SPATIUM
No. 49, June 2023, pp. 30-41

UDC 004.9:711.61
Original scientific paper
DOI: https://doi.org/10.2298/SPAT230120007N

SPATIAL VIDEO PROJECTION AND PUBLIC OPEN SPACES: A DISTINCT BIBLIOMETRIC STUDY APPROACH

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In the 21st century, digital technologies have begun to play a more active role in ensuring sustainability. This situation has led to studies examining the interaction between digital technologies and different academic disciplines in many study areas. In terms of spatial planning and design disciplines, this study focuses on spatial video projection (SVP). Through bibliometric analysis, this paper aims to identify and locate an assortment of SVP technologies and contemporary urban public open spaces (POSs) within the global research landscape. Utilizing WOS, Scopus, and the VOSviewer software, a 6-phase process is used to evaluate the current research landscape. The phases include: identifying groups of keywords for cross-examination within the manuscripts; exploring words inside articles with their dominancy levels and linkage clarity through bibliometric analysis; developing a grading technique regarding dominancy levels; grouping graded words into thematic fields; calculating overall values of each of the fields for both databases settings; and comparing the fields for developing discussions and strategies. The findings of this study indicate that architectural disciplines lack SVP-related research. In future academic studies, the approach used in this study could be used to develop topic selection strategies in multidisciplinary settings. In addition, it is expected that SVP will offer potential applications for enhancing the quality of the shared public spatial experience of cities. Thus, this study also forms a cornerstone for further research investigating the potential of utilizing SVP in POSs for the sustainability of cities.

***Key words*: video projection mapping, urban public open spaces, digital place-making, bibliometric study, mapping research.**

INTRODUCTION

Today, technology influences many aspects of life, including how people interact with their surroundings. Urban development and smart cities are increasingly being debated in this regard, and urban spatial experiences have evolved significantly since the early 20th century. Various city-related issues have been addressed using information and communication technologies (ICTs). Further, different sectors of urban development utilize ICT, including the urban landscape and its vital component, public open spaces.

By identifying and incorporating new technologies, urban landscapes can be adapted to satisfy the inhabitants' needs and expectations, and maintain their connection with open spaces (Sherman, 2012; Ivanović-Vojvodić and Stupar, 2015; Stefanita, 2018; Angelidou and Psaltoglou, 2018).

Mobile phones are common digital technology that affects urban life's social and spatial aspects. Through this technology, social experiences migrate from the physical to the virtual (Polson and Norum, 2020; Stokes *et al.*, 2021; Wiethoff and Hussmann, 2017). With this in mind, contemporary public open spaces require alternative solutions that capture people's attention. In this study, spatial video projection (SVP) is the specific technology discussed. By combining the virtual layer with a real-world object or space, a group of people can experience the same shared experience. SVP offers the potential to influence spatial experiences and foster new activities in contemporary city POSs.

As a part of the endeavor to examine the opportunities for utilizing SVP in POSs, a challenge was posed in terms of

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specifying, communicating, relating, and reaching related research. In the absence of research concerning this particular topic, the bibliometric study bridges the gap and provides a foundation for future research.

Bibliometric study

Bibliometric methods are useful when identification of the main tendencies or relationships in the development of a field is not possible because of the large volume of literature (Hajduk, 2017). A bibliometric study is a quantitative analysis of published works. This quantification process maps specific topics and investigates patterns in previous documents and publications (Marsilio *et al*., 2011; Cobo *et al.*, 2011; Markscheffel and Schröter, 2021).

Bibliometric analysis usually uses specific methods such as citation analysis, co-citation analysis, bibliographic coupling, co-author analysis, and co-word analysis (Zupic and Čater, 2014; Cobo *et al*., 2011). Citations and co-citations are the most commonly used methods (Marsilio *et al*., 2011).

Bibliometric methods are employed for two main purposes: performance analysis and science mapping. Performance analysis evaluates the research and publication performance of individuals, institutions, and countries. Science mapping reveals the structure and dynamics of scientific fields. It is useful for understanding structure and development when examining research topics (Noyons *et al.*, 1999; Zupic and Čater, 2014).

For creating and visualizing bibliometric maps, software such as Bibexcel, CoPalRed, Pajek, VOSviewer, Citespace, and VantagePoint are available (Hajduk, 2017; Hočevar and Bartol, 2021; Cobo *et al*., 2011), of which Citespace and VOSviewer are the most popular software (Markscheffel and Schröter, 2021).

VOSviewer software is used in the current bibliometric analysis; it was developed by van Eck and Waltman in 2010 at the Centre for Science and Technology Studies, Leiden University (Van Eck and Waltman, 2018; Arruda *et al*., 2022). VOSviewer is more user-friendly than Citespace and it provides adequate tools for this study's objectives (Cobo *et al*., 2011; Markscheffel and Schröter, 2021). A bibliometric analysis was performed to analyze and contextualize the research landscape around SVP and POS using the science mapping approach.

The bibliometric study used word co-occurrence rather than citation or co-citation. The methods and materials section of this paper provides precise explanations. Prior to this, the following topics are briefly covered: public open spaces, POS revitalization and its role in POS quality, digital placemaking, and SVP, as well as technologies related to them.

POS, POS revitalization, quality, and digital place-making

The benefits of public open spaces extend to culture, the environment, and the economy, affecting individuals, communities, and cities. Concepts of public open spaces have evolved over time in response to cultural contexts (Ramlee *et al*., 2015; Brill, 1989; Riether, 2016; Madanipour, 2019), with digital technologies also playing a vital role in this change. As a consequence, open public spaces are being used less in cities around the world (Spandou *et al*., 2010). Thus, urban revitalization has received increased attention, including its crucial component, POS. To find quality urban public spaces, POS revitalization is considered a priority (Gehl, 2011; Campos, 2012).

Creating a quality place involves both physical and non-physical components, including those of a social, cultural, economic, environmental, and political nature (Ramlee *et al*., 2015; Abd El Gawad *et al*., 2019; Stefanita, 2018). Place-making is an approach to revitalizing POSs (Abd El Gawad *et al*., 2019) that can also use digital technology (digital place-making). This term was coined due to discussions surrounding human-computer interaction concerning space and place (Sanaeipoor and Emami, 2020; Halegoua and Polson, 2021).

Spatial video projection, related terms, and technologies

SVP is a mixed reality technology consisting of projection-based augmented reality that enables the conversion of any 3D surface into a display (Empler, 2017). The term spatial video projection is used throughout this research, although it has several synonyms, including projection mapping, spatial augmented reality, and video mapping. Several technologies share features with SVP such as media facades, urban screens, and media architecture. Shared experiences are one of the most important features of these technologies. SVP is less commonly used and researched in relation to spatial urban experiences than these technologies.

Hybrid space is created when one of these previously mentioned elements is combined with physical space. At a city level, a number of terms have been proposed to describe the hybrid experience within the urban landscape, including urban media environment and cyberpark (Tscherteu and Tomitsch, 2011; Tomitsch *et al*., 2015; Wiethoff and Hussmann, 2017; Costa *et al*., 2019, Sanaeipoor and Emami, 2020).

Research aim and objectives

Through bibliometric analysis, this paper aims to investigate the academic interplay between SVP technology and POSs within the global research landscape for developing scholarly strategies for the benefit of cities. Benefitting from the WOS and Scopus databases and the VOSviewer software, this study defines its goals as:

- Exploring current keywords hidden inside SVP-related articles,
- Developing a grading technique to quantitatively compare words resulting in bibliometric maps,
- Defining thematic fields to group words resulting in bibliometric maps and calculate field values,
- Comparing graded fields for conducting discussions; and
- Developing strategies for the benefit of integrating spatial planning and design disciplines with SVP technology for POSs.

As a consequence, this study facilitated a comprehensive understanding of the research landscape surrounding the study topic. Hence, the study concludes with a reflection

on the findings and suggestions for potential research directions, laying a foundation for future research on related topics. Moreover, this study provides a framework for situating emerging topics within existing research contexts.

METHODS AND MATERIALS

To achieve the research aim, VOSviewer software was used to analyze data obtained from WOS and Scopus abstract and citation databases. This study carried out the following 5 steps: 1) conducting a literature review to formalize a primary contextualizing of the study topic; 2) identifying the keywords for WOS and Scopus databases analyses based on the literature review; 3) preparing the chosen keywords and grouping them in a format suitable for searching in each database; 4) processing in WOS and Scopus databases; and 5) VOSviewer analysis (Stage 1 and stage 2). Stage 1 of the VOSviewer analysis includes developing a grading procedure for evaluating.

Identifying and preparing keywords

It is essential to identify keywords for mapping and locating emerging topics within the existing literature. This is because they form the basis of the entire analysis. For abstracts and citation databases, keywords need to be organized appropriately. The VOSviewer software for word co-occurrence analysis uses the term "keyword" as a unit of analysis. In this study, to avoid misunderstanding, "word" as a term used for the discussion was connected to the VOSviewer analysis, while the term "keywords" was used for the keywords identified in this study in a group format to facilitate the analysis in the Web of Science (WOS) and Scopus databases. The word or keyword in this study may be single, like (projection), or multiple, like (projection mapping).

Identifying keywords

Based on research reviews, three categories of keywords were identified:

- SVP synonyms: keywords such as projection mapping, video projection mapping, and spatial augmented reality are all synonyms to describe the same technology of projection-based augmented reality, which is also a synonym for SVP;
- SVP-related technologies: keywords of urban screens, media facades, media architecture, and urban media environment are technologies that relate to one aspect or more of SVP; and
- Associated terms: Keywords of landscape architecture, urban design, and public open spaces used to discuss technologies correlated to these main fields. Additionally, to relate these technologies to the city's landscape, the keyword "public open spaces" and place-making terms were included.

Preparing keywords

To cover all possible research related to the topic of this study, the three categories of identified keywords were categorized into eight groups. Accordingly, the keyword groups were arranged in ascending order from general to specific. These groups were prepared for the two database searches (WOS and Scopus). These groups represent the texts entered into each database's search box. Each keyword in the group was enclosed in quotation marks and followed by a (*) symbol. The (*) symbol is used to include all possible alternatives in the search results for the identified keyword. For instance, if the keyword "Projection Mapping*" is entered into the search box, the search results will include projection-mapping, projection mapping, and Projection-Mapping. A keyword written as "projection mapping" will only return search results for the exact same keyword.

(OR) and (AND) are separate keywords within each group. By using these logical operators, the search process was organized and prioritized. For instance, the group of keywords ("projection mapping*" OR "spatial augmented reality*" OR "video mapping*" OR "video projection mapping*" OR "spatial video projection*" **AND** "architecture*" OR "landscape architecture*" OR "urban design*" OR "urban planning*") instructs the database to find one or more words before and after the conjunction "AND". All the keyword groups are mentioned and discussed in section: Analysis, results, and discussion.

Processing in WOS and Scopus databases

In WOS and Scopus databases, each prepared keyword group was searched separately. The search results were exported from WOS in plain text format, and from Scopus in CSV format (Comma Separated Values). Files were exported from WOS using the "All Records and Cited References" option. Citations, bibliographic information, abstracts, and keywords were all included in Scopus exported files. Scopus can store 2000 records per exported file, whereas WOS can store 500. This limitation is imposed by database search engines. WOS search results with more than 500 documents were exported in multiple files. In Scopus, only the first 2000 records were exported chronologically. Exported files were downloaded and then analyzed bibliometrically with VOSviewer.

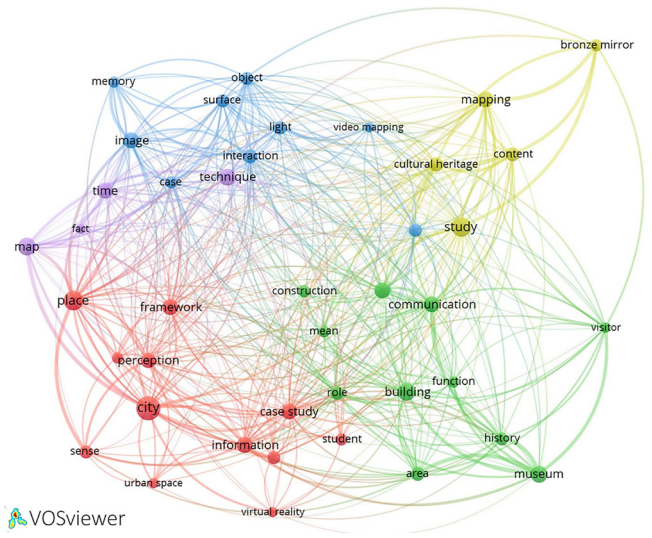
VOSviewer analysis

Rather than focusing on co-authorship or citations, this study explores the co-occurrence of words, because it aims to understand the geography of research around the suggested topic of SVP for POS. The WOS and Scopus databases were targeted to provide a closer insight into the landscape of research on the suggested topic through narrowed data results. Accordingly, bibliometric maps were created using the VOSviewer, and then the maps were read, analyzed, and the changes between them were traced.

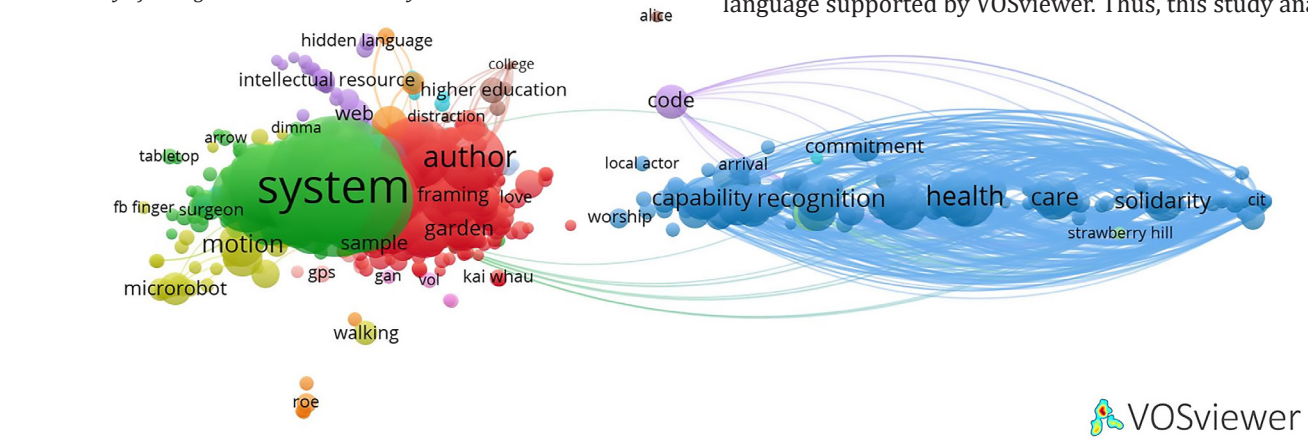
VOSviewer analysis consists of two stages. The first examines each keyword group separately. The second involves the analysis of all keyword groups jointly.

Stage 1:

Thematic fields were formed by grouping words found on bibliometric maps according to VOSviewer analysis. A grading procedure was developed for evaluating the existence and dominance of words in the bibliometric maps. Using this procedure, the overall value of each theme was calculated for both WOS and Scopus. Section WOS and Scopus databases bibliometric maps discusses this stage's results.



a. Low clarity of linkages and Word dominancy



b. Clear linkage and word dominancy

Figure 1. The three aspects of bibliometric map analysis (Source: Authors, 2023)

in Figure 1b, the word "system" dominates. Links between words are indicated by color, closeness, and number of links. Nodes representing related words are closer and share the same color (in the same cluster). One map may contain multiple clusters with nodes that share a common color and are close to each other (Figure 1). Each stage of the analysis includes a separate analysis of both WOS and Scopus files.

Using VOSviewer, bibliometric maps can be created based on network data, bibliographic data, or text data. In this study, two types of analyses were conducted: text-based and bibliographic-based. Analysis of text data involves analyzing terms in titles and abstracts of records. Structured abstract labels and copyright statements were ignored. This study utilized bibliographic data-based analysis to examine co-occurrences of research keywords. The full counting method option and all keywords as a unit of analysis were chosen. VOSviewer uses natural language processing (NLP) algorithms for identifying words. English is the only language supported by VOSviewer. Thus, this study analysis

Stage 2:

All groups of keywords were analyzed together for each of the databases separately. Section Analysis of all keyword groups in bibliometric maps discusses the results of this stage.

For bibliometric mapping, VOSviewer provides three different visualization options: network, overlay, and density. However, the study discussed here focused solely on the network visualization option. This option was preferred because of its ability to clearly display the labels, nodes, and links of the bibliometric maps. Each item (word) represented in the visualization is shown with a label and a circle whose size is relative to the item's weight. Larger labels and circles indicate items with higher weights. When necessary, labels are excluded to prevent overlap. Colors are assigned based on an item's cluster, while lines indicate the linkages between them. The visualization defaults to showing the 500 strongest links between items, and proximity on the map indicates relatedness.

For each stage, comparison and analysis of each bibliometric map are based on three aspects, including the word's appearance, dominance, and linkage to other words (Figure 1). Node size determines word dominance. For instance,

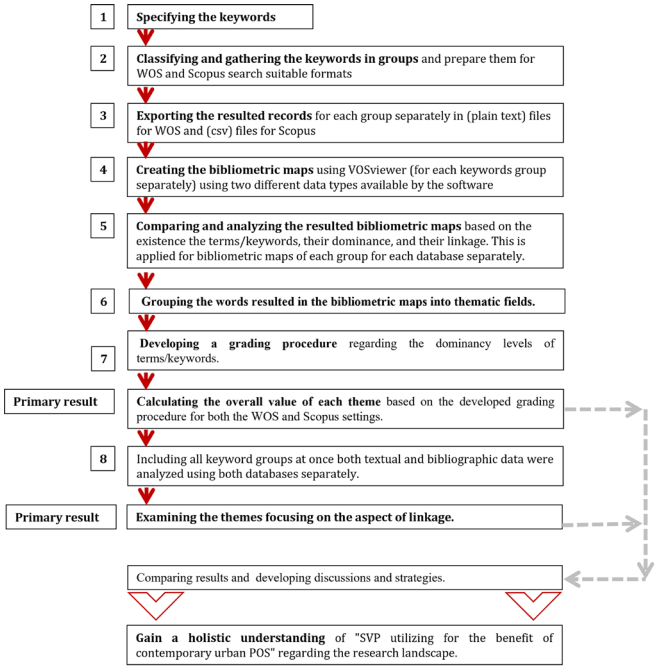


Figure 2. An outline of the methodology of this study (Source: Authors, 2023)

is limited to English language data (van Eck and Waltman, 2018). In the software, all words except abbreviations are handled in small letters.

A threshold of five coexisting words was specified in all analyses. Thus, the bibliometric maps of VOSviewer include words appearing five times or more in titles or abstracts of text-based analyses or keywords of the bibliographic analyses. VOSviewer analyzes text-based data based on relevance scores. High-relevance words indicate specific topics covered in the text. In contrast, words with low relevance tend to be general in nature. The focus shifts to more precise and informative words by excluding general words. The software automatically excludes 40% of terms based on their relevance score (Van Eck and Waltman, 2018).

The following section discusses the results of this process. The phases followed in this study are shown in Figure 2.

ANALYSIS, RESULTS, AND DISCUSSION

The eight groups of identified keywords

As discussed in the previous section, the identified keywords were classified into 8 groups in order to facilitate the search for them in the WOS and Scopus databases. For each database, each group of keywords was used in a separate search. Table 1 below provides these groups and the number of records returned for each search.

On some occasions, the difference between groups and others was only the sequence of keywords, as in groups 4-5 and 7-8. The change in sequence led to different results in WOS but the same results in Scopus. For this reason, the number of resulting documents in groups 4 and 5 is similar to the search results of Scopus, and this fact also applies to groups 7 and 8.

Based on the search results of these groups for each of the WOS and Scopus databases, the record files were exported for VOSviewer analysis and the creation of bibliometric maps. 16 bibliometric maps were generated. Eight of them were based on text-data analysis, and eight were based on bibliographic-data analysis. Based on the text-data analysis, the bibliometric maps display the top 60% of relevant words that exceed a threshold of five existences. Bibliographic data analysis maps display all words with more than five occurrences. Table 2 indicates the number of words presented in the bibliometric maps.

Table 2 shows that the count of resulting words differs between WOS and Scopus after being exported to VOSviewer for analysis. This is because each database has a different number of documents covered. Furthermore, there are fewer words that exceed the threshold than overall keywords. For instance, group 8 in the WOS database included 38,924 co-occurring words based on text-data analysis, but only 2,555 for words exceeding 5 co-occurrences.

It was expected that the number of search results would decrease when switching from general to specific keyword groups. A search for the first group, for instance, would return more results (number of records) than a search for group 3. These expectations were met in Scopus, but not in

Table 1. The keyword groups as they were used in WOS and Scopus, and the resulting number of documents for each search

Keywords group number	Groups of keywords used in database searches	The number of documents resulting from the database search	
		WOS	Scopus
1	"projection mapping*" OR "spatial augmented reality*" OR "video mapping*" OR "video projection mapping*" OR "spatial video projection*"	870	3,962
2	"public open spaces*" AND "projection mapping*" OR "spatial augmented reality*" OR "video mapping*" OR "video projection mapping*" OR "spatial video projection*"	384	82
3	"projection mapping*" OR "spatial augmented reality*" OR "video mapping*" OR "video projection mapping*" OR "spatial video projection*" AND "architecture*" OR "landscape architecture*" OR "urban design*" OR "urban planning*"	69	836
4	"projection mapping*" OR "spatial augmented reality*" OR "video mapping*" OR "video projection mapping*" OR "spatial video projection*" OR "Urban screens*" OR "Media facades*" OR "Media architecture*" OR "Urban media environment*" AND "public open space*"	1250	6
5	"public open space*" AND "projection mapping*" OR "spatial augmented reality*" OR "video mapping*" OR "video projection mapping*" OR "spatial video projection*" OR "Urban screens*" OR "Media facades*" OR "Media architecture*" OR "Urban media environment*"	771	6
6	"Urban screens*" OR "Media facades*" OR "Media architecture*" OR "Urban media environment*"	388	2553
7	"place making*" OR "public open space*" AND "projection mapping*" OR "spatial augmented reality*" OR "video mapping*" OR "video projection mapping*" OR "spatial video projection*" OR "Urban screens*" OR "Media facades*" OR "Media architecture*" OR "Urban media environment*"	2850	101
8	"projection mapping*" OR "spatial augmented reality*" OR "video mapping*" OR "video projection mapping*" OR "spatial video projection*" OR "Urban screens*" OR "Media facades*" OR "Media architecture*" OR "Urban media environment*" AND "place making*" OR "public open space*"	2089	101

Table 2. Resulting count of words in VOSviewer using the text-data-based and bibliographic-data-based analysis for both WOS and Scopus databases

	WOS					SCOPUS				
	Text-data-based analysis			Bibliographic-data-based analysis		Text-data-based analysis			Bibliographic-data- based analysis	
	The total number of resulting words	The total of words exceeding the threshold of 5	60% most relevant	The total number of resulting words	The total of words exceeding the threshold of 5	The total number of resulting words	The total of words exceeding the threshold of 5	60% most relevant	The total number of resulting words	The total of words exceeding the threshold of 5
1	16827	967	580	1271	30	37714	2368	1421	13516	799
2	8371	498	299	1320	38	2625	133	80	883	12
3	2070	80	48	35	6	17871	1120	672	6357	281
4	22665	1325	795	4297	130	275	9*	5	43	4**
5	14629	891	535	2459	74	275	9*	5	43	4**
6	7410	454	272	3241	91	33177	2067	1240	9338	510
7	49230	3020	1812	8634	524	2618	155	93	641	17**
8	38924	2555	1533	7124	393	2618	155	93	641	17**

** The threshold of 5 word co-occurrences was not met, and it was turned to 3 thresholds by VOSviewer software.*
*** The Scopus database did not show a change in the results when there was a change in the sequence of the keywords used for the search; therefore, the results were repeated for groups 4/5, and 7/8.*

WOS. Based on Table 2, the discrepancy is reflected in the VOSviewer results. Bibliometric maps were generated based on Table 2 data. As the number of words in Table 2 increases, so does the bibliometric map. Table 2 does not necessarily correlate with a word's dominance on the bibliometric map or its linkage to other words.

WOS and Scopus databases bibliometric maps

A total of sixteen bibliometric maps were read, compared, and analyzed to determine the appearance of the words, their dominance, and their links with other words for both WOS and Scopus. Table 3 illustrates the main observations of the bibliometric maps for Group 1 as an example of the analyses conducted for all 8 keyword groups. This link: https://github.com/LimaNajjar/2-SPATIAL-VIDEO-PROJECTION-AND-PUBLIC-OPEN-SPACES-A-DISTINCT-BIBLIOMETRIC-STUDY-APPROACH includes a table of analysis for all groups.

Generally, bibliometric maps based on bibliographic data provide more relevant results regarding the topic of this study than text-based analyses. The dominance of specific words over others was unclear on the bibliometric maps based on text data. At the same time, this was more obvious in the bibliographic-data-based analysis maps except for groups 7 and 8, where text-data-based results showed clarity in this manner. The linkages were clear on bibliometric maps of groups 1, 2, 4, 5, 7, and 8. Group 3 did not present any closeness between specific nodes to form linked groups of words. The bibliometric maps of group 6 contain some interconnected nodes but fewer than those of the other groups.

Scopus and WOS bibliometric maps are compatible to a good extent. Text-based Scopus-related bibliometric maps are less relevant to this study, except for groups 4 and 5. These groups' maps are almost identical in text and bibliographic data. The dominance of specific words is evident in bibliometric maps 1, 3, and 6, while dominance was not observed in other maps. In groups 1, 3, and 6, only a linkage was observed between the words. It is evident that there are differences between the resulting bibliometric maps by WOS and Scopus, such as the bibliometric maps for group 3.

Based on the analysis of all bibliometric maps for the 8 keyword groups, relevant words can be classified into several categories. These categories are required for a comprehensive understanding and thematic comparison. Categories include technical, applications, synonyms, effect/efficiency, related concept/topic, city component/element, aspects, related terms, related technology, field, and device/s. Table 4 explains each category with its associated words. To gain a clear understanding of the research coverage, simple calculations were conducted for each category. A higher total indicates that this category has received more research. Each word was assigned a weight of 1 or 2 based on bibliometric observations. When it appeared in the bibliometric map as a dominant word, a weight of two was applied. If the word did not appear in the bibliometric map as dominant, it received a score of 1. Table 4 shows the results of these calculations. The following calculation was used:

Table 3. An example of the analyses completed for all groups. It summarizes the main observations related to the bibliometric map generated by VOSviewer using text and bibliographic data analysis for group 1 of words.

Group 1 searched Keywords: "projection mapping*" OR "spatial augmented reality*" OR "video mapping*" OR "video projection mapping*" OR "spatial video projection*"			
WOS		Scopus	
Text-data-based bibliometric map	**Bibliographic-data-based bibliometric map**	**Text-data-based bibliometric map**	**Bibliographic-data-based bibliometric map**
Main observations: Dominant words: problems, color, and installations. Level of dominance: barely noticed * linkage: None ** Other noticed terms/ keywords expected to be in relation to this study topic: None	**Main observations:** Dominant words: Spatial augmented reality, augmented reality, and virtual reality ascendingly. Level of dominance: noticed * for the three mentioned terms. linkage: None ** Other noticed words expected to be in relation to this study topic: adaptive control, nonexpansive mapping, dynamic projection mapping, video mapping, cultural heritage, architecture, projection mapping, calibration, surface interaction, and animation.	**Main observations:** Dominant words: Projector, patient, heritage, and case. Level of dominance: slightly noticed * linkage: slightly noticed * ** Other noticed terms/ keywords expected to be in relation to this study topic: None	**Main observations:** Dominant words: augmented reality, mapping, spatial augmented reality, and human. Level of dominance: noticeable * linkage: noticeable * ** Other noticed terms/ keywords expected to be in relation to this study topic: projector calibration, camera calibration, calibration, mapping, public space, computer vision, dynamic projection, image processing, visual perception, design spaces, extended reality, and user interface.

** These evaluations are based on observations and analysis of the resulting bibliometric maps and the analysis of three aspects of the terms used: existence, dominance, and linkage.*
*** These terms were noted as potential terms relevant to this study topic.*
These evaluations were ordered descendingly as noticeable, moderately noticeable, slightly noticeable, barely noticeable, none (-).

A: Represents the weighted sum for words existing in text-data-based bibliometric maps. **Each word took a weight of 1.**

B: Represents the weighted sum for words existing in bibliographic-data-based bibliometric maps. **Each word took a weight of 1.**

C: Represents the weighted sum for words existing as dominant in text-data-based bibliometric maps. **Each word took a weight of 2.**

D: Represents the weighted sum for words existing as dominant in bibliographic-data-based bibliometric maps. **Each word took a weight of 2.**

A+C = text-data-based category total

B+D= Bibliographic-data-based category total

E: The total weight of the words according to their frequency and dominance in the bibliometric maps.

E = (A+C) + (B+D).

$\mathbf{E}_{w} = (A_w + C_w) + (B_w + D_w)$ . . . The total for the WOS database.

$\mathbf{E}_{s} = (A_s + C_s) + (B_s + D_s)$ . . . The total for the SCOPUS database.

In the table above, the majority of words fall into the categories of "technical" and "application". "Related technologies", "related fields", and "devices" have the lowest number and score of words. The categories of "applications", "cultural heritage", "visualization", and "media facades" received the highest scores. Thus, they are more frequently found in bibliometric maps and are dominant in some cases. Bibliometric maps based on text analyses received a higher score in the category of "technical" for results related to the WOS database on one occasion. In this kind of data (text-based), "related technologies", "related fields", and "related devices" obtained the lowest totals, respectively, with scores of 0,0,0 in the WOS database and 2,0,2 in Scopus.

In addition, it was indicated that there is a lack of research on SVP in the fields of architecture, landscape architecture, urban design, and urban planning. This result is in line with WOS and Scopus' primary analyses. Among these fields, SVP-related research was not even among the top ten. The majority of SVP research has been conducted in computer science, engineering, and mathematics. This applies to both databases.

The Scopus database showed another record, receiving a 1 for text-data analysis in the category "synonyms". Text-based versus bibliographic scores differed significantly in some categories. WOS, for instance, scored 15 for text-based data and 35 for bibliographic data in the "applications" category. In the category of "related terms", records (1,13) were also found. Compared to Scopus, WOS scores showed wider differences (Table 4).

The text-based data analysis scores are higher, which indicates that more research has been done on this category. It is only applicable to the category "technical". Based on the bibliographic-data-based analysis, the score might indicate that the words are only used as keywords or in the title of the research instead of in the actual text.

Table 4. The categories that resulted from the observation of bibliometric maps and the total of the resulting words in each category/ field

Categories (Thematic fields)	**Words**	**WOS database** (Aw+Cw)+(Bw+Dw)=Ew	**Scopus database** S(As+Cs) +(Bs+Ds)=Es	**Total** Ew + Es
Technical	problems, color, adaptive control, dynamic projection mapping, calibration, surface interaction, animation, Projector, mapping, projector calibration, camera calibration, computer vision, dynamic projection, image processing, user interface, operation, speed, projector-camera system, content, device, modality, light form, industry, surface, robot, viewpoint, human-computer interaction, HCI**, human-machine interface, interfaces, projection, image reconstruction, algorithm, system, positioning error, model, position control	26+23=**49**	13+22=**35**	49+35=**84**
Applications	cultural heritage, visualization, media facade, Installations, Heritage, design space, activity, event, real-world application,, communication, smart environment, decision-making, Exhibit, museum, graffiti, restoration, interaction design, collaboration, playful placemaking, communicative unit, game, design process, architectural design, play, media, education, pedagogical space, design exploration, social spaces, public pedagogy, place-making, tactical urbanism, urban development, co-design activism, participatory design, park visitation, recreation, physical activity, management, integration	15+35=**50**	13+17=**30**	50+30=**80**
Others *	patient, case, human, Practice, concept, designer, physical environment, efficiency, research, experiment, application, design, design challenges, author, health, experience, urban governance, community, young people, meet live, displacement, urban agriculture, architect, COVID-19**, land use, urban sprawl, climate change, microclimate, outdoor thermal comfort	10+13=**23**	9+5=**14**	23+14=**37**
Synonyms	spatial augmented reality, video mapping, projection mapping, SAR** technology	6+25=**31**	1+3=**4**	31+4=**35**
Effects/ efficiency	visual perception, perception, spatial presence, visibility, important role, interaction, spatial, awareness, user, experience, identity, community interaction, adaptation, belonging, reflections, intercultural, engagement, access, equity, quality, recognition	6+17=**23**	5+5=**10**	23+10=**33**
Related concepts/ topics	nonexpansive mapping, digital twin, city, urban HCI**, non-rigid surface, urban computing, smart city/ies, urban informatics, cities, urbanism, sustainability, digital technology/ies, digital, urbanization, ICT**	5+20=**25**	3+5=**8**	25+8=**33**
City components/ elements/ aspects	public space, site, facade, area, place, urban space, space, garden, neighborhoods, urban environment, location, public urban place, Park, public open space, built-environment, socio-economic status, urban green, space, urban parks	6+13=**19**	4+6=**10**	19+10=**29**
Related terms	augmented reality, virtual reality, extended reality, mixed reality, reality	1+13=**14**	2+12=**14**	14+14=**28**
Related technologies	urban screens, public displays, media architecture, digital screen	0+13=**13**	2+3=**5**	13+4=**18**
Related Fields	architecture, urban planning, urban design, planning public open spaces, landscape	0+10=**10**	0+6=**6**	10+6=**16**
Devices	HMD**, head mounted display, helmet-mounted display, wearable technology, interactive devices, interactive display, mobile-media	0+1=**1**	2+5=**7**	1+7=**8**

Categories explanations:
Technical: expected to pertain to some technical aspects of SVP.
Applications: reflect some utilization of SVP.
Synonyms: includes these words that are synonyms to SVP.
Effects/efficiency: the effect that SVP or some related technology applications could leave.
Related concepts/topic: some concepts that SVP could relate to.
City components/elements/aspects: city spatial elements.
Related terms: some terms related to SVP.
Related technology: technologies that are similar in one or more aspects to SVP.
Related fields: including fields of research of practice in the domain of this study topic.
Device/s: the devices that may be used in the process of SVP.
* Other: if the terms were not considered to be under any of the above categories, they were specified as other, and this category was *discarded from the analysis*.
** VOSviewer processes all the words in small letter format, except for abbreviations.
The numbers in **bold** represent Ew and Es

Analysis of all keyword groups in bibliometric maps

It was found that bibliographic data-based maps produced more relevant results when analyzing all keyword groups together for each of the databases (WOS and Scopus) separately. It is also consistent with the results of the previous analysis of the separate groups. Text-based bibliometric maps lack relevance to the topic of the current study, whereas bibliometric maps are derived from bibliographic data. Both the WOS and Scopus databases are affected by this fact. Health, system, and park dominated text-based bibliometric maps in the WOS database; there was also a clear link between the words, although there was no evidence of dominance or linkage in the Scopus database (Table 5). Following the discussion in the previous sections, words were categorized based on their presence and dominance. This section provides further information about the links between words that are relevant to this study.

Regarding the topic of this study, a map based on the WOS database shows that placemaking, spatial augmented reality, cities, and public open space dominate the bibliometric map based on bibliographic data. In the Scopus bibliometric map, human-computer interaction and augmented reality are the dominant words. These two databases show some words that deserve attention: sustainability, design, perception, management, public display, smart city, and visualization (Table 5). These words also appear on the bibliometric maps discussed previously.

Once the mouse cursor moves over a word, VOSviewer highlights other words associated with it. For this study, some words were selected in order to examine how they relate to other words. The research landscape can thus be better understood (Figure 3).

As shown in Figure 3a, the words "spatial augmented reality" are situated independently, with a slight link to "projector-camera system". Similar bibliometric maps show "public open space" links to more words than "spatial augmented reality". Considering its size and linkage with other words, the word "place-making" dominates.

The Scopus database bibliometric map in Figure 3b shows "urban design" as a stand-alone word without links to other words. This research examines the use of SVP for the benefit of POS, which is relevant to urban design. Similarly, spatial augmented reality relates to fewer words when compared to human-computer interaction and augmented reality on the same bibliometric map.

Findings and recommendations

According to the previous discussion, bibliographic-data-based maps visualized words related to this study. However, text-based bibliometric maps were expected to provide the most accurate picture of the current state of research. Text-data analysis, as discussed in the methods and materials section, includes existing research titles and abstracts, which are more comprehensive than bibliographic-data analysis, which is focused on just keywords and titles.

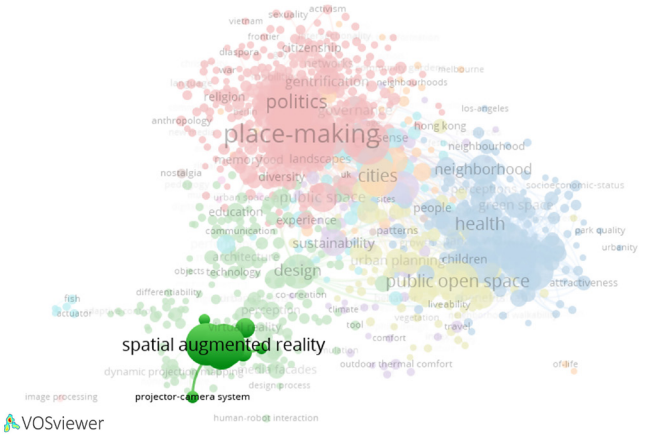
Spatial augmented reality, its synonyms, or related technologies have gained some prominence based on bibliometric maps. However, they do not have a significant connection to architecture, landscape architecture, urban design, or public open spaces. This study investigated the categories derived from the analysis of the bibliometric maps. Words in the category "related fields" were the least frequently mentioned. Bibliometric maps obtained by analyzing all keyword groups together provided further insight into the linkage of "related fields". For instance, "urban design" stands out alone among bibliometric maps in the category of "related fields".

Findings from this study are consistent with those from a manual literature review. Many studies have been published on SVP, but most are technical (Zhou *et al*., 2008; Halskov *et al*., 2014; Krauth, 2015). The most frequently used words fall under the category of "technical". According to text-based data

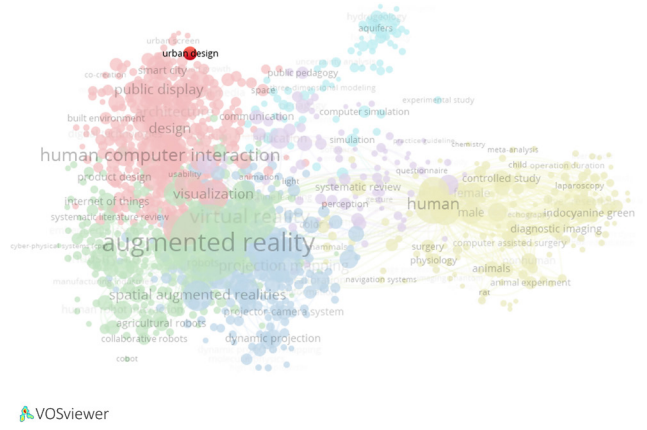
Table 5. Summary of the main observations related to the bibliometric maps that resulted from the analysis of all groups of keywords together for each database separately.

All Groups of keywords records were analyzed together.			
WOS		Scopus	
Text-data-based bibliometric map	**Bibliographic-data-based bibliometric map**	**Text-data-based bibliometric map**	**Bibliographic-data-based bibliometric map**
Main observations: Dominant words: system, park, and health. Level of dominance: noticeable * linkage: moderately noticeable * ** Other noticed terms/ keywords expected to be in relation to this study topic: None	**Main observations:** Dominant words: place-making, health, Spatial augmented reality, cities, and public open space. Level of dominance: noticeable * linkage: noticeable * ** Other noticed terms/ keywords expected to be in relation to this study topic: sustainability, design, perception, and management.	**Main observations:** Dominant words: projector, group, patient, and book. Level of dominance: barely noticeable* linkage: barely noticeable * ** Other noticed terms/ keywords expected to be in relation to this study topic: None	**Main observations:** Dominant words: Human-computer interaction, augmented reality, and humans. Level of dominance: noticeable * linkage: noticeable * ** Other noticed terms/ keywords expected to be in relation to this study topic: Spatial augmented reality, public display, smart city, public pedagogy, and visualization.

** These evaluations are based on observations and analysis of the resulting bibliometric maps and the analysis of three aspects of terms: existence, dominance, and linkage.*
*** These terms were noted as potential terms relevant to this study topic.*
These evaluations were ordered descendingly as noticeable, moderately noticeable, slightly noticeable, barely noticeable, none (-).



a. WOS
Spatial augmented reality term linkage with other terms.



b. Scopus
Urban design term linkage with other terms.

Figure 3. The links of specific words with others in the bibliometric maps resulting from the all keyword group analyses for the WOS and Scopus databases (Source: Authors, 2023)

analysis, this category also scored the highest. This category is perhaps the most researched. The subject of SVP has been discussed more frequently in the context of architectural heritage and pedagogy than in the context of public spaces in architecture, landscape architecture, and urban design (Moghaddam, 2014; Maniello *et al*., 2016; Nofal *et al*., 2018; Barber *et al*., 2017; Calixte and Leclercq, 2017). On the other hand, some digital technologies other than SVP have been discussed in terms of their impact on public open spaces. Media architecture, media facades, urban screens, virtual reality, and augmented reality are some of them (Tscherteu and Tomitsch, 2011; Tomitsch *et al*., 2015; Wiethoff and Hussmann, 2017).

The research of SVP related to architectural heritage and pedagogy provides a foundation for research in urban public open spaces. In addition, it is important to discuss SVP technology and its potential applications to enhance urban spatial experiences. Possible discussions include digital place-making, hybrid spaces, and urban media environments.

Comparing SVP with other digital technologies used to enhance urban landscapes is crucial. In comparisons, the potentials, advantages, disadvantages, and overall impacts are considered. A practice-based study is essential for determining the effectiveness of SVP for POS development.

In this study, it was revealed that most research on SVP focused on its technical aspects. Cityscape design and development were not the focus of most of these studies. Therefore, this study reveals a research gap in this area. The importance of interdisciplinary and multidisciplinary research is also emphasized. Collaboration between architecture disciplines and other disciplines is essential to enhance research and practice. This will fill a gap in the current research environment. The discussion should also include smart cities and sustainability. Sustainability goals in urban planning and design can be achieved by technology. SVP's impact on POS enhancement is a subject for further research. A reading of the existing research landscape in connection with the initiated topic is provided as a foundation for future research and practice. The study also provides a methodological approach to bibliometric data analysis, based on co-occurrences of words using VOSviewer. Therefore, this methodology has the potential to be used to explore the SPATIUM Journal research coverage, which is the venue for this study. The journal could be analyzed for key terms and topics together with the related classifications. Bibliometric analysis provides insights into the journal's research trends. Milinković (2016) conducted a bibliometric analysis of SPATIUM. This study provided only a brief overview of the keywords associated with the journal, which were analyzed based on bibliographic information in that study. To gain a better understanding of journal research landscapes, bibliometric VOSviewer analysis based on text data is recommended.

CONCLUSION

The utilization of spatial video projection for POS revitalization and development is an emerging research topic. By using bibliometric analysis, this study provided in-depth insight into the international research landscape related to this topic. The study demonstrated the rarity of SVP-related research in architecture, landscape architecture, and urban planning and design. There is a gap in the available research between these fields and other disciplines, which indicates the importance of interdisciplinary and multidisciplinary research. Therefore, discussion on this technology and its potential applications is recommended. This will enhance the spatial experience of contemporary urban public open spaces. The development of strategies for establishing collaboration between disciplines is of utmost importance. Ultimately, this study has aimed to lay the foundation for future research and practice in this area, providing a framework for situating emerging research topics within the context of existing research.

Acknowledgements

This research study supports the continuing Ph.D. thesis of Lima Najjar in the Graduate School at Istanbul Technical University.

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Received January 2023; accepted in revised form May 2023.
First published: 30 June 2023.