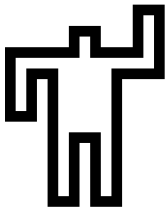


HELLO, ROBOT. has been layouted by an algorithm in collaboration with Double Standards, Berlin.

DESIGN BETWEEN HUMAN AND MACHINE

HELLO, ROBOT.

THE SEARCH FOR QUESTIONS

We can assume that Jacques Tati wouldn't be on Facebook were he alive today. And with their unquenchable thirst for user data, the likes of Google, Apple, Microsoft, and Amazon would hardly have been able to win the favour of the French filmmaker, who died in 1982, either. After all, Tati's unforgettable works such as *Mon Oncle* and *Playtime* made it abundantly clear what he thought of the new technology of the mid-twentieth century: not much. In one legendary scene, Tati's cinematic alter ego, Monsieur Hulot, enters his sister's fully automated kitchen.[1] First he burns his finger on a heating element, then he finds it impossible to open the kitchen cabinet. He pushes buttons and everything begins to buzz and beep. The door suddenly flies open and out rolls a jug, which falls to the floor. But nothing happens, for the jug is made of an elastic material. Relieved, Monsieur Hulot bounces it off the ground a couple of times. Then he tries the same thing with a glass. Crash! All he wanted was some iced tea.

He never says a word, but it's written clearly on his face: What is this good for? Why do we need it? Faced with the digitisation of our lives driven by companies such as the "Frightful Five of the tech industry" mentioned at the beginning of this essay,[2] we are still asking this question today and it still causes controversy. But actually it isn't a question at all, for just like in the past, technology cannot be stopped as long as it sufficiently indulges our existing habits and makes our lives easier. "Convenience is a world power", says author and Internet expert Sascha Lobo,[3] the best example of this being, of course, the smartphone. No one seemed to need a smartphone until the introduction of the iPhone in 2007, but less than a decade later it is impossible for most of us to imagine everyday life without these smart little helpers. Of course, Jacques Tati knew that progress had to progress, regardless of whether he liked it or not. "In the fully automated kitchen in *Mon Oncle,* he is not just running up against the often invoked 'malice' of the inanimate object," writes film critic Roland Mörchen, "rather he is spoofing the spirit (or rather demon) of a 'new artificiality'. *Mon Oncle* is the friendly wink of a man who knows he cannot do away with what is known as modernity."[4] And so we can be sure that, were he alive today, Tati would not be on Facebook, but he would almost certainly own a smartphone.

AMELIE KLEIN

1 See the work description for *Mon Oncle,* p. 170.
2 Farhad Manjoo, "Tech's 'Frightful 5' Will Dominate Digital Life for Foreseeable Future", in *The New York Times* (20 January 2016), http://www.nytimes.com/2016/01/21/technology/techs-frightful-5-will-dominate-digital-life-for-foreseeable-future.html, accessed on 4 December 2016.
3 Sascha Lobo, "Bequemlichkeit schlägt Datensparsamkeit", in *Spiegel Online* (September 28, 2016), http://www.spiegel.de/netzwelt/web/zugriff-auf-daten-bequemlichkeit-schlaegt-sicherheit-kolumne-a-1114091.html, accessed on 4 December 2016.
4 Roland Mörchen, "Die Anarchie der leisen Töne. Jacques Tatis pointierte Alltagskomik", in *Film Dienst* (no. 21, 1998).

JUST WHAT IS A ROBOT?

The appearance of the robot in our everyday lives is just as unavoidable – its visible appearance that is, for in fact robots have been lurking in parts of washing machines, automobiles, and automatic cash dispensers for years. Of course, such creatures will not look like robots, or rather they will not take the form that most of us have come to expect. "Robots are tools for dramatic effect. They are not a piece of technology," says Bruce Sterling, science fiction author and advisor to the exhibition *Hello, Robot. Design between Human and Machine.*[5] It is no coincidence that the word "robot" is the invention of a playwright. Karel Čapek's 1920 play described a mechanical working class – in other words, a class that has been dehumanised and hence robbed of its dignity – which first rises up against its masters, human beings, before revealing itself to be the morally and ethically superior species.[6] Čapek, a staunch antifascist, was engaging in a piece of social criticism which, based on humanity's age-old desire to reproduce itself, has been expressed time and again: the robot that serves us – and the robot that destroys us …

Thus, popular culture has influenced our expectations regarding robots for almost a hundred years. They should be humanoid in form, i.e., look just like us, and they should think, communicate, and move as we do. Our fascination for these human machines has reached the world's robotics laboratories, where researchers are eagerly working on creating humanoid robots. But they really ought to know better, for at present robots are not even capable of mastering the things that humans can do only two years after they are born: walk more or less confidently on two legs, even managing to stay upright on uneven ground, stairs, ice, and sand. It's no wonder that we always find real robots a bit of a let-down when we see them. They are even worse than Arnold Schwarzenegger in *Terminator.*

What we often forget, however, is that robots – unlike humans – don't actually need their own enclosed bodies. They only need three things, says Carlo Ratti, director of MIT's Sense*able* City Lab and also an advisor to *Hello, Robot.*: sensors, intelligence, and actuators.[7] In other words, they require measuring instruments; software that is capable of making sense of and using the information these gather, such as light, sound, or heat; and devices that trigger a measurable physical reaction. Viewed in this light, this means any house and any environment can be a robot. A robot can observe us through numerous cameras simultaneously and, for example, regulate a city's traffic lights or adjust the lights in our living room according to what it sees. We could also describe the smartphone as a kind of mini-robot – and paired with us we could say it forms a (partially) robotic system.

Ratti's definition of a robot is certainly very broad, but it nonetheless leaves out certain things that we think of as typical characteristics of robots.[8] For example, they are supposed to teach and steer themselves, they should make autonomous decisions, and they should be at least partially physical in nature. But this is not true of every robot. Classical industrial robots can only perform the movements they have been programmed to perform; they do not make decisions on their own, nor do they learn. Surgical robots are remote controlled – mercifully – and the same is true of most drones. And the Internet is teeming with softbots, self-learning software which can chat with users or provide shopping tips, but that have no physical form. It appears that there is no universally acceptable definition of robots. Only one thing seems to be clear: yes, two-legged humanoid robots such as Boston Dynamics' *Atlas,* which over nineteen million viewers have watched stumble through the snow on YouTube, do indeed exist.[9] But robots are much more than that. They make our physical world intelligent. They transform objects into "smart objects". They can give rise to a scenario in which all of the things we know from the Internet can step out of the screen and permeate three-dimensional space.

5 Bruce Sterling in an interview with Amelie Klein (Turin, 19 April 2016).
6 See the work description for *R.U.R. Rossum's Universal Robot,* p. 42.
7 Carlo Ratti in an interview with Amelie Klein (Weil am Rhein, 4 July 2016).
8 Erica Palmerini, Federico Azzarri, et al., *RoboLaw – Regulating Emerging Robotic Technologies in Europe: Robotics Facing Law and Ethics,* http://www.robolaw.eu/RoboLaw_files/documents/robolaw_d6.2_guidelinesregulatingrobotics_20140922.pdf, p. 15, accessed on 4 December 2016.
9 Boston Dynamics, *Atlas – The Next Generation,* on YouTube, https://www.youtube.com/watch?v=rVlhMGQgDkY, accessed on 4 December 2016.

10 Carlo Ratti in an interview with Amelie Klein (Weil am Rhein, 4 July 2016).
11 László Moholy-Nagy, *Sehen in Bewegung.* Edition Bauhaus 39 (Leipzig, Spector Books, 2014), p. 42.
12 Ibid.
13 Nicolas Nova (Near Future Laboratory), Nancy Kwon, Katie Miyake, Walt Chiu (Art Center College of Design), *Curious Rituals,* https://curiousrituals.wordpress.com/, accessed on 4 December 2016.
14 Ibid.

Nicolas Nova (Near Future Laboratory), Nancy Kwon, Katie Miyake, Walt Chiu (Art Center College of Design). *A Digital Tomorrow,* 2012. Video, 9 min 36 sec, produced as part of the study *Curious Rituals,* July–August 2012 © Nicolas Nova, Nancy Kwon, Katie Miyake, and Walt Chiu

The exhibition *Hello, Robot.* traces the successive development of our definition of the robot, as does this book. First, we encounter more or less friendly humanoid robots (as well as a vacuum cleaner) before moving on to examine robots from the spheres of work and industry. Taking a closer look, we confront the machines face to face: as smart assistants and assiduous helpers that help care for us. Finally, we ourselves meld with the robot: prosthetics and implanted chips bring the robot inside us, while robotic architecture and environments bring us inside the robot. On page 32 and at the entrance to the exhibition you will find our attempt at a robot taxonomy. It is nothing more than an incomplete approximation, for robots are just as diverse as the world they increasingly populate.

AND WHAT IS THE ROLE OF DESIGN?

If we follow the broad understanding of robots described above, this would mean that many robots are not different in appearance from non-robotic objects, such as ordinary dolls, cars, or houses, but only in how they behave. "The medieval city remains a medieval city," explains Carlo Ratti, a native of Turin, "what changes is how we interact with it."[10] Like in all other parts of the digital sphere, it is not only a question of the design of form and function, but of interaction, relationship, and the combination of the two: experience. This might sound new, but it isn't new at all. As early as 1947, László Moholy-Nagy, one of the most important figures of the Bauhaus, wrote: "Design is a complex and demanding task. It entails the integration of technological, social, and economic requirements, biological demands, and the psychophysical effects of materials, shape, colour, volume, and space: it is about thinking in relationships."[11] He continues: "There is design in the structure of emotional experiences, in family life, in work relationships, in urban planning, in cooperation among civilised people. Ultimately, all of the problems of design come together to form one large problem: 'designing for life'."[12]

How then are our interactions and relationships with the intelligent objects that increasingly surround us designed? Beyond the traditional interfaces of buttons, switches, and joysticks there are also a number of unusual gestures one is forced to perform when interacting with technology. We swipe our hands through the air when we want to open train doors and our fingers over the screen when we want to read our emails. We wave at the motion detectors when we find ourselves in darkened lavatories after making the mistake of sitting too long and we open the electronic entrance to the office with a saucy swing of the hips when we are too lazy to fish our ID cards out of our pockets. *Curious Rituals* is the name of a study conducted by Nicolas Nova, Nancy Kwon, Katie Miyake, and Walt Chiu as part of their degree course at the Art Center College of Design in Pasadena, California, which examined these and other gestural interactions with technology.[13] Their study also included a video, *A Digital Tomorrow,* which shows that things won't get any better in the future.[14] Smart devices are charged by swinging them in circles through the air, a slap on the cheek ensures better concentration when synching brainwaves, and voice recognition works just as poorly as it does today.

Indeed, we continue to imagine that in the future technology will always work perfectly. This is surprising, for there is nothing in the present that might indicate that this will be the case. Just how often, for example, have you spoken on the phone with your IT consultant or Internet service provider over the past month? We also tend to think that technology generally will (inter)act in our best interests – at least when it isn't focused on world domination and our ultimate destruction. What we are seeing even today, however, is a kind of well-intentioned paternalism. David Rose, researcher at the MIT Media Lab, entrepreneur, and expert for human-computer interactions, has developed a series of *Enchanted Objects,*[15] as he calls them: smart networked objects capable of fulfilling our wishes like in a fairy tale. One of these, a waste bin, doesn't just automatically order online the things we have thrown away; it also comments on the owner's consumption habits. It asks, for example: "Do you really want to order Asian mineral water again? Why don't you buy locally!?" Or reminds us: "That was your third packet of biscuits today." At least you can give the bin a kick when you're fed up with its remarks – it understands that, too.[16]

A project by the design studio Superflux offers a take on the same theme: *Uninvited Guests.*[17] In the video we are introduced to Thomas, a seventy-year-old widower who has received an assortment of smart objects from his concerned children. They are intended to help him get safely and healthily through everyday life. On the first day, Thomas reluctantly follows the ever more pestering instructions from his intelligent devices; on day two he simply ignores them. But everything is networked with everything else, and so it is that Thomas receives the first worried messages from his children: "Hi Dad, I see you're not using the smart cane today. Hope all is ok? xxx Gina." Design not only shapes our interactions with machines, it seems, but also how we interact with one another.

Superflux sees itself as a design studio that seeks a critical examination of new technologies and their effects on the world. *Uninvited Guests* is a speculative project that is meant to spur discussion. David Rose, however, has developed a smart screw cap for pill bottles that has enjoyed high levels of sales for several years.[18] *GlowCap,* the name of this intelligent device, reminds users to take their medicine. If they neglect to do so, the screw cap starts to blink, by all means a sensible reminder, for it is certainly important that patients take their medicines according to schedule. In 2010, it won the American Medical Design Excellence Award. But *GlowCap* goes one step further: if the patient fails to take his or her medicine after the reminder, the smart cap sends a message to their loved ones. And another one to the doctor. And another to the health insurance company, for they are the main distributors of *GlowCap.*[19]

JUST WHO'S THE BAD GUY HERE?

The boundaries between well-intentioned concern, surveillance, and outright espionage are blurry. In 2006, the German computer magazine *c't* referred to Google as a "Data Kraken",[20] and ever since then the term has become a byword for notorious data collectors and even had its own entry on the German Wikipedia website. According to the Wikipedia definition, Data Kraken are "systems and organisations that evaluate personal information on a grand scale and/or redirect it to third parties. In doing so, they allegedly or demonstrably are in breach of data privacy regulations or violate the personal rights postulated by privacy groups that go beyond these."[21] And even if Big Data has yet to evolve into "Smart Data", as an article in the weekly *Die Zeit* has claimed – that is, if the data collectors have not yet learned to properly classify all the information they gather[22] – it would still be naïve to believe that a health insurance company would not allow a patient who neglects to take his medication go unpunished. And if health insurance premiums are raised because a patient forgets his medicine, then we're just a hop, skip, and a jump away from a scenario in which premiums are raised on those who occasionally have one too many at the pub or dine too often at the corner chip shop.

15 David Rose, *Enchanted Objects: Innovation, Design, and the Future of Technology* (New York, Scribner, 2015).
16 David Rose, "Enchanted Objects", TEDxBeaconStreet (16 November, 2014), https://www.youtube.com/watch?v=I_Ahhhc-ceXk, 12:52 Min., accessed on 4 December 2016.
17 See work description for *Uninvited Guests,* p. 88.
18 http://www.vitality.net/, accessed on 4 December 2016.
19 David Rose, "Enchanted Objects", TEDxBeaconStreet (16 November 2014), https://www.youtube.com/watch?v=I_Ahhhc-ceXk, 08:39 min., accessed on 4 December 2016.
20 Jo Bager, "Der Datenkrake: Google und der Datenschutz", in *c't* (10/2006), p. 168, https://web.archive.org/web/20060613011608/http://www.heise.de/ct/06/10/168/, accessed on 4 December 2016.
21 https://de.wikipedia.org/wiki/Datenkrake, accessed on 4 December 2016.
22 Wolfgang Uchatius, "Warum glaubt Google, mein Kaninchen frisst Hundefutter", in *Die Zeit* (no. 47, 10 November 2016), p. 18.

The Internet unremittingly collects data about our behaviour. And with robotics, the arrival of the Internet in three-dimensional space, this is set to explode exponentially. The Internet of Things and the Smart City, all of these are projects for major corporations, and not only those that make these infrastructures available, but also those who are keen to evaluate the data we generate or sell it on to third parties like the advertising industry. "An Internet of Things," writes Bruce Sterling, "is not a consumer society. It's a materialised network society. It's like a Google or Facebook writ large in the landscape. Google and Facebook don't have 'users' or 'customers'. Instead, they have participants under machine surveillance, whose activities are algorithmically combined within Big Data silos."[23]

In an essay appearing in this book, the philosopher Rosi Braidotti speaks at length about the economisation of people. "But this exploitation is not limited to people: In substance, advanced capitalism both invests in and profits from the scientific and economic control and the commodification of all that lives. [...] Seeds, plants, animals, and bacteria fit into this logic of insatiable consumption alongside various specimens of humanity. The uniqueness of *Anthropos* is intrinsically and explicitly displaced by this equation."[24] Thomas Vašek, editor in chief of the philosophy magazine *Hohe Luft,* also introduces machines to this observation: "All of us – humans as well as robots, smartphones, and artificial intelligences of every kind – are slaves of digital capitalism. We all produce data that is economically exploitable for Google and the like, we all leave data trails in the infosphere, we are all digitally predictable – and therefore we can be easily controlled by a digital mega-superintelligence. We call it the capitalist system."[25] Before the filthy lucre we are all the same.

Unfortunately, design is all too willing to serve the will of this mega-superintelligence. But this need not be the case. Indeed, it shouldn't be the case. Even for Walther Gropius, design and ethics were inseparable. In his 1925 "Principles of Bauhaus Production", Gropius called for a "resolute affirmation of the living environment of machines and vehicles" and in doing so was clearly making a social claim: "The creation of standard types for all practical commodities of everyday use is a social necessity. On the whole, the necessities of life are the same for the majority of people. The home and its furnishings are mass consumer goods, and their design is more a matter of reason than a matter of passion."[26] In 1963, in the middle of an economic boom, the British graphic designer, photographer, and author Ken Garland published a manifesto titled "First Things First", in which he called for designers to dedicate their talents and attentions not only to the large corporations, but to socially relevant topics. A list of alternatives to advertising for cat food and striped toothpaste was followed by the statement: "We do not advocate the abolition of high pressure consumer advertising: this is not feasible. Nor do we want to take any of the fun out of life. But we are proposing a reversal of priorities in favour of the more useful and more lasting forms of communication."[27]

"First Things First" struck a chord that continues to resonate to this day. Garland's manifesto does not call into question the underlying political and economic system: "This is not feasible." After all, design is not a "neutral, value-free process", explains Katherine McCoy, a graphic artist and lecturer for two decades at the Cranbrook Academy of Art, one of the most recognised academies for design in the United States.[28] The fundamental decision of whether or not a designer offers his or her talent in the service of a Data Kraken is a political one and should be discussed as such. Perhaps this is why the "IoT Design Manifesto 1.0",[29] a ten-point list of demands concerning the design of the Internet of Things, leaves us with such an unpleasant aftertaste. Five of the ten demands are dedicated to the issues of security and data protection, which is a good thing of course. Point four reads as follows: "We keep everyone and everything secure" – a reference to attacks from hackers and similar threats. Why, then, did the manifesto's authors put this point first: "We don't believe the hype. We pledge to be sceptical of the cult of the new – just slapping the Internet onto a product isn't the answer. Monetising only through connectivity rarely guarantees sustainable commercial success."

23 Bruce Sterling, *The Epic Struggle of the Internet of Things* (London, Moscow, Strelka Press, 2014).
24 See Rosi Braidotti, "Becoming-World Together: On the Crisis of Human", p. 238.
25 Thomas Vašek, "Befreit die Roboter!", in *Hohe Luft_spezial Digitalisierung / Hohe Luft* (no. 1, 2017), p. 6.
26 Walter Gropius, "Principles of Bauhaus Production", in *Programs and Manifestoes in 20th-century Architecture* (Cambridge, MIT Press, 1970), pp. 95–96.
27 Ken Garland, "First Things First", facsimile in *Design Is History,* http://www.designishistory.com/1960/first-things-first/, accessed on 4 December 2016.
28 Rick Poynor, "First Things First Revisited", in *Emigré* (no. 51,1999), http://www.emigre.com/Editorial.php?sect=1&id=13, accessed on 4 December 2016.
29 www.iotmanifesto.com, accessed on 4 December 2016.

The issue here is not the fact that designers wish to develop a sustainable means of earning money. Quite the opposite, in fact, for there are simply too many designers who have to live in precarious conditions because their work is insufficiently valued. The problem here is that commercial success appears in the very first point of a manifesto that claims to serve as a "code of behaviour" for those involved in the development of the Internet of Things.

When "First Things First" was revised and republished at the turn of the millennium with the new title "First Things First Manifesto 2000", it received an important addition. It now reads: "We propose a reversal of priorities in favour of more useful, lasting, and democratic forms of communication – a mindshift away from product marketing and toward the exploration and production of a new kind of meaning. The scope of debate is shrinking; it must expand. Consumerism is running uncontested; it must be challenged by other perspectives expressed, in part, through the visual languages and resources of design."[30]

Bruce Sterling adds his own take: "Rather than thinking outside the box – which was almost always a money box, quite frankly – we surely need a better understanding of boxes."[31] In other words, we have to change the parameters, redefine the context, and ask different questions. "Instead of pursuing projects, defining goals, and thus describing a linear path to a solution, design is capable of drawing upon prototypes, experiments and mistakes, pilot projects, and speculation based on limited knowledge to sketch several paths that can describe the space for possibilities," writes the German graphic designer and university lecturer Florian Pfeffer.[32]

WHY IS IT SO HARD FOR US TO RELINQUISH CONTROL?

Ironically, there are designers who do exactly this while supported by robots and algorithms. Achim Menges is the director of the Institute for Computational Design (ICD) at the University of Stuttgart, where, after years of research conducted together with a large interdisciplinary team, he developed the *Elytra Filament Pavilion,* an extremely light, robot-constructed roof construction of carbon fibre and fibreglass which was first displayed at London's Victoria & Albert Museum in 2016 before being temporarily relocated to the Vitra campus in Weil am Rhein in February 2017. The individual modules are based upon biomimetic principles and are inspired by the wing cases of flying beetles known as "elytra". The modules themselves were designed by algorithms. Only a few individual parameters were predetermined, such as the fact that all of the modules should consist of hexagonal metal frames. However, the frames' exact geometry and structure of the fibres vary according to the bearing load, light, and weather conditions as well as the number of visitors. "In this instance the computer is more than just a tool," says Menges, "for it provides for levels of access that one otherwise would not have. One could compare it to a microscope or telescope, which do not change the world, but our view of it." He explains how computers are capable of dealing with complexities that go beyond the realm of human intuition. "This certainly does not mean that this is something that I would wish to simulate or control."[33] As a reward for this "controlled loss of control", the *Elytra Filament Pavilion* surprises designers with its unusual and fascinating aesthetics.

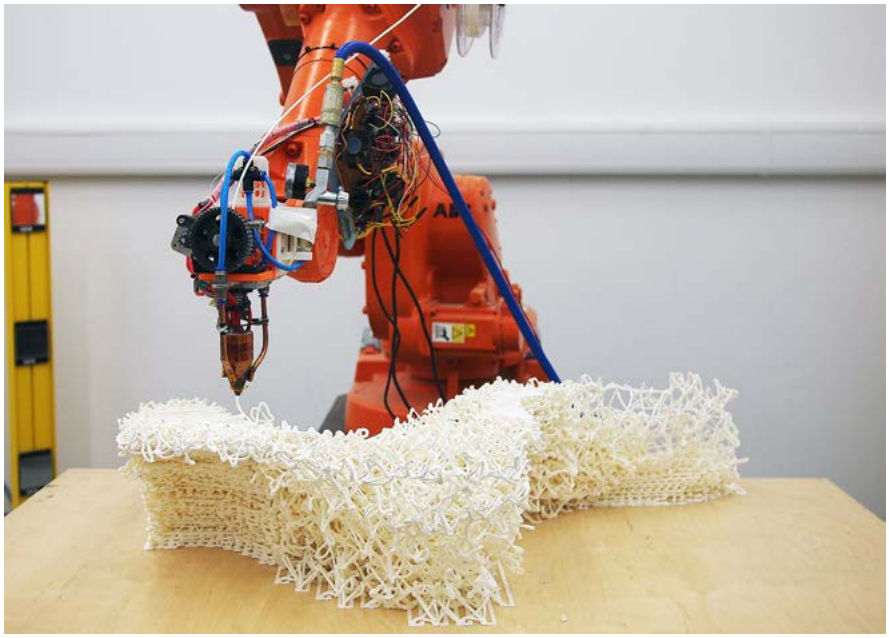
Achim Menges with Moritz Dörstelmann (ICD University of Stuttgart / Achim Menges Architect), Jan Knippers (ITKE University of Stuttgart / Knippers Helbig Advanced Engineering), and Thomas Auer (Transsolar Climate Engineering / TUM). *Elytra Filament Pavilion in the Victoria and Albert Museum,* 2016, photo: © NAARO, courtesy ICD, University of Stuttgart

30 "First Things First Manifesto 2000", in *Eye* (no. 33, vol. 8, Autumn 1999: no. 51, 1999), http://www.eyemagazine.com/feature/article/first-things-first-manifesto-2000, accessed on 4 December 2016.
32 Bruce Sterling, *Design Fiction,* http://shelovestofu.com/blog_uploads/2009/04/sterling-design-fiction.pdf, accessed on 4 December 2016.
33 Florian Pfeffer, *To Do: Die neue Rolle der Gestaltung in einer veränderten Welt – Strategien, Werkzeuge, Geschäftsmodelle* (Mainz, Hermann Schmidt, 2014), p. 176.
33 Achim Menges in a discussion with Amelie Klein (Weil am Rhein, 10 November 2016).

34 Chris Rehberger in a discussion with Amelie Klein (telephone interview, 26 October 2016).

The book which you are now holding in your hands was also designed by an algorithm devised by the Berlin graphic design firm Double Standards working together with a programmer. Here, too, a few fundamental parameters were determined – the basic raster, the fonts, a palette of type sizes, several options for illustrations, etc. – but the computer was given control over the overall design. At a touch of a button it came up with hundreds of thousands of layout options. Human designers were only responsible for selecting the final version, and, as Double Standards founder Chris Rehberger explains, they were better prepared to "try the impossible, for the algorithm schools the eye".[34] The result does not always fit with our reading and viewing habits, but we must remember that the graphic design and typography of the legendary Bauhaus books were also out of step with contemporary reading and viewing habits. After all, before Bauhaus there was no typesetting that allowed people to understand a text in its visual entirety at first glance.

The essence of experimentation is the process, not the goal. Perhaps the next book designed by Double Standards and its algorithm will do even more to shake up our habits – perhaps less. But for now this does not matter, just like it does not matter that the *3D Printed Cantilever Chair* designed by the CurVoxels student group takes itself to the point of absurdity. After all, it really isn't necessary to develop your own 3D printing software if you're setting out to produce the perfect *Panton Chair,* the design that served as a model for CurVoxels. The tried and true injection moulding process is certainly sufficient – after all, the *Panton* was designed to take advantage of the technique. The team's goal was not to print an improved version of the chair, however, for what they really wanted to do was experiment on an old complex form using complex new methods. A voxel is a three-dimensional pixel or, to explain it in different terms, a pixel in space. The *3D Printed Cantilever Chair* sets out to test – once again with the aid of an algorithm – just how many of these voxels a cantilever such as the *Panton Chair* requires in order to function properly. How much is possible with the minimum of material? A robot traces over the algorithmically determined path with hot plastic thread which solidifies while it is still in motion.



CurVoxels, Research Cluster 4, UCL The Bartlett School of Architecture, London. *3D Printed Cantilever Chair,* 2015. Chair and software for a 3D-printing technique. Team: (CurVoxels) Hyunchul Kwon, Amreen Kaleel, Xiaolin Li; Tutors: Gilles Retsin, Manuel Jiménez Garcia; Technical Support: Vicente Soler Senent, William Bondin © 2017 CurVoxels, photo: Sin Bozkurt, CurVoxels

Amelie Klein (born in 1971 in Vienna, Austria) is one of the curators of *Hello, Robot. Design between Human and Machine.* Since August 2011, she has been working as a curator at the Vitra Design Museum, most recently for the exhibition *Making Africa – A Continent of Contemporary Design,* for which she was nominated for the 2015 *ART* Magazine Curator Prize. Prior to this, Klein completed an MA in Design Criticism in New York and worked as Design and Creative Industry Editor at the Austrian daily *Die Presse.* She has published numerous articles in a range of design and architectural publications, including *Abitare, Domus Online,* and *Metropolis.*

William Williams. *The Cast Iron Bridge Near Coalbrookdale,* 1977. Oil on canvas, 86 × 102 cm. © courtesy Coalbrookdale Museum of Iron

For some time now, it has seemed as if we find ourselves at what could be described as the "Iron Bridge moment" of digital modernity. The Iron Bridge, built in the English county of Shropshire, is the world's first arch bridge to be constructed completely of cast iron. Yet even though it was built using what was then a fantastic new material, its construction rigidly follows the principles of wooden bridge design. It would take a few decades before the production and use of cast iron had been mastered to a degree that would eventually bring about a completely new aesthetic that was the natural result of the material's properties. Over the last few years we have certainly seen a number of 3D-printed "Iron Bridges", but the three examples described above provide us with a clue of the kind of aesthetics with which the early twenty-first-century will make it into the history books, if only we would learn to trust the algorithms and allow them to take control just for a moment. Perhaps we will one day come to accept that even though we may not be able to influence everything, something good can still result – such as an exciting roof construction, a new language of graphic design, or, to return to László Moholy-Nagy, life as a whole.

What does this all mean when it comes to how we deal with tyrannical forks and pill bottle tops that spy on us? Will it be enough if we – each and every one of us analogously to the scenarios outlined above – determine the parameters that can describe the scope of these smart devices and decide where humans take over again? Hardly. In this respect we are only now beginning to ask the right questions. You will find fourteen of them in this book and in the exhibition rooms of *Hello, Robot. Design between Human and Machine.* At first they might seem rather simple, but if you consider them more carefully you will soon realise that there are no simple answers. This, too, is a characteristic that weaves its way through the entire subject and reflects our postmodern world: there's no such thing as a single truth, for the contradictory strands of truth are often capable of existing alongside one another. But our fourteen questions invite visitors and readers to enter into a dialogue and reflect upon their own very personal relationship with technology as individuals but also as members of society as a whole.

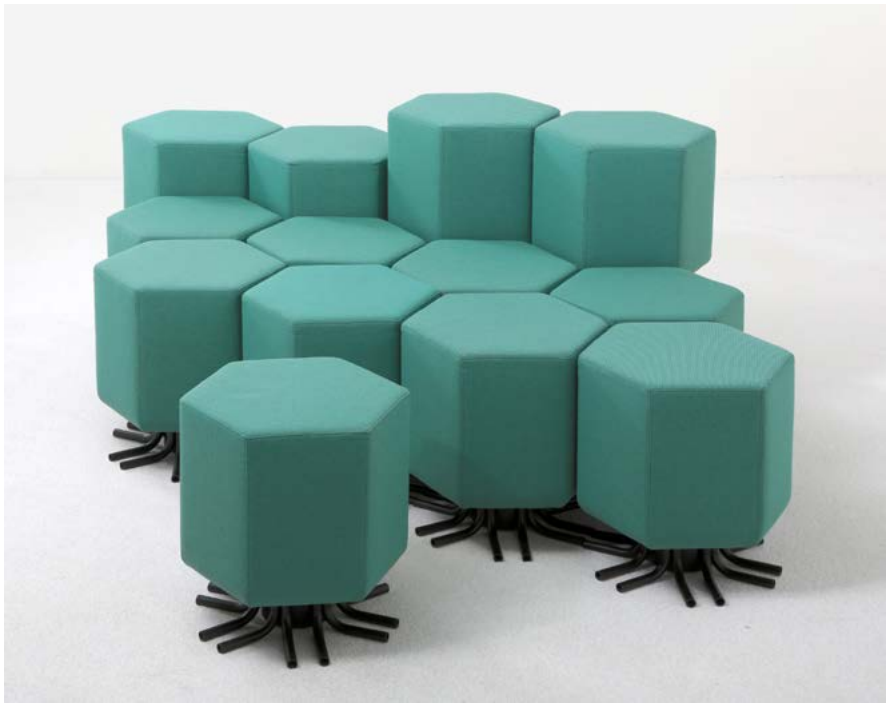
But this is just the beginning. There is so much more to do.

DO YOU WANT A ROBOT TO TAKE CARE OF YOU?

HOW MUCH DO YOU WANT TO RELY ON SMART HELPERS?

O YOU
ELIEVE IN
HE
EATH
ND RE-
IRTH OF
HINGS?

OW DO YOU FEEL
BOUT OBJECTS
AVING FEELINGS?



Lift-Bit, 2016

Carlo Ratti Associati. *Lift-Bit,* 2016. Programmable seating landscape, module 78 × 45 × 45 cm; technology and interaction design: Opendot © Carlo Ratti Associati, photo: Max Tomasinelli

CARLO RATTI ASSOCIATI – *LIFT-BIT*

These hexagonal, stool-like upholstered furniture modules were developed by the architectural office of Carlo Ratti, (also director of the MIT Sense*able* City Lab in Boston, Massachusetts). The modules can be positioned in a variety of seating arrangements and even be put together to create entire sofa landscapes. According to Ratti's website, they represent "the world's first digitally-transformable sofa," whose modules, thanks to their internal motors, can be raised and lowered by means of an app. They can also be adjusted manually by holding a hand over the units' built-in sensors. If left alone for too long, however, the units grow bored and develop a life of their own, adjusting their height according to their own whims. LH

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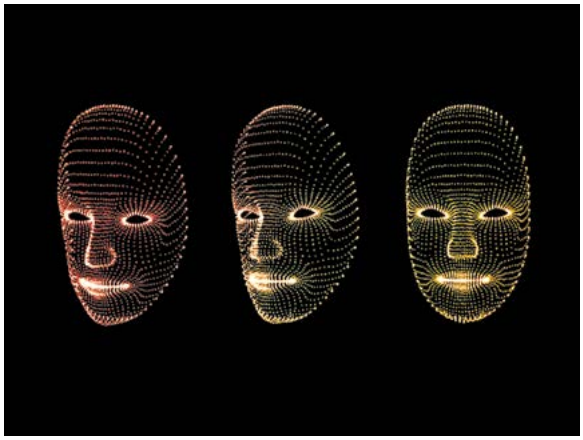
Innovative possibilities for graphic displays that appear in space in real time are the focus of the *Flyfire* project. Every pixel in the image is a self-organised micro-drone equipped with a small LED light. Each of these "smart pixels" moves according to a precise digitally controlled technology; as a group, or swarm, they can form a two-dimensional photographic image in open space, a three-dimensional figure, or they can morph back and forth between the two. As the drones can communicate with a smartphone in the pocket of a pedestrian, for example, advertisments aimed at the individual in public space are conceivable – just like the ones we already know from the Internet. TT



Flyfire, 2010

MIT Sense*able* City Lab. *Flyfire,* 2010. Video, 1 min 52 sec; in collaboration with the ARES Lab, MIT © MIT Sense*able* City Lab

MIT SENSE*ABLE* CITY LAB – *FLYFIRE*

HOW UBIQUITOUS COMPUTING
IS BRINGING ROBOTICS TO PLACES
YOU'D NEVER SUSPECT

CARLO RATTI WITH DANIELE BELLERI

"If your house needed
to hear a story to help it
to go to sleep, what
story would you tell it?
The 'Three Little Pigs?'
What information
would you give it?
Would you tell it that it
is just a machine?"

Rich Gold, *Cybernetics and Systems,*
vol. 26, no. 4, 1995

A ROBOT FOR LIVING IN

PART I – THE UBIQUITOUS ROBOT

According to the Encyclopædia Britannica, a robot is "any automatically operated machine that replaces human effort".[1] For the sake of this essay, however, we will adopt a more restrictive definition: we will call a robot a unit that has some sensors, some intelligence, and some actuators. In other words, it can read the world, process that information, and then respond in a purposeful way. By our definition, a robot could be many different and perhaps unexpected things at the same time. A thermostat is a robot. A car on driving assist is a robot. Our oven is a robot. A bracelet that measures our physical performance as we exercise is a robot. Even a bike can be a robot. That is, if it incorporates our Copenhagen Wheel, which is a wheel that can convert any bike into a hybrid vehicle, able to collect data from our daily rides (*disclaimer:* this is the first of many of our projects – from both MIT Sense*able* City Lab[2] and Carlo Ratti Associati[3] – that will punctuate this text as supporting examples for our arguments). And our omnipresent smartphone, too, is obviously a robot.

Based on the above, our definition is very different from traditional views of what constitutes a robot, at least in artistic and literary circles – views that often involved a certain degree of anthropomorphism. As described elsewhere in this publication, the term "robot" comes from the Czech word *robota* ("forced labour" or "serf"), coined in 1920 by Karel Čapek in his play *R.U.R. – Rossum's Universal Robots*[4] to describe the possibility – and, above all, the threat – of extremely skilful and apparently submissive automated workers. The idea of the robot was thus embedded in a framework of interaction with humanity: so deeply embedded, indeed, that the concept – from the dulcimer-playing automaton "La Joueuse de Tympanon"[5] in the eighteenth century to Hanna-Barbera's animated series *The Jetsons* – is almost inseparable from the idea of the android.

1 Hans Peter Moravec, "Robot", in *Encyclopaedia Britannica* (Winter 2016), https://www.britannica.com/technology/robot-technology, accessed on 28 September 2016.
2 Sense*able* City Laboratory is a research initiative directed by Carlo Ratti at the Massachusetts Institute of Technology.
3 Carlo Ratti Associati is a design and consultancy office based in Turin, Boston, and London.
4 Karel Čapek, *R.U.R.* (Prague, Aventinum, 1920).
5 CERIMES, "David Roentgen's Automaton of Queen Marie Antoinette, The Dulcimer Player (La Joueuse de Tympanon)" [video], MET Museum (uploaded 23 October 2012), http://www.metmuseum.org/metmedia/video/collections/esda/automaton-of-queen-marie-antoinette, accessed on 28 September 2016.

Carlo Ratti Associati. *Cloud Cast,* Installation commissioned by the Museum of Future Government Services, Dubai, 2015 © Carlo Ratti Associati, photo: Pietro Leoni

6 A range of responsive infrared heating elements are guided by sophisticated motion tracking, creating a precise personal (and personalised) climate for each occupant. Individual thermal clouds follow people through space.

To be sure, the conspiracy-laden landscape of films such as *Terminator* (1984) and *Robocop* (1987) and even the more recent *Automata* (2014) appears much more compelling than the existence of apps that monitor our jogging habits, the temperature in our bedroom, and the gradual cooking of a stuffed turkey. Yet this does not mean that contemporary robots have no impact upon our existence. Quite the opposite. It may seem paradoxical, but the more discreet presence of robots and the more "natural" our interaction with them, the more powerful their actual influence becomes.

This is the new universe in which we exist, every day. Take Nest, the thermostat which allows us to remotely control the temperature in our homes and which – if it comes into sufficiently widespread use – could have a major impact on energy consumption in buildings. The characteristics of Nest are barely noticeable, even almost humble – so radically remote from any flamboyant design gesture that it compels us to invent new ways to express it. We came to understand the challenges of such an approach a few months ago while developing our project for the renovation of the Agnelli Foundation's headquarters in the city of Turin. In the overall scheme of this project, the most notable innovation is located in the heart of the company's office rooms. Yet it is a rather intangible one. We are talking about a control system for heating, cooling, and lighting in the workplace – a system that can potentially follow people around inside the building, automatically synchronising to their needs and preferences. To allow the client to appreciate the design, we resolved to craft the visualisation of an individually tailored "thermal bubble".[6] But we know that, even behind so anthropocentric a metaphor, there is a vast battalion of tiny sensor-robots.

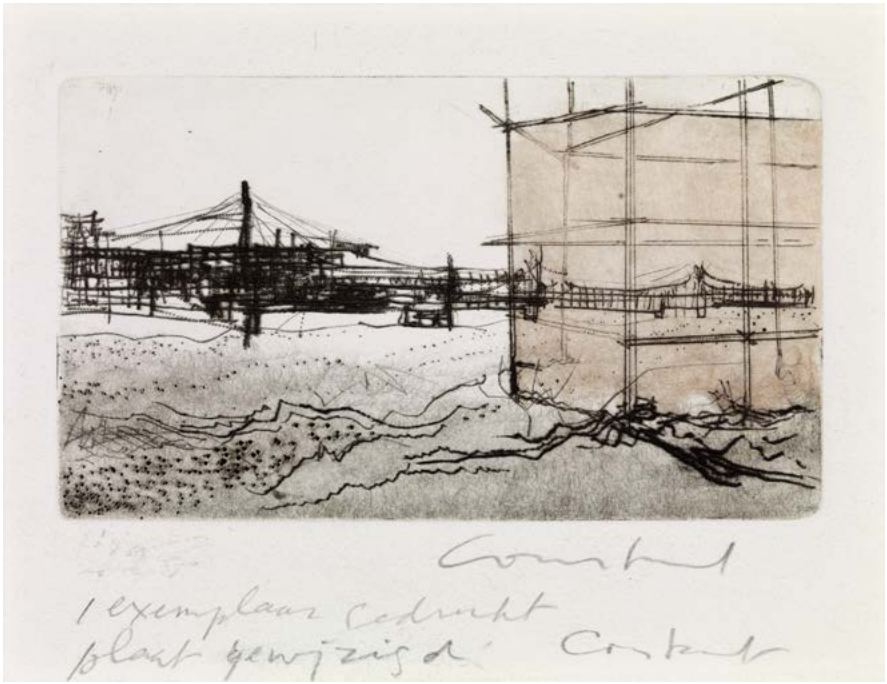
PART II – A ROBOT "FOR LIVING IN"

The phenomenon that has allowed robots to become so integrated into our lives is the next logical step of the digital revolution that we have been living out over the past few decades. As virtual systems become spatialised, our cities are being transformed into the so-called "Internet of Things" (IoT). The inanimate physical environment is increasingly associated with digital layers: code married to matter, physical brick to virtual bit. The city is becoming a physical companion to Big Data, even as the urban infrastructure allows for digital information to proliferate.

In fact, a full realisation of the Internet of Things could be a scenario in which technology takes the form of "smart dust"[7] – becoming so small and diffuse as to be almost pulverised, metaphorically allowing technology to enmesh with air. This, in turn, would bring to fruition a concept put forward by the late Xerox-Park computer scientist Mark Weiser, whose idea of non-intrusive – or "calm" – technology goes by the label of "ubiquitous computing". Weiser presciently said: "Ubiquitous computing names the third wave in computing, just now beginning. First were mainframes, each shared by lots of people. Now we are in the personal computing era, person and machine staring uneasily at each other across the desktop. Next comes ubiquitous computing, or the age of calm technology, when technology recedes into the background of our lives."[8]

7 Kristofer S.J. Pister, et al., "Smart Dust: Communicating with a Cubic-Millimeter", *Computer* (vol. 34, 2001), pp. 44–51.
8 M. Weiser, "The Computer for the Twenty-First Century", *Scientific American* (Autumn 1991).

9 Ibid.
10 Le Corbusier, *Vers une architecture* (Paris, G. Crès, 1924), p. 73.
11 Constant Nieuwenhuys, *New Babylon,* exh. cat. Gemeentemuseum, The Hague (The Hague, 1974).
12 Peter Blake, "Walking City", in *Architectural Forum,* translated by Alain Guiheux, *Archigram,* exh. cat. Centre Georges-Pompidou, Paris (Paris, 1994).



Constant. *New Babylon Under Construction,* 1970. Etching, photo: Tom Haartsen @ Constant/Fondation Constant © VG Bild-Kunst, Bonn 2016

In an article published in *Scientific American* in September 1991, Weiser wrote: "Hundreds of computers in a room could seem intimidating at first, just as hundreds of volts coursing through wires in the walls once did. But like the wires in the walls, these hundreds of computers will come to be invisible to common awareness. People will simply use them unconsciously to accomplish everyday tasks."[9] Now, what happens if we replace the word "computers" with "robots" in that quote?

The impact of ubiquitous computing – or, even better, ubiquitous robotics – on architecture could be immense. Throughout the twentieth century, architecture was often depicted in mechanical terms. It was Le Corbusier, almost a hundred years ago, who first referred to the modern house as a "machine for living in".[10] A few decades later, Constant's *New Babylon* raised the bar even higher, prefiguring a city that looked like an infinitely extended settlement in the form of a huge network of raised platforms spanning the whole of Europe. In this "camp for nomads on the planetary scale",[11] human lives would unfold within enclosed, reconfigurable spaces. A little later, in 1964, the avant-garde journal *Archigram* published a concept by Ron Herron for a moving metropolis consisting of mobile, intelligent robotic structures that could reach any place in the world. Walking cities are also modular, with the ability to connect as well as to disperse: "Walking City imagines a future in which borders and boundaries are abandoned in favour of a nomadic lifestyle among groups of people worldwide."[12]

No devotee of architectural history could fail to be fascinated by these examples. But how can we bring them into existence? Without venturing so far as to match Constant's all-encompassing utopias, we can think of certain designs that are robotic interfaces themselves. This is a field that we have directly explored in our own projects.

Our *Digital Water Pavilion,* designed for the Zaragoza Expo 2008, employs water as both an architectural element and a robotic interface. The building's walls are composed of digitally controlled water droplets, which can generate writing, patterns, or access spaces. The result is a space that is interactive and reconfigurable: each wall can potentially become an entrance or an exit, while the internal partitions can shift, depending upon the number of people inside the building. The only material elements are the two boxes and the roof, which can move vertically and can even be flattened to the ground, thus erasing the presence of the entire Pavilion.

Carlo Ratti Associati. *Digital Water Pavilion* for the Zaragoza Expo 2008. © Carlo Ratti Associati, photo: Ramak Fazel

At Milan Design Week 2016, borrowing from the work of Hiroshi Ishii at the Massachusetts Institute of Technology (MIT) Media Lab,[13] we presented *Lift-Bit*. Realised with the support of the Swiss manufacturer Vitra, this is a modular, digitally reconfigurable seating system consisting of a series of individual, upholstered stools. The elements are motorised and can be raised or lowered using a linear actuator; their height can be doubled (or halved) in a matter of seconds. *Lift-Bit* can be controlled in person, via a touchless gesture, or from a distance, through the use of a mobile app which includes both a series of predetermined three-dimensional shapes and a tool to create new combinations. The system is further enhanced when assembled in large compositions. In this context, activating a single stool triggers a broader effect, with the entire system recalibrating itself and generating a potentially infinite number of arrangements. Two elements together can make a chair. Four elements, a chaise longue. Nine elements, a large sofa. Dozens can radically redefine any settings, drawing new interior landscapes.

Often described as a kind of "third skin" – in addition to our own biological skin and our clothing – architecture has for too long functioned rather like a corset: a rigid and uncompromising addition to our body. Ubiquitous robots have the potential to change this.

These are only a few examples. Yet they clearly show how the scenario is changing, developing in a direction that echoes, at least in part, the imagination of the post-war avant-gardists of design.

13 The Tangible Media Group is a research project led by Professor Hiroshi Ishii at Massachusetts Institute of Technology.

PART III – RISKY ROBOTICS

Despite its ability to meet our needs, the idea of a robotic house still prompts some disturbing thoughts. Living within a robot-controlled house is not necessarily reassuring – probably because of the robot's simultaneously mysterious and uncontrollable intelligence. This intelligence may be thinly concealing the looming possibility of a "betrayal" or a "hacking", irrespective of whether the agent behind such an act is robotic or human. Surely this was what another Xerox-PARC member, the composer Rich Gold, had in mind in his essay in *Cybernetics and Systems,* entitled "How smart does your bed have to be before you are afraid to go to sleep at night?"[14]

But how could our own nest manage to deceive us? We can imagine a house that plays malicious pranks on us – for example, if our flat suddenly turned into a haunted mansion – or we can consider an intelligence that gathers data about us so as to implement some subtle form of blackmail. This could take the form of an "ethical house", which would monitor your actions and could, say, result in unfavourable deals from insurance companies if you managed your own health in ways that were deemed reckless. This scenario could, in fact, become a reality in the not-too-distant future: in May 2016,[15] in keeping with the industry's principle of loss prevention, the insurance and risk management company Munich Re contributed to the $20 million, GV-led funding of Helium, a startup selling smart sensors that measure domestic variables such as temperature, pressure, light, humidity, and barometric pressure.

How then to deal with possible hacking and intrusions? Hacking can be carried out anywhere and everywhere, potentially involving multiple networks in obscure locations. We all know what happens when our computer gets a virus or is hacked – and crashes. But what if our very house should crash? This possibility defies conventional strategies of retaliation and protection. As the then US Defense Secretary Leon Panetta warned in 2012: given its current systems, the United States is vulnerable to a "cyber-Pearl Harbor"[16] that could derail trains, poison water supplies, and cripple power grids.

14 Rich Gold, "How smart does your bed have to be before you are afraid to go to sleep at night?", in *Cybernetics and Systems* (vol. 26, 1995).
15 John Brownlee, "We've Been Approaching The Internet of Things All Wrong", in *Fast Company* (Spring 2016), https://www.fastcodesign.com/3059355/weve-been-approaching-the-internet-of-things-all-wrong, accessed on 28 September 2016.
16 U.S. Department of Defence, http://archive.defense.gov/transcripts/transcript.aspx?transcriptid=5136, accessed on 28 September 2016.

How could we prevent such a scenario? One option, surprisingly, might be to promote the widespread adoption of hacking itself. Familiarity with hackers' tools and methods provides a powerful advantage in diagnosing the strength of existing systems and can help us to design tighter security from the bottom up – a practice known as "white hat" hacking.[17] Ethical infiltration enables a security team to render digital networks more resistant to attack by identifying their flaws. This could become routine practice – a kind of cyber fire drill – for governments and businesses in the near future, while academic and industry research continues to focus on developing further technical safeguards.

In general, today's security measures take the form of autonomous, constantly vigilant digital "supervisors" – computers and code that control other computers and code. Like traditional military command-and-control protocols, they gain power in numbers and can respond swiftly to a broad array of attacks. Such a digital ecosystem strengthens checks and balances, reducing the possibility of failure and mitigating the effects of an incursion. One could imagine a house as an army of robots, each keeping track of the other, while also checking up on us.

17 Kim Zetter, "Hacker Lexicon: What Are White Hat, Gray Hat, and Black Hat Hackers?", in *Wired* (Spring 2016), https://www.wired.com/2016/04/hacker-lexicon-white-hat-gray-hat-black-hat-hackers/, accessed on 28 September 2016.

PART IV – A CEMETERY, AFTER ALL

Even assuming that we can solve the hacking issue, will we really end up with a living, tailored architecture that constantly shape-shifts and adapts to the needs, personalities, and desires of its inhabitants? Are we heading towards Archigram's Walking City and other utopias of the past? Are we on the verge of seeing a city made up of moving robots?

This may be a realistic hypothesis from a technological point of view. Yet we should perhaps begin by questioning the possibility of such a change, going back to the very nature of our buildings and cities. In fact, our metropolises, despite being the stage on which the forces of capitalism's "creative destruction" continually act, are rooted in an idea of timelessness and stasis. It was Lewis Mumford, in his classic work, *The City in History,* who reminded us of this aspect. A city or a building also represents permanence, an antidote to the transience of life: "Mid the uneasy wanderings of Palaeolithic man, the dead were the first to have a permanent dwelling: a cavern, a mound marked by a cairn, a collective barrow. [...] The city of the dead antedates the city of the living. In one sense, indeed, the city of the dead is the forerunner, almost the core, of every living city."[18]

Cities are at the same time an anchor against the transience of life and a reminder of our need to belong. In her memorable account of the Emperor Hadrian's life, Marguerite Yourcenar attributes to him the following words: "I have done much rebuilding. To reconstruct is to collaborate with time gone by, penetrating or modifying its spirit, and carrying it toward a longer future. Thus beneath the stones we find the secret of the springs."[19] And again, when the old emperor reflects on the city he plans to build for Antinous, his deceased lover: "To build is to collaborate with earth, to put a human mark upon a landscape, modifying it forever thereby; the process also contributes to that slow change which makes up the history of cities."[20]

18 Lewis Mumford, *The City in History* (San Diego, Harcourt, 1961), pp. 6–10.
19 Marguerite Yourcenar, *Memoirs of Hadrian* (New York, Farrar, Straus & Giroux, 2005), p. 174.
20 Ibid., 126 and 134.

Robots are complicit in the shift from a city made of atoms only to a universe made of atoms and virtual bits. But can we really discard the primacy of stone-like elements? Marco Romano has highlighted the crucial continuity in the history of the Western European city between the development of a civic sense and the existence of a shared architectural aesthetic: "The desperate thirst for immortality [...] is entrusted by European citizens in the material substance of their city, in those walls which – despite continuously changing before our eyes – appear to be embodying the memory and promise of a boundless time and duration. [...] Our social life finds its meaning only as we spiritually belong to the physical figure of the city, and we materially belong to its moral figure."[21] This passes through a series of "collective themes" by which local construction rules are set and a canon of beauty is defined.

The "collective themes" are simply brick-and-mortar archetypes – from the main square to the market place, the church square, the national square, the main street, the triumphal way, the promenade, the boulevard, and many others. Romano concludes: "Themed roads and squares permit collective themes to be arranged in sequence, in a closely connected contiguity wherein their meaning as a collective expression of *civitas* is confirmed and even exalted [...] even citizens who live in the very outer suburbs can understand that they belong to the symbolic figure of *urbs* because of the presence of such a sequence. Thus the dignity of their moral membership of *civitas* is fully recognised." [22]

21 Marco Romano, *L'estetica della città europea* (Turin, Einaudi, 1993).
22 Ibid.

PART V – PERMANENT CITIES, TRANSIENT INTERACTIONS

At the beginning of the ubiquitous robotics revolution, the city is confronted with one of the key dilemmas of its multi-millennial existence – of either embracing transience and responsiveness or, instead, perpetuating a sense of timelessness as a collective attempt to counter the inevitable passing of time. Robots have the power to change our relationship with the built environment and potentially even with our bodies witness the recent diffusion of devices for the quantified self. But will they be able to do it?

The interesting aspect is that we do not need to move bricks to move our cities. We can imagine that, from an architectural point of view, the robotic city of the future will not look very different from the city of today – much in the same way that the Roman *urbs* is not all that different from the city as we know it today. In any case, it will be able to retain its character of permanence. It will always have horizontal floors for living, vertical walls to separate spaces, and exterior enclosures to protect us from the outside – such "fundamentals", celebrated in Rem Koolhaas's 2014 Venice Biennale, are unlikely to change. The key elements of architecture will still be there, and our models of urban planning will be quite similar to what we know today. What could change is our way of experiencing the city through ubiquitous robotics.

However, the impact might be increasingly forceful at the soft edge – the interface between humans and "bits and bricks". Technologies are shrinking and even vanishing from sight, gently suffusing our buildings and cities with their effects. Thanks to this discreet robotic revolution, the soft edge is acquiring a character of dynamism and responsiveness that was barely conceivable in the past. In the near future, despite being unchanged in much of its physical traits, a building might well be animated to something resembling life, becoming a direct, immediate extension of our own character and desires.

Carlo Ratti Associati. *Future Food District,* Installation for the World Expo 2015, Milan © Carlo Ratti Associati, photo: Delfino Sisto Lignani

23 Oleg Grabar, "The Mediation of Ornament", *The A. W. Mellon Lectures in the Fine Arts,* 1989, The National Gallery of Art, Washington, D.C. (Princeton, Princeton University Press, 1992), p. 284.
24 Donna Haraway, "A Cyborg Manifesto: Science, Technology, and Socialist Feminism in the Late Twentieth Century", in Donna J. Haraway (ed.), *Simians, Cyborgs, and Women* (New York, Routledge, 1991).
25 Antoine Picon, *La ville territoire des cyborgs* (Paris, Les Editions de l'Imprimeur, 1998).

The art historian Oleg Grabar once said: "Good architecture is always meant to be an invitation to behave in certain ways; it always adorns life [...]. Without it, life loses its quality. Architecture makes life complete, but it is neither life nor art."[23] This statement was based on the historic distinction between architecture itself and its host. But this may be about to change. We now see architecture as an extension of our "post-human" condition: the dramatic departure from pure organic life and the possibilities of extension to the body and brain offered by prostheses, networks, and avatars – with our mobile phones always in the foreground. Authors like Donna Haraway[24] and Antoine Picon[25] have mobilised the figure of the cyborg to characterise the growing dependence – a dependence close to a co-production – of man on technology in contemporary society. In this robotics-driven living experience, buildings will not appear as pieces of machinery or equipment, but rather as extensions of the lives of the subjects who inhabit them. They will provide environments in which more and more dimensions will be customisable, engaging our senses and resonating with our moods.

Robots may not transform the core of our buildings – but they will certainly change the lives inside of them.

Carlo Ratti was born in 1971 in Turin. After studying Architecture and Engineering in Paris, Cambridge, and Turin, Ratti became a fellow at the MIT Media Lab under Hiroshi Ishii before taking on teaching posts at Harvard and the Stelka Institute in Moscow. He founded his own architectural office in Turin in 2003 and the Sense*able* City Lab at MIT in Boston one year later. He is still its director today, researching the concept of the Smart City by combining new digital technologies with design and urban planning. Ratti has lectured on the Smart City all over the world and has written countless articles on the subject for design and architectural publications. He lives and works in Boston and Turin.

ARE

WOULD YOU A ROBOT?

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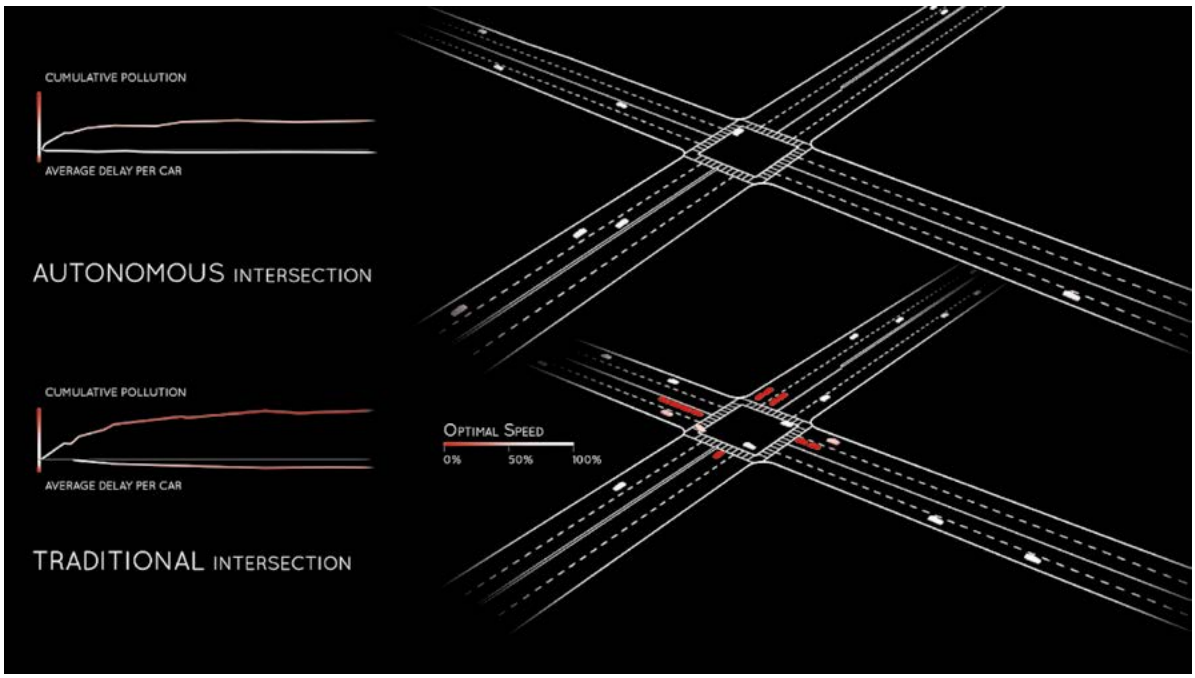
ROBOTS ADVANCING EVOLUTION?

LIVE IN



DriveWAVE, 2014

MIT SENSE*ABLE* CITY LAB – *DRIVEWAVE*

MIT Sense*able* City Lab. *DriveWAVE,* 2014. Video, 1 min 26 sec © MIT Sense*able* City Lab

In a future world in which self-driving cars are a given – as has been predicted for the year 2030 – will we still need traffic lights to make us stop and wait at intersections on our way home from work? No, say the researchers at the MIT Sense*able* City Lab. Their *DriveWAVE* is a digital traffic control system, a "smart intersection" which can calculate gaps in traffic at lightning speed and guide the networked vehicles through the intersection without stopping. It is fast enough to ensure a steady flow of traffic while still allowing for sufficiently safe distances between the individual vehicles. This will not only enable us to get from A to B more quickly, but will also cut fuel consumption by eliminating the constant need for vehicles to brake and accelerate. According to the researchers' model for the future, Traffic 4.0 will be fluid and seamless. TT