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Original

The Influence Factor for Walkability of Street Furniture: In Case of Turin / Shi, Xiaolei; Bosia, Daniela; Savio, Lorenzo. - ELETTRONICO. - 966(2019), pp. 347-357. ((Intervento presentato al convegno AHFE 2019 tenutosi a Washington nel 24-28 Luglio 2019.

Availability:

This version is available at: 11583/2787038 since: 2020-01-30T16:14:18Z

Publisher:

Springer

Published

DOI:10.1007/978-3-030-20151-7_33

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Smart Street Furniture: Innovation in the Layout Design Process

Abstract. There are so many pieces of street furniture in the city to improve our daily life through supply different service for people, which changing the way we live is also influencing our behavioral pattern in public place. The placement of the street furniture should be based on their functions, and consistent with the patterns and designs of the hardscape at the site. But the changes of people behavior resulted in the limited mobility of street furniture are rarely studied. In the fact, it is helpful to improve the usage rate of street furniture through research on the theory of how street furniture affects the people movement trace in the public, which would improve the walkability and visibility. The research group of Department of Architecture and Design (Politecnico di Torino) participates to a demonstrative project called “Smart square meter, looking the city meter by meter” where a partnership of companies intends to test smart street furniture in the city of Turin and Milan. The paper describe the relationship among citizen behavior pattern, open public space cognition and the placement of smart street furniture, and the elements of the space and street furniture influence the people behavioral pattern.

The Phd research at Politecnico di Torino will focus on supporting the project “S[m]²art, walking the city meter by meter”. Starting from the concept of “smart meter square”¹, the candidate will support the DAD research group in the development of activities, which will support the new street furniture design:

- **Phase 1 - the analysis of public spaces, with particular interest for residual area. The test area of via Pisa will be analysed in deep considering all the elements, which make livable a urban public space: functions, cultural identity, services, street furniture, environmental outdoor comfort, safety, physical degrade, ... In particular the analysis will be focused on:**
 - the interaction relationship among people behavior, space cognition and street furniture,
 - the influence elements of street furniture and space to people behavior
 - The theoretical model on the way how the placement of street furniture influence the people behavior

The “deliverable” will be a list of guidelines and requirements for the street furniture integrations in the public urban spaces, which can be use both by the local administrations for the public commissions or by the design teams to the project development.

- **Phase 2 - the design of a new service which can be supplied by the s[m]²art street furniture. The “service design” starts from a reflection about the new needs of the contemporary society in the public space fruitions and from the new opportunities from the smart technologies.**

Some examples of new proposal based on the s[m]²art concept are given: an outdoor working station [doc1] and a “smart point” for the food distribution, avoiding wastes and in a social inclusion prospective [doc2]. Using the same framework, other services can be designed on the base of the different/specific users’ needs analysis and design requirements definition.

The “deliverable” will be a systematic list of guidelines and requirements for the proposed new service supplied by the s[m]²art furniture.

The two contributions can be developed in parallel at the beginning, finding in the research conclusion an integration (the new service placed in the test area following the integration guidelines and requirements from phase 1).

Keywords: street furniture, layout, behavioral pattern, public place

¹ The s[m]²art concept comes from the public telephone box, which was, in the past, an essential small infrastructure, diffused as a network in the urban build environment. Which should be the contemporary telephone box? A deep reflection about people need in public space fruition, integration of urban furniture in urban spaces and opportunities from the new smart technologies is required.

1 Introduction

Sm²art is a research project supported by the Italian Ministry of Research Education and University aimed at the design of innovative street furniture, in which digital technologies are integrated. The research project partnership sees the collaboration between research partners and private enterprises in both the fields of street furniture design and production, and smart technologies. Two Italian cities gave their endorsement to the research project: Torino, supported by Politecnico di Torino, and Milano, supported by Politecnico di Milano. The one of main aims of the project is to test the use of new smart furniture for citizens to realize the improvement of the public space through the *Sm²art* solution.

The location decision problem is as important as the other issues of street furniture to city plan and development. The rationality of its layout and the fairness of distribution directly relate to the fairness and harmony of urban construction and development. More importantly than all of that, the placement of street furniture will directly influence the usage results. A more suitable placement is helpful for citizens to find the furniture, and then arise to people to take part in the social activities organized by the street furniture, which is another important objective of *Sm²art*. In this paper, the smart street furniture in Turin, as a case study, which location decision process and how to affect the people behavior in public space would be discussed through the following layers:

- the interaction relationship among people behavior, space cognition and street furniture
- the influence elements of street furniture and space to people behavior
- the theoretical model on the way how the placement of street furniture influence the people behavior
- the dynamic decision model on the placement of street furniture

2 Literature Review

In 1957, Zevi. B firstly promoted the concept of architectural space come out from philosophy, and stated that the space was built by the people walking in it, named the “forth space” (*Architecture as Space: How to Look at Architecture*). From then on, people began to use “body” to measure space, as a result, human-being became the subject of space. People behavior turned into a method to describe the space. In the following theological works on open space, the theorist promoted the ways of “human being in the space” (Tuan Y-F., *Topophilia: a Study of Environmental perception, Attitudes, and Values*. 1974, Relph W. *Place and Placeness*, 1976. Tuan Y-F., *Space and Place: The Perspective of Experience*. 1977). “Being-in-the-World” (Heidegger M., 1918.) is not just kept in the philosophy or geography field, and transformed in the architectural field in 1985 (Seamon D.: *The Human Experience of Space and Place*). In this work, Seamon showed his research on geography, environment, environmental psychology and behavior, as well as architectural knowledge, discussed from geography and environment, environment and place. In 1988, Norberg-Schulz C, a famous architectural theorist, stated that existential space is more stable perceptual schema system, the environmental image. The existence of space was abstracted from the similarity of a large number of phenomena and had “the property of being an object” (*Architecture: Meaning and Place*). After building the closed relationship between people behavior and spatial cognition, people turned their perspective to how people discovery the space. Mapping theory², Pathfinding theory³, Space Syntax⁴ and so on, focuses on the interaction between people behavior and space.

In the late 1950, urban system theory was wildly used in the architectural design field and special in city planning (Lynch K. 1959). The promotion of urban research 5 elements, path, edge, district, landmark

² Theory mapping is a technique for visually outlining scientific theory. It allows researchers to concretely display interrelations between concepts, which provides for rapid communication and easy evaluation of ideas.

³ Pathfinding is closely related to the shortest path problem, within graph theory, which examines how to identify the path that best meets some criteria (shortest, cheapest, fastest, etc) between two points in a large network.

⁴ Space Syntax is applied in variety of research areas and design applications in architecture, urban design, planning, transport and interior design, which can supply visual way for researchers the visibility and walkability of district and street, and the people behavior pattern.

and node, deconstructed the city cognition into detailed different scales of blocks. As a result, the 5 basic research layers about the influence of city open space to people behavior have been established. From then on, the theoretical framework of urban space system was improving day by day. At the meanwhile, the relationship of the elements in urban system was violently discussed on the people behavior (Jacobs J.: *the Death and Life of Great American Cities*. 1961, Glaeser E.: *Triumph of the City: How Our Greatest Invention Makes Us Richer, Smarter, Greener, Healthier, and Happier*. 2011, Speck J.: *Walkable City: How Downtown Can Save America, One Step at a Time*. 2012). The deep argumentation unfolds the complex and deep systematic relation of urban space and people behavior, which undoubtedly became the best evidence of social eco-field hypothesis⁵ (Farina A, Belgrano A., 2006).

The introduction of street furniture could be dated back to ancient Rome in BC900, such as horse post and fountains. But for a long time people didn't pay attention to the special study of street furniture. With the worldwide city planning boom upsurge starting, the designers began to turn their vision to the "urban components" (Merlin P, Chaoy F., 1998), to make the city more comfortable in 1990s. The development of the contemporary street furniture research is a product of great city plan (Hausmann B. G-E. 1953). In late 1860s, the industrial revolution greatly changed the face of cities and urban street furniture became used to decorate public space (Cerda, 1867). In 1898, Camilo Sitte stated that design should be taken to stage public life and enhance the relationship between individuals and institutions. The street furniture, as public space, supplied the stage of city life for citizens and became the life itself. In 1898, the ideal "garden city" provided a direct relationship between street objects and citizens (Howard E., 1989). With the improvement of urban planning theory and practice day by day, the research on street furniture has been developing well. Many countries and districts in the world introduced their own guideline and regulation to supply the guidance on design, placement, service radius to the local street furniture in the past 20 years.

There are numerous works on the analysis of relationship between urban open space and people behavioral pattern, but rarely articles or research discussed with the street furniture. In the most research work, the street furniture is classified to landscape node, as discussing the common character as losing the special aspects without detailed data. As a result, mostly placement problems on the street furniture focus on qualitative research not quantitative one, lacking the research in datafication or visualization. The current theoretical results are not intuitive or direct in guiding the layout of street furniture in urban public open space.

3 Relevant Definition

3.1 Urban Public Space

In an obvious way, human societies are spatial phenomena: they occupy regions of the earth's surface, and between these regions material resources move, people encounter each other and information is transmitted. It is through its realization in space that we can recognize that a society exists in the first place. But a society does more than simply exist in space. It also takes on a definite spatial form and it does so in two senses. First, it arranges people in space in that it locates them in relation to each other, with a greater or lesser degree of aggregation and separation, engendering patterns of movement and encounter that may be dense or sparse within or between different groupings. Second, it arranges space itself by means of buildings, boundaries.

3.2 Urban Street Furniture

Street furniture is a collective term for objects and pieces of equipment installed along streets and roads for various purposes. It includes benches, traffic barriers, bollards, post boxes, phone boxes, streetlamps, traffic lights, traffic signs, bus stops, tram stops, taxi stands, public lavatories, fountains, watering troughs, memorials, public sculptures, and waste receptacles. The design and placement of furniture takes into account aesthetics, visual identity, function, pedestrian mobility and road safety⁶.

3.3 People Behavior Pattern

⁵ Eco-field Theory, the organisms in the Eco-field interact with each other, and the ecological model can be assumed to predict the change of an ecological space under kind of intervention.

⁶ https://en.wikipedia.org/wiki/Street_furniture

When a man walks across the public space, his route will form an invisible curve on the ground. And if a group of people cross the plane, you will get a series of curves, which includes a lot of information. The curves will begin at the entrances or exits. It is possible that there is sculpture or some other facilities in the place to attract people's attention, which bends their path from a line to a curve. Certainly, the force of the street furniture is not an attraction, but a rejection. The curves to express the routes of people crossing could state some people behavior when they pass away the open flat. At the meantime, the curves form a kind of pattern. So we can name this curves as people behavior Pattern.

3.3.1 We Can Get What from People Behavior Pattern

Obviously, the pattern, like a graphic image, will show more or less mixed and disorderly because of the indeterminacy in the people behavior. However, by ignoring the accidental event, we can obtain the main tendency of the people behavior rules in a certain place. Besides the exits and entrances, in fact, that the curve without vector property, so we has no ability to distinguish which is entrance or exit, we can also get the attraction or rejection value of a street furniture. If we compare a space into a magnetic field, everything there will be a different value to measure the magnetic force. The attraction or rejection value means the same with that. For example, the fountain on a yard often attracts people to stop and admire (Fig 1). And the attraction value should be connected close to the size and location. So when you find a blank area in the pattern, there would be a piece of street furniture. Even you can't get the accurate contour line of the facility, but you can get the scale relationship among different furniture in the same behavior pattern image.



Fig. 1 A fountain in Hyde Park North, Sydney, designed by Francois Sicard⁷

3.3.2 We Cannot Get What from People Behavior Pattern

Because lacking of the vector information, we can't get the neighborhood relationship of this space, unless trying to join adjacent space people behavior pattern. In addition, the information of curves excludes time, which is real 2D information image. As a result, we can't get how long people stop in a special point in the space. The advantages are that we could focus on the fewer research objects and this kind flat information graphic is more convenient to apply in the other studies and design work.

4 Method

- **Bibliographical research**

Through reading and review the relevant literatures on the topic, tease out the timeline of research development, and summarize the research results and deficiency. It is not only as the proof of the significance of this program, but also provides the theoretical basis for the next step research.

- **Research analysis**

Record the people behavior in the field, including the start point, end point, movement route, and usage situation of the street furniture in the site, such as use time and the purpose. Summarize the behavioral habits of people walking across the area and the street furniture usage habits, and analyze the potential causes. Find out the obvious problems on the street furniture usage of people.

⁷ <http://www.cityartsydney.com.au/artwork/archibald-memorial-fountain/>

- **Analytic hierarchy process⁸**

Through the logical deduction of the relationship among the influence elements of people behavioral pattern from public open space and the street furniture, establish the furniture-urban public open space-people behavioral pattern interference model.

- **Data visual analysis**

To turn the data to the visual computer geography information through computer algorithm with the platform grasshopper⁹, we can trace the change of visible horizon of people when he or she walks across the site (Fig 2). And we can monitor the detail change of the shortest route of people get to any street furniture in the site as soon as a new one put into the place. It can not only bring timely feedback to various hypotheses, but also provide a new auxiliary means for the placement selection of new street furniture and the prediction of the usage.

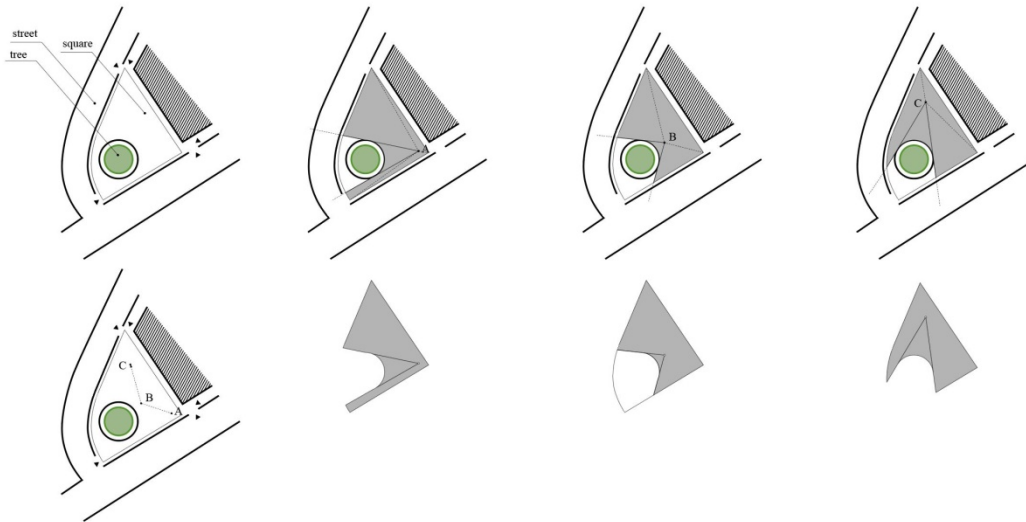


Fig. 2 The visible horizon problem is a classic problem in computer geometry algorithms: a variant of the monitor. The best visual range is obtained through the triangle field of view, which is equivalent to the best monitor range.

5 Program Design

- **literature review** 1 month

Through reading a large number of related literatures, obtain the framework of relationship among people behavior elements, spatial elements and street furniture and the timeline of development based on the previous theoretical research, as well as different research result through different research methods, and list the influence factors of open space and street furniture to people behavior pattern.

From the literature review work, it can be gotten that the datafication¹⁰ and visualization of the related research is limited now, which links more tightly to modern open space layout design.

- **Investigation** 3 months

Study the target site for continuous 3 months, and chose 3 time periods a day. Use the path recording method to record the entrance and exit the people come and leave from the site, the

⁸ The analytic hierarchy process (AHP) is a structure technique for organizing and analyzing complex decisions, based on mathematics and psychology. It is effective for us to help clarify the complex relationship among plentiful of influence factors.

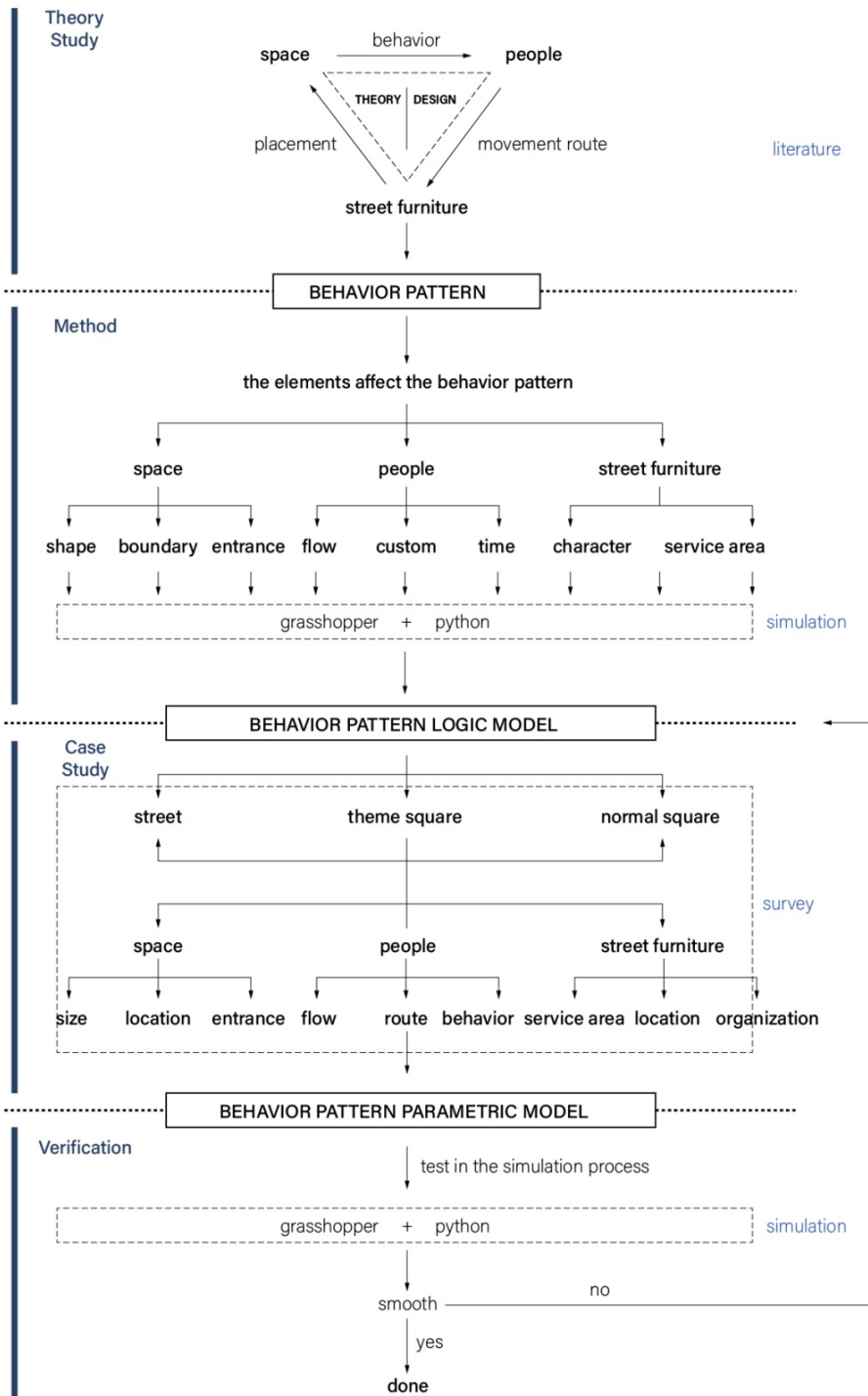
⁹ Grasshopper is a plug-in installed on the Rhino 3d modeling software. It integrates multiple languages to realize visual programming architectural modeling, which visualization of the parameter adjustment can help us to make different decisions quickly.

¹⁰ Datafication is a modern technological trend turning many aspects of our life into computerized data and transforming this information into new forms of value.

usage situation of the street furniture in the site, including the usage purpose and time. It can be concluded that the people behavioral habits pattern in the site and the relationship among various influence factors from the environment.

- **Comparative study** 1 month
Compare the influence factors got from investigation and literature review to people behavioral pattern, and try to analysis the gap to find the reasons.
- **Establish the framework of people behavioral pattern** 0.5 month
That, building tree-model on the forming of people's behavior pattern, should include factors of behavior in open Spaces, street furniture, public open space, and their relationship to each other.
- **Establish a human behavior prediction model** 1 month
By programming, transform the data information to logic computer language so that the logic could be reused in other sites.
- **Model parameter validation** 1 month
The correlation parameters in the behavior tree-model could be confirmed by the data obtained from the 3-month-investigation. The actual measurement is matched with the parameter model to obtain a predictable model of the behavior pattern of the people in the survey place. In this way, the layout changes caused by the addition of new street furniture will result in the change of the movement route pattern of the people in the potential location.

6 Technical Roadmap



7 Conclusion

7.1 Expected Results & Aims

The people behavior pattern model will be obtained through target site investigation with the interaction rules between people and the street furniture. And then, propose the people movement route pattern prediction model caused by the placement of new street furniture. It can supply several visual comparison schemes for the placement selection of smart street furniture.

7.2 Deficiency

The systematic relationship of different street furniture could not be verified through investigation. As

the result the people movement route pattern prediction model would be a prototype theory, could only supply suggestion in trend.

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