ARTIFICIAL INTELLIGENCE AND THE CITY

How GAN's Could Be Used for a Bottom-Up Approach

Mustapha El Moussaoui[1]
[1]Faculty of design and Art, Free University of Bolzano
[1]Email: mustapha.elmoussaoui@unibz.it

***ABSTRACT**: Smart cities use advanced technologies to create more efficient, sustainable, and livable urban environments. Central to this transformation is the integration of artificial intelligence (AI), which enhances urban planning through data analysis and predictive modeling. This paper explores the concept of convergence within smart cities, focusing on citizen-centric design and the application of Generative Adversarial Networks (GANs) to visualize future urban spaces. During a research to redesign Don Bosco's public space in Bolzano, Italy, six scenarios were developed. Four scenarios drew from Eurac's 2020 research on sustainable development, while two new scenarios addressed current urban issues and a dystopian future vision. The research utilized qualitative and quantitative methods to gather feedback from residents, ensuring an inclusive participatory process. The findings highlight the essential role of community involvement in urban planning and demonstrate AI's potential in generating predictive +models for future urban scenarios. This study underscores the importance of visual tools in enhancing public participation and informed decision-making in urban redevelopment.*

Keywords: Artificial Intelligence; Urbanism; City-planning; Smart City; Bottom-up

INTRODUCTION

The concept of a "smart city" is more and more becoming a cornerstone in urban development, driving technological innovation and enhancing the quality of life for residents. At its core, a smart city integrates advanced technologies, particularly artificial intelligence (AI), to create efficient, sustainable, and responsive urban environments. This transformation is not just about technology but also about fostering new economic opportunities and attracting investment to build a sustainable business ecosystem that supports ongoing urban growth. Investment alone, however, is not sufficient. Each city's journey towards becoming smart is influenced by its unique geographic location, physical characteristics, population, workforce, and governmental structures (Naphade et. Al, 2011). However, understanding the evolutionary process of technology adoption and integration is crucial for tailoring solutions that meet the specific needs of each city. Cities evolve in both teleonomic (undirected) and teleological (directed) ways, converging towards AI-driven, autonomous, self-regulating systems. These systems, much like our societies, are self-organizing by nature. The goal is to leverage AI to assist in the self-regulation of cities, treating them as living systems that can monitor and manage themselves in real-time, anticipating and addressing issues proactively (Kirwan & Fu, 2020).

Traditional city governance often involves reactive measures akin to triage, where resources are allocated based on immediate needs. In contrast, smart cities aim to use AI and machine learning to predict and mitigate problems before they escalate, optimizing resource use and enhancing overall efficiency. This shift from automation, which has been central since the industrial revolution, to autonomization marks a significant step in urban evolution. In the 21st century, as physical labor is increasingly automated, human work becomes more abstract, and the role of technology becomes increasingly critical in meeting the needs of urban populations (Nissim & Simon, 2021).

The convergence of various technological and societal trends is essential in this context. The integration of AI into urban planning not only enhances efficiency but also brings about new

ways of engaging with citizens. Citizen-centric design becomes pivotal, ensuring that the technological advancements align with the needs and aspirations of the residents. This participatory approach empowers communities, making urban spaces more responsive and inclusive.

This paper explores these themes through a case study in Don Bosco, Bolzano, Italy, where a public space was reimagined through AI. In October 2023, six scenarios were developed for the project, drawing from previous research and addressing current urban challenges. Generative Adversarial Networks (GANs) were employed to create immersive images that helped visualize potential futures, facilitating community engagement and feedback. This participatory process underscored the importance of involving residents in urban planning and demonstrated the potential of AI in enhancing these processes. The findings from Don Bosco highlight the critical role of community involvement in shaping urban environments that reflect the collective needs and values of their inhabitants. AI's ability to process extensive data and generate predictive models offers valuable insights, informing more effective urban planning strategies. This study emphasizes the importance of visual tools in public participation and showcases the transformative potential of AI in urban development.

CONVERGENCE OF THE CITY

Smart city convergence represents the integration of advanced technologies and infrastructure to enhance urban living. This convergence involves the amalgamation of IoT (Internet of Things), AI (Artificial Intelligence), 5G, and big data technologies to create interconnected systems that optimize city operations. For instance, the deployment of IoT sensors across urban landscapes facilitates real-time data collection on various aspects such as traffic, energy consumption, and environmental conditions. This data, when processed through AI algorithms, enables predictive analytics and efficient resource management, thereby improving the overall quality of life for citizens and promoting sustainability (Bellini et al., 2022; Gohar & Nencioni, 2021).

One of the key aspects of smart city convergence is the integration of 5G technology, which provides the necessary infrastructure for high-speed, low-latency communication between devices. This technological backbone supports numerous smart city applications, including intelligent transportation systems (ITS), which enhance traffic flow and reduce congestion through real-time adjustments and autonomous vehicle coordination (Gohar & Nencioni, 2021). Moreover, the convergence of these technologies facilitates the creation of more resilient and adaptable urban environments, capable of responding swiftly to emergencies and dynamically adjusting to changing conditions (Bibiri et. al., 2021). (Fig 1)

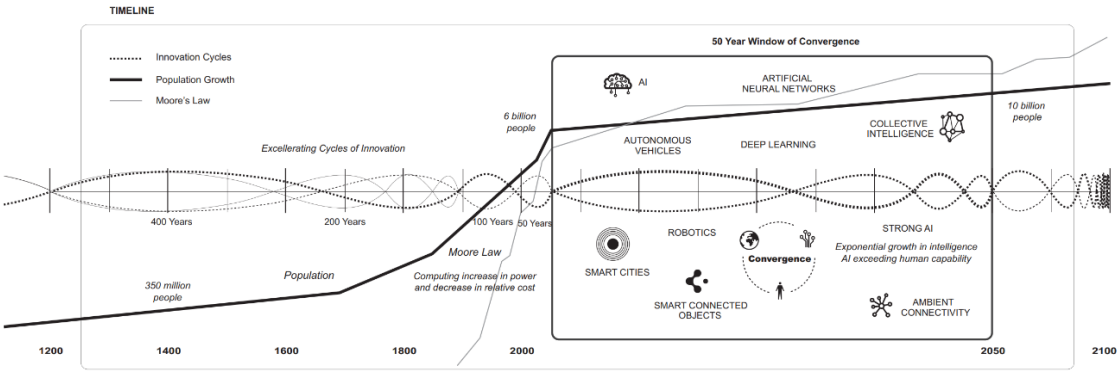

Figure 1 Timeline of converging system
Source : 2020 Kirwan & Fu

Furthermore, the integration of these advanced technologies contributes to economic growth by creating new business opportunities and improving service delivery. For

example, smart grids powered by IoT and AI can optimize energy distribution, reducing costs and environmental impact, while smart healthcare systems can provide more efficient and personalized medical services (Bellini et al., 2022). This concept of convergence, grounded in theories of evolution, society, science, media, nature, technology, knowledge, organizations, and globalization, manifests in the smart city as a "convergent socio-cyber-physical complex." Such a city is highly adaptive to its environment, state space, and inhabitants. However, the convergence goals is not only on the physical aspect of a city, and cyber-digitizing it, as according to Kirwan and Fu, the goal of convergence concept is to optimize our way of living in the city, create a balance, and to enhance the well-being of the citizens. (Fig 2)

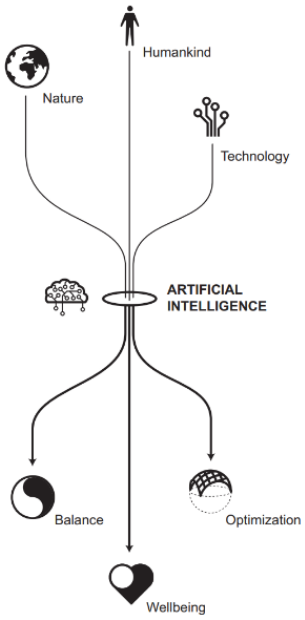

Figure 2 Convergence Goals
Source : 2020 Kirwan & Fu

Co-Design and Citizen-Centric Design

Co-Design is a successful approach to creative practice, particularly in the public sector, it is often used as an umbrella term for participatory, co-creation, and open design processes. In fact following Sanders' position, it could be argued that co-design is part of a wider-notion, co-creation. CoDesign could be routed back to the participatory design, that was developed in Scandinivian countries in the 1970s, in addition, to the 'Design Participation' conference that took place in the UK in 1971 (E Sanders & Stappers, 2008). We are currently witnessing a shift in design research, processes, and methodologies that puts a renewed emphasis on co-design. This is fueled by an erosion of the single designer as the gatekeeper between means of production and consumers, a move to make design more strategic by people like Roger Martin (Martin, 2009), and a move to go beyond tokenistic engagement with non-designers involved in design projects (Lee, 2008).

In smart cities, co-design plays a crucial role in shaping urban environments that are not only technologically advanced but also responsive to the needs and aspirations of their inhabitants. The integration of co-design in smart city initiatives ensures that the development and implementation of urban technologies and infrastructures are aligned with the community's values and requirements. This participatory approach leverages the collective intelligence and creativity of diverse stakeholders, including residents, policymakers, designers, and technologists, fostering a more inclusive and sustainable urban growth.

One significant advantage of employing co-design in smart cities is its potential to enhance the effectiveness and acceptance of smart technologies. By involving citizens in the design process, cities can develop solutions that are more likely to be embraced and utilized by the community. For instance, co-design can be instrumental in the development of smart transportation systems, where the input from daily commuters can lead to more user-friendly and efficient transit options. Additionally, co-design facilitates the creation of public spaces that cater to the specific needs of different demographic groups, thereby promoting social cohesion and well-being (Björgvinsson, Ehn, & Hillgren, 2010). Moreover, co-design contributes to the democratization of urban innovation. It breaks down traditional hierarchies and empowers citizens to have a say in how their city evolves, thus fostering a sense of ownership and responsibility towards the urban environment. This is particularly important in the context of smart cities, where technological advancements can sometimes create a disconnect between decision-makers and the general populace. By embedding co-design principles into the fabric of smart city projects, cities can ensure that technological advancements serve the broader public interest and contribute to the overall quality of urban life (Manzini, 2015).

Nevertheless, codesigning a city leads a city to be framed as a "citizen-centric city". A citizen-centric city prioritizes the needs, preferences, and well-being of its residents in all aspects of urban planning and development, which both ideas, co-design and citizen-centric, can . This concept emphasizes the active involvement of citizens in decision-making processes, ensuring that their voices are heard and their needs are met. By focusing on the people who live in and use the urban space, a citizen-centric approach aims to create more livable, equitable, and sustainable cities (Brown & Wyatt, 2010).

Co-design, as a participatory process, naturally aligns with the principles of citizen-centricity by involving residents directly in the design and implementation of solutions. This ensures that the resulting technologies and infrastructures are tailored to the specific needs and contexts of the community (Björgvinsson, Ehn, & Hillgren, 2010). For example, when developing smart public transportation systems, incorporating feedback from daily users can lead to more accessible, efficient, and user-friendly services.

In smart cities, the combination of citizen-centricity and co-design can lead to numerous benefits. Firstly, it fosters a sense of ownership and empowerment among residents, as they play an active role in shaping their urban environment. This can lead to higher levels of civic engagement and stronger community bonds (Manzini, 2015). Secondly, solutions developed through this collaborative approach are likely to be more sustainable and resilient, as they are based on a deep understanding of local needs and conditions (Sanders & Stappers, 2008). Furthermore, involving citizens in the design process can uncover innovative ideas and insights that may not emerge in top-down planning approaches, leading to more creative and effective solutions (Brown & Wyatt, 2010).

Moreover, a citizen-centric approach ensures that technological advancements in smart cities are inclusive and equitable. By considering the diverse needs of all community members, including marginalized groups, smart city projects can avoid perpetuating existing inequalities and instead contribute to social justice (Lee, 2008). This bottom-up approach allows city governments to learn from their constituents within a more inclusive and responsible urban environment, encouraging a more inclusive and responsible urban culture.

GANS and the Public Space

Generative Adversarial Networks or GANs in abbreviation, hold promising potential in the realm of urban design by enabling the creation of speculative future scenarios that transcend conventional design limitations. By using their ability to generate novel and

detailed visual content, GANs can help the public get more engaged into the design of their future space. In 2014, Ian Goodfellow and his colleagues introduced GANs as a significant innovation in the field. GANs consist of two neural networks, the generator and the discriminator, which engage in a continuous game-like training process. The generator creates data samples, such as images, that it attempts to pass off as real, while the discriminator evaluates these samples against real data, aiming to distinguish between authentic and generated inputs. Over time, through this adversarial process, the generator improves its ability to produce highly realistic data, often indistinguishable from actual data. This dynamic and iterative method of training allows GANs to excel in generating high-fidelity visual content, which has wide-ranging applications from image synthesis to video generation (Goodfellow et al., 2014).

To put that into course, in October 2023, while we were working on redesigning the public space of Don Bosco, Bolzano-Italy, 6 scenarios were created, 5 of which where created through a GAN tool, in specific through Midjourney V6 and ComfyUI, and 1 scenarios was created based on the authors interpretation of the problematics in the neighborhood. (Fig 3)

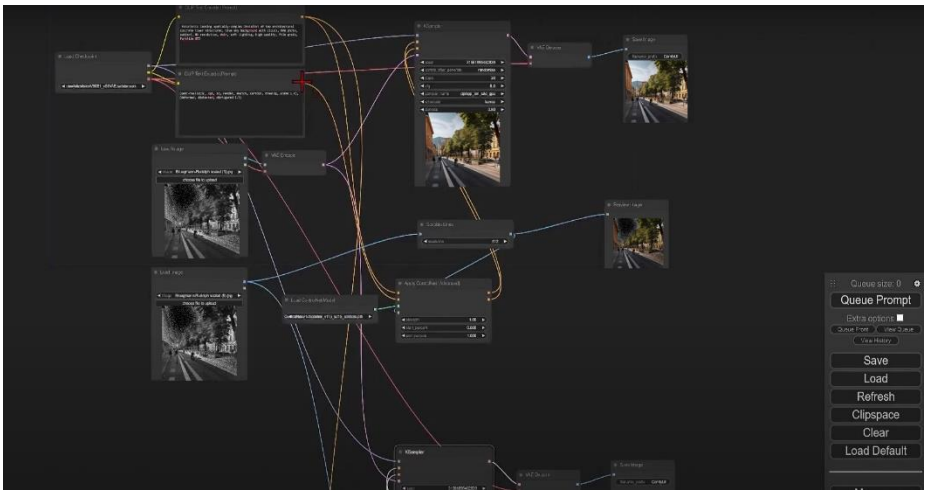

Figure 3 Editing the photos with ComfyUI
Source : 2023 Author

The first 4 scenarios where hypothetical scenarios based on a research project working on the 2030 Agenda for Sustainable Development and the European Green Deal which has outlined four plausible scenarios for the region's future by 2030, aiming to utilize sustainable development paths. The project's multidisciplinary approach, emphasizing participatory processes, underscores the role of regional foresight in addressing global challenges and guiding societal change by emphasising on four different scenarios; Scenario 1: world of regional consciousness – 'Our strength lies in tradition', Scenario 2: world of neo-cosmopolitanism – 'Think global, act local', Scenario 3: world of individual freedom – 'I am the architect of my own happiness', Scenario 4: world of green innovation – 'There is a (technological) solution to everything' (Habicher et al., 2022).

These scenarios range from integrating green spaces into urban areas, promoting pedestrian-friendly environments, enhancing public transportation systems, to encourage community-driven development projects. In addition to these, the author introduced two new scenarios to address the unique challenges and opportunities presented by the urban context of Don Bosco-Bolzano. The first of these new scenarios envisions a future where concerted community and policy efforts have led to the resolution of pressing urban issues, such as housing affordability, green space accessibility, and public transportation efficiency, this scenario which we will call a human scenario, is achieved through a phenomenological

approach made on the studied zone. Conversely, the other scenario serves as a cautionary tale, depicting a dystopian future characterized by exacerbated social inequalities, environmental degradation, and a marked decline in public health and quality of life, all stemming from a persistent lack of innovation and community engagement in urban planning processes.

To achieve those scenarios, Generative Adhersive Networks (GANs) where used to recreate the hypothesised future public space or scenarios. To enhance the impact of these scenarios and directly involve the local population in the urban redevelopment process, a public event was held in Bolzano. This event provided a platform for residents to engage with the six scenarios presented and express their preferences regarding the redevelopment of five key public spaces within the city. The methodology employed for collecting and analyzing residents' feedback was designed to ensure the inclusion and representativeness of the participation process. This involved a combination of qualitative and quantitative research methods, which enabled a comprehensive understanding of the community's visions for their urban environment, and their understanding of the potentialities of Artificial Intelligence in recreating their future public space.

Figure 4 One of the scenarios created by a GAN tool
Source : 2023 Author

A BOTTOM-UP APPROACH

A bottom-up approach in urban planning is crucial for the regeneration of public spaces, as it incorporates the perspectives and consent of diverse community stakeholders. This method ensures that their voices are heard and creates a sense of inclusion and belonging within the city (El Moussaoui, 2024). During the public event held in Bolzano, the methodological framework emphasized a bottom-up approach, aligning with the principles of co-design and citizen-centric urban planning discussed earlier. After thoroughly explaining the rationale behind each scenario, how they were generated, and the reasons for the proposed solutions, participants were invited to engage actively in the decision-making process. This engagement involved selecting one scenario for each of the five redesigned public spaces, as well as identifying and commenting on specific elements within these scenarios. Participants were not merely passive recipients of information; they were

encouraged to critically evaluate and express their preferences, thereby directly influencing the future design of their urban environment.

The event saw diverse participation, with a total of 87 individuals from various age groups, including children, young adults, and the elderly. This diversity ensured a broad spectrum of perspectives and needs were considered, reinforcing the inclusive nature of the bottom-up approach. Participants provided valuable insights by not only choosing preferred scenarios but also by articulating the reasons behind their choices. This qualitative data, combined with quantitative measures of preference, offered a comprehensive understanding of community priorities and aspirations.

The bottom-up approach employed here echoes the participatory and inclusive principles central to co-design and citizen-centric urban planning. By involving residents in the scenario selection process, the project ensured that the final designs would be reflective of the community's values and needs. This method also enhanced the legitimacy and acceptance of the proposed changes, as the community had a tangible role in shaping their future public spaces. Such engagement fosters a sense of ownership and responsibility among residents, promoting sustained civic involvement and community cohesion.

Moreover, this approach addresses potential gaps between technological advancements and public acceptance, a challenge often encountered in smart city initiatives. By incorporating citizen feedback into the design process, the project mitigates the risk of disconnect between decision-makers and the populace, ensuring that technological solutions are not only innovative but also practically and socially relevant. This alignment with community needs is crucial for the success and sustainability of smart city projects, as it encourages the utilization and maintenance of new infrastructures. (Fig, 5)

Figure 5 Participants making scenario choices,
Source : 2023 Author

CONCLUSION

The transformation of urban environments into smart cities is a multifaceted process that hinges on the convergence of advanced technologies, citizen-centric design, and participatory governance. This paper has explored these themes through the lens of a case study in Don Bosco, Bolzano, Italy, demonstrating the role of artificial intelligence (AI) and co-design in fostering innovative, inclusive, and sustainable urban development.

Co-design and citizen-centric design emerged as pivotal concepts in our framework, highlighting the necessity of involving residents directly in the design and implementation processes. This participatory approach enhances a sense of ownership and responsibility among citizens, promoting higher levels of civic engagement and social cohesion. The public event in Bolzano exemplified this, where diverse participants actively contributed to the selection and refinement of urban scenarios, ensuring that the final designs were reflective of their collective vision.

The framework of smart cities presented in this paper underscores how AI technologies can be introduced to design our urban futures, particularly Generative Adversarial Networks (GANs), to visualize and shape potential urban possibilities. Through the case study in Don Bosco, we illustrated how GANs can create detailed and speculative future scenarios that engage and empower residents, facilitating a bottom-up approach to urban planning. This method enhances the relevance and acceptance of proposed changes but also ensures that urban redevelopment aligns with the community's needs and aspirations.

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