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The future of urban models in the Big Data and AI era: a bibliometric analysis

Sudhir Allam, *Sr. Data Scientist, Department of Information Technology, USA*

Abstract— *This paper aims to conduct a bibliometric analysis on the future of urban models in the Big Data and AI era. A city is perceived to be a dynamic structure. It is made up of many interconnected subsystems that are influenced by a variety of factors such as government land policies, demographic development, transportation networks, and market behavior. In the long run, land use and transportation networks are known as the two most critical subsystems defining urban structure and shape. Meanwhile, one of the most relevant subjects in urban modeling is urban growth, and the key driving factors are demographic growth and infrastructure progress. Modeling and simulation are thought to be useful instruments for investigating the processes of urban evolution and providing planning assistance in growth management [1]. The rise of urban big data is reshaping current science concepts in urban studies. In China, the use of big data in urban studies and development activities exploded in 2014. Big data has the benefit of disclosing features instead of a description, which is compatible with the principle of urbanization and urban-rural planning. To address the methodological problems, new hypotheses and analytical methods are needed. This essay explores the impact of the Big Data and AI transition in urban management on the complexities of urban science [1]. It concentrates on two fields of urban science: one on academic research on big data and the other on artificial intelligence. First, we monitor the development of AI and Big Data parameters in these fields. The second is to study the development of the proportion of publications concerning urban big data and AI in various urban studies applications. The paper will depend on the information from literature reviews to conduct this bibliometric research. The thesis's ultimate aim is to explore how urban modeling could be utilized in the future in the age of Big Data and AI.*

Keywords: *Urban modeling, Big Data, Bibliometrics, Urban planning, urban growth, Research dynamics*

I. RESEARCH PROBLEM

The problem that this research will try to solve is how urban modeling will look like as the era of big data and artificial intelligence continue to grow. Many challenges will be solved by understanding its significance

considering that the population of urban areas continues to grow all over the world. Proper planning is needed to accommodate the people while also preventing disasters from congested urban areas**.** With vast volumes of data gathered from modern sources like computers, sensors, and satellites, urban cities around the world now can track and maintain their urban infrastructure in real-time. Urbanization is this century's biggest threat and potential [2]. Urban scientists have been lacking the requisite resources and technology to completely leverage urban data for study purposes. As a result, there is an intense need to consider the various facets of communities and urbanism, while still developing cutting-edge hypotheses, methodologies, data archives, data mining, and improved technology to cope with the complexities of the modern urban era [3]. The last few decades have seen exponential population and urbanization development, with the consequence that, for the first time in human history, cities now house more than half of the population of the world. In recent decades, ICTs (information and networking technologies) have also been unprecedentedly developing, computer science with its based on big data mining techniques, and AI (artificial intelligence). This can change the dynamics and function of communities, as well as the experiences of those who work in them.

II. INTRODUCTION

Human civilization has experienced significant demographic shifts from rural to urban areas over the last 200 years, especially in the last few decades. The increase in megacities and the unparalleled scale of the major towns are two consequences of this accelerated urbanization. There were just two megacities in the world in 1970which were inhabited by more than 10 million people. There are currently 23 megacities, with the figure expected to rise to 37 by 2025 [4]. The bulk of modern megacities have appeared or would emerge in Asia. This leads to a strong pattern of accelerated urbanization in developed countries. In every urban system, population increase is one of the most powerful motivating factors of transition. As the metropolitan population increases, the area would either extend inward or outward. A multi-faceted framework can incorporate data from multiple sources to forecast and assess the effect of urban activity on critical ecosystem features. This multilayered method is well adapted for preparation purposes [4,5].

Almost all market and company data has seen exponential growth in recent years has resulted in the accelerated emergence of "Internet plus" [3]. Big data is a common phrase in the industry and science communities, relating to large amounts of digital data obtained by multiple sources. Historic architectural frameworks for urban management are focused on evidence and clusters of experts that are often quite remote, and their execution is centered on interactions with private actors and utility companies [15. Public transport and water are two metropolitan processes that seem to be evolving independently and that mobilize somewhat different data and information. Without a question, big data is now a popular subject of environmental studies and development activities. However, this increase in large data not only embodies the conventional increase in mathematics outcomes but also incorporates develop useful elements that include the growth and outgrowth of academia, creation of self-organized research centers, and convergence of academic-industrial media. In particular, the growth of academic groups is part of stronger collaboration between geography, urban development, and the knowledge science, and of a more regular connection between conventional institutes of study and IT firms. This paper explores the literature on the prospects of urban modeling in the age of big data and artificial intelligence. It will also highlight the future of urban modeling in the big data and AI era, its future in the U.S, and its economic benefits to the United States.

III. LITERATURE REVIEW

A. Urban modeling

In general, urban big data growth has opened up numerous urban research opportunities. Urban Informatics is described as the study and analysis of urban patterns and systems, including the examination, simulation, perception, and description of organized and unstructured urban wide data [6]. In theory, the study of urban environments is enabled by a multitude of fiscal, political, developmental, technological concepts that permit the simulation of complex relationships, flows, interactions, commerce, delivery as well as other experiences and interactions and trends [6]. Whereas certain urban models seek to enhance long-term planning and policy assessment, others help to develop an analytical perception of urban dynamism and validation of conceptual planning principles and contribute to short-term projects and urban sector development. Big Data, on the other side, has been strongly correlated with data-driven modeling and simulation, which is generally an observational methodology lacking the societal, cognitive, fiscal, and regional development framework that frames urban analysis [7]. Data-driven modeling incorporates innovative new computational methods, especially through the use of some of the more unstructured and chunky forms of Big Data, as well as a bottom-up methodology to analyzing urban spaces, which is especially useful for enhancing complex resource management.

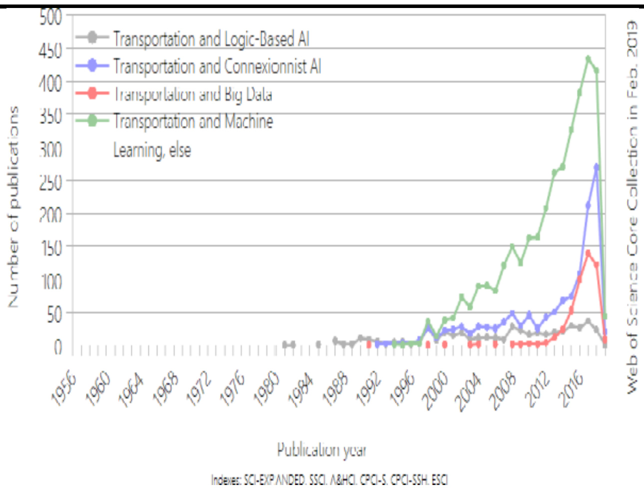

Fig i: Growth of Big Data, AI in various urban models

B. Different Types of Urban Big Data

1. Sensor Networks:

Public infrastructure sensors (infrastructure, environmental, power, garbage, climate networks, institutional health surveillance systems, water protection, structures, etc.) generate massive volumes of data on smart cities. This data may be used to generate new market and consumption trends [8]. The sensors track movement and shifts in a broad spectrum of urban phenomena that affect the community. These include the physical dimensions of urban environments, transportation, and operation. Sensor information can be utilized by urban scientists to research extensive network, infrastructural, and innovative programs, as well as their impacts on cities and populations if it is connected to other datasets and stored over extended periods. The evolving smart cities group is becoming more active in industrial sensors, especially their deployment and performance optimization using smart devices. Most urban sensor networks are expected to be remotely wired, handheld, and even more, integrated and evenly distributed in the future [9]. Examples from a broad variety of operating and proposed applications involve cooperative or wired cars, car- to-grid networks, smart grid systems, and a spectrum of indoor and outdoor assistance systems for elderly and disabled persons. The dynamic area of remote sensing has also seen rapid advancements, with vast quantities of spatial and temporal data being gathered faster than it has ever been with sensors installed on rockets, ships, and, most recently, drones.

2. User-Generated Content:

In the past decade, there have been significant shifts in the ways users are interested in co-creating material, and more have been published regarding User-Generated Content (UGC) [9]. People range between passive participants in the survey and study studies to active knowledge producers with the use of sensing devices or social networking sites, and other data produced from their participating in the community, socioeconomic or civic acts. Publics methods may be classified as contributing, collective, or co-creating. UGC can be developed promptly by producing suggestions, input, and problem-solving. Information and communications technologies (ICT) innovations have broadened the variety and diversity of forms by which the public contributes to community planning and architecture sourcing, votes and shares suggestions about infrastructure improvements, and provides feedback on policies and strategies that could impact city life. This varies from targeted focus groups, through which users contribute to "hackathons," where people who have a passion for ICT and the cities come together and find answers to public issues using data [9]. Citizens often fix problems; for instance, using population calculation to measure living conditions or quality in cities where quantitative sensor and computer measurements are not correct. These tasks provide vast amounts of organized and unstructured data which can be studied to provide insights into preferences, habits, etc.

3. Administrative data

Information sharing programs have also been supported by national and municipal governments around the globe. This has contributed to the expansion of accessible data databases through which state governments submit administrative data compiled or modified by the removal of personal data, which is license-free and non-proprietary [10]. While they provide many benefits, open data projects pose obstacles for a range of purposes, including a closed government atmosphere in some localities, regulations on confidentiality, quality management constraints that prevent publishing, and limits on usability. For urban social scientists who work in public policy studies, private organizational micro-data is of major benefit.

C. The application of artificial intelligence in smart cities

It's incredible what technologies can accomplish these days! Satellites relay day-to-day photographs from nearly anywhere on earth and computers can process large volumes of data produced thereof to provide insightful and interesting information. This is but one illustration of artificial intelligence in reality (AI). AI can do more than only read pictures from space; it will even help people live happier lives. Artificial intelligence and machine learning are constantly widely utilized in urban modeling to provide almost real-time analyses of how communities develop in reality, such as with the utilization of natural spaces into built-up structures [10]. Constantly developing streams of satellite data (commercial and public), along with data mining algorithms, may be used to easily show how real community growth aligns with design and zoning, or growing neighborhoods are more vulnerable to floods, by training machines what to search for in satellite photographs. This encompasses a wide array of satellite simulations and time-lapse visual analytics which can now be produced quickly for any field of interest.

Since aerial photography is not necessarily an optimal option for all purposes of "free" satellite (imagery released by government agencies and other public authorities), satellite images have shown the overall effectiveness of data mining techniques to evaluate aerial imagery and highlight several of the critical variables for successfully implementing AIs [10]. The method was created to serve as a jumping-off point for additional case studies, particularly those involving industrial high-resolution photography. "Free" satellite images are accessible all over the world which are used to map parts of the globe, although the trade-off is that it has a poor temporal resolution, which is insufficient for certain purposes that need a lot more precision.

D. Urban modeling's challenges

1. Challenges in Technology

The requirement to produce, collect, handle, store, disseminate, and explore urban knowledge creates technological challenges. The difficulties in dealing with vast amounts of organized and unstructured data have been well documented already. The complexities in knowledge management include building computer storage, cloud services, and multi-cloud systems, and resource exploration frameworks, and also communication and output contexts [11,12]. Additional factors involve hardware, software, well-defined APIs required for recording, integrating, arranging, searching and querying, and analyzing the data. Scalability, errors, and performance, as well as frameworks for flexible implementation, are all equally essential. Numerous Big Data applications, including Hadoop, MapReduce, and many others, have appeared in the industry, including some that are highly customizable. Amongst the most difficult aspects of utilizing Big Data in Urban modeling is that the dataset may not even have to be massive. It's more likely that urban Big Data is scattered, chaotic, and often unstructured [12]. Whenever it comes to data integration, specifically when moving outside structured, hierarchical database management systems to receiving input from APIs that lead to text, picture, and other unstructured data forms, heterogeneity and fragmentation may be a major issue.

2. Problems with Methodology

Sensor and co-created data need specific techniques for analysis and processing to handle very large quantities of unstructured data where the knowledge can be collected and extracted. The basic facets of the process from data gathering to interpretation are specifically defined by experts from diverse backgrounds by using conventional sources of urban data. In comparison to this paradigm, in the context of some types of unstructured data, data analytics (– for example, utilizing artificial intelligence for subject identification and classification models) occurs concurrently with, or as a result of, knowledge extraction or “collecting” of knowledge from the existing data sources. As a result, the "data collection" and "analytics" elements of the process are far more closely connected, necessitating the acquisition of new expertise by urban researchers seeking to utilize certain data or near cooperation with data analysts who possess these skills. To conclude from empirical Big Data, many methodological problems must be addressed. For example, administrative data could pose problems attributable to cause and effect, omitted variables, and other problems that can imply bias [14]. Technologically produced evidence from sensors and open data is likely to be non-representative since providers are unlikely to be statistical models.

3. Challenges to Theoretical and Epistemological Knowledge

The theoretical and epistemological problems concern the capacity for observations and hypothesis formation regarding urban structure and dynamics, and also the relevance of the methods used or the limitations to information exploration about urban structures supported by evidence. Big Data for Urban modeling has two distinct origins: systematic urban analysis and empirical analysis. While the boundaries between these are referred to as "urban simulations" remain sensitive, these are usually theoretical, simulation-based, or computational methods that are drawn from a variety of methodological frameworks (e.g., queuing theory, multi-agent processes) and require strong practices of calibrating with expert evidence [15]. These models, which are based on theoretical concepts, aid in the interpretation of urban structure, modeling of urban infrastructure, modeling of potential expenditure possibilities, methods for community interaction, and assessment of planning and management, as well as detailed data of transportation, industrial, and other processes [16]. Big Data is also being used in a variety of ways in these models.

IV. ITS FUTURE IN THE U.S

Since the United States is an environment where communities are constantly developing, it makes use of big data and artificial intelligence to make the best of the metropolitan environments. When it comes to the future of urban modeling, the development of small, autonomous robots that can "listen in" and deliver feedback and solutions when required could become the next step in this ever-changing technology world. While several individual IoT systems and technologies are functional, the idea of the "Internet of Things" (IoT) credited to Ashton (1999) is still largely a vision at this point, while some imagine a future of Machine-to-Machine (M2M) interactions, where "billions to trillions of daily artifacts and the natural ecosystem are linked and controlled by M2M communications [17]. Without a doubt, the amount and range of data sources accessible for studying urban areas would skyrocket.

V. ECONOMY BENEFITS

Urban modeling for the U.S economy will bring positive impacts in planning for economic hubs. Well-planned cities attract more investors in the country which is good for economic gains. Every city has a unique style to say. The spatial shape of a metropolitan region, in particular, is essential to understanding its economic growth. Compact towns are almost as productive as larger cities, and compactness tends to be purely a consumer benefit. Cities are finding that reforming land management planning and redirecting real estate growth pays off in terms of making their cities more compact and less reliant on personal vehicles [18]. California and Oregon have taken the lead by adopting state law that encourages communities to follow suit. This is not, though, a phenomenon confined to the "left coast." Cities throughout the United States are realizing the need for more environmentally responsible urban development. Cities such as Atlanta, Dallas, Salt Lake City, Houston, and Oklahoma City have realized that reducing overpopulation and slowing the rise of personal automobile use leads to improved quality of living and economic prosperity. The support for change and creative technology to planning and construction has only grown after the federal government proposed $140 million in new funding for urban planning last fall. And besides, American cities also have a great history to go in mitigating the consequences of sixty years of sprawling suburbs and the ever-increasing number of vehicles and automobile miles traveled per capita. Cities are increasingly convinced that transit-oriented construction is a win-win situation, and that accommodation adjacent to work retains its worth even better than suburban housing in surrounding towns [18]. Also, in most residential communities, where big lots and long drives are the norms, mixed-use town centers are proving to be profitable. One of the brightest points of the American economy right now is the development of light rail networks and real estate growth along new paths. Texas is notorious for its pick-up vehicles and vast open fields, but it has recently found that mass transportation is cost-effective.

VI. CONCLUSION

This paper looked at urban modeling in the age of big data and artificial intelligence, as well as the primary motivators of urban big data, their advantages and drawbacks, and how they are influencing urban data science. The era of Big Data and artificial intelligence in urban modeling is not a discrete step of technology, but rather a continual method of searching out new sources of data to resolve problems resulting from high prices, architecture, or organizational constraints. While big data is mostly used very narrowly to cover data produced by sensors several other ways are relevant to various categories of urban modeling, and they involve administration data as well as other data sources to explore such fields. But it is much more critical to combine data that have evolved in a fragmented manner in various fields (through data linking or otherwise) with a systematic comprehensive urban development.

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