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THE MALTESE TOWNHOUSE: A SPACE SYNTAX ANALYSIS

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Abstract. *This article applies space syntax analysis to investigate how spatial organisation shapes residential space in the Maltese archipelago. It focuses on the typology of the townhouse, a distinctive urban dwelling widely found across the Maltese islands characterised by the presence of a courtyard. Constructed in local building limestone, this type of unit is typically erected on two storeys, with variable depth and width depending on the size of the building plot. Through space syntax analysis, information is extracted on how the network of domestic spaces responds to the needs of the building's users. The study reinforces traditional observations that the courtyard is a crucial space within the spatial layout of this residential typology. Identified as a central space, it conditions the way inhabitants move through and perceive the dwelling.*

Keywords: *space syntax*, *accessibility*, *visibility*, *connectivity*, *townhouse*, *Malta*.

Introduction

Li et al. define space syntax as (a) a theory of urban planning and design, and (b) a software-based technology.[1] As regards to the former, it refers to Hillier and Hanson:[2] "space syntax differs from classical urban morphology because it focuses on open space systems to pursue a form of spatial representation."[3] Thus, space syntax analysis (SSA) is an analytical technique used in urban morphology and behaviour research. It has been applied to investigate street networks and visitors' preferences;[4] a recent application of this kind is a study of socio-spatial relations in the urban spaces of Tirana by Yunitsyna and Shtepani.[5] Given that SSA has fractal properties, it is suitable for application at every design level, whether micro or macro, "starting from the smallest unit of space, such as [a] room and continuing with the analysis of the apartments, buildings, neighbourhoods, districts and cities."[6] Recalling Hillier and Vaughan,[7] Dettlaff notes that "the availability inside buildings and inside neighbourhoods or cities can be explored in the same way."[8] A comprehensive

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[1] Li et al. 2016, p. 31.

[2] Hillier, Hanson 1984.

[3] Li et al. 2016, p. 31.

[4] Ismail et al. 2010; Li et al. 2016.

[5] Yunitsyna, Shtepani 2023.

[6] Ibid., p. 2.

[7] Hillier, Vaughan 2007.

[8] Dettlaff 2014, p. 289.

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overview of the various concepts that are used in SSA – a review of its literature, concepts and applications – is given by Yamu et al.[9]

SSA has been applied to urban contexts in the Maltese archipelago – composed of three habitable islands: mainland Malta, sister island of Gozo, and Comino (**fig. 1**) – by Formosa[10] and Said-Zammit.[11] The most recent example is by Borg and Bianco[12] who applied SSA to the vernacular farmhouse, a residential typology with the potential to inspire contemporary sustainable architectural design solutions.[13]

Fig. 1. The Maltese archipelago: (left) the location within the Mediterranean Basin; (right) the islands of Malta and Gozo with the location of Birgu (red pin) and the Citadel (green pin), respectively (© Google Earth)

Based on archival, comparative, and historical research, the study by Said-Zammit focuses on the evolution of residential spaces from the late medieval period to the second part of the twentieth century.[14] His research included decoding domestic space and village settlements through space syntax.[15] The study was based on a survey of thirty historic houses he deemed representative of the various residential typologies – farmhouse, townhouse, palazzo, cave dwelling and village house (the preceding two being the predecessor and successor of the farmhouse, respectively), maisonette, and apartment.[16] The objective of this article is to expand on Said-Zammit's

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[9] Yamu et al. 2021.

[10] Formosa 2000.

[11] Said-Zammit 2016.

[12] Borg, Bianco 2025.

[13] See Bianco 2016; Bianco 2017.

[14] Said-Zammit 2016.

[15] Ibid., p. 228–280.

[16] Ibid., p. 333–365.

research with reference to the townhouse typology, a theme covered by the dissertation developed by Borg.[17]

Space syntax

Prior to Hillier and Hanson,[18] Michael Benedikt studied ways to represent glimpses of sensory and non-sensory inter-relationships within a given space.[19] A better understanding of the human experience within such a space may reveal how it has, and continues to subconsciously influence users and how, in turn, users can be informed to design spaces that respond to their needs.

The axial map and the convex map are two models which represent a given spatial system.[20] The former is the "least set of … straight lines which passes through each convex space and makes all axial links (…) and a convex map [is] (…) the least set of fattest spaces that covers the system."[21] The four basic syntactic parameters are computed during an SSA:[22]

1. connectivity,
2. depth/degree of depth,
3. control value (CV), and
4. integration/availability (local and global).

Connectivity "measures the number of neighbour axes directly connected to a space. It specifies the number of immediate neighbours of an axis."[23] Depth is "the smallest number of syntactic steps (in topological meaning) that are needed to reach one space from another."[24] The control value is

> the sum of the inverse values of the parameter connectivity of all neighbours from the selected axial line. It measures the degree to which a given space controls access to all immediate neighbours of the axis line.[25]

Integration is "a variable that refers to how a space is connected with other spaces in its surroundings. (...) The relationship between the global availability of space (global integration), and the local availability of space (local integration) is the clarity and readability of the space (intelligibility)."[26]

For ease of reading this article, the terms used in the text and as defined by Said-Zammit[27] are included in **table 1**. His definitions are based on the

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[17] Borg 2023.

[18] Hillier, Hanson 1984.

[19] Benedikt 1979.

[20] Hillier, Hanson 1984, p. 91–92.

[21] Ibid., p. 92.

[22] Dettlaff 2014, p. 288–289.

[23] Ibid., p. 287.

[24] Ibid.

[25] Ibid., p. 288.

[26] Ibid., p. 288–289.

[27] Said-Zammit 2016, p. 229, 246–247.

works of Grahame,[28] Laurence et al.,[29] Hillier,[30] Hillier et al.,[31] Kasemsook and Boonchaiyapruek,[32] and Turner et al.[33]

Term	Definition
total depth of a node *n*	Total of the shortest distances from node *n* to the other nodes in the system, that is TD(*n*) is the total of line *n* (or column *n*) in the distance matrix.
mean depth for a node *n*	The average depth (or average shortest distance) from node *n* to all other nodes or units.
integration value	Parameter that describes integration by a high number when a node is highly integrated; it describes the integration of one space in relation to all other spaces.
control value	The degree to which a unit controls access to its immediate neighbour; it considers the number of alternative connections that each of these neighbours has.
connectivity	This is a measure of the number of immediate neighbours that are directly connected to any given location.
entropy	The path of least disorder from a point to all other points within a system; low values indicate low disorder (which implies it is easy to move around), while high values show high disorder (it is hard to move around).
integration	The normalised measure of the mean shortest path from a particular point to all other points in the system, ranked from the most integrated to the most segregated.
mean depth	The shortest path through the graph to each other node, then summed and divided by the total number minus one.
total depth	The total of the shortest distances from point *n* to other points within the spatial network of a settlement.
control	Locations which are dominant over more constrained areas.
controllability	Locations that are more easily dominated.
through-vision	The point (or points) within the spatial network of a settlement which provides the highest degree of visibility.
choice	The quantity of movement that passes through each spatial element on the shortest or simplest trips between all pairs of spatial elements in a system and so corresponds to mathematical betweenness.

Table 1. Definitions of terms[34]

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[28] Grahame 2000, p. 34–35.

[29] Baldwin et al. 2013, p. 158–160.

[30] Hillier 1996, p. 47–53.

[31] Hillier et al. 2012, p. 155–193.

[32] Kasemsook, Boonchaiyapruek 2015, p. 1–12.

[33] Turner et al. 2001, p. 103-118.

[34] After Said-Zammit 2016, p. 229, 246–247.

The two metrics point first moment and point second moment are the first and second area moments of inertia of the isovist, respectively –

> they can be thought of as the potential for an isovist to spin around its generating point. More elongated isovists have more potential to spin, and that potential increases if the generating point is towards the edges of the shape. In that sense, the two metrics can be considered the inverse of compactness.[35]

Recalling Yunitsyna and Shtepani, when it comes to residential typologies, the visibility graph analysis (VGA graph) is generated by superimposing the grid on top of the planning layout and calculating the isovists from the centres of each grid cell.[36] In the case of residential typologies, the VGA graph is created by overlaying the grid on the planning layout and computing the isovists from the centres of each of the cells making up the grid.[37]

Purpose and methodology

The courtyard is a recurring but evolving feature within domestic spaces in Malta. This article analyses the relationship between this space and others in dwellings on the archipelago. Applying differing SSA to local case studies, this research attempts to: (a) provide insight into the dynamics of the courtyard within townhouses, (b) visually and numerically reveal – through graphical spatial representation and analysis – how this space plays a part in affecting users' activities and movements, and (c) apply space syntax to further understand the courtyard through a perspective governed by the user's experience, perception and movement.

This article tackles townhouses with a courtyard included in Said-Zammit's study,[38] namely, House 20 (H20), House 21 (H21), House 23 (H23), and House 24 (H24) (**table 2**).

Sample	Mode of access	Estimated % use of façade	Date of erection (century)	Number of windows		Number of rooms	
				external	internal	ground	first
H20	multiple	70	late 19th	3	4	8	9
H21	doorway	50	17th–18th	2	2	5	5
H23	doorway	25	17th	3	1	2	2
H24	doorway	25	17th–18th	1	1	2	2

Table 2. Samples of townhouses with a courtyard[39]

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[35] Koutsolampros et al. 2019, p. 6.

[36] Yunitsyna, Shtepani 2023, p. 2.

[37] For a discussion on the term isovist, see Conroy Dalton et al. 2022, and for definitions of the terms isovist area, visual control, and visual mean depth, see Yunitsyna, Shtepani 2023, p. 2–3.

[38] Said-Zammit 2016.

[39] Ibid., p. 355–356, 358–359.

All houses are constructed in load-bearing ashlar on two storeys with interconnecting rooms and an entrance from the public street. Only H23 and H24 have an uncovered staircase. Three of the case studies are located at the Citadel in Gozo, and date back to the times when the Hospitaller Order of Saint John ruled over the archipelago (1530–1798); the other one, H20, is in Birgu and belongs to the British Period (1814–1964). The study is based on their floor plans, reproduced in **fig. 2** to **fig. 5**. Houses H21 and H23 have a similar built-up footprint (H21: 116.5 m^2, H23: 129.5 m^2); H20 is the largest (247.8 m^2) while H24 has the smallest (74.4 m^2) footprint.

Three distinct types of SSA were applied:

1. access analysis,
2. VGA, and
3. axial line analysis (ALA).

Applying the *AGRAPH* software,[40] access analysis involves a form of spatial representation aimed at achieving a better understanding of spatial networks by converting the network to a graph. Nodes are represented in circles, each representing a space, and lines connecting them represent the physical connection of a space to another. By visualising spaces through such a manner, references of spatial patterns start to emerge.[41]

To evaluate visual and physical connectivity through the network, and thus provide insights into its morphological structure, VGA is undertaken using *Depthmap* software. A grid is applied to the dwelling plans and the areas to be analysed are selected. The software's analysis runs on point locations, each located at the centre of a grid square;[42] the unit size of the grid is selected to ensure optimal coverage of a given space. Analysis of each plan is performed on the selected attribute; a graph is generated that visually represents the range of values for a given dwelling – higher values are in warmer colours (red is the highest while dark blue is the lowest). Corresponding graph data are also produced alongside the graph, providing information on the minimum (min), maximum (max) and mean values.

ALA represents space as a set of axial lines;[43] it also makes use of *Depthmap*. Graphs are generated from each attribute. This analysis generates movement pattern and accessibility results, in contrast with the visibility and visible accessibility results reproduced by the VGA. Thus, ALA reveals different movement patterns, highly traversed areas within a given dwelling, and whether the courtyard directs human movement through the dwelling.

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[40] Manum 2005.

[41] Hillier, Hanson 1984, p. 147–155.

[42] Turner 2004, p. 9.

[43] Hillier, Hanson 1984, p. 91–92.

Results

The results obtained from each of the case studies are included according to each analytical technique being addressed.

Access analysis

As regards to access analysis, the movement along the entrance root and the courtyard root, and the corresponding justified accessibility graph for each sample were plotted and the respective access analysis for each was tabulated – control value, integration value, total depth TD(n), and mean depth – and are included in Borg.[44]

Each space within a given residential unit was assigned a consecutive integer, commencing with 0 as the root. "If a space has a CV of more than 1, then it is considered as a controlling space, while a space with a CV of less than 1 is considered as a controlled space."[45] The following colour notations were used:

⚪	entrance
🟡	courtyard
🔴	staircase
🔵	transitory space
⚫	room
🟤	terrace/balcony

The justified accessibility graphs for sample H20 are given in **fig. 2**. The entrance and courtyard roots exhibit a deep map structure. As regards to the former, most spaces require sequential access with multiple interconnected rooms at both ground and first floor levels. The courtyard is denoted as two connected spaces (8 and 9) both leading to other spaces; the staircase is located adjacent to it. Room 31 is the deepest space within the network while the corridor on the upper level (16) is the most central. The courtyard, while granting access to other spaces, does not have the highest integration value; however, it is considered a well-integrated space within the system. The courtyard has a high CV; while not being the dwelling's centre point, it is a valuable space for movement and connection. With the courtyard as the root space, high integration values were obtained for spaces 2, 12 and 16. Control is distributed throughout the dwelling, particularly in spaces 6, 8, 23 and 28, with most spaces being transitory and highly interconnected with adjacent spaces. Due to the interconnected nature of the rooms, although the courtyard provides access to multiple spaces within the dwelling, it is less central within the network. Room 31 exhibits the deepest space.

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[44] Borg 2023, p. 99, 102, 105, 108, 110, 112, 114, 116.

[45] Said-Zammit 2016, p. 229.

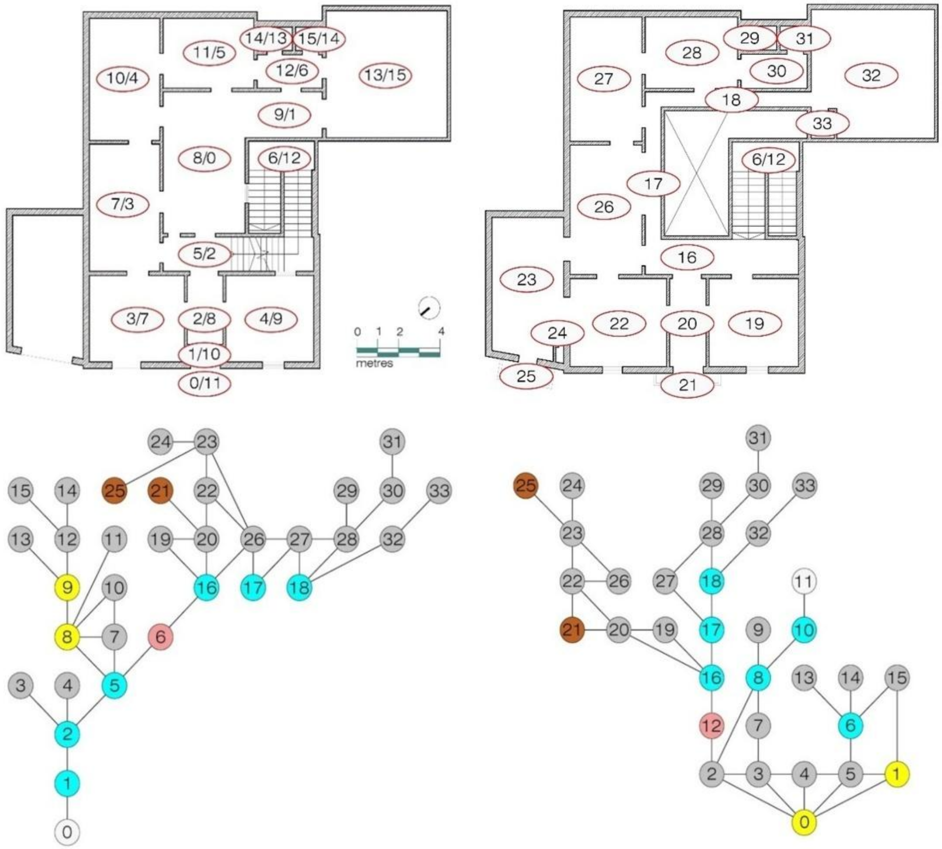

Fig. 2. House H20: (top) – (left) ground floor plan, [x/y] refer to movement along the entrance root [x] and the courtyard [y] root, and (right) first floor plan; (bottom) – justified accessibility graph for (left) entrance root and (right) courtyard root. © Authors

The justified accessibility graphs for H21 are given in **fig. 3**. The entrance and courtyard roots exhibit a similar map structure. As regards to the former, grouped spaces centre around foci (1, 5 and 12) and the sample displays a shallow graph structure. As in H20, the courtyard (5) is centrally located. These spaces have the highest CV, while the highest integrated space is the upper level corridor (10). Room 19 is the deepest, thus most private, while, similarly to H20, the upper level corridor – which has the lowest TD(*n*) value – is the most central space. The most controlling spaces include the courtyard and transition spaces 1 and 12. This suggests that the courtyard also served as a point of transition to access other spaces within the dwelling. Using the courtyard (0) as the root, high integration values are attributed to the main staircase (9) and upper level corridor; the latter remains integral from the entrance root map. Similarly to the entrance root, high CV scores were obtained for the courtyard and transition spaces 1 and 12. Similarly to H20, integration and control are primarily distributed to the courtyard and transition spaces within the dwelling; the upper level corridor is the centre of the network.

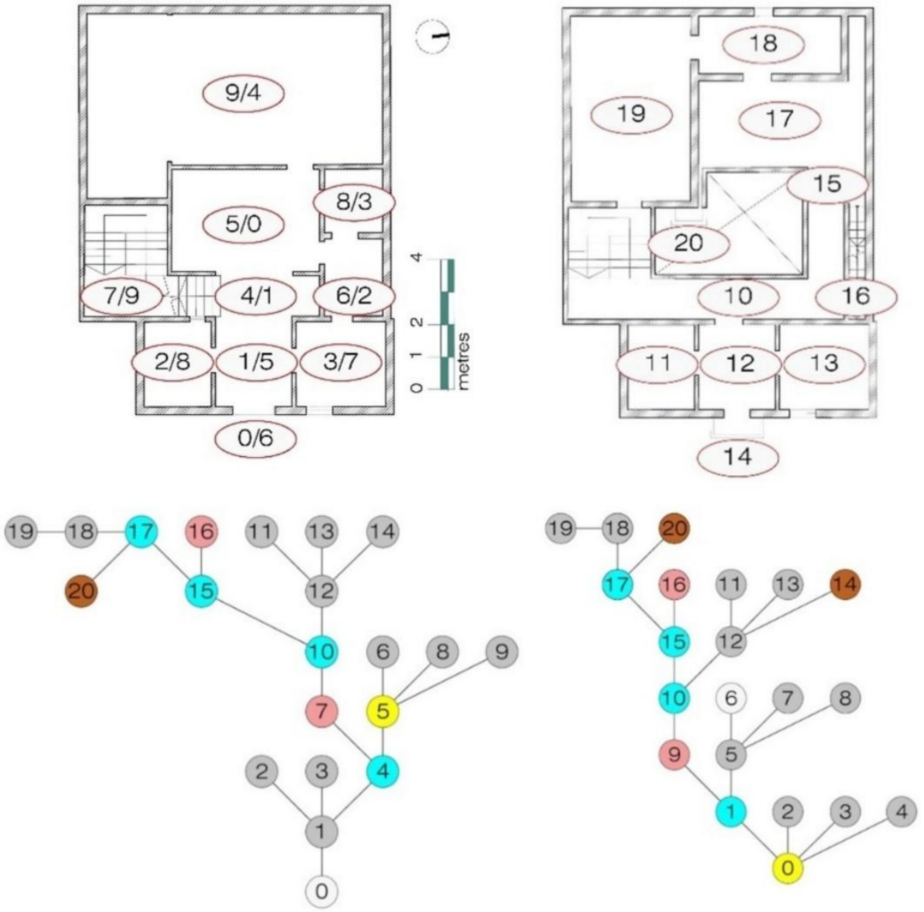

Fig. 3. House H21: (top) – (left) ground floor plan, [x/y] refer to movement along the entrance root [x] and the courtyard [y] root, and (right) first floor plan; (bottom) – justified accessibility graph for (left) entrance root and (right) courtyard root. © Authors

The justified accessibility graphs for H23 are given in **fig. 4**. This example has a deep map structure as most spaces are accessed sequentially, and it exhibits a less complex network than examples H20 and H21. The courtyard is in proximity to the main entrance and includes an open staircase, the only access to the upper level. With the entrance as root, a high CV is noted in space 1, which offers access to different spaces at the ground level. Higher integration values are distributed between transition space 1, the courtyard

(2) and the main staircase (5). The courtyard is central within the network; it has the lowest TD(*n*) value, while spaces 7 and 8 – being the deepest spaces within the network – have the highest. With the courtyard (0) as the root, the structure of the justified graph is shallow, with a high CV allocated to space 1. High integration values are similar for the entrance root. Spaces 7 and 8 have the highest TD(*n*) values and thus represent the deepest, most private spaces.

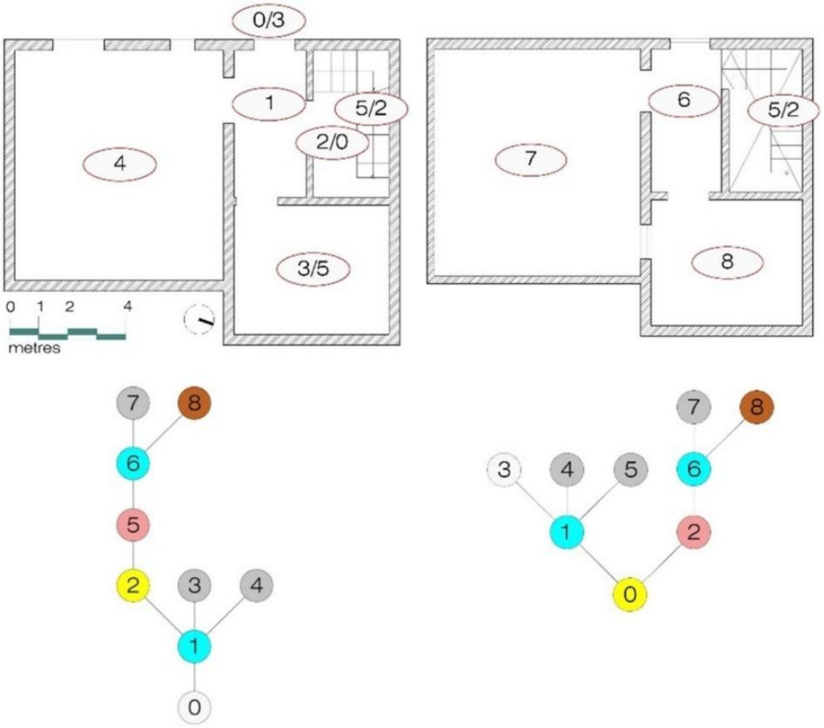

Fig. 4. House H23: (top) – (left) ground floor plan, [x/y] refer to movement along the entrance root [x] and the courtyard [y] root, and (right) first floor plan; (bottom) – justified accessibility graph for (left) entrance root and (right) courtyard root. © Authors

The justified accessibility graphs for H24 are given in **fig. 5**. Similar to H23, this example reveals a deep map structure and does not exhibit a complex system of spaces. Taking the entrance root, room 6, with the highest TD(*n*) value, is thus the deepest and most private space. The courtyard (3), which is central to the dwelling, has the lowest TD(*n*) value. This space is also characterised by the highest integration value, while space 1 is the most controlling space. This suggests that the courtyard is the most integrated space within the dwelling, but space 1 is the desired space that users go through.

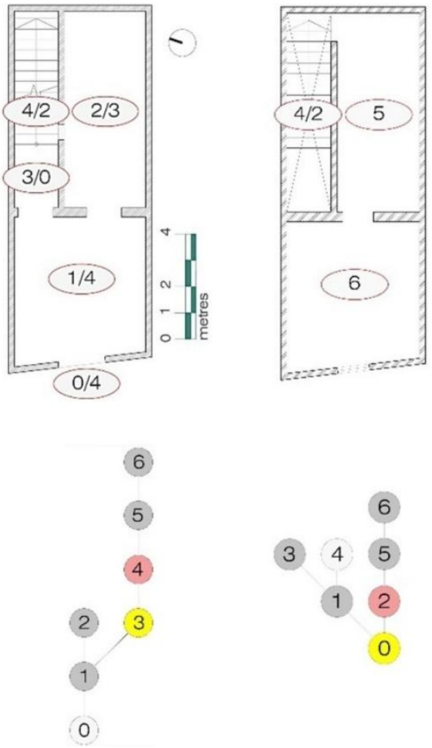

Fig. 5. House H24: (top) – (left) ground floor plan, [x/y] refer to movement along the entrance root [x] and the courtyard [y] root, and (right) first floor plan; (bottom) – justified accessibility graph for (left) entrance root and (right) courtyard root. © Authors

Visibility Graph Analysis

Data obtained for the VGA for each floor of each case study were tabulated for the following six studied attributes: connectivity (connect), the point first moment (Point 1), point second moment (Point 2), visual integration (HH), metric mean shortest-path distance (MMSPD), and through-vision (TV) (**table 3**). The metric distance is one of the three types of distance metrics used in SSA, the others being topological and geometrical, which correspond to the fewest turns and least angle change paths, respectively.[46] Each attribute can produce either "local" or "global" values. While the former are based on a point location of the adjacent surrounding spaces, the latter are influenced by the whole system of the selected grid area. The results are discussed according to the implication of different attribute values by focusing on similarities and differences between the courtyards. The respective graphs for connectivity

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[46] Turner et al. 2005; Turner 2007; Li et al. 2016.

are reproduced hereunder (**fig. 6**). While recalling Alagamy et al.,[47] Yunitsyna and Shtepani reiterate that connectivity in VGA denotes the total of the direct connections of a cell with the other cells and indicates its level of exposure: high connectivity indicates increased direct movement while lower connectivity relates to variations in movement.[48] The plots of the remaining attributes are included in Borg.[49]

		H20			H21			H23			H24		
		mean	**min**	**max**	**mean**	**min**	**max**	**mean**	**min**	**max**	**mean**	**min**	**max**
Ground floor	Connect	930	0.00	1900	760	0.00	1610	1120	5.00	1950	766	3.00	1220
	Point 1	4,140	0.00	10100	2780	0.00	7480	4450	1.17	9680	3080	0.683	6580
	Point 2	26700	0.00	87000	13600	0.00	52500	22700	0.28	66500	17700	0.160	53900
	HH	19.30	5.24	3530	12.00	5.87	92.40	13.40	5.85	73.5	23.90	11.5	87.6
	MMSPD	7.68	0.00	14.0	5.54	0.00	9.16	6.33	0.194	10.6	4.49	0.171	8.05
	TV	18700	0.00	82700	12300	0.00	50500	19300	0.00	58300	14000	0.00	56000
First floor	Connect	806	34.0	1550	389	0.00	765	1250	322	1940	866	164	1250
	Point 1	3110	25.3	7180	1030	0.00	2530	4980	921	10200	3400	340	5650
	Point 2	17200	21.4	55500	3680	0.00	12800	25000	3160	64600	19300	840	44700
	HH	7.44	3.69	11.7	4.44	2.35	7.79	16.3	6.46	46.9	31.4	7.27	396
	MMSPD	11.0	7.72	17.6	8.92	0.00	16.3	6.81	4.86	10.8	5.00	3.67	7.74
	TV	13900	0.00	71500	4500	0.00	17200	21600	0.00	58900	15300	0.00	58700

Table 3. Visibility graph analysis

Having an equal number of rooms at both ground and first floor levels, sample H20 exhibits a complex spatial network. The courtyard presents the highest connectivity values at the centre and at connections with adjacent spaces. At the upper level, high connectivity values are at room connections whereas the lowest are at distant areas from the dwelling's centre, such as balconies. Similarly, at ground floor level, high Point 1 and Point 2 values are within spaces adjacent to the courtyard. Such values are at the edge of the dwelling, where large visual distances are present; high values are also encountered at the upper level, where long distances can be viewed through aligned rooms. At these points the user has high visual control over large areas of the dwelling. Visual integration is equally distributed at the ground floor; however, on the first floor, higher values occur at room connections. The centre of the courtyard has low metric distance values; the lowest are in segregated spaces. The centre of the courtyard also presents low values that concentrically increase as one moves from its centre. At the upper level a similar scenario occurs, in that distances increase from a central low value area located in the middle of the connected spaces. Increased through-vision values

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[47] Alagamy et al. 2019.

[48] Yunitsyna, Shtepani 2023, p. 2.

[49] Borg 2023, p. 149–153, 156–158, 161–163, 165–167.

are located within the central courtyard at ground floor level; at the upper level, the highest values are between the connecting rooms. The high through-vision values indicate that the central courtyard is traversed more frequently than most spaces within the dwelling.

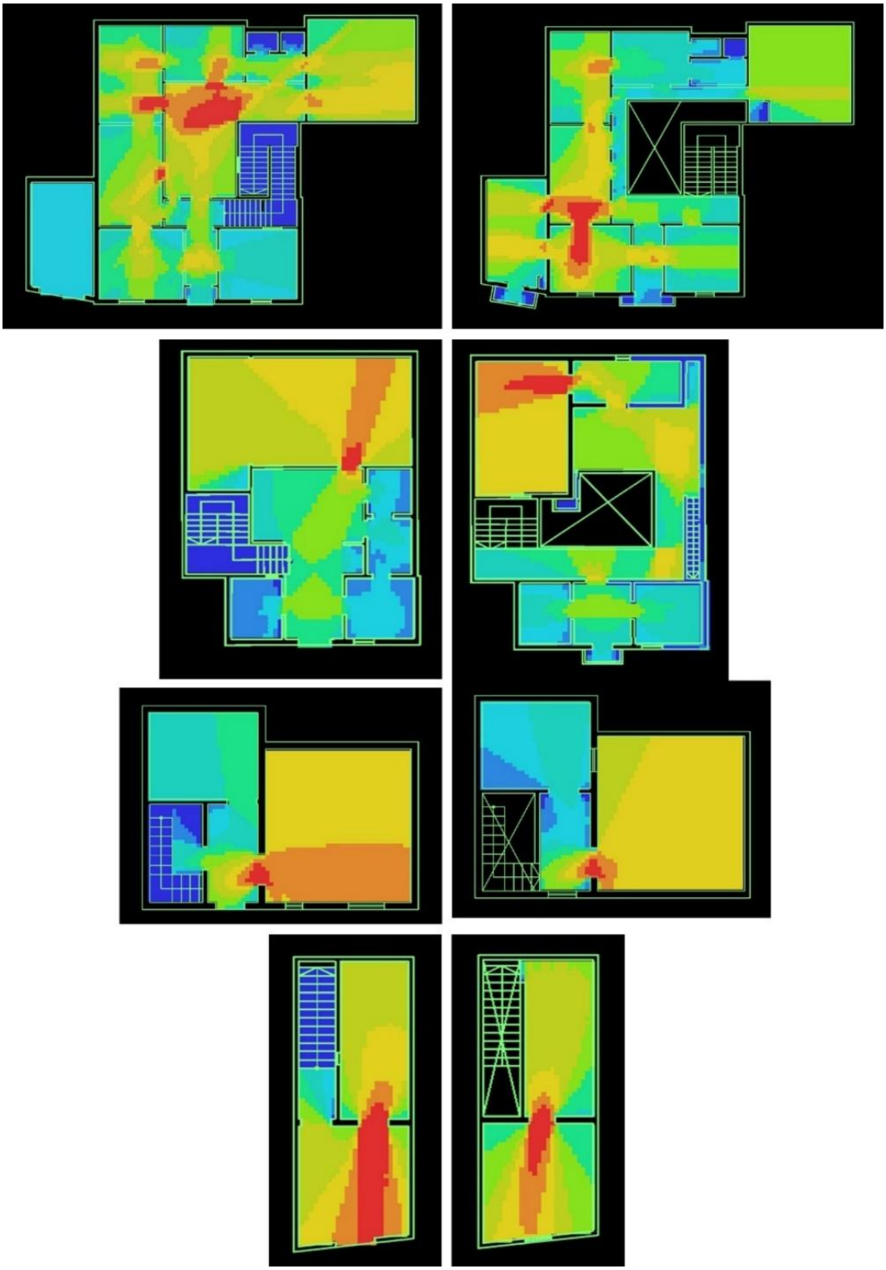

Fig. 6. Visibility graph (connectivity): (top to bottom) House H20, House H21, House H23, House H24; (left) ground floor and (right) first floor. © Authors

At ground floor level, high visual connectivity in H21 is present at the opening/junction between the courtyard and an adjacent space, while on the first-floor level the highest values are at a junction between two rooms. With regards to visual distances, high values occur at the same junction between the courtyard and an adjacent room and, due to interconnecting aligned openings, at the edge of the adjacent space. This is also visible at the far corners at first floor level. On both levels, high-value locations offer visual control and high visual information over most of the dwelling. Visual integration is more uniformly distributed across the ground floor level, with higher values at the connection between the courtyard and an adjacent room. At the upper level, high integration values occur along the transition spaces, whereas there is more segregation at the spaces located at the edges of the dwelling. The courtyard, at its connection to adjacent space, also displays low metric distance values, suggesting that the area is easily accessible and highly utilised. Similarly, at the upper floor level, the centre of the dwelling displays the shortest metric distance. The junction at both levels exhibits the highest through-vision values, making it a highly crossed-over space.

At ground floor level, the lowest level of connectivity in H23 is at the courtyard; the highest at both levels is at the junction between spaces. At both levels, Point 1 and Point 2 values are highest at the longest visual distances, that is, at the edges of the largest room. The courtyard does not offer visual control over the rest of the spaces. At both levels, visual integration of the largest room is higher than that of the courtyard, particularly at the access point to this room. Spaces 4 and 7 have the lowest metric distances, suggesting that they are central to the network and provide ease of access when traversed. In addition, along with their connection to the rest of the dwelling, they reveal high through-vision values and are thus indicative of highly active spaces and junctions.

Sample H24 displays high visual connectivity within the junction of spaces adjacent to the courtyard at both ground and first floor levels. At the location of the highest Point 1 and Point 2 values at ground floor level, the user experiences the highest visual distance and information across to the deepest part of the dwelling. Similarly, at first floor level, the front area of the house offers the same high visual distance. At both levels, the junction adjacent to the courtyard has the highest levels of visual integration. The junctions also display the lowest metric distances, suggesting that they are highly frequented. This is further reinforced by high through-vision values, making the junctions active points within the domestic network.

Axial Line Analysis

Data obtained for ALA for each floor of each case study were tabulated to three significant figures according to the following: connectivity (connect), choice, entropy, HH (visual integration), MD (mean depth), and control (**table**

4). The respective graphs for connectivity are reproduced in **fig. 7**; the plots of the remaining attributes are included in Borg.[50]

		H20			H21			H23			H24		
		mean	**min**	**max**	**mean**	**min**	**max**	**mean**	**min**	**max**	**mean**	**min**	**max**
Ground floor	Connect	*	*	*	132	16	235	47.7	6.00	67.0	33.0	14.0	48.0
	Choice	*	*	*	183	0.00	1240	42.5	0.00	178	28.5	0.00	116
	Entropy	*	*	*	1.07	0.77	1.42	1.12	0.779	1.56	1.09	0.706	1.54
	HH	*	*	*	10.7	3.50	25.4	9.64	2.07	17.3	8.48	3.17	18.5
	MD	*	*	*	1.60	1.22	2.63	1.51	1.23	2.89	1.48	1.19	2.08
	Control	*	*	*	1.00	0.233	1.79	1.00	0.382	1.46	1.00	0.517	1.42
First floor	Connect	138	5.00	306	37.6	2.00	69.0	20.1	8.00	27.0	13.6	10.0	17.0
	Choice	475	0.00	5340	351	0.00	3390	9.40	0.00	33.0	3.44	0.00	11.0
	Entropy	1.40	1.00	1.88	2.28	1.75	2.60	0.888	0.397	1.51	0.669	0.078	1.00
	HH	7.45	2.32	16.5	2.69	1.18	4.36	11.2	2.62	36.7	9.15	4.61	32.3
	MD	1.96	1.39	3.76	2.99	2.13	5.17	1.32	1.07	1.97	1.20	1.00	1.41
	Control	1.00	0.090	1.99	1.00	0.234	1.66	1.00	0.442	1.38	1.00	0.695	1.31

Table 4. Axial line analysis

Due to the complexity of sample H20, only the first floor level was analysed using *Depthmap*, as the programme crashed repeatedly when the ground floor ALA was carried out. High connectivity values are seen through paths cutting across connected rooms. High choice axial lines are also present within the same area, passing through interconnected spaces. Pathways through such spaces are ones that are frequently used to access segregated rooms while offering the user options to access multiple areas within the dwelling when moving along the path. Low entropy values are present across interconnected spaces while similar paths contain high integration values. Such characteristics suggest that the low value entropy paths are central to the domestic network while the high integration paths indicate that such pathways are highly integral to user movement across the level. Other analysed characteristics include mean depth and control, where low mean depth axial lines are spread across the dwellings and high control values are seen cutting across connected spaces through the dwelling. The high control axial lines indicate that such pathways provide the most access to different areas within the dwelling.

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[50] Borg 2023, p. 200–202, 204–206, 209–211, 213–215.

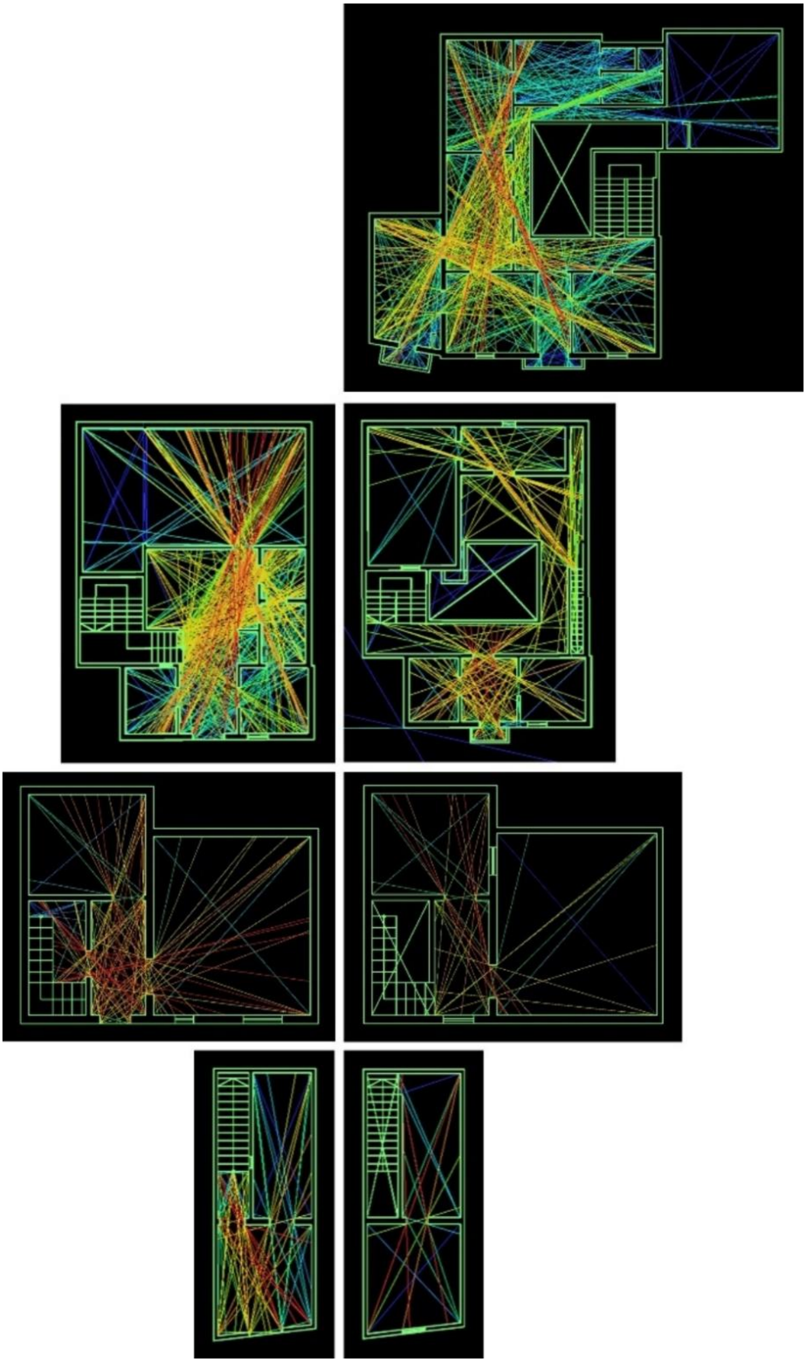

Fig. 7. Axial line graph (connectivity): (top to bottom) House H20, House H21, House H23, and House H24; (left) ground floor and (right) first floor. © Authors

High connectivity axial lines within H21 run across the dwelling through interconnected spaces, one of which is the courtyard, at ground floor level, while at first floor level they are located at the front connected rooms. At ground floor level, high choice values cross sequentially connected rooms, while at first floor level high choice axial lines pass through the transition spaces leading to other rooms. Low entropy values are dispersed across the ground floor level, while at first floor level transition spaces include the lowest entropy values, indicating that the other rooms are equally distributed from the transition spaces. At first floor level, high integration axial lines cross through the transition spaces, while at ground floor level high integration axial lines cross through connected spaces, similar to the high value axial lines. Low mean depth values cross through the connected dwelling spaces at ground floor level, while at first floor level these axial lines are within the transition spaces. Such lines suggest that these movement paths are central to the dwelling and require minimal effort to access. Within similar pathways at ground floor level, high control values are present indicating that such movement pathways allow the user to access multiple spaces within the dwelling.

Example H23 exhibits high connectivity axial lines at ground and first floor level, indicating that all spaces are highly interconnected. High choice values pass through the courtyard into an adjacent space at ground floor level and connect through all three spaces making up the first floor level. Low value entropy axial lines reach all areas of the dwelling on both levels, indicating that little effort is required to reach most spaces. With regards to integration values, most rooms lie on high integration axial line pathways on both levels, indicating that they are integral to the domestic network. Similarly, low mean depth paths link most spaces within the dwelling on both levels, indicating that most spaces require little effort to reach from any part of the dwelling. Also, high control pathways reach across to areas within the dwelling. Their distribution is likely due to the limited number of spaces that comprise each floor and their interconnected distribution, making movement patterns highly crossed over with one another. Within this context, the entryway space is the most crossed-over area within the dwelling.

In H24, high connectivity axial lines cross through the courtyard to an adjacent space while at first floor level, high connectivity values reach both rooms that make up the upper level. A high choice axial line does not pass through the courtyard space at ground floor level but crosses through both adjacent spaces, while at first floor level, high choice paths pass through both rooms making up the level. Thus, all rooms at both levels are well connected but the courtyard does not present the user options to access different areas within that level. Low entropy values connect the courtyard to an adjacent space; on the first floor level, the two spaces are also connected through low entropy values. This kind of distribution with high integration values can also be observed where the courtyard and connected space show high integration, as do the two rooms on the first floor level. Such a distribution suggests that these rooms are well integrated within the domestic network. Low mean depth values occur at connecting spaces on both levels, indicating that all the rooms are easily accessible from one another within the network. Similarly, high control axial lines occur where such movement paths reach towards each room within the dwelling, both at ground and first floor level. The analysed characteristics reveal a domestic network within which, due to its number of spaces and their organisation, exhibits an interconnected interdependent network of spaces – a case similar to H23.

Discussions

The highest visual connectivity is frequently located at the centre of the courtyard or at connections between it and adjacent spaces. Point first moment and point second moment values often occur within the same spaces, notably along the internal perimeter of the yard. This implies that this place is one of visual control – large visual distance can be comprehended – further suggesting that it is a space which allows the user to make choices and interact with others with ease. The visual integration graphs indicate approximate equal values across both floor levels. Regarding metric distance, the shortest are within isolated spaces; segregated room distances are considered spaces that are separate from the rest of the dwelling. The second lowest values occur at the centre of the various courtyards, suggesting these spaces are highly used within a given domestic network. At the ground floor level, high through-vision values occur in the courtyard and, occasionally, in adjacent transition spaces and rooms. These high through-vision values indicate that the courtyard is a highly visible space within the dwelling.

As VGA reveals, due to its nature and location, the courtyard is both a space of gathering and a space of transition, a space for inhabitants and, on occasion, a threshold for visitors. It is therefore a distinctly vital space within the townhouse as it encourages encounters and communication across the dwelling.

With regard to ALA, and depending on the analysed attributes, the results identified user movement paths. In complex townhouse networks such as House H20, varying characteristic values are distributed across different areas. In simpler networks, values mainly centre around a space, thus exhibiting more interdependency and integration between spaces where movement paths intersect, resulting in more integrated spaces within the system. Location and accessibility attributes indicate that the courtyard is a common space where high movement paths intersect. The courtyard's centrality, together with its accessibility, results in the courtyard being on highly traversed pathways that are highly integrated and connected within the dwelling and that offer the user options to access different spaces within the dwelling, as it is the only accessible route to them.

The centrality of the courtyard is often highlighted as paths containing low entropy and mean depth values are common across the dwelling. In addition to identifying how spaces distribute themselves to their neighbours, such characteristics aid in the understanding of how easily accessible certain spaces are over others by calculating how distant or segregated chosen rooms are according to the rest of the spaces within that floor. ALA shows that the courtyard as a space lies on frequently traversed movement paths and often represents an integral space through which users navigate different spaces within a given dwelling. The courtyard is often physically located at the centre of the dwelling and central to its network of spaces.

Conclusions

This analysis of the courtyard within the context of the spatial network that makes up the dwelling builds on the existing knowledge of these spaces covered by Said-Zammit.[51] The courtyard is a distinct feature within the network of domestic spaces. In the townhouse, it is located at the centre adjacent to transition spaces, namely, the hallway and corridors at ground and first floor levels, respectively. It conditions the physical movements of the building's users. Given that indoor spaces – notably at ground floor level – open onto the courtyard, users, once in such a space, have significant visual information about the residence. Although it is not always the first space that a user experiences on entering a townhouse, the courtyard is one of the earlier spaces someone is likely to encounter. It is often the space that navigates choice and movement; this navigation is also conditioned by the transitional spaces. Findings emerging from the SSA, outlined in terms of the types of analysis, namely, (a) access analysis, (b) VGA, and (c) ALA, are included hereunder.

In the access analysis – a mode of spatial representation that transforms the network into a graph in order to gain a deeper understanding of spatial networks – the courtyard exhibits the lowest depth values, that is, it is close to all other spaces within the network. Regarding control and integration and given its location within the planning layout of a particular townhouse, the courtyard is not always the most influential. Such influence, when present, is relatively high. Consequently, unlike the case of vernacular farmhouses,[52] the courtyard in a townhouse may not be the central point of control for the other spaces in the dwelling. The stairwell to the first floor, bordering the courtyard and linking both levels, is de facto a space; it may hint at the courtyard's function as a medium of control.

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[51] Said-Zammit 2016.

[52] Borg, Bianco 2025.

Applying VGA, whereby the range of values for a specific dwelling is represented by a graph, the highest values of visual connectivity are at the centre and at junctions where the courtyard connects to adjacent space/s. Higher values for point first moment and point second moment correspond to longer visual distances, often at the edge of the dwelling, due to aligned openings. Visual control over most of the premises is not always possible; it is greatest at junctions adjacent to the courtyard. Low metric distances occur at the centre of the courtyard, a position which exhibits low values that increase as one moves away from its centre. High through-vision values are indicative that it is traversed more regularly than other spaces within the dwelling.

ALA studies movement patterns, the intensity of use of a given space, and the manner in which the courtyard influences the route users take within the dwelling. High connectivity axial lines traverse interconnected spaces of the dwelling; at ground floor level, this occurs through the courtyard. At this level, high choice values pass through it into adjacent spaces. Low value entropy axial lines are indicative that spaces, inclusive of the courtyard, are equally distributed. High integration values indicate spaces that are well integrated within the dwelling. Low mean depth values are indicative that interconnected, interdependent spaces require minimal effort to reach them. High control values suggest that movement pathways are central to the dwelling and that the user may access spaces with minimal effort.

The use of SSA is beneficial for assessing and analysing the connections – visual and physical – of courtyards in townhouses. Insights on how courtyards mediate social interaction and influence both the movement and perceptions of users (a) illustrate the wider connection between space and community life, and (b) provide a broader understanding of the relationships between social dynamics and spatial arrangements. SSA reinforces the axiom that the courtyard is the core of the townhouse; indeed, it is useful to assist traditional observation techniques when using *Depthmap*. By analysing connectivity in this type of building, we can comprehend the tangible experience of past generations and can understand how people's perceptions affected the construction of domestic spaces.

Declaration of competing interest

The authors declare that no funding was received from any financial organisation to conduct this research, and they have no financial or non-financial competing interests in any material discussed in this paper.

Data availability

No data was used for the research described in the article other than that included in the dissertation of Borg.[53]

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[53] Borg 2023.

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