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A Function-based model of Place

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Abstract

People assign context to space by defining places. Formalizing place enables digital systems to provide a human-centred representation of the geographical world. In this paper we propose a multi-dimensional definition of place including spatial properties, composition and functionality. These dimensions define place as a set of functions, which entail a spatial structure expressed in patterns of spatial descriptions. Relying on this model, it is possible to define places as space infused with functional context by converting geometries to interrelated components that support certain functions.

1. Introduction

There is a long standing conflict between the representation of the geographical world, as it is depicted in the digital and the human world. On the one hand, digital systems understand and analyse space, whereas on the other hand, people perceive and refer to places. Attempting to reconcile these disparate views requires methods that represent the vague and individual-driven concept of place in the rigid and strict formulations of space, and vice versa.

There have been attempts to soften these sharp differences guided by Tuan's definition of place as "space infused with human meaning" (Tuan 1977). There are two general directions in defining the notion of place, either by infusing spatial representations with semantics or by projecting semantics on space.

A leading approach of augmenting space with semantics is the objectification of space (Smith and Mark 2003). According to this, spatial structures are converted into sophisticated objects with ascribed properties, attributing a context to them.

In the opposite way, digital gazetteers (Goodchild 2011) offer a linkage between place names and semantics to spatiotemporal footprints. Finally, the affordance-based model of place (Jordan et al. 1998) focuses on annotating space with context derived from people's actions. Particularly, space, expressed as a set of affordances, is imbued with meaning expressing the ability to serve human intentionality on achieving a final goal.

Most of the aforementioned methods do not fully utilize the expressive power of place. The first two methods associate space with semantics, although it does not always define a human context. On the other hand, the affordance-based model approximates a context; however, affordances provide limited and individual-driven knowledge, defining whether space affords a final goal, which impedes the model's operationalization.

We propose an alternative approach of defining place, adopting the concept of functions and considering that place is space that supports certain functionality. In this way, operationalization is achievable because functions provide an understanding of how and why places operate given a set of properties, avoiding questions of spatial perception. To illustrate this, consider the following example. Suppose we have access to an urban map either without annotations or ones that are incomprehensible due to language barriers. Would it be possible to define the potential location of a shopping centre, using exclusively lines and polygons? Answering this would require to interrelate the spatial organization of places with their functionality.

2. Defining Place

2.1 Background

Place is a product of human thinking, consequently, it can be rightfully considered as an object of discourse, as it was developed by (Couclelis 2010). An object of discourse is whatever we can talk about, regardless of its nature. Four main dimensions describe an object of discourse. The formal dimension focuses on the properties that determine the object's category. The constitutive dimension analyses the composition of the object in terms of associated parts (material or abstract). The agentive dimension identifies the functions of the object relative to a final goal. Finally, the telic dimension refers to the reasons of the object's existence.

Each dimension reveals a semantic resolution level, as it is derived from the semantic contraction process (Couclelis 2010), outlining what is possible to say about the object under consideration. With respect to the notion of place, the derived semantic levels describe its categorization, composition, function and purpose, respectively. Considering that place can be projected on space, the aforementioned levels can be extended with even more coarse-grained semantics, revealing low cognition descriptions such as clarification, perception or even awareness. The aforementioned layers can be viewed as a gradual description of the "platial" structure, from spatial existence and properties to more complicated notions, such as intentionality.

2.1 Function-based Place

Relying on the aforementioned set up of semantic layers we propose a model of place that conforms to the following assumptions. First, our model represents only places that exist in the real world. Second, our approach focuses only on places marked by human intervention and designed for certain goals. Third, we only consider those semantic levels whose information is gained through cognitive process, skipping primitive steps such as perception and awareness of existence.

We propose a multi-faceted definition of place incorporating the dimensions of spatial properties, composition and functions. The dimension of spatial properties reflects the semantic level of classification, describing place as a set of properties (e.g. geometries). The dimension of composition illustrates the constitution level, representing the spatial organization of a place as a composite object formed by simple interrelated components. Finally, the functional perspective points to the semantic level of functions that provides a sense of context by depicting the set of operations that the place supports.

We assume that place is space infused with functionality. The underlying functions suggest a context by describing how a place operates based on its spatial structure. The unique feature of the functional perspective is the implied objectiveness that stems from the dimension of composition. Particularly, it is considered a blueprint of place; it describes how the spatial objects that form a place should be organized in order to enable a desired function. This emphasizes the crucial difference between affordances and functions. Affordances refer to individual perceptions, giving answers on whether an operation can be provided by a place or not. On the contrary, functions driven by the composition process justify why a place supports a specific operation, in terms of strict spatial rules. For instance, in order for an industrial area to be functional, it has to comply with a set of standards. These standards are not products that support affordances, such as characteristics that allow an area to be perceived as industrial. Instead they are strict rules, such as topology, inclusion, and so on, introduced by urban planners and architects, which suggest a spatial design plan that will make an area to operate as industry. The lack of functions' subjectivity facilitates formalization, precision and a degree of inter-subjectivity. It is worth noting that there are

additional perspectives that determine the context of place, such as purposes, feelings or meaning. However, these are out of the scope of the work presented in this paper, but constitute future developments of our approach, as mentioned in the next section.

A place can provide several functions. With respect to the motivating example, a shopping center mainly facilitates shopping and allows re-supplying operations, while it might also provide leisure facilities. Based on our model, we propose that a set of functions, which are supported by a certain type of place, composes a functional class. This class categorizes places according to their major and minor functions, forming its functionality.

In order for the proposed model of place to support domain independence, its formalization should be flexible, reusable and extensible. An inspiring solution is the ontology design pattern (Gangemi 2005), which introduces the model of place as a self-contained building block able to be integrated into other ontologies. As stated by Gangemi (2005), an ontology pattern is discovered and refined through a set of competency questions. In our case, these questions should indicatively focus on function-based search of places, semantic annotation, reasoning, and so on. The complete definition of the ontological design pattern is currently under preparation. An initial version of the model of place is shown in Figure 1.

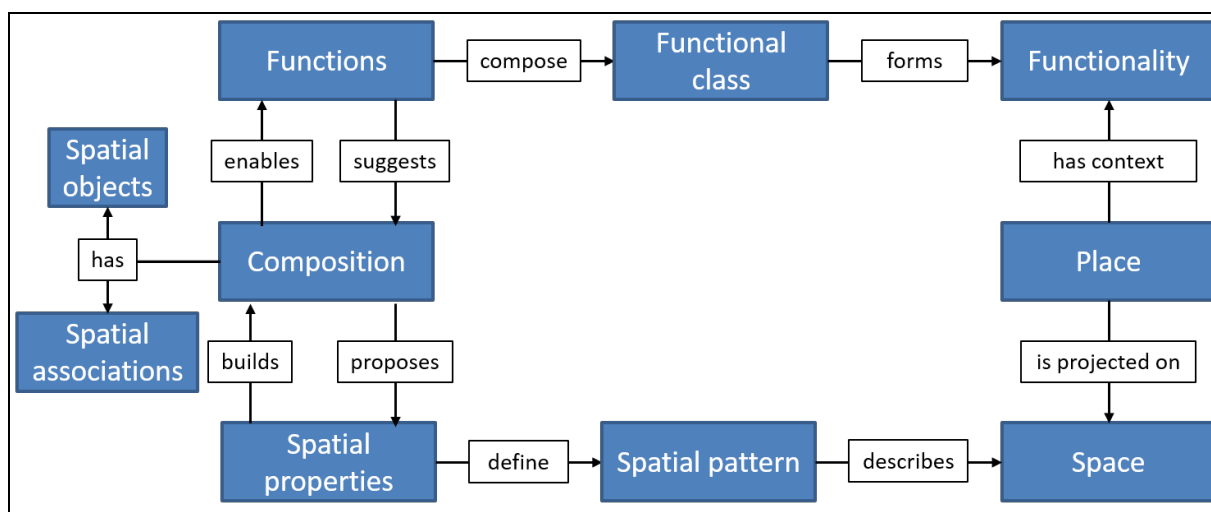


Figure 1. Function-based model of Place.

In the sequel, we provide an example of spatial design and function-based search of place that illustrates the operationalization of the proposed model. Spatial design is the process of defining an archetypal composition and hence a set of spatial properties, which shape a spatial pattern based on a set of functions. Based on our motivating example, the shopping center should be located away from unpleasant industrial areas and close to major roads, facilitating re-supplying operations. Furthermore, it should occupy a minimum profitable space that allows shoppers to move freely and also provides separate places for its re-supply operations. Optionally, it should include a parking area along with other facilities such as restaurants and cinemas that attract customers.

Rule sets such as the aforementioned one suggest archetypal compositions for places that are described by the corresponding functional class. Such compositions reveal spatial patterns by analyzing the comprised components and their associations into geometries and hence spatial properties, as shown in Figure 2a. Having obtained these spatial patterns we can answer the question of the motivating example as follows. Space can be infused with a functional context by converting spatial properties to interrelated components that conform to a composition, which supports shopping center's functionality, as shown in Figure 2b.

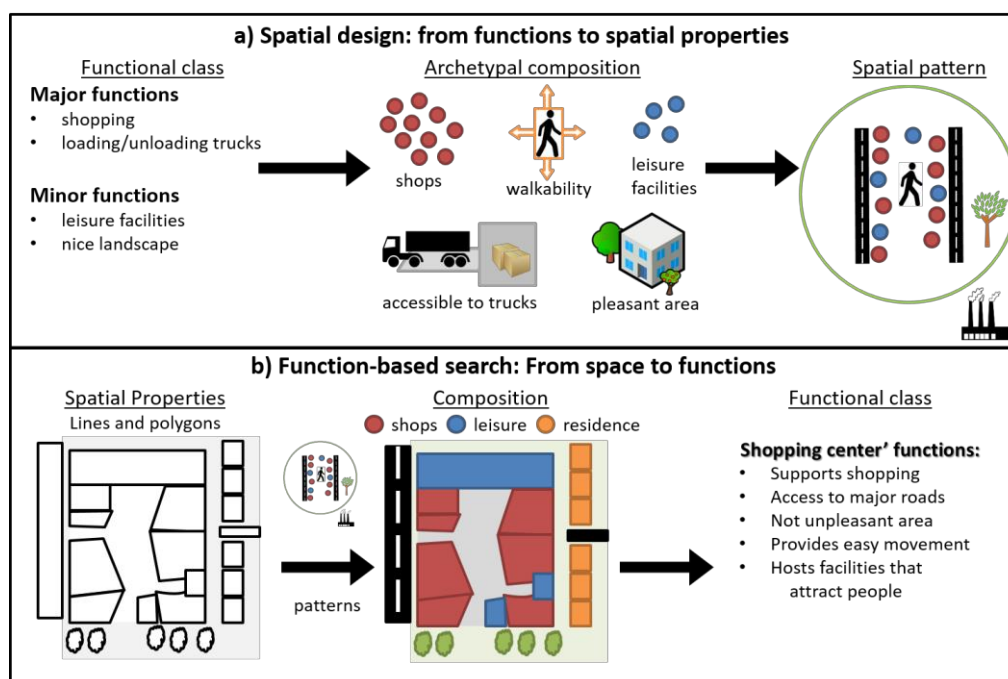


Figure 2. Interrelating functions and space.

3. Conclusions and Future work

In this work we provide an ontological model of place, based on the notion of functions. We propose a multi-faceted definition of place including the dimensions of spatial properties, composition and functions. These dimensions define place as a set of functions that entail an archetypal spatial structure. This model introduces the extraction of spatial patterns of places and the infusion of space with a functional context by converting geometries to interrelated components that support certain functionalities.

Future research includes the formalization of the proposed model by defining a representative ontological design pattern of place, and then evaluating its applicability on spatial design and function-based search. Additionally, we plan to extend the existing definition of place with the perspective of intentionality describing how places' functionality serves humans' purposes. Furthermore, we will also focus on the sentimental perspective describing how people associate places with emotions. The integration of these perspectives will provide insights on adding an element of subjectivity in the current definition of place.

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