

Science Mapping of Interdisciplinary Domains: a Geographical Approach for Smart City Research

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Extended Abstract

Introduction

The widespread, networked and ubiquitous use of information and communication technologies (ICTs) in city management (transportation, energy, pollution, education and so on) paved the way for research about the ‘smart city’. Scientific discussion about smart cities is fairly new, interdisciplinary and has become more intensive in recent years (Rozario et al (2021)).

While there is a strong technological component of the research on smart cities, clearly there are social and socio-economic constituents (such as smart living (Kumar (2020)), smart governance (Pereira et al. (2018)), smart businesses (Kraus et al. (2015)) or sustainability-oriented components (such as smart environment (Liu and Zhang (2021)), smart energy management (Maier (2016)) of the ongoing discussion. The field is truly interdisciplinary, indicated by the high number of attempted definitions (Zubizarreta et al. (2016)).

In developed economies the vast majority of the population lives in urban areas (Kundu and Pandey (2020)) and there is a concentration of the creative class in urban and metropolitan areas (Florida (2014)). The creative class (including scientists, researchers-developers, engineers, legal experts, designers, ergonomists etc.) need to be increasingly involved in the development of smart cities. As such, concentration and the scientific networks of the broadly interpreted ‘smart city professionals’ is an interesting field of research enquiry.

Objectives

The overarching research objective is increasing our understanding about the smart city concepts, the knowledge domains comprising it and the scientific networks of the knowledge domains involved. More specifically, the following research questions guide our work:

- Has the smart city field been integrating and framing its own disciplinary boundaries and reach towards other fields? What are the (sub)disciplinary fragments?
- Which cities and urban regions are home to smart city professionals?

- How has the scientific collaboration between smart city professionals evolved? How can the quality of the connections and the social and cognitive relationships between them be described?
- How can the scientific collaborations be described in geographical space and across cities?
- Is it possible to identify certain patterns and gaps in the knowledge domains comprising the smart city concept and the above geographical patterns?

Data and Methods

The Web of Science (WoS) is a widely used and renowned database for academic journal articles. Using WoS, first, a search for relevant ‘smart city’ articles was implemented and the related metadata were downloaded. Then three distinct lines of research (based on author-defined keywords, bibliographic coupling, scientific network analysis via cities) support finding the answers to our questions (Figure 1).

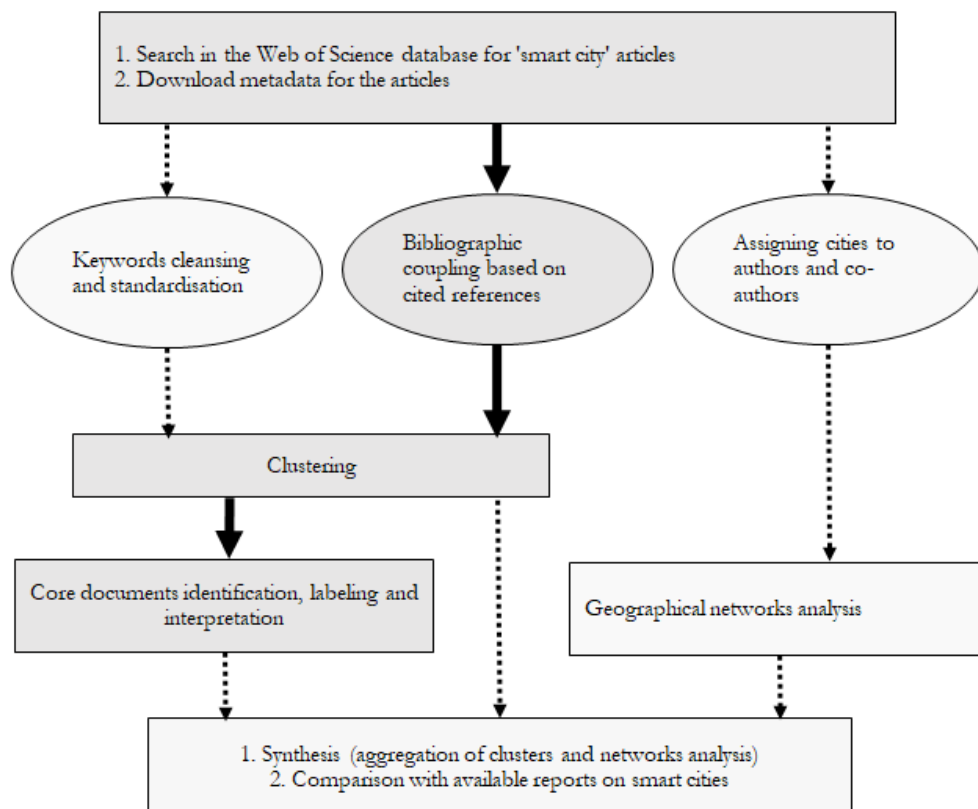


Figure 1 Research workflow. The arrows marked as dotted indicate work in progress.

The core-document-based clustering is implemented using keywords-based and bibliographic coupling based approaches (bibliographic coupling occurs when two articles refer to a common third article, see e.g. [Jarneving \(2007\)](#)). In the first step of the clustering procedure the similarity

matrix of the document set was created, based on shared keywords and shared references. We used cosine similarity as similarity measure. The similarity matrix was transformed into a proximity network of papers (with edge weights representing the degree of proximity). The clustering was undertaken with the help of community detection procedure within the network (Louvain method). This way the optimal community structure with a maximal modularity could be achieved by grouping the nodes (papers) in the network, based on their weighted connections.

New knowledge is created more and more in research groups instead of single authors ([Ziman \(1994\)](#), [Mali et al. \(2012\)](#)). Scientific network analysis is based on the network defined by cities of the collaborating researchers' affiliation ([Csomós et al. \(2020\)](#)). Then we analysed geographical patterns of smart city professionals at the city level. By analysing the 'geographical' network of cities, it is possible to identify strong and stable 'city ties' among smart city researches. The relationship between scientific research topics (via core documents) and the network of city ties is also studied.

Preliminary Results, Conclusion and Future Plans

At this stage of the research in progress, results of analysing the WoS dataset are presented, including descriptive statistics of smart city research evolution over time. It has to be noted that the metadata always contain articles, which are not relevant. This is natural in this kind of extensive analysis and the upcoming research steps will ensure increasing also the reliability of the input data.

The number of published smart city related scientific articles have risen exponentially and culminated at above 2000 articles per year since the first records in the WoS database in 1999. The number of journals followed this trend, whereas the number of smart city articles per journal stabilized between 3 and 4 (Figure 2).

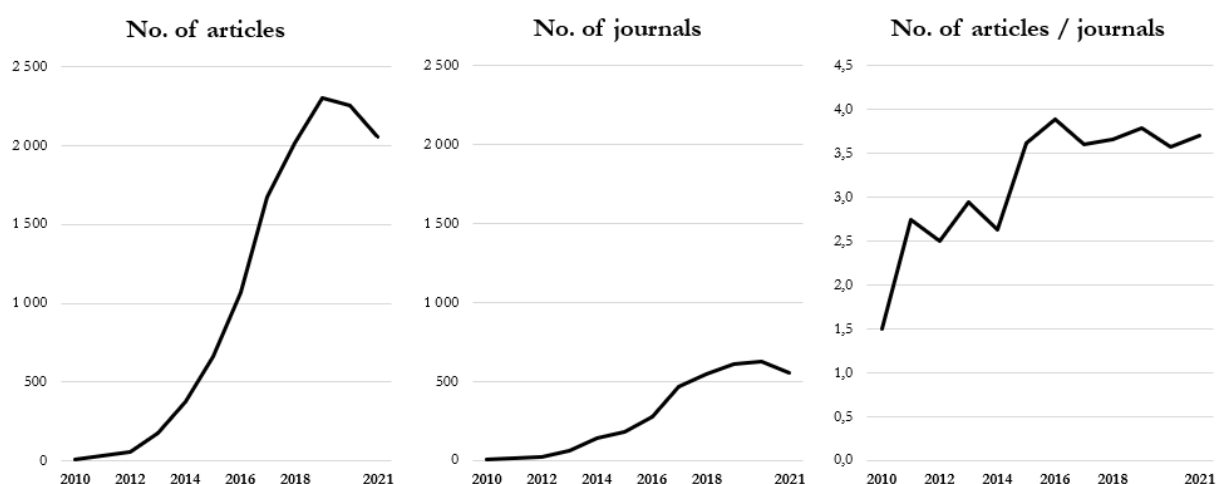


Figure 2 Descriptive statistics of the dataset

The highest number of smart city articles are published in computer science journals and the lion's share of smart city articles is published in technology and engineering outlets, with computer

science journals at the top (Figure 3). Nevertheless, the fastest growing disciplinary areas, which publish smart city articles also include business and economics, public administration and geography as well as environmental sciences, although the number of publications in these disciplines are still fewer. As characteristic for the technological disciplines, there is a significant number of proceedings papers in the dataset.

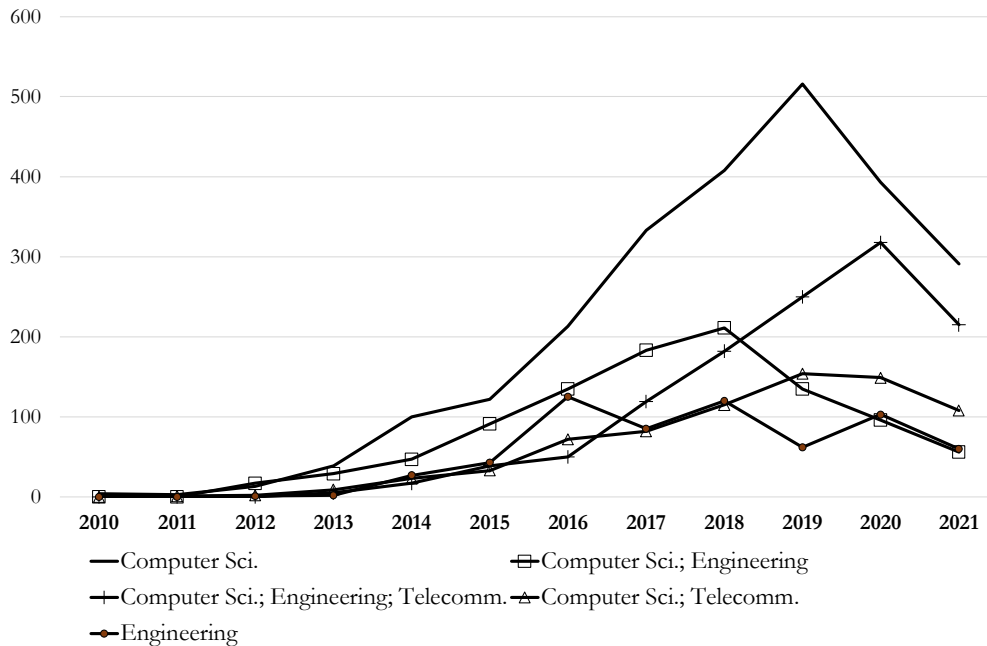


Figure 3 Number of ‘smart city’ articles in the top five Web of Science disciplinary categories. (the abstract contains the term ‘smart city’).

In accordance with the dominating computer science journals, the most frequently used author-defined keywords are computer-related (such as ‘internet of things’, ‘big data’, ‘wireless sensor network’, ‘security’, ‘cloud computing’ and so on). Nevertheless, there are keywords related to the social and human side of smart cities (such as ‘privacy’, ‘governance’) as well as to the environmental concerns (‘sustainability’).

China, the United States and India are the top three home countries for smart city authors, but Italy follows India closely. Certainly, this is only a raw indication of the geography related part of the research, which can greatly change as we progress.

The research steps to take until the conference presentation include:

- enhancing and verifying the quality of the input metadata (refined search profile development);
- cleansing and standardising author-defined keywords;
- city-level network analysis of the affiliation of the researcher-authors;
- consolidation of the segments of the smart city research knowledge-base (analysing the resulting clusters and the concepts in the related cited references).
- In the last stage of research, a comparison with available smart city rankings or lists (such as Giffinger et al. (2007)) will be made.

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