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## THE RELATIONSHIP BETWEEN CULTURAL AND GEOGRAPHIC PARAMETERS IN ALGORITHMIC DESIGN – SAMPLE ALGORITHM

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### ZALEŻNOŚĆ MIĘDZY PARAMETRAMI KULTUROWYMI I GEOGRAFICZNYMI W PROJEKTOWANIU ALGORYTMICZNYM – PRZYKŁADOWY ALGORYTM

#### **Abstract**

The article presents selected issues related to the role of cultural and geographic parameters in architectural and urban design. The author defines the groups of parameters and analyses a relationship between them and its influence on design process. The relationship between the groups of parameters is presented at the example of evolutionary algorithm that searches for proper location for Roman military camp. Presented algorithm is an example of possible usage of the relationship between the groups of parameters in modern algorithmic design where cultural factors are used for evaluation of geographic parameters.

**Keywords:** cultural and geographic parameters, algorithmic design

#### **Streszczenie**

Artykuł przedstawia wybrane zagadnienia związane ze znaczeniem parametrów kulturowych i geograficznych w projektowaniu architektonicznym i urbanistycznym. Autor definiuje grupy parametrów oraz analizuje zachodzącą między nimi zależność i jej wpływ na proces projektowania. Relacja pomiędzy grupami parametrów została przedstawiona na przykładzie algorytmu poszukującego lokalizacji dla historycznego obozu rzymskiego. Prezentowany algorytm jest przykładem możliwości zastosowania zależności pomiędzy grupami parametrów we współczesnym projektowaniu algorytmicznym, gdzie czynniki kulturowe mogą zostać wykorzystane w celu ewaluacji parametrów geograficznych

**Słowa kluczowe:** parametry kulturowe i geograficzne, projektowanie algorytmiczne

## 1. Introduction

The aim of the research is to analyse selected issues related to the relationship between cultural and geographical parameters and its influence on the design process. Due to expansion of parametric and algorithmic design better understanding of fundamental parameters and relationships between them is a key to more effective, conscious and successful design [1, 2].

A starting point for the research was a question: whether cultural or geographic parameters play the main role in the design process. Janusz Ballenstedt in a book: “Architektura. Historia i teoria” emphasises the role of geographic parameters in the development of architectural styles and in design [3]. From the other side, the importance of cultural factors is widely debated by Patrik Schumacher, for example in the paper: “The Stages of Capitalism and the Styles of Architecture” and in the interview “On Styles, Society, and Architecture’s Communicative Capacity”, where he states that architecture “...is a dynamic layer of a multi-layered society” [4, 5]. The definition of architecture strongly connects the design with human factors. Due to this fact, we have decided to focus not on the role of each group separately but on the relationship between them. Such approach leads to more natural observations. Human beings are always a part of design process, so the groups of parameters always come together.

Being involved in research in the field of evolutionary computing in design we have observed a correlation between the relationship characteristic for the group parameters and fitness function, which is an important element of evolutionary algorithms [6, 7]. The research is focused on the possibility of using cultural parameters as a starting point for the definition of fitness function in evolutionary computing for evaluation of geographic parameters in algorithmic design.

In this paper, we describe the location of the research, define and explain the groups of parameters and finally, we present and visualise the key relationship at the example of an evolutionary algorithm that searches for the location for historical Roman military camp [8–10].

The basic tools for final visualisation are: Rhinoceros 5, Grasshopper and Galapagos, the tools that are commonly used for algorithmic design and evolutionary computing in architecture and urban design [11–13].

## 2. Location of the research

The research area covers the coast of Adriatic Sea between the towns of Makarska and Venetia, now parts of Croatia, Slovenia and Italy. Over the centuries the region was ruled by many different cultures and countries, like: Illyrian tribes, ancient Rome, Slavic tribes, Venetia, Hungary, Austria, Yugoslavia with Soviet Union influences and finally Italy, Slovenia and Republic of Croatia in the southern part of the coast [14]. The variety of cultures that were creating an architectural landscape of this region at similar geographic parameters was crucial in the selection of the location for this research. It allows to isolate the influence of cultural parameters on the design process and to specify their role and relationship with geographic parameters more precisely.

### **3. Groups of parameters**

Architectural and urban design is determined by vast number parameters. The analysis of each parameter separately would be very difficult or even impossible and would lead to unintelligible results of research. For that reason, the parameters were divided into two main groups: cultural and geographic. Definition and nature of this division is an important element of the research.

The group of cultural parameters is defined as a set of parameters related to human activities and associated with entities that have true impact on the design process, like architects, designers, construction engineers, builders, but also officials, investors and representatives of the ruling class. The group consists of following factors: ethnic origin, cultural background, customs, beliefs, aesthetic background, relation to the monuments, political and economic situation, level of technology and civilization, individual features, etc.

Human activity factors associated with location only, like: existing buildings, societies and their historical background are classified as cultural context and are included in geographic parameters group. This is crucial for understanding the relationship between the groups of parameters that is presented in this paper. The reason for placing cultural context in the group of geographic parameters is the fact that cultural background of entities being involved in design process may be different than cultural background of the location.

The group of geographic parameters is defined as a set of parameters related to location of the project, like: terrain, climate, accessibility of materials, the presence of reservoirs and waterways, flora, fauna, cultural context, etc.

### **4. Relationship between cultural and geographic parameters**

During the field research, we stated that at selected locations we can observe a variety of different design solutions at very similar geographic parameters, for example: Town hall in Piran rebuilt under Austrian rules side by side with Venetian house built under Venetian rules, The Roman Arena in Pula and nearby modernistic building with the remnants of Roman Octagonal Mausoleum, Pre-Romanesque St Donatus' Church in Zadar built exactly at the place of Roman Forum, etc. (Fig. 1).

It means that the diversity of design in such cases is determined mostly by cultural parameters. Due to this fact, we suggest that geographic parameters do not have a direct impact on design. It does not mean that they do not have an impact at all. Their importance is determined by cultural parameters as defined in this article. In other words, the key is the relation of designers and other entities that have a true impact on the design process to geographic parameters associated with given location. For example, the relation of the designer, which is determined by cultural parameters, to the cultural context associated with a specific location can lead to different decisions, like: protect or destroy existing buildings. In such case, cultural context, which is classified as a geographic parameter, doesn't determinate design solutions and the final decision is determined by cultural parameters.



Basing on the described relationship we observed that the value of constant set of geographic parameters may vary depending on cultural factors. This led us to the conclusion that cultural parameters may be used for the evaluation of geographic parameters in evolutionary computing in algorithmic design.

## **5. Basic algorithm**

To visualise and test suggested relationship between groups of parameters, we have created an algorithm that uses evolutionary computing and cultural factors for evaluation of geographic parameters (Fig. 2). The aim of the algorithm is to search for a proper location for historical Roman military camp in given terrain.

### **5.1. Overview**

Galapagos, an evolutionary computing tool for Rhino, generates the first randomised population of locations. Each location is evaluated by fitness function, which bases on cultural parameters. Better locations are chosen for reproduction, while worse ones are eliminated from the population. During the reproduction process, Galapagos generates a new generation of locations. Evaluation, selection and reproduction processes are repeated until a good location is found.

### **5.2. Parameters**

Geographic parameters for the algorithm are reduced to curves that represent the shoreline and levels. The terrain data used in the simulation represents a part of the Adriatic coast between the towns of Červar and Zelena at Istrian Peninsula in Croatia (Fig. 3a). The area covers the centre of Poreč town, where Roman Castrum was built during II century BC. Thanks to this fact we can compare the location chosen by the algorithm with the true location of Roman Castrum in this area.

It needs to be noted that it is difficult to define some of the cultural factors as simple parameters in algorithmic design due to their complexity. For that reason, we use a cultural pattern of Castrum and its properties for the definition of cultural parameters' group. It should be mentioned that those properties are a result of more basic parameters, for example, related to the political and economic situation, size of military troops and strategy.

Cultural parameters are reduced to the shape and size of the Roman military camp and its desirable accessibility: protected by the shape of shoreline but easily accessible by Roman military troops (flat terrain). Those factors are a starting point for the definition of a fitness function that evaluates the locations generated during evolutionary computing process.

### 5.3. Genome

The genome for evolutionary computing is defined as X position, Y position and rotation of the shape of Roman Castrum. In Grasshopper and Galapagos each of genes is represented by a slider. The ranges of X position and Y position sliders are set to correspond with position and size of the curves that represent the terrain.

### 5.4. Fitness function

The parameters of shape and size of Roman military camp are passed to fitness function as a rectangle with specified dimensions. Accessibility factors are defined as an algorithm. The rectangle is divided into twelve equal segments. The algorithm measures the distances between division points and curve that represents shoreline. Each of distances is squared and those values are summed together being a starting point for fitness value. Galapagos is set to search for the minimal value of fitness function, what means that the lower fitness value the better location.

The algorithm then detects if division points are located on land or on sea by checking the side of shoreline on which each of the points is located. Fitness value is multiplied by the number of points located on sea + 1.

Finally, the algorithm detects intersections between area of the rectangle and curves that represent levels. Fitness value is multiplied by total length of curves that are a result of the intersection divided by 20 and increased by 1.

### 5.5. Galapagos settings

Galapagos is set to search for the minimal value of fitness function as described in point 5.4 Fitness function. We use the population of 200 locations with an initial boost of 2. Maintain parameter that defines the percentage of individuals that can be carried over to a new generation, is set to 10% and inbreeding parameter is set to -50%. Those settings increase the diversity of individuals in a population and are crucial for the probability of finding the best location.

### 5.6. Results of computing

During the computing process algorithm analyses, many of locations and detects that the most valuable ones are located on the peninsula of Poreč town, what corresponds with the true location of Roman castrum in this area. Depending on the randomly generated first generation algorithm finds the almost exact location of historic Roman castrum or a similar one (Fig. 4).



## 6. Additional simulations

To verify the algorithm, two more tests have been done. In one of them, we change the terrain data by adding additional levels at peninsula where the historical military camp was located (Fig. 3b). The other assets and parts of the algorithm are the same as in the case of the basic one described in previous division. In this case the algorithm detects that the most valuable location is placed at flat terrain by the shoreline close to Mali Maj town (Fig. 5a). The locations at the peninsula, where Poreč town is located, are omitted as well as other locations where the terrain is not flat.

In the case of second alternative test, we use original terrain data, the same as in the case of the basic algorithm (Fig. 3a). , However, we change a part of the fitness function, which is related to accessibility factors and evaluates the levels. The algorithm detects intersections between the area of the rectangle and curves that represent levels and measures total length of curves that are a result of the intersection. The length is divided by 20 and increased by 1 as in basic algorithm. However, the fitness value is not multiplied, but divided by this value.

It changes the meaning of desired accessibility of location from the one suitable for Roman castrum to the one characteristic for a medieval castle. We still use the shape of Roman military camp, so it doesn't exactly represent the algorithm suitable for medieval cultural factors. However, even such modification of basic fitness function affects the results of evolutionary computing. A tiny peninsula, which is located in the southern part of the terrain, is now chosen as best location (Fig. 5b). The location is well protected by the shoreline and additionally, there is a small hill that makes this location more valuable to the modified version of the algorithm. A peninsula, where Poreč town is located, is omitted due to flat terrain.

## 7. Conclusions

The simulations presented in the article confirm the correlation between fitness function and the relationship between cultural and geographic parameters. It should be emphasized that the basic version of algorithm precisely points to the location where historical Roman castrum was located. The accuracy of the computing is very high even despite the fact that the geographic parameters were reduced to terrain only. It should be mentioned, that true process of finding the location for the Roman military camp was much more complex and based on a larger number of parameters including the cultural context. However, despite of the simplifications the algorithm finds correct location.

It should be also noted that modifications in fitness function affect the values of geographic parameters and the final results of computing. That confirms the observation described in division 4 that the value of geographic parameters in design may depend on cultural factors. As Janusz Balenstedt stated, "nature creates the opportunities and human is the one who can choose out of them ... human is free to choose, but not the humankind" (translation: author) [3]. The relationship presented in this paper is essential at the level of the design process; however, it is important to be aware of the fact that it does not cover the whole complexity of the relationships between the culture and nature.

The presented algorithm by itself is an example of a practical implementation of the results of this research in design. By changing the fitness function, the algorithm can be adapted to current cultural factors and expectations and used in the modern algorithmic design. An additional conclusion is that evolutionary computing can be an effective tool that supports research in the field of architecture and urban design as presented in the article.

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Fig. 1. Examples of buildings designed at similar geographic parameters and different cultural ones:  
a) Town hall in Piran rebuilt under Austrian rules and b) Venetian house in Piran built under Venetian rules, c) The Roman Arena in Pula and d) modernistic building in Pula with the remnants of Roman Octagonal Mausoleum, e) Pre-Romanesque St Donatus' Church in Zadar built on the Roman Forum, f) Remains of Roman buildings built in to the foundation of St Donatus' Church (M. Nessel, 2017)

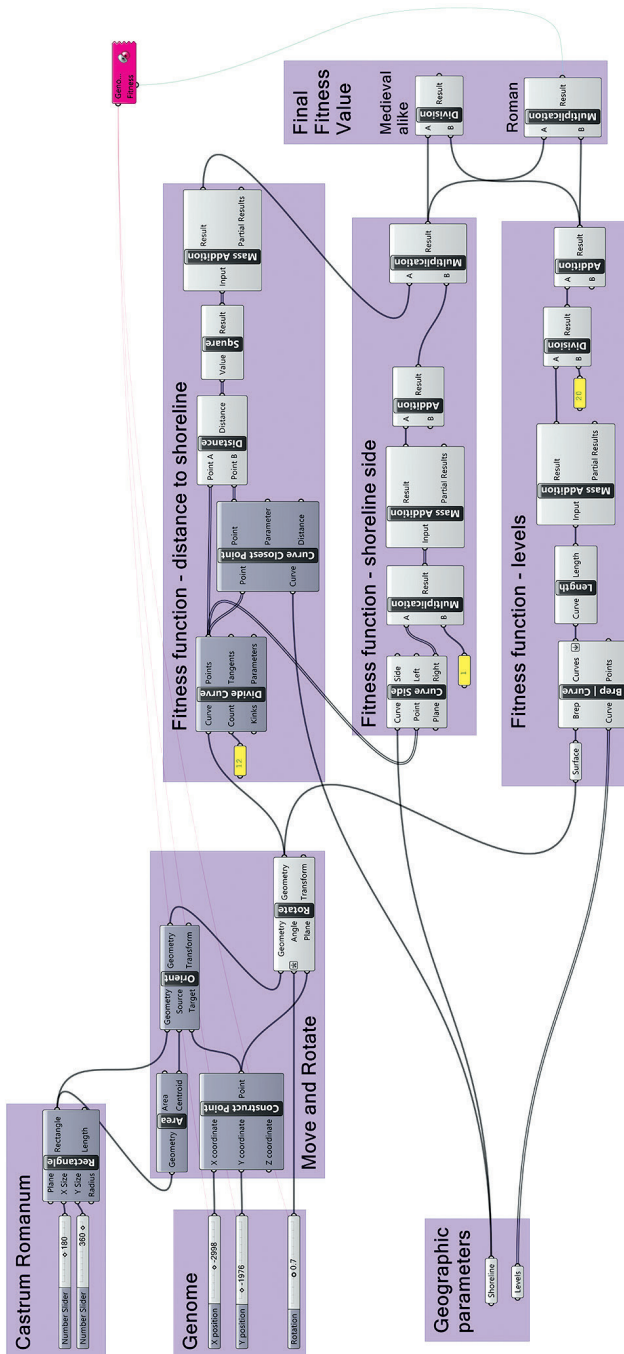


Fig. 2. Basic algorithm as described in division 5. (M. Nessel, 2017)



Fig. 3. Terrain data: a) original one used in basic algorithm, b) modified terrain data used in first additional test with additional levels at peninsula of Poreč town. (M. Nessel, 2017)

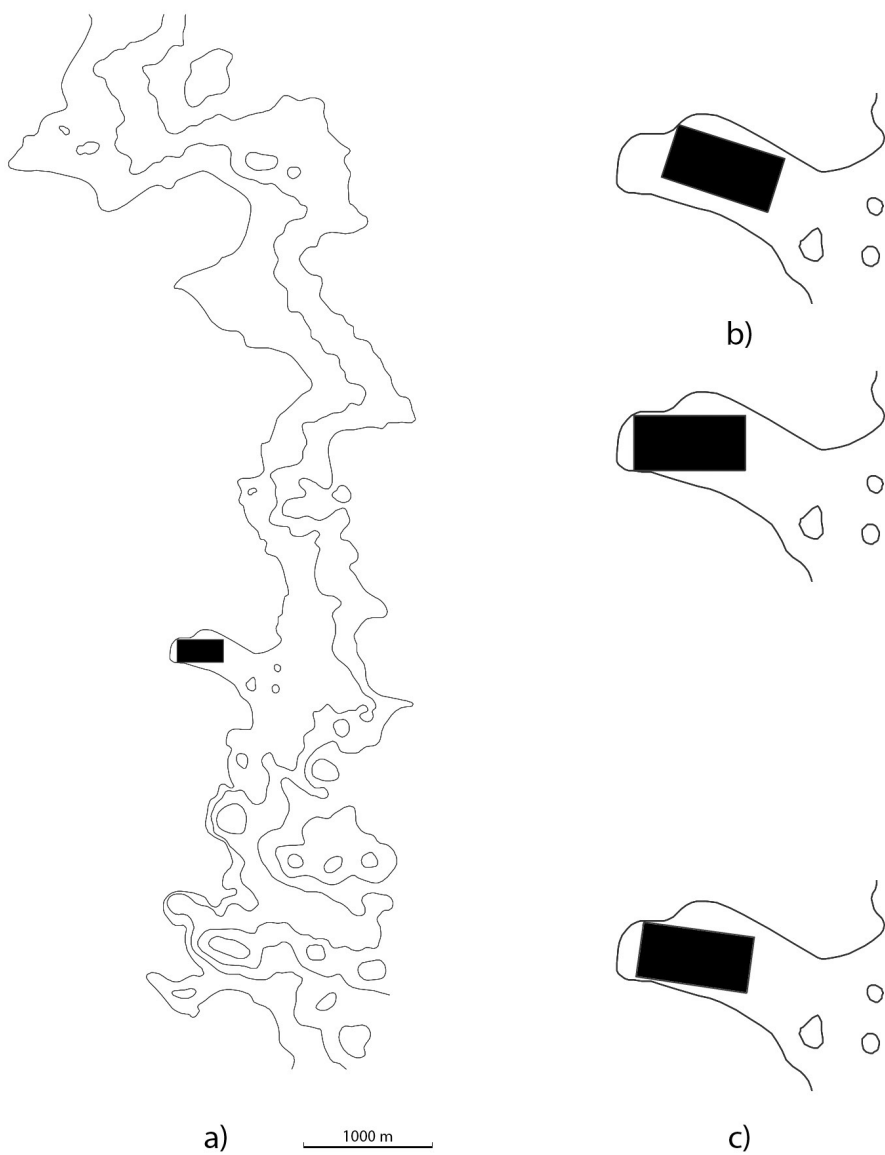


Fig. 4. Results of basic test: a) location for Roman castrum found by basic algorithm, b) close up of alternative locations found in different runs of basic algorithm, c) approximate location of historical Roman castrum (M. Nessel, 2017)

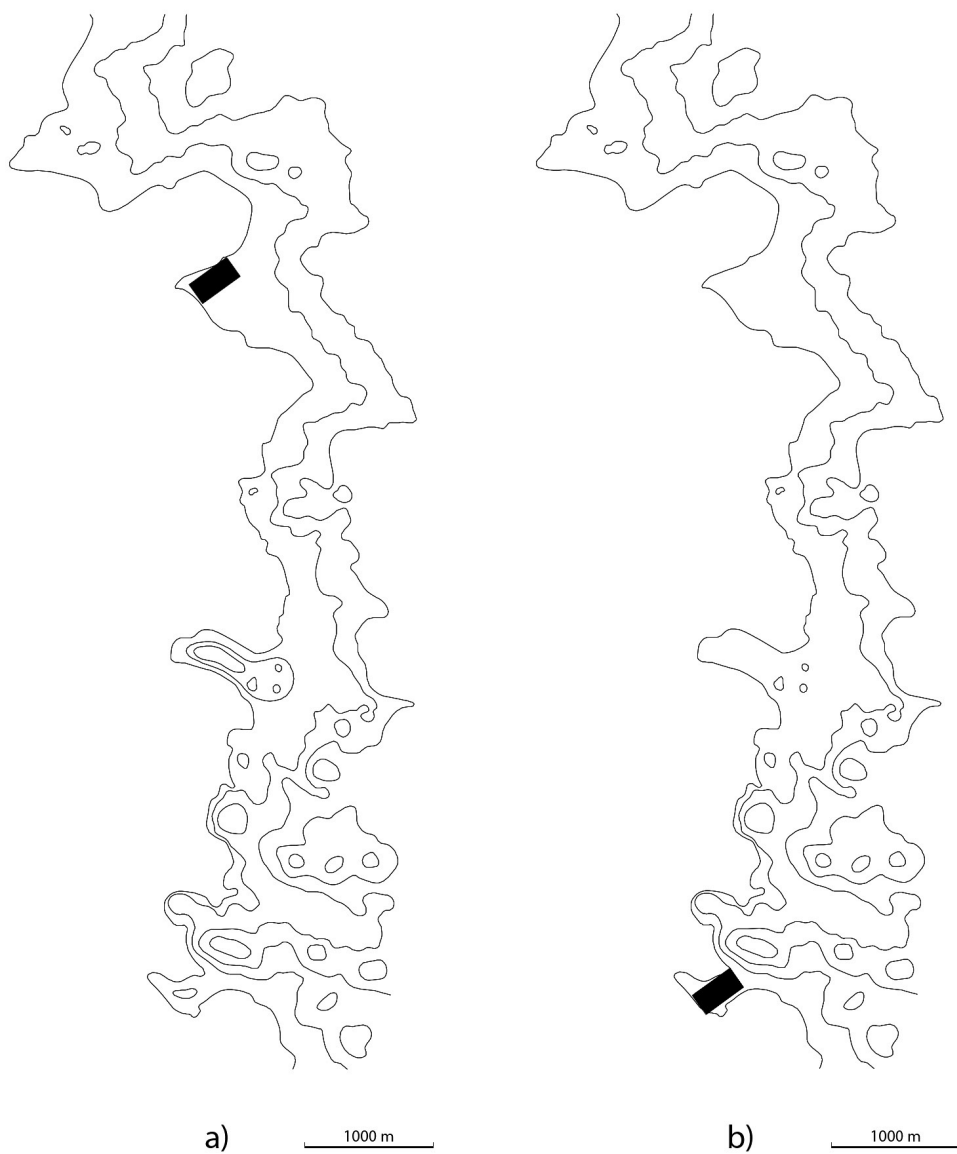


Fig. 5. Locations for Roman castrum: a) found in first additional test with modified terrain data, b) found in second additional test with modified fitness function (M. Nessel, 2017)