data is gathered and recorded, and even though 80 per cent of it is still unstructured, the global 'analytics boom' proves the potential this raw data possesses. Complex calculation processes are making our behaviour increasingly easy to predict. What is more, this data will influence our behaviour in ever more specific ways. The next time you find yourself dreaming of beautiful clothes or a holiday in an exotic destination, you should consider for a moment whether it really is *your* dream or whether it was actually planted in your mind. Former Google CEO Eric Schmidt put it in a nutshell: 'We know where you are. We know where you've been. We can more or less know what you're thinking about.'[13] Internet retailers already know their customers so well that they disguise their targeted adverts with a few random ads because otherwise customers would feel they were being spied upon.

Big Data is to the twenty-first century what steam power was to the eighteenth or electricity to the nineteenth century: a fundamental revolution. But connectivity is not limited to smartphones and laptops, it also potentially includes all the devices that surround us. With each year that passes, electronic devices can be made smaller and smaller, meaning that sensors can be integrated into any object you like for just a few pennies. It is estimated that more than 10 billion appliances and devices are already connected to each other on this earth, from thermostats to spare tyres, from coffee machines to vacuum cleaners, from shoes to cars, from machine tools to automatic rifles.

Under the current system, doctors only get to work when a patient has fallen ill; the wheels of the criminal justice system are only set in motion when a crime has been committed. But this order could soon be reversed because data algorithms have turned our world on its head. Healthy people will be operated upon because medical data indicates a potential risk of disease. Innocent citizens will come under suspicion because indicators point to a high probability of offending in the near future. That is the approach explored by the EU research programme CAPER, which is dedicated to the 'prevention of organised crime through sharing, exploitation and analysis of open and private information sources'.[14] When the Generali insurance company announced that it would use apps to

capture data about the fitness, diet and lifestyle of its customers – the first major European insurer to do so – it was as if they were breaking a major taboo.[15] The move, however, makes sense. Those living a healthy lifestyle cost health insurance companies less money, and willing consumers are being lured by discounts. Total digital transparency will have a permanent effect on lifestyles. We will soon go jogging because an app tells us to. We will be eating fruit rather than fries because our health insurance premiums will otherwise go up. Before long, 'voluntary' data sharing will gradually become coercive self-optimisation.

Is it not merely a question of time before cars pass on the speed profiles of their drivers? If so, speed cameras will be a thing of the past. Tax returns will be completed automatically because every financial transaction is recorded electronically. The true potential of Big Data is hidden in these countless snippets of data that can be combined and correlated. An in-depth analysis could reveal whether an individual has a tendency towards depression, whether a couple is drifting apart, or whether an employee is becoming less and less committed to his or her employer. For the first time in human history machines would understand us better than we understand ourselves. Developments in this direction are moving at a rapid pace and analytics companies are sprouting like mushrooms. IBM alone has spent more than $24 billion in this field over the past few years, and internet giants such as Google, Amazon and Facebook are pursuing similar aims.

The digital revolution is based on the deeply rooted assumption that the diversity of our lives can be converted into a measurable stream of numbers. This abstraction of the real world, where algorithms emulate natural processes, turns a tangible reality into a predictable process.

The origins of this mindset lie in the distant past. Historians have still not succeeded in determining the exact time and place of the invention of the first mechanical clock but it must have been a magical moment. For the first time ever, man had created a device with a heartbeat of its own. Where once the course of our lives had been determined by the sun and the stars, it was now controlled by a sophisticated assemblage of cogs, springs and hands that produced the reliable, regular ticking of time. The first clocks were somewhat lacking in accuracy, but with the implementation of the pendulum principle in the mid-seventeenth century, Christiaan Huygens combined the mechanical counter with a universal natural phenomenon, the movement of the pendulum. The rhythm of the pendulum remains constant and is dependent only on its length. Pendulum clocks count only the oscillations, and they transfer these to a counter that then moves the hands of the clock. The pendulum clock is a wonderful combination of natural laws and craftsmanship – reality and artificiality merge into one. At a stroke, Huygens' invention was superior to all other clocks.

I became so fascinated with this method of taming time that I spent several days calculating and drawing cogs. It took several attempts before I really understood the exact principle of escapement, which splits the energy of the weight in a stop-and-go process in order to transfer the force to the individual teeth on the escape wheel gear and to keep the pendulum swinging. I disappeared into my workshop for a whole week; I sawed cogs out of wood, carefully constructed an escapement and experimented for hours until I had finally built a working pendulum clock out of wood. What was the motivation behind this handcrafting escapade? A deep desire to reconstruct down to the last detail the magical moment when that first artificial heartbeat was heard. While filing and drilling, my respect for the early clockmakers, who built their devices with very modest tools, grew deeper and deeper.

The pendulum clock began its global conquest in the seventeenth century. Having previously only had an hour hand, tower clocks now showed the minute. Incidentally, it is fascinating how

different nations responded at the time to this momentous innovation. In the book *Leibniz, Newton and the Invention of Time*,[16] Thomas de Padova describes how clockmakers in Germany were organised into trade guilds which followed rigid rules and regulations, as a result of which they missed out on the synergistic opportunities offered by science and the manual crafts. Augsburg, home to at least 182 authorised clockmakers between 1550 and 1650, lost its dominance and London became the new metropolis of timekeeping. It is there that the physicist Robert Hooke and the master clockmaker Thomas Tompion built a precise pocket watch, transferring the pendulum principle to an oscillating spring. The timepiece thus became mobile, and from then on its universal, artificial heartbeat was the engine which drove forward all progress.

The erstwhile continuum of time is divided into countable parts. The movement of the sun is depicted in a linear process by discrete numbers. Vague time concepts such as dusk, nightfall, midnight and daybreak are assigned precise numbers in the form of time. Humanity's time culture is digitalised and time becomes a number. This fundamental change from the diffuse to the discrete changed our everyday world. From this point onwards, life is organised in diaries and calendars; businesses, factories and public institutions arrange their activities in accordance with numerical time units; and the hands of railway station clocks become the reference point for our increasingly mobile lives. In sporting competition, digitalised time became an opponent in and of itself. Around the end of the nineteenth century the engineer Frederick Taylor used a stopwatch to investigate how manufacturing processes could be made more efficient, thereby laying the foundations for the industrial assembly line. Time kept on accelerating, leading a century later to the inaudible pulse of high-frequency trading.

The watch was the first device that people wore or carried constantly – until it was replaced by the smartphone, that is. The same basic idea underpins both technologies: reality is depicted in a world of numbers. Today, an entire aircraft is initially designed on a computer. Each part of the fuselage or wing is assembled from separate elements like a mosaic. No single individual would be able to deal with all the statistics relating to loads, strength and stability of such a complex structure, let alone predict them based on a theoretical model. Only by transferring real phenomena into the universe of numbers are such gigantic objects as those conceivable in the first place. Digitalisation – that is, converting reality into the world of figures – leads to an excess. That which is calculable surpasses our wildest dreams. It shapes the way we think, and the artificial heartbeat of the machine determines the way we engage with one another.

We are currently in a transitional phase, between eras, similar to when the Renaissance saw off the Middle Ages, or when Modernism rocked society to its core. In such epochs in the past, technological innovations changed society and the way in which people perceived themselves. The digital revolution will change us, and it is down to us whether we experience this journey in the driver or the passenger seat. Perhaps future generations will envy us the opportunity of living through this period of radical change and look back at this time in the way we look back at the Renaissance.

[…]

The book betrays the reader

Download. The new novel has arrived. The colourful e-reader icon indicating the title is flashing. Double-click. You start reading. As you immerse yourself in the story, getting more and more into it with every line, a tiny camera above the screen follows the movement of your eyes. It records exactly where you look – line by line, paragraph by paragraph. When you reach the end of a page, the device automatically turns to the next page for you. Very convenient! You read on, without the interruption of having to turn the page yourself, free to concentrate fully on the story.

Cut to a very different scene: Danderyd near Stockholm in February. I have an appointment with some engineers from the research centre at Tobii Tech. The tour I am undertaking – a four-day trip with a packed programme of visits to some of the country's high-tech enterprises – was organised by the Swedish Institute. I am here to discover why Sweden, of all places, is so innovative. Having a population of just under 10 million, the country is home to fewer people than the German state of Baden-Württemberg. Yet its capacity for innovation is impressive: the zip, the pacemaker, Tetra Pak, Skype, Spotify … were all invented here.

At the Tobii Tech laboratories they are experimenting with the technical applications of corneal reflection eye tracking, searching for ways to control devices using eye movements. Vincent, a young development engineer at Tobii, is excited about the possibilities the new technology offers. 'Our eyes are the fastest pointing method we have, faster than any hand movement, faster than any computer mouse or trackpad. With our technology we can track the field of vision very precisely, and that promises new applications in fields such as advertising, medicine and psychology. We help paraplegic people who can't move their arms – our eye-tracking technology allows them to control their wheelchair using their eyes.'

I notice a collection of images and postcards on the wall, most sent by young patients who are writing to say how the tracking technology has changed their lives. 'Talking to these patients really reminds us why we're researching so intensively here day in day out. The technology developed here means that one young man was able to take part in a chess championship – and he won!' Vincent's delight and enthusiasm are genuine. Technology can do wonders for people, and make everyday life a little easier.

The engineer tells me about other possible fields of application. Eye tracking is now being used to prevent motorists from momentarily nodding off at the wheel. The Smart Eye system monitors the driver's eyelid movements, viewing direction and head posture, and recommends taking a break as soon as it detects the first sign of fatigue. Another application being developed is in the field of the man-machine interface. Eye tracking can be used to identify the exact point of gaze on the control panel, allowing plant manufacturers to optimise the layout of the control buttons. If test subjects repeatedly fail to notice a warning indicator, for example, the position of that indicator can be changed, ensuring that engineers always have the most important information to hand.

The same principle can be used to design advertising in new and more effective ways. For example when looking at some adverts the consumer fails to notice the brand name. But with the aid of this new technology the brand name can be placed exactly where the viewer will see it. Every smartphone and laptop will soon be fitted with such technology. Internet advertising will change as a result of these developments, and companies will only be charged when consumers actually look at their advert.

The point where a person first looks can reveal much about their internal state. 'Try it and see for yourself,' says Vincent. I take a seat at a special monitor fitted with two tiny cameras and

infra-red sensors that follow the movement of my eyes. Vincent gives me a brief induction, and calibrates the system to my eyes, which involves looking at the crosshairs that appear first in the centre of the screen and then in each of the corners. I am then asked to look at a few images. A landscape, a street scene involving people, a billboard, a party scene …

'She's pretty, isn't she?' Busted! Vincent grins. In one of the images I had apparently looked at an attractive woman's breasts and the tracking system had noticed. 'Everyone does that – sex sells,' he says with a laugh.

Every single one of my eye movements is recorded by the system. Afterwards, Vincent shows me my personal observation pattern. With faces I immediately – but subconsciously – focus on the eyes, before moving to look at the mouth. Only then do I scan other features, but I jump back to the eyes again and again.

He then shows me a game that is based on grouse shooting in which the player aims the gun using only the eyes. To shoot and reload you just blink. The system is incredibly fast and I really begin to appreciate the potential of the eye control system.

The next field of application is text processing. I can use my eyes to mark words and to move them on the screen. The eye tracking system can tell very precisely whether I skip or re-read a paragraph as I read, and it records exactly what I read, word by word, line by line. Generations of lazy students have set aside their copies of *Macbeth*, *Pride and Prejudice* or *Wuthering Heights*, and relied on a synopsis before sitting exams. In future, with the aid of eye-tracking technology, teachers will be able to check whether students really have read and studied the classic texts. 'Poor students,' I tell Vincent. 'Big teacher is watching you!'

But let us return to you and your novel. The plot is exciting, and you just cannot stop reading – and that activity is constantly being communicated over the internet. The publishers know exactly what chapter you are on and for how long you kept reading before falling asleep the previous night. Can you think of a publisher who would *not* want to know whether and how those who buy the book read it? Regarding e-readers it would be very easy to tell whether the majority of readers stop reading at a certain passage in the text. If readers give up or start skipping pages after the second chapter it might be an indication of boredom, and that the author would do well to revise that section of the story.

Novels of the future will be optimised in the same way that many consumer products are already being developed. What started out as unconstrained ideas become a controllable product. TV channels have long been subject to the dictates of minute-by-minute ratings and these are analysed closely after every programme. Producers take an even closer look if they notice that the number of viewers takes a nosedive at any given point. If that happens repeatedly when a certain presenter goes on air, you can be pretty sure they will be called to an awkward editorial meeting before too long. The ratings decide it all!

So while you are reading your novel, your e-reader is recording what and how you are reading. The e-reader even charts tiny fluctuations in your reading speed. This can reveal whether you are a true bookworm or more of an occasional reader. If you hesitate over certain words such as 'polyvinylpolypyrrolidone' (a binding agent used in beer production), the e-reader knows that you are probably not a chemist. In contrast, if you read on without difficulty when you encounter terms such as 'prosopagnosia' (an inability to recognise familiar faces) and 'deuteranomaly' (reduced sensitivity to green light), it can assume that you have a medical background.

The built-in camera also records your facial expressions and checks whether you, like other readers of the text, smile or laugh at certain passages. How do you react to an exciting part of the story? How high do you score on the empathy index?

Today it is possible to determine a large number of characteristics through a study of the face. Mathematical algorithms can register the state of the eyes, the nose and the corners of the mouth instantly. Based on that data, they can read the individual's current emotional state within fractions of a second. Some cameras have similar software modules to ensure that the shutter is only released when everyone in the frame has their eyes open. The latest programs are getting better and better at identifying whether a person is laughing or whether they are sad or angry. Are the eyes laughing too, or is it just a feigned laugh? As you might expect, algorithms can also estimate an individual's age by their face.

In his project 'Selfiecity' the Russian–American artist Lev Manovich examined 120,000 selfies taken by people in Bangkok, Berlin, Moscow, New York and São Paulo.[81] The selfies in the five cities were taken from Instagram's enormous data pool, and sorted and evaluated in a multi-stage process. Manovich and his team wanted to discover whether there were significant differences between the smiling faces in the five cities. The results reveal that the subjects in Bangkok and São Paulo smiled more in selfies than the subjects in the other cities. Moscow was at the bottom of the smiling league, with an average 'smile score' of 0.53. In all the cities examined it was mainly women who took selfies of this nature; in Moscow there were 4.6 times more selfies by women than by men. The variation in the poses is particularly pronounced in São Paulo, where women tilted their head by an average of 16.9 degrees! Analysis methods such as these provide a new generation of social scientists with large quantities of useful material.

One of the camera systems at Tobii Tech not only tracked my eye movements in real time, but also the dilation of my pupils. The pupils contract in bright sunlight, allowing less light to enter in order to protect the eye from too much brightness. The pupils thus function as an automatic aperture. Back in 1904, however, the psychiatrist and neurologist Oswald Bumke, then an assistant at the Psychiatric Clinic and Mental Hospital in Freiburg, noticed another related phenomenon: the pupils also dilate when shaking hands or during a volitional impulse. Using only the technology available to him at the beginning of the twentieth century, Bumke was able to observe 'how every act of mental exertion, such as solving a puzzle or thinking about an answer to a question, finds an external expression in the pupil function'. Pupil dilation is therefore a window into our innermost self. Since Bumke's time, the reaction of the pupils to psychophysical influences has been researched in more detail in a number of medical studies. When you show test subjects images of potential sex partners, their pupils dilate immediately. That also happens, as Bumke had discovered, when people succeed in solving a problem. Our brain rewards us by releasing neurotransmitters that induce positive feelings. In this biochemical cascade of happiness our pupils dilate. When asked to solve the same puzzle, people with a higher IQ exhibit less pronounced pupil dilation than those with a lower IQ. If a study triggers fear in test subjects, their pupils also become dilated – and that, incidentally, is more pronounced the more 'intelligent' the individual. This physical reaction cannot be consciously controlled and it reveals much about our mental and emotional state.

Armed with this knowledge, let us now return to you and your novel. The built-in camera on your e-reader detects changes in your pupils and thereby captures your emotional reaction to the text. This information is combined with your reading speed and facial gestures. In a way, you are like a patient in an Intensive Care Unit whose physical functions are monitored using a network of tubes

and devices. When you are reading, however, you think you are free and unobserved – you are unaware that you are being read.

Your other activities are also being tracked and recorded. While you are surfing the internet, writing emails or shopping online, another data stream is transmitting your personal typing pattern as you enter one letter after the other. The miniscule time differences before pressing the letter 'r' after an 'e' are recorded – and these can be surprisingly informative. Do you display a typical daily pattern? Are you more nimble in the mornings than in the afternoons? Is there a huge drop in performance, or do you keep up the same pace all day? Does your typing speed change over the weeks and months? And what about your error rate? Could a higher number of typos indicate tiredness, or even an illness? Just a few years ago no one would have paid any attention to such seemingly trivial details, but using the unbelievable processing speed of the systems available today, these data flows are like powerful lenses that offer valuable insights into your innermost being.

The book is reading you!

By now you are completely gripped by the story. The novel is unbelievably exciting, the best you have ever read. It is engrossing, addictive and you just cannot put it down.

The suspense trajectory, as we now know, was perfected beforehand to have maximum emotional impact. Moreover, the novel was tailored specifically to your preferences. Don't tell me you have forgotten already? The internet knows you!

The data available about your transport patterns, shopping profiles, eating habits and your friends and interests in social networks – all these data flows are woven into the story via powerful algorithms. These personal elements make the story even more appealing to you. The protagonist likes the same things as you, feels the same emotions as you and responds to situations like you, and this mysterious connection helps you to identify deeply with them. A few days later you notice something curious. While drinking a glass of wine after work, you look at the label: 'Baron Philippe de Rothschild'. Wasn't that the protagonist's favourite wine? And the fitness watch on your wrist or the new milk frother from Denmark that finally allows you to make the perfect cappuccino? Is it all a coincidence? Since reading that book you have even changed your breakfast habits and have recently been enjoying fruit salads with chia seeds.

You have even started to subconsciously take on the views and opinions of the main character in your novel. All of a sudden you are using the same figures of speech, are interested in the same issues, and your political views are changing. Even your friends have noticed how this novel is affecting you.

Incidentally, your friends also appear in the novel and some of the scenes take place in very familiar settings. Events from your real life are reflected in the story in rather astonishing ways. The cycling accident in which your daughter injured her shoulder – the exact same thing happens in the story. And you and the protagonist celebrate your birthdays on the same date. When you start reading it in the morning, it is there in black and white. 'Happy birthday, I'm thinking of you!' This convergence is fascinating and eerie at the same time. Your life increasingly resembles the plot of the novel, or is it the other way around? The story responds dynamically to the events of your life. The novel's protagonist sometimes even leaves messages for you on your smartphone: 'Come on, let's go for a jog!' Of course, the character knows your mobile number, your working hours, your

movement patterns, your heartbeat, and more. 'Get well soon!' Your novel has just realised that you are not feeling well today – how nice of it!

Never before have you devoured a book with such fervour, never before have you been so deeply immersed in this different yet very familiar fictional world. Then, in the middle of chapter seventeen, you suddenly receive an unsettling message from your health insurance company, requesting you to contact a neurologist as soon as possible. The clinic's address is displayed and the appointment has already been added to your calendar. The text is written in a very polite style and notes that some minor discrepancies have been detected in your data pool. It is purely a precautionary measure, of course, and only to ensure your safety and wellbeing. Two days later you visit the recommended doctor, who explains that the automated analysis of your data indicated an increased risk of Parkinson's disease. You are, naturally, in a state of shock.

More than six million people around the world suffer from Parkinson's, a neurodegenerative disease for which there is still no biochemical diagnosis test. The onset of the disease is very gradual, and only with time do the symptoms become unmistakeable. Certain nerve cells in the middle brain die, which leads to a reduction in dopamine production. The resulting symptoms include a less pronounced swing in one arm when walking, and shoulder pain in one side. Parkinson's is a treacherous disease because the first signs only become apparent once half the affected nerve cells have already been killed. In addition to the motor limitations and tremor, the disease also affects the voice by attacking the muscles of the vocal tract and interfering with the vocal cords. Early detection has been nigh on impossible but there is a promising approach in the pipeline.

The British mathematician Max Little has been using algorithms to assess success rates in vocal cord surgery. He has developed a piece of software that analyses voice recordings to determine to what extent the patient is healing based on typical patterns present in the pitch of the voice. One day a colleague gave him a batch of voice samples featuring healthy subjects and patients suffering from Parkinson's disease. Little experimented to see whether his software could distinguish between the two groups based on voice analysis alone. The first attempts were surprisingly successful. As Little optimised his algorithm, the success rate improved even further. His analysis software can now distinguish between healthy people and people suffering early-stage Parkinson's disease with 99 per cent accuracy. Little initially conducted his experiments under laboratory conditions, but in a follow-up project, the Parkinson's Voice Initiative, he set up special telephone lines in nine countries and requested participants to leave voice samples.[82] The mathematician intends to optimise his algorithm further, not only to improve early diagnosis but also in order to develop a way of using the data to identify how the disease is progressing. Study participants can remain anonymous, of course.

Achieving good health is in all our best interests, and there is a growing number of mobile health apps on the market. In the case of Alzheimer's, increasing disorientation is regarded as an early symptom of incipient memory loss, but no specialist studies had been carried out on this marker until recently. During the spring of 2016, Deutsche Telekom was involved in a project that resulted in the release of a free game app called Sea Hero Quest.[83] Developed by researchers at University College London, the University of East Anglia and the Alzheimer's Research charity, the app will provide comparative medical data for dementia research. In the game, players navigate the oceans in search of some of the wonders of the sea. They can move from one island to another by sailing a ship or by swimming. The challenge lies in the fact that the small sea charts are only visible for a few seconds – players must memorise the route between one wonder and the next. The app gathers data about each player's navigational abilities. By using this basic data and using the

registration information entered by players, it is possible to track differences between the spatial orientation skills of men and women, young and old, and between city and rural dwellers. If a player's navigational skills deviate substantially from the average, it may be an indication of early-stage Alzheimer's. It is hoped that this will improve early diagnosis of the disease over the long term.

However, Sea Hero Quest's anonymised data pool is not owned by a public initiative, it is the property of Deutsche Telekom. Higher education establishments such as University College London and other research establishments must request access to the data. The health business is clearly expanding, and new players such as telecommunications companies now also have their finger in that pie. This development is being driven by a belief that mushrooming data pools could be the gold mines of the future.

Regarding Parkinson's and Alzheimer's there are plausible and comprehensible theories behind the early recognition methods: changes in the voice or deterioration in navigation skills. In future, we will be able to deduce even more from the complex data Cloud. The real magic of Big Data is in the possibility of recognising correlations that have until now remained hidden: our internal condition is revealed in the enigmatic web of typing patterns, movement profiles, speech changes, facial expressions and pupil dilation. In the same way that a doctor can make a judgment about the overall state of your health based on a blood test, data analysts will be able to evaluate the Cloud using their algorithms. Whoever succeeds in linking certain characteristics to the relevant but subtle variations will be opening the door to valuable knowledge. In dragnet investigations in Germany during the 1970s a combination of certain tenant characteristics such as registration data, car-related details, the specific location of the apartment, and electricity bill payment methods, were enough to ascertain the whereabouts of RAF terrorists. But imagine the power of a model which includes thousands of attributes layered one on top of the other. The new algorithms will be able to predict whether we are at risk of a heart attack, suffer from depression, have financial or job-related worries, or whether we will soon be breaking up with our spouse.

Your phone knows when you're dancing

Let us return to the present for a moment. For many of us, it is almost as if the smartphone has become part of our body. We carry them with us wherever we go, whether we are working, jogging, shopping or travelling on the underground. People who always have their phones with them are constantly generating data, even when they are not making a call or taking a photograph. Smartphones are like a mini laboratory, packed with electronic sensors that are perpetually recording the environment.[84] The remarkable advancements made in sensor technology mean we can now detect and evaluate countless physical and chemical parameters using very compact devices. What was previously only possible with a laboratory cabinet full of expensive equipment can now be done using a device the size of your fingernail.

The acceleration sensor in your mobile phone is even smaller, measuring just 3 x 3 millimetres.[85] Inside this chip a silicon bar a few micrometres wide functions as a kind of spring. With each movement, the bar is moved because of its inertia, and the distance between it and an electrode changes as a result. The tiny changes in distance cause fluctuations in the electrical capacity, making it possible to measure the acceleration of your mobile phone very precisely. Right next to that sensor is a tiny barometer. This is another technological miracle: a silicon membrane only ten micrometres thick with piezoresistive stretch-conductive strips that change shape when the air pressure fluctuates, resulting in changes in electrical resistance. The device can measure changes

in air pressure of just 0.12 hectopascal, which corresponds to an altitude difference of around one meter.

This combination of acceleration and pressure sensor data is enough to reveal whether you are climbing or descending a flight of stairs. The distinctive up-and-down pattern of acceleration when using the stairs, combined with an increase or decrease in air pressure, results in a typical pattern. When used in combination with a gyroscope sensor it is even possible to tell whether the stairs spiral up in a clockwise direction or not. If you move progressively slower as you climb, it could be an indication that you are becoming tired, revealing something about your physical condition. In contrast, if the sensor reports vigorous, rhythmic movements without any change in air pressure or GPS location, it may be a sign that the phone's owner is dancing. By referring to the time of day, it is possible to narrow down the possibilities because it is more likely that someone is dancing at 11 p.m. than at 11 a.m. A quick check of the location data can also reveal whether the individual is in a nightclub or not. The built-in microphone captures the music currently being played and *voila*, your phone knows whether you are dancing – and it even knows to which song!

So your smartphone can reveal whether you are dancing, climbing stairs, sleeping, jogging or painting your fingernails at work. Yes, the integrated BME680 unit also has a tiny gas sensor that responds to volatile organic compounds in the air and can detect glues, solvents, cleaning supplies and alcohol.[86]

Let me ask you a question: would you have any objection to allowing the new app to access your sensor data? You would only have to press the little button next to which it says: 'Access sensor data.' The light-grey declaration text ambiguously states: 'We use this data to improve certain services.' So, what is your decision?

Perhaps it would be more honest if, next to the button, it said: 'May we track your way of life?'

Today, smartphones have a thermometer, barometer, acceleration sensor, echo sensor, fingerprint sensor, GPS, inclinometer, humidity meter, magnetometer, proximity sensor, NFC sensor for wireless data transfer, light sensor, two cameras (front and back), a microphone, a touchscreen, a Wi-Fi antenna and a tiny transmitting antenna.[87] To be honest I am amazed the manufacturers manage to include all these components in such a small device. However, I have to admit that I find the extent to which providers can track what we do frightening.

Incidentally, I forgot to mention something. When you visit your doctor after being told by your novel that there might be a problem, you discover that this 'novel' is no ordinary book. It was developed by a major pharmaceutical company in cooperation with your health insurance company. A new method of early detection screening was developed on the basis of the user data transmitted. The gripping story and the unusual protagonist were designed to trigger certain responses in you, which are then recorded and analysed. This kind of early diagnosis alone could save millions in the healthcare sector. 'You should be grateful,' the doctor tells you. 'Perhaps that novel saved your life.'

[…]

I am not a robot

We can only see a short distance ahead.[173]
– Alan Turing

I am not a robot. We are often asked to confirm this by ticking a box when we try to send a message online. Alternatively we may be asked to identify a series of letters on an image to prove that we are creatures of flesh and blood.

This is similar to a virtual doorman whose function it is to block spam programs or other automated services. These so-called CAPTCHA programs are used to identify whether website visitors are humans or simply machines.[174] CAPTCHA is an abbreviation for 'Completely Automated Public Turing Test To Tell Computers and Humans Apart', and it is essentially an algorithm that gives us humans a task to solve that would be too difficult for automated software. Sometimes it is a matter of identifying a series of blurred letters, sometimes we are asked to click on only the cats or dogs in an image mosaic. The basic idea behind these tests can be traced back to the brilliant mathematician Alan Turing, and that is why it is known as the Turing test.[175] For Turing, a computer passed this test if a person, when communicating with the computer, was unsure whether it was communicating with another human or with a machine.

In 1950 Turing posed a provocative question: can machines think? He was convinced that they could. 'We may hope that machines will eventually compete with men in all purely intellectual fields,' he said. Turing would be proven right (even if the 'men' sounds strange to the modern ear), and computers now play chess and the Asian board game Go, beating even the best human opponents. Robots build cars and are becoming increasingly independent. They can perceive their surroundings and respond to external stimuli. Robots disguised as baby seals are used to provide company and comfort to residents in nursing homes, a Japanese invention that has also been introduced in Europe by now. The baby seal is fitted with a number of sensors and can respond to light, sound and touch. It can also communicate by moving its flippers, making sounds, and opening its eyes. Old people long retreated into their shells often respond to the animal by stroking it and talking to it. Patients affected by dementia possibly see a real living being in this machine.

In Alex Garland's science fiction film *Ex Machina*, the main character Caleb meets the stunningly beautiful female robot Ava. Caleb becomes so besotted with the individuality of the pretty robot that he protects her from being reprogrammed, overriding the security system in order to do so. Ultimately, however, Ava turns out to be a cool, calculating machine that takes advantage of the affection shown to her by humans to organise her escape. In this reverse Turing test, the human beings lose and the machine takes over.

In such fictional worlds there is often a clear dividing line between humans and machines; the organic and artificial worlds stand in battle against each other. Such plots are reminiscent of the formulaic Westerns of old: cowboys against Indians, black against white. But what if the boundary became indistinct, what if adversaries united to create a hybrid of the two worlds?

A hundred years ago doctors would issue a death certificate when a patient's heart stopped beating. According to the medical understanding of the day, cardiac arrest was synonymous with death. These days, however, intensive care wards regularly 'bring back to life' those who would previously have been declared dead.[176] And with cardiac pacemakers, these patients are given a second chance at life. Devices such as pacemakers, cochlear implants and insulin pumps are cold, lifeless pieces of technology, but they are effective replacements for diseased body parts. In

Germany alone around 180,000 artificial hip joints and around 100,000 pacemakers are implanted each year.[177] The first prostheses that can be controlled by thought are already in use. Experiments are also being conducted on bionic eyes with light-sensitive sensors that relay signals to the brain, and on touch-sensitive artificial hands that give back amputees their sense of touch.[178]

So while one branch of research and development is focusing on compensating for damaged organs and limbs and producing intelligent prostheses, a second branch is working on the use of thought to control such devices. Machines can now be controlled by eye movement alone and scientists are always looking for new ways of reading brain signals. Companies such as Facebook are keen to make the keyboard obsolete, claiming that we will all one day be able to compose texts using only our thoughts.[179]

An artificial womb developed by scientists at the Children's Hospital of Philadelphia created quite a stir recently. The 'BioBag' is a transparent plastic bag filled with amniotic fluid that can keep a lamb foetus alive.[180] The lamb foetuses, which corresponded in terms of their development to a human premature birth in the twenty-third week, survived and grew normally during the four-week experiment. Doctors hope this method could be used in future to improve the survival rate of babies born extremely prematurely.

In addition to artificial wombs and electronic machine implants, scientists are also working on growing organs. Using stem cells, it is now possible to recreate mini-organs in the laboratory – heart muscle cells and tiny stomachs throbbing in small glass jars.[181] In 2009 the immunologist and molecular geneticist Hans Clevers developed a revolutionary method by which an almost limitless number of so-called organoids could be produced using the patient's own stem cells. By now, more than 200 laboratories around the world are growing miniature stomachs, kidneys and livers.

In 2016 I met Hans Clevers in Hamburg, where he was presented with the Körber European Science Prize, and we discussed the potential of his research. He told me some amazing things. For a long time, biologists had assumed that stem cells aged and that there was a limit to how many times they could divide. After all, at some point the natural process of division comes to an end and the cells in our bodies die. In his laboratory at Utrecht University, Clevers and his team experimented with mouse stem cells and even after seven years, far longer than the life expectancy of the rodents themselves, the stem cells continued to divide. This discovery opens up an exciting vision for the future: the medical industry may one day be able to supply us with a constant supply of fresh cells and organs – making us immortal! 'So is it conceivable that we could meet again in 500 years' time?' I ask Hans. He hesitates before answering, 'Technically that might be possible, but do you really want that?'

The dream of eternal life is a red thread running through our cultures. The Frenchwoman Jeanne Calment holds the record for living longest – she died in 1997 at the grand old age of 122.[182] As a fourteen-year old she worked in a Paris art supplies store and sold pencils to Vincent van Gogh. She saw construction engineers build the Eiffel Tower and she experienced both world wars. As average life expectancy has grown in industrialised nations over the past few decades, the number of so-called supercentenarians – people who reach their 110th birthday – has also been on the rise.

Jan Vijg, a geneticist at the Albert Einstein College of Medicine in New York, has carried out studies on maximum life expectancy in 38 countries.[183] There was a dramatic increase in life expectancy between 1940 and 1980, but since then it has largely stagnated. The statistics show a plateau at around the age of 115. Progress achieved in the field of medicine thus far is reflected in these figures. But imagine what would happen if in a few years we had mini-robots in our blood vessels and artificial organs to assist us?

We prefer to suppress the knowledge that the natural ageing process increasingly takes its toll over time. In Roman times the average life expectancy was under 30 years – most people died young. Most of us, in contrast, live long enough to feel our aging body get closer and closer to its best-before date. By the time we reach 60, people in developed countries have already lost around a third of their teeth, and twenty years later four out of ten people no longer have any teeth left. With time, our bones become brittle, our blood vessels harden, our muscles atrophy, our hair becomes grey and falls out, and we become hard of hearing. Even if we exercise and eat a healthy diet, it is impossible to avoid the ravages of time. In his excellent book *Being Mortal*, surgeon Atul Gawande describes this gradual process of decay with shocking clarity. Over time our bodies well and truly fall apart – the fate that awaits you and I is not a pleasant one! But what if it were possible to stop this process? What if the medicine of the future could save us from this decline?

One of the most outrageous places I have ever visited is the premises of Alcor in Scottsdale, Arizona. 'The Alcor Life Extension Foundation' is displayed in blue lettering on a large sign at the entrance. When I visited, the company had only just recently moved to Scottsdale from California. My guide explained that the location had been chosen very carefully. The new site in Scottsdale is very safe, and no earthquakes or other natural disasters have ever been recorded there. If you, like Alcor, are planning for the long term, such considerations are vital – as they would be when looking for a final storage area for radioactive waste. The mission of the Alcor Foundation is to freeze dead people and store the corpses in large liquid nitrogen tanks for decades in order to defreeze them in the distant future. By then – so Alcor members believe – medicine will have advanced so much that it will be possible to bring the preserved bodies back to life.

Over the following days, Igor (as my cameraman and I had christened him) introduced me to the crazy logic behind the dream of eternal life. They believe that anyone dying today could have lived on for years if only they had had access to more advanced medicine. In just a few decades, heart attacks, infections, cancer and all other diseases and complications will – they assume – no longer result in death. The procedure at Alcor is very simple, explained Igor. You pay the Foundation around $200,000, fill out a series of forms, and you will be preserved for eternity when you die. Immediately after death the Alcor team travels to collect the corpse and then flush out the blood vessels using various anti-freeze agents and preservatives. These substances allegedly prevent ice crystals from damaging the fine membranes of the body cells. After that, the body is subjected to a controlled cooling process in which the temperature reaches −296 ˚C. Submerged in liquid nitrogen in one of the large cryogenic tanks, the deep-frozen body is then left to be resurrected in a utopian future.

Until it becomes time to defrost the body, the interest accrued on the $200,000 is used to pay for staffing costs and for the regular refilling of the liquid nitrogen tanks. Igor explained that there was also a cheaper option. 'We can also just preserve the head.' Those choosing that option will have their heads severed and frozen, an increasingly popular choice, he says.

I looked at the large, gleaming steel tanks before me. 'Are you saying that there are decapitated heads and dead bodies stored in these?'

'We call them *patients*,' answered Igor.

That evening I had an appointment to meet Sally, who lived in a large house with her husband and children, and was prepared to be interviewed about her membership of Alcor. She and her husband Rick had decided on the 'head only' option – they could always upgrade to 'whole body' in a few years. Sally talked enthusiastically about this amazing opportunity, but while she described

how she and her husband arrived at the decision, all I could see in my mind's eye was Sally's decapitated head floating in a liquid nitrogen tank.

I asked her what she thinks it will be like waking up in the future. No big deal, she said. With high-tech medicine, the doctors of the future would first put her thawed head in a special solution. Intelligent robots would then connect her brain to a computer. From that point on she would be able to communicate with the outside world again.

'But what about your body?' No problem either. By then the human race will be so advanced that they will be able provide her with an artificial replica body. Yes, it is entirely possible that, as a head-only person, she would be free to choose her new body from a catalogue, perhaps with a leaner belly and a bigger bust than she has now.

In my hotel in Scottsdale that night I slept uneasily, dreaming of decapitated heads and lifeless, bloodless bodies, and of Sally and her husband Rick arguing over the different models of their future bodies. The following day Igor told me about an interesting court case. A few years ago a mathematician from California had been diagnosed with a brain tumour. The cancer threatened to gradually destroy his brain and therefore his consciousness. The man wanted to take his own life before reaching that stage, and to have his head frozen and preserved after he died. However, since the police investigation following a suicide would prevent the Alcor team from quickly completing the necessary preservation measures, he turned to the courts for official approval. 'He wanted to kill himself so that he could live longer, see?' said Igor. The court in California would certainly have rejected his request, but luckily the tumour stopped growing.

Unfortunately we were refused permission to take a look inside the large cryotanks so I still have some lingering doubts about how much truth there is behind all the sensational stories Igor and his friends told me. However, Alcor proudly reports that the Foundation now has more than a thousand members and 150 'patients' already awaiting resurrection.[184] Who knows – perhaps it is all just a phenomenal swindle. A huge show put on to convince gullible people like Sally and Rick that eternal life is possible and to scam them out of hundreds of thousands of dollars. Which would make Alcor a kind of modern-day indulgence!

But what if eternal life really did become a technical possibility one day? Visionaries such as Ray Kurzweil are convinced that, in future, machines will be able to read our brains, allowing us to live forever as virtual beings.[185] In his books and lectures, Kurzweil extrapolates this moment of *singularity* from advancements in memory capacity and in processing power in the field of IT. In future, he believes that technical systems will merge into superorganisms with a consciousness of their own, and that we – or whatever is left of us – will be part of this magical machine. Kurzweil and other representatives of transhumanism hope one day to see humanity reach this redemptive stage of development that will finally see us become immortal. And again, as elsewhere in this book, we see remarkable parallels between religion and technology: the technological utopia is a promise of paradise.

However, amid all this talk of technological feasibility, we have forgotten a crucial question. Do we even want to be immortal? Is our impermanence not an essential part of who we are? In her novel *All Men Are Mortal*, the French philosopher Simone de Beauvoir tells the fictional story of Raimon Fosca.[186] Born in 1279, he was a prince in the Italian city of Carmona. One day a beggar offers him a magical elixir that is said to bestow eternal life. Fosca does not hesitate long before taking the potion, and does indeed become immortal. Although he becomes increasingly powerful, as the years pass his wife and children die. Locked in the lonely prison of time he experiences a series of episodes. He becomes an explorer and spends time living with a tribe of American Indians; he later

becomes an advisor at the court of Charles V; and he lives through the French Revolution and experiences the ebb and flow of history first hand. This cycle of striving and failing becomes intolerable because he always loses the people he loves. In the end he is always left standing alone. After half a millennium he meets and falls in love with Marianne. But she is horrified when she learns of his immortality: she is giving her whole life to him, while for him she is merely a brief episode in eternity.

Beauvoir's message is still valid today. Death is not the curse we may perceive it to be. It is precisely our mortality that gives meaning to our lives and actions. All the promises of salvation offered by computer visionaries in their attempts to open the door of immortality with questionable experiments[187] fail to recognise the redemptive significance of our human impermanence.

P.S. It is, of course, entirely possible – a few centuries from now – that this book falls into the hands of a beautiful woman called Sally, who has been reborn after decades in liquid nitrogen.

Dear Sally, if you are reading this, it means I was wrong all this time. But don't worry about me. I enjoyed my mortality – every single day of it!

[…]

Footnotes for translated sections

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