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Misurata City Street Network Analysis Using Space Syntax

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ABSTRACT

This study aims to analyse the urban road network in the city of Misurata using Space Syntax methodology. The primary goal is to understand the structural characteristics of the city's street network and its implications for urban planning and development. The importance of this research lies in its potential to inform policies and interventions for optimizing the efficiency and equity of the urban road infrastructure. The Space Syntax approach was employed to evaluate measures of integration, accessibility, and potential movement within the Misurata street network. The findings reveal significant variations in the network's topological properties across different neighbourhoods, indicating uneven distribution of urban connectivity and accessibility. Based on the analysis, the study provides recommendations for urban planners and policymakers. These include strategies to enhance connectivity in underserved areas, improve accessibility to key destinations, and foster a more equitable distribution of mobility options for the city's residents. The application of Space Syntax techniques has demonstrated its value in diagnosing and guiding the complex urban road systems.

Keywords :Urban road network analysis, Misurata city, Space Syntax , Street network characteristics,

تحليل شبكة شوارع مدينة مصراتة باستخدام منهجية التركيب المكاني

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ملخـــــــص البحـــــــث

هدف هذه الدراسة إلى تحليل شبكة الطرق الحضرية في مدينة مصراتة باستخدام منهجية **(Space Syntax)**. يتمثل الهدف الأساسي في فهم الخصائص الهيكلية لشبكة الشوارع في المدينة وما يتبع ذلك من آثار على التخطيط والتطوير الحضري. تكمن أهمية هذا البحث في إمكاناته لإعلام السياسات والتدخلات الهادفة إلى تحسين كفاءة وعدالة البنية التحتية للطرق الحضرية. تم استخدام منهجية **(Space Syntax)** لتقييم مقاييس التكامل والوصول، والحركة المحتملة داخل شبكة شوارع مصراتة. تكشف النتائج عن تباينات ملحوظة في الخصائص الطوبولوجية للشبكة عبر أحياء مختلفة، مما يشير إلى توزيع غير متساوٍ للاتصال الحضري والوصول. استنادًا إلى التحليل، تقدم الدراسة توصيات للمخططين الحضريين وصانعي السياسات. تتضمن هذه التوصيات استراتيجيات لتعزيز الاتصال في المناطق المحرومة، وتحسين الوصول إلى الوجهات الرئيسية، وتعزيز توزيع أكثر عدلاً لخيارات التنقل لسكان المدينة. وقد أظهرت تطبيقات تقنيات "**Space syntax**" قيمتها في تشخيص وإرشاد أنظمة الطرق الحضرية المعقدة.

الكلمات الدالة: تحليل شبكة الطرق الحضرية، مدينة مصراتة، سبيس سانتكس، خصائص شبكة الشوارع.

1. INTRODUCTION

The management of urban road networks is a crucial aspect of urban planning and development, as it directly impacts the accessibility, mobility, and overall lovability of a city (Hillier & Hanson, 1984; Hillier, 1996). The spatial configureuration and topological properties of a street network can significantly influence the patterns of movement, social interaction, and economic activities within an urban environment (Jiang & Claramunt, 2002; Porta et al., 2006).

One approach to analysing urban street networks is the Space Syntax methodology, which provides a set of analytical tools for understanding the relationship between spatial configurauration and human behaviour (Hillier & Hanson, 1984; Hillier, 1996). Space Syntax has been widely applied in various urban planning and design contexts, with a focus on evaluating measures such as integration, connectivity, and potential movement within the street network (Hillier et al., 1993; Peponis et al., 1997).

In the context of the city of Misurata, Libya, understanding the characteristics of the urban road network is crucial for informing effective urban planning and development strategies. This study aims to analyse the urban road network in Misurata using the Space Syntax methodology, with the primary goal of identifying the structural characteristics of the city's street network and their implications for urban planning and development.

The findings of this research can inform policy and intervention decisions to optimize the efficiency and equity of the urban road infrastructure in Misurata, ultimately contributing to the overall improvement of the city's liveability and sustainability (Banister, 2008; Cervero, 1998).

1.*1 Research Objectives*

This study aimed to analyse the urban organization, improve traffic management and city accessibility, enhance overall urban planning, and support sustainable development in the city of Misurata. The research utilized Space Syntax to evaluate the spatial relationships and provide recommendations for enhancing communication, mobility, and the overall quality of life within the city.

1.2 Importance of the Study

The key importance of this study is its focus on improving traffic management, city accessibility, urban planning, and promoting sustainable development in Misurata. The Space Syntax analysis aims to identify congested areas, enhance traffic routing and road planning, improve pedestrian experience and connectivity, and provide recommendations to enhance the overall organization and utilization of space within the city, ultimately contributing to a better quality of life.

1.3 Research Methodology

The study's methodology will involve data collection and mapping, network analysis using Space Syntax techniques, extracting key findings, and applying the recommendations to enhance traffic management and urban planning in the city of Misurata. The researchers will gather data to create a comprehensive map of the city's street network, analyse the spatial relationships and organization using Depthmap software, identify critical areas and main routes, and then apply the findings to improve the management of the urban road network and implement the proposed changes.

2. The Importance of Road Network Analysis in Urban Road Management

Road network analysis is an important tool for managing urban roads for several reasons:

Firstly, the analysis helps identify the weaknesses and strengths in the urban road network, which assists in making the necessary administrative and planning decisions.

Secondly, the results of the analysis can be used to design new roads or modify existing ones to improve traffic flow and reduce congestion.

Thirdly, the analysis can help improve the public transportation system and guide vehicles and pedestrians more effectively. Additionally, road network analysis can be used in urban planning to achieve a better distribution of activities and improve accessibility for the population.

In summary, road network analysis is a crucial tool for managing urban roads, as it provides insights that can inform decision-making, infrastructure design, transportation system optimization, and overall urban planning efforts.

3. The concept of Space Syntax

The concept of Space Syntax is an analytical model that aims to understand the interaction between the built space and social activity and movement in the urban realm. It examines how the arrangement of architectural elements, streets, paths, and public spaces affects people's movement, social interaction, and use of spaces. Space Syntax relies on analytical tools to measure spatial relationships and identify features that influence the individual's urban experience, such as visual connectivity, safety, and accessibility. This approach is utilized in various fields, including urban design and planning, to improve city design and enhance the overall urban experience.

3.1 The Importance of Using Space Syntax in Road Network Analysis

The Space Syntax approach can be applied to analyze road networks and study their spatial arrangement and its impact on human movement and interaction in the urban realm. The analysis involves using analytical models to measure the spatial relationships between roads, evaluate their connectivity and importance within the urban system, and generate metrics such as street centrality, path continuity, and path visibility.

These insights can provide useful information for traffic management in an existing city. The analysis can identify traffic centers, assess congestion levels, suggest ways to improve traffic distribution, evaluate accessibility and comfort, and enhance pedestrian safety. The results of the Space Syntax analysis can guide traffic management efforts and road network planning to create a more efficient and user-friendly urban environment.

Overall, the Space Syntax analysis of road networks offers a comprehensive methodology to understand the spatial conFigure uration of the urban realm and its influence on mobility and social interaction, ultimately contributing to the improvement of city design and the enhancement of the overall user experience.

4. Case study "Misurata City"

4.1 location and morphology :

Misurata is a city located in the north-western corner of the Sirte municipality in Libya, with a coastline stretching 125 km along the Mediterranean Sea. The city is situated at longitude 15° 5' 26" E and latitude 32° 22' 28" N, and its elevation gradually increases from east to west, reaching up to 80 meters in the south-western part of the city (Asadi, 2022).

Its two coastlines – the northern coastline and the eastern coastline, distinguish Misurata. The northern coastline characterized by rocky elevations, locally known as "Al-Hashum," and sand dunes, locally known as "Al-Qaisan," which reach an elevation of about 50 meters above sea level. The eastern coastline starts from Qasr Ahmed and heads south, passing through several areas before ending at Al-Washka.

The city's strategic location, with its proximity to the Mediterranean Sea and its two coastlines, has significant implications for the city's development, infrastructure, and economic activities. The city's geographic features and coastal characteristics are important factors to consider in urban planning and management efforts. (Figure 1)

Fig 1. Misurata City's location**.**

4.2 Network Analysis Using Space Syntax

4.2.1. Street Network Pattern and Route Choice Diversity

The connectivity of the city of Misurata (Figure 2) was found to be below the average for Libyan cities. This low connectivity value reflects a network pattern dominated by short, winding, and sometimes closed urban spaces, with limited route choices. The city's spaces are sequential in depth, and the street connectivity value of 2.868 is close to the average for Arab cities, characterized by narrow alleys and pedestrian-only streets. This result raises several research questions about the factors contributing to the connectivity patterns in Misurata and other Arab cities.

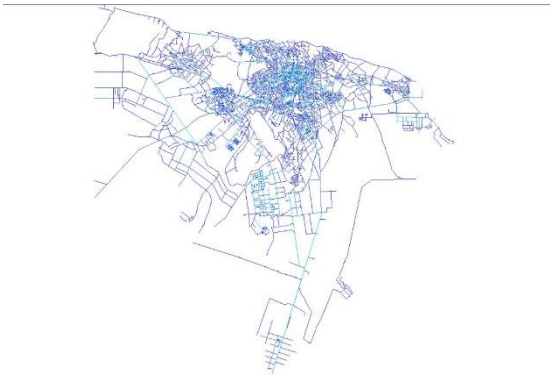

Fig2. Connectivity.

4.2.2. Global Spatial Accessibility and Mobility for Urban Structures

Based on the results of the measurement values, the overall integration value reached 0.582 global integration (Figure 3). This means that the value is average, and this interpretation indicates that the spatial conFigure uration of this city is less integrated than modern cities, and its spatial structure weakly encourages movement from any part of the city to the other parts in an easy way, and confines movement within specific streets and alleys.

Fig 3. Global Integration.

4.2.3. Local Spatial Accessibility and Mobility for Urban Structures

The local integration value reached 1.44, indicating a relatively low level of interconnectedness between the urban parts of Misurata City. This suggests a higher degree of privacy and a hierarchical access and mobility system for pedestrians, with the highest local integration values (Figure 4) found in the main squares and streets.

Fig 4. Local Integration.

4.2.4. spatial network complexity

The spatial network complexity of Misurata City's road system is indicated by the high entropy value of 4.57, which suggests a highly interconnected network with multiple paths between different neighbourhoods and areas. This complexity can improve accessibility, social interaction, and cultural diversity. The entropy (Figure 5) measure is useful for understanding the spatial organization and designing the streets and different zones of the city.

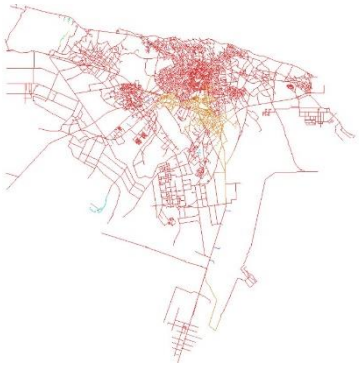

Fig 5. Entropy.

4.2.5. The average depth of sites in the spatial network.

The "mean depth" measure in Space Syntax theory indicates the variation in the average depth of different spaces within a spatial system. A high value of this measure suggests strong spatial differentiation, while a low value implies greater homogeneity in accessibility across the system. This measure can also be used to study the different uses of spaces, with low-depth areas associated with social and commercial activities, and high-depth areas being less visible and utilized. In transportation studies, mean depth represents the average distance from a given point on the road network to all other points, and is used to evaluate accessibility and connectivity within the network. The mean depth value (Figure 6) in the city of Misrata was 19.1, indicating significant variations in accessibility and longer paths to different areas, creating a strong spatial disparity.

Fig 6. Mean Depth.

4.2.6. The available options for movement between roads

The choice measure refers to the number of times a particular path appears on the shortest route between all possible origin-destination pairs in the system. The values of integration and choice reflect the decision-making process that humans undergo before moving to any location in the system. Humans decide on the origin and destination, and the most accessible destinations are likely to be displayed, resulting in more integrated locations.

Before a person can begin to move, they must choose the streets (lines) they must pass through to move from the origin to the destination. The less accessible (less integrated) destinations will be displayed. When we know where we are going, we need to choose the route.

The global values (long diameters) are associated with the main paths in the urban system, while the local values (low radius) are associated with secondary streets or neighbourhood level. The streets of Misurata city have recorded an average of 130481 for the choice measure (Figure 7). As for the streets that were more preferred choices, they are: Alkhroba Street , algheran gzer street .

Fig 7. Choice.

4.2.7. The level of control or dominance of streets within a city or urban environment.

The control measure evaluates the level of control or dominance of a specific space or street within a city or urban environment. The average control value recorded for the city of Misurata is 0.9878, indicating that most of the streets and spaces in the city have a moderate level of control. This suggests that the majority of the spaces have a moderate influence on transportation movement and accessibility to neighbouring spaces. The significant difference between the minimum and maximum values (0.0555556 and 16.3741, respectively) reflects the diversity in control levels (Figure 8) among the spaces within the city.

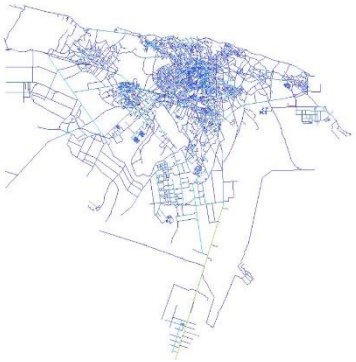

Fig 8. Control.

4.2.8. The control of movement flow.

Controllability (Figure 9) is a measure in Space Syntax theory that indicates the ease of controlling the flow of movement within a spatial network. The average controllability value of 0.3309 for the city suggests a moderate level of control over the road network, with potential variations across different spaces in the city. The minimum and maximum values of 0.0555556 and 1, respectively, highlight the range of controllability within the urban environment, where some areas may have higher levels of control over movement compared to others.

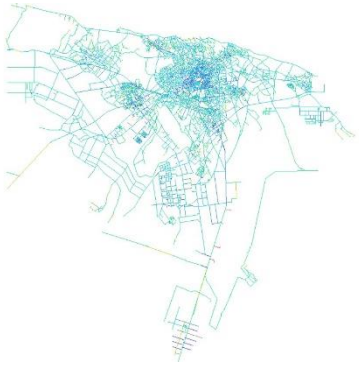

Fig 9. Controllability.

4.2.9 The expected traffic density in the streets.

The intensity measure in Space Syntax analysis indicates the expected level of congestion or density in a given street. Higher intensity values suggest higher levels of movement and utilization within that space. The reported global intensity value (Figure 10) of 0.283 and local intensity value of 1.1977 suggest that the overall city-wide spaces have lower movement density compared to the more localized, neighbouring spaces, such as internal alleys, which tend to have higher levels of activity and movement density.

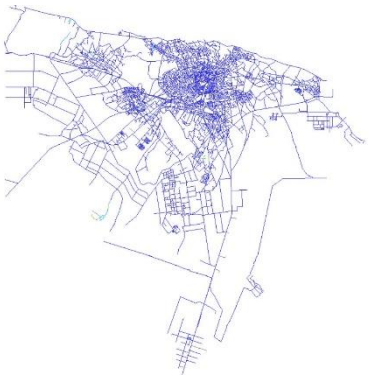

Fig 10. Intensity.

4.2.10. The pattern of the city's network.

The length of the city's axial lines indicates the scale of the urban fabric, reflecting whether the city and its streets are primarily designed for vehicular or pedestrian movement. Shorter axial lines suggest a mix of modern vehicle-oriented and traditional, more enclosed neighbourhood layouts, or even car-free, pedestrian-focused historic towns. The average axial line length (Figure 11) of 70.42 meters falls within the moderate range.

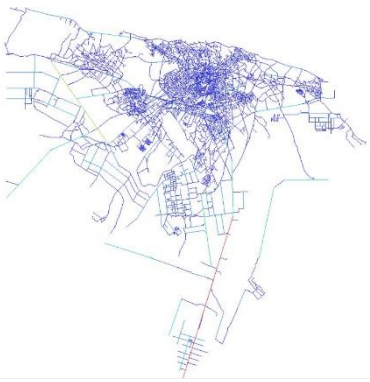

Fig 11. Axial line length.

4.2.11. The intelligibility of the city's spaces (intelligibility).

The city's intelligibility, measured by the correlation between integration and connectivity, indicates how well the observer can understand the entire urban system by perceiving a limited number of spaces. A high intelligibility value suggests the spatial structure can be readily comprehended, while low intelligibility means the observer needs to see most of the city's spaces to understand the whole. The analysis shows Misurata has a low global intelligibility (Figure 12) of 0.087, meaning the observer will struggle to grasp the full spatial layout solely by understanding the immediate neighbours. However, the local intelligibility of 0.508 is higher, implying the observer can better understand the local areas without navigating extensive parts of the city. The city comprises 7,389 total spaces, and the observer needs approximately 12 topological steps to comprehend the entire system.

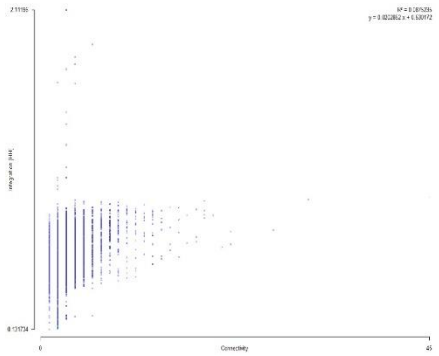

Fig 12. Intelligibility.

4.2.12. The connectivity between the local structure and the global system (synergy).

Spatial synergy refers to the physical-spatial characteristics of a city that enhance individual activities and behaviours, especially in public spaces. This is achieved through the interconnected arrangement of buildings, structures, specialized offices, and farms to create open spaces. Spatial synergy is measured by the relationship between local and global integration, indicating the integration of the local system within the larger network. The synergy value (Figure 13) for the city of Misurata was 0.314, considered a moderate level.

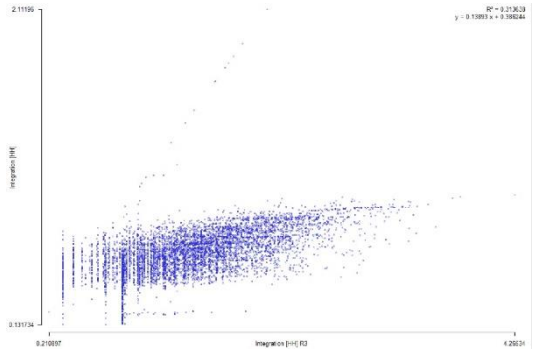

Fig 13. Synergy.

5. DISCUSSION AND RESULTS

Based on the analysis of the street network in the city of Misurata using Depthmap software and Space Syntax theory, the following results can be summarized:

Street Connectivity: The street connectivity value in Misurata is 2.868, which is close to the average connectivity of Arab cities (2.98). This suggests that Arab cities are often composed of spaces with limited connectivity, such as winding alleys and closed streets, and are characterized by relatively short axes. This architectural pattern reflects the structure of traditional Arab cities.

Global Integration: The global integration value in Misurata is 0.582, indicating that the connectivity between different parts of the city is lower than in modern cities. It is difficult to move easily from one part of the city to another, and movement is limited to specific streets and alleys.

Local Integration: The local integration value in Misurata is 1.44, which is low compared to other Libyan cities. This suggests that the city environment lacks strong connections between its parts, meaning that movement between the different areas is limited.

Entropy: The entropy value in Misurata is 4.57, indicating a high level of complexity in the spatial network of the city's road system. There is a high level of interconnectedness between the streets, which suggests the existence of a large number of different paths and connections between neighbourhoods and different places. This complexity can lead to improved accessibility and increased social interaction and cultural diversity in the city.

Mean Depth: The mean depth value in Misurata is 19.1, which is very high. This indicates significant differences in accessibility to different places in the city, creating a strong spatial contrast. Accessing different points on the road network requires longer paths and greater travel time.

In summary, the analysis of the street network in Misurata using Depthmap and Space Syntax reveals insights into the city's spatial structure, including its relatively low connectivity, limited integration between different parts, high complexity, and uneven accessibility, which are characteristic of traditional Arab cities.

6. CONCLUSION

The analysis suggests that the city of Misrata is composed of interconnected but limited spaces, with short axes and weak connections between its different parts. The high average depth indicates significant variation in accessibility across the city. These findings depend on the data and inputs used, and may be impacted by urban changes not accounted for. Further comparative studies and deeper analysis of the spatial characteristics and their sociocultural context could provide additional insights into the city's structure and development.

7. RCOMMENDATION:

The analytical results of the study of the city of Misurata may reveal findings related to the urban level, road and street planning, and road management. Here is an explanation of some potential results at each level:

Urban level:

- The limited interconnected public and private spaces in Misurata reflect a particular urban organizational pattern and distribution of spaces in the city.
- Creating distinctive architectural elements, especially at major intersections and roundabouts, to give a specific identity to the place and create a distinct mental image that differs from any other location.
- The presence of short corridors suggests challenges in connecting the different areas within the city and facilitating smooth traffic movement.
- The weak connections between different parts of the city may affect mobility and accessibility to various locations.

Road and street planning level:

- The high average depth may indicate challenges in the design of the road network and street layout in Misurata.
- There may be a need to improve the engineering design of roads and provide more connecting routes and corridors to enhance traffic flow and accessibility to different locations.

•There may be challenges in the distribution and effective connection of public facilities through the roads and streets.

Road management level:

•The variation in accessibility to different parts of the city suggests the need to enhance road management and traffic regulation.

•There may be a need to improve traffic signals, directional signage, and traffic flow management to enhance vehicle safety and driving experience.

• There may be a need to address road maintenance and infrastructure issues.

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