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## Human-centric digital urbanism: data, participatory design, and inclusive decision-making

### 以人为本的数字城市规划: 数据、参与式设计与包容的决策

Gamze Dane is a tenured Associate Professor at the Department of Built Environment at Eindhoven University of Technology (TU/e). From 2020 to 2024, she also served as one of the Principal Investigators of the Digital City Program within the Urban Development Initiative (UDI). She has an interdisciplinary background, holding a Ph.D. in “Human Behavioral Modeling in Urban Planning”, an M.Sc. in “Geographical Information Systems (GIS) and Decision Making”, and a B.Sc. in “Urban Planning”. Gamze is an urban planner with a strong foundation in computational urban science, behavioral sciences, and urban planning. Her research focuses on the intersection of citizen behavior, digital tools, and sustainable urban transformation, particularly interested in integrating citizens into urban (re)development decision-making processes. She has led several large-scale European and national research projects, collaborating with citizens, non-profit organizations, enterprises, and local governments across European cities. Her current research explores how data-driven and citizen-centered approaches can support inclusive urban planning, enhance public participation, and guide digital innovation toward more sustainable, inclusive and human-centric urban futures.

甘泽·丹, 荷兰埃因霍温理工大学 (TU/e) 建成环境系助理教授。2020-2024年, 担任埃因霍温“城市发展倡议”下属数字城市项目的核心研究负责人。甘泽拥有跨学科背景, 本科毕业于城市规划专业, 硕士研究地理信息系统 (GIS) 与决策支持, 博士则聚焦于“城市规划中的人类行为建模”。作为一名兼具计算型城市科学与行为科学基础的城市规划学者, 她的研究重点是市民行为、数字工具与可持续城市转型的交叉领域, 尤其关注如何将市民有效纳入城市开发或更新的决策过程。她主持了多个欧盟及国家级大型科研项目, 与欧洲多地的居民、非营利组织、企业及地方政府开展合作。目前, 正探索数据驱动与市民中心的规划方法如何支持包容性城市规划、提升公众参与, 并引导数字创新迈向更加可持续、包容及以人为本的城市未来。

Gamze Dane = GD

杨森琪 = SY

## Bridging Digital Innovation and Human Experience

### 融合数字创新与人本体验

SY: Digital urbanism has become a major trend in planning today. Your research brings together advanced digital tools and spatial analytics to support urban decision-making. In your opinion, what does it mean to make digital urbanism truly human-centric? How can planners benefit from including citizens' perceptions, behaviors, experiences, and feedback in urban digital models, especially when compared to more techno-centric approaches?

近年来，数字城市规划正在成为全球趋势。您的研究着眼于利用前沿数字工具与空间分析技术赋能城市决策。您如何理解“以人为本”的数字城市规划趋势？与偏向技术导向的方法相比，将个体感知、行为、体验与主观反馈纳入数字城市模型有哪些价值？

GD: Making digital urbanism truly human-centric means shifting the focus from purely technical optimization of urban functions or adopting technology for its own sake toward addressing the real, diverse needs and experiences of people in the city. It is not just about modeling efficiency in land use, energy or transport, but it is about understanding how people actually live, move, interact, and feel in urban spaces and ensuring this understanding can meaningfully inform our urban models.

真正“以人为本”的数字城市规划，意味着将关注点从单纯追求技术性能，或“为技术而技术”的目的，转向回应城市中使用者真实、多元的需求与体验。这不仅是为了优化

土地、能源或交通规划的效率，更是为了理解人们在城市中如何生活、移动、互动与感受，并确保这些深度理解能够切实影响到我们的城市建模与设计决策。

My research combines advanced data analytics and digital tools such as immersive virtual reality, artificial intelligence, and digital twins with participatory methods to make sure citizens are not reduced to just data points, but become active contributors to the planning process. When we integrate lived experiences, behavioral patterns, and community feedback into our models, we achieve a much richer and more grounded understanding of urban challenges. It helps reveal nuances that purely data-driven or techno-centric approaches often miss. For instance, the big data we use often contain biases or blind spots such as certain population groups are underrepresented, informal uses of spaces are invisible, and emotional and social dimensions are missing, as such we cannot capture why certain spaces feel unsafe, or why social interactions change with time of day, weather, or land use options. When such big data is complemented with subjective experiences of people, we can have deeper insights on the urban challenges and how we can solve these challenges.

我的研究将数据分析建模与数字工具（如沉浸式虚拟现实、人工智能和城市数字孪生）相结合，并采用参与式实验方法，目的是使市民不再仅是孤立的数据供给者，更是规划决策的主动参与者。当我们将市民生活体验、行为感知与社区反馈整合进城市数字模型时，就能获得更丰富、更接地气的针对现存城市问题的洞察。我们使用的海量数据往往存在偏见或盲点，例如某些群体在数据集中缺席，非正式空间的使用难以被捕捉，个体情感与社会互动的维度常被忽略。这些盲点使我们很难理解一些人本导向的城市问题，如为什么一些空间让人感到不安全，社交互动为何随时间、天气或土地利用的变化而改变。只有当大数据与人们的主观体验数据可相互补充时，我们才能对城市问题有更深入的洞察，并探索解决这些挑战的途径。

This approach enables to inform planners and practitioners based on both subjective and objective data so that they can design not just functional cities, but attractive, inclusive and liveable ones. It builds trust and legitimacy by showing citizens that their voices matter and have tangible influences on the outcomes. And ultimately, it leads to solutions that are more adaptable and equitable, because they are rooted in how people actually experience their environments, not just in how urban systems should perform on paper.

这种整合式数字方法为规划者提供了兼具客观与主观的数据支撑，不仅能辅助建设功能完善的城市，更有利于塑造对市民有吸引力、包容、宜居的城市空间。同时，通过让市民的反馈真正影响设计，决策者得以建立信任与正当性。由于扎根于人本的真实体验而非纸面指标，这类规划设计解决方案将更具适应性与公平性。

## Empowering Citizens through Participatory Design 纳入公众的参与式设计

SY: Many cities today aim to make planning more inclusive and participatory. Based on your experience, how can digital platforms support meaningful public involvement in the planning process? What strategies or design methods have you seen that truly empower citizens to influence outcomes, rather than just provide feedback? Are there specific cases where digital participation changed the direction or quality of a project?

许多城市的开发或更新规划中都在追求更加包容、更多融入公众参与。基于您的实践经验，数字规划平台如何支持有实质意义的公众参与？有哪些策略或设计方法能让市民真正影响决策结果，而不仅是提供反馈？是否有案例显示数字化参与改变了项目的方向或质量？

GD: In my experience, digital platforms can play a powerful role in moving participation from symbolic or tokenistic to genuinely empowering if they are designed intentionally as part of a broader participatory process rather than as isolated tools. The key is to go beyond asking for feedback after decisions are made and instead involve citizens throughout the planning process, from problem definition to co-designing solutions, to assessment and evaluation of interventions.

在我看来，数字规划平台只有作为更大范围参与式过程的一部分，而非孤立工具时，才能真正实现由象征性参与向实质赋权的转变。关键在于不要仅仅在决策后再征求反馈，

而是要从发展策划、问题界定、方案共创到干预设计评估的全过程中，持续纳入公众参与。

Platforms that support visualization, scenario-building, and real-time collaboration (such as immersive virtual reality or interactive mapping tools or digital twins), can lower technical barriers and make planning processes more tangible and accessible. When people can see, interact with and modify urban design interventions and also experience the effect of urban interventions on urban life in ways that feel tangible, whether through drawing, storytelling, or walking through virtual environments, they gain a stronger sense of agency. It allows them to express preferences, negotiate trade-offs, and imagine alternatives in a way that static documents, scale models or surveys simply do not allow.

具备可视化、沉浸式情景构建和实时协作功能的数字规划平台（如沉浸式虚拟现实、交互式地图或城市数字孪生平台），能够降低技术门槛，让规划过程更为直观和易于让非专业人员理解。当市民能看见、操作并改动方案，甚至沉浸式体验设计干预对个人生活的影响（无论是通过绘图、故事讲述或在虚拟环境中“漫步”），他们就能更有主体感。主体感能够使个体更自由地表达偏好、讨论权衡并想象替代方案，这是静态图纸、沙盘或问卷难以实现的。

In my work, co-design settings where digital tools are embedded into workshops or iterative urban design loops has proven effective. For example, in recent projects on public space transformation, we used immersive virtual reality with communities to evaluate public space interventions. Residents did not just react, they reshaped the design based on their needs and opinions and could experience the future of the area. Experiencing proposed changes through immersive environments is particularly impactful, allowing participants to sense scale, movement, and atmosphere in a way that 2D plans or reports cannot achieve. This approach ultimately led to changes in urban design interventions that better reflected social dynamics and safety concerns that could have been overlooked.

在我的工作中，将数字规划工具嵌入工作坊或迭代式城市设计循环的共创模式尤为有效。例如，在近期的一个社区公共空间改造项目中，我们让社区居民借助沉浸式虚拟现实来体验方案，居民不仅是在被动回应，而是可以依据自身需求直接修改设计，并实时感受未来场景。沉浸式环境体验的影响力引人注目，能够让参与者亲身体会到空间的规模、相对运动和环境氛围，这是二维图纸或报告无法实现的。通过这种参与式方法，居民提出的安全性与社交需求得到充分体现，推动了后续设计方案的调整。

What makes these methods really empowering is not just the technology, but the participatory co-design process around it: building trust, offering multiple entry points for participation, and ensuring follow-up for participants on design decisions. When digital tools are used to support transparency, negotiation, and shared authorship, they can shift power dynamics in urban planning and lead to outcomes that are more democratic, inclusive, and context-sensitive.

这些方法能够真正赋权公众的核心不在于技术本身，而是在于围绕技术展开的参与式共创过程：建立信任机制、提供多样的公众参与途径，并确保参与者在设计决策过程中的后续跟进，形成闭环。当数字规划工具服务于透明开放、鼓励协商的共创体制时，它才能改变城市规划中的权力动态，让规划决策成果更民主、包容和因地制宜。

## Using Human-Centered Data 人本数据的使用

SY: You've worked with technologies like immersive virtual reality, wearable sensors and GPS. These tools often allow planners to gather fine-grained data about how people experience urban spaces. How do such tools influence the design or planning process? Can you share a project where these technologies helped translate people's behaviors, emotions, or physiological responses into design decisions?

您曾使用沉浸式虚拟现实、可穿戴传感器和GPS等技术工具收集人们与城市空间互动的细微体验。这类工具如何影响规划与设计决策？能否举例说明，它们如何将人们的行为、情绪或生理反应转化为设计决策？

GD: Technologies like sensors embedded in immersive VR (eye-tracking, head-tracking), GPS and wearable sensors allow researchers and planners to access a layer of insight that is often missing in traditional planning: how people actually experience space, so it not just about what they say about spaces, but what their bodies and behaviors reveal. These tools help us “read” human responses in a more nuanced way, capturing emotional, physiological, and behavioral cues that often remain invisible in conventional engagement processes.

植入虚拟现实的传感器（如虚拟现实中的眼动追踪或头部追踪）、GPS与可穿戴设备让研究者和规划者得以捕捉传统方法缺失的一层信息：个体真实的空间体验。经典问卷调查中

可以获得“他们说了什么”的信息，而这类方法则提供了“他们的行为和身体语言透露了什么”的关键信息。通过记录人们的情绪、生理和行为信号，我们能更细腻地“读懂”个体与建成环境互动的直观体验。

For example, in few of our projects, we equipped participants with sensors while they navigated through virtual prototypes of urban public spaces. We were able to collect data like head-tracking, gaze tracking, movement paths and heart rate, which helped us understand moments of stress, excitement, and attraction in the virtual space in real time. Combined with post-experience interviews, this information allowed us to identify spatial features that triggered positive or negative reactions, such as a lack of visibility around corners, behavioral patterns while crossing a street with moving vehicles or the calming effect of greenery and open views.

例如，在一个公共空间设计方案的对比测试中，我们让参与者佩戴传感器，在虚拟环境中行走并采集他们的注视轨迹、头部运动、运动路径及心率等生理数据。结合后续的访谈，我们对以下问题有了更深入的理解：哪些空间环境元素会引发兴趣、愉悦或压力；拐角处缺乏可视性；行人过街的行为模式；绿化和开阔视野对情绪的疗愈效果。

This kind of fine-grained, human-centered data has the potential to inform concrete urban design decisions. Based on these insights, we adjusted spatial layouts, rethought lighting and planting strategies, and added elements that can enable social interaction or a sense of safety. What is important in these projects is that the data was not treated as a standalone metric in isolation, it was always interpreted in context, and often triangulated with qualitative input to avoid overly deterministic interpretations.

这种尺度精细、以人为核心的数据可直接指导设计决策。基于数据分析结果，我们调整了公共空间的布局、照明与绿化种植策略，并增加了促进社交互动或增强安全感的空间设施。有一点需要额外补充，这些数据的分析需要始终结合具体的案例背景信息来解读，并与定性信息交叉验证，避免得出机械化的结论。

Ultimately, these digital technologies and tools can help bridge the gap between technical design and lived experience. They support planners in designing with empathy, by literally seeing the city through the bodies and senses of its users. That is a powerful shift, especially when working with vulnerable groups whose voices are often underrepresented in planning conversations.

这类数字工具能够有助于弥合专业的技术设计与使用者实际体验的差异，让城市规划设计更具同理心，通过市民的身体与感官来观察城市。这是一种极重要的转变，对于在传统规划进程中常被忽略的弱势和少数群体而言，这种转变尤其有意义。

## Urban Digital Twins: Potential and Challenges

### 城市数字孪生的潜力与挑战

SY: Urban digital twins are getting more attention around the world, especially in the context of smart cities. In China, for example, there's been a wave of digital twin projects, but many have ended up as just dashboards. Based on your experience, how are digital twins being developed in Europe and elsewhere? Do you see a gap between academic research and practical applications? And how might digital twins help create more sustainable and human-centered urban futures, despite their current limitations?

城市数字孪生作为智慧城市母题下的热点方向，在全球范围内备受关注。在中国，过往的一些数字孪生项目最终停滞于可视化的城市数据“看板”。您如何看待城市数字孪生在欧洲及其他地区的发展？学术研究与实际应用之间是否存在落差？数字孪生应如何突破当前局限，助力可持续、以人为本的未来城市发展？

GD: Urban digital twins are gaining momentum worldwide, but I agree that many implementations, especially in smart city contexts, still fall short of their potential. In some cases, they become glorified dashboards: rich in data, but static and mainly used for monitoring, also disconnected from actual decision-making or citizen engagement.

城市数字孪生确实正经历着飞速发展，我认同许多的应用案例，尤其是在智慧城市领域，仍未充分发挥其潜力。在某些情况下，这些“数字孪生平台”沦为华而不实的数据看板：虽然展现数据丰富，但缺乏动态性，主要用于监控，且与实际的决策或市民参与脱节。

In Europe, there is a growing emphasis on positioning digital twins as planning support systems rather than passive monitoring tools. European research and pilot projects explore how urban digital twins can be used to

simulate and test policy options, assess multi-sector trade-offs, and integrate community-generated insights. These efforts often link urban digital twins to broader goals such as sustainable development goals including climate resilience and participatory governance. However, in practice, the uptake is still slow and fragmented. Municipalities often lack the capacity, data governance frameworks, or interdisciplinary teams needed to operationalize these systems meaningfully.

在欧洲，我们越来越重视将城市数字孪生定位为规划支持系统，而非被动的监控工具。欧洲的科研与试点项目正在探索如何用城市数字孪生来模拟和测试政策选项、评估多部门之间的利益权衡，并整合来自居民和社区的信息。这些努力通常与更宏大的发展目标挂钩，例如联合国可持续发展目标，包括气候韧性或参与式治理。然而，在落地层面，推进依旧缓慢而碎片化，地方政府往往缺乏数据治理体系或跨学科团队来支撑。

There's definitely a gap between academic potential and real-world applications. Research tends to emphasize integrated, open, and participatory models for urban digital twins, while practice often remains siloed, tech-driven, or vendor-led. One way to bridge that gap is to design urban digital twins as iterative and co-evolving systems of interdisciplinary efforts, ones that can be enriched with citizen-generated data, local knowledge, and behavioral insights over time.

学术研究探讨的潜力与实践落地之间确实存在差距。研究往往更强调城市数字孪生的开放、整合及参与性，但实践中往往仍存在孤岛式、技术驱动或供应商主导的现象。弥合这一差距的路径之一是将城市数字孪生视为跨学科协作的迭代共生系统，该系统应随时间推移持续地纳入来自居民的数据、在地的知识信息，以及个体层面的行为洞察。

In terms of sustainability and human-centricity, digital twins hold real promise. They can help us visualize the long-term impacts of planning decisions, assess trade-offs across domains (e.g., mobility vs. emissions vs. equity), and simulate how people might respond to interventions. However, to do this well, we need to embed social science and co-design perspectives into their development from the start, not as an afterthought. That way, the technology supports shared understanding and collaborative problem-solving rather than reinforcing top-down control.

在可持续性与人本方面，城市数字孪生潜力巨大。它们能够帮助我们可视化规划决策的长期影响，评估不同领域之间的权衡关系（例如交通与碳排放、公平性等），并模拟市民对干预措施的可能反应。然而，要做好这一点，我们需要从一开始就融入社会科学与共创设计视角，而非事后补救。唯有如此，该技术才能有助于在决策者和使用者间建立共识，协作解决问题，而非成为强化自上而下控制的工具。

The key is to stop thinking of urban digital twins as purely technical tools, and start seeing them as collaborative infrastructures, a way to make urban complexity more navigable for both

planners and citizens.

关键在于，不应再将城市数字孪生单纯视为技术工具，而应将其视为支持协作的城市基础设施，一个让城市复杂性对专业规划人员与市民都变得更易理解的平台。

## From Research to Practice: Comparing Global Contexts 从科研到实践：全球经验对比

SY: You've worked with both academic institutions and businesses across Europe. What lessons have you learned about linking research with practice in the field of human-centric digital planning? In China, there is a wealth of data from advanced infrastructure, but individual-level data remains underused, partly due to gaps in regulation and skepticism about its practical value. How does this compare with what you've seen in Europe?

您与欧洲的学术机构还有企业有过广泛合作。在以人为中心的数字规划领域，您在将研究与实践相结合方面有哪些经验教训？在中国，先进的基础设施确实带来了海量丰富的数据，但个体层面的数据尚未得到充分利用，这在一定程度上归因于监管缺失以及对其实际价值的怀疑。这与您在欧洲的观察有何相似或不同？

GD: One key lesson I have learned in bridging research and practice in human-centric digital planning is that technology alone doesn't create long-term impact, and institutional, cultural, and ethical context really matters. In Europe, there is a strong emphasis on privacy, data protection, and democratic governance, which sometimes slows down the adoption of individual-level data and high-tech solutions but also ensures more trust and long-term legitimacy in the process. This creates a fertile ground for participatory approaches and co-design methods, where citizens are treated not just as data sources but as partners in shaping their urban environments.

我深有体会的一点是：单靠技术难以产生长期持续的影响，制度、文化与伦理语境同样关键。在欧洲，隐私保护、数据安全和民主治理备受重视，这虽在某些情况下会延缓个人数

据或高科技方案的采用，却换来整个过程中更高的信任与长期合法性。这种环境为参与式方法和共创设计提供了肥沃的土壤，因为市民不仅被视为数据来源，更是与决策者共同塑造城市环境的合作伙伴。

What I observe in the Chinese context is a very advanced digital infrastructure and a massive volume of data, but with a stronger focus on system-level optimization rather than individual-level empowerment. This reflects not just regulatory gaps but differing assumptions about the citizen's role in decision-making. The result is that rich experiential data remains underused, even when it could enhance relevance and responsiveness.

相比之下，我观察到中国拥有高度先进的数字基础设施与海量数据，但更强调系统级优化，而非个体赋权。这不仅反映了监管缺口，还体现了对公民在决策中角色定位的不同假设。结果是丰富的体验数据未能得到充分利用，尽管这些数据本可以提升决策的相关性和响应能力。

In Europe, there is a growing interest in combining behavioral, emotional, and sensor-based data with spatial modeling, especially in pilot projects and academic research. However, translating research insights into policy still requires the "bridging work". That means aligning evidence with planning priorities, overcoming departmental silos, and building interdisciplinary teams. Businesses and cities that succeed in this space tend to be the ones that are open to experimentation and iteration, and that view digital tools not as fixed solutions, but as part of an ongoing, adaptive planning and governance process.

在欧洲，对于融合行为、情绪和传感器数据与空间建模的关注正不断上升，尤其是在试点项目和学术研究中。然而，将研究成果转化为政策仍需“桥接工作”：对齐规划优先级，打破部门壁垒，并构建跨学科团队。在这一领域取得成功的企业和城市，往往是那些愿意进行实验和迭代的，并将数字工具视为持续演进的治理过程，而非一锤定音的技术产品。

So, while Europe may lag behind in large-scale technical integration compared to places like China, there is a stronger emphasis toward ethical, participatory, and human-centric innovation. The challenge now is to scale these efforts while maintaining transparency and equity, and that is where academia, practice, and policy need to stay in active conversation and collaboration.

因此，尽管欧洲在大型技术整合方面可能落后于中国等地区，但其更注重伦理、参与性和以人为本的创新。当前的挑战在于进一步扩大这些探索，同时保持透明与公平，这需要学术界、实践者与政策制定者的持续对话与协作。

## Advice for the Next Generation 给下一代规划者的建议

SY: When you look five to ten years into the future, what developments in digital urbanism are you most excited about? What should young urban planners and scholars be paying attention to, whether it's emerging technologies, interdisciplinary collaboration, or key challenges they should be aware of?

展望未来五到十年，您对数字城市规划领域的哪些发展最为期待？年轻的城市规划师和规划学者应重点关注哪些方向，无论是新兴技术、跨学科合作，还是潜在挑战？

GD: Looking five to ten years ahead, what excites me most is the shift toward integrating digital innovation with values such as equity, inclusion, and sustainability, not just as buzzwords, but as core drivers of digitally-enabled urban decision-making. We are entering a phase where digital urbanism is no longer just about experimenting with new tech, but about embedding it responsibly into the everyday systems that shape how people live.

我最期待的是数字创新与公平、包容、可持续等价值观的深度融合，这种融合不再只是空洞的口号，而能够成为数字城市决策的核心驱动力。我们正进入一个阶段，数字城市主义不再仅仅是尝试新技术，而是要负责任地将这些技术融入塑造人们生活方式的日常系统中。

One major development I am hopeful about is the maturation of participatory digital tools from immersive co-design platforms to AI-supported citizen engagement processes. These can help planners move beyond consultation to real co-creation, especially when combined with advances in spatial computing, human-centered sensing, and generative design. However, we should be cautious about using these new fast-pace advances in technology and computing. Therefore, I see two priorities for the next generation of urban planners and scholars. First, I would advice them to focus on the social and ethical layers of these tools and technologies. Who is designing them? Who gets to use them? Whose voices can be amplified or silenced with them? These questions will only become more important as digital systems grow more complex and influential in shaping urban life. Secondly, I think interdisciplinary collaboration is key for the challenges we look at with digital human-centric urbanism. No single discipline has all the answers. The most transformative projects emerge when designers, social scientists, engineers, and artists work together, often in non-traditional settings, to rethink what cities can be in a digital age.

我尤其对参与式数字工具的成熟发展充满期待，例如从沉浸式共创平台发展到人工智能辅助的市民参与与流程。这些工具能帮助规划师从单项咨询迈向真正的共创，尤其是结合了空间计算、以人为本的感知技术以及生成式设计等领域的前沿进展时。不过，我们也应谨慎应对快速发展的技术浪潮。对下一代城市规划者和学者，我有两点建议。第一，要关注这些工具与技术的社会与伦理维度。谁在设计它们？谁在使用它们？在这些系统中谁的声音被放大或被压制？随着数字规划系统的复杂性和影响力不断增强，这些问题将变得愈发重要。第二，我认为跨学科合作是破解人本数字城市问题的关键。没有任何单一学科能独立回答这些问题。最具变革性的项目往往来自设计师、社会科学家、工程师与艺术家在非传统环境中的共创。

So my overall advice would be to stay curious, question the assumptions behind the tools and technologies for a more human-centric and inclusive digital urbanism, and don't be afraid to iterate (prototype, fail, and adapt). Digital urbanism is a field still in the making, and there is a real opportunity for young professionals to shape its future, not just as technologists, but as ethical, creative, and human-centered urban thinkers.

因此，我的总体建议是保持好奇心，勇于质疑工具与技术背后的假设，以实现更以人为本和包容性的数字城市主义。不要害怕迭代（包括提出原型、遇到失败、调整适应），通过试错不断探索。数字城市主义是一个仍在发展中的领域，年轻的从业者和学者完全有机会成为其推动者，不仅是作为技术专家，更是兼具伦理意识、创造力与人文关怀的城市思想者。✍

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