ALGORITHMIC CLUSTERING OF SPATIAL ENTITIES

Clustering of 64 single rooms using the Self-Organizing Map algorithm.

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Abstract. Grouping spatial entities according to any kind of parameters has always been important both for practical and for theoretical purposes in architecture. For a long time, classification according to traditional reference systems was considered the only method to fulfil this purpose. However, in recent years, information technology has led to the hybridization and spread of design outputs, challenging the limits of applicability of these traditional reference systems and making it meaningless to refer to classification. This paper suggests the method of clustering spatial entities using user-defined reference systems. The method is demonstrated with a case study where 64 single rooms are clustered according to user-defined parameters with the use of the Self-Organizing Map. This method gives the power to the user to define and determine reference systems for the clustering of architectural projects according to their needs.

1. Introduction: Clustering Instead of Classification

Classification of a number of spatial entities is performed in relation to a traditional reference system. Classification in architecture has been based on historical, technical, geographical, aesthetic, functional, social, political or other parameters that are regarded as traditional reference systems. For example, according to a history-time based traditional reference system the Notre-Dame Cathedral in Paris belongs to gothic architecture, the Palazzo Rucellai of Leon Battista Alberti in Rome belongs to the Renaissance and the Villa Savoye of Le Corbusier in the outskirts of Paris belongs to modernism.

Nowadays, the introduction of information technology has driven a shift in the practice and theory of architecture. During a lecture on the foundations of digital architecture Peter Eisenman deferred to the notion of
Multiplicity in an attempt to explain the epistemological implications of the introduction of information technology in architectural practice and theory. Multiplicity is linked with possibilities for form variation, optimization of construction, the global networking of any kind of architectural data and eventually leads to the proliferation of hybrid architectural vocabularies and to the creation of insurmountable loads of data. The results are characterised by the blending of once discretised architectural attributes. They defy old schools of thought and test the limitations of classification according to traditional reference systems.

Another view on the impact of multiplicity in architecture came during the 14th Biennale of Architecture in Venice “Fundamentals” (2014), which was curated by Rem Koolhaas. In reaction to the emergence of millions of variants of architectural parts in the last decades, Koolhaas suggested that architects are in need of finding the common denominator among them. Therefore, the central exhibition of the Biennale, which was called “Elements”, featured the 15 fundamental elements of architecture, which, according to Koolhaas (2014), are “used by any architect, anywhere, anytime: the floor, the wall, the ceiling, the roof, the door, the window, the façade, the balcony, the corridor, the fireplace, the toilet, the stair, the escalator, the elevator, the ramp...”. Koolhaas explicitly negated the difference and complexity of all these elements and deferred to the traditional reference system of typology in order to classify them.

Classification has been a very efficient and successful method to address the subject of grouping of spatial entities until now. However, in the contemporary context which is characterized by the emergence of numerous hybrid design vocabularies it no longer qualifies as the appropriate process for this purpose. Traditional reference systems cannot interpret the hybrid designs that overflow reality. A recent example of a vast collection of data was the results of the first stage of the design competition concerning the Guggenheim museum in the Finnish capital of Helsinki in 2014. Entries from all around the world amounted to 1715 and composed a database that can no longer be treated in analogue terms. In the website of the competition statistics concerning the geographical origin of these proposals can be found, but the problem remains. Hence, the need for a new method of classification of architectural entities becomes apparent. One that is capable of dealing with the multiplicity of the current architectural theory and practice and simultaneously of considering different traditional reference systems without flattering them, while being applied on big data.

Clustering a number of spatial entities using a user-defined reference system is proven to be a valuable alternative of the traditional classification, which tackles the modern needs of architecture. This reference system makes use of a combination of attributes of traditional reference systems and therefore can be adapted to the needs of the user in each particular case.
Similar research has been conducted using the Principal Components Analysis algorithm. This statistical procedure uses an orthogonal transformation to convert entities of possibly correlated variables into a group of values of linearly uncorrelated variables called principal components. As Vahid Moosavi has shown, however, this procedure assumes a universal traditional reference system towards which all of the entities are projected and related.

This paper suggests that clustering using a Self-Organizing Map algorithm can be adopted as an alternative method for the grouping of spatial entities, as it operates regardless of any traditional reference systems and only based on a user-defined reference system. The use of this method has already shown promising results when used at the level of the plot. This paper goes one step further presenting the results of the application of the same method in the level of rooms.

2. Method and Application: Self Organizing Map Algorithm

The use of the Self Organizing Map (SOM) algorithm is suggested as an unsupervised process to cluster spatial entities. The SOM algorithm was created by Teuvo Kohonen in the 80s. The algorithm is based on the neural network methodology which enables the representation of multidimensional data in much lower dimensional spaces and their clustering according to user-defined numerical parameters without supervision. This means that no predefined output or traditional reference system influences the clustering process, but, on the contrary, the output depends only on the user-defined parameters.

An application of the SOM is featured in the work of Benjamin Dillenburger. The SOM was used for the rearrangement of the plots of Zurich’s city centre, making it possible to have clusters of plots with similar properties important for the user.

For the case study presented in this paper the same algorithm was used, but on another scale. The clustering potential of the SOM was examined in a set of 64 single rooms shown in Figure 1, which were arbitrarily chosen. These 64 rooms were clustered according to a set of seven user-defined parameters, i.e. area, outline length and numbers of corners, staircases, windows, doors and fireplaces of each room.
The artificial network was created from a 2D grid of 10 x 10 nodes. Each node had a set of seven parameters representing the parameters of the rooms. Initially, the value of these parameters was randomized for each node. The first step was to pick randomly one of the single rooms and check one by one all of the nodes in order to find the one whose parameters match the best to the values of the parameters of the room. The node that was selected through this process is called the Best Matching Unit (BMU). Depending on their distance to the BMU, the other nodes started to adjust the values of their parameters so that they get close to the ones of the BMU. The process was repeated for all of the single rooms of the initial set until the end of the clustering.
3. Result Analysis and Future Work

The result was clusters of rooms according to the values of the seven user-defined parameters, represented on a map as illustrated in Figure 2.

![Figure 2. The clustered set of rooms.](image)

During the execution of the algorithm the nodes of the SOM were trained in iterations and adapted themselves to the input.

As the SOM used to cluster the rooms without relating to any traditional reference system it is understood that different kinds of numerical parameters will result in different clusters of the same rooms. At the same time, the fact that the algorithm is absolutely set up by the user, who defines the input data and the values of parameters, induces a new idea of clustering in architecture. In an extended version any database of spatial entities can be clustered according to the specific purposes of the user. Therefore, the user
has the possibility to both determine the sample spaces and define the parameters of the clustering process. It is also crucial to refer to the limitations of the use of SOM. In this quantification process there is uncertainty related to the primacy of numbers when the symbolic dimensions of spaces are analysed. The user should also bear in mind that the quality of the results of the clustering process is sensitive to the input, i.e. sample spaces and numerical parameters. Those two critical points should be investigated in the future.

4. Conclusion

This paper presents the potentials of clustering using user-defined reference systems as an alternative to the classification method using traditional reference systems. The case study where single rooms were clustered according to user-defined parameters using SOM algorithm shows promising results for further implementation of the method in various scales of spatial entities. The results demonstrate how empowering these methods can be proven for the user and the potential for various applications. Future work includes the determination of the uncertainties related to the numerical expression of symbolic dimensions and the sensitivity of the method to the input parameters.

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