Walkability Evaluation of Alvalade District for Child-friendly Cities

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Abstract. The 15-minute city promotes walkability in the city arguing that it makes it more sustainable and allows it to become an inclusive and safe place that guarantees quality of life. To understand whether walkability is thought of in urban design it is necessary to quantify it and to identify which urban fabric characteristics favour walkability the most. Our study studies the walkability of the Alvalade neighbourhood in Lisbon, Portugal. This quarter was built in the mid-twentieth century (1945-1970) mostly as low-cost housing for workers but is currently inhabited by the middle and upper classes. The neighbourhood was structured in eight cells that considered the maximum limit of 500 meters away from the housing to the school located on its premises. Each cell has a different urban morphology, some being more permeable than others. The neighbourhood is home to a large population of young people, including children and teenagers who attend the schools located in the area. We present an agent-based model which investigates the walkability of the neighbourhood for these young people, focusing on the mobility patterns of children and teenagers as they navigate their daily routines of going to school. We simulate pedestrian movement by considering factors such as the availability of sidewalks, crosswalks, distance to schools, and the presence of other amenities. Our research reveals the mobility patterns emerging in this area and compares them across the different schools in the area. These results inform both urban policies and interventions that promote safe and accessible routes to school and state the quality of the early XX-century urban design principles that hold in the age of the 15-minute city.

INTRODUCTION

Alvalade was designed by the architect João Guilherme Faria da Costa (1906-1971) between 1940 and 1945, who studied Urbanism at the *Institut de Urbanisme de la Université de Paris* [1,2]. Faria da Costa interconnects various influences from the traditional city, the English and American Garden City, the Modern Movement, the expansions of Amsterdam (1915-1934) and the Siedlungs of Berlin [2].

The neighbourhood of Alvalade is designed with different architectural styles supported by an urban design, which gives rise to a qualified environment. This still today continues to be a reference for architects who wish to make a new city and for those who live in Lisbon.

The region of Alvalade corresponds to an area of the city of Lisbon of great centrality, with numerous urban characteristics and quality of life. Its qualities make the *Laboratoire de Sociologie Urbaine Générative* distinguish it as one of the best examples of European residential complexes of the mid-twentieth century [3]. According to this group of experts who analyzed Alvalade, it is strange that this example is not more prominent in international professional literature [3]. Alvalade represents an ideal form typical of the Modern City, comparable to that developed by Haussman in Paris or by Cerdá in Barcelona [3].

At the end of the 1930s, the city of Lisbon needed housing, and it was considered urgent to expand it [1]. The urbanization of the place where the neighbourhood of Alvalade was born begins to be thought of many years before the plan that gives it its name [1]. This urbanization originates in the Municipal Master Plan of Lisbon of 1938 [2].

Also, this year the General Plan of Urbanization and Expansion of Lisbon was developed by the Municipality of Lisbon. This plan was proposed by Duarte Pacheco (1900-1943) - Minister of Public Works and Mayor of Lisbon simultaneously and had the participation of the Architect Étienne de Groër (1882-1974) [1,4]

In 1938, an analysis programme (report) offered by De Groër was published. This report was carried out by the municipal engineer Emílio Abrantes through extensive and innovative work, for the time in such a way that it became a methodology for the following plans [5].

The project of the neighbourhood of Alvalade is based on the Urbanization Plan of the Zone South of Avenida Alferes Malheiro (regulated by Dec.-Law No. 33921 of September 5, 1944), current Avenida do Brasil and was planned. The plan of Alvalade is limited to the north by Av. of Brazil (former Av. Alferes Malheiro); to the East by Av. Admiral Gago Coutinho; to the south by the waist railway; and to the West by Campo Grande and Rua de Entrecampos.

The site of Alvalade, located on the outskirts of the city, was part of a campaign of expropriations of rural soils, being an ideal place to experiment and practice the principles of the Modern Movement [6].

Alvalade arises during the consolidation regime of the Estado Novo and under the expansion policy of the city of Duarte Pacheco. From 1947 to 1957 the modality of the construction of “rent-controlled housing” guaranteed the growth of the Alvalade neighbourhood [6].

Duarte Pacheco had an entrepreneurial attitude. He was responsible for the vast program of expropriation of land that allowed the urbanization of the neighbourhood of Alvalade, through the municipalization of the land from 1945 [1]. The Alvalade plan has 230 hectares of which 218 hectares result from expropriation actions. Of the total space, 33 hectares were allocated to free spaces [1].

The new neighbourhood of Alvalade was intended to house a population of 45,000 inhabitants (12,000 dwellings) [1] - decentralizing the equipment and services located essentially in the Baixa Pombalina (city centre) and seeking to solve the problems of housing.

The models of urban design, whose concepts emerged innovatively in twentieth-century Europe, were methodically tested in Alvalade, reconciling the coexistence of tradition and the Modern Movement.

In Alvalade a synthesis of different influences of the traditional city and the Modern Movement was carried out. We can still identify today the various urban concepts coming from these different models of the city [1]. This neighbourhood functioned as an experimental laboratory of housing solutions.

The Plan of Alvalade, being innovative, shows in its structure concepts and influences that marked the first decades of the twentieth century. the neighbourhood is organized in eight cells designed from the intersection of the pre-existing paths and those that delimit it.

The cells are – neighbourhood units [concept created by the American sociologist and urbanist Clarence Arthur Perry (1872-1944)] structured from the central element – the school [1]. According to Perry's principle, the perimeter of the neighbourhood unit is obtained by a circumference with a radius of 500m (the maximum distance a child would walk to school). The urban complex provided for the coexistence of housing of various social categories, supported by equipment (schools, markets, civic centres, sports parks, and small industry).

The connections between home and school are facilitated by the existence of pedestrian footpaths that cross the backyards of the housing blocks.

The neighbourhood is designed with several types of blocks, where the public places were thought to be large common outdoor spaces for the enjoyment of the inhabitants. This urban core emerges as something never experienced in the panorama of social neighbourhoods of official promotion. This new neighbourhood allowed the establishment of a diversified and multifunctional social fabric [7].

FIGURE 1. Diagram of the Alvalade borough with the school's areas in green.

Recent research has been proposing new city models aimed at solving the problems caused by long-distance urbanism. Building safer, resilient, inclusive, and sustainable cities, as specified in the United Nations "Sustainable Development Goal" forces us to think about new urban planning models that must adapt to these trends to ensure a sustainable and safe urban future.

In this context, one of the most publicized concepts in urban planning is, as we have already mentioned, the "City of 15 Minutes" [8,9]. This concept is grounded in proximity, for such an urban neighbourhood is planned to accommodate an ideal density that gives access to basic essential services at 15 minutes on foot or by bicycle [8,9]. The concept envisages that within that 15-minute radius, residents will be able to have a better quality of life, as they will have to travel less to access basic services such as public spaces, culture, and work. They will then have more time and opportunities to interact with other members of the community and to perform other social functions, which are increasingly important, but which have been missing as a central function of contemporary urban planning models [8,9].

We consider that the current concept of the "15 Minute City" is very identical to another urban model from the early 20th century - Clarence Perry's 1929 proposal which had a huge influence on the evolution of the Modern City form.

Recent political campaigns in an urban context proposed the 15-minute city as a central concept. In the 15-minute city, most daily needs should be attended to on foot or by bicycle. These 15-minute cities would be constituted by a series of 5-minute boroughs also known as complete communities or walkable neighbourhoods [8,9]. This highlights the relevance of the approach taken here to explore the Alvalade neighbourhood in Lisbon. It was initially designed as a working-class neighbourhood constituted of 8 cells occupying approximately 230 hectares. The premise for each cell was that a maximum distance of 500m was a threshold for the distance to the cell's school. The map of the area is seen in Figure 1 with the area occupied by schools highlighted in green.

The idea of an urban environment providing quality-of-life expectations to its inhabitants has come a long way. From the ideas of the garden city to the 15-minute city, all these urban planning proposals aim (at least in the kindness of intent) to provide its citizens with what the authors consider a better way of living in the city. The recent 15-minute city offers a perspective where the chrono-urbanism takes centre stage and where boroughs are further divided into 5-minute communities where motion would be exclusively achieved by walking.

The simulation of the neighbourhood via an Agent-Based Model allows for the construction of a playground where many possible factors can be turned on and off, and their relative impacts on walkability are studied (if not in a quantitative manner, at least in qualitative terms). In this paper, we present a NetLogo Agent-Based Model of the borough of Alvalade in Lisbon, Portugal, where we explore the characteristics influencing the behaviour of pedestrians (namely children) in the context of going to/from school.

This paper is organized as follows. After this introduction, a section about the methodological approaches taken in this work is presented. It is followed by the presentation of the results and in the concluding section they are discussed in light 15-minute paradigm discussed earlier.

METHODOLOGICAL APPROACH

Problem Formalization

The main aspect of this project concerns the understanding of the movements of pedestrians inside the neighbourhoods of residential areas. We want to understand how the built environment in Alvalade is adapted to the movement of children in their daily routines and determine the average time distance of each location of the neighbourhood to their respective central schools. Understanding their movement allows us to characterize the neighbourhood in the face of the urban theories of the past.

The pedestrian movement has been studied in many ways by past research and in the field of engineering they can be roughly divided into analytical models and simulations. These modelling efforts will often use metaphors and analogies from other fields like analogies with fluid dynamics or gas kinetics [10,11,12]. Other strategies aim to maximize entropy, use multi-level dynamic networks, or have the model be represented by stochastic processes. In the simulation field, agent-based simulation has been extensively used by representing the behaviour of the individual agent following a set of predetermined local rules of interaction (either with the environment or with other agents).

Also partially inspired by physical phenomena Helbing introduced a model based on the idea of social force [13]. This force acts as a sort of internal driver for the agent to perform certain movements and influences the value of certain variables like velocity, acceleration, etc. at each timestep of the simulation.

Another advance has been the use of cellular automata (CA) models for the simulation of pedestrians [14]. In CA the entirety of the world is defined by individual cells on a grid (in 2D simulations) and each cell updates its state according to a set of rules, usually dependent on the states of a defined set of neighbouring cells.

CAs have been used for the study of pedestrian movement, namely in the context of bidirectional movement in walkways [15]. Another approach uses CA where agents can have long-range interactions with what the authors name *floor field* that changes the transition rules of each cell. This field is subject to diffusion and decay, inspired by the notion of chemotaxis (the movement of a biological entity in response to a chemical substance deposited in the environment) [16].

Modelling approach

It was therefore decided to build an *in-silico* simulation of the territory of Alvalade. This would become a tool for the exploration of the built environment, with the potential to act as an oracle eye into future design alternatives and interventions.

The simulation depicted in Figure 3, was programmed in NetLogo [17], a platform for agent-based simulation focused on exploratory research. Procházka et al. have shown the use of the NetLogo platform for the modelling of pedestrian movement under three different modelling approaches: based on cellular automata, implementing a social force model, and using a network model of pedestrian movement [18].

The model uses ground images representing the main features of interest as maps. They are obtained as 1024x1024 raster images from openstreetmap.org [19]. These images are loaded and used as stationary features of the environment. They might include roads, schools, building blocks, and crosswalks, among many others. In the case of this work schools, streets, and pedestrian passages were selected. The CA maps each location of the map to a distance from the nearest school. Each location (a patch in the nomenclature of NetLogo) can hold any set of properties desired by the researcher.

As schools in the area depicted by Figure 1 encompass all levels of schooling (1–12) it is necessary to break down the study in age brackets. The public school system comprehends 3 main brackets in the area with different schools for each bracket: levels 1–4 (ages 6–9), levels 5–9 (ages 10–14), and levels 10–12 (ages 15-17). In this work, we only considered public schools, although there are some private schools in the area. This leads to 3 layers of analysis with a different set of schools. This is shown in Figure 2 where the public schools for each set of levels are shown.

FIGURE 2. Locations of public schools in Alvalade corresponding to levels 1–4 (left), 5–9 (middle) and 10–12 (right)

Metrics

The CA computes the time taken to update the cells of public circulation (roads, pedestrian passages, squares, etc.) to the nearest school of interest. Each cell is updated according to its Moore neighbourhood and takes the value of time as the max of its neighbours added by one. Starting from the zones of interest this corresponds to the formation of a wave of diffusion that corresponds to the effective minimum time from the school areas. This process is like the breadth-first traversing algorithm on a tree.

From the final time of each patch, we obtain a density distribution of all public circulation cells and compare them both visually and numerically. These distances are scaled according to the average speed of movement and the cell size for the area. In the case of the model, the cell side is 2m and the speed is set to 1m/s (This agrees to a traversal of one cell in 2s, or a speed of 3.6km/h). This speed was chosen as a lower bound. In real scenarios, children exhibit a range of speeds that can be modelled by distributions [20].

FIGURE 3. The interface of the simulation environment shows the resulting analysis on the left viewport and the different interaction widgets (buttons, plots, monitors) on the right side. The interface was designed to be expanded further with new models of pedestrian movement.

RESULTS

FIGURE 4. Chrono-map of the Alvalade neighbourhood for the 3 levels of schools studied: (left) levels 1–4, (middle) levels 5–9, (right) – levels 10–12.

Considering the typical speed of 1m/s (3.6km/h) it is possible to determine how far every building of Alvalade is from a school. This is seen in the resulting Figure 4 where the different chrono-maps are visible. Each colour marks the locations in the public space whose time travel to the closest schools falls in one of 4 brackets: red for times up to 5 minutes, orange for times up to 10 minutes, green for times up to 15 minutes, and violet for times over 15 minutes.

It is clear from the measurements that the east cells of Alvalade lack it terms primary school (left on the figure). For levels 5–9, the southwest cell becomes isolated while in the cases of secondary schooling, both the northwest and southeast cells become also further distant from the schools. The northeast cell, although distant from schools of levels 1–9 is mostly an urban green park. This analysis shows that the flanking limits to the east (av. Gago Coutinho) and to the south (train line) are the most distant.

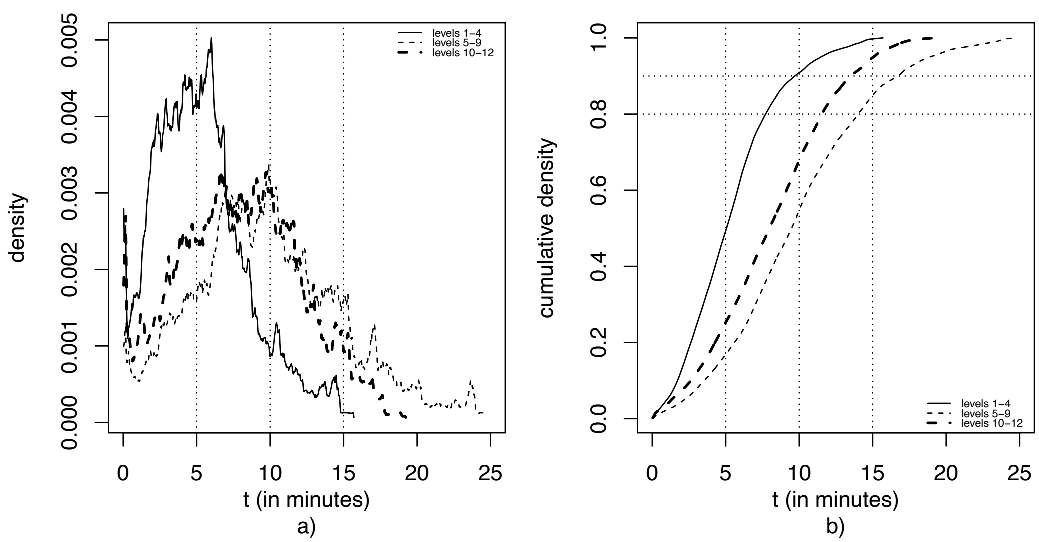

FIGURE 5. Time taken by walker of different levels to the nearest school considering a walking speed of 1m/s: a) density, b) cumulative density.

The distribution of the times described visually can be confirmed by the results shown in Figure 5. Most children studying in levels 1–4 will get to school under the 15 minutes proposed. Indeed, more than 90% are within the 10-minute walk mark. In contrast with this, elder children and adolescents will be at a disadvantage taking more time to go to school. Levels 5–9 have only approximately 55% inside the 10-minute walk and 85% under the 15-minute mark. Levels 10-12 are slightly better with 70% at 10 minutes or less, while almost 95% reside under the 15-minute time.

One could argue that elder children will be able to walk faster than the proposed 1m/s used in the simulation. In any case, this would shrink the distances for the elder students. As an example, using a walking speed of 1.3 m/s would reduce the 25-minute distances to approximately 20 minutes, still leaving students of levels 5-9 outside the 15-minute distance proposed in the literature.

CONCLUSION

Understanding the relationship between walkability and the city implies understanding the urban morphology of the territory we are studying. The built environment resulting from urban morphology has influence and repercussions on the decision to walk. The urban form has an impact on walkability and can encourage people to walk. Thus, walkability and access to all services should be a priority in cities. To create pedestrian environments in cities, the provision of pedestrian-only streets should be increased, and vehicular traffic should be reduced to a minimum.

The quality of life in the city is directly related to the attributes of its public spaces. Pedestrianisation is facilitated by the excellence of public spaces. To study the impact of the quality of public space on the pedestrian environment, Alvalade, a neighbourhood in Lisbon, Portugal, designed in the 1940s, which realizes some of Perry's principles, was selected.

In this paper, we show that the historical neighbourhood of Alvalade has been designed following doctrines laid down in the early XX century by the modern movement. The site was a location of experimentation and application of urban design principles of the time.

We developed a cellular automata simulation in Netlogo that allows us to survey and test the urban design options used in Alvalade. In this paper, we've shown how a model seems to explain and be following principles of the modern movement where the public school was the structural entity grounding each sub-community of the neighbourhood. The simulation allows for the possibility to integrate roads, squares, voids, and pedestrian passages into a description of urban design. It was shown that concerning schools, the neighbourhood of Alvalade corresponds to the current directions of urban design. The 15-minute city has many valences other than the school routes.

Simulation sheds new light on what is possible to study, and future work will develop on the shortcomings of this model. More valences will be studied, and agents' motion can be modelled in a description that is closer to natural movement. The incorporation of different vehicles was not considered, and neither was it considered that a fraction of children doesn't live in the area. This heterogeneity will be incorporated into what will become a multi-level dynamical simulation.

Throughout history many ideas of what constitutes "a good city for living in" have been proposed, and many applied to experimental sites. In many cases, those ideas follow technological needs. The car industry of the XX century pushed for cities with large avenues, and more parking areas, up to the point when those models became excessive and are now rejected. The 15-minute city program tries to return the city to the local dynamics of the small village, by localizing services, promoting walking, and cycling, and trying to integrate housing with green areas. It was shown that Alvalade has features of the 15-minute city and at least concerning schooling, the analysis attests to the perennial value of the urban design practised.

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