

SMART CITIES, DIGITAL TWIN AND NEW CONNECTIONS ON CIVIL ENGINEERING

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Abstract. *This study explores the fusion of a wide variety of city data and technologies applied to smart cities and analyzes some key characteristics of them. In recent years, new technologies are being implemented with a focus on sustainability and joy of living of those communities. The literature focuses on technical aspects of digital technologies, although human factor is the key factor for a project success. Significant features of smart cities are applying technology for solving urban issues and improving the quality of citizen's life. This paper defines the concepts of Smart Cities and discuss the main necessary competencies for smart cities development. The paper also indicates the challenges facing the civil engineering design and construction of smart cities in concept of Digital Twin.*

Keywords. *Smart City, Digital Twin, Building Information Modeling, Internet of Things.*

Introduction

This article aims to review the literature on the relationship between Smart City and competencies considered fundamental for urban management.

Before starting the study on new competencies related to civil engineering, it is important to investigate the different definitions of Smart Cities. There are several definitions of smart cities, many related to the evolution of the digital society. The term smart would have emerged from discussions about factories based on production model with connected intelligent machines and systems and with the use of the internet of things. The movement originates when Cisco, in 2005, began research and technologies to help cities meet future challenges at the request of the Clinton Foundation. Cisco points out that smart cities are characterized by the adoption of scalable information and communication technology solutions to "increase efficiency, reduce costs, and improve quality of life." According to Komninos (2008), the intelligent city is the one that brings together three forms of intelligence: that of human beings, which constitute the population of cities, the collective intelligence of innovation institutions and the artificial intelligence of digital networks and applications.

Since 2000, information technology applied to urban planning has been tested by companies such as Siemens, Cisco and IBM in the Middle East and Asian countries. IBM defines smart city as one that uses all available means of information to better understand and control operations, optimizing the use of scarce resources (COSGROVE et al., 2011). Thus, the first definitions of smart cities were based on new technologies. Hall (2000) defines: The city that monitors and integrates all critical infrastructure (roads, bridges,

tunnels, subways, trains, airports, ports, communication, water, energy, and large buildings), optimizing the use of resources, planning preventive maintenance and monitoring safety aspects to maximize the performance of services offered to citizens.

The South Korean government, for example, has defined Smart City as an approach to harnessing digitization, clean energy, and technologies to promote sustainable economic growth. (CARNEIRO et al. 2021). In Japan, the concept of smart community is more widespread, implying a community that uses various state-of-the-art technologies and integrated advanced social systems. China, which is implementing the national "Guidance on Promoting Healthy Smart City Development" strategy for smart cities, according to which, the smart city 2 is shown as a new concept or city model, which uses the most advanced information technologies, such as IoT, cloud computing and big data, to promote intelligent urban planning, construction, management, and services for cities (CARNEIRO et al., 2021).

Criticisms of these concepts were presented by the Phantom Urbanism project, developed at Harvard University (DE GRAAF; SOLAR, 2018) with evidence demonstrating the failure of initiatives based exclusively on technologies. The digital education of citizens began to be discussed as well as the culture of public agencies and their servants. The experience and life of the residents were also valued, leading to the definition of intelligent cities with a more humanistic and holistic vision. According to Angelidou, 2015, smart cities should have a more human-oriented vision, giving conditions for citizens to express more intensely their ability to innovate and participate in problem solving in the collective creation of common goods.

The United Nations' New Urban Agenda (UN, 2017) highlights smart cities as a means of boosting sustainable economic growth, enabling cities to improve their service delivery through digitization and use of clean technologies and energies (CARNEIRO et al., 2021). According to the OECD- the Organization for Economic Cooperation and Development, smart cities must improve the efficiency of urban services and sustainability, highlighting the collaborative aspect by involving multiple social actors in the design of solutions to the problems of cities. (Carneiro, 2021) Defines that the smart city is the urban space oriented to investment in human and social capital, sustainable economic development, and the use of available technologies to improve and interconnect the services and infrastructure of cities, in an inclusive, participatory, transparent, and innovative way, focusing on raising the quality of life and well-being of citizens.

According to Morozov and Bria, 2020, so far, the "city" component of the concept of smart cities has attracted far less attention than "smart", yet it demands an equally critical analytical approach.

Morozov and Bria, 2020 also state that some cities opt for smart technologies with the expectation of pragmatic resolution of specific problems of certain urban centers: congestion caused by road infrastructure falling apart; lack of jobs, which – with some luck – can be solved with the entry of smart money into smart and creative urban districts, followed by smart citizens; or inefficient waste collection and disposal systems that obstruct streets and frustrate citizens, either because garbage trucks seem too big when there is little garbage or are always overloaded when needed them most.

At present, a smart city (VIVELIBRE, 2019) is one that uses technology to provide urban services more efficiently, improve the quality of life of citizens and transform the relationship between local entities, businesses, and citizens, facilitating the way of living. A differential element is that technology is, this time, disruptive and alters the pattern of

relations between the actors of the city: citizens, government, productive sector, third sector etc. (ACCENTURE, 2014).

ARUP, the UK's leading multinational engineering and architecture firm, defined in its 2010 report that smart cities are urban areas where digital capabilities create value. Recent literature emphasizes the importance of focusing on the citizen thinking and ensuring that the value created has a tangible dimension and totally positive impact on the quality of life of citizens.

The European Union defines this term as a place where interactions and services are done more efficiently and uses technology for the benefit of the inhabitants and businesses.

Material and Methods

In order to try to ascertain some convergence of the concept of Smart Cities, to obtain the overview of smart cities, this study performed a literature revision to identify concepts, the evolution, and contributions to keep on developing the Smart City. It was identified that since its creation there has been an evolution in the concept of smart cities, after some unsuccessful implementations.

Competencies

Castro, 2021, says that projects in which mayors and companies focus on problem solving simply by trying to copy success stories from other cities, without considering the aspects of the local ecosystem, are already born bankrupt because they are not "future-proof" and that public policies and investments in basic technologies such as connectivity, distributed infrastructure and computing capacity are critical to the development of any smart city.

Cities across many the world are enhancing their digital infrastructure, and this has implications for workers across career areas. Smart cities imply high technological complexity and it have an impact on the competence level of their citizens and professionals. In a context of ongoing social transformation, we have argued for the use of sociotechnical design principles to understand the dynamics of sustainable careers in smart cities. Such understanding could lead to policies that support the creation and maintenance of a dynamic synergy that is at the core of smart city and career sustainability (CURSEU, 2020).

Civil engineers should value commercial innovation and technical innovation equally. A recognition that technology alone cannot bring change could take many forms, including increasing the value associated with entrepreneurship and develop an interest in business model disruption in other industries.

However, an understanding is not enough, individuals need to continuously consider how it would affect their role. By understanding how technologies link to societal outcomes, engineers can have confidence in promoting new uses, and new human capital that is required. Civil engineering needs to take a bolder, more proactive role in shaping its future if it is to succeed in the Smart City age. The profession needs to come together to achieve digital solidarity and should transition from a view of isolated infrastructure outputs to industry-wide societal outcomes.

Sensors are increasingly “smart” infrastructure systems, civil engineers need to know as much about Big Data and algorithms as about roads or bridges. It is responsible for the design of a large part of urban infrastructure. But to build the smart cities of the future, in addition to engineering skills, it would be also need knowledge about the environment, climate change, technology, sensors and data science.

Civil engineers can identify innovative technologies to improve the delivery of urban resources and services; must consider the environmental and social impacts of smart infrastructure applications; manage existing, and growing risks of natural disasters, emergencies and climate change, must integrate diverse expertise to develop smart infrastructure programs; manage the safety of people who use smart technologies; and it could take the lead in intelligent infrastructure discussions and policy development.

Some research findings reflect that smart city planners perceive and do need training in certain competencies to generate own additional and sustainable human capital. The findings reflect that smart city planners perceive and do need trainings in certain competencies to generate own additional and sustainable human capital.

(Cosgrave, 2018) In order to be able to contribute to smart infrastructure and construction that serve social as well as technical requirements, engineers must be able to engage in critical debates that incorporate and value human experience. They must develop a language and a knowledge system that is complementary to local, national, and international policies, so that technical knowledge may better inform political decision making. Smart technologies hold an opportunity to challenge modes of design. As engineers explore this, they should not miss the opportunity to create an urban infrastructure system that serves all urban dwellers.

Results and Discussion

China has announced the development of a city controlled exclusively by Artificial Intelligence (AI), a small smart city interconnected with sensors and devices that will collect the habits and preferences of each of its inhabitants. There is a risk that surveillance mechanisms will further increase social segregation. During the pandemic, the Chinese government intensified the development and use of artificial intelligence (AI) surveillance cameras, drones, facial recognition technologies, big data collection and analysis, tracking applications and QR codes that associate travel history with health data.

An intelligent city offers joint solutions by connecting its services, information technologies and communication with practices that seek solutions to urban challenges and create a sustainable and accessible infrastructure. In a smart city, sensors collect data in real time, and it is analyzed for information on the operation of services. The results of these analyses are passed on to decision-makers and for the implementation of measures that can improve services and generate greater well-being. The population can participate and interact with the ecosystems of smart cities through mobile devices, vehicles and connected buildings, obtaining data, and informing about issues of public life.

Tel Aviv, Nonstop City, involved the entire population in the implementation of smart city concepts, in decision-making and collaboratively, with the various sectors of society, from companies to city hall to improve the quality of life of citizens. At the heart of the strategy are citizens and their needs. With this, Israeli companies are developing technological infrastructure solutions for the integration of intelligent urban services. Currently the most significant investments in smart cities can be found in the United

States, Western Europe, and China.

An example of Smart Cities deployed since 2014 is Singapore, where it is possible to detect if people are smoking in forbidden places, whether disposal is being done on public roads, monitoring people density, public cleaning or even knowing where any car registered in Singapore is. All this due to thousands of cameras scattered at specific points around the city or to Big Data.

Another example is Dubai, in which it is gradually creating an app of the city where it is possible to do all your needs around, such as: searching for bank, ask for a taxi, pay bills and fees, among others. However, this app works best for locals, leaving it unfeasible for potential tourists.

Barcelona, in turn, used the technology to its advantage and the world as well, by implementing the Government's Digital Agenda of Barcelona deployed the city's on-and-off sensors when there is no need for public lights, saving thousands of dollars a year. Parking space work from sensors connected to a software and sent to an app, showing where there are spaces available throughout the city, both in parking lots and on public roads without having to drive in circles. Smart dumpsters are also part of the city, with internal pipelines taking garbage to their respective collection sites, reducing costs, odors, and noises. The municipal network has 500 km of fiber optics, free Wi-Fi routed by street lighting and sensors that monitor air quality and parking spaces. Barcelona is at the forefront of testing the Internet of Things.

Here in Brazil, we have limited structure to implement a Smart City, but it is already possible to see transformation with facial recognition camera projects, rainwater collection, intelligent urban mobility, and a history of population health. However, one of the biggest challenges is the connection, because many cities do not yet have (or have a limited) internet connection, which is essential for the implementation of this technology. But in São Paulo it is possible to see some changes in relation to the theme, such as sensors that mark the amount of water in rivers near important avenues, GPS on public transport indicating where they are and the estimated time of arrival, cameras of the city hall (City Cameras) installed in neighborhood residences to promote greater security in the region (with has more than 20,000 cameras scattered). A much-cited reference in the world is the Rio de Janeiro-COR Operations Center, inaugurated in 2010 by the city of Rio de Janeiro in partnership with IBM. The COR brings together secretariats and other municipal agencies that monitor on screens the events of the municipality captured by cameras and that aims to anticipate crises and allow to broadcast alerts on possible environmental disasters. This, however, did not prevent the great collapse caused by the rains of 2019.

According to IRÓN and IMILAN, 2020, in Latin America, the idea of Smart Cities has become attractive based on the seductive possibility that urban development can be improved through the city's technologization, reducing the complexity involved in coordinating various actors. That is, the promise that Big Data would solve governance problems, depoliticizing urban life to free it from conflict.

As a small and very organized country, New Zealand has quickly implemented the concept of Smart Cities along with digital Twin in large cities such as Wellington and Christchurch has already created specialized councils in this area. Before the implementation of any new technology, it goes through a phase of testing among the population while the council seeks to understand if this technology positively or negatively impacts the population of the region. Some technologies do not go through

this phase of testing because they have already been used outside the country, such as the implementation of intelligent dumpsters in the coastal area, in which there was a huge wind problem, thus leaving the area dirty and attracting animals.

Apart from Smart Cities, some cities have implemented Digital Twin, especially in cities where the risk of flooding is high. It is used to predict flooding and recommend the best way to take and stay safe. Often the population is not sure what is happening with the new implementations, but in the case of New Zealand, they make a point of showing this new technology with information center on Smart Cities and Digital Twin, showing examples and data of local cities, thus encouraging residents to understand this technology and help.

The case of Vienna, Smart City Wien, deserves special attention for the way technology is understood, as an instrument and not as an end. The idea of becoming a smart city began in 2011 through the involvement of universities, associations, and private companies. The city analyzes the need for two types of innovation: technology and social. In the administrative field, Vienna aims to become the most progressive European city in relation to government transparency. It also wants to ensure that everyone in the city has good living, neighborhood, and safety conditions. To this end, the Smart City Vienna Agency highlights in its plan the objectives of providing affordable quality housing for the entire population and ensuring that workers are adequately paid so that they have access to all the necessities of life. Although electric cars are a cleaner modal, the city government does not intend to promote this type of vehicle and works to foster the creation of more connected transport lines.

The data management systems that integrate big data, cloud computing and the Internet of Things (IoT) are improving infrastructure. IoT generates a large volume of data, structured and unstructured. As a result, there is a need for more advanced technologies to store, process, and analyze this data, to extract and synthesize relevant information, and to make decisions and initiate actions based on results.

The Smart City also receives a lot of criticism. Some researchers argue that inequality of access to technology and opportunities aggravate the landscape of social inequalities. For the development of smart cities, it is imperative to develop the necessary infrastructure to sustain development projects.

According to The Guardian (2021), the city at Toronto has abandoned a partnership with Google to create a high-tech waterfront venture, Canada's largest city. With a new vision of the future, focused on accessibility, sustainability and low-carbon design, an emphasis on local businesses, the new project seeks to escape the pitfalls of new and often untested technologies. The initial plans were daunting for many people, it seemed that quayside would become a technology-based community, where everything would be monitored, personal data collected by thousands of cameras.

There are smart cities designed from scratch like Masdar and Songdo. Masdar is a half-built city rising out of the desert, planning of which has been overseen by the master architect Norman Foster. Richard Sennett, in an article for The Guardian, makes remarks about the Masdar Smart City in Abu Dhabi: "The city is conceived in "Fordist" terms – that is, each activity has a suitable place and time. Urban planners become consumers of choices made for them by recalculations of where to shop or get a doctor more efficiently. There is no trial-and-error stimulation; people learn their city passively. "Easy to use" in Masdar means choosing menu options instead of creating the menu. "Creating your own, new menu entails, as it were, being in the wrong place at the wrong time. In mid-20th-

century Boston, for instance, its new "brain industries" developed in places where the planners never imagined they could grow. Masdar – like London's new "ideas quarter" around Old Street – on the contrary assumes a clairvoyant sense of what should grow where. The smart city is overzoned, defying the fact that real development in cities is often haphazard, or in between the cracks of what's allowed.”

(Cosgrave, 2018) argues that many universities across the UK are beginning to understand that training their students in critical thinking and supporting them in developing an understanding of their role in global urban challenges is a core part of their engineering education. As society moves towards the smart city, engineers will work increasingly with computer scientists, economists, and environmentalists, as such it is imperative that the education provided to students equips them appropriately. Engineers should be equipped to work with people from other domains to deliver integrated smart city solutions, rather than considering engineering as the sole producer of the smart city. Engineering education will play a key role in developing the capabilities of engineers to interact with expertise beyond their discipline, including the social and political sciences.

Conclusion

Palacios and Callegaro (2020) write that the UN declaration (2015) includes safe and accessible transportation systems, participatory and integrated human settlements, protection of cultural heritage and reduction of urban environmental impact from the perspective of smart cities with urban sustainability. While technology can help social inclusion, it can also deepen social exclusion, expel former occupants of valued urban areas away from their original places of residence.

Investing in professionals with experience in the different areas prepared for smart infrastructure projects will be the way to successfully empower citizens for Smart Cities. It will be necessary to invest in a solution that allows the management of all the data obtained by the city sensors efficiently.

It is also concluded that it is important to study the best solution for each city and stimulate local technology initiatives.

According to Muvuna et al. [25] Smart cities need to be redesigned to become more sustainable, integrated and collaborative. According to RADU, L-d, 2020, smart projects require specialized staff and create new jobs and opportunities for start-ups.

Other areas where smart cities can help improve overall quality of life include smart housing, smart administration, and smart infrastructure. Machine learning scientists, data scientists, experienced city officials are professionals that urban communities are looking for, people with proven abilities to manage and innovate the applications that are most interesting and engaging for citizens and businesses.

The engineering education challenge involves the need for training in critical thinking and its role in global urban challenges and development of digital skills.

Goals

As a goal to the entire project, it is planned and expected to be studying more the theoretical part to as a result implement and apply in some real-life projects, such Ilha dos Arvoredos at Guarujá. Another goal related to Digital Twin is to understand more and implement the digital twin that already exists of Instituto Maua de Tecnologia. What is

expected is to implement what it was study in real-life, although in the fact of being a new theme and nowadays it is not that much popular, it is kind of difficult to find a project related to Smart Cities in the case of sensors. But looking for Digital Twin and BIM, it is also a new theme, but people related to civil engineering understand and it is in a period where the most companies are transitioning to that technology.

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