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Ethics of Smart Cities: Towards Value-Sensitive Design and Co-Evolving City Life

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Abstract

The digital revolution has brought about many societal changes such as the creation of "smart cities". While the initial concept of smart cities was largely technology-driven and focused on the automation of processes and logistics, this concept is currently being replaced by technology-enabled, human-centred solutions. However, this is not the end of the development, as there is now a big trend towards "design for values". Such "value-sensitive design" will take ethics, law and culture on board. Furthermore, a "democracy by design" approach could promote a more sustainable pathway of cities that better serves people and nature.

Keywords: Smart Cities, Digital Democracy, Participation, Co-Creation, Sustainability, Resilience

Contents

1 Early Use of Information Technologies in Cities

Since the very beginning of their existence, computers have been used to simulate and improve cities and mobility. Traffic simulation models, for example, were around already in the 1950ies (May 1990). Traffic light control, as well, applied computers early on (Engelmann 1996). Later on, auto-CAD programs were used for building design (Coons 1963; Edward 1963; Harper 1968; Mitchell 1977) and urban planning (Dangermond and Smith 1988; Forrester 1969; Harvard University, Laboratory for Computer Graphics and Spatial Analysis, and Dougenik 1975; Lowry 1964; Negroponte 1970; Plummer 2005; Robertson 1967). Eventually, digital technologies became pervasive. By now, they are used to monitor, manage and control cities on all imaginable levels and scales.

1.1 Automated Cities

The birth of the idea of "smart cities" was a logical consequence of this development (Hutchison and Mitchell 2011). Some of the earliest attempts were put forward by IBM (IBM 2008) and Cisco (Villa and Wagener 2008). The company proposed the Smarter Planet Project (IBM 2008) and the Smarter City Challenge (Wilson 2017). In 2008, Cisco detailed the "Connected Urban Development program" and dedicated US$15 million to it (Villa and Wagener 2008). However, by the year 2020, the company quit its efforts to digitize cities (Tilley 2020).

Before this decision was taken, a data-driven vision of cities had spread, assuming ubiquitous sensing, using the Internet of Things (IoT). In this way, everything from traffic flow to logistics and waste disposal would be optimized and automated (Zanella et al. 2014); people would be surveilled as well. Eventually, in Germany a "Smart City Charter" was drafted, which went so far to aim for a post-decision and post-voting society (Bundesinstitut für Bau-Stadt und Raumforschung 2017, p.43). According to this vision, societies would be run in a data-driven way, using Big Data and powerful Artificial Intelligence (AI).

However, despite all efforts and many billions spent, automated society did not meet the expectations. An evaluation of smart cities projects resulted in a rather disillusioned view (Foreign & Commonwealth Office 2016). Moreover, in the year of 2019, only one Silicon Valley city—San Francisco—had made it into only one out of five ratings' top ten list of the world's most liveable cities (Getzoff 2020; Mercer 2019; Nielson 2019; Reid, Nicol, and Allen 2019; The Economist Intelligence Unit 2019).[1]

Moreover, smart cities projects around the world are still far from being sustainable, even though the political goal is to reach sustainability by 2030 (United Nations 2021b), i.e. in less than a decade.

Further problems result from the mass surveillance approach underlying many smart cities concepts. According to Germany's "Smart City Charta", "[b]ehavioral data can replace democracy as the social feedback system" (Bundesinstitut für Bau-Stadt und Raumforschung 2017, p.43), as long as enough data is collected. According to our judgement, such concepts for the society of the future are based on privacy intrusion, profiling, behavioral manipulation, and discrimination. They can, hence, undermine fundamental human rights. Moreover, there is a danger of an emerging digital divide. It is, therefore, no surprise that in Toronto, for example, citizens rejected Google's surveillance-based smart cities vision (Cecco 2019).

1.2 Digital Twins

By 2030 it is expected that around 50 billion measurement sensors of various kinds will be used worldwide, many of them connected to the Internet (Statista 2021). This establishes the Internet of Things (IoT) (Ashton 2009), which enables smart homes and smart cities.

Given the vast amount of data produced by the IoT, it has also become fashionable to produce "digital twins" or "digital doubles" of everything and everyone. For infrastructures, traffic, production, or climate, such models of reality can be certainly helpful (Batty 2018, 2019; Tomko and Winter 2019). However, there are some risks and challenges. First, it is crucial how the data is used, and who has access to it for what purposes. A war room approach would certainly be inappropriate for the use of this data (Helbing and Seele 2017). Second, the application of digital twin technology to individual lives, personalities, or health is particularly tricky. While

- cyberthreats such as hacking,
- false positives or negatives, wrong classifications,
- misleading patterns and spurious correlations in the data,
- overfitting ("not seeing the forest for the trees"),

[1] San Francisco was ranked 9ths on the Deutsche Bank Liveability Survey (Reid, Nicol, and Allen 2019).

- problems of calibration, validation, sensitivity, or convergence,
- wrong interpretations or lack of explanatory understanding

are not uncommon when applying digital twins to humans or things, the following issues are especially problematic in connection with humans:

- violations of privacy and human rights,
- the possible misuse of data (e.g. for manipulation),
- related psychological and health risks,
- distraction from the relevant details ("attention economy"),
- discrimination,
- inadequate simplifications,
- ignorance of relevant aspects (e.g. non-measurable qualities),
- treatment of subjects like objects,
- confusing "digital twins" (the picture) with reality,
- "butterfly effects" (according to which small details may matter in complex dynamical systems).

As a consequence of the above, the wrong use of a "digital twins" approach may cause considerable damage. Therefore, risks and benefits must be carefully and transparently weighted against each other, appropriately involving the people who would be affected by decisions and measures taken. Considering possible future applications, we also want to caution from overwriting the functional principles of self-organizing systems by a new "operating system", using AI-based control. This could produce serious malfunction or major damage.

Given the above, one pressing question to answer is, how to manage the massive amounts of data produced about people and environment by the Internet of Things (IoT). Should data be centrally stored by governments or businesses and allowed to be applied to humans in intransparent ways? An increasing number of people is extremely concerned about such developments and sees considerable risks of such an approach. To address these concerns, city-led and human-centered AI approaches have recently been pursued.

1.3 City-Led Approaches: City Councils Taking Back Control

To some extent, smart cities that intended to collect lots of data about everything and everyone, to optimize all processes (including human decisions and behaviors) with supercomputers, and to impose the supposedly "best solution" on the entire system by means of AI, have failed. But why? Such an approach typically works well when applied to production processes and logistics. However, while a business often pursues a particular goal, a city is not a business—and should not be run like one. It should rather enable and catalyze certain socio-economic processes.

The reason is simple: Determining a goal function that reflects all needs of society regarding prosperity, fairness, health, education, culture, environment etc. is difficult, if not impossible. Different goals may even contradict each other. Therefore, cities try to reach different, often non-aligned goals in parallel, possibly in different locations. This requires political decisions and a city-led approach, which can be technologically supported. Here, rather than outsourcing city services to one company and letting it run the city like a company, the city decides about its goals, and each of it is addressed with one or more specifically tailored technological solutions.

1.4 Citizen-Centered Solutions

Until today, creating liveable cities is an art. Cities are not just giant optimization problems, nor are they giant entertainment parks, where pre-manufactured experiences are consumed. Cities are places, where people meet, communicate, make friends, and fall in love. In other words, cities are first and foremost about people.

This has promoted the concept of trustworthy, explainable, human-centered AI (Knowledge 4 All Foundation Ltd. 2021; Shneiderman 2020). Accordingly, AI solutions should serve humans, not the other way round. People—their needs and interests—should stand in the center of AI applications. So far, the pursuit of this principle has mainly resulted in personalized information, products, and services.

However, citizen-centered solutions are not necessarily value-sensitive solutions[2] that are compatible with established constitutional and cultural values. Often, they are based on profiling, targeting and behavioural manipulation, thereby violating privacy, informational self-determination and other rights (Helbing 2021c; Zuboff 2019), which are implied by the Universal Declaration of Human Rights (United Nations General Assembly 1948).

The discussion about surveillance-based approaches in smart cities has been particularly fierce around methods of predictive policing. Great concerns were triggered not only by the high false positive rates of corresponding algorithms (Gless 2018). Also, the issues of systematic bias and discrimination have been raised (Kim 2016; Mayson 2018), for example against people of color (Obermeyer et al. 2019) and other socially or economically disadvantaged people. Major discrimination was also found in face recognition algorithms (Cavazos et al. 2020). As a result, California banned the use of face recognition in public spaces—at least temporarily (Conger, Fausset, and Kovaleski 2019). Also, various big tech companies have decided to restrict the use of their face recognition software (Greene 2020).

In summary, human-centered AI is not sufficient to satisfy the needs of citizens in smart cities, particularly collective (social and cultural) needs. Given the diversity of citizens, their individual goals and values may often oppose each other. However, amplifying contradictory goals and attempts to achieve them by technical means, as it is often done by individually centred IT solutions, will undermine social cohesion. This may eventually lead to fragmented communities and broken societies, which finally may not be able to serve the goals and needs of humans well.

Hence, a human-centered AI approach as promoted today is insufficient. It lacks coordination capacity and the ability to promote collective intelligence. It also does not sufficiently support the emergence of shared values and collective action to address urban challenges that require cooperation and consensus. Therefore, future smart cities solutions should be focused on the needs of the citizenship and the civil society, not just human-centered in the sense of focusing on individuals.

1.5 Learning from Self-Controlled Traffic Lights

In recent years, some interesting lessons have been learned from the example of traffic light control in a city. This is an NP-hard optimization problem, which cannot be exactly solved in real-time, even with super computers (Papadimitriou and Tsitsiklis 1994). Hence, highly performing solutions—typically synchronized periodic service patterns—are usually determined off-line, which are then applied in certain time windows or typical situations.

Such pre-determined solutions often suffer from large minute-to-minute, hour-to-hour, day-to-day, and week-to-week variability of traffic flows as well as from disruptions by accidents and building sites. Even adaptive traffic control schemes would not continuously change the order in which traffic lights are being served. They would typically shorten or extend the green times of a more or less synchronized, cyclical control scheme, which is changed in the course of the day (Papageorgiou et al. 2003). Non-cyclical services are typically not considered.

Surprisingly, classical control strategies based on a traffic control center and optimization or machine learning approaches may be outperformed by a self-organized, decentralized traffic light control. Such a self-control approach can be based on the flexible adaptation to local needs (Lämmer and Helbing 2008). This is determined by short-term predictions considering the physics of queuing systems and traffic flows (hence, an "analytical approach") (Lämmer, Donner, and Helbing 2008). Overall, this approach enables an extremely efficient management of limited resources such as spatial and flow capacities. Even though the exact timing of green phases is less predictable than for classical control approaches, average travel times are more predictable and shorter, which comes as a surprise.

Altogether, the conclusion does not change, if machine learning approaches are being used (Korecki and Helbing 2021). These require a large computational effort to learn the complex dynamical features of a traffic flow network. Hence, when it comes to traffic light control we find:

1. Self-control approaches perform surprisingly well as compared to machine learning solutions.
2. In order to find superior solutions, one needs a "hybrid approach", where the scientific knowledge behind the analytical approach needs to be fed into the machine learning approach.
3. Even in the age of Artificial Intelligence, analytical approaches remain important, but hybrid approaches are best.

Altogether, in a complex dynamical system such as urban traffic flow, the flexible response to measurement-based short-term predictions of upcoming local demands can outperform classical planning and optimization

[2]Batya Friedman (Friedman 1997; Friedman, Kahn, and Borning 2008; Friedman and Kahn Jr 2007) was one of the first to formulate the concept of value-sensitive design

approaches, as the latter are often not adaptive enough to match real-life variability (Lämmer and Helbing 2008). Similar kinds of challenges concern global and city logistics as well. Hence, the flexible management of scarce resources based on the response to short-term predictions of local needs is expected to lead to less wasteful, more sustainable solutions (Helbing 2013; Helbing, Lämmer, et al. 2004). It is, furthermore, expected to contribute to the resilience of cities, i.e. the ability to recover from shocks and disruptions, disasters and crises. A decentralized, adaptive approach is also more compatible with democratic principles than a centralized control approach imposed on the entire city.

2 Value-Sensitive Smart Cities

In the past years, it has become increasingly clear that technologies should be designed in compliance with constitutional and cultural values, because their use could otherwise damage the foundations of our society. Compared to the Universal Declaration of Human Rights (UN General Assembly 1948), however, in many countries fundamental rights have been restricted[3] in the years 2020 and 2021, often with support of digital technologies. These restrictions include

- the right to life (Art. 3), given the application of triage,
- the rights of equality (Art. 1) and non-discrimination (Art. 7),
- the presumption of innocence until proven guilty in a public trial (Art. 11), given various predictive policing practices (see e.g. Selbst 2017),
- the protection of privacy (Art. 12), in view of mass surveillance,
- the freedom of movement (Art. 13), in view of geofencing applications and travel restrictions,
- the freedom of opinion and expression (Art. 19), in view of ongoing censorship on social media platforms, and
- the freedom of peaceful assembly and association (Art. 20), in view of network shutdowns to interfere with assemblies (United Nations 2020)

While many of the restrictions have been attributed to the COVID-19 pandemics, there has been a trend in this direction at least since the "war on terror" (Schmitt and Shanker 2005) after 9/11/2001. Overall, the restrictions of freedoms and of human rights have affected human dignity altogether: in digital times, humans are increasingly being administered and managed like things, which should not be the case. The growing problem of hate speech, which often leads to real-world harm, also indicates that human dignity is affected. Furthermore, the circumstance that "code is law" (Lessig 1999) has undermined the principle that all political power should originate from The People (Art. 20, (2) GG). In a sense, "social engineers", who are not known to The People or accountable to them, have hacked society and now determine how it works.

In the digital age, fundamental principles such as *checks and balances*, which call for a division and decentralization of power, have been compromised. While in surveillance capitalism, some big IT companies have grabbed more and more power, in countries like China, the ruling political party has taken over control. Overall, however, it seems that neither of these approaches have managed to create a favorable state of the world. The development has rather been paralleled by environmental degradation (often framed as "climate emergency" (Ripple et al. 2020)) and by a global loss of control in further essential matters such as international migration and health, or loss of species and diversity.

2.1 Design for Values

In view of this situation, experts have increasingly demanded a "value-sensitive" or "ethically aligned" design approach of digital platforms and technologies (Van den Hoven, Vermaas, and Van de Poel 2015). Accordingly, one should design, operate and use technologies in a way compatible with our fundamental values. In this connection it is to be considered that, for a society to thrive, one needs to pay attention to a plurality of values (Stiglitz 2019, 2020). Hence, diverse values need to be well balanced, depending on context. Efficiency and economic growth are not the only values that matter for societies, but also environmental conditions and health, safety and security, human dignity, well-being and happiness, privacy and self-determination (autonomy,

Table 1: Conventional vs. Value-Sensitive Smart City

	Conventional Smart City	**Value-Sensitive Smart City**
Design	Technology-centric	Value-sensitive
Organization	Top-down control	Bottom-up participation
Governance	Public-private partnerships	Multi-stakeholder, inclusive, and collaborative
Citizenship	Data producers	Active digital citizenship, informed consent
Technology	Data-driven	Ethical, citizen-centric
Data ownership	Proprietary data	Open data, digital rights
Dynamics	Political, corporate	Society-driven, social capital

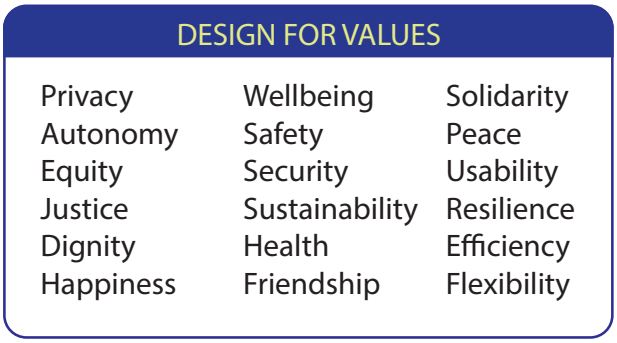

Figure 1: When engaging in a "design for values" approach, it is important to consider that there is not only one value that matters. Different goals must be well balanced, which requires political negotiation and public deliberation.

sovereignty, freedom), fairness, equality, and justice, consensus, peace, solidarity, sustainability, and resilience, for example (Figure 1).

Technology built by a value-sensitive design approach bears the potential to foster a citizens first approach through open technology, digital rights, and an inclusive and collaborative environment. Stone (2021) developed an analytical framework on how to include values in urban technologies in a systematic way. This paper takes a more practical approach. Table 1 contrasts conventional smart cities and value-sensitive smart cities. The latter would finally promote meaningful interaction and participation of citizens. Smart cities of the future would promote a bottom-up participatory approach where multiple stakeholders together establish priorities for policies that reflect a community's interest. In this type of city, the use of technology is not limited to data collection, but creates a participatory ecosystem that promotes fairness, social innovation and democracy. The data ownership is with the people, who are the custodians of their data and have the right to decide what data is collected and how it is used. It is important to re-imagine smart cities in such a way that they promote multiple stakeholder interactions, online as well as offline.

2.2 Sustainable Innovation: An Example

In the following, we illustrate the value-sensitive design approach for a couple of concrete examples. Let us start with the value of sustainability.

In 2019, the Dutch city of Utrecht introduced 300 new sustainable bus stops with plants and grass covered rooftops (Sempergreen 2019). This generated considerable international interest. The green bus stops not only support biodiversity by attracting bees and other insects, but also capture fine dust particles, store rainwater and reduce heat stress in summer in the city. They are made of eco-friendly material, and their transparent design increases citizens' sense of security. What strikes us as smart and admirable about them is that a number of our values, namely sustainability, well-being, and security, are all realized in one coherent design.

There are two important ideas for the city in this specific example of sustainable innovation. First, there is the idea that our moral values can be designed for, that they can be embedded, incorporated, and exemplified in technology, in the same way as our values such as dignity, respect, equality, and justice can be expressed in the design of the constitution of a country or in its basic institutions. As recent work in value-sensitive design

[3]Bonavero Institute of Human Rights (2020) provides an assessment of the measures taken concerning their impact on human rights across 11 jurisdictions.

(Friedman and Hendry 2019) has shown, moral ideas and ethical principles should not be seen as an obstacle. It can motivate or inspire designers, engineers and architects in their work to come up with new solutions that match requirements and specifications. Such innovations become "value sensitive" and go beyond optimization. Van den Hoven (2013) shows how this can generally work in architecture and the built environment.

The sustainable bus stop examples nicely illustrates that inter-, cross- and trans-disciplinary teams, for example, of applied scientists, engineers and designers, can learn to accommodate many values at the same time in one design. While each of them may feel morally overloaded by a multiplicity of values, together they often resist selecting a single value. Instead, they are committed to inventing new ways that allow them to satisfy as many values as they can. They aim for prosperity and clean energy. They want privacy and transparency. They are constantly pushing the limits of technology, because they want to design for all of the moral values at play. The individual is facing multiple values—often represented and advocated by different stake holders—and there often seems to be no obvious way to unify them, reduce them to each other, or resolve the conflict. Nevertheless, creativity and persistence may lead to superior solutions that were not imaginable before. Hence, responsible innovation can be seen as moral challenge: it encompasses the introduction of novel functionality that allows one to satisfy more moral values than one could do without it.

2.3 Preconditions and Design for Responsibility

By explicitly, transparently and continuously designing for our plurality of values, we may hope to innovate responsibly. However, there is a "hidden" challenge in all of this that looms large: responsibility itself has become a design challenge. If we want to be able to take, hold, feel and make responsible decisions, we need to design for responsibility and accountability. This, in turn, requires design for knowledge, freedom of decision-making, and control. In a world with ubiquitous AI, however, it cannot be assumed that the basic conditions for responsibility are satisfied. In fact, the use of deep learning approaches may seriously undermine responsible moral agency:

1. Because of the black box character, AI may make it difficult for us to know what we are actually doing, resulting in a situation where it is always possible to say: "I did not really know what I was doing".

2. Deep learning applications may also—as known from the literature on nudging and psychometrics—corrode our free choice and liberty. Thus, are choices really our choices any longer, or have individuals succumbed to AI-powered manipulation, big nudging, propaganda, and brainwashing? In that case, one could always truthfully say: "It was not a choice of my own. I was influenced, nudged or manipulated."

3. A further condition for responsible agents besides knowledge and freedom, is control. However, automated decision-making and autonomous systems are becoming more prevalent, not only in self driving cars. So the question becomes: "Are we in control?" Often the answer will be negative.

Therefore, we will later have to come back to the challenge of designing digital systems for freedom.

2.4 Measuring Happiness and Designing for Well-Being

We would also like to give examples how aspects such as happiness and well-being might be measured, given the availability of datasets about various aspects of society. For some time now, the gross domestic product (GDP), widely adopted as an indicator of well-being in society, has been criticized as misleading tool for public policy-making, since it is a poor proxy for a complex world. On one hand, defining objective well-being is difficult due to its inherent multi-faceted dimensions. However, the Organisation for Economic Co-operation and Development (OECD), the United Nations Development Programme (UNDP) and many national Statistics Bureaus have identified six major, observable ("objective") dimensions for the measurement of "good life": health, job opportunities, socioeconomic development, environment, safety, and politics. On the other hand, there is a "subjective" approach, which examines people's perception of their own lives, or happiness, defined by the degree to which an individual assesses the overall quality of the own life-as-a-whole favorably (Veenhoven 1984).

Traditionally, both, objective and subjective well-being, is measured with surveys of household income and consumption, an approach that carries strong scalability limitations. For example, surveys cannot provide dynamic accounts of well-being variations, cannot easily give a disaggregated picture of cities or neighborhoods of metropolitan areas, cannot easily be stratified for groups, gender, age, or minorities, especially marginalized and vulnerable ones. That is why big data has been put forward as a complementary source, and scientific communities such as the European research infrastructure SoBigData[4] have developed innovative methods to

[4]www.sobigdata.eu

address the measurement of well-being and, more generally, to provide a Social Mining and Big Data Ecosystem for open, responsible Data Science (Pappalardo, Grossi, and Pedreschi 2021; Voukelatou, Miliou, et al. 2021). Figure 2, from (Voukelatou, Miliou, et al. 2021), illustrates the potential proxy connections between Big Data sources on the left and objective well-being dimensions on the right.

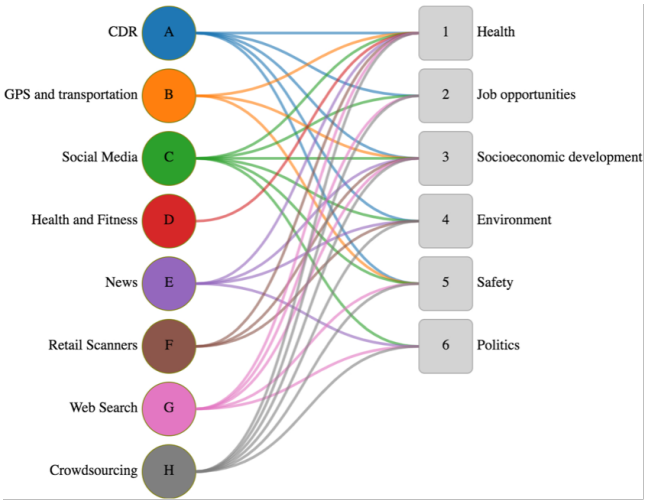

Figure 2: Bipartite network relating sources of Big Data (left) with the dimensions of objective well-being (right). Reproduced based on the Creative Commons Attribution 4.0 International License `https://creativecommons.org/licenses/by/4.0/` from Voukelatou, Miliou, et al. (2021).

SoBigData and other communities focused on "Data Science for Social Good" have proposed many examples of sophisticated, privacy-protecting analytical processes such as

- nowcasting economic development on the scale of small areas, based on the diversity of human activities as measured by mobility data, such as anonymized GPS spatio-temporal trajectories and mobile phone call data records (CDR) (Marchetti, Giusti, and al. 2015; Pappalardo, Vanhoof, et al. 2016),
- nowcasting and forecasting the dynamics of influenza epidemics leveraging anonymized consumption profiles inferred from supermarket retail records (Miliou et al. 2020),
- assessing migrants' integration patterns using anonymized supermarket retail records (Guidotti et al. 2020) or migrants' home and destination attachments using anonymized Twitter data (Kim et al. 2021),
- inferring citizens' mobility profiles from car navigation data in order to inform strategies to maximize pollution reduction (Bohm, Nanni, and Pappalardo 2021) or identify best locations for public services (e.g., recharge stations for electric vehicles) (Nanni et al. 2021),
- analyzing anonymized social media conversations and news to infer the level of happiness, from country- to city-level (Dodds et al. 2011; Voukelatou, Pappalardo, et al. 2020).

The impact of big data analytics and social mining on cities has been widely discussed, e.g., in (Andrienko et al. 2021; Batty et al. 2012). Of course, privacy-by-design approaches should be adopted in all of the above mentioned examples for social mining, to ensure that the methods used effectively protect personal information and individuals (Monreale et al. 2013). However, this is not enough.

3 Digital Sovereignty

From our point of view, personal data should ideally stay on personal devices. However, individual citizens should be enabled to easily collect detailed information about their own location and movements, shopping transactions, social interactions and many other aspects of life. Furthermore, the users should be provided full control of such data together with the necessary tools to share only the information they want to share—at the preferred level of detail or aggregation. In fact, it should be easy to customise the sharing of information, depending on the individuals/entities with whom someone is interacting and depending on the purposes of data use (Nanni et al. 2021).

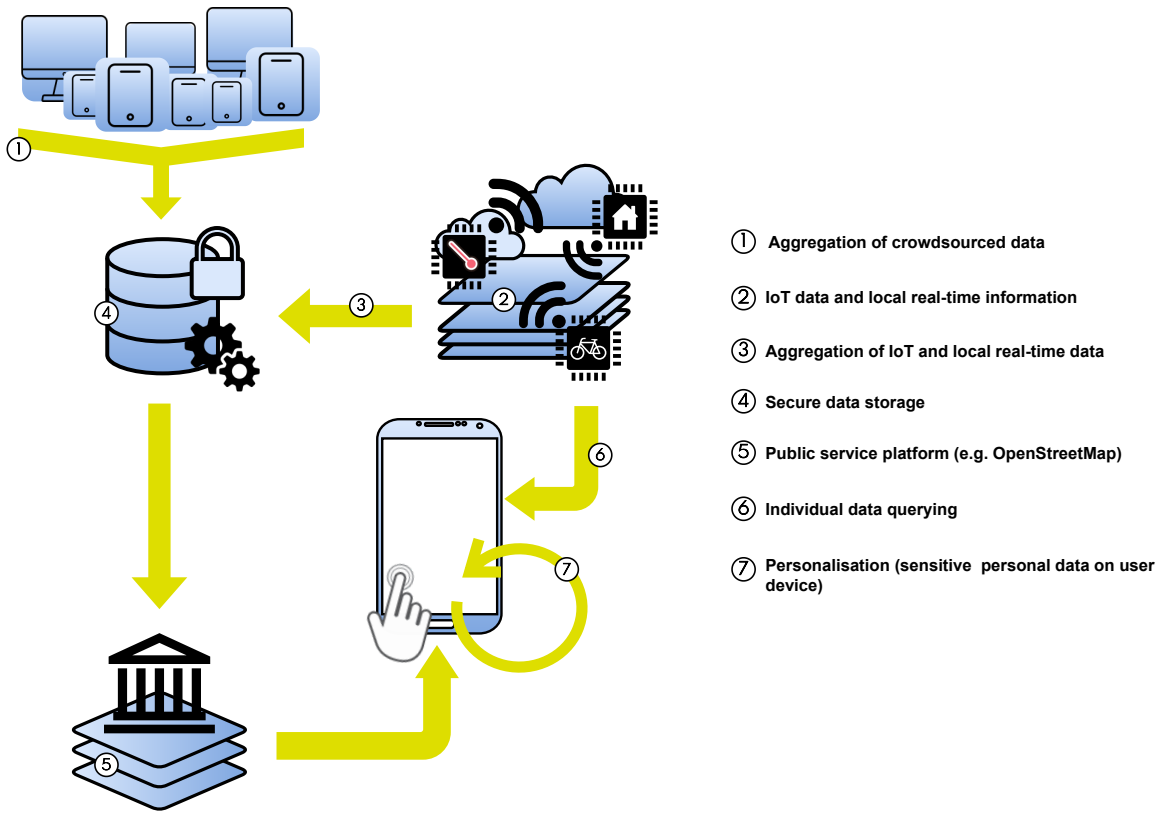

Figure 3: Proposed workflow for data management and privacy protection

Hence, our envisioned data management paradigm calls for a Personal Data Storage (Giannotti et al. 2012), where users are helped to collect and manage their own data, equipped with data management and analytics tools for elaborating them, as well as with functionalities for controlling what kind of information—raw or derived from data—should be shared with other users or third parties, including public authorities. If properly designed, empowering citizens with such kind of tools would enable active trustful participation in socio-economic, ecological, political and cultural affairs.

Accordingly, governments should ensure that

1. any data of personal relevance (also inferred metadata generated by transactions of any individual person with any kind of private or public institution) will also be shared with that person and included in the individual Personal Data Storage,
2. every individual person will be able to determine which company or institution is allowed to access, upon request, what part of the personal data, for what purposes and period of time,
3. every individual person will have a digital assistant that makes it easy to manage own data (e.g., a personalized AI system on our smartphone that learns our data preferences),
4. systems will be designed with security in mind to prevent unauthorized access to personal data,
5. misuse of personal data will be punished (this includes the unauthorized use of personal data by third parties, which has not been intentionally made accessible to them for a particular use).

Then, the competition for data access would lead to a competition for trust and, thereby, to a trustable digital society. "Solid" seems to be one of the platforms trying to provide such functionality in the future (Solid 2021).

Of course, one may still allow for statistical evaluations of anonymized data for the purpose of evidence-based governance (Metcalf 2016; Pitt and Ober 2018; TU Delft Design for Values Institute 2021). However, procedural and algorithmic transparency will be needed (Lee et al. 2019).

3.1 Nervousnet Platform and Finance 4.0

The urgency of solutions for informational self-determination amplifies with the amount of data collected about people. Suitable solutions are particularly needed as Internet of Things technology becomes more pervasive.

To address the related concerns, it has been proposed to manage the Internet of Things in a distributed way. Figure 3 presents an overview of the proposed workflow for data management and privacy protection. Data collection should be done in privacy-preserving ways (Bennati and Jonker 2017; Bennati and Pournaras 2018; Pournaras, Moise, and Helbing 2015), e.g. data should be aggregated before it is being stored or it should be deleted immediately after local real-time feedback was provided. Personalization should happen on user devices, not on government or business servers. In this way, informational self-determination is enabled, as demanded in section 3.

This participatory IoT approach has been the core of the "Nervousnet" project, which aimed to develop a public measurement network managed as a citizen web (Helbing and Pournaras 2015). The collectively generated data would be used to support greater awareness, coordination and adaptation (Helbing 2019a).

The ideas for such a platform resulted from the preparations for the FuturICT flagship project (Giannotti et al. 2012). Within the FuturICT 2.0 project, the Nervousnet concept was further extended by a multi-dimensional incentive system. This would consider externalities and risks, which are measurable by the Internet of Things or social proofs (Pournaras 2020b). Specifically, the FuturICT 2.0 project proposed a socio-ecological finance system called "Finance 4.0" (Dapp, Helbing, and Klauser (eds.) 2021), for which a demonstrator[5] was built. The concept brings the Internet of Things together with Blockchain technology in order to create a multi-dimensional incentive system. It may be envisioned as a digital coordination system for complex adaptive systems that is based on various feedback effects.

Imagine, for example, that we would measure different kinds of externalities such as CO_2, temperature, or various resources by means of IoT sensors. In contrast to our current economic system, which valuates certain externalities by means of dollars, the Finance 4.0 system would do a separate accounting for different kinds of (measurement-based) currencies, which would not be easily convertible into each other (only for a considerable transaction fee/tax). This would establish a multi-dimensional finance system that would be better suited to incentivize environmental-friendly production and behavior, friendly working conditions, or cultural engagement than our current monetary system. In a sense, it would add new forces to our socio-economic system, which would encourage, for example, a recycling and reuse of resources, thereby promoting the co-evolution towards a circular and sharing economy.

3.2 Human-in-the-Loop Approach

Figure 4 shows how one can create an IoT ecosystem, in which humans are central and have control over what data is being used and how. A collaborative ecosystem approach ensures that data does not serve exclusively corporate interests, but promotes collective intelligence and the interests of civil society. Priority is given to creating a network that connects to human values, and not just to "things" (Mahajan 2018). Such an ecosystem approach can bring the Internet of Things together with people in a way that creates a synergy between the city and the citizens.

There are several benefits of having a human-in-the-loop approach:

- a participatory design to understand the right problems to address,
- aligning technology for long-term community use and sustainable development,
- creating value for end users by providing better data services.

In some cases, however, it may not be enough to have a human in the loop. An example for this are triage apps (Hao 2020), which were suggested to support medical doctors in taking life-death decisions (e.g. when hospitals are overrun, as it happened in many cities during the COVID-19 pandemic). Here, the problem is that recommendations of a data-based expert system may enact "epistemic authority" (Helbing, Beschorner, et al. 2021). As a result, people may just execute what "intelligent machines" suggest, even though there might be serious scientific, legal, socio-political and ethical issues. In effect, this would mechanise death and eliminate the freedom of decision-making that human dignity is largely based on.

3.3 The Importance of Freedom

One of the essential preconditions for freedom is informational self-determination, as it was demanded above. As long as companies and secret services can determine people's ideas, decisions, and actions to a considerable extent, people are kind of remotely controlled and free decisions are largely an illusion. That is why we need solutions that comfortably allow for informational self-determination in the spirit of a *digital sovereignty approach*.

[5] `http://www.finfour.net`

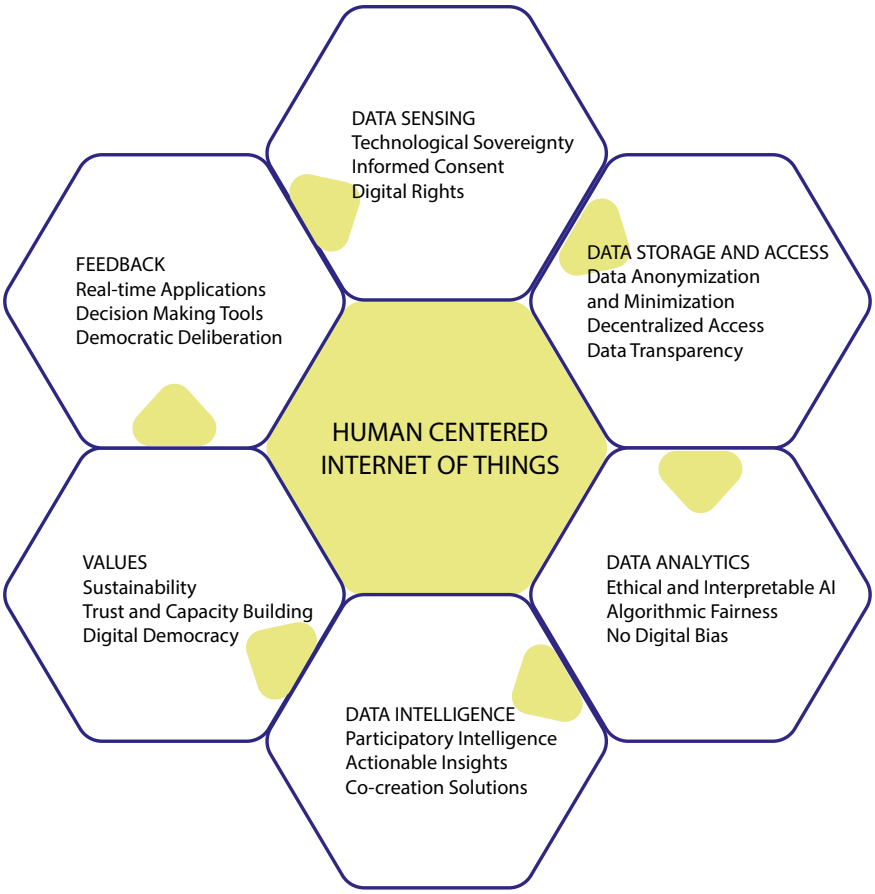

Figure 4: A citizen-centered IoT is at the core of a value-sensitive smart city.

Freedom, in turn, is an important precondition for creativity and innovation, as innovation questions previous solutions (which have been considered optimal before). Nevertheless, it is increasingly common to let algorithms decide for humans, in favor of efficiency and process automation. As this can fundamentally undermine the freedom of decision-making, it is important for software engineers to carefully reflect what decisions can be automated without undesired side effects and what decisions a human being should take—or might want to take.

In fact, freedom of decision-making should be used particularly in "unclear" cases (where different indicators or goals suggest different decisions). These deserve a careful deliberation and assessment. Note that, even in situations of scarcity, freedom of decision-making does not need to be sacrificed. For instance, one may also imagine a system, in which all humans are granted a certain number of "vouchers", which they may use in the course of their life to override decisions that automated systems would otherwise take on them. The following subsection will provide a further example, how freedom can be exercised in situations, where resource constraints must be met.

3.4 Freedom vs. Optimality: The Example of Smart Grids

As pointed out before, digital technology is consuming a quickly increasing amount of energy (Jones 2018), thereby undermining the sustainability goals (United Nations 2021a). Even though some well-known tech giants were among the first to commit to renewable energy use (Cook et al. 2017), most of them do not currently plan to cut back on their overall energy use. Recently, there are even growing concerns that peak demand from data centres may potentially drain resources needed to run services like schools and hospitals (Ballard 2019).

To overcome some of these energy-related issues, it has been proposed to operate power grids as smart grids. These provide a good example to discuss the issue of self-determination vs. optimality. From the perspective of energy generation it is desirable (1) to cut peaks in the energy consumption and (2) to adjust to the fluctuating patterns of electricity generation (think of solar or wind energy). Therefore, political plans foresee the optimization and control of the power consumption by citizens.

While some prefer a centralized control of energy production and consumption, others favor scalable, decentralized solutions, which flexibly respond to the local supply and demand. Those pushing for centralized control often argue with the "tragedy of the commons" (Hardin 1968). They stress the failure of cooperation if everyone is selfish (i.e. non-cooperative), i.e. everyone shows the individually preferred consumption behavior without considering others. According to them, an optimization approach should determine a desirable consumption pattern, which would then be imposed on all consumers. This, however, would contradict the principle of self-determination, and it would eliminate individual freedoms.

Figure 5 illustrates that centralized control of everyone's power consumption is not necessary to coordinate the latter. According to experiments, most people show some flexibility to adjust their energy consumption (the flexibility seems to be around 48% on average). The same figure also shows that a fully cooperative behavior is not required to avoid energy peaks. A semi-cooperative behavior (50% flexibilty for everyone) achieves the goal of cutting peaks almost as well as fully cooperative behavior (requiring 100% flexibility). This speaks in favor of applying decentralized cooperation mechanisms rather than centralized optimimization, as it meets societal sustainability goals while providing the maximum amount of freedom and self-determination (Fanitabasi and Pournaras 2020).

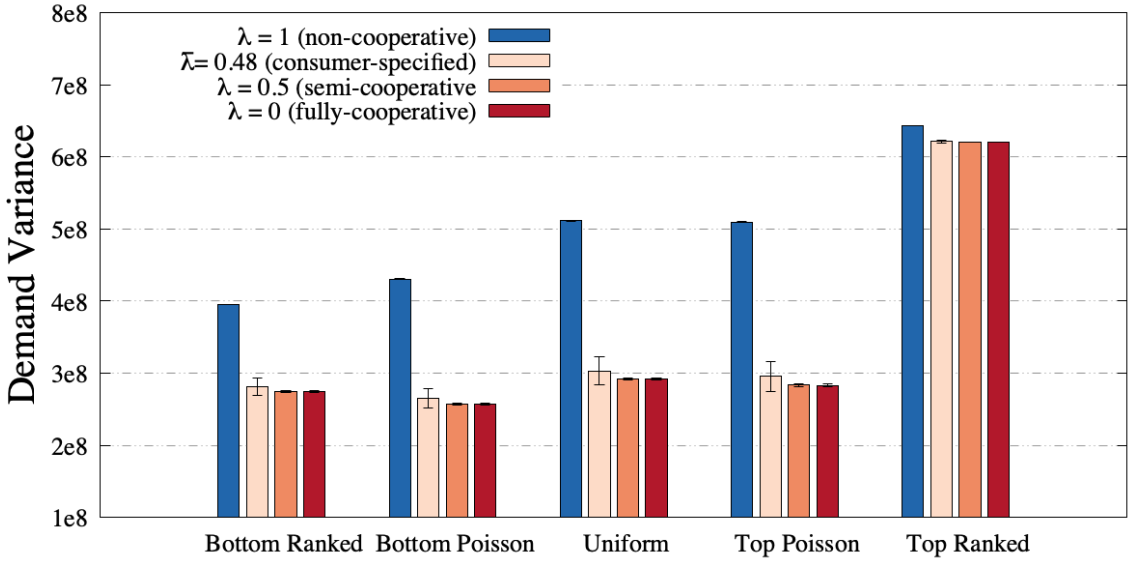

Figure 5: Variance in power demand in dependence of the cooperation strategy applied (adapted in compliance with the Attribution 4.0 International Creative Commons License, `https://creativecommons.org/licenses/by/4.0/` from Fanitabasi and Pournaras (2020)).

3.5 More Sustainable Consumption

In a similar way is it possible to support more sustainable consumption. Previously, it has been suggested to steer consumption patterns through personalized offers, nudging and neuro-marketing (Ariely and Berns 2010). However, such approaches, based on behavioral control attempts (even when they are euphemistically framed as "liberal paternalism"), contradict democratic values and human rights (Kirchgässner 2017; Rostbøll 2005).

Recent research has discovered alternative approaches promoting sustainable consumption. It turns out that consumers do not only care about the price of a product, but also about quality, health, environment, and social issues. Therefore, desirable behavioral change towards more sustainable consumption can also be supported based on self-determination, using value-sensitive digital shopping assistants (Asikis et al. 2020). Such assistants (see Figure 6) would consider the stated preferences of users, while evaluating specifics of products and ranking them, using data from various databases. This creates a threefold benefit: (1) Users find and consume products that match their preferences better. (2) Based on the aggregated user preferences, businesses learn to produce better products, which can be sold at a higher price. (3) Nature and health benefit as well.

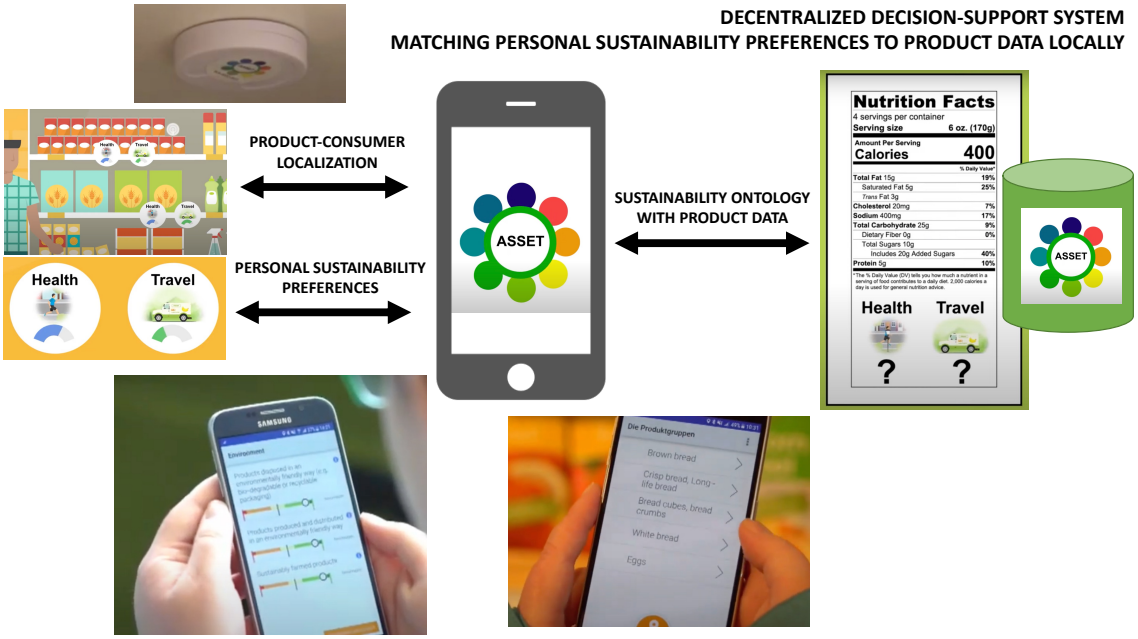

Figure 6: Illustration of elements of a value-sensitive personal shopping assistant to support more sustainable consumption, which was developed in the ASSET project. For an explanatory video watch `https://www.youtube.com/watch?v=uur5BXXspgI`.

4 Democracy by Design

In the 21st century, our cities will need to deal with a long list of grand challenges. Design solutions are paramount. But they will not add up to a liveable and just city unless we successfully design for the values of well-being and justice. Aizenberg and Hoven (2020) discusses the design for values in AI, particularly for human rights.

If we want governance and decision-making to be democratic, we need to have or to carve out and specify a conception of democracy that suits us and then shape information technology to support that. Furthermore, we will have to continuously revisit our democratic mechanism designs and check whether they are performing as expected (Verdiesen et al. 2016).

In the following, we will reflect on "democracy by design". This approach aims to manage complex dynamical systems in a participatory way (Helbing 2007; Metcalf 2016; Pitt and Ober 2018; TU Delft Design for Values Institute 2021)—or even to build autonomously self-organizing and self-regulating systems, based on complexity science and evolutionary game theory, mechanism design and network engineering (Helbing 2021b). From the point of view of citizens, it would certainly be desirable if political leaders institutionalized efforts towards the creation of digital platforms that support civil participation, coordination, and self-organization (Torfing et al. 2012).

4.1 Civic Deliberation

A key element of "democracy by design" is to acknowledge the fact that every citizen should have the right to express their opinion on the systems that affect them in order to improve them. To allow for this, suitable methods and tools for civic deliberation and decision making need to be created. These should serve not only to promote meaningful interactions between multiple stakeholders, but also to create trust between the citizens and those who govern them.

Note that civic deliberation can actually help to overcome conflicts and promote consensus. For this, consensus does not have to be engineered by manipulating opinions, as this is often done since the days of Edward Bernays (Leipold 2017) and his book on propaganda (Bernays 2005). Given suitable interaction mechanisms, repeated interactions will naturally lead to the emergence of self-organized conventions or social norms (Helbing, Yu, et al. 2014). This applies to situations with different preferences as well (such as multi-cultural, conflict-prone settings) (Hänggli, Pournaras, and Helbing 2021; Helbing and Johansson 2010).

4.2 Harnessing Collective Intelligence

For a practical implementation, platforms for Massive Open Online Deliberation (MOOCs) were proposed (Helbing and Klauser 2019). These aim to find innovative solutions that work for more people, obtained by a structured deliberation process. In recent decades, a lot of lessons have been learned on how collective intelligence or a "wisdom of crowds" superior to expert opinions can be promoted (Lorenz et al. 2011; Moussaïd et al. 2009; Page 2008; Surowiecki 2005). Inspired by the functional principles behind swarm intelligence (Seeley 2010), the process fostering collective intelligence involves different stages: (i) independent exploration, (ii) information exchange, and (iii) integration of solutions (see (Helbing 2021a) for details).

In social systems, an additional voting step (iv) to select one of several integrated solutions may follow, if no full convergence was achieved. However, the mechanism in the fourth step has to be chosen with care: Research shows that the voting rule itself directly influences the quality of the outcome (Emerson 2020). Therefore, the voting rule should be designed in such a way that voters can express their true preferences (Ahn and Oliveros 2016). In other words, rather than using a simple majority rule, one should consider multi-option preferential voting rules (Tullock 1959), which have a higher probability of selecting an option that works for more people (including minorities). Such rules can increase the social welfare (Pivato 2016), which is desirable.

We would like to point out that all four steps mentioned above may be supported by properly designed digital platforms (Pournaras 2020a). Furthermore, suitable incentive systems may improve performance beyond traditional democratic and market-based solutions (Mann and Helbing 2017).

4.3 Benefits of a Participatory Approach

In the meantime, the great potential of Massive Open Online Deliberations (MOODs) (Helbing and Klauser 2019) has been demonstrated in real-world settings. Taiwan's digital democracy has successfully applied it many times, using the POL.IS platform (Polis 2021). It matches people with different points of view and tasks them to find suitable compromises and solutions. When sufficient consensus is reached, the discussion enters the political stage and the process of law-making.

With this novel approach, Taiwan sets an example of how societies can be digitally upgraded in a way that promotes collective intelligence. By contrast, most current social media platforms today promote an "opinion war" rather than constructive dialogue, deliberation, and consensus. One possible side effect of this "attention economics" approach is the spread of fake news and hate speech. However, to achieve a "wisdom of crowds" (Kittur, Chi, et al. 2007; Kittur and Kraut 2008; Mollick and Nanda 2016; Surowiecki 2005) rather than a "madness of crowds" (Mackay 1841), it is important to give room for diverse opinions and avoid manipulation (Woolley et al. 2010).

Well organized civic deliberation assures that the digital transformation does not undermine democracy, but rather strengthens it. Not only does it serve to raise the transparency and legitimacy of governance, but also to increase the participation and satisfaction of people. It further supports resilience, i.e., the ability of societies to flexibly adjust to unexpected surprises, challenges and crises.

Resilience is promoted, for example, by diversity and decentralized organization (Johnson 1999) as well as by digital assistance, fairness and solidarity (Banerjee et al. 2020). Particularly the recent concept of "participatory resilience" is based on bottom-up empowerment, enabling people to help themselves and support each other. Based on suitable tools (e.g. `https://www.unocha.org`), this concept is expected to increase the crisis-response capacity of societies considerably and even to lead to "anti-fragility" (Taleb 2012).

4.4 Collective Learning ("Co-Learning")

A human-centered smart city with built-in human values would foster learning not only on an individual level, but also on a collective level. The EPOS project (Pournaras 2020b; Pournaras, Pilgerstorfer, and Asikis 2018) is a research endeavour harnessing this concept. There, collective learning is realized within decision-support systems that assist citizens to make a choice among a number of options. However, a choice recommendation is not just personalized to individuals. It considers several citizens. Moreover, decisions are incrementally updated as a result of exchanging aggregated data of previous choices, without revealing sensitive personal information or relying on a centralized authority. This is to avoid the risks of a systematic, large-scale manipulation of decisions. The intended outcome of the system is emergent consensus as a result of human-machine symbiosis and collective intelligence that involves humans and intelligent machines.

Note that collective learning ("co-learning") has already been successfully applied to several smart city application scenarios (Pournaras 2020b):

1. *Transport systems:* By coordinating route choices of vehicles, traffic jams can be prevented and overcrowded, polluted city centers can be alleviated, while safety, fuel consumption and driving comfort can be improved (Davis et al. 2021).

2. *Energy consumption and production:* By coordinating the use of home appliances or the charging of electric vehicles, power systems can be made more reliable and decarbonized, shifting demand to off-peak times or to times with high power production from renewables (Pournaras, Pilgerstorfer, and Asikis 2018).

3. *Bike sharing:* The choice of bike sharing stations from which bikes are picked up or left can be coordinated to avoid bike sharing stations that are overloaded or left without bikes. These imbalances increase the operational costs of bike sharing infrastructures requiring manual reallocation of bikes at the end of the day (Pournaras, Pilgerstorfer, and Asikis 2018).

4. *Urban commons:* The shared use of libraries, shared apartments (Airbnb) or parking spaces can be coordinated to prevent the over-exploitation of public resources, e.g. overcrowded libraries, overcrowded city centers, parking spaces, etc (Pournaras 2020b).

The EPOS algorithm is open-source[6] and has been crash-tested for its robust operation of a high Technology Readiness Level (TRL$\geq$6) in decentralized and highly volatile environments (Fanitabasi, Gaere, and Pournaras 2020).

4.5 Co-Creation and Open Innovation

Smart cities of the future should offer spaces that support deliberative processes, namely for the sake of fairer community representation, better informed decisions and more meaningful outcomes. For example, "Living Labs" (Paskaleva et al. 2015) and "Maker Spaces" (Troxler and Wolf 2010; Van Holm 2014) bring together multiple stakeholders and promote open innovation by creating a fair and inclusive environment, where technology and innovation come together in real-life contexts. This can create various benefits: (i) diverse people see problems from different perspectives, together providing a more complete picture of complex problems, (ii) local knowledge will be considered and local resources better used, (iii) the potential of neighborhood communities will be mobilized, (iv) solutions can be developed for places that are not well reached by politics and business (this is of concern not only for marginalized communities).

Over the years, an increasing number of cities has been using such "open innovation" platforms to tackle challenging issues like air pollution (Mahajan et al. 2021), noise mapping (Zipf, Primack, and Rothendler 2020) and radiation monitoring (Kenens et al. 2020). Some initiatives, such as "Make City" (MakeCity 2018) or "Open Source Urbanism" (Bradley 2015; Finn 2014; Jiménez 2014; Sassen 2011) do not leave it there, but truly co-create the city. Importantly, the idea of co-creation can overcome classical hierarchies, and thereby promote respectful eye-level exchange between policy makers, researchers, citizens and other stakeholders. This can support social innovation in the sense of responsible innovation in societally relevant contexts (Strasser et al. 2019).

Note that such kinds of exchange are desirable, if the equality principle shall be filled with life. It is also important to realize that equality is a principle that can promote optimality in self-organizing systems (Helbing and Vicsek 1999). In connection with the call for participatory opportunities, this brings us to the co-* principles (Seele, Jia, and Helbing 2019). These success principles for a complex, networked societies include, for example, co-learning, co-creation, co-ordination, co-operation, and co-evolution (Figure 7). Importantly, the co-* principles also create "social capital" based on network effects and beneficial social interactions.

In favour of higher legitimacy and societal progress, private businesses as well should learn to pursue their profit-oriented goals in ways that fit society's collective goals (Helbing 2019b; Krogh and Torfing 2020). Such goals are obviously very important for a thriving society, while they easily be undermined. This is why we need a suitable governance framework—one which takes externalities and systemic risks into account. Torfing et al. (2012) have coined the term "interactive governance" for joint efforts to address public issues that produce (more, smarter) public value. They define it formally as "the complex process through which a plurality of actors with diverging interests interact in order to formulate, promote and achieve common objectives by means of mobilizing, exchanging and deploying a range of ideas, rules and resources".

4.6 City Challenges: A Scalable Approach to Address Global Challenges

Finally, how can we address the challenges our world is faced with? Collaboration networks among cities are suited to unleash collective intelligence, allowing one to find solutions for global problems. Collaboration

[6]Available at `https://github.com/epournaras/EPOS` (last accessed: May 2021).

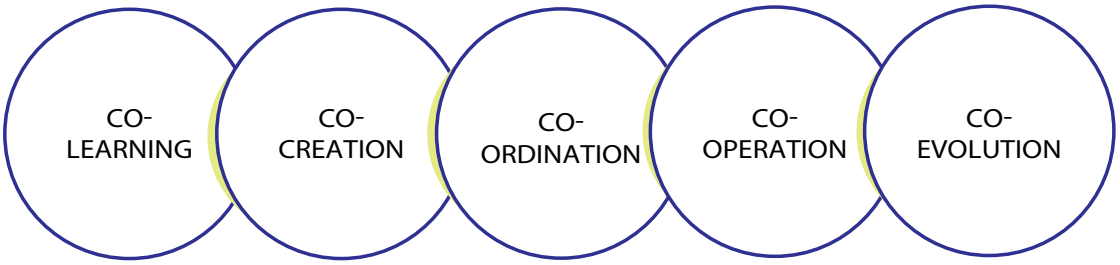

Figure 7: Illustration of some co-* principles

can further be catalysed through friendly competition. For example, ideas for Climate (and) City Olympics (Complexity Science Hub Vienna 2018; Helbing 2014) have, in the mean-time, been experimented with in various promising real-life settings (Bloomberg Philanthropies 2019; European Investment Bank 2019; European Week of Regions and Cities 2019; *The Climate City Cup* 2019; World Wide Fund For Nature 2020).

When combined with principles of "open innovation", they could turn the regions of the world into giant maker spaces and innovation motors. This approach promotes a new kind of globalization, called "glocalization" (Robertson 2018), which is based on thinking global, while acting local (and diverse). Such co-opetition frameworks (combining competition with cooperation) promise great benefits for the future.

5 Summary, Conclusions, Discussion, and Outlook

Traditionally, when people reflect about ethical issues, they do not think primarily of cities. However, cities are the places, where many problems of the world are concentrated—and solved. They determine the lives of billions of people every day, and shape our future. So, we should spend more time reflecting what it means to design, build and operate cities ethically? In this connection, one immediately thinks of the problem of sustainability. However, there are a lot more ethical issues to consider. In this paper we could only explore a few. Therefore, we hope that it can trigger a lively discussion about what is life about (in cities and beyond), and what we can do to improve the quality of life, proposedly in harmony with nature?

In response to this question, our paper has offered a number of puzzle pieces. We have argued for responsible innovation—in other words to design for values—through a value-sensitive design approach (Friedman 1997; Friedman, Kahn, and Borning 2008; Friedman and Kahn Jr 2007).

We would like to point out that ethics should not be considered as obstacle to desirable solutions. In many cases, design for values will deliver better solutions, which satisfy the needs and expectations of more people. Such solutions should not be "subtractive" in the sense of "bad compromises" (the least common denominator). They should be "good compromises", as they result from collective intelligence. For collective intelligence to emerge, however, certain organizational principles must be applied, as was mentioned above.

In recent years, we have seen that politics started to appreciate "citizen councils" as valuable framework to solve difficult societal problems, where classical politics faces limitations. We have also seen the emergence of platforms such as POL.is (Polis 2021), Consul (Consul 2021), LiquidDemocracy (Liquid n.d.), or SmartCitizen.me (SmartCitizen 2021), which are encouraging a constructive engagement of citizens. So, slowly but surely, a new generation of social media platforms is growing. These enable more participatory forms of democracy, powered by digital technology, in other words: digital democracy. Such approaches are also relevant for participatory sustainability (Asikis et al. 2020; Dapp, Helbing, and Klauser (eds.) 2021) and participatory resilience (Banerjee et al. 2020).

As we have pointed out, solutions designed for values do not need to be inefficient. They just work differently. In the beginning of this paper, we have stressed that planning, optimization and control may not be the best approaches to manage complex dynamical systems, which are often characterized by feedback, side and cascading effects as well as large variability, randomness, uncertainty, and disruptions. Such systems are frequent in our hyperconnected, globalized world, and managed better based on a flexible response to local needs. In fact, such solution approaches can be a lot more resilient, while being efficient and compatible with fundamental democratic principles.

We point out that self-organization, self-regulation, and self-control are widespread principles in biology. It is, therefore, interesting to note that nature has already managed to establish a "circular economy" despite

the absence of centralized control. We might, in fact, learn a lot from organizational principles of biological and ecological systems. It is for such reasons that researchers have suggested to organize the digital world in a participatory way, as an "information ecosystem" (Helbing, Brockmann, et al. 2015). If designed well, such a system would be beneficial for all, by fostering synergy effects.

When addressing the ethical issues of smart cities, we should turn away from the exploitation of people and nature that is common today and engage in a new paradigm based on mutually beneficial relations (Helbing 2015). Again, symbiotic interactions in nature may serve as source of inspiration. In view of the problems of the world, a novel approach is needed—a new paradigm that moves away from the manipulation and control of people towards citizen empowerment and coordination. If properly done, this will be able to mobilize civil society for change to the better. Our vision is one of "synergistic intelligence", which combines artificial and human intelligence in beneficial ways and leads to cooperative benefits. Now, digital technologies can help to catalyze this favorable kind of organization, if used well and designed for suitable values.

Author Contributions

D.H. put together the author team. He initiated and coordinated the writing of this paper, drafted its structure, contributed text to all sections and inputs to various research projects reported throughout this paper. F.F. and E.P. performed the smart grid study in Section 3.4. R.H. contributed to the social science perspective of the paper, to thoughts about democracy and legitimacy, and commented on the paper. C.I.H. helped to develop the red thread, reviewed literature, edited the paper, co-organized the writing process, and contributed to subsection 4.1. J.v.d.H. wrote significant parts of Section 2 on Value-Sensitive Design. S.M. reviewed and edited the paper, contributed to Section 2.1 and 4.5, co-developed data management and privacy production framework in Section 3, and contributed the Human-in-the-Loop approach in Section 3.2. D.P. and F.G. wrote the section on happiness and well-being, and contributed to Section 3 on digital sovereignty. E.P. furthermore contributed to the conceptualization and writing of the paper. Together with colleagues, he performed research reported in Sections 3 and 4.

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[7] `https://github.com/nervousnet`

Conflict of interest

The authors declare that they have no conflicts of interest.

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