Smart Cities and Connected Intelligence

Internet and World Wide Web platforms, big data analytics, software, social media and civic technologies allow for the creation of smart ecosystems in which connected intelligence emerges and disruptive social and eco-innovation flourishes.

This book focuses on three grand challenges that matter for any territory, no matter where it is located: (i) smart growth, a path that more and more cities, regions and countries are adopting having realised the unlimited potential of growth that is based on knowledge, innovation and digital technologies; (ii) safety and security, which is a pre-requisite for quality of life in a world of intense social, natural and technological threats; and (iii) sustainability, use of renewable energy, protection of living ecosystems, addressing climate change and global warming in a period of rapid urbanisation that makes established sustainability models and planning patterns quickly obsolete.

The core argument of the book is that problem-solving and novel solutions to these grand challenges emerge in smart ecosystems through connected intelligence. It is the broadest form of intelligence that combines capabilities from heterogeneous actors (humans, organisations, machines) and propel problem-solving through externalities and resource agglomeration, user engagement and collaboration, awareness and behaviour change. This book will be of interest to students and researchers of urban and regional studies, innovation studies, economic geography and urban planning, as well as urban policy makers.

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(John of Salisbury, Metalogicon, 1159)


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Introduction

This book is about the smart everything paradigm, intelligent cities and smart ecosystems, and how they can contribute to solving challenges of growth, sustainability and safety and security, which are major challenges for the 21st century. We explore paths of discovery and problem-solving based on digital platforms, cyber-physical spaces and smart ecosystems, which are becoming indispensable components of all contemporary cities and regions.

The book is also about connected intelligence, an unparalleled power of contemporary problem-solving that is emerging and taking form over platforms and smart ecosystems. The main argument of the book is that novel solutions to grand challenges of the 21st century rely on connecting physically and digitally heterogeneous entities: (a) human intelligence, unrelated areas of science and technology, and methods from different disciplines; (b) artificial intelligence, mining large datasets, supervised learning and analytics; and (c) collective intelligence, knowledge and resources distributed in communities, organisations, and places. This connectivity becomes feasible thanks to digital platforms and smart ecosystems. Consequently, problem-solving and innovation depend on digital technologies and spaces that mediate and facilitate interconnections between humans, machines, and communities, such as the Internet and world-wide-web technologies, sensors and IoT, artificial intelligence networks, data analytics, social media and civic technologies, smart environments and smart cities. All these networked environments enable people to connect, collaborate and share knowledge and resources over digital networks and cyber-physical spaces.

Origin

Smart Cities and Connected Intelligence is based on the ideas presented in the trilogy on *intelligent cities*, which was published between 2002 and 2014. In the first book of that trilogy (Komninos, 2002), the genesis of intelligent cities was credited to the evolution of systems of innovation and the creation of cyber-physical systems that link global Internet-based information networks with local and regional innovation networks. The second book (Komninos, 2008) focused on the structure of intelligent cities, their building blocks, the platforms that provide advanced knowledge functions, and the architectures of

city intelligence. The third book (Komninos, 2014) moved from structure to strategy, discussed the components and roadmap of smart city strategies, top-down and bottom-up strategies deployed by city authorities, as well as strategies for creating smart clusters and districts, smart environments for company growth, and smart city infrastructures every city should have.

There is a connecting line across the three books, related to modes and stages of intelligent city making and operation. Everything started with cities entering the knowledge era and the spatial agglomeration of knowledge-intensive industries, research institutions, technology driven start-ups, and risk capital funding. During the 1990s, technological innovations in networks and computing allowed the creation of a digital space over the physical and social space of cities. The cyber-physical system of innovation formed, amplified existing innovation systems with digital networking, online collaboration, large datasets and analytics, and capabilities from crowdsourcing and user engagement. Within these advanced systems of innovation, connectivity between humans, organisations and digital agents gave birth to new capabilities of problem-solving, due to empowerment, better decision-making, real-time awareness and user behaviour optimisation.

The present book, *Smart Cities and Connected Intelligence*, continues this line of thinking to address challenges of growth, safety and security, and sustainability. We argue that connected intelligence, which emerges in connected environments, smart cities and smart ecosystems, augments the capabilities of humans and organisations to deal with complex and wicked problems. It is not the digital technology per se that makes the difference, but the use of technology to connect humans, organisations, objects, machines, data and know-how. The heterogeneous systems created are the sources of augmented capabilities. Connectivity and network structures, mediated by technology, are the game changers thanks to network effects, digital collaboration and online agglomeration. In this regard, different types of digital spaces that support connectivity and smart ecosystems have a pre-eminent role in bringing together and integrating those heterogeneous elements that enable connected intelligence to work.

Challenges

We focus on three major challenges of the 21st century that are universal and matter for any territory, no matter where it is located: (a) smart growth, a path that more and more regions and countries are following having realised the unlimited potential for growth that is based on knowledge, innovation and digital technologies; (b) safety and security, which is a pre-requisite for quality of life in a world of intense social, natural and technological threats; and (c) sustainability, use of renewable energy, protection of living ecosystems, addressing climate change and global warming, in an era of hyper urbanisation that makes the established models of environmental sustainability and spatial planning obsolete.

Growth, sustainability, and security and safety, which are the major challenges of this period, have the features and complexities of wicked problems with no definitive formulation but continuous transformation of the problem: no idealised end-state to arrive at; no template to follow; more than one explanation; interconnected and chaotic processes; no simple mitigation strategy; uniqueness of each case; no definitive solution but instead a need for continuous problem-solving effort (Rittel and Webber, 1973). Most importantly, the usual problem-solving approaches and market-led innovation are not sufficient to address these complex and global challenges. New forms of innovation, such as eco-innovation and social innovation, user-driven and data-driven innovation, data-intensive discovery (Tansley and Tolle, 2009) are complementing mainstream innovation based on technology, traded exchanges and the protection of intellectual property.

The above challenges related to growth, sustainability, and safety and security, are universal. They concern both all cities in developed and developing countries and all ecosystems and vertical markets into cities (Table I.1). They are permanent over time. What changes is the way they appear in each period and the drivers behind their occurrence. Considering cities and regions as agglomerations of ecosystems, life within each ecosystem depends on its capacity for growth and renewal, sustainability over time, and the safety and security of agents that operate in the ecosystem. From an engineering and planning perspective, which focuses on problems and solutions, these are priorities we

Table I.1 One city, a hundred ecosystems, three common challenges

A hundred city ecosystems	Ecosystems defined city by activities	• Manufacturing sectors • Construction • Finance • Service sectors • Trade and wholesale • Education • Health • Social care	***Common challenges -growth sustainability -safety and security***
	Ecosystems defined city by districts	• Central Business District • Shopping malls • Housing districts • University campus • Technology districts • Port areas • Recreation areas • Open and public spaces	
	Ecosystems defined city by networks	• Transportation • Energy provision • Water provision • Waste management • Telecom	

should address by understanding their causes and by developing theories, methods and tools that allow good solutions to be developed.

Our argument throughout the book is that these major and varied challenges can be addressed by a common solution, which is based on digital and cyber-physical platforms that create smart ecosystems, release connected intelligence into the networked environments and ecosystems, and offer externalities, user engagement, and awareness.

Smart ecosystems and connected intelligence

The 21st century is also an era of connectivity enabled by the Internet, of sharing resources over collaborative platforms, of collecting data and using artificial intelligence to reveal insights hidden in data, and of automating almost everything. Streitz (2017) vigorously described the explosion resulting from connectivity: the Internet of Everything (IoE), a term coined by Cisco for people, processes, data and things connected into an overall network that includes machine-to-machine communication (M2M), machine-to-people (M2P) and people-to-people (P2P) interactions; hubs connecting many urban objects, in the form of public spaces, streets, parking lots, marketplaces, shopping malls; commuting spaces working as 'transient spaces'; smart cities and ecosystems; self-aware cities that know themselves and communicate this knowledge to citizens; hybrid cities that combine real and virtual worlds through augmented reality solutions which generate overlays and multiple representations of the environment; and cooperative cities supported by computer-enabled cooperative work.

All these networked environments of intense connectivity between humans, objects, infrastructures and communities are parts of the smart everything paradigm, in which "smart devices and underlying algorithms are controlling processes, services and devices as well as the interaction between devices and humans" (Streitz, 2017, p. 9). However, feasibility problems related to the tendency to remove human operators from the control of automated systems, the uncontrolled behaviour in some cases of fully automated systems, and the limited transparency of the algorithmic logic guiding AI and deep learning are warning signs and point to the need to design alternative paths in the development of the 'smart everything', which can be *summarised as "keeping the human in the loop"* (Streitz, 2017, p. 10).

This alternative path underscores the central position taken in this book: connectivity and integration of different types of intelligence – human, collective, organisational, AI – offer capabilities and ways for addressing the grand challenges of the 21st century. Connectivity and collaboration platforms may counterbalance the tendency of smart systems to automate everything with algorithms and event management software, putting humans outside of problem-solving heuristics.

Throughout the book, we discuss cyber-physical environments that enable people, organisations and machines to connect, work together and resolve

complex problems. These environments appear in multiple forms, as digital crowdsourcing platforms gathering resources from people and organisations; as clusters of organisations connected by digital networks; as IoT solutions having both physical and digital elements; and as augmented reality hybrid spaces, among others.

We use the term 'smart ecosystems' to refer to all these cyber-physical spaces, networks and communities. Reflecting cities that are composed of ecosystems, smart cities are composed of smart ecosystems. An ecosystem is a community of actors and organisations that interact with each other and their environment. A smart ecosystem is a community of actors and organisations in which physical and institutional interactions are coupled with digital interactions based on software platforms, digital infrastructure, networking technologies (IoT, Blockchain, Web 2.0, Cloud Computing, etc.) and other forms of smart environments. There is no need for physical linkages or locational proximity to set up a smart ecosystem; persons, organisations and objects can connect everywhere, regardless of physical and spatial restrictions, via digital communication and connectivity.

Under the smart everything paradigm, the logical path from challenges to cyber-physical spaces, smart ecosystems, connected intelligence, new forms of innovation and problem-solving is presented in Figure I.1. Connectivity, web platforms and IoT solutions allow smart ecosystems to be formed, in which users can share resources, become motivated about common initiatives, increase their awareness and adopt more efficient behaviours. Connectivity platforms are the foundation of smart ecosystems, and connected intelligence, within these ecosystems, is both an outcome and driver behind new forms of innovation and problem-solving, such as disruptive innovations for growth, social innovations for safety and security, and eco-innovations for sustainable places.

Connected intelligence (CI), which appears in smart ecosystems, is the path and solution we propose to the major contemporary challenges of growth, sustainability, and safety and security. Connected intelligence is the wider type of intelligence produced by the integration of human, collective and artificial intelligence (following Yolles, 2005, organisational intelligence is an extension of collective intelligence). As shown in Table I.2, CI is based on a combinatory logic and emerges mainly in communities. Three out of four manifestations of CI presuppose the existence of a community of actors or an organisation as an entity representing a group of actors. The Internet, web platforms and smart ecosystems connect the different types of intelligence, and their heterogeneous entities, allowing them to work together in common processes. Throughout the book, we argue that connected intelligence is released via the processes of association, externality, engagement and awareness.

An example of connected intelligence is when you use Google Translate to get a draft translation and then you edit the text to improve syntax and meaning. In this case, connected intelligence comes from connecting human and machine intelligence. Lance Ng recently wrote a short story on Medium

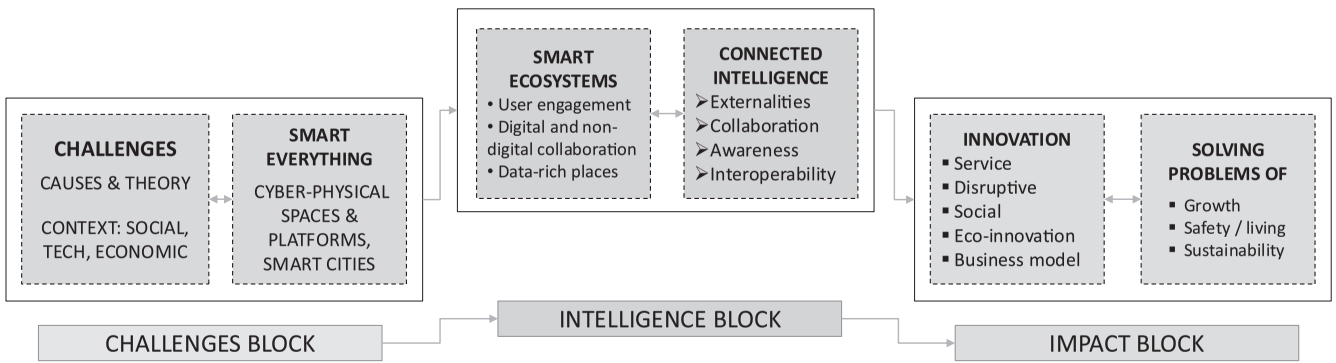

Figure I.1 Cyber-physical spaces, connected intelligence and problem-solving

Table I.2 Connected intelligence

Fundamental types of intelligence	*Connected intelligence as combination of fundamental types of intelligence*
• Human intelligence • Collective intelligence based on groups of agents, humans or 'bots' • Artificial or machine intelligence	• Human intelligence + collective intelligence • Human intelligence + machine intelligence • Collective intelligence + machine intelligence • Human intelligence + collective intelligence + machine intelligence

about hidden human work behind AI, which tech companies do not disclose. Under the title "Just how much of AI is really artificial? And how much is actually human work?" he refers to humans improving AI in companies such as iFlytek and Appen; even Google search is "aided and corrected by over one million human beings" (https://goo.gl/ViBtjp). Also, James Manyika wrote about autonomous vehicle companies hiring hundreds of people to manually annotate hours of video from prototype vehicles to do training of autonomous vehicle algorithms (Ford, 2018). Deep learning algorithms largely rely on labelled data, huge amounts of such data are needed, which means that humans must label the necessary data and provide this input before the machine is able to perform intelligent operations, such as object classification, prediction or natural language processing.

We can assume that a variety of connected intelligences will appear, based on combinations of human and specialised machine intelligence, some having more human features relying on human cognition and some having more machine-type features. If you add collective intelligence to this combination of humans and machines, with its rule-based thinking and use of the extensive resources of organisations and public institutions, you get the full picture of connected intelligence. It is a broad intelligence, integrating the capabilities of human and non-human actors. It is the intelligence we commonly use to deal with real-life challenges and problems.

Structure of the book

Connected intelligence with its concepts, methods, networks of actors, digital technologies and smart environments appears to be a promising path for addressing wicked problems and the grand challenges of today. The book offers a way of thinking along this path rather than off-the-shelf solutions. It focuses on and advances the idea of deploying smart ecosystems for sharing resources,

engaging users and increasing awareness, in which we engineer new solutions and find means for implementation.

Part I is about *the grand challenges of the 21st century and the smart everything/smart city paradigm*. We look into the nexus of smart growth propelled by knowledge, innovation and digital agendas; the nexus of sustainability, including the preservation of natural habitats and ecosystems, sustainable use of land, pollution, air quality, reduction of CO_2 emissions, energy saving and renewable energy; and the safety and security nexus with challenges emerging from man-made or natural threats, such as crime and vandalism, natural catastrophes, urban accidents and other emergencies. We discuss how intelligent/smart cities work as environments of innovation over cyber-physical spaces, producing innovation and problem-solving capabilities through digital collaboration and connected intelligence.

Part II is about *platforms, smart ecosystems and connected intelligence*. Here we go deeper into the microcosmos of the smart everything/smart city paradigm and discuss how smart ecosystems trigger connected intelligence. We outline three forces that contribute to capacity building: (a) connected intelligence emerging in digital platforms and smart ecosystems, (b) innovation circuits operating in smart cities, and (c) knowledge processes and functions generated by digital applications and smart environments. Then, in the next three parts of the book, we discuss how these forces work together and activate different forms of innovation to enhance growth, safety and security, and environmental sustainability.

Part III is about *externality platforms, disruptive innovation and smart growth*. We focus on the interface between innovation systems and digital systems and examine how innovation and digital strategies converge to sustain smart growth. We present various types of platforms that create externalities, enable disruptive innovations and open up growth opportunities.

Part IV is about *engagement platforms*, *social innovation, safety and security*. We examine the components of social innovation and experiments in social innovation via digital means. We discuss the linkages between software applications, user engagement, and social innovation. Then, we focus on safety and security, a rising challenge for cities and regions, and discuss digital and cyber-physical spaces for safety and security applied to the external and public environment of cities. We outline drivers for user engagement and collaboration based on social innovation that can resolve problems of safety and security in smart city ecosystems.

Part V is about *awareness platforms, eco-innovation and sustainability*. We outline sustainability challenges related to greenhouse gas emissions and climate change, pollution of natural ecosystems, waste and water management in cities, and discuss the changing logic of sustainability under the smart everything/smart city paradigm.

The last chapter identifies connections and interoperability between knowledge processes taking place over externality, engagement and awareness platforms: how the three types of platforms are converging into a more generic

architecture. Based on platform interoperability, we outline a model of smart ecosystems and connected intelligence that combines resources and capabilities from heterogeneous actors (humans, organisations, machines) and propels problem-solving through agglomeration of resources, motivation for engagement and collaboration, awareness and behaviour change.

A few parts of the book have been published previously. An early version of Chapter 2 was published in Komninos (2016a); the survey referred to in Chapter 3 was published in Komninos et al. (2015); and a previous version of Chapter 5 was published in Komninos (2016b). All have been revised and adapted to the logic and content of the present book.

Notes

1 www.cityzen-smartcity.eu/the-european-project-city-zen-under-the-microscope/
2 www.cityzen-smartcity.eu/home/about-city-zen/objectives/
3 www.greenspread.nl/diensten/smart/city-zen
4 https://amsterdamsmartcity.com/city-zen

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