Data Science Ethics in Smart City Initiatives

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ABSTRACT

Smart cities are an emerging trend across the world, and through an intelligent management of an "Internet of Things", Smart City projects seek to optimize the lives of city dwellers in every way imaginable. These projects are primarily a joint venture between local governments and private companies that provide investments in growing areas of the Smart City economy. These partnerships can sometimes come at a cost of data, where some types of data collected by the vast array of sensors, cameras, and trackers in the Smart City are provided to a company for monetization purposes. These relationships create a risk for a breach of data privacy, and several of these projects have been either scaled back or postponed until these privacy issues are resolved. However, the benefits of these projects can include reduced carbon emissions, major quality of life improvements across the city, and an economic boon to the area itself and the businesses operating there. In areas where these projects are being considered, it is essential that citizens are thoroughly informed on the potential risks and benefits, and in particular are made aware of the full degree of the surveillance which is occurring. Clear ethical boundaries must be established before a project begins, and periodic examination is necessary to ensure that the collected data is still being handled safely and ethically. If this can be accomplished, then Smart Cities could be a huge leap forward in improving the quality of life of city-dwellers everywhere.

CCS CONCEPTS

- **Human-centered computing** → HCI
- **Security and privacy** → Human and Societal

KEYWORDS

smart cities, data privacy, human-computer interaction, computer science ethics, data collection ethics

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1 Introduction

Smart City initiatives are a growing trend across the world, and city planners are increasingly interested in finding ways to incorporate data-driven optimizations to existing city design problems. Utilizing data for urban planning has been popular long before the recent Smart City trend, but technological advances which have decreased the cost and size of data collection systems have opened up new possibilities in design.

The incorporation of these data collection systems into urban environments allows cities to collect massive amounts of data in real time, ranging from traffic patterns, utilities usage, consumer practices, and even real-time location data of every resident. The volume and breadth of data collected allows for cities to become more efficient in the way resources are allocated, and also potentially allows them to become more environmentally friendly.

However, the scale of this data collection also raises a number of potential data security issues, at a level only previously seen in Big Data companies like Google. The ethics of both the way the data is collected, and also how the data is used have been an ongoing debate throughout the lifespan of these Smart City projects. [2][9]

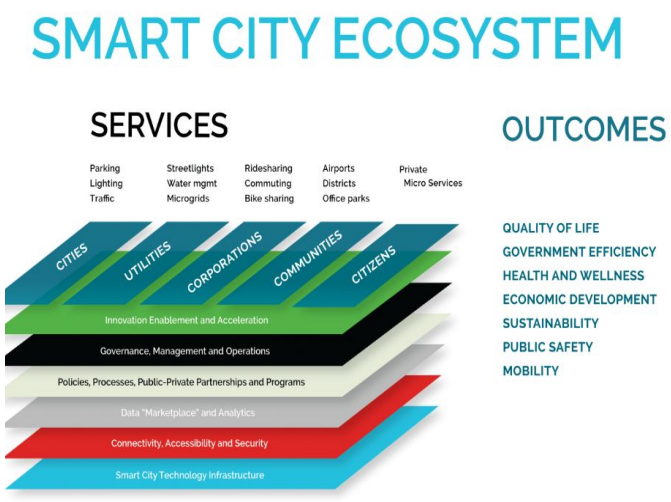

Figure 1: Smart City Structure
Source: iiot-world.com

The above figure shows us, at a brief level, what some of the major optimizations are that Smart Cities look to make, as well as some of the main benefits that these optimizations seek to achieve.

1.1 What Makes A City "Smart?"

Pinning down a precise definition of what a Smart City is can be challenging. These projects span a wide range of scopes, and the details of their implementation can vary considerably. The degree to which local governments are able to manage and utilize the collected data can be a complicated issue, which can lead to a great deal of misunderstanding amongst the public about how much risk they may actually be facing by being part of these projects.

For example, in some of these projects, potentially huge amounts of sensitive data could be collected, and it is unclear to what extent it would be required to inform citizens of this collection. Due to the widely varying nature of these projects, a citizen may assume that a given project for their home city will share a risk profile similar to other projects that they are familiar with, resulting in a skewed understanding of the ramifications of these technologies.

1.2 Financial Incentives

One emerging issue across these projects stems from a conflict of interest between the main groups of people that are implicated in these systems. Broadly speaking, the three main interest groups are the local government, the residents of the city, and finally the technology companies working to develop, install, maintain, debug, and control the wide array of hardware and software involved in a Smart City project. On the one hand, you have a city government with a limited budget, that must partner with tech companies to develop the infrastructure of the city. On the other hand, you have companies with a pure profit motive, who may be choosing to take on a Smart City project only to the extent that it is profitable to them. [10]

This tension has led to a number of potentially harmful arrangements being made in some projects, where companies may use consumer data to sell to other businesses, allowing them to generate profits without significantly taxing the limited budgets of the local government. Of course, these arrangements could also pose a significant data privacy risk to consumers. In the planning of these projects, it is therefore important that developers and local governments work together to define at a precise level what the goals of the project are, and what ethical standards must be maintained throughout the (perhaps unlimited) lifespan of the project. [10]

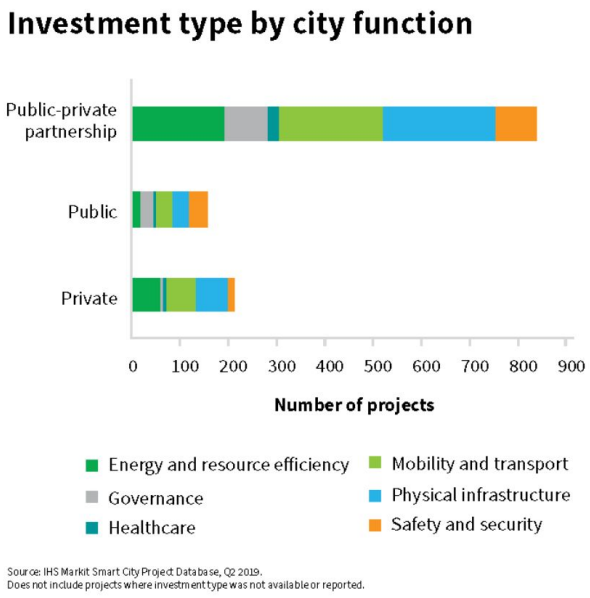

Figure 2: Smart City Budgets
Source: technology.informa.com

The above figure shows a collation of data from Smart City projects across the world. As we can see, the overwhelming majority of the investment money for these projects involves private companies in some fashion, either through a partnership with local governments, or through a purely private investment. The corporations who hold the money will therefore also hold a degree of power in these relationships.

Marianna Cavada, et al, wrote in their 2014 dissection of the global Smart City trend that "What is required here is for commercial companies, if they want to be part of the smart initiatives, to consider the real values of smart cities and focus in on things that have more human value than profit alone. However, there should also be ways that smart cities are protected by regulations and frameworks that emphasize the human existence as a priority for resilience in smart cities." Essentially, it is important that we focus these technologies upon humanitarian efforts, rather than allowing them to become simply another vector upon which people across the world are exploited by profit motives. [7]

1.3 The Importance of Definition

While exploring the precise definition of the term may not seem useful, it has been argued that this is necessary for the projects to operate in an ethical fashion. In some cases, the focus of the project has been on environmental concerns. In others, the focus is mainly on quality of life improvements. In other cases, the focus is on stimulating the local economy through partnerships with local businesses to create jobs, attract tourists, and open up new lines of revenue into the city.

There is concern however that projects utilizing the branding of "Smart City" may be attempting to leverage a person's most optimistic assumptions about the nature of the project in order to gain favor. For instance, a person may assume that a proposal in their area is primarily about sustainability, when in fact the majority of the efforts may be going towards simple quality of life improvements, which may in fact be more detrimental to the environment than beneficial.

By creating clear goals on the mission and ethics of the Smart City initiative, citizens will have a more granular set of objectives by which to judge a project, and this can help with holding developers and planners more accountable for the projects they design. These projects have the potential to bring about major improvements to people's quality of life, while doing so in an ethical and sustainable fashion. It ought to therefore be the job of government and private citizens to monitor these projects closely and ensure they are adhering to the goals they initially laid out. [7]

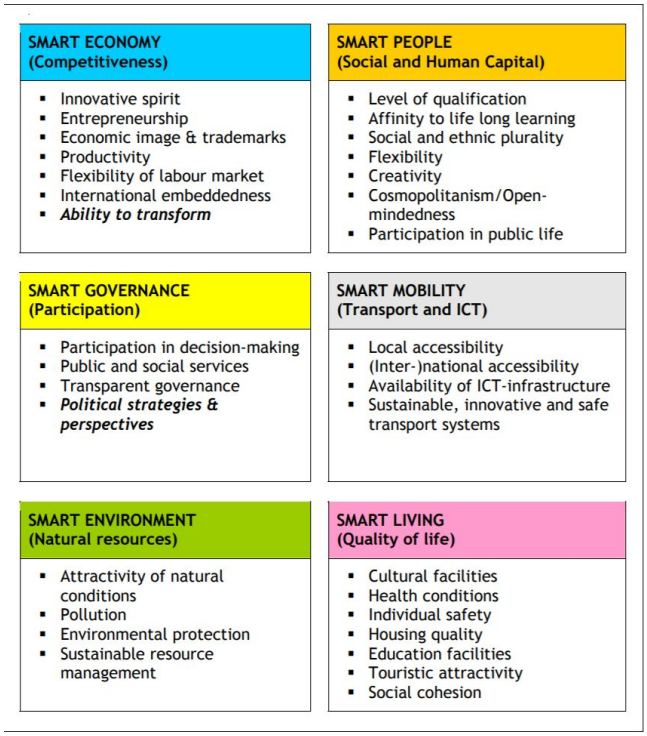

Figure 3: Smart City Goals

Source: smart-cities.eu

Figure 3, shown above, attempts to define more precisely the set of characteristics that a truly "Smart" city would have. It is worth noting that the description here goes well beyond simply how the city itself is structured, and also speaks to the values that the citizens themselves ought to strive for. If one goal of these projects is to empower citizens to engage more directly with their government, then it certainly follows that citizens must also feel compelled to participate in these systems. The value of open-mindedness is also mentioned, which is essential to the inclusivity and diversity of a community.

2 Cities Of Tomorrow

These projects promise a wide range of potential benefits, and have the capability of solving or at least significantly easing problems which have plagued urban centers since the dawn of civilization. Issues of how to most efficiently allocate resources, such as water, food, electricity, or even internet bandwidth. Common issues like traffic congestion could be reduced significantly by monitoring the flow of vehicles through the city, and altering the patterns of stop lights to match the pace and flow of traffic. Some proposals have shown plans of parking spaces being monitored across the city, allowing drivers to be seamlessly directed to open spots on demand.

Other proposals have included camera surveillance technology to be deployed across the city, which in communication with law enforcement could reduce crime by creating a constant deterrent to illegal activity, and making the process of collecting evidence far simpler. [4]

2.1 Smart Technologies in the Developing World

While in the US we may take for granted having regular access to basic amenities such as food, clean water, and electricity, and in many parts of the developing world, these things are not assured to people. For instance, many cities across the world struggle to intelligently allocate electricity where it's needed, leading to blackouts in some areas, and an excess in others.

Using Smart City technologies, these issues could potentially be observed and mitigated in real time using the large volume of data collected by sensors installed across the infrastructure of the city. While these cities themselves likely lack the funding to support a project of this scope, it would take no more than a humanitarian effort from a sufficiently generous organization to fund such a project, and potentially improve the quality of life of thousands of people for generations to come. [1]

2.2 Boosting the Economy

Another benefit of this technology lies in the fact that, in addition to being a massive project in terms of construction, these projects would require the contribution of countless engineers, computer scientists, and city planners in order to work. The scope of these projects will on average far exceed that of a traditional city design, which generates a variety of employment opportunities for workers across a number of fields.

Additionally, the general marketability and media hype surrounding these projects could provide a boon to businesses operating in the city, both through the increase in tourism, and through an increased connection to the consumer base driven by increased access to data on consumer habits. For instance, a business could use data to determine which locations across the city are most frequently traveled, potentially allowing advertisements to be more targeted in how they promote their businesses. Further, if social media data is tied in to the data collected, this information can allow local businesses to have their pulse constantly on the interests and needs of their customers. [11]

Figure 4: Smart City Environmentalism
Source: renewableenergyfocus.com

Figure 4 demonstrates the way in which a Smart City economy seeks to satisfy both the profit motive and the goals of environmentalism at the same time. By encouraging the use of recycled materials, and refocusing the business model to be service-and-repair oriented, business can remain competitive, perhaps becoming even

more competitive, while also participating in the humanitarian goals of the Smart City initiative. [11]

2.3 Sustainable Cities

There is a tension which exists in the broad goal of environmental sustainability, where large corporations are often among the largest contributors to climate change and environmentally unsustainable practices, and there is often no profit motive for being environmentally conscious. This often means that, without pressure from the public or the government, that businesses will do only the absolute minimum necessary for preserving their reputation as a "green" company, which is of course a simple profit motive.

It is therefore the responsibility of citizens and governments to hold corporations accountable to the goal of Smart Cities being, as a primary objective, environmentally sustainable. By planning and implementing these projects from their very onset with the goal in mind of sustainability, there are a wide variety of ways that these cities can promote these values.

For instance, many of these projects intend for sustainable energy sources such as solar and wind power to be a major part of the city's power source. Many projects also seek to incorporate citywide greenery throughout not only the streets and neighborhoods, but also across rooftops. Studies on the effects of plant life being maintained across the city, and particularly near rooftops, can help with temperature regulation in the buildings, and, with a sufficient volume of vegetation, can also improve the air quality throughout the city.

Another way in which Smart Cities can benefit the environment is through the use of utilities monitoring technologies. By tracking water and energy usage across the city, waste percentages can also be determined, which allows the city to dynamically reallocate resources to reduce the waste of utility resources.

One estimate from the McKinley Global Institute estimated that these tracking protocols on just water and electricity usage could reduce a city's greenhouse gas emissions by 10-15%, and reduce the water consumption by approximately 50 liters per person per day, further reducing the carbon footprint of the city. [9]

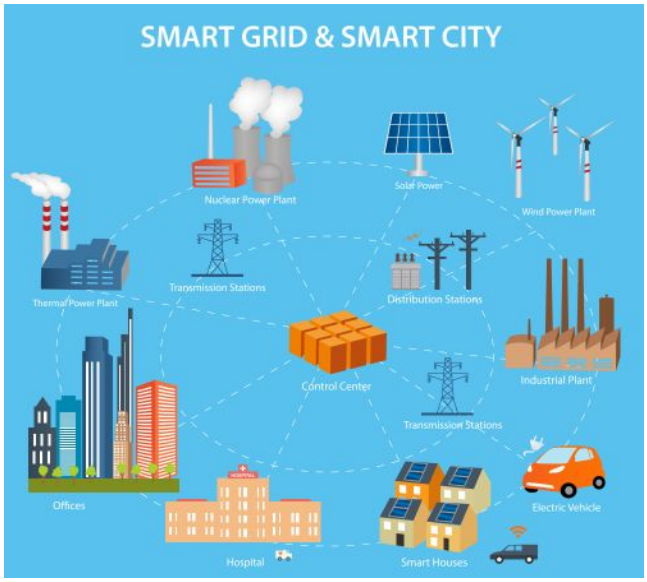

Figure 5: Smart City Environmentalism
Source: renewableenergyfocus.com

In Figure 5, we can see an abstract depiction of the way in which each aspect of the city's energy system is connected to a central place of control, where data can be fed in real time to algorithms which can reduce waste, and detect problems before they lead to larger, harder to solve issues.

There are also other, more subtle ways in which a city can reduce its environmental impact. By integrating the public transit system of the city with a user's smartphone, applications can be designed which take real-time measurements of a bus or tram's position and speed, as well as the general traffic congestion of an area. These applications can then provide to the user highly accurate estimates of when and where public transportation will arrive. This technology could even coordinate with traffic signals in the city to operate in such a way that public transit options are favored by the flow of traffic, bringing their travel-time efficiency more in line with personal vehicle ownership. [4]

Through a combination of these measures, public transportation options can become more attractive to

citizens, resulting in decreased usage of private vehicles. Not only does this reduce greenhouse gas emissions by reducing the number of vehicles on the road, it also eases roadway congestion, which impedes the flow of traffic and reduces the amount of time a vehicle spends idling in city environments. When combined with other roadway optimizations such as spotlight management to improve the flow of traffic, the city's carbon footprint can be reduced even further. Taken in total, these measures could represent a significant step forward in creating truly sustainable cities.

2.4 Which Cities Are Ready To Be "Smart"?

Another aspect of the Smart City initiative which must be considered is, of course, deciding which cities will receive the limited amount of governmental funding to launch their projects. Some have argued that city-ranking metrics could be used to identify cities which are already succeeding, and theoretically are most prepared to successfully launch a project of this scale.

This seems reasonable at a first glance, and there is merit to this approach. However, speaking from the perspective of an American, gentrification has been a major issue which has affected minority communities across the country. Many of the metrics used to select "top performing" cities will also implicitly select for factors such as wealth. Of course, due to systems of racial inequality in the US, selecting for wealth often has the side effect of selecting against minorities, who face economic hardships at disproportionate rates due to ingrained structures of bias in society.

Therefore, before we even *begin* an initiative, we need to consider carefully our own biases in selecting the target area of these projects, and be certain that we are indeed fulfilling the humanitarian goals that were originally laid out.

3 Big Data Issues

Despite all of the exciting features that these cities can promise, it is important to acknowledge the potential risks as well. Even if these risks are not sufficient to warrant cancelling any given project, they should at least be recognized and accounted for by the engineers and programmers that develop the accompanying systems.

A primary point of concern from data privacy advocates is centered around the sheer scope of the data collected from these cities. Data collected from residents of these cities can range from movement patterns (tracked from smartphones, from license plate scanning technology, or from public transit use), consumer behaviors (from businesses in the area, or from certain smartphone apps), or even video recordings at certain areas of the city to track traffic flow, and observe the composition of the traffic.

This data is often stored in a way which lends itself more easily to access and analysis, and can be collated and analyzed in real time. The speed of access is a major factor in not only the utility of this data, but also its potential danger. For instance, a malicious actor could potentially gain access to these databases, and have access to massive quantities of sensitive information, captured and analyzed in real time.

3.1 Security Issues With Big Data

Any person that has actively followed the news surrounding large data collecting companies is aware that security breaches are alarmingly common, even among very large businesses such as banks, credit card companies, and major software companies. While measures can be taken to reduce the chances of a security breach, and further measures can also be taken to reduce the impact of a potential breach, there will always be an inherent level of risk involved in collecting and storing large quantities of data. Critics of these projects question whether a few extra conveniences are worth this cost. [4]

Indeed, some of these projects have even been scaled back in the face of backlash and concerns regarding the collection of this data. The original Smart City proposal for the eastern part of Toronto was originally planned to span nearly 190 acres of land. Following a large amount of backlash from residents of the area, and from data privacy advocacy groups, the scale of the project was limited to 12 acres of land. [3]

3.2 Who owns the data?

A major point of contention across many of these projects is the question of who should own and control the data that is collected from the variety of censors, trackers, and cameras installed across the city. In the case of Toronto, the original proposal was for data to be controlled by a private tech company, which was a subsidiary of Google. Naturally, these companies have argued that they have the expertise to collect, collate, and process this data more quickly and efficiently than a government agency can.

Data privacy advocates have argued that these companies have nothing more than a profit motive, and under the current laws, particularly in the US, would have far too little oversight on how this data is collected and managed. One critic of Toronto's 190 acre project referred to these projects as an attempt to create "corporate surveillance states, modeled after Disney-style developments and sold to police services and corporate partners." Indeed, with surveillance technology becoming increasingly common as a tool for generating profits among corporations, and as a tool for spying on citizens in case of many governments, it is troubling to imagine some of the more pessimistic outcomes of these projects. [3]

Another deliberation we must make when considering these proposals is the impact to people who have not consented to being monitored at a large scale.. It is often the case with movements which diminish the privacy rights of individuals, that you, so to speak, cannot put the genie back into the bottle. By allowing corporations to enter cities and set up mass surveillance technology, not only will every person who enters the city be monitored, but future generations will also have to leave with this diminished privacy as well.

3.3 Government Oversight

So on the one hand, if the data is owned by private corporations, without significant oversight or regulation, the data could be potentially sold off or leaked to other private corporations, violating the privacy of citizens residing in the city. On the other hand, if the local government were to control this data, this also raises a number of potential issues. As we have seen across a number of different governments across the world, many governments are fully willing to skirt or outright violate the law when it comes to data collection and privacy.

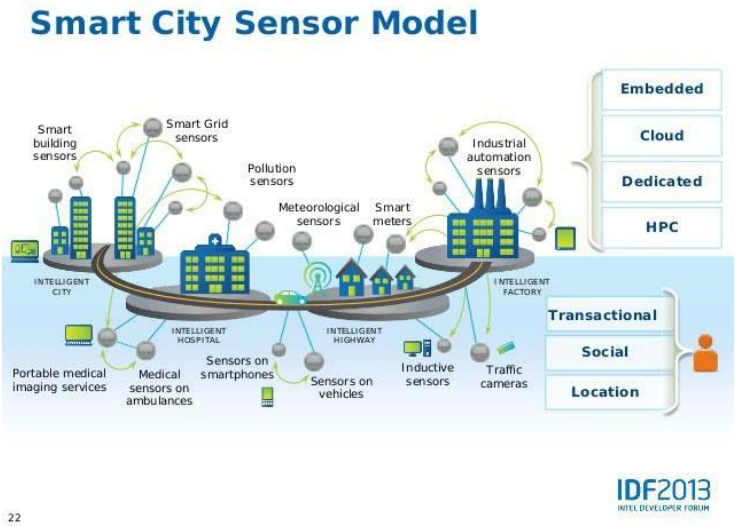

Figure 6: Smart City Surveillance

Source: renewableenergyfocus.com

Viewed from the perspective of an individual living under the rule of an authoritarian government, the above figure perhaps strikes more of a note of fear than it does excitement. Of course, it is hard to imagine how some of these censors could be used for malicious purposes, but at the very least the scale of this data collection is likely alarming to many people.

In the wake of the 2020 protests surrounding issues with discrimination in law enforcements, many local and federal agencies are responding with force to these protests. Certainly, if these agencies had access to wide scoped surveillance technology with little to no oversight on how the data is used, these could be used to quell protests and to coordinate the legally questionable and violent crackdowns on protests. For instance, the cameras and tracking technology could be utilized to coordinate the efforts of federal agents in Portland who are fighting against people participating in demonstrations.

Furthermore, as we learned from the whistleblowing efforts of former NSA analyst Edward Snowden, the American government is fully willing to skirt or even fully ignore

legal and ethical guidelines in the pursuit of information. Essentially every possible technology available was utilized to spy on American citizens, in many cases with no legal justification whatsoever. Given the recency of these events, and the current political climate not appearing any more sensitive to data privacy issues than the previous, we should be cautious about allowing data collection on this scale.

A report from the ACLU on the ethics of Smart City projects expressed significant concern regarding the scope of this surveillance:

> "In a city blanketed with cameras — including in LED light bulbs found in streetlights — it would be very easy for the government to track which political meetings, religious institutions, doctors offices, and other sensitive locations people go to and to focus its attention even more on traditionally over-policed communities. This is why these 'Smart Cities' are also referred to as 'Surveillance Cities.'"

In this report, they go on to highlight the Community Control Over Police Surveillance (CCOPS) campaign, which advocates for regulation and transparency in police surveillance activities, with the ideal in mind that if the police are allowed to surveil the public, then the public ought to have the right to fully understand the scope and nature of this surveillance, and, to some degree, should be able to surveil police activity itself. [6]

3.4 Illegal Access

Setting aside the issues of privacy, and assuming that the data is used for neutral or benevolent purposes, there are other issues that can arise from the collection of this data. A large database and "internet of things" that naturally accompanies Smart City developments is a prime target for hacking, either for the purpose of stealing the collected data, or in order to disrupt the vital technological systems of the city itself.

Due to the fact that each of these development projects handles the management of the data differently, sometimes being handled by governments, sometimes by private companies, and sometimes both, the risk profiles of these projects can vary widely, and even depends on the company that is contracted to develop and deploy the surveillance systems. In 2014, a cyber security expert named Cesar Cerrudo led a study which exposed major security vulnerabilities in traffic control sensors installed in many major cities across the US. If even simple technologies such as this are exploitable, then the much more complicated web of technologies involved in Smart City projects could contain major vulnerabilities. [5]

Perhaps the most alarming aspect of these security flaws is that a malicious actor could exploit these to cause extreme danger to huge numbers of people. For instance, manipulating the patterns of traffic lights, targeting the distribution of utilities to certain areas, or manipulating the appearance of digital roadway signs.

4 Conclusion

Having reviewed the scope of these projects, and looking at both the pros and cons of the general Smart City movement, it is challenging to draw a definitive conclusion in either direction. On the one hand, the benefits in terms of sheer convenience passed on to residents is significant, and these technologies have huge potential for innovations in environmental protection, safety, and community interconnectedness, some of which have currently not even been considered.

These projects promise benefits for already highly developed cities simply looking to use data to make the daily lives of their residents more convenient while also mitigating their environmental impact. These projects also show significant promise to cities still in development, even in less wealthy regions of the world, and could be a critical piece to the puzzle of lifting people out of poverty. The potential humanitarian benefit of these projects alone could make them worth pursuing, despite the risks.

On the other hand, as we explored earlier, the sheer scope of the data which could be collected, and well as the

general lack of oversight on the companies involved in these projects leaves a lot to be desired from a data privacy and data security standpoint. While these Big Data collection technologies allow local governments to make better decisions about their city, they also create potentially huge vulnerabilities for malicious actors, to attack and disrupt cities in ways which were simply not possible with a more analog city design. This data could also enable an almost unprecedented level of authoritarianism on the part of the police or the government in terms of the level of surveillance possible.

Whether the pros outweigh the cons will be something which can only be decided on a case-by-case basis, and each project would require oversight from not only cyber security experts, but also would require ethical oversight to ensure that the scope of data collected does not exceed that which is absolutely necessary for the functioning of the project.

Overall, these projects show great promise for the future, and with most budding fields of technology, there will likely be many stumbles and setbacks before the average citizen gets to reap the rewards. However with enough planning, oversight, and ingenuity, Smart Cities could very well be the way of the future for urban centers across the world.

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