Guest Editorial

Mapping Digital Landscape Architecture Research via JoDLA

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Abstract: With the mission to support the future of research in digital landscape architecture, I map the current cognitive and actor structures of our research community.

Keywords: Digital Landscape Architecture, JoDLA, Science Mapping

1 Introduction

The digital landscape architecture (DLA) community started with the first conference in August 2000. The vision for the conference has been to explore and share all facets of digital approaches in landscape architecture (in the early days, 'CAD' and 'GIS' were two important keywords, but the scope has always been much broader.) The conference has been one of the main outlets for sharing ideas, experiments, results, techniques, and new knowledge among a global community of academics, researchers, and practitioners.

In this editorial, I use bibliometrics theories and methods to quantitively assess contributions to the Journal of Digital Landscape Architecture (JoDLA). I use bibliometric procedures of performance analysis which is "evaluating groups of scientific actors" (countries, researchers), and science mapping which is representing "the cognitive structure of a research field" (COBO et al. 2011).

With performance analysis, I report the collaboration index, and the networks of country collaboration, author's coupling, and bibliographic co-citation. With science mapping, I perform keyword co-occurrence network analysis, mapping the conceptual structure of the field of digital landscape architecture research and its evolution, based on six years' worth of JoDLA bibliometric information (abstracts, keywords, authors, references, etc.). I conclude the paper by proposing questions for the digital landscape architecture community to reflect on further.

2 Methods

I downloaded the bibliometric information of 244 papers published in the journal of digital landscape architecture from 2016 to 2021 in Bibtex format from the Scopus platform.

I used two bibliometric and text mining R-packages, i. e., *bibliometrix* (ARIA & CUCCURULLO 2017) and *topicmodels* (GRÜN & HORNIK 2011), to analyze the BibTex file downloaded from the Scopus platform. The *bibliometrix* package uses a systematic, transparent, and reproducible review process to synthesize literature findings, whereas *topicmodels* clusters the abstracts of the articles into groups.

Methods for calculating each of the analyses in performance analysis and science mapping are explained further under the sections for each analysis. The explanations for the methods are all directly adopted from *bibliometrix* and *topicmodels* packages reference manuals. For network visualizations, the Louvain method for community detection (BLONDEL et al. 2008) is used to create clusters among the nodes. The Fruchterman-Reingold layout is used to visualize the clusters (FRUCHTERMAN & REINGOLD 1991).

3 Performance Analysis

420 authors contributed to the 244 papers from JoDLA. 50 papers were single-authored. The number of Co-authors per document is 2.53. The collaboration index which is “a co-authors per article index calculated only using the multi-authored article set” for this corpus is 2.03.

3.1 Country Collaboration

The country collaboration network is a network where nodes are countries and links are co-authorship (ARIA & CUCCURULLO n. d.). USA, Germany, Australia, UK, and China are the top five countries that contributed to the journal. The country collaboration network of the 20 most frequently contributing countries shows five clusters of countries in research: 1) US, UK, China, Italy, Korea, Canada, and Belgium, 2) Germany and Hungary, 3) Australia, Finland, Denmark, and Netherlands, 4) Switzerland, Spain, Ireland, Serbia, Norway, and the Czech Republic, and 5) Turkey. Germany and UK also show a strong co-authorship connection. Norway and the Czech Republic are now well connected with the other countries of their community.

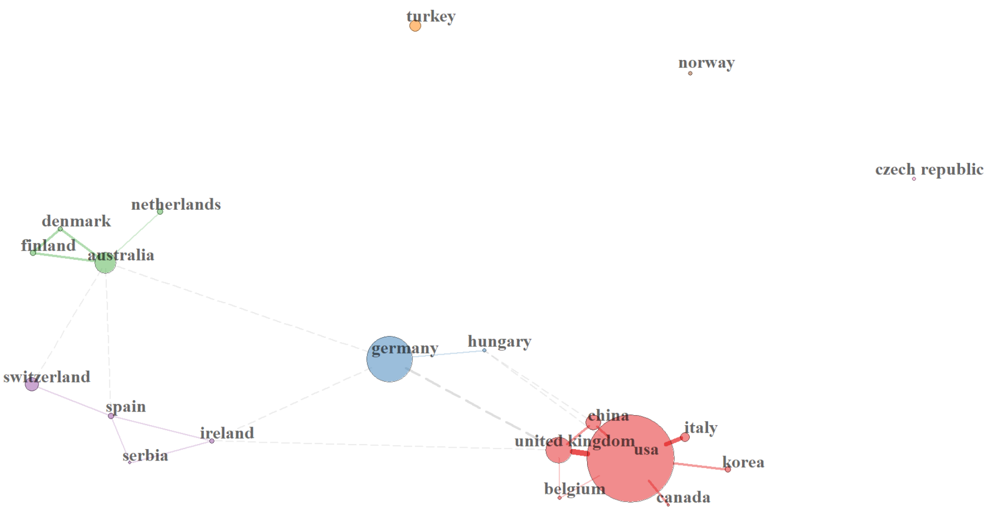

Fig. 1: The country collaboration network. The nodes are the countries. The node size is proportional to the number of papers per country, and the node color shows the cluster that they have fallen into based on the Louvain method for community detection. The link width is proportional to the number of co-authorships between the countries.

3.2 Authors' Coupling

Two authors are said to be bibliographically coupled if at least one cited source from one author appears in the bibliographies or reference lists of the other author (ARIA & CUCCURULLO n. d.). The authors' coupling network shows this relationship as well as the communities that have emerged from it.

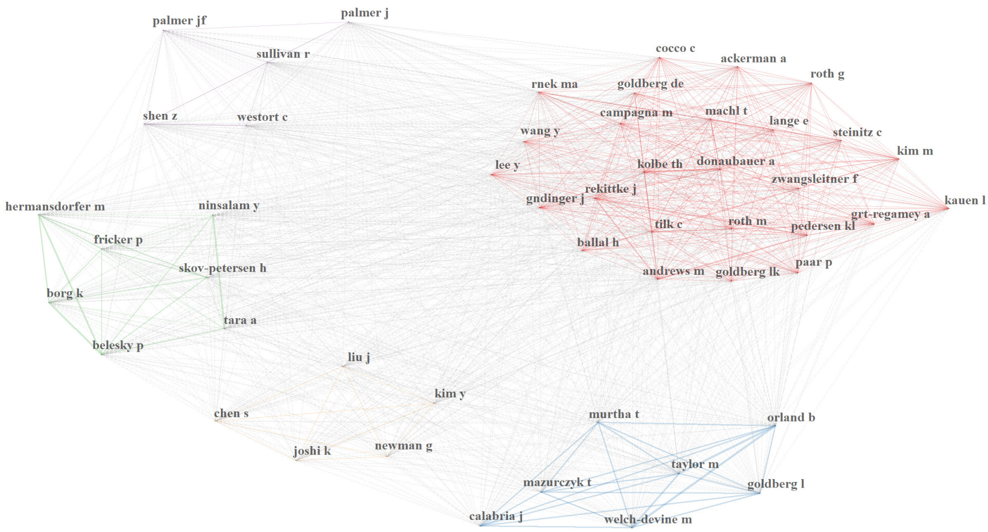

Fig. 2: The authors' coupling network. The nodes are the authors. The node and link colour show different clusters of the authors' coupling based on the Louvain method. The link width is proportional to the strength of the coupling.

3.3 Bibliographic Co-citation

Two references are co-cited "when both are cited in a third article" and Co-citation has been seen "as the counterpart of bibliographic coupling"(ARIA & CUCCURULLO n. d.). The co-citation network is a network where nodes are references and links are co-citation appearances. STEINITZ (2012) seminal book on geodesign; "*A Framework for Geodesign: Changing Geography by Design*" is the most dominant reference connected to several of the communities of co-cited papers. Other high-weight manuscripts that co-cited are "*Landscape Architecture and Digital Technologies: Re-conceptualising design and making*" (WALLISS & RAHMANN 2016), "*The Death and Life of Great American Cities*" (JACOBS 1961), "*Responsive Landscapes: Strategies for Responsive Technologies in Landscape Architecture*" (CANTRELL & HOLZMAN 2015), and "*Codify: Parametric and Computational Design in Landscape Architecture*" (CANTRELL & MEKIES 2018).

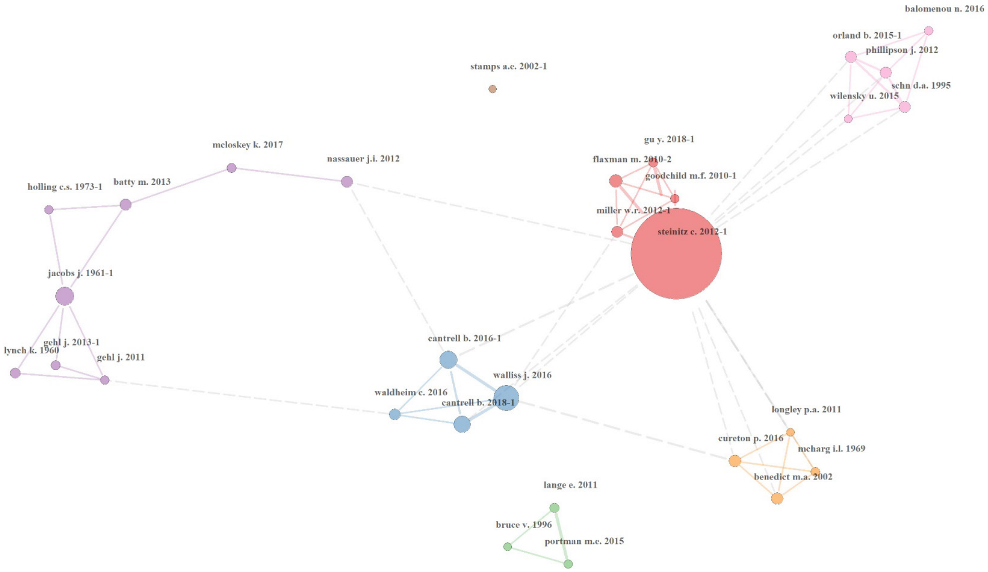

Fig. 3: The co-citation network. The nodes are the references. The node and link colors show different clusters of co-cited references. The link width is proportional to the strength of the co-citation.

4 Science Mapping

To understand the research topics that have been at the center of the digital landscape architecture scholarship, I performed several science mappings analyses on the JoDLA papers' keywords and abstracts.

4.1 Keyword Co-occurrence

The keyword co-occurrence network is based on the number of publications in which both keywords occur together in the title, abstract, or keyword list (ARIA & CUCCURULLO n. d.). Mapping the network of keyword co-occurrence, we see five distinct clusters. Geodesign is the dominant keyword. BIM, resilience, landscape planning, system thinking, and land-use modeling are the main keywords connected to the main geodesign research area. GIS is the second area of research. Remote sensing, landscape assessment, lidar, social media, and big data are the main keywords connected to the GIS research community. Geodesign and GIS keywords also have a strong co-occurrence relationship. Virtual and Augmented Reality (VR/AR) in landscape architecture creates the third main community of research. Education and teaching, UAV, crowdsourcing, computational design, and public participation are the main subareas in VR/AR field. Simulation in landscape design with a focus on climate change is the fourth area of research. Other keywords related to this field are flooding, 3d visualization, algorithmic design, perception. While perception appears in this research area, it also constitutes the fifth category of research. Landscape perception and assessment are the main keywords in this smaller research area.

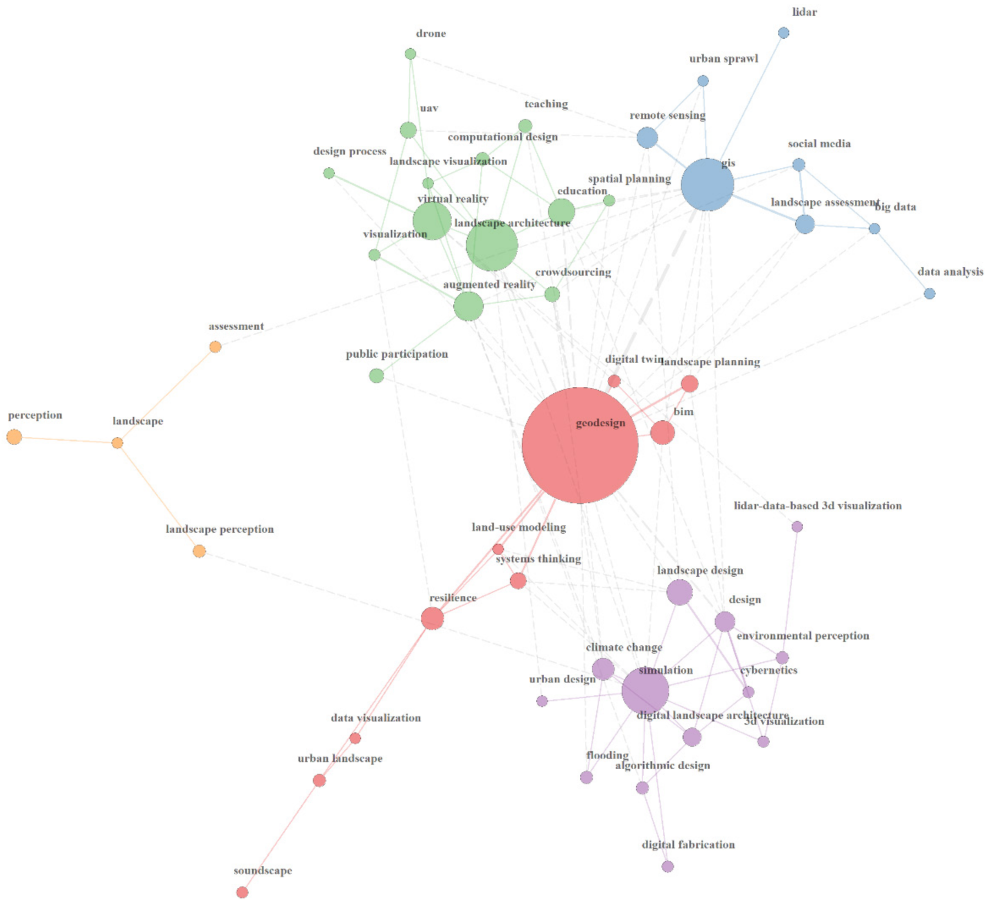

Fig. 4: The keyword co-occurrence network. The nodes are the keywords. The node and link colours show five different clusters of co-occurred keywords. The link width is proportional to the strength of the co-occurrence.

4.2 The Conceptual Structure of the Field

I use co-word analysis to "map the conceptual structure of a framework using the word co-occurrences in a bibliographic collection" (ARIA & CUCCURULLO n. d.). Different dimensionality reduction techniques such as Multidimensional Scaling (MDS), Correspondence Analysis (CA), or Multiple Correspondence Analysis (MCA) can be used for performing this analysis ARIA & CUCCURULLO n. d.). When using the minimum number of co-occurrences of 10 times and using the dimensionality reduction algorithm MCA, we get to the core structure of the scholarship in the digital landscape architecture community in three clusters of topics: 1) Geodesign and GIS, 2) AR and VR, 3) simulation in landscape architecture and design.

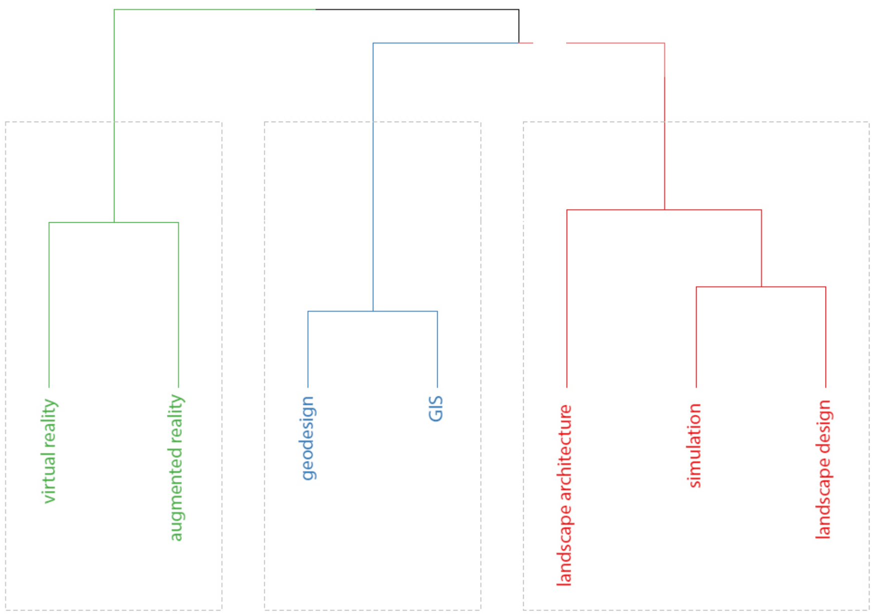

Fig. 5: The conceptual structure of digital landscape architecture scholarship in the JoDLA corpus

4.3 Topic Modelling

Topic modeling using the abstracts of the papers provides similar results to keyword co-occurrence analysis and mapping the conceptual structure of the field (Fig. 6). I ran a Latent Dirichlet Allocation algorithm (LDA) (BLEI et al 2003) for finding three clusters of topics on the papers' abstracts. I used stemmed words in the process of tokenization. The three main clusters of topics can be categorized as 1) geodesign, 2) virtual reality (VR), and 3) spatial analysis and modeling (Fig. 6).

Because the nature of abstracts is different from the keywords, we can also see the most frequently used verbs in each of the categories resulted from the topic modeling (Fig. 6). The verbs that emerge in the geodesign category are: inform, support, discuss, include, integrate, construct. The verbs in the virtual reality category are: assess, provide, study, increase, explore, understand. The verbs in the spatial analysis and modeling category are: develop, study, evaluate, investigate. These verb lists provide a powerful way to look at how and why we use these different methods of inquiry in the digital landscape architecture scholarship.

Similarly, the nouns in each category provide more insights (Fig. 6). Nouns in the geodesign category include design, data, process, and digital. These nouns get more specific in virtual reality and spatial analysis clusters: in VR, the examples of nouns are 3d, technology, software, environment, tool, user, map, student, and visual; in the spatial analysis cluster, we see urban, plan, park, city, scenario, ecology, and climate. This shows a transition of more theoretical concepts in geodesign, to tool development focus in the VR category and application-focused terms in spatial analysis.

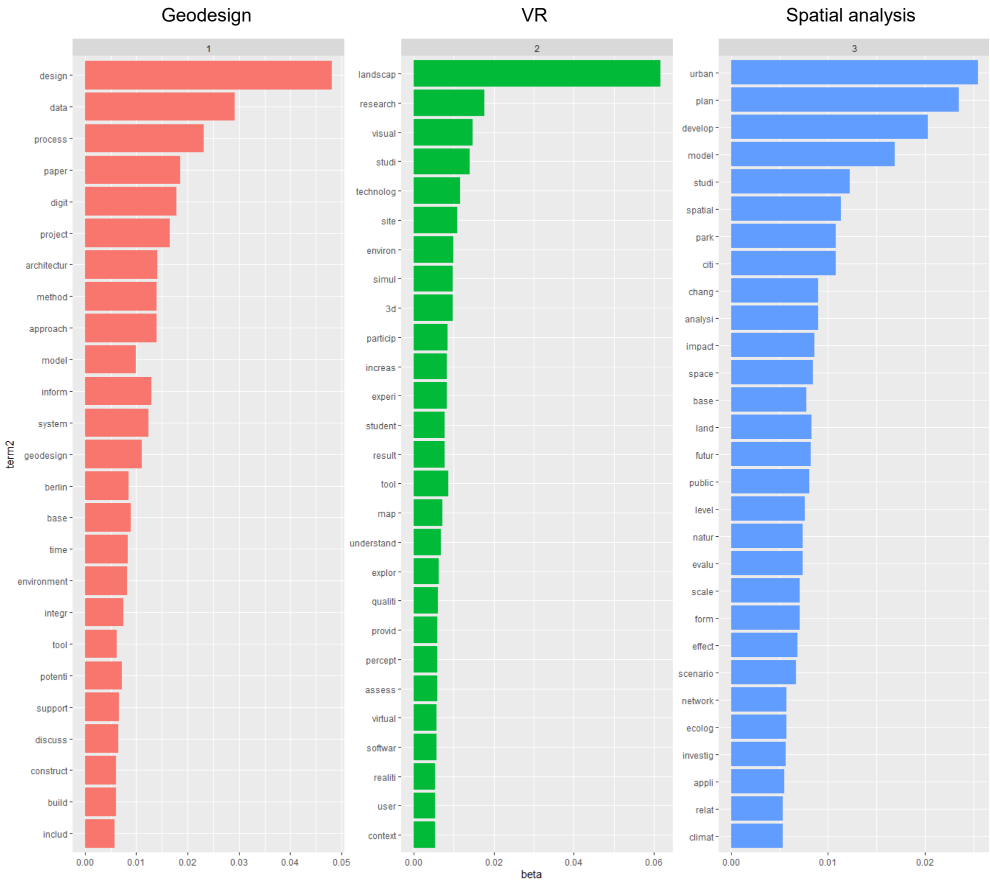

Fig. 6: Topic-word density from topic modelling of the abstracts with three clusters

Expanding the three clusters to nine, the topics expand to 1) geodesign with a focus on urban systems and 2) geodesign with a focus on land cover modeling, 3) virtual reality, 4) education, 5) 3D modeling, 6) tool development, 7) BIM, 8) perception/visualization and 9) flooding. While other themes emerged from other analyses, flooding seems to be a domain that did not appear as significant in others.

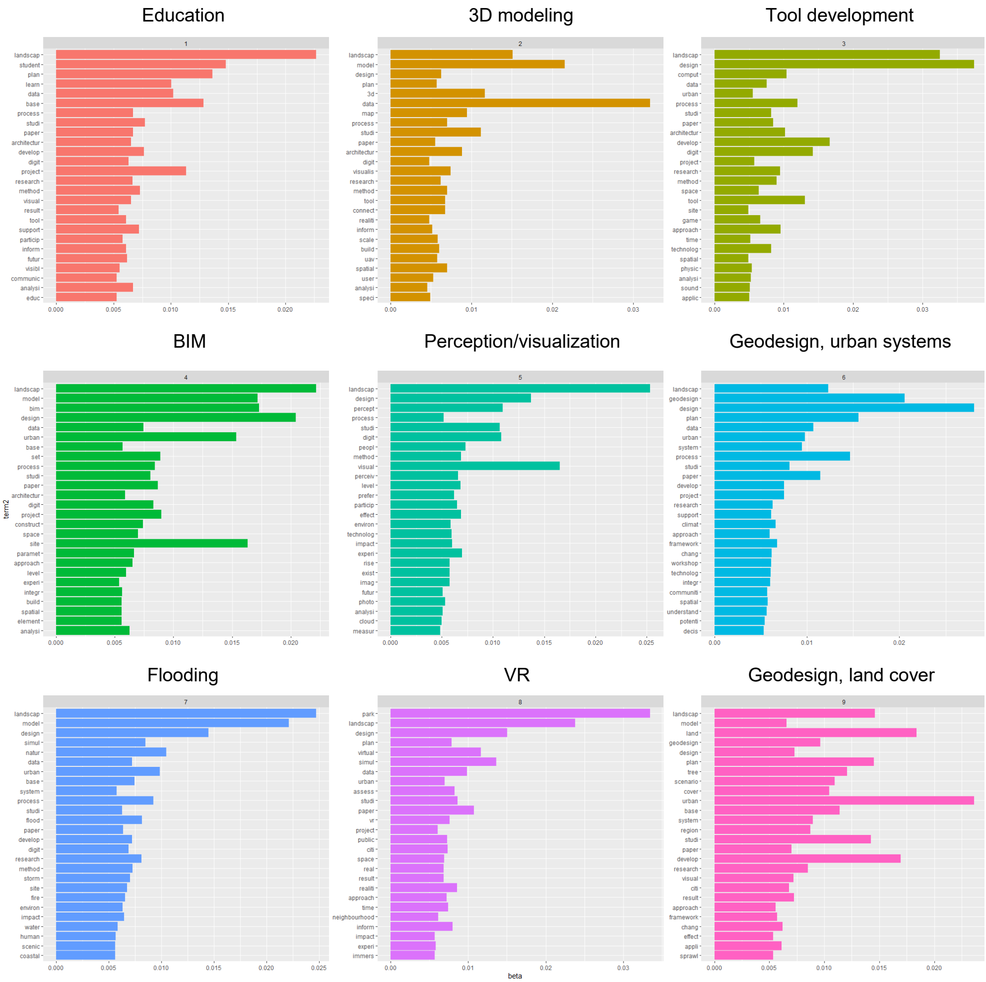

Fig. 7: Topic-word density from topic modelling of the abstracts with nine clusters

4.4 Thematic Maps

This analysis is based on COBO et al. (2011) approach to the analysis of the evolution of specific research. The approach has two main steps;1) "to detect the themes treated by the research field by means of co-word analysis for each studied subperiod" and, 2) "layout in a low dimensional space the results of the first step (themes)" (COBO et al. 2011).

Clusters of keywords resulting from the co-word analysis are considered research themes. Each research theme has two parameters: density and centrality. Density "measures the strength of internal ties among all keywords describing the research theme" (COBO et al. 2011). Centrality measures the interaction of one network with other networks (CALLON et al. 1991). Based on these two parameters themes can be categorized into one of four kinds in a 4x4 grid.

The themes that have high centrality and low density (the lower-right quadrant in Fig. 8) are very important for a research field but are not very developed. This group that is tagged as *"basic themes"* includes "transversal and general" themes. The themes that have high centrality and density (the upper-right quadrant in Fig. 7), are both developed and important for the structuring of a research field. This group is tagged as *"motor themes"*. The themes that have low centrality and high density are tagged as "*niche themes*" (the upper-left quadrant in Fig. 8) which "have well-developed internal ties but unimportant external ties and so are of only marginal importance for the field". Themes that have low centrality and low density (the lower-left quadrant in Fig. 8), are tagged as *"emerging or declining themes"* (COBO et al. 2011).

Figure 8 shows the themes in the JoDLA corpus resulting from the analysis with 300 most frequent words, with the co-occurrence rate of at least 5 times. According to this analysis, the basic themes of the field are geodesign, augmented reality, virtual reality, simulation, and landscape perception. The motor themes include landscape architecture and design, education, visual impact assessment, BIM, and network analysis. Design tools are a niche theme that is fairly developed and marginally relevant to the structuring of the field. No theme appears in the emerging/declining category.

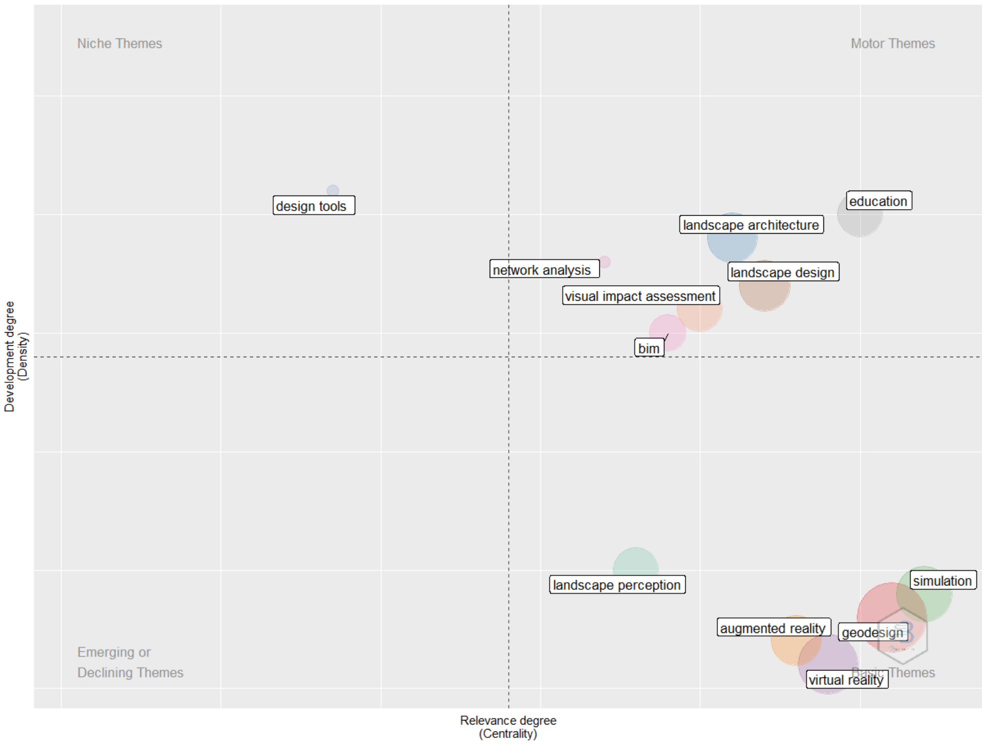

Fig. 8: Thematic map of the JoDLA corpus

Using the yearly period of the journal and mapping the scientific evolution based on the COBO et al. (2011) approach (Fig. 9), we see that geodesign was the main theme in 2016 and persisted as the main theme in each year except that the theme evolved to resilience in 2021. GIS theme has shrunk in the last two years of the journal, especially in 2020. Land-use modeling theme in 2018 evolved to landscape design in 2019 and 2020 and into climate change theme in 2021. Simulation and landscape architecture themes are fairly connected. Virtual reality appeared as a significant theme in 2019 and 2020, while Augmented reality appeared in 2020 and 2021.

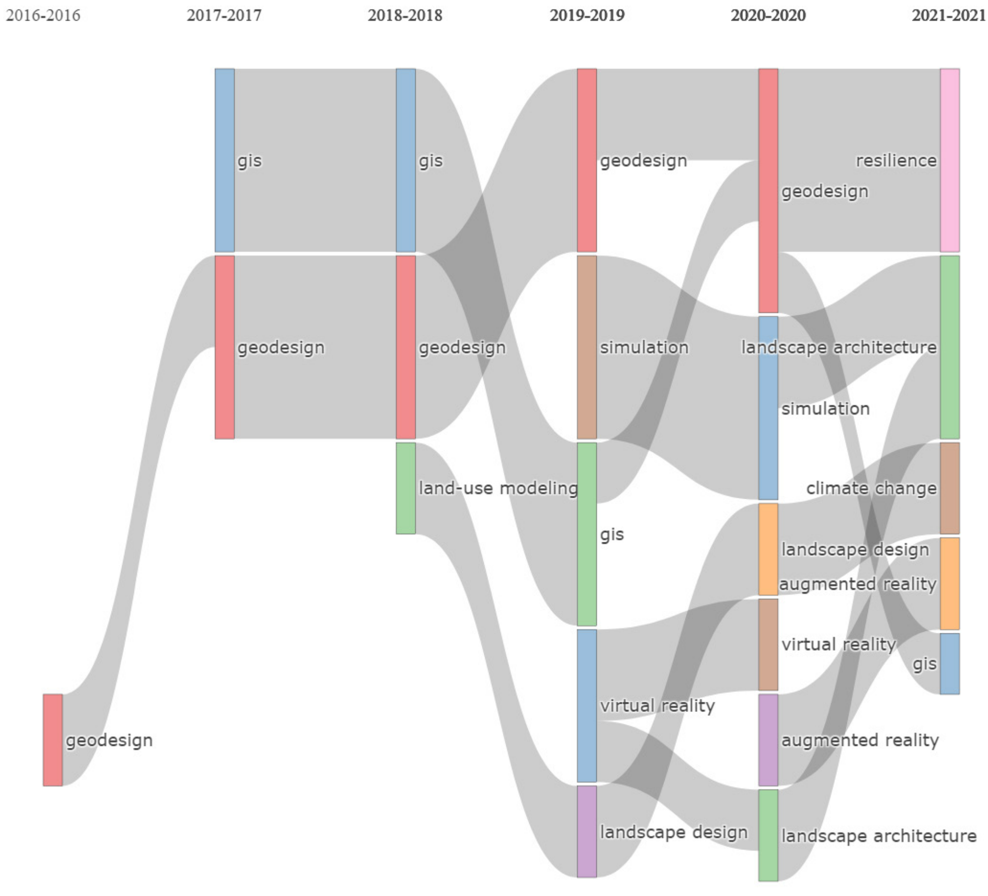

Fig. 9: Thematic evolution over six years in JoDLA

5 Conclusion and Outlook

The results of our analysis provide new insights into the current cognitive and actor structures of our research community.

These results can be further investigated to create action items on what we as a community think that is missing and what we want to evolve into in the future. Some suggested questions to further explore are: What are the synergies between topics, institutions, world regions, and individuals that can be reinforced? What seemingly far-apart ideas can be connected? How can we increase collaboration outside of the existing sub-networks of collaborators? How diverse do we want the seminal works that inform our research to be?

While these analyses provide a high-level understanding of the field, they might not capture the nuances of the research community. In the larger research themes context, it is important to ask why that analysis does not show any significant "emerging themes" (Fig. 7). FUCHS (1993) argues that higher task uncertainty (where the research is exploratory in nature and not routinized) and higher mutual dependence (social and organizational dependence between the scientists) together facilitate scientific change and new research frontiers (CHEN 2017). What are the current exploratory research areas in digital landscape architecture and how can we reinforce social and organizational mutual interdependence between our scholars, researchers, and practitioners that work on those subjects?

SHNEIDER (2009) proposes the evolution of a scientific discipline as a four-stage process; stage one is conceptualization, stage two is tool development, stage three is investigating the research questions with the newly developed tools and developing more tools as new domains emerge, and stage four is when the tacit knowledge of the domain transfers to codified and routinized knowledge and this is when comprehensive textbooks are written (CHEN 2017). It is worth asking: Where are we in the DLA community in this four-stage process in the different topics we are exploring?

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