

## #134.

### From streets to screens:

A deep dive into urban configuration and Google reviews

Müslüm Hacıar\*<sup>1,2</sup>, Özge Öztürk Hacıar\*<sup>1,3</sup>, Diego Altafini<sup>2,4</sup>, Luca Pappalardo<sup>3</sup>, Fatih Gülgen<sup>1</sup>, Valerio Cutini<sup>2</sup>

\*Corresponding authors: mhacar@yildiz.edu.tr and ozgeo@yildiz.edu.tr  
diego.altafini@phd.unipi.it; luca.pappalardo@isti.cnr.it; fgulgen@yildiz.edu.tr;  
valerio.cutini@unipi.it

<sup>1</sup>Department of Geomatic Engineering, Yildiz Technical University

<sup>2</sup>Department of Energy, Systems, Territory and Construction Engineering, University of Pisa

<sup>3</sup>Knowledge Discovery and Data Mining Laboratory, ISTI-CNR

<sup>4</sup>Welsh School of Architecture, Cardiff University

---

#### ABSTRACT

*The experiences of urban visitors are frequently captured and shared on various websites and social platforms through reviews and ratings. These "digital footprints" help us understand what visitors think about a certain place. High visitor traffic may stem from the urban layout and configuration, such as the importance of a street, the building characteristic, or the location of the place within an urban settlement. Hence, these digital footprints are shaped by a complex interplay of spatial, emotional, self-organizational, and socio-behavioural factors. This presents us with compelling research questions: To what extent does urban configuration influence these digital footprints? And how exactly does this dynamic play out? This research examines the intricate relationship between urban spatial characteristics and digital footprints in the realm of urban tourism. Our approach taps into Space Syntax metrics and associates them with places, extracted as points of interest from Google Maps API. This framework helps ascertain what is the linkage between urban configuration and visitors' digital activities, to reveal another layer of social behaviour within the cities. Our research centred on the historic city of Sassi di Matera, Italy, distinguished by its cave dwellings and intricate pathways. Initial findings from our research present significant correlations between Space Syntax metrics and visitors' reviewing activities at specific places. By correlating the configurational patterns with reviews and ratings, we observed that these places are influenced by surrounding space, and that this situation varies depending on the type of place.*

#### KEYWORDS

Urban morphology, space syntax analysis, digital footprint, Google Maps API, social media data

## 1 INTRODUCTION

Human interactions with urban spaces are increasingly captured through the concept of the digital footprint—trails of data we leave behind as we navigate cities. The digital footprint encompasses a wide spectrum of data, from geo-tagged photographs to online reviews, each piece offering valuable insights into visitor behaviours and preferences in different environments. Studies have demonstrated the profound impact of place and location on these digital traces, suggesting that the configuration of an urban space can significantly influence the activities and behaviours of its visitors (Girardin et al. 2008, Martí et al. 2020). This relationship between place and digital presence is foundational to urban studies and provides a powerful tool for analysing the interplay between physical spaces and the virtual world.

Among the scientific methods for investigating urban space, Space Syntax stands out as a particularly robust approach. It allows for a detailed examination of the spatial configurations and their implications for social interaction (Hillier and Hanson 1984, Hillier 2007) and pedestrian movement (Ozbil et al. 2011, Monokrousou and Giannopoulou 2016, Lee et al. 2020, Öztürk Hacı et al. 2020, Fareh and Alkama 2022) within urban environments. This theoretical and methodological framework has been effectively employed to explore the correlations between the physical layout of places and the digital footprints of visitors, yielding insights into how urban design influences online behaviour and perceptions. Visitors leave behind a trail of digital footprints, rich with insights into their urban experiences. Girardin et al. (2008) emphasize the importance of digital footprints, including georeferenced photos and mobile network data, in uncovering tourists' movements and behaviours in urban spaces. This aligns with the findings of Önder et al. (2016) who discuss the value of tracing these footprints to understand tourist behaviour. The research explores using Flickr's geo-tagged photos as an indicator for tourism demand, demonstrating the potential of digital footprints in analysing tourist behaviour. McElhinney et al. (2022) introduces a novel computational approach for identifying 'aha moments' in spatial configurations using isovists, with applications in urban design and cognitive psychology. This method, applied to various case studies, highlights systematic potential locations for sudden spatial understanding, linking physical space perception to cognitive experiences. Maldonado-Gil and Psarra (2022) analyses Instagram images from three London locations to understand social dynamics and spatial characteristics. It employs a new algorithm to assess visibility and interaction within these urban spaces, demonstrating the value of social media data in urban analysis. Of course, several factors such as the trustworthiness of online evaluations (Filiari 2016), the motivations behind the sharing of online experiences (Hennig-Thurau et al. 2004) and regional attractiveness in tourism (Giambona and Grassini 2020) may keep such scientific research far from building a general theory. Nevertheless, these trend-like aspects

contribute to a more comprehensive understanding of the interaction between urban spaces and visitor experiences mediated through digital platforms.

The Space Syntax includes techniques such as axial analysis, which utilizes convex maps to analyse lines of sight and movement potential within an environment, and road centre line (RCL) analysis, which examines the centrality of street networks (Dalton 2001, Turner 2001, Turner 2004, Turner 2005, Turner 2007, Penn et al. 1998). These methodologies facilitate the measurement of various spatial properties, such as integration, connectivity, and choice, which have been shown to correlate with pedestrian movement patterns and, by extension, with digital footprints (Hillier 2009, Peponis et al. 2007). Hillier (2009) and Hillier and Stonor (2010) delve into the concept of spatial sustainability in cities and strategic urban design. Their research provides a framework for understanding urban spaces as networks, contributing to our understanding of how urban form and configuration shape social interactions and visitor experiences.

To effectively study digital footprints within urban spaces, it is essential to analyse geospatially accurate data that retains the locational context of user interactions. Google Maps API emerges as a valuable resource, providing a vast database of geolocated reviews and ratings that reflect visitor impressions of specific points of interests (POIs) (Martí et al. 2020). Analysis of review counts and ratings can reveal visitor engagement with a place, and potentially indicate that visitors may be similarly influenced by similar spatial features in different locations. Scientific research has begun to explore these correlated relationships, offering new insights into the spatial dimensions of visitor experiences (Xiang et al., 2017; Maldonado-Gil and Psarra 2022).

In this paper, the subsequent sections present the specifics of spatial data generation, the distinctive urban fabric of Sassi di Matera, and the statistical approach applied to examine the correlations between spatial configurations and visitor's digital feedback. Readers can anticipate the methodological framework in Section 2, followed by a presentation of quantitative results in Section 3, which examines the correlation trends of spatial measures within visitors' rating scores and the number of reviews.

## **2 MATERIALS AND METHODS**

### **2.1 Spatial data generation**

This study examines the relationships between spatial configuration of places in Sassi di Matera, Italy and digital footprints of their visitors derived from Google Maps API. We propose an approach to transforming all source maps into a combined ready-to-use report for subsequent statistical analysis.

The study utilizes Space Syntax' software Depthmap X (2018) to produce axial lines, which capture the most direct and interconnected routes, and RCL segments that highlight significant pathways within the urban settlement. Axial line generation is constrained by a convex map which simplifies

the intricate web of roads into a more manageable form, presenting the spaces among building areas. The complexity of Sassi di Matera, distinguished by its cave dwellings, steps, and intricate pathways, led us to apply a pragmatic rule-based approach to generate the convex map. The pre-process begins with topological cleaning of municipal main road polygons, which are extracted from ZTL (Limited Traffic Zone) and APU (Urban Pedestrian Areas) layer in OpenData Matera (2023) (Figure 1). This step is to ensure the integrity and accuracy of the data, which is paramount for the reliability of the subsequent fusion process. Also, OpenStreetMap (OSM) data, known for its extensive and current road information, comes into play, where tag-based buffering delineates areas of interest according to specific road attributes (OSM Map features 2024). In this process, buffer widths are determined by the type of *highway=\** and the presence of other tags. For instance, *unclassified* and *service* roads are buffered by 2.5m, *tertiary* roads by 5m, and *pedestrian* and *footway* roads are given a narrower buffer of 1.5 and 1m respectively, reflecting their relative importance and usage in urban navigation. Similarly, path and steps roads are buffered by 1m. Notably, while *residential* roads with an asphalt surface are buffered by 5m, other residential roads are given a buffer of 2.5m, emphasizing the higher traffic flow and significance in urban connectivity. These buffer thresholds are observed manually on satellite images via Google Earth (2023) and on corresponding roads via QGIS (2022). Following the buffering, a fusion of municipal- and OSM-based polygons forms a comprehensive representation of the convex map (Figure 2).

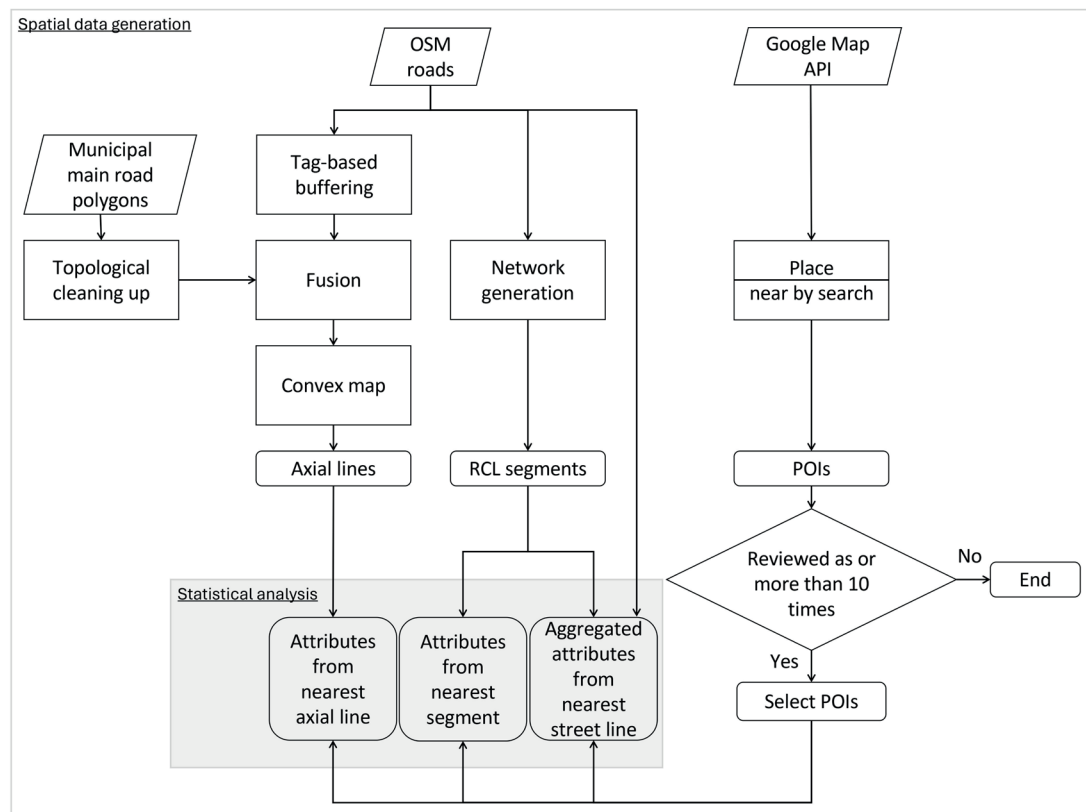
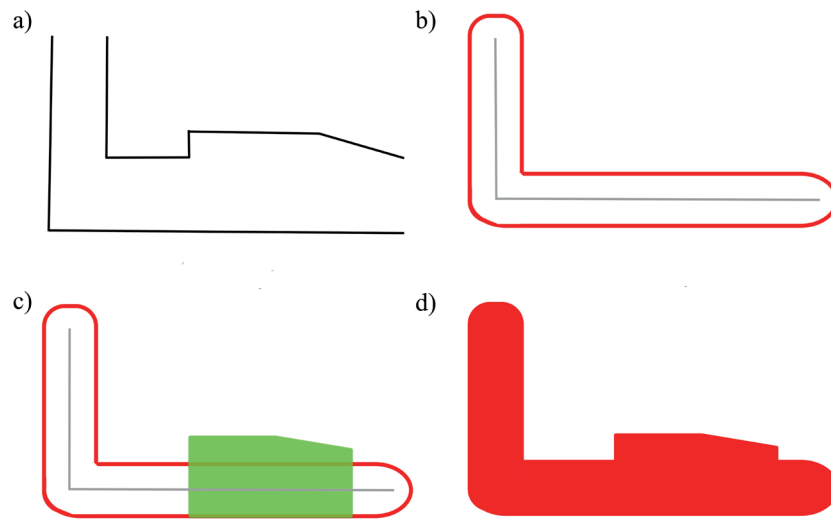


Figure 1: Workflow of the spatial data generation for statistical analysis.



**Figure 2:** Fusion of municipal polygons and tag-based buffers: a) real-world road entities (black), b) buffer (red) generation surrounding OSM road data (grey), c) a polygon (green) from ZTL & APU layer, and d) fusion (red) of all polygons.

The attributes of measures in axial lines and RCL segments are central to the study as they represent potential movement flows and interactions within the urban fabric.

Google Maps API (2023) plays a critical role in providing a dynamic and near real-time collection of POIs through its 'Nearby' search functionality for places. The inclusion criteria for POIs are selective, requiring a minimum of ten reviews to ensure relevance and significance in the urban context, highlighting the popularity of the places.

Each POI is associated with the nearest axial line, nearest RCL segment, and nearest street. While the attributes from the nearest axial line and RCL segments are directly associated with the POIs, we also propose an aggregated association that considers the mean of attributes from all segments corresponding to the nearest street, offering a detailed snapshot of the street-level features. As a result, the configuration attributes of places are associated with the digital footprints (reviews and ratings in Google Maps) of visitors in three methodological flows (Figure 1).

## 2.2 Study area and data structures

The study focuses on the Sassi di Matera, a historical settlement in Italy, celebrated for its unique urban fabric and recognized as a UNESCO World Heritage Site. Matera is characterized by its spontaneous urban structure, known as 'self-organized,' which emerges from the irregular and complex network of pathways and public spaces without the influence of modern urban planning. This complexity is further accentuated by the intricate system of stairs and arches, which contribute to the distinctive and convoluted layout of the city (Figure 3). These elements create

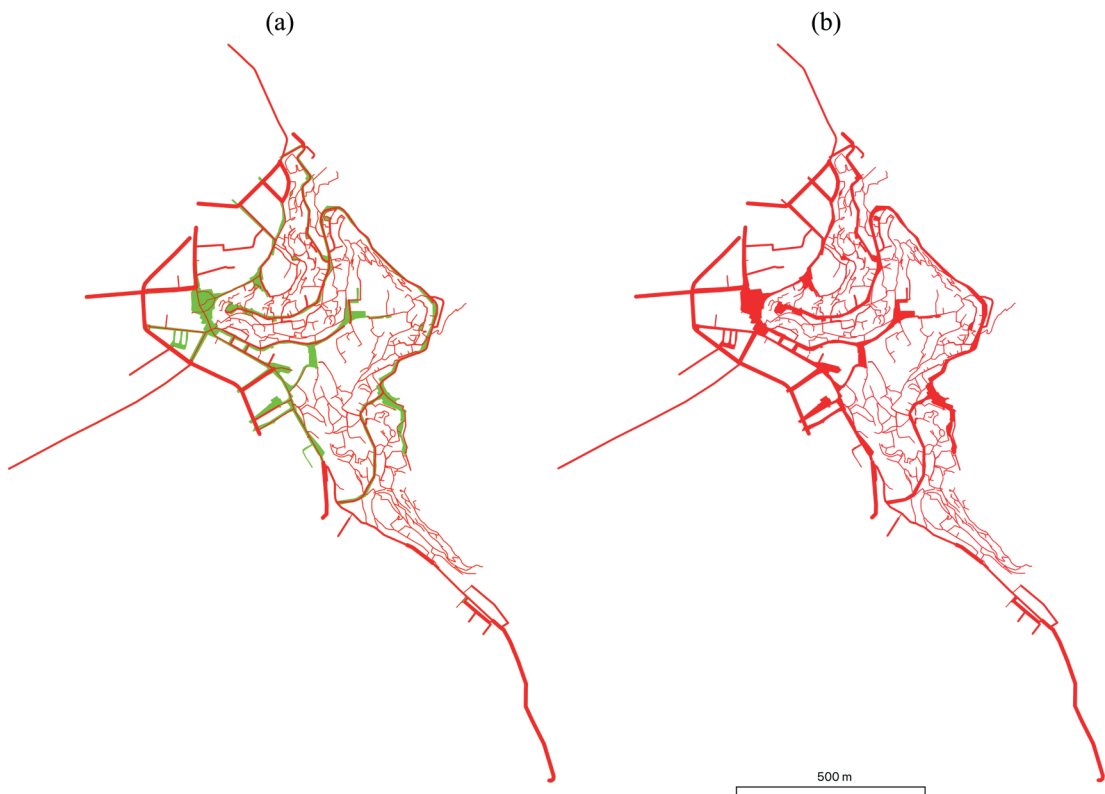
a challenging landscape for spatial analysis because of the labyrinthine-like pattern instead of conventional grid system.



**Figure 3:** Study area and the street views from Google Maps (2024).

The OSM data, a critical component of the study, is a volunteer-generated repository of global spatial information. Within this dataset, the '*highway*' key values play a crucial role as they categorize the road classes, providing a hierarchical structure (OSM Map features, 2024). This OSM road data is instrumental not only in generating the RCL segments, which identify significant routes within the urban matrix, but also in creating the convex map, which abstracts the complexity of the city's layout into a more practical form.

Municipal polygons, extracted specifically from the ZTL and APU layer (OpenData Matera 2023), was utilized to complement the OSM data. These polygons cover the surfaces of some of the most significant roads within the historical city. They are crucial in refining the tag-based buffers converted from OSM roads, enhancing the precision of the convex map representation (Figure 4). These polygons fine-tune the data to mirror the actual urban space more accurately, enabling a more realistic and detailed understanding of its complex urban structure.



**Figure 4:** The tag-based buffers (red in (a)), municipal polygons (green in (a)), and the fusion of them (b).

### 3 STATISTICAL RESULTS

This section presents the statistical analysis correlating the spatial measures derived from axial lines and RCL segments with the digital footprints of visitors, as indicated by Google Maps ratings and the number of reviews. The analysis employs Pearson correlation coefficients to explore these relationships within the urban fabric of Sassi di Matera. Figure 5 illustrates the Pearson correlations of the axial measures with visitors' rating scores (Figure 5a) and the number of reviews (Figure 5b). Notably, negative correlations (represented in red) suggest that longer line lengths and higher choices within axial lines are associated with lower visitor rating scores at museums. Conversely, a positive correlation (green) with the Harmonic Mean Depth indicates that more accessible churches are rated more favourably. For the number of reviews, a positive correlation with the Entropy measure can be seen in Figure 5b. Entropy measures the distribution of locations of spaces in terms of their depth from a space, rather than the depth itself. This indicates that the more symmetric is the distribution of depth is around a certain road-element, higher is its entropy (Hillier et al. 1987). This indicates that places that are more regular in the distribution of its surroundings – which also would deem them more accessible, as Integration tends to be higher on orthogonal spaces – tend to receive more reviews. This suggests that areas with more accessible and regular spatial layouts may encourage visitors to engage more with the place.

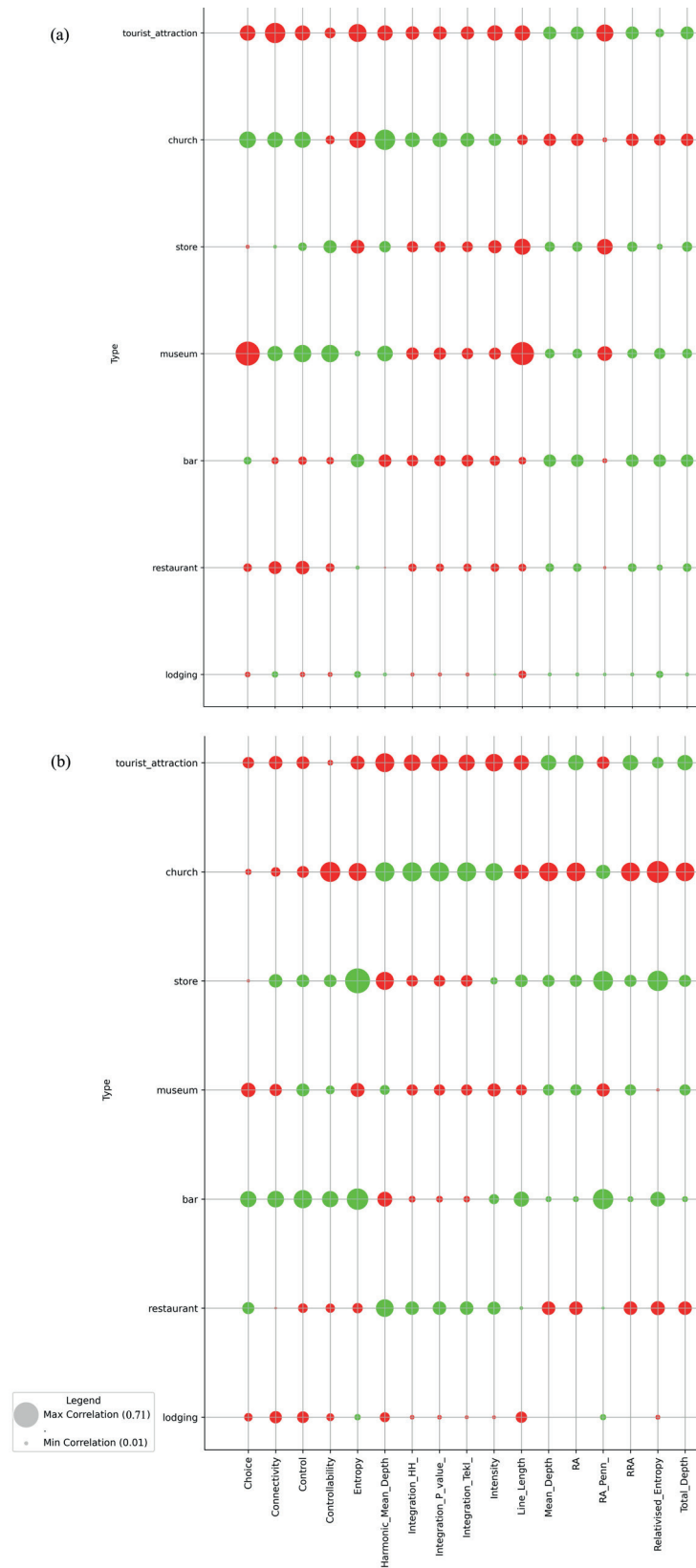


Figure 5: Pearson correlations of the axial measures with (a) visitors' rating scores and (b) the number of reviews on places: positive correlation (green) and negative correlation (red).

Figure 6 and Figure 7 depict the correlation of RCL measures with rating scores and the number of reviews, respectively. The Segment Length and T1024 Choice display strong negative correlations with visitors' rating scores. This suggests that the museums close to shorter segments and have less choice value in RCL segments has the potential of higher ratings. The trend continues with the number of reviews, where lower Integration and higher Total Depth are indicative of a greater number of reviews, reflecting greater visitor engagement. Moreover, Table 1 consolidates the measures with more than a 50% correlation with visitors' rating scores and the number of reviews on places. A striking observation is the highly correlated measures are entropy and integration-based metrics for number of reviews and choice-based measures for visitors' ratings.

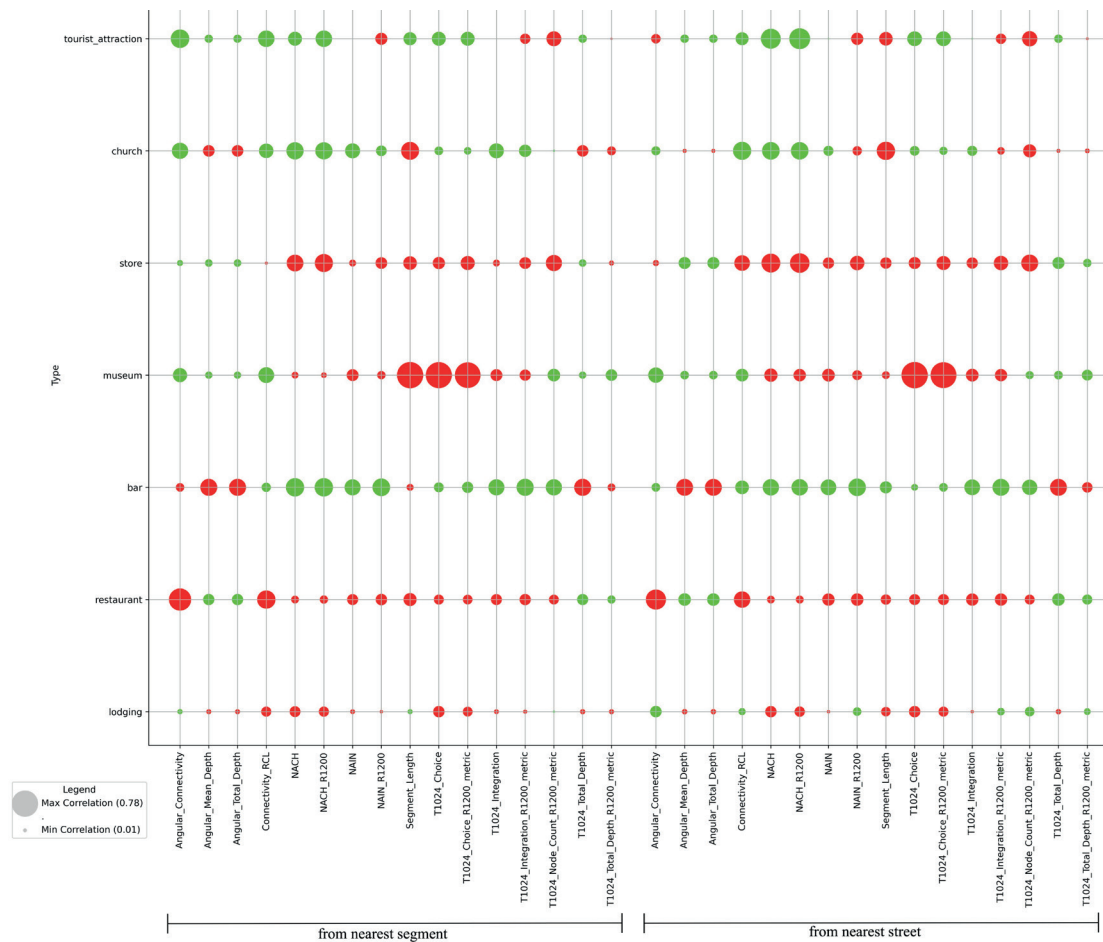
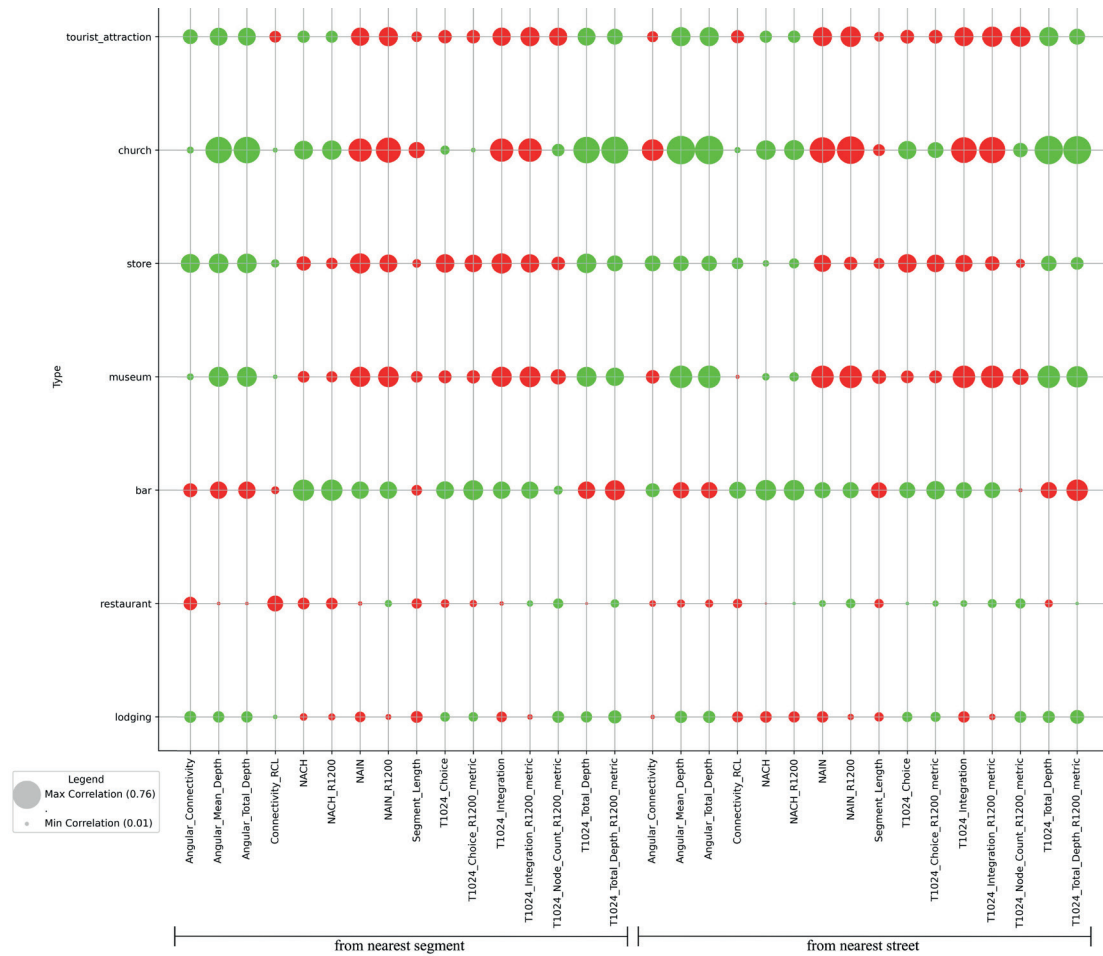


Figure 6: Pearson correlations between RCL measures and visitors' rating scores on places: positive correlation (green) and negative correlation (red).



**Figure 7:** Pearson correlations between RCL measures and the number of reviews on places: positive correlation (green) and negative correlation (red).

Table 1 shows the RCL measures retrieved by 'Nearest street' have higher correlations than segment-based RCL measures, which remarks novelty of using the aggregation approach to associating the measures to the places. Table 2 also supports the success of the 'Nearest street' association. The aggregation approach is more commonly linked with the maximum correlation values. This suggests a broader approach, considering the collective characteristics (mean values) of all segments within a street to evaluate their impact on visitor reviews and ratings at a certain place. This aggregated method may capture the compound effects of the street's spatial configuration, providing a more holistic view of how the urban form influences visitor experiences. It underscores the importance of the street in visitor engagement rather than individual RCL segments.

**Table 1:** The measures more than 50% correlated with visitors’ rating scores and the number of reviews on places.

Reviews	POI	Map	Association	Measure	Corr.
Visitors’ rating scores	museum	Axial	Nearest line	Choice	-0.714
				Line Length	-0.656
	church			Harmonic Mean Depth	+0.503
	tourist_attraction			Connectivity	-0.502
	museum	RCL	Nearest segment	Segment Length	-0.781
				T1024 Choice	-0.771
				T1024 Choice R1200	-0.746
	restaurant			Angular Connectivity	-0.551
	museum	RCL	Nearest street	T1024 Choice	-0.784
				T1024 Choice R1200	-0.758
Number of reviews	store	Axial	Nearest line	Entropy	+0.625
	church	RCL	Nearest segment	T1024 Total Depth R1200	+0.686
				T1024 Total Depth	+0.655
				Angular Mean Depth	+0.654
				Angular Total Depth	+0.654
				NAIN R1200	-0.592
				T1024 Integration R1200	-0.516
				NAIN	-0.505
				T1024 Integration	-0.505
	church	RCL	Nearest street	T1024 Total Depth	+0.759
				Angular Mean Depth	+0.759
				Angular Total Depth	+0.759
				T1024 Total Depth R1200	+0.733
				NAIN R1200	-0.718
				T1024 Integration R1200	-0.645
				NAIN	-0.620
				T1024 Integration	-0.620

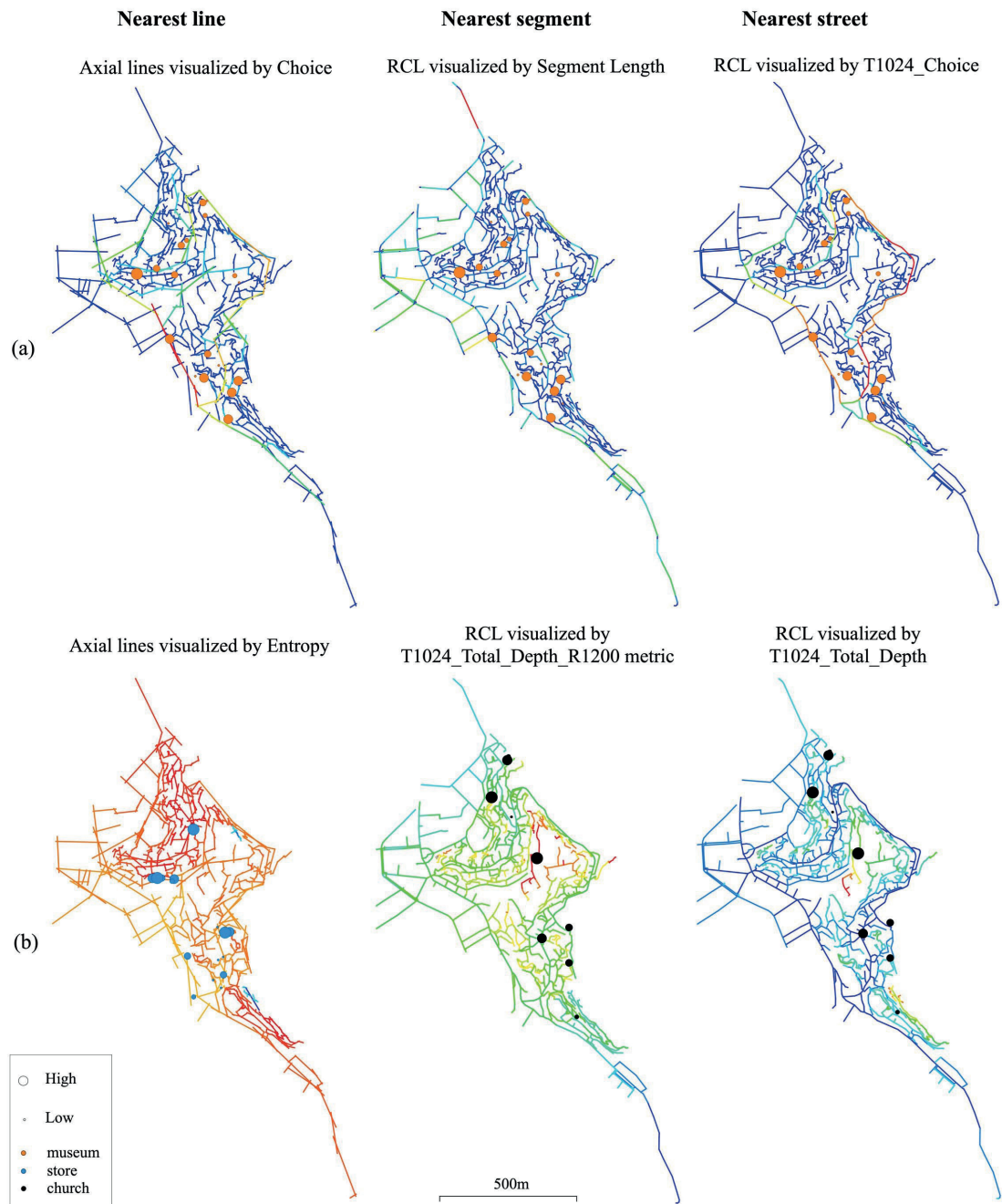
**Table 2:** Minimum and maximum absolute correlation (Corr.) values of visitors' rating scores and number of reviews for each place.

Reviews	Corr.	POI	Map	Association	Measure
Visitors' rating scores	Minimum	bar	Axial	Nearest line	RA Penn
		church	RCL	Nearest segment	T1024 Node Count R1200
		lodging	RCL	Nearest segment	T1024 Node Count R1200
		museum	RCL	Nearest segment	NACH R1200
		restaurant	Axial	Nearest line	Harmonic Mean Depth
		store	RCL	Nearest segment	Connectivity
		tourist_attraction	RCL	Nearest segment	NAIN
	Maximum	bar	RCL	Nearest segment	NACH R1200
		church	Axial	Nearest line	Harmonic Mean Depth
		lodging	RCL	Nearest street	Angular Connectivity
		museum	RCL	Nearest street	T1024 Choice
		restaurant	RCL	Nearest segment	Angular Connectivity
		store	RCL	Nearest street	NACH R1200
		tourist_attraction	Axial	Nearest line	Connectivity
Number of reviews	Minimum	bar	RCL	Nearest street	T1024 Node Count R1200
		church	RCL	Nearest segment	T1024 Choice R1200
		lodging	Axial	Nearest line	RA
		museum	Axial	Nearest line	Relativised Entropy
		restaurant	RCL	Nearest street	NACH
		store	Axial	Nearest line	Choice
		tourist_attraction	Axial	Nearest line	Controllability
	Maximum	bar	Axial	Nearest line	Entropy
		church	RCL	Nearest street	T1024 Total Depth
		lodging	RCL	Nearest street	T1024 Total Depth R1200
		museum	RCL	Nearest street	NAIN R1200
		restaurant	Axial	Nearest line	Harmonic Mean Depth
		store	Axial	Nearest line	Entropy
		tourist_attraction	RCL	Nearest street	NAIN R1200

Table 2 categorizes the minimum and maximum absolute correlation values between visitors' rating scores / number of reviews, and various spatial measures for each type of place. A particularly intriguing pattern emerges when considering bars, which in the Italian context often serve as places for breakfast and social gatherings, and stores, the commercial hubs for transactions and interactions. The minimum correlations for the number of reviews are particularly telling, as 'T1024 Node Count R1200' for bars and 'Choice' for stores suggest that these spatial measures may not significantly drive review counts. However, the maximum correlations seen with 'Entropy' for both bars and stores indicate that areas with more accessible and regular spatial layouts may encourage visitors to engage more with these places. Similarly, it is observed that 'NACH R1200', which denotes the Normalised Angular Choice within a 1200-m radius, exhibits maximum absolute correlations in relation to visitor ratings: a positive correlation for bars, but a negative one for stores. This could imply that while bars benefit from their central locations within the urban network, enhancing visitor satisfaction, stores may not necessarily receive higher ratings for similar centrality, possibly due to the increased competition or congestion associated with such locations.

Table 1 and 2 also show that some of the measures such as 'T1024 Integration R1200', 'T1024 Choice R1200', 'T1024 Total Depth R1200', and 'NAIN R1200', which are limited by a radius of 15-minute walk distance (i.e., 1200m), have commonly higher correlations with visitors' experiences. This suggests that spaces designed within 15-minute city concepts may have a pronounced impact on visitor behaviour and/or satisfaction.

Finally, Figure 8 allows us to see the spatial distribution of the maximum correlations, offering potential insights into how different places within the urban network align with the digital footprints left by visitors. The ratings at museums are highly but negatively correlated with Choice (in axial), Segment Length (in RCL), and T1024\_Choice (in aggregated RCL). Therefore, higher correlated museum POIs align with blue lines in each map visualisation in Figure 8a. The number of reviews is positively correlated with Entropy at stores, T1024 Total Depth R1200, and T1024 Total Depth at churches. The higher correlated POIs are commonly close to red or yellow lines in each map in Figure 8b.



**Figure 8:** Visualizing by highest correlated measures with (a) visitors' rating scores and (b) the number of reviews on places.

#### 4 CONCLUSIONS

This research presents the complex connection between the spatial characteristics of urban environments and the digital reflections of visitor experiences as captured in Google reviews. By leveraging the analytical power of Space Syntax metrics combined with the richness of Google Maps API data, we have identified a clear correlation between urban spatial attributes and the patterns in visitor activities and their digital feedback.

Our findings reveal that spatial dimensions such as accessibility, centrality, and the configuration of pathways significantly influence visitor perceptions and interactions with places of interest. The positive and negative correlations between spatial measures and digital footprints illuminate the diverse ways in which urban form can impact visitor experiences. As a result, certain spatial characteristics can affect visitor satisfaction differently across various types of places.

The methodological approach of associating spatial measures in RCL to POIs using the 'Nearest street' technique has proven to be particularly effective, offering a nuanced understanding of how the collective spatial configuration of streets influences visitor experiences. This suggests that urban planners and researchers can benefit from aggregated spatial characteristics of urban environments to enhance the attractiveness and satisfaction of urban spaces.

Our research contributes to the ongoing dialogue on the importance of integrating urban planning and digital data analysis to foster more engaging and satisfying urban environments. The correlations drawn between Space Syntax measures and digital footprints not only validate the relevance of spatial analysis in understanding urban experiences but also open up new avenues for enriching the urban experience through data-driven insights.

## REFERENCES

Dalton, N. (2001, May). Fractional configurational analysis and a solution to the Manhattan problem. In *Space Syntax 3rd International Symposium*, Atlanta.

depthmapX development team. (2018). depthmapX (Version 0.8.0) [Computer software]. Retrieved from <https://github.com/SpaceGroupUCL/depthmapX/>

Fareh, F., & Alkama, D. (2022). The effect of spatial configuration on the movement distribution behavior: The Case Study of Constantine Old Town (Algeria). *Engineering, Technology & Applied Science Research*, 12(5), pp. 9136-9141.

Filieri, R. (2016). What makes an online consumer review trustworthy?. *Annals of Tourism Research*, 58, pp.46-64.

Giambona, F., & Grassini, L. (2020). Tourism attractiveness in Italy: Regional empirical evidence using a pairwise comparisons modelling approach. *International Journal of Tourism Research*, 22(1), pp.26-41.

Girardin, F., Calabrese, F., Fiore, F., Ratti, C., & Blat, J. (2008). Digital Footprinting: Uncovering Tourists with User-Generated Content. *IEEE Pervasive Computing*, 7(4), pp.36-43.

Google Earth. (2023). View of Matera. Available at: <http://www.google.com/earth/index.html> [accessed on 1 September 2023].

Google LLC. (2023). Google Maps API. [online] Available at: <https://developers.google.com/maps> [accessed on 1 September 2023].

Google LLC. (2024). Google Maps Street View images from Matera streets. Available at: <https://www.google.com/maps/place/Matera/> [accessed on 1 February 2024].

Hennig-Thurau, T., Gwinner, K. P., Walsh, G., & Gremler, D. D. (2004). Electronic word-of-mouth via consumer-opinion platforms: what motivates consumers to articulate themselves on the internet?. *Journal of Interactive Marketing*, 18(1), pp.38-52.

Hillier, B. (2007). *Space is the machine: a configurational theory of architecture*. Space Syntax.

Hillier, B. (2009). Spatial sustainability in cities: organic patterns and sustainable forms. In *Proceedings of the 7th International Space Syntax Symposium*, Stockholm, Sweden.

Hillier, B., & Hanson, J. (1984). *The social logic of space*. Cambridge University Press.

Hillier, B., Hanson, J., & Graham, H. (1987). Ideas are in things: an application of the space syntax method to discovering house genotypes. *Environment and Planning B: planning and design*, 14(4), pp.363-385.

Hillier, B., & Stonor, T. (2010). Space Syntax - Strategic Urban Design. *City Planning Review, The City Planning Institute of Japan*, 284.

Lee, S., Yoo, C., & Seo, K. W. (2020). Determinant factors of pedestrian volume in different land-use zones: Combining space syntax metrics with GIS-based built-environment measures. *Sustainability*, 12(20), 8647.

Maldonado-Gil, G., & Psarra, S. (2022). Constructing Sociospatial Maps from Instagram Images. In *Proceedings of the 13th International Space Syntax Symposium*. Bergen, Norway.

Martí, P., García-Mayor, C., & Serrano-Estrada, L. (2020). Taking the urban tourist activity pulse through digital footprints. *Current Issues in Tourism*, 24(2), pp.157-176.

McElhinney, S., Conroy Dalton, R., Dalton, N., & Mavros, P. (2022). Detection of Intelligibility leaps using Isovist-waves: joining the dots to map potential 'aha moment' locations. In *Proceedings 13th International Space Syntax Symposium*. Bergen, Norway.

Monokrousou, K., & Giannopoulou, M. (2016). Interpreting and predicting pedestrian movement in public space through space syntax analysis. *Procedia - Social and Behavioral Sciences*, 223, pp.509-514.

OpenData Matera (2024). ZTL e APU. Retrieved from <http://dati.comune.matera.it/dataset/ztl-e-apu> [accessed on 1 February 2024].

OpenStreetMap Wiki. (2024). Map Features. Available at: [https://wiki.openstreetmap.org/wiki/Map\\_Features](https://wiki.openstreetmap.org/wiki/Map_Features) [accessed on 1 February 2024].

Ozbil, A., Peponis, J., & Stone, B. (2011). Understanding the link between street connectivity, land use and pedestrian flows. *Urban Design International*, 16, pp.125-141.

Önder, I., Koerbitz, W., & Hubmann-Haidvogel, A. (2016). Tracing tourists by their digital footprints. *Journal of Travel Research*, 55(5), pp.566-573.

Öztürk Hacı, Ö., Gülgen, F., & Bilgi, S. (2020). Evaluation of the space syntax measures affecting pedestrian density through ordinal logistic regression analysis. *ISPRS International Journal of Geo-Information*, 9(10), 589.

Penn, A., Hillier, B., Banister, D., & Xu, J. (1998). Configurational modelling of urban movement networks. *Environment and Planning B: Planning and Design*, 25(1), pp.59-84.



Peponis, J., Allen, D., French, S., Scoppa, M., & Brown, J. (2007, June). Street connectivity and urban density. In *6th International Space Syntax Symposium*, Istanbul, Türkiye.

QGIS, Firenze version 3.28 LTR (2022). Available in: <http://www.qgis.org/en/site/index.html> [accessed on 1 September 2023].

Turner, A. (2001, May). Angular Analysis. In S. Peponis, J., Wineman, J. & Bafna (Ed.), *Proceedings 3rd International Space Syntax Symposium*, Atlanta.

Turner, A. (2004). Depthmap 4: A researcher's handbook. *Bartlett School of Graduate Studies, University College London*. London, UK.

Turner, A. (2005). Could A Road-centre Line Be An Axial Line In Disguise? *Proceedings 5th International Space Syntax Symposium*, pp.145–159.

Turner, A. (2007). From axial to road-centre lines: a new representation for space syntax and a new model of route choice for transport network analysis. *Environment and Planning B: Planning and Design*, 34(3), pp.539-555.

Xiang, Z., Du, Q., Ma, Y., & Fan, W. (2017). A comparative analysis of major online review platforms: Implications for social media analytics in hospitality and tourism. *Tourism Management*, 58, pp.51-65.

