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Describing and locating public open spaces in urban planning

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One of the problems that planners face currently is the difficulty in finding appropriate guidelines for organizing public open spaces in urban areas. This invokes the need to create a system tool to describe and guide the planning of such components of the urban space. This research explores the problems related to the description and the location of public open spaces, and defines a system that integrates three distinct and complementary phases – appraisal, description, and location of public open spaces – each involving a specific methodology and associated tools. The main purpose is to provide computer-readable descriptions of patterns for planning urban space, to make available programmatic strategies and design options to the participants of the urban development process.

Keywords: public space, data mining, urban ontologies, eco-problem solving, patterns

1 Introduction

Although different authors say it differently, there is the common belief that open spaces deeply benefit the urban condition. The Council for Europe identifies public open space as "an essential part of the human heritage, a strong element in the architectural and aesthetic form of a city". The definition points towards the educational role of open spaces, and its importance in fostering social interaction and promoting community development, by supporting "economic objectives and activities".[1] [2]

This research discusses how to plan public open spaces and what methodologies and tools to use to do it adequately.[3] [4] Urban planning is the process of analysing, envisioning, deciding, and implementing plans for adapting social organization to meet society's needs.[5] Planning public open space plays, therefore, an important role in this process as it is an essential ingredient of spatial organization. By planning public open spaces adequately planners can promote a wide range of benefits to communities, such as social interaction and cohesion, thereby building social capital.[6]

In this article, it is described the development of an integrated system tool to plan public open spaces. This tool will constitute a repository of structured information on the urban context that will support the development of intervention programs and designs by the participants of the urban development process. The proposed system integrates three distinct and complementary phases: appraisal, description, and location of public open spaces. Each phase involves a specific methodology. In the appraisal phase data mining techniques are used to support an automated search for patterns within the urban space following the methodology proposed by Gil et al.[7] The purpose of the appraisal

1 Council of Europe (1986) [www.coe.int/t/dg4/cultureheritage/heritage/landscape/Textes_en.asp]

2 Woolley H. (2003). Urban open spaces. Taylor & Francis

3 Montenegro N. et al (2011a). Public Space Patterns: Modelling the language of urban space. In: Carrara G. et al eds, Connecting Brains Shaping the World, Proceedings of the 13th International Conference on Advances in Design Sciences and Technology, Europia Productions, Paris

4 Montenegro N. et al (2011b). An OWL2 Land Use Ontology: LBCS in Lecture Notes in Computer Science (LNCS), Proceedings 11th International Conference on Computational Science and its Applications, Springer, pp 185-197

phase is twofold: first, to identify public open space patterns in the existing urban structure, and second, by comparing with standard requirements to identify new patterns required in the face of an expected growth or environmental adaptation. In practical terms, the data mining process clusters sets of parameters describing different types of public spaces. In the description phase, the concepts of public open spaces are encoded into an ontology using the Protégé ontology authoring tool.[8] The Web Ontology Language (OWL) is the W3C standard language for modelling ontologies in the Semantic Web. The ontology design issues faced were previously tested in a land use standard. The information obtained in the appraisal phase, with the clustering process, allows the ontology to identify the parameters of the identified public open space patterns. Once this information is stored and the concepts defined, one can identify existing types of public open space and the further needs in terms of completing the planning requirements. Finally, there is an important task. It is important to define the location for the required public open spaces. The location algorithm, supported by an agent based search system, consists of searching for the best placement of different public open spaces depending on the requirements for serving a certain amount of population and a certain attraction effect called irradiance which evaluates how far a public space is from the population it serves. The location problem-solving follows the methodology and tools proposed by Montenegro, already tested for public facilities location. The proposed model was built in NetLogo 4.1.3, due to the suitability of this environment for modelling multi-agent systems.

In this paper related work is discussed in Section 2 and a definition of public open space in Section 3. Section 4 is dedicated to the presentation of the method for the appraisal, description and location of public open spaces in the urban context while Sections 5 and 6 summarise the results and present the conclusion.

2 Related work

The methodologies and the tools proposed in this research have already been developed separately, regarding to different problems, within the City Induction project. The City Induction project aims at designing and building a tool for assisting in the urban development process. It is targeted at the district planning scale and the goal is to promote the generation of more sustainable urban environments.[9] To provide a system tool for manipulating public open spaces knowledge for the benefit of plans is one of the core goals of the City Information Modelling (CIM) model developed within the City Induction project.[10] This research article involves the first approach that tries to focus on the integration of the mentioned techniques and tools towards development planning. These can be described as follows.

2.1 Data mining techniques

The data mining process is characterized by a recursive withdrawal procedure supported by a statistical platform leading to information discovery, and is commonly used to perform three different tasks:[11]

- classification – arranging the data into predefined groups
- clustering – where the groups are not predefined and the algorithm creates natural groups of similar items

5 Legacy C. (2010). Regional planning for open space, Australian Planner, 47, pp 105-106

6 Duarte J.P. et al (2011). City Induction: formulating, generating, and evaluating urban plans. In: Müller Arisona S. et al eds, Digital Urban Modelling and Simulation. Communications in Computer and Information Science (CCIS), Volume 242, Springer Berlin

7 Gil J. et al (2012). On the discovery of urban typologies: Data mining the multi-dimensional morphology of urban areas, Urban Morphology

8 Protégé (2005). Stanford Medical Informatics [protege.stanford. edu]

9 Duarte J. et al (2011). ibid

10 Montenegro N. & **Duarte J.P.** (2009). Computational Ontology of Urban Design. In: Colakoglu B. & Cagdas G. eds, Proceedings of the 27th Conference on Education in Computer Aided Architectural Design in Europe - eCAADe, Istanbul, Turkey, pp 253-260

11 Fayyad U.M. et al (1996). From data mining to knowledge discovery: an overview. In: Fayyad U.M., Piatetsky-Shapiro G. et al eds, Advances in knowledge discovery and data mining, American Association for Artificial Intelligence, Menlo Park, CA, pp 1-34

12 Gil J. et al (2009). On the discovery of urban typologies: Data mining the multi-dimensional character of neighbour-hoods. In: Colakoglu B. & Cagdas G. ed, Procee-dings of the 27th Confe-rence on Education in Computer Aided Archi-tectural Design in Europe - eCAADe 2009, Istanbul, Turkey, pp

- regression – to find a function that models the data with the least error.

Gil et al colleagues argue that "Recent studies use clustering as a classification technique in the comparative study of buildings:[12] for example, in defining archetypal office building layouts ,[13] and Arabic house types[14] and in identifying residential building types according to energy use, correlated with building age.[15] At the urban scale there have been studies on urban block shape and density[16], of neighbourhoods[17] and of whole cities.[18 19] These examples demonstrate that the use of techniques of semi-automatic classification of data patterns according to multiple variables reveals building and urban form types in a systematic way." The reported experiences suggest that the same proposed techniques can be applied in discovering urban patterns for public open spaces.

2.2 Semantic web ontologies

The use of semantic web ontologies has been a hot topic for researchers involved in the development of computational tools for urban planning, mostly due to their capacity to externalise, share, integrate, and reuse urban planning knowledge.[20 21] Urban planning has evolved from a rationalistic model to a transactional model where public participation, multi-stakeholder partnerships, and strategic planning become a motto in the domain. Ontologies could thus be seen as a way of responding to difficulties that arise from these new models, so they can become inter-operative across systems and people.[22 to 25] The inference mechanism of an ontology, as well as the open characteristics of the Web, are strong enough arguments to motivate and justify the design of an ontology for any urban classification standard and in particular, the design of a public open space ontology for the Semantic Web. In short, an ontology is modular and can be easily extended, it can be shared and reused, information can be inferred and data consistency maintained, and it is ready for integration, thereby fostering interoperability between distributed urban knowledge and different applications.[26] The ontology design issues faced were previously tested in a land use standard, which constitutes useful guidelines towards the development of an OWL ontology for other planning standards, particularly when it has a hierarchical structure, as seems to be the case of public open spaces.

2.3 Eco problem solving methods

The location problem can be solved by using a computational ecosystem.[27] The basic idea is to model the problem as a set of components of an ecosystem, where space and population are considered the environment, and where the public open spaces are the living beings, whose goal is to adapt to the environment as best as possible. Usually this form of problem solving is called "Eco-Problem Solving". The proposed model has been already tested within City Induction project, as a prototype for locating public facilities, following the rules specified by the DGOTDU regulations.[28] Some of the results were previously presented at the eCAADe 2011 conference.[29] The proposed model was built in NetLogo 4.1.3, due to the suitability of this environment for modelling multi-agent systems and also because it provides a rich visualization, which is essential for understanding the evolution of the solution. It is expected that the adaptation of the model to the location of public open spaces can be easily made due to similarity of the problem.

269-278

13 Hanna S. (2007). Automated representation of style by feature space archetypes: distinguishing spatial styles from generative rule, International Journal of Architectural Computing, 5, pp 2-23

14 Reffat R. (2008). Investigating patterns of contemporary architecture using data mining techniques. In: Procee-dings of the 26th Conference on Education of Computer Aided Ar-chitectural Design in Europe, Higher Institute of Architectural Sciences, Antwerp, pp 601-608

15 Alexander D. et al (2009). The identification and analysis of regional building stock characteristics using map based data', unpublished paper presented to the Eleventh International IBPSA Conference, Glasgow, UK

16 Laskari A. et al (2008). Urban identity through quantifiable spatial attributes: coherence and dispersion of local identity through the automated comparative analysis of building block plans. In: Gero, J.S. & Goel, A.K. eds, Design computing and cognition '08, Proceedings of the Third International Conference on Design Computing and Cognition, Springer, Dordrecht

17 Thomas I. et al (2010). Clustering patterns of urban built-up areas with curves of fractal scaling behaviour, Environment and Planning B: Planning and Design 37, 942–954

18 Crucitti P. et al (2006). Centrality in networks of urban streets, Chaos, 16:015113, pp 1-9

19 Figueiredo L. & **Amorim L.** (2007). De-

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20 Rinner C. (2006). Argumentation Mapping in Collaborative Spatial Decision Making. In: Dragicevic S. & Balram S. eds, Collaborative geographic information systems, Idea Group Publishing, pp 85-102
21 Teller J. (2007). Ontologies for an Imp-roved Communication in Urban Development Pro-jects. In: Ontologies for Urban Development , pp 1–14
22 ibid
23 Ekholm A. (2005). ISO 12006-2 and IFC–Prerequisites for coor-dination of standards for classification and interoperability, Journal of Information Technology in Construction, 10, pp 275–289
24 Roussey C. et al (2004). Le projet Towntology: Un retour d'expérience pour la construction d'une ontologie urbaine, Revue Internationale de Géomatique, , 14:2, pp 217–237
25 Benslimane D. et al (2000), On the definition of generic multi-layered ontologies for urban applications, Computers, Environment and Urban Systems, 24, pp 191-214
26 Montenegro N. (2010). Building a Pre-Design Ontology: Towards a model for urban programs. Msc Dissertation, Faculty of Architecture, Technical University of Lisbon, Portugal
27 Huberman B.A. & **Hogg T.** (1993). The Emergence of Computational Ecologies. In: Nadel L. & Stein D. eds, Lectures in Complex Sys tems, 5, pp 185-205
28 DGOTDU (2002). Di-

3 Public open space: Towards a definition for urban planning

Rob Krier defines urban space as "space geometrically bounded by a variety of elevations" stressing that this definition underlines the main formal qualities of streets and squares.[30] The definition of public space introduces the social dimension by considering urban space in relation to the public use. Public open space is seen as capable to deliver a range of benefits across economic, social and environmental spheres. Empirical evidence strongly suggests that public open space has a positive impact on property prices, is good for business by boosting commercial trading, raises land value and levels of investment, and helps improve regional economic performances. Its social impact is also relevant. Open space delivers learning benefits to children by providing creative play and reducing absenteeism. It nurtures social and cognitive skills helping to reduce incidents of crime and anti-social behaviour, and promotes neighbourliness and social cohesion providing a venue for social events, as a support for the social life of communities. Environmentally, open space encourages the use of sustainable modes of transport, and improves air quality by reducing heat islands effects, pollution and water run-of. It also creates opportunities for urban wildlife to flourish.[31]

One of the problems currently posed to planners, seems to be the difficulty to find appropriate guidelines for organizing public open spaces in urban areas. There are several codes for application to specific parts of public spaces, but few studies describe urban patterns within a global perspective. This invokes the need to create a guide to describe and orient the planning framework related to these components of urban space. But should these descriptions be encoded in a format of a standard? The term standard is generally defined as "a rule, principle, or means of judgment or estimation". It might also be seen as "having the quality of a model, pattern or type, a level and grade of excellence, or as the measure of what is adequate for some purpose." Standards are used in the realm of physical planning. In this case, standards are widely used to determine the minimal requirements in which the physical environment must be built and perform. Standards not only shape and control physical space, but are also an important aspect of planning practice. Planning developers spend most of their time writing and enforcing these rules. Even though they often complain about the constraints imposed by the multitude of codes, they actively pursue their formulation.[32]

Patterns are also a relevant mean to define public open spaces. All well-structured space is full of patterns. In fact, one of the ways that one can measure the quality of a plan is to judge whether or not its developers have paid special attention to the common collaborations among the diverse components of the space. The importance of patterns in crafting complex systems has been recognized in several disciplines. Alexander et al were perhaps the first to purpose the idea of using a pattern language to create buildings and cities.[33] In short, the pattern concept is to find pertinent objects, factor them into classes at the right granularity, and establish key relationships among them. The basic idea is to set patterns to the specific problem at hand, but above all general enough to address future planning problems.[34] The patterns are associated with certain concepts of urban space and its components, and they have a qualitative approach related to the definition of a network of relationships between a base-pattern and complementary patterns. If one considers a Square as a pattern,

which formalizes a set of recurring features of that space, one can easily consider that the Square has a Fountain, a set of Benches, a Café, a Terrace, and Trees.[35] The Square is incremented with patterns that may be important for experiencing the space, and subsequently to qualify the public space. Each of such Square sub-patterns contain other semantic descriptions associated with other patterns, for example, an esplanade can have other associated patterns like a Commercial Street, a Promenade, etc. The network structure will therefore continue to extend, since those patterns will have other patterns also associated, and so on. A system of values is therefore embedded in the ontology providing the emergence of qualitative relations and consequent qualitative design decisions. The result is an extensive network of pattern connections - a semi-lattice in accordance with Alexander.[36]

4 A method for the appraisal, description and location of public open spaces

The main objective of this research is to provide decision makers of the urban development process with a system tool to describe and locate public open spaces in urban areas. As stated before, the particular aim is to develop an integrated system tool to plan public open spaces. That tool will constitute a repository of structured information on the urban context to support the development of intervention programs and designs by the participants of the urban development process. The proposed system integrates three distinct and complementary phases: appraisal, description and location of public open spaces. Each phase involves a specific methodology and their associated tools. The three main tasks of the proposed system are described in the Figure 1.

4.1 Appraisal phase: Using data mining and other techniques

As mentioned, Gil proposes a method for identifying urban form types using data mining following the recommendations and procedures found in Witten and Frank.[37] [38] The main concept is to identify patterns from an intervention context using data mining techniques. This approach allows the identification of local cultural patterns, as well as the characterization of the parameters of their morphology. The discovery of such patterns enables the description of a set of public open spaces, and any missing associated patterns. This allows one to verify what patterns appear to be absent from the network of public spaces and how to interpret certain inaccuracies in existing urban fabric.

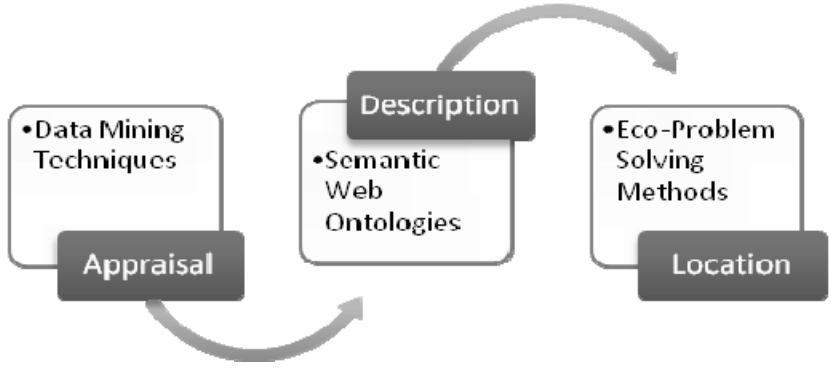

Figure 1 The diagram of the proposed method for the appraisal, description and location of public open spaces. The arrows show the flow of information that occurs between the various stages of the proposed method. Between the existing urban context condition, and the location of public open spaces

recção Geral do Ordenamento do Território e Desenvolvimento Urbano [www.dgotdu.pt]

29 Montenegro N. et al (2011c). Public Space Patterns: towards a CIM standard for urban public space. Proceedings of the 29th Conference on Education in Computer Aided Architectural Design in Europe – eCAADe, Ljubljana, Slovenia, pp 79-86

30 Krier L. & **Porphyrios D.** (1984). Leon Krier, houses, palaces, cities, Architectural Design Editions, London

31 Carmona M. et al (2008), Public Space, The Management Dimension, Rutledge

32 Ben-Joseph E. & **Szold T.**, (2004). Regulating Place: Standards and the Shaping of Urban America. Routledge

33 Alexander C. et al (1977). A pattern language: Towns, buildings, construction. New York: Oxford University Press

34 Gamma, E. et al., (1995). Design Patterns: Elements of Reusable Object-Oriented Software B. Kernighan, ed., Addison-Wesley.

35 Montenegro N. et al (2011a). ibid

Gil method proposes a three step procedure to implement these techniques, namely: representation, analysis and interpretation. "These are broken down into the following tasks:

- Representation
  - Preparation of the plan
  - Selection of classification attributes
- Analysis
  - Spatial analysis of the plan
  - Statistical clustering of attributes
- Description
  - Statistical profiling of types
  - Semantic description of types[39]

To identify patterns in public space three additional methodological approaches are proposed. The first one refers to the identification of patterns in a wide range of cities supported by a literature review,[40] as a sort of universal high level patterns. The outcome will be a set of patterns that encode design theories for development of cities. The second defines the identification of patterns according to sustainability criteria. The outcome will be a pattern language to provide levels of quality to public space.[41] The third one identifies patterns from several case-studies using traditional analytic techniques (manual and visual). The result is a repository of patterns used in the design practice to share and reuse – essentially these are morphological patterns obtained from recurrent design operations.[42] The goal is therefore to identify the patterns that are needed to generate adequate urban design programs. The approaches mentioned above permit the identification of the high level description of urban environment, which defines the generic type of public space; the qualitative parameters that affect urban sustainability; the morphological descriptions of public space patterns that are basically geometric parameters; and the semantic properties, which allow relating their values with morphological qualities of space. These main concepts of public open spaces are encapsulated into five different dimensions City Objects, Function, Material, Morphology and Mobility; each corresponding to a pattern's descriptive concept. Figure 2 shows a diagram of the correspondent dimensions. Technically, in terms of applicable knowledge towards description of the concepts, it is proposed:

- For the "City Objects" and "Functions" dimensions, the use of the LBCS: the land-use standard already mapped in an ontology using the OWL 2.0 language within previous research.[43]
- For the "Materials" dimension, the CityGML standard,[44] which consists of a standard for the representation of 3D city objects. This semantic web ontology is available online for modelling purposes;
- For the "Morphology" dimension, it is intended to use an ontology based on the clustering process derived from the data mining techniques;
- For the "Mobility" dimension, the Soft Mobility ontology, albeit it was necessary to adapt its domain concepts to fulfil specific aspects of the patterns.[45]

36 Alexander C. (1966). A city is not a tree. City, 122:1, pp 58-62 [www.chrisgagern.de/Media/A_City_is_not_a_tree.pdf]

37 Gil J. et al (2012). ibid

38 Witten I.H. & **Frank E.** (2005). Data mining: practical machine learning tools and Techniques, Morgan Kaufmann, San Francisco

39 Gil J. et al (2012). ibid

40 Moughtin C. (2003). Urban design: street and square, Architectural Press, Amsterdam

41 Montenegro N. (2010). ibid

42 Beirão J.N. et al (2011). Creating Specific Grammars with Generic Grammars: Towards Flexible Urban Design', Nexus Network Journal 13:1, pp 73-111

43 Detailed information on this subject can be found in Montenegro N. et al (2011b). ibid

44 Kolbe T.H. et al (2005). CityGML–interoperable access to 3D city models. In: Proceedings of the first International Symposium on Geo-Information for Disaster Management, Springer Verlag

45 Montenegro N. (2010). ibid

46 Krier R. (1979). Urban Space (Stadtraum), Rizzoli
47 Detailed information on this subject is available in Beirão (2011). ibid

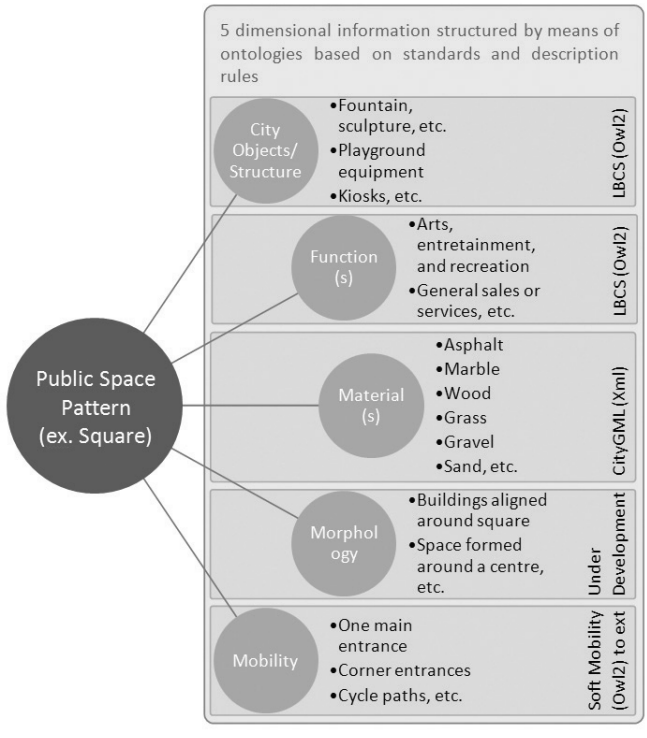

Figure 2 The five dimensions of public open space patterns

Some practical examples have been explored in terms of morphological dimension, trying to capture the geometrical genesis of public square types. Six types of public squares have been identified and were used to model the corresponding pattern for reuse in planning. Five types result mainly from planned processes and the remaining results from non-planned ones. The six types are:

- Sq1: a main plaza, a structuring square specifically designed with this purpose and which can have different but well-defined shapes, such as circle, a square or distortions of these shapes as highlighted by Krier[46]
- Sq2: a square that results from the subtraction of a block in a grid (e.g.: the Rossio square in the Manuel da Maia's plan for the reconstruction of Lisbon)
- Sq3: a square that results from the subtraction of part of a block in a grid (e.g.: public space in front of the Seagram Building in New York)
- Sq4: a square that results from subtracting shapes from the corners of city blocks in a crossroad (e.g.: the Barcelona Cerdá´s plan squares)
- Sq5: a square that results from the opening of an inner courtyard in a block (e.g.: the Spanish Seville patios; Sq6 - a public space formed out of a remnant space in an irregular grid (e.g.: typically the mediaeval square). Sq6 is an emergent type corresponding to an unplanned square.[47]

4.2 Description phase: Using semantic web ontologies

The hierarchical structure of the public open space patterns, and the extensibility of its multidimensional network of conceptualizations, makes patterns suitable

for mapping it onto ontology. The modelling of the public open space patterns into ontology provides planners with logic mechanisms that facilitate the use of different types of patterns in a context. By using ontology, it can be provided a common model of semantic descriptions, thereby avoiding the inconsistencies and ambiguities that usually arise in the urban development process when different models, stakeholders and decision-makers are involved. Ontology is therefore useful to analyze domain knowledge, to share the common understanding about the structure of information, to enable the reuse of the domain knowledge, and to make domain assumptions explicit.[48] This objective is thus to describe the construction of an ontology to support the description of public open spaces. The Web Ontology Language (OWL) is the W3C standard language for modelling ontologies in the Semantic Web. OWL2 extends the first OWL version with several new features, some of them used for the purpose of this research.[49]

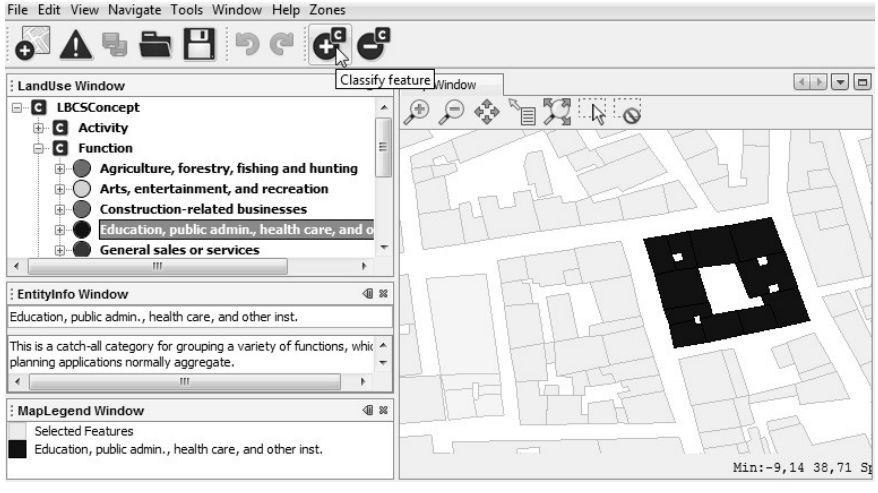

Figure 3 A screenshot of the tool interface. A land use category is selected (left), displaying in the map the features related with that category. There are some Parcels selected in the map (right) as the user classifies them with the selected LBCS category

A set of urban ontologies were formerly developed in previous research including an ontology for land use, a population ontology, and the process of description and identification of the urban context as a workflow ontology.[50] The developed ontologies led to the need for creating an interface for the tool with an associated protocol to facilitate operations within the ontology knowledge. Such a tool is under development and it is partially described in *City Semantics, GIS-Semantic Tool for Urban Intervention Areas*.[51] The basic idea was to develop an urban planning system tool, relaying on Semantic Web technologies and incorporating the LBCS ontology among others. The base concept of the tool was defined by top-level system ontologies, namely land use, workflow, and population ontologies. These ontologies, called skeleton ontologies, can be extended by user ontologies. For example, the land use ontology is extended with the categorization of the LBCS land use standard. Furthermore, the land use is linked to geographic features on an underlying map, which is stored as a shape file.

The developed system tool offers a visualization map where the different

48 Montenegro N. & **Duarte J.P.** (2009). ibid
49 OWL2 (2010). Web Ontology Language Document Overview [www.w3.org/TR/owl2-overview]
50 Montenegro N. et al (2011d). CitySemantics: GIS-Semantic Tool for Urban Intervention Areas, Proceedings of the 7th Virtual Cities and Territories Conference - 7VCT, pp 549-554
51 ibid

assertions are coloured based on its classifications (Figure 3). The tool also incorporates a workflow ontology, which acts as a guidance for the urban planner. Basically, the idea is to design a top ontology, which is extendable with user defined axioms. The goal is to apply Semantic Web techniques in the development of a system for the urban planning process. In practical terms, this ontology-driven visualization and classification tool makes available a set of editing tasks that provides the participants of the urban development process with a comprehensive set of features to select, classify, and interpret urban space. The goal is to facilitate the use of all available information to describe urban space, in order to formulate appropriate design solutions to meet context-driven requirements. This tool interface will be used to accommodate the ontology for public open space patterns. This will enable the ontology to be enhanced with additional knowledge, by the fact of interacting with the other developed ontologies.

4.3 Location phase: Eco problem solving methods

The location of public open spaces involves a set of tasks that are difficult to do manually because they cover a considerable number of variables. For this reason is difficult to reach an optimal solution. However, the ultimate goal is not to find an optimal or rigid solution, but a good solution that can be adjusted interactively by the user to adapt gradually the changes he/she wishes to implement. To make this possible, it was necessary to create a tool. This was made by using a computational ecosystem as described as follows. The general concept of the tool is thus to solve the location problem using a computational ecosystem.[52] Usually, this form of problem solving is called "Eco-Problem Solving". In general, the model proposes that solutions to problems can be seen as the production of stable states in a dynamic system. Basically, this means that evolution processes are the result of the behaviour of a large set of simple reactive agents, that is, agents that do not make plans, but behave according to a set of tropisms (eco-agents), behaviours which are reactions to the environment. Some applications of this paradigm can be found in models for the resolution of organizational problems[53] and also in cases where the problem is solved as N-Puzzle.[54] There are some studies where the resolution of the facility location problem is demonstrated with the use of reactive agents, but in these cases, location covers only one type of buildings, at a time, and is known a priori the building type that should be placed.[55]

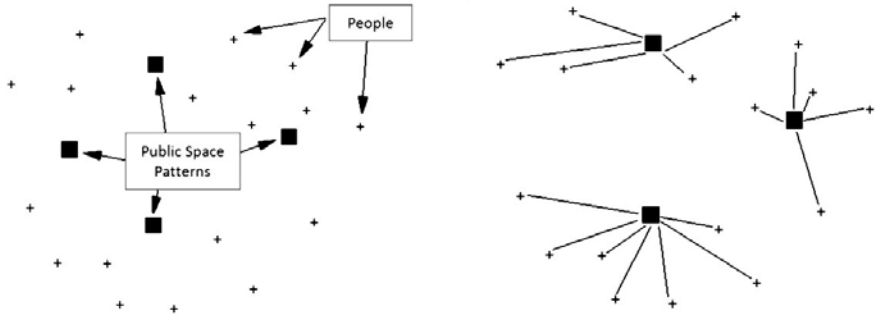

Figure 4 Diagrammatic representation of a public open space location problem (left) and solution (right)

52 Huberman B.A. & **Hogg T.** (1993). ibid

53 Kapustík I. & **Hercek J.** (2002). Stability of eco-problem solving in positional problems, Intelligent technologies: theory and applications: new trends in intelligent technologies, p 207

54 Drogoul A. & **Dubreuil C.** (2010). Puzzle: Solving the battleship puzzle as an integer programming problem, INFORMS Transactions on Education, 10, pp 56-162

55 Moujahed S. et al (2010). A reactive agent based approach to facility location: Application to transport, 4th Workshop on Agents in Traffic and Transportation in the 5th International Joint Conference on Autonomous Agents and Multiagent Systems, AAMAS '06, Hakodate, Japan

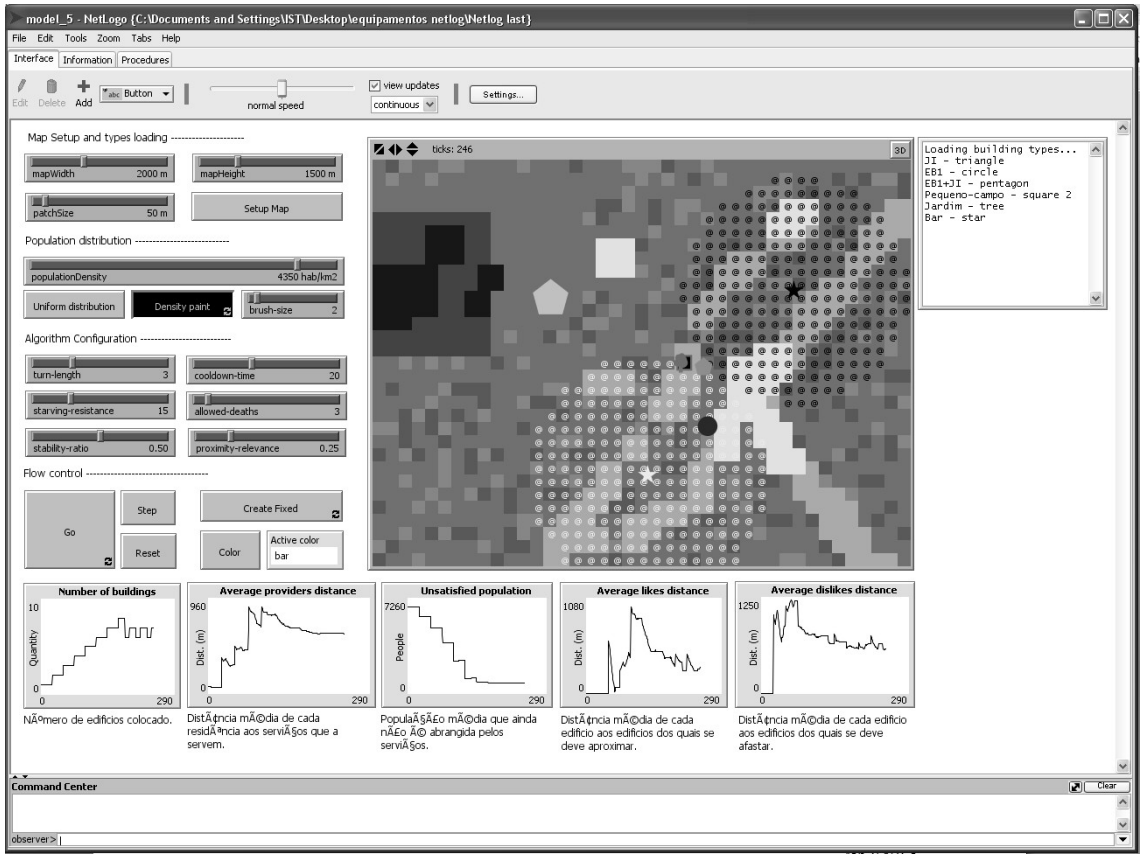

Figure 5 Prototype for spatial location: Netlogo. The map shows the irradiation of diverse public facilities that seek to find the best location in space, according to a set of simple rules. This model allows one to edit various aspects related to site characteristics (population) and the rules of each facility, feature or space

The conclusion is that using this model with various types of agents that interact with each other does not seem to be very explored or used, and typically also does not address the dynamics of death/creation of agents. Figure 4 shows a graphical representation of the problem (left) and one possible solution (right).

The proposed evaluation system does not influence the dynamics of the system. The process is simple. Some values are calculated globally and separately. This information can be used by planers to evaluate the overall solution in real time. In summary the values applicable to public open spaces concerns:

- The number of public spaces placed
- The average population that is not covered by public open spaces – 5 or 10 minutes walking distance for public spaces at a neighbourhood level; 20 minutes walking distance for larger or relevant spaces at district level
- The average distance of each public open space in relation to buildings, landmarks and focal points, to which should be near
- The average distance of each public open space in relation to buildings, landmarks and focal points, to which should be far

The proposed model was built in NetLogo 4.1.3 due to the suitability of this environment for modelling multi-agent systems. Figure 5 shows a map with the irradiation of diverse public facilities that seek to find the best location in space,

according to a set of simple rules. This model allows one to edit various aspects related to site characteristics (population) and the rules of each facility or space. The objective was thus to build a tool to determine which public open spaces should be placed in a predefined area, and where they should be approximately located. The selection and the location of these spaces will be made according to: a) the distribution of the population, b) the location of buildings or utilities, and c) of certain landmarks and focal points, marked on the area under study. This tool allows the visualization of the evolution of the solution and observes, in real time, changes in the solution when some parameters are changed. A key aspect of this model is that small changes in configuration should result in small changes in solution, in order to allow planners to understand how certain parameters influence the solutions.

5 Results and discussion

Are planning standards the desirable solution to achieving design quality of place, or are they part of the problem? Rephrasing, is it desirable to consider public open space as standard? Obviously, development standards can assure a level of quality in performance. The problem arises when standards overstep their bounds and lose grounding in the objective measures of their benefit or break the connection with the original rationale for their existence. The combined use of the term "standard" and "pattern" for the characterization of public open spaces seems to be somewhat complex, especially because each one of these concepts participates in some way, in the definition of the other. Yet, the terminology is not so clearly in conflict. The expression “standard” is already widely used in the urban planning theory, although both terms tend not to cross often in the literature (perhaps because users of “standards” seem to oppose repeatedly to the pattern language theories). The final definition, for the purpose of this research, will remain captive of future implementations. In summary, it seems to be important for humans to rely on patterns and standards to define limits within concepts. One way to describe the concepts adequately is through the use of semantic ontologies. By using the mentioned ontology in the research, the participants in urban development processes may identify and interpret public open space patterns within an intervention site, and semantically annotate them with knowledge regarding its requirements. This enhances the analysis phase of the planning process by using web ontologies to describe the urban context, thus providing a more intelligent and capable system. The location model tested was also able to solve the proposed problem when applied to public facilities. The difficulties raised by the location of public open spaces are well known. Rules are more complex and ambiguous, and there is no available standard for mapping into a computer language. However, to overcome the problems related to the analysis and description of public open spaces were used additional techniques, including data mining techniques and semantic web ontologies. The use of these techniques has demonstrated advantages because they allow better descriptions of the main types of public open spaces. The application related to the location of public open spaces seems to be very useful to the planning process. The model shows the progressive evolution of the location system of spaces, providing the ability to change parameters. This capacity allows one to observe in real time, how such changes can affect the

56 OWL2 (2010). ibid

solution. Another aspect observed was the ability to manually change the population distribution along the system dynamics. In the case of public open spaces it would be is possible to observe how they easily adapt to a new reality. This is particularly relevant because, when one is planning for a new area, there is still no clear picture of how the population will be distributed. With this tool is thus possible to observe how changes in people's distribution may affect the location of public open spaces.

6 Conclusions

The main outcome of this research is the development of a proposed system to analyze, describe and locate public open spaces in the urban environment. The system integrates three distinct and complementary phases: appraisal, description and location of public open spaces. Each phase involves a specific methodology as follows:

- Data Mining techniques: Data mining techniques are used to analyze types of public open spaces within a defined area, and then to store it in clusters to reuse;
- Semantic web ontology (OWL2 language):[56] Public open spaces types are mapped into an ontology, which allows for a better description of the concepts. Web language ontologies can be shared, reused, extended, and customized;
- Eco-problem solving in an ecosystem scenario: The location of public open spaces is made through the use of reactive agents to define the more appropriate location for each public open space.

The proposed system could provide for a more adequate way of organizing urban space, also functioning as a valuable tool to understand how parameters can influence the urban life. Testing the proposed system in urban planning seems therefore to offer a promising research field.

The main goal of future research is implement the described system in a real planning stage in order to support decision-making in urban design processes.

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