# Syntactic Outdoor and Indoor Study of the Great Mosque of Algiers

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# Syntactic Outdoor and Indoor Study of the Great Mosque of Algiers: Space Syntax Measures

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**Abstarct**

In this paper, we studied the Great Mosque of Algiers "Djamaâ El-Djazaïr" using the space syntax method, which leads us to deduce new properties related to its external spatial environment relationships and its inner spatial configuration. Djamaâ El-Djazaïr has a religious, cultural and scientific character; it was chosen because it expresses contemporary, development, modernity and the capabilities of this era. Using the Depthmap programme, new outdoor and indoor spatial properties related to visibility and movement were identified: Concerning the outdoor environment, the Great Mosque of Algiers is visible from many sides due to its size and the dominance of its mass. However, areas show defects when speaking about movement: the northern region lacks real connections. Concerning the indoor spatial structure, when walking from gates via centres, wayfinding can be scattered between columns due to their numbers, dimensions, and placement.

**Keywords:** Depthmap, Great Mosque of Algiers, indoor, outdoor, space syntax.

## INTRODUCTION

The mosque is one of the most important public facilities in the traditional Islamic city because of its fundamental role in the life of its community (Mebarki & Bouchahm, 2019). It is the distinguishing feature and the nucleus of planning for these traditional cities and their most important urban element. The mosque is closely related to what surrounds it in its environment, which confirms the unity of the mosque with the urban fabric in its area, forming by itself the central spatial block as a prominent architectural landmark. The mosque has long been evident in the planning and design of Islamic traditional cities and their neighbourhoods and residential areas, constituting their most prominent feature. Its architecture (Ahriz et al., 2021) did not come spontaneously but was the result of the continuous and natural development of Islamic society and its civilization (Mebarki, 2019). The styles of mosque architecture are diverse, depending on the environment in which the mosque is built. Architectural history recorded the immortal living examples of building mosques and their conformity with their environments according to their geographical location.

In Algeria, the Great Mosque of Algiers "Djamaâ El-Djazaïr" was built with a religious, cultural and scientific character, dating to an important stage in the history of Algeria, namely the era of independence. It was designed by the two German offices (KSP Jürgen Engel Architekten) and (Krebs Und Kiefer) (Constantinescu & Köber, 2013; Chebaiki-Adli & Chabbi-Chemrouk, 2015) to be characterised by futuristic modernity. It is the third-largest mosque in the world (Akkermann et al., 2015) after the Two Holy Mosques in terms of area, and the largest in Africa, extending over an area of 20 hectares. Its area, size, and mass imposed its presence on the urban movement of the city of Algiers. This required a search for its spatial characteristics with the accuracy of digitization via the *space syntax* approach, which leads to understanding the spatial structure and relationships (Hillier, 1996) outside and inside the Great Mosque of Algiers and to knowing whether urban and architectural elements influence the level of visibility and movement outside and inside the mosque. The space syntax approach was founded by Bill Hillier and originated in the 1970s. It is also a theory based on visibility of space, movement through space, and behaviour within space. It was developed to be more accurate by using intelligent craft and software in order to understand spatial relationships and configurations mathematicallysuch as algorithms (Sheng, 2012; Nourian et al., 2013; Assassi & Mebarki, 2021), "typically in the form of building floor plans or plans of urban fabric." (Bafna, 2003).

After converting layouts in the second dimension to the extension "DXF", *Depthmap*, one of the most important analytical tools of the space syntax approach, performs a visibility graph analysis of space through global and local measures (Turner, 2001) for representing the interrelationships of space via parameter values (Zhuguang et al., 2019) "In Depthmap, the colour values formed across the graph are based on the spectral field, i.e., from the indigo colour with low values to the blue, purple, green, yellow, orange, red and purple colour with increasing values." (Guedouh et al., 2020)

## THE CASE STUDY

The Great Mosque of Algiers complex is located near the heart of the Gulf of Algiers in the municipality of Muhammadiyah (Akkermann et al., 2018) (Figure 1), 10 kilometres east of the old city of the capital (Sekhri, 2019) on a plot of 20 hectares. The site of the Great Mosque of Algiers in the Muhammadiyah municipality is distinguished by its seaside view. It is considered a new pole that imposes itself through spiritual architecture with an aesthetic aspect whose perfect harmony with the Gulf of the capital allows structuring of the public landscape (Chebaiki-Adli & Chabbi-Chemrouk, 2014).

The northern part of the site parallel to the highway consists of four squares arranged on the qibla direction axis from west to east (Sekhri & Bellal, 2018). These physical spaces range from the open (outer) courtyard to the prayer hall, passing through the courtyard of the mosque. The southern part of the site, parallel to Azzouz Road, consists of three buildings, namely the cultural centre, the library and Dar al-Quran, linked to each other by public spaces. The complex's management department, the civil protection centre, the functional housing and the technical equipment centre are located on the elevated eastern side of the mosque floor. The mosque is easily accessible, as worshipers can drive to it from its northern side via the highway linking the centre of the capital and the international airport. Footbridges link the north area by the mosque. From the south via Azzouz Road, in addition to its strategic location, it can be seen from several sides of the city of Algiers. Entry to the prayer hall is through the main gate in the courtyard, which follows the central axis of the direction of the qibla. The hall has a private entrance for official figures leading to the honour hall, and other entrances and exits are from the north towards the outer corridor and from the south towards the southern garden.

The components of the functional programme of the Great Mosque of Algiers include (Sekhri, 2018):

A spacious prayer hall (20,000 m$^2$), a multi-storey lighthouse (minaret) consisting of a museum and research centre, Dar Al-Quran (a higher education institute – post graduation - with seats for 300 learners), an Islamic cultural centre (library with a capacity of one million titles, Mediatech), administration, functional houses, garage for 4,000 to 6,000 cars, green and water structured areas (20,000 m$^2$). Behind the qibla wall of the prayer hall is the wing designated for the imam and the honour hall, a place designated for receiving official figures.

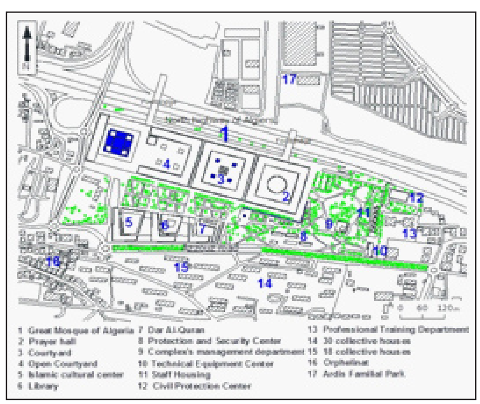


**Figure 1.** The site plan of the Great Mosque of Algiers

## METHOD AND MATERIALS

In our research, we adopted the space syntax method characterised by elementary spatial units: the axial sightline for movement, the convex space for interaction, and the isovist field for orientation (Yamu et al., 2021) (Figure 2).

We used Depthmap software (UCL DepthmapX) as one of the computing programmes for this method to analyse the outdoor and indoor spatial configuration of the Great Mosque of Algiers.

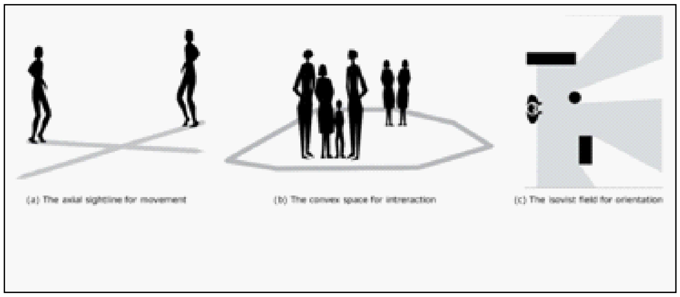


**Figure 2.** The elementary spatial units used in space syntax (Yamu et al., 2021)

- **Outdoor analysis through**

***Axial map:*** This helps to quantify the configuration and the relationships of space or the urban grid by an accurate set of intersecting lines (Turner et al., 2005; Vaughan & Geddes, 2009) "the least amount of straight lines that cover all accessible urban space...; where the network components are affordances related to human visibility and accessibility." (Stavroulaki et al., 2017).

***Convex map:*** This is a decomposition of an urban area on the largest and least (minimum) convex spaces, which generates a spatial framework of an urban ambience or system (Hillier & Hanson, 1984; Osmond, 2011). The convex map answers the question of how the space is shaped and perceived (Hillier & Hanson, 2005). To capture and investigate the configurational relationships between human behaviour and the built environment are objectives of the convex map graphs and analysis (Dawes & Ostwald, 2013; Lee & Ostwald, 2019).

- **Indoor analysis through**

***Visibility graph:*** This leads to collecting visual information and understanding spatial perception. The related metrics of the visibility graph help to understand the behaviour of space occupiers (Koutsolampros et al., 2019).

***Isovist Field Analysis:*** This determines the area and the form of the field viewed by the user of space in a certain position. "The space that can be seen from any vantage point is called an isovist..." (Batty, 2001) Isovist Field Analysis leads to understanding the movement patterns "to provide a measure of how well integrated isovists themselves are within a plan of an environment." (Turner & Penn, 2006).

***Agent analysis:*** This leads to understanding the behaviour of individuals/agents within space, with consideration of agents' movement in space. (Al-Sayed et al., 2014) Agent analysis concerns the adaptability of individuals' and agents' behaviour concerning space.

## SYNTACTIC OUTDOOR STUDY

The following figure 3 shows an east external view of the Great Mosque of Algiers:

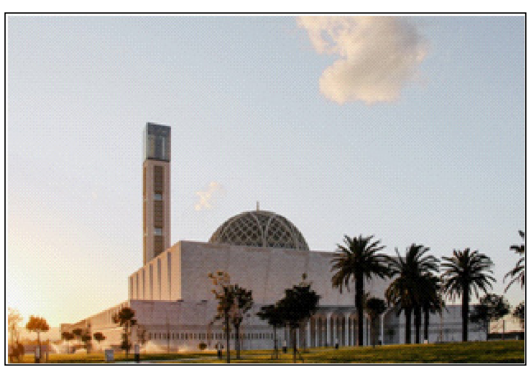

**Figure 3:** An east external view of the Great Mosque of Algiers

For analysing the outer spatial composition of the Great Mosque of Algiers, we used the following two maps:

### Axial map

Figure 4 is the axial map of the ground floor environment of the Great Mosque of Algiers.

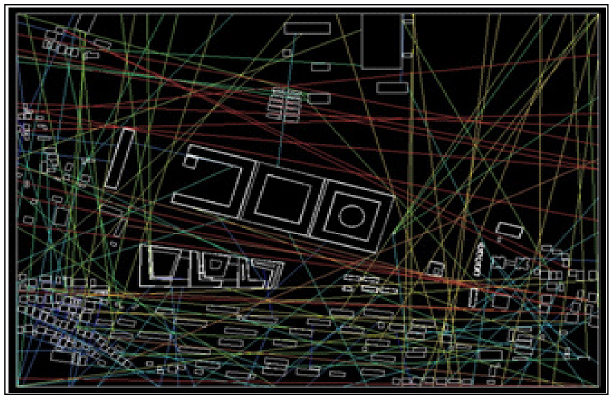

**Figure 4.** The axial map of the ground floor environment of the Great Mosque of Algiers

In our analysis we focused on choice and integration, which are explained as follows:

***Choice:*** "measures movement flows through spaces…Choice is a powerful measure at forecasting pedestrian and vehicular movement potentials." (Al-Sayed et al., 2014). In Figure 4 the busy vehicular axes are highlighted in red, especially the highway in the northeast as the longest axis and the Azzous Road in the southwest as a lengthy one. The busy pedestrian axes are highlighted in red, especially between the library building and the mosque building characterised by the length of its lines, and we observe that other important pedestrian axes, highlighted in yellow, are located to the east of the mosque building and to the west the open courtyard with less length. Other axes are represented by cold colours. This means they are not as busy as the first axes, which are not characterised by the length of their lines. The movement that flows through this spatial environment is more concentrated to the north and south of the mosque than to the east and west. This explains the localization and placement of the mosque and the necessity of inserting the footbridges over the highway.

***Integration:*** "The integration (I) of an axial line (i) is a function of its topological depth related to all other axes" (van Nes, 2021). Regarding Figure 4, the more integrated lines are those coming from the east and west sides, which means to and from Algiers City, such as the highway and Azzous Road, via this location of the Great Mosque of Algiers. Attractors of movement in constructing the measure of integration have been well considered: where the Ardis Park at the north area of the mosque and many collective housing buildings at the south area of the mosque are generators of movement in this important urban environment.

## Convex map

Figure 5 is the convex map of the ground floor environment of the Great Mosque of Algiers.

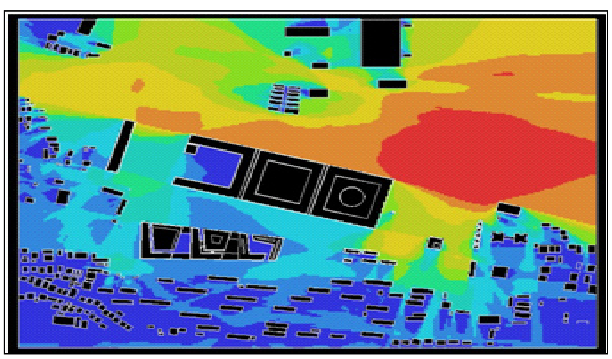

**Figure 5.** The convex map of the ground floor environment of the Great Mosque of Algiers

Researchers developed many measures, and in our analysis, we focused on some of the most important ones as follows:

***Connectivity:*** "measures the number of immediate neighbors that are directly connected to a space" (Al-Sayed et al., 2014). In Figure 5 the northeast and east areas of the mosque's outer environment appear in warm colours such as red, orange, and yellow with higher values; the highest one is in the red spot, which equals 20788. The southwest area of the mosque outer environment appears in cold colours such as green and blue with low values; within small interspaces, the lowest one equals 3. This means that the northeast area of the mosque's outer environment is more connected than the southwest area in terms of visibility, due to the number of buildings constructed in this area and the small interspaces between them in the southwest area. The Great Mosque of Algiers is well connected to the immediate urban elements; accessibility is through different movement elements such as roads, streets, public squares, and footbridges over the north highway of Algiers.

***Integration:*** This measures the shallowness or the deepness of spaces compared to other spaces. It "is thought to correspond to rates of social encounter and retail activities" (Hillier, 1996). In Figure 5, the deep areas are blue and are located far from the Great Mosque of Algiers, where visibility is broken by buildings of the south environment. Despite this, the spatial hierarchy is well applied regarding the transition from warm colours where the shallow and vast spaces or free spaces in northeast areas, and from cold colours, where the deep and small spaces or interspaces of southwest buildings arrive at the open courtyard of the Great Mosque of Algiers, coloured blue as a central deep space leading to the main entrance axis.

## SYNTACTIC INDOOR STUDY

For analysing the inner spatial composition of the Great Mosque of Algiers, we studied the courtyard (Figure 6a) and the prayer hall (Figure 6b) as two important spatial elements that characterise the mosque, where we opted for the following techniques:

The following figure shows two spatial elements of the Great Mosque of Algiers: Courtyard, and Prayer hall.

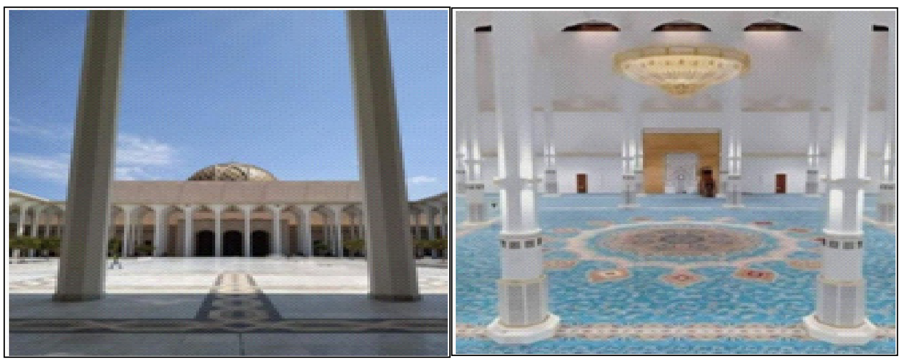

**Figure 6.** *Two spatial elements of the Great Mosque of Algiers: (***a***) Courtyard; (***b***) Prayer hall*

### Visibility Graph

Figure 7 was produced as the result of a visibility graph analysis of the ground floor layout of the Great Mosque of Algiers.

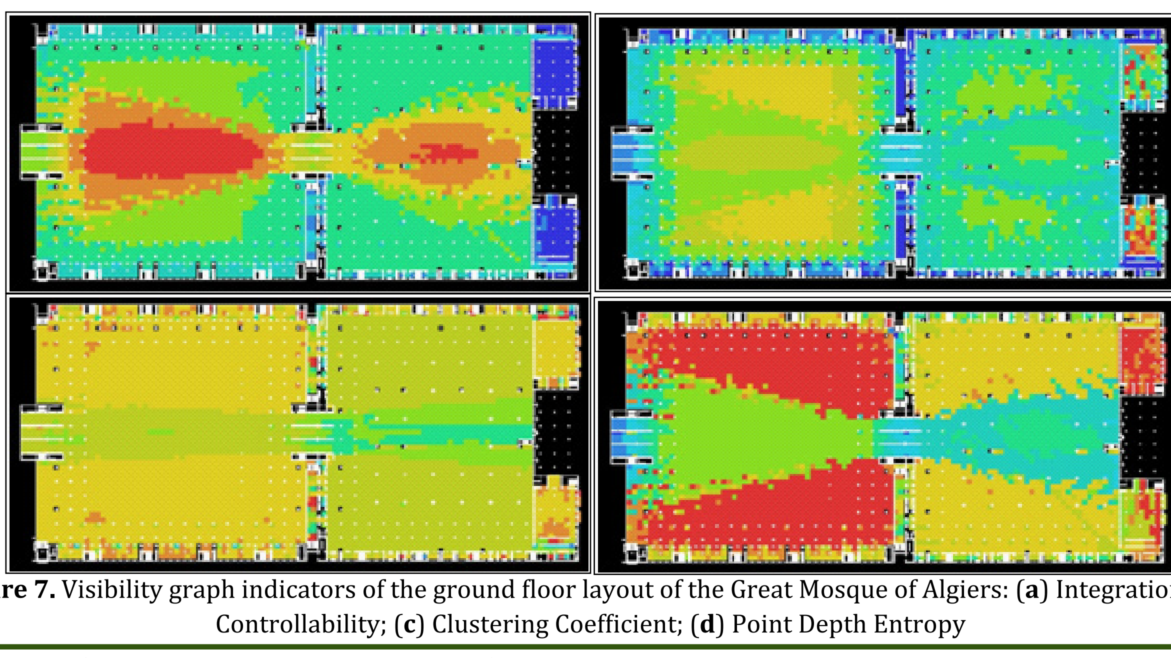

**Figure 7.** Visibility graph indicators of the ground floor layout of the Great Mosque of Algiers: (**a**) Integration; (**b**) Controllability; (**c**) Clustering Coefficient; (**d**) Point Depth Entropy

Firstly, the Integration indicator is a global measure that determines the average depth of a space compared to other spaces. Figure 7a indicates the two most integrated spaces (courtyard and prayer hall) with a maximum value of 1,5771, the two most segregated spaces (imam's compartment and honour hall) with a minimum value of 0,2601, and other moderate spaces, such as linear tape space between the courtyard and the prayer hall, with an average value of 0,9851.

Secondly, the Controllability indicator is a local measure that calculates the level of how space can control access to its neighbouring spaces. Controllability values ranged between 0,8020 as a maximum value, and 0,0026 as a minimum value, with an average value which equals 0,3760. Figure 7b indicates that the linear tape space between the courtyard and the prayer hall is a space lacking controllability, due to the restriction of movement using the windows on the courtyard side instead of the doors. Also, Figure 7b indicates that the imam's compartment and the honour hall have high values of controllability, which means they are well positioned spaces.

Thirdly, the Clustering coefficient indicator is a local measure that determines the inter-visibility of the space. Figure 7c indicates that the vertices within the spatial configuration of the Great Mosque of Algiers are similar in terms of values and are generally low, with an average which equals 0,6888. This means that the spaces are assembled around the courtyard and the prayer hall, and we mention here the existence of omni-directional fields of view.

Fourthly, the Point Depth Entropy indicator is a global measure based on permeability of vision, which calculates the rate of the shortest distance to depth. Point Depth Entropy values ranged between 1,9115 as a maximum value, and 0,7915 as a minimum value, with an average value which equals 1,5877. Regarding these values and Figure 7d, the spatial composition of the Great Mosque of Algiers does not allow free visibility and movement due to the columns.

## Isovist Field Analysis

Figure 8 was produced as the result of the Isovist Field Analysis of the ground floor layout of the Great Mosque of Algiers.

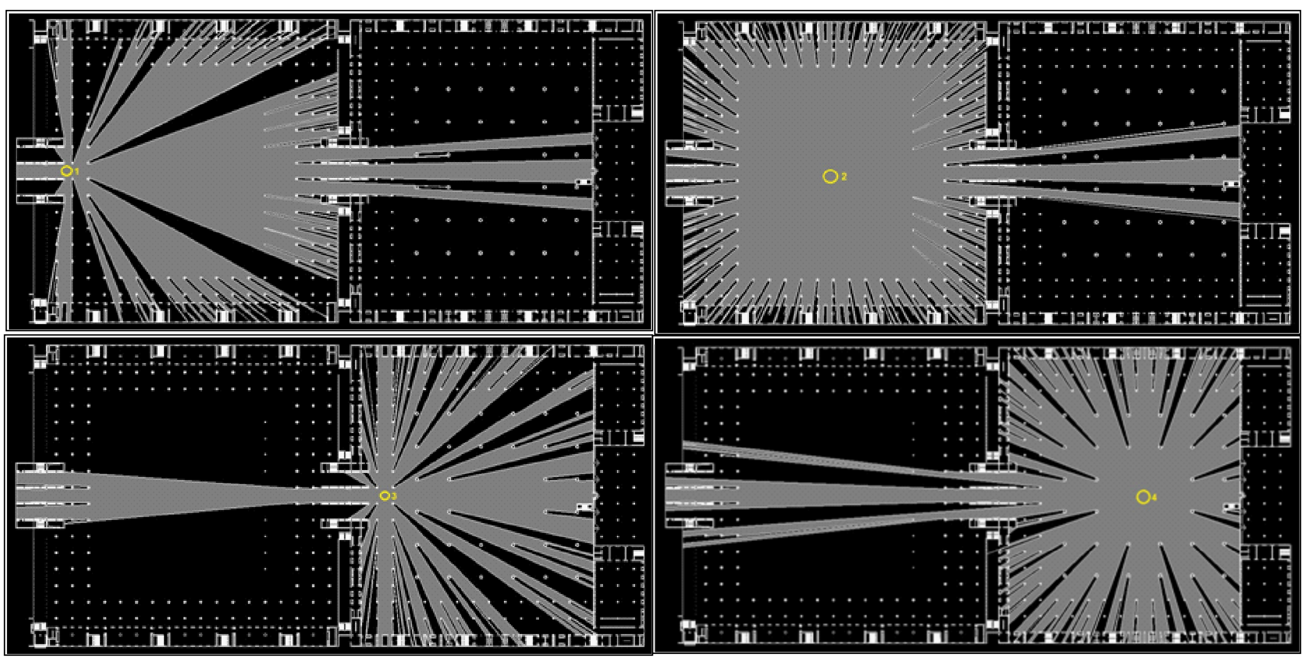


**Figure 8.** Isovists fields of four sequences within the ground floor layout of the Great Mosque of Algiers: (**a**) Sequence 1; (**b**) Sequence 2; (**c**) Sequence 3; (**d**) Sequence 4

In our case, the Isovist Field Analysis is based on four sequences. The first one is from the entrance of the courtyard, the second is from the centre of the courtyard, the third is from the entrance of the prayer hall, and the fourth is from the centre of the prayer hall.

Regarding Figure 8a, although the axes of vision reach the place where the imam prays, there are triangular-shaped areas that are not visible. In this sequence, the area percentage of the field of vision that is lost is more than 30% of the total area of the courtyard, which proves the lack of familiarity with the space of view despite the simplicity of the form.

The presence of the columns prevented the space user from being able to see all places.

Regarding Figure 8b, as the position of the sequence within the courtyard is central, the field of vision becomes greater than it is from the first sequence, but there are triangular-shaped areas that are not visible; although these are small, they add up to a lot. In this sequence, the area percentage of the field of vision that is lost is less than 30% of the total area of the courtyard, due to the presence of the columns, which means that there is a classical design logic based on the principle of centralisation at the expense of other spaces.

Regarding Figure 8c, the Isovist Field Analysis of the sequence from the entrance of the prayer hall indicates that many axes of vision are broken and stopped at many points due to the structure system, whereby the area percentage of the field of vision that is lost is more than 40% of the total area of the prayer hall. This means that the field of vision that is lost in this sequence is more than the field of vision that was lost in the first two sequences.

Regarding Figure 8d, the field of vision from the centre of the prayer hall becomes greater than from its entrance. We note here that the area percentage of the field of vision that is lost is less than 40% but more than 30% of the total area of the prayer hall.

When comparing the fields of vision of the courtyard and the prayer hall, we conclude that the vision in the design composition within the prayer hall is more restrictive than that within the courtyard. We also note that the visual relations between the worshipers' places and the pulpit are not well planned, because many axes of vision are broken and stopped at many points, due to the number of columns and their dimensions.

## Agent Analysis

Figure 9 was produced as the result of the Agent Analysis of the ground floor layout of the Great Mosque of Algiers.

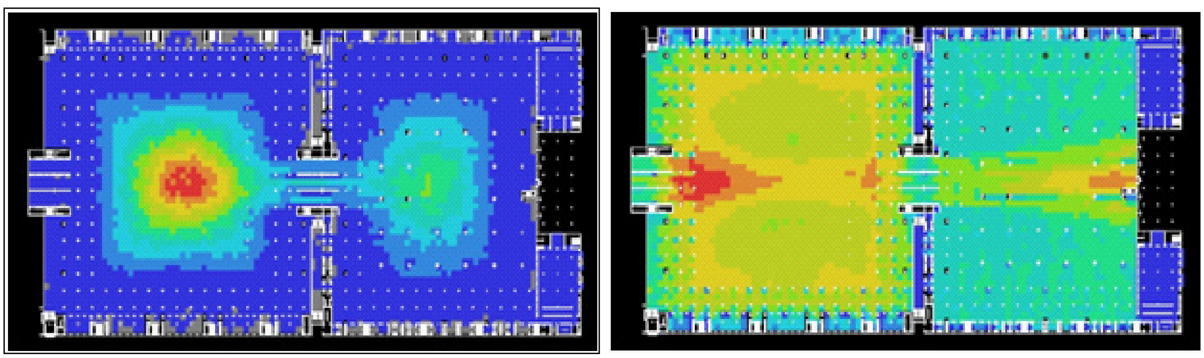

**Figure 9.** Agent Analysis of the ground floor layout of the Great Mosque of Algiers: (**a**) Gate Counts; (**b**) Point First Moment

Figure 9a represents the graph of Gate Counts, where the colours run from the red in the centre of the courtyard, with 713 as a maximum value, to the blue colour toward its edges, with 1 as a minimum value. This means that the worshipers can memorize easily in their mind the path from the centre of the courtyard to the prayer hall. The green colour in the centre of the prayer hall means that despite gates directly from the exterior, the gate from the courtyard is more structured and so more easily memorized by the worshipers. The north gate and the south gate are not landmarked, which explains their light blue colour.

Analysing the agents' behaviour within the ground floor layout of the Great Mosque of Algiers, regarding Figure 9b, we note that the minimum value of the First Point Moment is 3, and its maximum value equals 177781. This means that the way finding starts from clear gates and clear centres, but it can be scattered between columns. This is confirmed by the colours within both the courtyard and the prayer hall, where the red colour and the green colour are clear inside the inner frame of both the courtyard and the prayer hall. The blue colour is situated specifically within the linear tape space between the courtyard and the prayer hall, and within the imam's compartment and the honour hall, which are not accessible to the public.

Although the German Studies Office is aware of the advanced structural systems, and although this office was able to get rid of the columns, the office preserved them as they are considered among the architectural elements that represent the identity of the mosque.

## CONCLUSIONS

The Great Mosque of Algiers, which was designed by the German company consisting of the two German Studies Offices (KSP Jürgen Engel Architekten) and (Krebs Und Kiefer), has a religious, cultural and scientific character. It dates back to an important stage in Algerian history, the era of independence, and it is the third-largest mosque in the world in terms of area, after the Two Holy Mosques. It represents a sign of the future and is one of the most important projects of the century through the use of advanced building materials. The engineering designs prepared by the German designer Jürgen Engel carried futuristic modernity in the design of the mosque. It is easily accessible, as worshipers can drive to the mosque from the northern side via the highway linking the centre of the capital and the international airport, and from the south via Azzouz Road, in addition to its strategic location, where it can be viewed from many parts of the city of Algiers. The contemporary "Djamaâ El-Djazaïr" complex features several functions, such as a spacious prayer hall, Dar of Quran, a history museum, a research centre in the historical and scientific fields of the mosque's minaret, a cultural centre, a library, and the complex's management department. On two ground floors, it is of a religious, cultural and scientific character, indicating a new trend in Algeria in the design of contemporary mosques by including different functions in addition to the mosque's original function.

To study the Great Mosque of Algiers spatially, we adopted the space syntax method through the Depthmap programme. This is based on mathematical computational analysis, with *VGA* logic and colour spectrum, generated maps and graphs, which helped us to deduce new quantitative properties related to the spatial configurations both for the outside or inside the mosque. The syntactic outdoor study, using the *axial map,* shows that pedestrian movement is characterised by the opportunity of *choice* in thesouthwest area more than the northeast one due to the highway, which is considered a barrier without the presence of the footbridges. The vehicular movement is multiple in all directions with various lengths and the existence of generators of movement such as Ardis Family Park and different cultural and scientific buildings created in the mosque complex. The syntactic outdoor study, using the *convex map,* shows that the urban environment space of the mosque is characterised by *connectivity* in terms of visibility, where the mosque is visible from all environing sides. The *integration* measure indicates that the southwest environment is deeper than the northeast area, which is shallow, making a difference in terms of movement. The syntactic indoor study, using the *visibility graph,* shows that the more *integrated* spaces are the courtyard and the prayer hall, with a high level of *controllability*, and other spaces are *clustered* around these two spaces. The *Point Depth Entropy* measure indicates that the columns as architectural elements can negatively influence visibility and movement within the Great Mosque of Algiers. This result was confirmed based on the *Isovist Field Analysis*; in addition, the visual relations between the worshipers' places and the pulpit are broken and stopped at many points for the same reason. The syntactic indoor study, based on the *agent analysis,* showed that some gates, such as the gate from the courtyard to the prayer hall, are more memorized by the inner space users, and showed that the wayfinding starting from gates to central spaces can be scattered between columns.

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