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Intangible trajectories of urban connectivity. An application of physics in architecture

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Abstract. This research aims to identify the intangible urban geometries of the physical-environmental, social-cultural, and political-economic components of Avenue 1 East, Caobos, San José de Cúcuta, Colombia. This in order to represent and quantify the connectivity trajectory of the intangible networks that are generated from the analysis of the meso and micro scale of the city. The applied methodology is based on the theory of the urban network, the study used a mixed approach, under a strategy called multi-methods or methodological triangulation. Within this research, physical concepts such as trajectory, displacement and space-time were assumed. This type of research allowed the study topics to be approached through layers through which the implicit dynamics in the sector under study were identified. As relevant results it is obtained that the use of a mathematical and physical logic strengthens the studies focused on city planning, the importance of hierarchically and quantitatively organizing the connection networks (meso and micro) in order to solve problems or phenomena typical of the daily life of the sector under study, guaranteeing a dynamic and real process for its growth.

1. Introduction

The systems theory focuses on the formulation of elementary principles that favor the acquisition of knowledge about living or non-living systems. From this perspective, the city as a living system presents a series of phenomena that need to be studied in an integral way with the possibility of generating analyzes that strengthen the planning and design processes of the urban and territorial component. This becomes relevant when considering that the theory of the systems takes as a base the components of the city, analyzing the level of existing relations between them and applying scientific methods that allow forecasting future scenarios, through simulation processes that lead to the taking of right decisions [1].

Thus, in the study of the territorial ordering it is important to note that in the conceptualization of the mathematical-urban models, the dynamics of systems is presented as a method and a tool that allows the recognition of urban phenomena and problems for the formulation of strategies, programs and projects at the urban level, benefiting the quality of life in the city [2]. Also the basic concepts of physics such as trajectory; understood as the distance traveled by pedestrians at the urban level that can be carried out under a straight or curved line [3], the displacement that refers to the starting and ending point of the route [4]; and, space-time understood as a mathematical pattern based on the theory of relativity where it is stated that space and time are two inherent concepts [5].

The study of the dynamics of the systems must consider aspects such as: the identification of variables that allow the understanding of the territory in real time, which favor the registration and



generation of conceptual maps of the city, supported by mathematical logics that allow the study and the geometrization of the dynamics present in the city, under simulation processes that promote the development of possible solutions for the different interventions at urban scale [2-6]. Thus, it is important to mention that within the academic and governmental field today the study of public space and its phenomena, constitute a bet focused on improving the quality of life of the inhabitants of urban areas, by putting in progress of initiatives and policies around the generation, recovery and sustainability of public space [7]. Under this order of ideas, public space is understood as a network composed of spaces for collective use, which through the daily experience of the inhabitants reassign the city, through the use, appropriation and transformation of the territory, under readings substantially modify how to understand, perceive, experience and evaluate the urban landscape [8-10].

In this context, it should be noted that international organizations have developed studies focused on the phenomena present in the public space in order to establish evaluation parameters that make urban quality of life more efficient, this being one of the fundamental components for the understanding of the city and its dynamics. In this regard, the United Nations Organization (ONU) in 1992 defined three variables and their evaluation aspects established from the Environmental, social and economic dimensions, managing to collect for the first time measurement indicators on public space, cataloged today as a model for the formulation and generation of projects in the public space [11,12].

The foregoing becomes relevant, taking into account that public space must be understood as part of the urban fabric that is structured from the networks of tangible and intangible connections that configure and give meaning to the city [9]. These networks are generated from overlapping connections at different levels and scales. Therefore, mathematically it is not possible for them to coincide, however when there are crosses and overlaps originate cross connectivity's [13].

For the study of cities, it is important to analyze the territorial dynamics around the identification of phenomena or problems, which after their analysis can be improved. For this purpose, this analysis should be carried out based on the scales: macro (city), meso (area of influence) and micro (polygon of study) [14]. In addition, it must be taken into account in the conformation of the network the importance of identifying principles such as: urban nodes (human connection with respect to work, parks, shops, churches; etc), connections (resulting from the union of nodes) and hierarchy (organization of the network at different levels). These principles present a direct link with architecture, urban design, planning and mathematics, since each element is cataloged as an urban complex that makes sense and generates connections when it comes into contact with human activity [13].

2. Method

This research is done under the analytical method, with one dimension per measurement. Its approach is quantitative, length, non-experimental, and transversal type. The population corresponds to the San José de Cúcuta, Norte de Santander, Colombia, the sample is the 407 properties and 96 blocks that represent an area of 313,086 m², which are part of the commune number two in the neighborhoods: "Quinta Velez" (70 lots), "Caobos" (285 lots) and "Barrio Blanco" (52 lots), between 1 avenue East, "Cero" and 2 avenue east and between 11th and 21st streets, including the macro block of the "Ventura Plaza" Shopping Center (micro scale), contemplating an action range of 500 meters that contains (1423 lots, 418 blocks, meso scale). This sample is of an intentional type, since the transformation at the urban level that the sector has undergone in the last twenty (20) years (1998-2018), this being a representative transformation in the economic, social and environmental fields for planning from the city.

The technique used to obtain the data of the present investigation were technical data sheets for the collection of cartographic material. These contain guidelines such as: name of the activity, apple number, number of properties, planimetry area of the study polygon, different views of the apple under study (isometric-plant) and observations. The validity of the instrument was carried out by expert [15] by the proportion measurement technique according to the inter-judge agreement [16] This validity index is calculated by counting the agreements and dividing this value by the total items. In accordance with the above, the instrument with its respective items meet the established criteria, since the values

obtained are greater than 0.70 [17]. The evaluation process of the instrument of this research had three (3) experts: two architects and one (1) civil engineer, all with a master's degree.

In order to represent and quantify the connectivity trajectory of the intangible networks that are generated from the analysis of the meso and micro scale of the city within the study area, Table 1 identifies the dynamics of study for each One of the scales, establishing for this research three (3) variables that are taken from the valuation of the indicators of the public space [11], these are: the environmental physics that relates the aspects of infrastructure, services, environment and contact with the outside, the cultural partner that includes security, protection, social events and citizen attitudes and finally, the economic policy that encompasses the economy and institutionality.

Table 1. Identification of city dynamics by scale levels.

Study dynamics	Meso scale elements	Micro scale elements
Physical- environmental	Green areas, public spaces, health, education and large-scale shops	Infrastructure, roads, platforms, lots, blocks, shops, facades, natural vegetation, artificial vegetation, public space, housing typology, invasion of public space, street vendors, informality, parking areas, vehicles, public and private transport, deforestation and land use
Social-cultural	Hotels and tourism, heritage and large-scale shops	Hearing pollution, visual pollution, sale of drugs, traffic, insecurity, homeless, neighborhood life, families and residents, security, garbage, cultural events and citizen contributions
Political-economic	Government and institutions and large-scale shops	Regulations and government, construction indexes, occupancy rate, land use, property value, housing value, decrees, agreements, resolutions and investments

In the second phase, conceptualization of the problem occurs at the meso scale (500 m² of influence area) and micro (study polygon), identifying the service nodes (government, institutional, environmental, health, hospitality and tourism, educational institutes and heritage) , then the data is recorded in the field by means of the technical data collection sheets, to finally perform the analysis, geometrization and representation of intangible networks.

The research process carried out the following steps: Initially, the study and mapping of the polygon by land use was carried out, then the nodes, the trajectories, the displacement and the conformation of the seven (7) service networks present in the study radius of 500 m², (meso scale), then the number of farms and blocks in the area under study was quantified, later the relative weight of the coverage and incidence (%) by service networks was determined (meso scale) and uses (micro scale) in the sector under study, consequently the analysis and definition of the trajectories by connectivity of uses (relationship or connection through three (3) links, when this is irregular its connection is given from the closest points in the area through a straight line) through juxtaposition of layers, this led to prioritization by quantitative values (quantity, capacity, frequency) with different measurement scales depending on its use, as well as the organization of hierarchies and intersection points, which allowed the crossing of information by temporalities and finally the generation of results matrix.

3. Results

3.1. Polygon of study by land uses

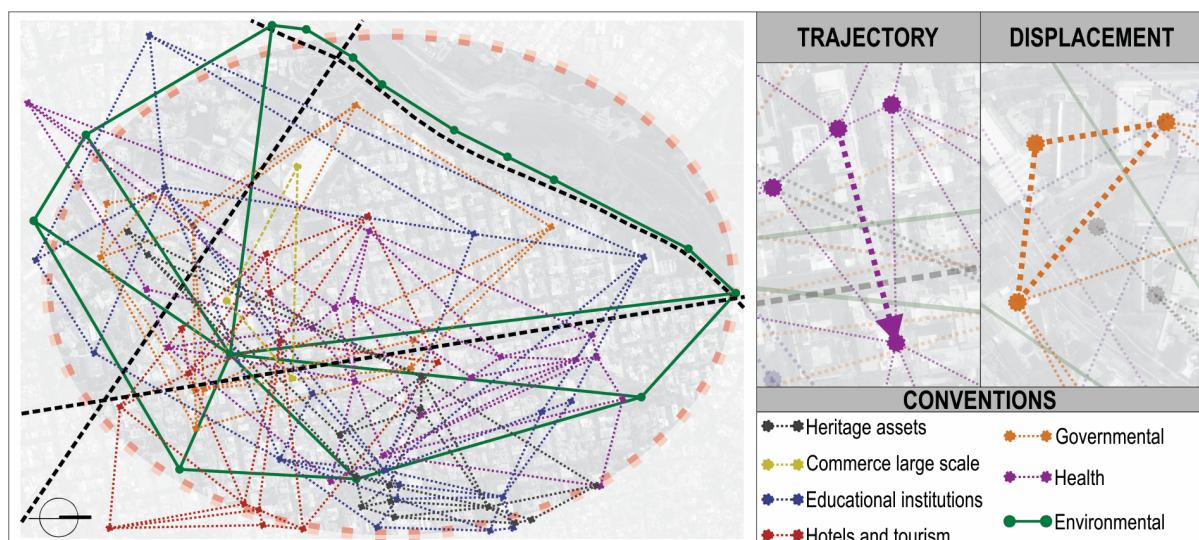
Once the cartographic survey by land use has been carried out, Table 2 shows that for the micro scale, the trade network has a higher percentage of occupation of land uses with 32%, followed by 31% corresponding to the use of housing, 20% of mixed use, health with 9%, government use with 3% and religious, educational, green areas, construction and empty uses with 1%.

Table 2. Land use occupation.

Land use	# Lots	% Occupation
Family home	126	31%
Mixed shops	81	20%
Health	129	32%
Religious a	37	9%
Religious b	3	1%
Educational	11	3%
Parkland	6	1%
In construction	3	1%
Empty	5	1%
Total	6	1%
	407	100%

3.2. Analysis of dynamic connection networks at meso scale

The analysis starts from the recognition of the nodes and the conformation of the service networks present in the radius of study of the 500 m², this taking into account that this range of action corresponds to the movement on foot of a person within their environment immediately, in a period of 15 minutes; approximately, being consistent with the provisions of the indicators plan of urban sustainability [18]. Figure 1 presents the recognition of the nodes and the conformation of the service networks present in the study radius of 500 m² by juxtaposition.

**Figure 1.** Juxtaposition of meso scale networks.

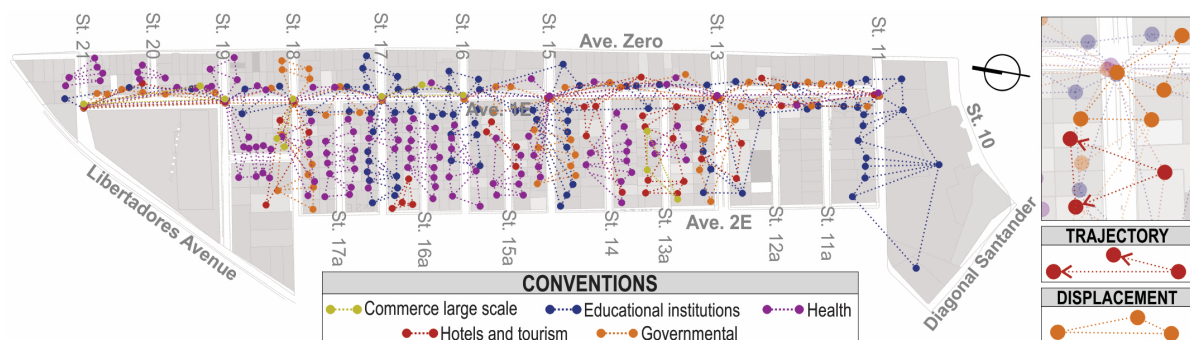
As can be seen in Table 3, the study shows that the system of networks of environmental elements creates a ring on the perimeter margin, with 61% of the study radius of 500 m² while the system of networks of health elements has 34% coverage and 24% incidence, transcending its limits and locating elements of tension that alter and reconfigure the urban space. The network system of institutional elements presents for the study a coverage index of 58% and 45% incidence, occupying a high percentage of spaces, the government services network presented 35% coverage and 22% incidence, remaining its nodes grouped into a specific sector (this network is not part of the polygon on the micro scale), the hotel and tourism network has an incidence of 25% and a coverage of 17%, the heritage elements network has a 19% coverage and 12% incidence, also this network is located outside the study polygon; and finally with 4% coverage and an incidence of 2% is the network of commercial points (large-scale commerce) represented by large-scale commercial platforms.

Table 3. Coverage and incidence meso scale.

Network services	# Nodes	# Blocks	% Coverage	Incidence (m ²)	% Incidence
Heritage assets	14	34	19%	283856.52	12%
Educational institutions	17	102	58%	1081885.61	45%
Environmental	7	107	61%	1144311.16	48%
Governmental	12	62	35%	540136.41	22%
Hotels and tourism	12	44	25%	417688.65	17%
Commerce large scale	3	8	4%	49035.50	2%
Health	18	61	34%	591189.62	24%

3.3. Analysis of dynamic connection networks at micro scale

The juxtaposition of the networks of uses on a micro scale allows identifying the points and areas of greatest pedestrian connectivity (displacement and trajectory) showing the variety of land uses in the area under study and the frequency of use by people with respect to the place, stimulating urban dynamics, which configure changes according to time zones. Figure 2 presents the juxtaposition of use networks in the study area.

**Figure 2.** Juxtaposition of micro scale networks.

In Table 4, it can be seen that in the micro scale the network of educational institutions has 92% coverage and 82% incidence, followed by the government network with 64% coverage and 60% incidence, the network of health is found with 64% coverage and 59% incidence, the hotel and tourism network has 36% coverage and 39% incidence and finally the large-scale trade network has 16% coverage and 11 % of incidence. The heritage assets network and the environmental network are not part of the micro scale. Regarding the frequency of use (temporality), it is obtained for the study of the micro scale that 100% of frequency of use corresponds to the health network (37 properties), followed by 90% represented in commercial use (129 local between small and large scale), 80% locating mixed use (housing-commerce), followed by 60% frequency of use of the housing network and the government network, and 40% the network of educational institutions.

Table 4. Coverage and incidence micro scale.

Use network	# Nodes	# Blocks	% Coverage	Incidence (m ²)	% Incidence
Educational institutions	17	23	92%	239415.99	82%
Governmental	12	16	64%	174181.47	60%
Hotels and tourism	12	9	36%	115289.22	39%
Commerce large scale	3	4	16%	32423.37	11%
Health	18	16	64%	1711254.45	59%

4. Conclusions

The development of this investigative exercise through analytical, mathematical and physical methods favored the recognition of individual trajectories and movements (pedestrian) by services (meso scale) and by uses (micro scale), necessary for the generation of multiple connectivity's within the sector under

study. For the environmental network, it was detected the importance of establishing a significant number of paths that allow connecting the nodes of the meso scale with the micro scale. The importance of hierarchically and quantitatively recognizing the trajectory and displacement in the connection networks (at meso and micro scale) was evidenced in order to solve problems or phenomena typical of the daily life of the sector under study, guaranteeing a dynamic process that is consistent with the needs for growth. The establishment of the urban geometries typical of the physical-environmental, social-cultural and political-economic dynamics of the study area, allowed us to analyze the connectivity trajectories of the networks of intangibles giving rise to new areas that comply with the theory of urban networks, through crossings and overlaps that cause cross connectivity's.

This study allowed recognizing two areas resulting from the urban connectivity layout: the dynamic zones, classified as the intersection points of the street that present a high concentration of uses of ten properties or more according to the corresponding use, represented in the network of commerce and the health network by points of care located between 13th street and 1st avenue, the timing and frequency of use of the health network is condensed in the strip corresponding to Monday to Friday. The transition zone, defined as a connection point between nodes and/or dynamic points, located within this investigation on 13th street, 16th street, 18th street and 19th street with 1 East avenue, the timing and frequency of use of the micro scale trade network (local between small and large scale) is condensed in temporality weekend. While temporarily from Monday to Friday, the transition areas of the commercial network are located at 16 A street with 1 East.

These results show how architecture glimpsed from the perspective of the city approach studied from the general theory of systems can be nurtured by means of a mathematical and physical logic that allows strengthening its results by studying significant variables for the understanding of urban reality.

References

- [1] Tamayo Alzate A 1999 *Noos: Revista del Departamento de Ciencias* **8** 84
- [2] Toro Fernández B 1989 *Norba: Revista de Geografía* **8-9** 531
- [3] Ohanian H C, Market J T 2009 *Física para Ingeniería y Ciencias* (Nueva York: Mc Graw Hill)
- [4] Serway R, Jewett J 2008 *Física para Ciencias e Ingeniería* (Mexico: Cengage Learning Editores)
- [5] Heiblum A 2017 *Física del Espacio-Tiempo in Diccionario Interdisciplinar Austral* (Chile Facultad de Filosofía Universidad Austral)
- [6] Bertalanffy L V 2003 *Teoría General de los Sistemas* (México: Fondo de Cultura Económica)
- [7] Góngora L, Caballero C, Avellaneda J D, Bello J S, Buriticá A F, Vásquez A F, Hernández García J 2017 *Apropiación del Espacio Público como Mejoramiento Social y Espacial, en Parques Vecinales de Bogotá* (Bogotá: Universidad del Rosario)
- [8] Borja J, Muxi Z 1998 *Espacio Público: Ciudad y Ciudadanía* (Barcelona: Electa)
- [9] Rangel M 2002 *Los Cien del Espacio Público para la Vida Sociocultural Urbana* (Venezuela: Universidad de los Andes)
- [10] Ayala García E T, Hernández Suarez C A 2017 *Encuentros* **15(2)** 115
- [11] Páramo P, Burbano A, Fernández Londoño D 2016 *Revista de Arquitectura* **18(2)** 6
- [12] Ayala García E T 2018 *El Espacio Público Desde la Perspectiva del Colectivo Infantil y el de los Adultos Mayores: Un Estudio Interdisciplinar Entre la Arquitectura y las Ciencias Sociales* (Barcelona: Universidad Politécnica de Cataluña)
- [13] Salingaros N A 2005 *Principles of Urban Structure. Desing, Science and Planning* (Michigan: Techne)
- [14] Bernal Granados M A 2015 *Análisis y Diagnóstico Urbano-Regional. Metodología para la Caracterización Territorial* (Bogotá: Universidad Piloto de Colombia)
- [15] Escobar Pérez J, Cuervo Martínez A 2008 *Avances en Medición* **1(6)** 27
- [16] Muñoz F, Montor F J, Luque T 2006 *Quality and Quantity* **4(40)** 519
- [17] Hurtado J 2012 *Metodología de la Investigación: Guía para una Comprensión Holística de la Ciencia* (Caracas: Quirón Ediciones)
- [18] Agencia de Ecología Urbana de Barcelona 2009 *Plan de Indicadores de Sostenibilidad Urbana de Vitoria-Gasteiz* (Vitoria-Gasteiz: Departamento de Medio Ambiente del Ayuntamiento de Vitoria-Gasteiz)